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V. MOLCHANOV, Y. DOMBROVSKAYA, D. LEBEDEV

PROPEDEUTICS *of* CHILDREN'S DISEASES

A Textbook for Future Pediatricians

EDITED by Prof. Y. DOMBROVSKAYA,
Member of the USSR Academy of Medical Sciences

Translated from the Russian by
MIRIAM KATZ

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CONTENTS

PREFACE TO FOURTH RUSSIAN EDITION

The principal authors of this fourth edition are, as in the previous editions, the late Professor V Molchanov, Honoured Scientist, Member of the USSR Academy of Medical Sciences, Professor Y Dombrovskaya, Member of the USSR Academy of Medical Sciences, and Professor D Lebedev, Honoured Scientist All three authors are representatives of the school of Nil Filatov, the founder of Russian pediatrics As in the previous (third) edition the exposition of all the chapters of propedeutics follows the principles of age level physiology and the teachings of Ivan Pavlov The aim of the authors was to help students in acquiring a proper conception of physiological and pathological processes occurring in childhood, and also to set forth the principles underlying expedient methods of prophylaxis and therapy of children's diseases The present edition has been supplemented and revised following discussions of the book with college instructors who conduct practical lessons in propedeutics

Professor Y DOMBROVSKAYA,
Member of the USSR Academy of Medical Sciences

INTRODUCTION

Prof. *V. Molchanov*

I HISTORICAL OUTLINE OF RUSSIAN PEDIATRICS

Pediatrics (from the Greek words *pais*, a child, and *iatreia*, medical treatment) is a young branch of medical science Pediatry, the teachings on children's diseases, did not exist as *an independent discipline* before the 19th century, there were neither hospitals for children nor specialists in children's diseases

The first children's "doctors" were the village crones who assisted at childbirth, later midwives and the physicians who came into closer contact with mothers—obstetricians and internists Child mortality, especially in the first year of life, was extremely high

As far back as the 18th century Russian scientists and prominent public figures spoke of the necessity of evolving and enacting measures for combating morbidity and mortality among children The gifted founder of Moscow University, Mikhail Lomonosov (1711 1765), wrote a work concerning the propagation and protection of the Russian people In this work Lomonosov emphasized the enormous death rate among children in Russia and suggested a number of measures for eradicating this curse N Novikov (1744-1818) and A Radishchev (1749 1802), progressive writers and public figures of the end of the 18th century, also pointed out the exigency of state care for children's health

Professor N Maximovich Ambodik (1744 1812) was a person who deserves particular attention, he was very active in the propaganda of knowledge on mother and child hygiene among physicians and the population at large Soviet physicians remember Ambodik's services in the field of pediatrics at a time when this branch of medical science had not been evolved as an independent discipline N Ambodik was the first learned obstetrician in Russia and the first teacher of obstetrics in the Russian language Ambodik compiled a dictionary on anatomy and physiology in which all the parts of the human body were for the first time given in both the Russian and Latin terms, thus laying the foundation for Russian medical terminology Ambodik was for many years engaged in the Petersburg Foundling Asylum in the capacity of obstetrician and teacher In an original work called *Iskusstvo povivaniya ili nauka o babichyem dele* (1786) (The Art of Delivering Babies or the Science of Midwifery) he devoted an entire section to problems of early childhood including care of the child from birth to adolescence and a description of the diseases of Infancy and their treatment N Maximovich Ambodik was a zealous proponent of breast feeding He wrote that mother s milk was a most wholesome reliable and irreplaceable food Many of his recommendations on child care still retain their value

Foundling asylums were established in Moscow in 1764 and in Petersburg in 1771 on the initiative of I Betsky (1704 1795) However they were actually not hospitals for children but homes for foundlings At that time there were still no special hospitals for children Children who were seriously ill were placed in ordinary hospitals for adults and their treatment there was very difficult to manage

Specialists in children s diseases appeared only after the establishment of hospitals for children and only then did it become possible to institute independent systematic studies of children s diseases throughout all periods of childhood as well as of methods for treating these diseases

One of the first children s hospitals in Europe was founded in Petersburg in 1834 This was followed by the establishment of a similar hospital in Moscow (1842) At present both hospitals carry the name of the famous Russian pediatrician Nil Filatov Thus *children s hospitals appeared in Russia earlier than they did in a number of other countries of Europe*

It is likewise worth mentioning that *the first hospital in the world for young children* was founded in 1844 in Petersburg under the name of the Yelizaveta Hospital (now named after Louis Pasteur) In this too Russia was ahead of other countries

The development of pediatry in Russia may be divided into three basic periods

The first period was that of the formation and development of pediatric science in the higher medical schools as a constituent of other disciplines Of all the branches of medicine pediatrics was connected most closely with obstetrics and internology the science of internal diseases This period approximately covers the years from the middle of the 18th century when the first Russian University Moscow University was founded to the sixties of the nineteenth century

The first prominent pediatricians were obstetricians foremost among them N Ambodik S Khotovitsky N Tolsky and others Many leading internists had long been interested in problems of childhood and had published popular books on the subject The first Russian Professor of Medicine in Moscow University *S Zybelin* (1736 1802) allotted much space in his works to child welfare for instance he compiled a set of valuable instructions on the nutrition of nursing infants In 1846 Professor *G Sokolsky* (Moscow University) published a book on the nutrition and management of newborn infants (*O kormlenuyi i vospitaniyi novorozhdennykh detei*) which was re issued in 1848 Even in our days all the methods of examination and treatment employed in the clinical management of internal diseases are widely used in pediatry the progress of pediatrics owes much more to internal medicine than to any other clinical discipline

S F Khotovitsky

During *the second period* special courses in pediatric diseases were introduced into medical training curriculums and clinics were founded for child patients

However, notwithstanding the founding of children s hospitals there were still very few pediatricians in the second half of the 19th century Planned training of such specialists and the profound study of pediatric diseases became possible only after the institution of children s clinics in the Petersburg Medico Surgical Academy and in the universities when courses in pediatrics for medical students had been introduced there

The duration of this period was from the 1860's to the October Revolution of 1917

The third (Soviet) period was a qualitatively new stage in the progress of Russian and world pediatrics as a science

During this period pediatrics has developed on the basis of Marxist-Leninist methodological principles, advancing hand in hand with Soviet medical services in the field of child health welfare

N A Tolsky

Much was done to further Russian pediatrics and the teaching of children's diseases by *the Medico Surgical Academy in Petersburg* (at present *the Military Medical Academy of Leningrad*) The first professor to read a course in children's diseases in Russia (1836) was Stepan Khotovitsky (1796 1885), Professor of Obstetrics in the Medico Surgical Academy However, his was only a theoretical course, with no clinical demonstrations In 1847 Khotovitsky published the first textbook on children's diseases in the Russian language, *Pediatrika*, in which he exponed the thesis that a comprehension of the nature of children's diseases obligated familiarity with the "qualitative distinctions" of the child as compared with adults, i e , the pediatrician must know the anatomical and physiological features of childhood In *Pediatrika* and other works Khotovitsky allotted much space to the causes underlying the high death rate among children, and to measures for combating it

The teaching of pediatrics declined after Stepan Khotovitsky resigned from the Academy in 1847 During some of the following years no lectures were read at all, and the pediatric department of the clinic of obstetrics and gynecology, opened in 1842, stopped most of its activities A conference of the Academy held in 1860 assigned Docent (assistant professor) I Radetsky to the post of lecturer on children's diseases, but he read the course for only one year, and then left the Academy, after which instruction in pediatrics was again dropped The children's department in the hospital was also closed down

In 1863 Dr V Florinsky began teaching children s diseases, he restored the children's clinical department From then on children's diseases have been taught in the Academy without intermission

A course of lectures on children's diseases was first read in Moscow University in 1886 by Nikolai Tolsky, then an assistant professor in the obstetric clinic, later a full professor There was no independent course of children's diseases in the University before Tolsky's lectures, formerly a few lectures in the course of obstetrics were devoted to children's diseases, chiefly diseases of newborn and nursing infants Students gleaned some knowledge on the diseases of older children in the therapeutic clinics for adults At the beginning Tolsky read only a theoretical course, for no children's clinic had yet been instituted at the University

The first clinic for children was founded by N Tolsky in 1866 It was set up in the building of the clinic of facultative therapy, and had only 11 beds

Soon children's clinics were established in other cities, too in 1880 Professor Tolmachov founded one in Kazan, in 1887 a pediatric clinic was opened by Professor V Chernov in Kiev, etc

The children's clinic of Moscow University played a most prominent part in the development of pediatry in Russia

Notwithstanding the small number of beds—only eleven—N Tolsky succeeded in creating the first Moscow school of pediatricians His clinic graduated such outstanding pediatricians as N Korsakov (Professor of the Moscow University Children's Clinic) V Gundobin (Professor of the Military Medical Academy), and others

Professor Tolsky was a physician with a broad medical outlook He was much ahead of his contemporaries in understanding that the aim of pediatrics as a discipline was not only the cure of diseases, but their prevention as well He was probably the first person in Russia to clearly define the role and tasks of the school doctor

In this respect a speech he made at a plenary meeting of the Council of Mocow University was very instructive, its subject was "The Influence of School on the Health of Pupils" In this speech Tolsky contended that many diseases observed among schoolchildren were caused by faulty regimens, insufficient outdoor activities and

Very few physicians are acquainted with Filatov s experimental work entitled *Concerning the Connections Between Bronchitis and Catarrhal Pneumonia* (Thesis 1876) the purpose of which was clarification of the role of atelectasis in the pathogenesis of pneumonia in children

Filatov s methods and conclusions anticipated the results obtained by American researchers (C O Jackson et al) by almost 50 years

Some of the aspects of child pathology little known to pediatricians were first studied and described by Filatov They include *diseases and syndromes of the nervous system* (pseudomeningitis acute ataxia, etc)

Before Filatov there were no manuals on children s diseases in Russia except Khotovitsky s *Pediatrika* which was little known among physicians of the 19th century The textbooks manuals lectures and monographs of Nil Filatov were study aids for many generations of Russian physicians They included to name but a few such works as *Semeiotics and Diagnosis of Children s Diseases Lectures on Acute Infections of Childhood Clinical Lectures* and *Textbook of Children s Diseases* Filatov s works reflected his exceptional powers of observation his skill in singling out from among many others the essential symptoms and reaching a correct diagnosis by a comparison of these symptoms with anamnestic data and then foretelling the outcome of the disease always treating the patient and not the ailment

The manner of exposition adopted by Filatov was always simple and lucid

Almost all of Nil Filatov s works were translated into many European languages These works not only lifted Russian pediatry to a high level they also had a telling effect on world pediatrics

Filatov s works have not lost their value even now In addition to a wealth of factual data they contain valuable information on the proper approach to medical examination of children and determination of diagnosis on the basis of such examinations they teach how to prognosticate the disease and treat the patient

Nil Filatov was one of the founders of the Moscow Society of Children s Doctors (1892) and until his death its permanent chairman

Filatov died in 1902 at the height of his creative activity His method of clinical thought was subsequently developed by his school as represented by a number of physicians headed by Professor V Molchanov on the staff of the First Moscow Medical Institute and also in the works of Professor G Speransky (Institute of Pediatrics of the USSR Academy of Medical Sciences)

The centenary of the birth of Nil Filatov was commemorated on April 4 1947 The Soviet State and the medical world celebrated this notable date in the history of Russian medicine in May of 1947 the 6th All Union Congress of Pediatricians called the Filatov Congress was held At present *Semeiotics and Diagnosis of Children s*

Diseases has been re issued and a Filatov Prize for the best works in pediatrics has been instituted

Other leading pediatricians who worked in Petersburg at the same time as Filatov did were N Bystrov (1841 1901) N Gundobin (1860 1908) and K Rauchfuss (1835 1915)

Nikolai Bystrov headed the chair of pediatrics in the Military Medical Academy from 1870 to 1896 Under his guidance the chair of pediatrics engaged in extensive (for those days) scientific and teaching activities Bystrov created his own school of pediatricians Many of his pupils later became well known specialists in children s diseases

N P G ndob n

and headed chairs in several Universities V Chernov in Kiev V Zhukovsky in Tartu Yakubovich in Odessa, Karnitsky in Warsaw Argutinsky Dolgoruki in Kazan A Kissel in Moscow etc Bystrov was the founder of the first Russian Society of Pediatricians in Petersburg (1885)

Nikolai Gundobin was Prof Totsky s assistant in the Moscow children s clinic later he became a professor in the children s clinic of the Medical Military Academy in Petersburg N Gundobin taking as a basis the works of his associates (about 100 theses) created the only capital work in pediatric literature of those days *Specific Features of Childhood* which has been translated into many European

2*

languages In collaboration with N Russkikh a country doctor N Gundobin was very active in the organization of the Union for Combating Child Mortality

Karl Rauchfuss became widely known for his works on congenital heart defects suppurative arthritic inflammations in infancy, and others Rauchfuss also described the area of dullness observed on the healthy side of the chest in pleurisy with effusion (the paravertebral Rauchfuss or Rauchfuss Grocco triangle) Rauchfuss will also be remembered for his endeavours in the development of new projects for building children s hospitals In 1869 a new hospital for children was built in Petersburg on the basis of his project (it is now the Rauchfuss Hospital) a second one was built in Moscow in 1876 (it was called the Vladimir Hospital and is now the Rusakov Hospital)

Of other leading pediatricians of the Petersburg school contemporaries of Filatov D Sokolov also merits attention he headed the chair of children s diseases in the Petersburg Medical Institute for Women In 1911 Sokolov founded a journal called *Pediatriya*

From 1902 to 1922 the clinic of children's diseases of Moscow University was headed by Nikolai Sergeyevich Korsakov Korsakov was a widely educated physician a prominent pediatric clinicist and teacher He is remembered for his investigations in the field of experimental rickets all researchers occupied in the study of rickets cite Korsakov

By the close of the 19th century pediatrics had already begun applying to an ever increasing extent the data of theoretical sciences such as microbiology biochemistry physiology Owing to the outstanding achievements of microbiology it became possible to study the bacteria causing acute infectious diseases of childhood These studies were the basis for the subsequent preparation of specific therapeutic serums and for evolving methods of active immunization

The first attempt to create active immunization against diphtheria was made by the Russian microbiologist Dzerzhgovsky (Petersburg) He applied the diphtheria toxin to the nasal mucosa by means of a cotton tampon

Georgi Norbertovich Gabrichevsky (1860 1907) developed a theory on the part played in scarlet fever by the streptococcus he obtained an antistreptococcal serum for the treatment of scarlet fever and a vaccine of killed scarlet fever streptococci for preventing the disease he was the founder of the first institute of bacteriology in Russia

In association with N Filatov Gabrichevsky promoted the establishment in Moscow of laboratories where laryngological examinations were done free of charge (for diphtheria)

Ivan Grigoryevich Savchenko (1862 1932) isolated the scarlet fever streptococcus toxin in 1904 almost 20 years before the American researchers George and Gladys Dick (1920) The antitoxic serum for the treatment of scarlet fever patients obtained by Savchenko was very effective

A feature characteristic of the turn of the 20th century was the study of the physiology and pathology of infancy and early childhood Biochemistry made many contributions in this field Biochemical methods were introduced in pediatric clinics on a wide scale, proving instrumental in the study of metabolic processes during various diseases of infancy and early childhood, particularly during gastrointestinal and nutritional disorders, these diseases were mostly responsible for the high lethality among children in the first year of life

At the same time measures for combating infant mortality, and for advancing mother and child welfare were introduced at the initiative of leading Russian scientists and medical practitioners Societies for combating child mortality were founded in Moscow, Petersburg, Saratov and other large cities These societies established health centres and hospital wards for infants Thus, the Moscow Society for Combating Child Mortality opened two such health centres In 1910 G Speransky founded a hospital department for young children However, these were but modest attempts to solve a truly stupendous and extremely important problem by means of public donations and private initiative

There were no adequate conditions in tzarist Russia for any wide development of pediatric science, or of a systematic drive against child morbidity and mortality based on the achievements of this science Any advances made in pediatrics were due to the talents and energetic efforts of individual outstanding representatives of this branch of medicine Favourable conditions for the development of science were only created during the years of Soviet power

The third Soviet, period in pediatry began directly following the October Revolution

From the very first days of its existence the Soviet government declared mother and child welfare to be a matter of state importance On December 28, 1917 V I Lenin signed a historical document on the creation of a Mother and Child Welfare Department under the People's Commissariat of Social Security In 1920 this department was transferred to the auspices of the newly created Commissariat of Public Health The first People's Health Commissar was N Semashko The Department of Mother and Child Welfare was headed by V Lebedeva she was very active in the organization of this new form of child health security, and enlisted the services of leading obstetricians and pediatricians of Moscow An enormous number of nurseries and nursery schools, health centres, children's homes, children's hospitals and other prophylactic and therapeutic institutions for children of an early age were built Their number increases with every passing year

Besides the chairs of pediatrics instituted at all Soviet medical training institutes many medical schools also have pediatric faculties (departments), and there is a special medical training Institute of Pediatrics in Leningrad

The disease rate among children and child mortality have decreased considerably during the years of Soviet power

Proper management of public health services and successful control of children s diseases depend on a truly scientific development of the essential problems of child physiology and pathology To further pediatric research the Soviet state provides the chairs and clinics

N A Semashko

of children s diseases at medical schools with all that is necessary for scientific research Moreover a number of research institutions have been set up for the development of problems in the field of child health There are two such research institutions in Moscow the Institute of Pediatrics under the USSR Academy of Medical Sciences and the Institute of Pediatrics sponsored by the Ministry of Public Health of the Russian Federation Similar institutes have been founded in other cities of the Soviet Union

Soviet pediatry has made extensive use of its possibilities and has initiated comprehensive scientific research activities All the scientific achievements of the two previous periods of development of pediatrics have been retained but the nature, methods and trends of the work have changed strikingly

The specific features of Russian scientific research in pediatrics after the October Revolution may be summed up as follows

1 Work according to plan is the important principle which underlies the development of pediatrics as a science

A A Kissel

2 Complex development of essential problems with enlistment of representatives of the various medical fields, including physiology, pharmacology pathological anatomy, and microbiology This approach is particularly important in pediatry, as this discipline is more than any other a complex science, in so far as it is engaged in the study of children of all ages in health and illness

3 Theory and practice are inseparable The purpose of theoretical works is to meet practical requirements in raising healthy, sturdy children, future builders of communist society, and to lower the incidence of disease among children

Soviet pediatricians have made considerable contributions in all aspects of world pediatric science by their scientific investigation of a number of problems of child physiology and pathology.

During the Soviet period Alexander Kissel (1859 1938), professor of the Second Moscow Medical Institute, contributed extensively to the further development of pediatrics Professor Kissel studied under N Bystrov and S Botkin His scientific endeavours were chiefly directed towards the investigation of the clinical pattern, prophylaxis and treatment of chronic infections of children, such as tuberculosis, rheumatic fever, and malaria Kissel is remembered for his efforts in establishing sanatoriums and health spas for children Always a public minded person, Professor Kissel actively participated in the elaboration and realization of various measures for improving child health

The closest of Professor Kissel's pupils were two prominent pediatricians, Professor S Fedinsky (1876-1926), who specialized in physiology and pathology of infancy, and Professor A Koltypin (1883 1942) whose contributions in the field of acute infectious diseases of childhood were quite considerable

One of Nil Filatov's favourite pupils was Professor Vasili Molchanov (1868 1959), Member of the USSR Academy of Medical Sciences, in the period between 1922 and 1950 Professor Molchanov headed the chair of children's diseases at the First Moscow Medical Institute Molchanov developed the teachings of Nil Filatov in his scientific treatises on the pathogenesis of cardiac paralysis in diphtheria (the role of the adrenals), on the pathogenesis of the scarlatinous heart (the role of the autonomic nervous system), on the connections between rheumatic fever and scarlet fever, on diseases of the endocrines (growth and development disturbances), on the part played by social and domestic factors in the pathology of childhood, on diseases of the nervous system, and on many other subjects

Representatives of the older generation of the Filatov school are D Lebedev, Honoured Scientist, Professor of the Second Moscow Medical Institute, known for his valuable works in the field of acute childhood infections and cardiovascular pathology, and Professor Y Dombrovskaya, Member of the USSR Academy of Sciences, who has published numerous works on the etiology, pathogenesis and clinical findings in respiratory diseases of children and also on the role of vitamins in the physiology and pathology of the growing child

All the scientific activities of this galaxy of researchers in pediatrics are outlined by painstaking examination of the patient, new and original thoughts and a striving to converge theory and practice

The school of the Institute of Pediatrics of the USSR Academy of Medical Sciences is headed by Professor Georgi Speransky (born in 1873), Member of the USSR Academy of Medical Sciences and Hero of Socialist Labour. Georgi Speransky was also one of Filatov s favourite pupils Speransky's school is represented by a number of gifted physicians, among them Professor N Nikolayev (died in 1955), who left a number of extremely valuable works on metabolism in childhood, Corresponding Members of the USSR Academy of Medical Sciences Professor A Dobrokhotova (1884-1958), a leading infectionist of the Soviet Union whose works on pertussis and measles are of considerable value, and Professor N Schelovanov (born in 1892), author

V I Molchanov

of a number of works on the development and upbringing of children The works of Speransky's school in the fields of physiology of infancy, gastrointestinal and nutritional disorders pneumonia, sepsis and other diseases are valuable assets in the study of childhood physiology and pathology, particularly in infancy Chairman of the All Union Society of Pediatricians and Editor of the journal *Pediatriya* Georgi Speransky spends much effort on improving the qualifications of specialists in children's diseases

The Leningrad school of pediatricians is headed by Mikhail Maslov (born in 1885), member of the USSR Academy of Medical Sciences, Professor of the Military Medical Academy and the Leningrad Institute of Pediatrics

Professor Maslov has done some outstanding work in the fields of nutritional disorders, various forms of diathesis, and other diseases of childhood He is the author of a number of textbooks and hand books on children s diseases Among his works are *Principles of Teachings on the Child Diagnosis and Prognosis of Children s Diseases* and *Textbook of Children s Diseases* (this latter book has been published in several editions)

Representatives of the Leningrad school are Professor A Tur Member of the USSR AMS (author of a book entitled *Propedeutics of Children s

G N Speransky

Diseases* and of a number of monographs dealing with dietetics of childhood and with hematology) Professor M Danilevich (author of *Handbook of Acute Infections of Childhood*) a most prominent infectionist who has created a school of pediatric infectionists Professor A Volovik who is elaborating the clinical pattern of rheumatic fever and heart diseases in children Professor P Medovikov and Professor V Mochan

A pupil of Ivan Pavlov Professor N Krasnogorsky Member of the USSR Academy of Medical Sciences holder of a State Prize has for a number of years been studying the dynamics of the formation of conditioned reflexes in children

These schools have trained a great number of highly qualified pediatric researchers people who in their turn are training future specialists in children s diseases all over the Soviet Union

The journals *Pediatrics Problems of Pediatrics and Mother and Child Welfare Pediatrics Obstetrics and Gynecology* all play an important part in training medical staff in the spirit of devotion to their native country and high principles necessary for everyday practical work in improving their abilities in working out measures for a further

M S Maslov

decrease of child mortality and in general for bringing up a healthy generation The countrywide republican and regional congresses and meetings of pediatricians are also very important for furthering the progress of pediatric science

II PRINCIPAL IDEAS IN THE TEACHINGS OF IVAN PAVLOV AND THEIR INFLUENCE ON PEDIATRICS

It is necessary to set forth some of the principal ideas of Pavlov s teachings and to point out their importance in pediatrics

First of all comes *the concept of the integral nature of the organism* A living *organism* is no mechanical assemblage of cells tissues or thoroughly investigated the patient's nervous and mental state can the physician comprehend the individual reactivity of his patient the peculiarities of the course of the given disease and its outcome, such comprehension is the prerequisite of consistent purposeful control of the pathological process in the body

III PURPOSE AND CONTENT OF PEDIATRICS IN REGARD TO PROPEDEUTICS OF CHILDREN'S DISEASES

The curriculums of medical schools include pediatrics as one of their chief disciplines together with the teachings on internal diseases, surgery, and obstetrics This is understandable for children comprise almost one third of the entire population of the USSR

In the Soviet Union pediatricians are trained at the pediatric faculties of medical schools and at a special school of pediatrics, Institute of Pediatrics in Leningrad

Every pediatric faculty has three chairs propedeutics of children's diseases, faculty pediatrics, and hospital pediatrics each with its own clinics Lectures and practical studies begin with the sixth and end with the tenth term, that is they are conducted for five terms Sixth year students work in the capacity of sub interns Moreover the pediatric faculties of some medical schools have special chairs and clinics of pediatric surgery pediatric infections, pediatric neurology etc

Many medical school graduates, on being assigned to posts in rural areas to treat adults, find that they are also called upon to give pediatric service To equip them with sufficient knowledge for coping with this work the chair of children's diseases must provide graduates with necessary knowledge in the field of pediatrics, both in theory and practice

The course of pediatry is read for students of therapeutic faculties in the 9th and 10th terms (5th year of studies) During their sixth year students can qualify in pediatrics as sub interns attached to the chair of pediatrics

There is a certain minimum of knowledge in pediatry without which no physician can do at present

The course of pediatry is a large one it is composed of four parts

The first part is *propedeutics of children s diseases* The course includes, first of all, the anatomic and physiologic features of the child during all stages of childhood secondly the specificities of medical examination of child patients thirdly semeiotics (or symptomatology), that is description of the symptoms of the most frequently encountered diseases of childhood, and finally, dietetics, the basic rules of nutrition for healthy children Propedeutics also includes principles of baby and child care and management

The second part is *physiology and pathology of new born and nursing infants* This very important part of the course is the most difficult one for students just beginning the study of children s diseases This is due to the fact that in their first year of life children display a greater number of specific morphological and physiological features and that these features are more pronounced at this stage than during subsequent periods As a result diseases also take a different course at this time of life

Until recently physiology and pathology of infancy was taught as a separate division in the course of children s diseases There were even special chairs of infancy However since it is currently held that there should be one pediatrician for all periods of childhood diseases of infancy are studied simultaneously and in close association with diseases of older children This gives the medical student a clear picture of the specific features of the physiology and pathology of babies in their first year of life

The third section deals with *the pathology of older children* Much time is devoted to chronic infections—tuberculosis rheumatism—that have many specific features in children of this age level

The fourth section deals with *acute childhood infections* (measles diphtheria scarlet fever dysentery etc) This is a very important section of the course The founder of Russian pediatrics Nil Filatov held that any physician not conversant with children s infectious diseases could be no true pediatrician

When beginning the study of pediatry the student must remember that although the course is an extensive one the theoretical knowledge and practical skill acquired in the pediatric clinics cannot be recognized as being sufficient for independent medical practice In order to be a successful practitioner in the cure and prevention of disease the pediatrician must be a widely educated physician he must be well grounded in the theoretic disciplines (anatomy physiology) and in the various chapters of adult pathology particularly in internal diseases Only thus will he be able to understand the specificities of the child organism only this will enable him to become a conscientious and purposeful proponent of all the measures forwarded by the public health service system for protecting the life and health of the child population

CHAPTER 1

STAGES OF CHILDHOOD

Prof V Molchanov

A comparison of the morphology and functions of separate organs and systems of children and adults shows the former to possess many distinct features The anatomophysiological properties of the child and the specific conditions of his life are the cause of the great difference existing between many aspects of child and adult pathology It is therefore necessary to commence the study of children s diseases with the anatomical and physiological specificities of childhood

The first thing to remember is that the child s body has not attained its final development that the child is *a growing and developing organism*

Growth and development are not equivalent concepts Under the term *growth* we understand an increase in the mass and dimensions of the body and its separate parts, under the term *development—metamorphosis* i e , conversion of the embryo into an adult organism

Thus, for instance, when tadpoles are fed on thymus gland their dimensions increase strikingly, however, although they turn into gigantic tadpoles their metamorphosis, or development into adult forms, lags

The immature development of the child is quite noticeable telling first of all on his external appearance

The external appearance of the human body is dependent chiefly on the *proportions* or correlations of its parts—the head trunk, and extremities Even a casual glance at a child and an adult convinces us of the great difference in the proportions of their bodies

Fig 1 contains schematic depictions of the outer form of the human body in various stages of development the fetus the newborn the child at two, six, and twelve years

The most prominent distinction is the size of the head In the newborn the height of the head takes up $^1/_4$ of the entire body length, in the two year old it is $^1/_5$ in the six year old $^1/_6$ and in the twelve year old $^1/_7$ of the body length (in adults only $^1/_8$), the head of the fetus is still larger, taking up almost half of the body length in a two months embryo

The distinct shape of the child's body, as displayed by his relatively large head and short (as compared with adults) legs is evidence of immature formation.

Incomplete development is also easily discerned in the structure of all the organs and systems of the child's body, and in their functions as well

Thus, for instance, although there is no marked difference between the surfaces of the brain of the newborn and the adult (the same chief sulci and gyri) the qualitative difference is very marked *insufficient differentiation* of the nerve cells and *incomplete myelinization* of the nerve fibres The nerve cells are embryonic in structure, being rounded

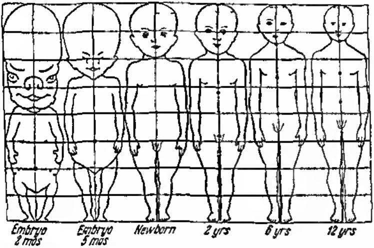

Fig 1 Proportions of the human body

or oval, with one or two straight, unforked branches There are comparatively few nerve fibres, and many of them possess no myelin sheaths

Owing to the immature formation of the brain of the newborn its functions are likewise relatively simple

The developing organism of the child reacts to environmental stimuli differently than does the adult organism

This may be illustrated by the respective reactions of the adult and the newborn to *environmental temperature* When an adult is chilled or overwarmed his body usually maintains a stable temperature, and considerable variations in atmospheric temperature are tolerated uneventfully But in the case of a young child, particularly a newborn infant, a decrease in the environmental temperature causes the bodily temperature to go down to 36 or 35°C Overheating simi larly causes a rapid elevation of the temperature to 40 41°C and this rise is attended by convulsions and the development of a heat stroke syndrome The main reason for such a difference in the reaction to environmental temperature is that in the newborn and in young babies the brain substance is little differentiated and the centres regulating heat formation and emission are immature

Some part is also played by the fact that the ratio between the body surface and the weight is 2 or 3 times greater in the newborn and in infants than in adults A simple physical law states that emission and absorption of heat are directly proportional to the squared sur face of the body other conditions being equal

Let us take another example—relation to *pyogenic bacteria* If the wound of an adult is contaminated with some pyogenic infection an inflammatory process develops in the wound and the regional lymphat ics but the infection does not usually penetrate into the blood In infants the course of local inflammations is always atypical (feeble mobilization of leukocytes deficient fibrin secretion) the lymphatics are weakly developed the formation of antibodies is very slow and insufficient owing to all this the pyogenic bacteria are not detained in the local lymph nodes easily passing into the blood they cause a generalized infection—*sepsis* In young children sepsis (or septice mia) is often provoked by such a slight abrasion of the skin that would cause only a local reaction in an adult Here too the difference is due to the immaturity and deficient functioning of the infant s nervous system

The child s body all the tissues of which possess an intensive fac ulty of growth and regeneration displays greater *regenerative pro pensities* than the adult body does (for instance in the healing of asep tic wounds and fractures) It is also common knowledge that children easily get over such severe diseases as scarlet fever diphtheria pneu monia etc Destroyed tissue elements are replaced by new ones and biochemical and functional lesions are restored much faster than in adults

Consequently it is quite clear that a child cannot be looked upon as being an adult with a lesser weight and stature "an adult in min iature the child is an organism possessing distinctive qualities as compared with adults

Disease is a reaction of the organism to external harmfulness there fore the courses of all children s diseases differ from the courses of diseases caused by the same etiologic agent in adults

At the same time it is impossible to give *a general characteristic of children s diseases* i e to define the sum total of differences in the courses of children s diseases as compared with the same diseases in adults for the child s body from the biological viewpoint is not a stable entity it is a growing and developing organism Growth and development are a continuous process which follows a definite sequence from the moment of birth until the time when the child becomes a full grown human being he passes through definite stages or periods of childhood in the process of which his anatomic and physiologic features change, as do his environment and the conditions in which he lives.

The founder of Russian physiology I. Sechenov declared that the organism and its environment were one. Therefore a scientific definition of the organism must include the environment affecting it. The concept of the close interrelationship existing between the organism and its environment was most extensively developed by Ivan Pavlov. The idea of the unity of the organism and its environment is one of the principal concepts in the physiological teachings of Pavlov.

The nature and course of a child's disease depend on two basic moments: age level features of anatomy and physiology, and environmental conditions. Thus, we must first of all define the periods into which childhood is divided, and characterize the course diseases take in every period separately.

No sharp delineation can be made between the different developmental stages in the child's life. The authors, as, indeed, the majority of Soviet pediatricians, employ the divisions which are most convenient from a practical point of view. This takes into consideration the anatomo-physiologic features of the child in every period, and the conditions in which he lives.

Two basic periods, prenatal (intrauterine) and postnatal (extrauterine), are differentiated.

The duration of *the prenatal period* is from the moment of conception until birth, approximately 9 months (270 days). It is customary to differentiate the stage of embryonic development (the first 3 months), and the stage of fetal (or placental) development (from the 3rd to the end of the 9th month).

The postnatal period is subdivided into 6 stages.

1. *The newborn stage* continues from the moment of birth to the time the infant is 3-4 weeks old. One of the external signs of this period is the sloughing of the slump of the umbilical cord and the healing of the umbilical wound. However, the anatomic and physiologic features, the specificities of metabolism, blood formation, and other physiological processes peculiar to this period disappear earlier in some infants, later in others, so that the border line between the newborn stage and infancy is even more conventional than between all the other stages of childhood.

2. *Infancy*, or the breast-nursing period, lasts from the age of 3-4 weeks to one year. Some pediatricians prolong this period to the age of $1^1/_2$ years, as occasionally babies are only weaned from the breast at the age of 16-18 months.

3. *Early childhood* is the period between the ages of 1 and 3 years.

4. *The preschool age* is from 3 to 7 years.

5. *The early school age* lasts from 7 to 12 years.

6 *The later school age* or *adolescence* is the time of *sexual maturation*, its duration is from 12 to 18 years of age

In Soviet pediatric terms the stages of infancy and early childhood are called the creche (or nursery) age, the period of sexual maturation is called the juvenile stage.

PHYSIOLOGICAL CHARACTERISTICS OF STAGES OF CHILDHOOD

What are *the physiological characteristics* of the different stages of childhood?

The prenatal period is characterized by nutrition derived solely through the maternal organism, and by an extremely rapid growth of the fetus

A normal course of pregnancy and normal development of the fetus depend on the condition of the mother's health Severe maternal diseases, such as acute and chronic infections, nutrition faulty in either quality or quantity, poor working or living conditions have an unfavourable effect on the development of the fetus and may be the cause of stillbirths prematurity, deformities, etc Therefore care of the prospective mother is actually antenatal care of the future child Antenatal (or prenatal) care is an extremely important aspect of the Soviet system of child welfare

The newborn period All the organs and systems of the newborn infant are underdeveloped The nervous system is the most immature and least differentiated among all the other systems The stimuli that are continuously transmitted to the morphologically and functionally immature brain of the newborn maintain a state of protracted cortical inhibition Hence the almost continuous sleep, the unconsciousness of environment, the inability to hold the head the flabby and automatic movements characteristic of the newborn During this stage the insufficiency of adjustment of the infant to its environment is particularly vivid

The period of infancy During this stage the baby's diet consists mainly of milk and dairy products owing to a relative functional weakness of the digestive organs Rapid growth of the entire body is characteristic of this period (see Chapter VII) The formation of the first signal system occurs in infancy The baby begins recognizing objects and faces, gradually finds his bearings in the environment Ivan Pavlov pointed out that the higher nervous activity of the child begins with the first signal system on which the activity of the second signal system is subsequently superimposed By the end of this period the baby begins to talk

The early childhood and preschool age periods are characterized by a further growth and development of the child, however, the intensity of growth is somewhat slowed down in comparison to infancy As the child begins to walk alone he comes into closer contact with the surrounding world, and the environment, acting through the neural reflex mechanisms (the exteroceptors) is conducive to the functional development of the cerebral cortex and the development of the second signal system (speech) This is why correct management of the child and organization of his environment are so important during this period of life

The early school age period is characterized by an intensified muscular development, but growth is already not as rapid as in the preceding periods At school the child mingles with a group, and in his further development he adjusts himself to group interests

The later school age period of sexual maturation, adolescence, or *the juvenile stage* From the physiological aspect this period is characterized by the maturation of the sex glands, which become capable of exercizing the function of reproduction, the sex gland secretions are controlled by the nervous system The sex hormones are substances (catalysts) which cause striking changes in all vital processes affecting the condition of the autonomic and central nervous systems For girls the period of sexual maturation is between the ages of 12 and 16 to 18 years, for boys it begins at 13 15 years and ends at 18 20 years The first signs are the appearance of the so called secondary sex characteristics the growth of hair on the pubic area and in the armpits, the development of the breasts in girls, voice changes in boys, etc Visible manifestations of the maturity of the sex glands and their readiness to function are the menstrual periods in girls, and pollutions in boys

In problems dealing with child care and upbringing the pediatrician must take into account the physiological features characteristic of each stage of childhood For instance, in the newborn stage, when thermoregulation is immature and the infant is therefore susceptible to chilling or overwarming it is necessary to maintain a constant normal bodily temperature, providing for this by according precautions In infancy strict observance of feeding rules is an essential factor It is the duty of the pediatrician to supervize the conduction of gym lessons and sports in school We shall later dwell on the age level prophylaxis of childhood

CHARACTERISTICS OF CHILDHOOD IN REGARD TO PATHOLOGY

What is characteristic of each of the above listed stages of childhood in regard to *pathology*?

The prenatal period The immature embryonic organism does not react to bacteria However, as the embryo develops it becomes susceptible to infections This occurs in the human fetus after the 16th week of gestation, susceptibility appears first of all to the germs of syphilis, then to tuberculosis, then to germs causing suppuration, and by the end of the pregnancy to acutely infectious, particularly virus, diseases In this manner congenital infectious diseases are acquired, mostly syphilis, malaria, less frequently tuberculosis, and still rarer acute infections like measles, scarlet fever, and others

The newborn period As compared with other stages of childhood this period is marked by a higher mortality rate The main cause of this is that the newborn possesses fewer abilities for adaptation to environmental changes, owing to the insufficient development of his organs and protective mechanisms and, principally, to the immaturity of his central nervous system As a result even slightly unfavourable factors (a change in the temperature of the atmosphere or of the food) that is easily tolerated by adults may be fatal to the newborn The earlier the baby is born, the more pronounced is his faulty adaptation to environmental changes

Premature infants, that is, infants delivered before term, succumb more frequently than infants born at term It was formerly held that 60 to 80 per cent of premature infants weighing from 600 to 1,000 g at birth died in their first year of life, while the corresponding figure for the 2 000 to 2,500 g group was 30 per cent However, observations in Soviet maternity hospitals have shown that with proper and attentive nursing and care (including a special feeding technique and maintenance of a constant bodily temperature) premature infants weighing even as little as 500 600 g at birth can survive

Of the pathological conditions observed only in the newborn period the most important are those which are due to disturbance of the normal *course of antenatal life* deformities developmental defects, etc Next comes pathology associated with parturition, *the act of childbirth* birth injuries and hemorrhages in various organs Brain hemorrhages are the most dangerous, as they may cause convulsions, and spastic paralyses (see Chapter V) Finally, there are *the diseases of the umbilicus and umbilical wound*

The specificities of the anatomy and physiology of the skin of the newborn make these infants very susceptible to various types of skin inflammation, *dermatitis* (see Chapter XI)

As has already been mentioned the acute infections observed in newborn babies include the extremely rare incidence of *congenital* measles, scarlet fever, etc Still rarer are inborn chronic infections—syphilis, malaria congenital tuberculosis This is the result of state-sponsored prophylactic measures enacted in the Soviet Union

The extreme susceptibility of the newborn to bacteria of the coccal group (streptococci, staphylococci, pneumococci) must be noted This susceptibility leads to the frequent incidence of purulent inflammations of the skin (*pyoderma*) and of the navel, and less frequently to erysipela, all these conditions may lead to generalized sepsis

Finally, the newborn period is also characterized by certain disorders that appear owing to the functional insufficiency of various organs so that it becomes difficult to make a clear distinction between pathological and physiological conditions One such condition is *the physiological jaundice of the newborn*, observed in 50 to 60 per cent of cases This jaundice is caused, on the one hand, by intensified decomposition of erythrocytes in the days immediately following birth and by functional insufficiency of the liver on the other, further comes *physiological albuminuria, urinary infarct*, and the so called *sexual crises* of the newborn (see Chapter XXII) *A physiological weight loss* is normal in the newborn, proper nursing rapidty restores the initial weight

Infancy The most common diseases of this period are *gastrointestinal* and *nutritional disorders* This is understandable if we consider the physiological features of infancy, particularly the specificities of the digestive and metabolic organs, and the demands put on them The anatomical and physiological features of this period will be de scribed in a corresponding chapter Here it is only necessary to point out that digestion and assimilation of *food are very restricted in infancy*, even slight deviations from the normal quantity or quality of the infant's food lead to a functional weakening of the digestive organs But at the same time the demands put on these organs are very high as compared with what is observed in older children and in adults

Speaking of these demands we must bear two circumstances in mind

The first is the necessity of generating energy for both muscular ac tivity and the normal functions of all the organs, as well as for main taining the bodily temperature Muscular activity requires the great est energy expenditures in adults, but in infants it is very limited the most active organs are the secretory organs, the endocrines

The infant is in unfavourable conditions in regard to maintenance of bodily temperature As we have already noted the relative surface of the infant's body is 2 3 times greater than that of adults hence other conditions being equal, infants dissipate 2 3 times more heat than adults do And, since the baby s thermoregulation nerve centres and his skin are insufficiently developed, it is clear that an infant must produce a relatively greater amount of warmth than an adult in order to maintain a normal temperature

The second circumstance is the infant s growth both the mass of his body and its length are increasing The most intensive period of growth is the first year of life Normally developing babies double their birth weight (3 250 3,400 g) by the middle or the end of the fifth month, and almost treble it by the end of the first year (9 000 10 000 g) But the weight of the one year old child is doubled only by the time he becomes 7 years old The same is observed in growth the crown heel length of the newborn (52 cm) is increased by 20 cm (becoming 72 cm) by the end of the first year of life and the yearly gain is thereafter only from 5 to 10 cm Consequently, both weight and length gains are most intensive in the first year of life

The material necessary for growth (weight and length gains) as well as for the production of warmth can only be obtained from food Accordingly *the food requirements of infants should be relatively higher than those of adults or older children*

The natural physiological food of the infant is *breast milk* This is the food his gastrointestinal system is adapted to breast feeding is a guarantee above any other method of normal processes of digestion and therefore of normal development Clinical observations have shown that *gastrointestinal disorders are not so frequent nor so dangerous in breast fed babies* as in artificially fed babies Digestion and assimilation of the milk of animals call for greater efforts on the part of the digestive organs than breast milk does Moreover cow s milk (or the milk of any other animal) however aseptically handled always contains a certain amount of bacteria which decompose it and have a bad effect on the gastrointestinal tract The advantages of breast milk over cow s milk will be discussed in greater detail in Chapter XIX At present suffice it to point out that in the first year of life *digestive and nutritional disorders are much more frequent and severe among bottle fed babies* than among breast fed babies Digestive trouble is especially frequent in the hot months

Faulty feeding (for instance too much cow s milk) and vitamin deficiencies (vitamin D in particular) especially in connection with unfavourable environmental factors (chiefly too little sunlight) are very often the cause of *rickets* in babies

Rickets is a generalized disease which affects the entire body It involves the nervous system (increased excitability sleeplessness profuse perspiration) the muscular system (muscular hypotony) and the skeletal system (softening of the skull bones craniotabes widening of the epiphyses and bending of the shafts of the long bones beading of the ribs) The pathogenesis of this disease is based on a disturbance of calcium and phosphorus metabolism resulting in defective bone growth *Spasmophilia* a tendency to convulsions is frequently concurrent with rickets

Still another feature of infancy is the frequency of *diatheses* The most frequent form is *exudative diathesis* characterized by a tendency to exudative (inflammatory and catarrhal) diseases of the skin and mucous membranes eczema pruritic rashes (nettle rash) upper respiratory catarrhs etc The etiology and pathogenesis of exudative diathesis cannot be looked upon as being perfectly clear however there can be no doubt of the fact that faulty feeding (excessive amounts of milk and eggs) and poor care are conducive to its manifestation

The study of the diseases of infancy is very important for these diseases are traceable for a protracted period of time and sometimes are even reflected in adult pathology

Acute infectious diseases particularly acute childhood infections (measles scarlet fever diphtheria etc) are rarely encountered in the first year of life particularly during the first six months while mea number of people and are therefore more likely to be exposed to infection Another reason is a reduced immunity to acute infections in children from 1 to 10 years of age Newborn infants and young babies possess native non reactive and inborn passive immunity conferred on them by their mothers Between the ages of one and two years they lose the non reactive and passive maternal immunity while having had no time in the majority of cases to develop any active immunity

Blood tests made to ascertain the immune body content in particular as regards the diphtheria antitoxin have proved that newborn and nursing infants possess the diphtheria toxin in 85 per cent of cases its content approaching that of the maternal blood between the ages of 1 and 10 years the diphtheria toxin is found in the blood of only 15 to 30 per cent of children

Of the chronic infections tuberculosis is observed more frequently during this period than in infancy and its pattern is somewhat different True children in their second and third years of life are more frequently affected by miliary tuberculosis than in the subsequent stages of childhood but after this age local *lesions of the bones joints glands serous membranes* and *skin* begin to appear

The early school age Frequency of acute infectious diseases is characteristic of this period of childhood the incidence of these diseases is much higher at this time than it is in infancy or in adult life The reason is the same as for the two preceding age periods

During this period infections seldom observed in the preschool age and exceptionally rare in infancy appear for instance *rheumatic fever* and *typhoid fever*

Adolescence Teachers and school doctors must train pupils to sit correctly at their desks as at this age incorrect posture in writing and reading may cause spinal deformities (scoliosis kyphosis) Not only the function of the sex glands is intensified during this period but also that of the endocrine glands—the thyroid and pituitary *Functional disturbances of various organs* are not uncommon in the period of sexual maturation This is partly associated with an unproportional growth of the entire body and of separate organs (the heart for instance) but is chiefly the result of the unstable autonomic endocrine functions so characteristic of this period Functional disorders include the so called juvenile or adolescent heart juvenile hypertension orthostatic albuminuria (appearance of protein in the urine following a prolonged upright posture) and also a number of endocrine disorders (hyper and hypofunction of the thyroid gland and pituitary)

During the period of sexual maturation the morphological and physiological features distinguishing the child from the adult gradually disappear

At the same time *the character and course of diseases begin to acquire an increasingly adult pattern*

Thus we have seen that owing to anatomical and physiological peculiarities and environmental factors certain diseases are prevalent at one age, others at another age, in infancy digestive and nutritional disorders are most prevalent, while in the preschool and school ages they give way to acute infectious diseases Even one and the same disease shows different age patterns (tuberculosis, pneumonia, and many other diseases)

We have already dwelt on tuberculosis *Pneumonia*, as well as gastrointestinal disorders, is a frequent disease in infancy However, the form and nature of pneumonia in infants differ greatly from the findings in older children The form prevalent in the first year of life is lobular pneumonia (bronchopneumonia), while typical lobar pneumonia is very rare In the schoolchild, however, lobar pneumonia is just as frequent as bronchopneumonia The younger the child the more severe the course of pneumonia in early childhood Lobar pneumonia is more apt to take an atypical course in preschool and school age children as compared with pneumonia in adults However owing to the greater fortitude of the child's heart, prognosis is more favourable than for adults

Besides the anatomical and physiological features and environmental factors conditioning such differences in the frequency and pattern of diseases there are also a number of other noteworthy points Thus, much Importance is attached to allergies (from the Greek words *allos* other, and *ergon*, energy, work, action), that is, altered sensitivity of the organism under the influence of the recurrent action of one and the same antigen Some pediatricians point out a difference in the course of tonsillitis caused by the same germ in an infant who encounters it for the first time, and in older children or adults The problem of age level pathology has not been sufficiently studied as yet A development of the teachings of Ivan Pavlov on the regulating function of the nervous system in physiology and its protective role and significance in human pathology should help in the solution of this problem However that may be, it has already been proved that all processes associated with immunity and allergy depend on the state of the central nervous system and on environmental conditions

ROLE OF THE INDIVIDUAL FACTOR IN CHILDHOOD PATHOLOGY

Aside from age level pathology there also exists *individual pathology of the child*, i e , peculiarities in the course of a disease which depend on the child's individual properties, and first of all on the state of his nervous system Individual traits are conditioned by the mutual influence of two principal moments (1) the environment, i e , the conditions in which the given child lives (*the exogenous factor*), and (2) inborn individual traits (*the endogenous factor*)

The environment (the exogenous factor) plays a highly important part in childhood pathology There is not a single disease which this factor does not affect to some extent

It has been established that inferior domestic conditions are conducive to a greater severity and higher lethality of many acute and chronic infections of childhood (scarlet fever, diphtheria, measles, tuberculosis, rheumatic fever)

The endogenous factor is also important in childhood pathology Some children show poor adaptability to environmental conditions from their very birth Notwithstanding satisfactory environmental conditions their development and weight are backward and they are frequently ill In a number of such babies various defects or developmental anomalies are discovered, congenital heart failure, for instance, or early neuropathies and endocrinopathies, however in the majority of cases this developmental backwardness is purely functional

The origin of inborn pathology is by far not clear yet but clinical findings mostly indicate harmful influences on the embryo or fetus during gestation Thus, *the origin of the endogenous factor* is in the majority of cases actually of an exogenic nature, in so far as the unfavourable conditions in which the parents live (chiefly the mother) are reflected on the intrauterine development of the baby

According to Ivan Pavlov all the diverse individual traits of human beings are summed up in the intensity and degree of equilibrium of the two basic processes occurring in the cerebral cortex excitation and inhibition Dr N Krasnogorsky, proceeding from the correlations of the cortex and subcortical centres, divides children into four types, each of which possesses a characteristic reactivity to external and internal irritants Chapter X will deal at greater detail with the types of the child's nervous system and its reactivity

The pediatrician must take into account both age level and individual factors in the pathology of childhood, this is important first of all for understanding the nature and course of the disease in every separate case, and for its correct *diagnosis* In determining the diagnosis the physician must not limit himself to defining the lesion of this or that organ, as the morbid process involves the entire body The functional state of all the organs must be investigated, particularly important is the central nervous system which governs all the bodily processes

When determining the pathogenesis of the disease (the mechanism of the formation of the morbid condition) the physician must always bear in mind the close correlations of the child's body and his environmental conditions (domestic circumstances, upbringing etc)

To foretell the outcome of a disease (*prognosis*) the physician must consider the patient's age, his individual traits, and his environmental conditions This is also necessary for the final purpose of clinical examination, *treatment of the patient and elaboration of suitable prophylactic measures*

CHAPTER II

PRINCIPLES OF PROPHYLAXIS AND THERAPY IN CHILDHOOD

Prof V Molchanov

Prophylaxis Pediatry is more deeply involved with problems of preventing diseases than are other clinical disciplines The pediatrician deals with subjects requiring special care and protection for normal development, therefore much of his activity should be aimed at the prevention of diseases

Two routes are open to childhood prophylaxis (1) the child must be placed in conditions ensuring his normal development, as only normally developing children can best manifest their natural resistance to harmful influences (2) all factors having a harmful effect on the child should be eliminated or at least mitigated to a minimum by means of all available measures

The basic condition ensuring normal development of the child is proper *care*, understood in the wide sense of the word adequate and properly given food, extensive exposure to sunlight and air, cleanliness, etc These essential points of prophylaxis are common to children of all ages However, each individual stage of childhood, with its specific biological features, puts specific demands on each of these elements Thus, the nutrition of infants differs greatly from the nutrition of older children Further, as we have already noted, each period of childhood is characterized by a conspicuous difference in the nature of morbidity Hence it is only natural that preventive medicine must first of all be directed against the diseases which prevail and are most dangerous during the given period of childhood

Normal development of the child should be a matter of concern before his birth, during antenatal development, this is called *antenatal prophylaxis* or *prenatal care* It resolves into improving the nutrition and domestic conditions of the pregnant woman, having her transferred to easier work in the later part of her pregnancy, etc Soviet legislation provides expectant and nursing mothers with a sufficient paid maternity leave from work and maternity hospital facilities for confinement free of charge For prophylactic purposes pregnant women with toxicoses or other forms of pathology associated with their condition are also hospitalized

The newborn and nursing infant is in need of particular care, owing to the immaturity of many of his organs First of all he must be provided with adequate nutrition and proper conditions for normal development Breast milk is the best prophylactic agent against digestive trouble and other ailments of infancy Consequently, it is important, from a prophylactic point of view, to nurse the baby on the breast until it is time to wean him, should this for some reason or other be absolutely impossible, and mixed or artificial feeding be necessary, the rules of these types of feeding must be followed with utmost strictness To cope with this task on a state wide scale is made possible by the legislative protection of the prospective and nursing mother, maternity leave, and the establishment of a wide network of infant health centres, dairy kitchens, creches and infant homes The health centre (at the local children's polyclinic or one established specially for babies) checks the child's development, and if necessary supplies the mother with milk, formulas, and all other infant and baby foods If the mother finds it necessary she places her baby in a day nursery (creche) for the time she is occupied at work In the creches the babies are properly cared for and fed

One of the greatest achievements of the Soviet system of mother and child welfare is a striking decrease in child mortality during the first year of life

Prophylactic measures enacted in *early childhood and the preschool and school ages* should be directed at combating acute childhood infections For an infectious disease to be contracted there exist two prerequisites The first is the penetration of the causative agent into the human body, the second is susceptibility of the subject to the given disease Accordingly, *prophylaxis of infectious diseases* should aim at (1) building up the child's resistance to infections rendering him unsusceptible, or immune, to them, (2) gaining control of the pathogens of infectious diseases, preventing their penetration into the body, destroying these germs as far as possible

As has already been pointed out above, resistance to infection can be built up only by creating all conditions necessary for the normal development of the child

The first place in *germ control* should be allotted to *sanitary and hygienic measures*, including domestic hygiene and proper management of child care establishments (creches, nursery schools schools) polyclinics hospitals etc, to prevent the possibility of infections being transmitted from sick to healthy children (careful elimination of suspected patients, quarantine wards isolation cubicles and so forth), scrupulous cleanliness in taking care of children teaching them to be neat and tidy, and sanitary and hygienic education of the population, when an infection is discovered *the patient must be isolated and thorough disinfection performed*

Specific prophylaxis is conducted concurrently with *general prophylaxis* This resolves into active immunization against scarlet fever, diphtheria, poliomyelitis, the introduction of adult serum or gamma globulin for the prevention of measles, and antituberculosis vaccination Protective vaccination against measles and diphtheria have undoubtedly lowered the incidence of these diseases and mitigated their courses among inoculated children

The preschool and school ages are the periods of formation of the skeletal and muscular systems, and a continuation of the establishment of the basis of physical health It is therefore very important to attend to *the correct physical development* of children of this age by the institution of properly managed physical exercises (gym lessons, sports) at school, observation of school hygiene, alternation of work and recreation, etc In the Soviet Union there exists a network of health promoting centres for children—young pioneer camps, sanatoriums, forest schools, and other child care institutions

The commencement of sexual maturation, closely associated with alterations in the correlations of the cerebral cortex, the subcortical centres, and the entire autonomic-endocrine system, calls for special attention to the state of the nervous system during the older school age, the period of *adolescence*, in addition to the previously mentioned measures for building up physical sturdiness The school doctor should work in close contact with teachers and with the parents' council in planning schedules, so that overstrain and exhaustion of the child s nervous system are avoided He should discuss with parents and teachers the harmful effect of too much cinema and TV viewing and, too much reading out of school hours, even of interesting books, all these activities should not interfere with the schoolchild's sleep Sufficient sleep is protective inhibition, and as Pavlov's teachings show, it is absolutely imperative for restoring the work capacity of the overfatigued brain

Therapy Non specific general treatment In medical treatment it is also necessary to consider the anatomy and physiology of childhood The basic principle of therapy should be followed, when dealing with children with still greater consistency and strictness, than when treating adults This principle resolves into *placing the body in conditions that will enable it to cope with the disease on its own* Although the child does, in certain cases, display a lower resistance than adults do, yet his regenerative capacities as well as the endurance of his cardiac muscle (see Chapter XVII) are higher It is only necessary to provide for conditions in which the child's resistance will be highest *Therefore the basis of medical treatment of the child, as well as of prophylaxis, is care and good nursing*

The first important thing is *nutrition* The food of the sick child should be suitable for his age, be sufficient both in quantity and in wholesomeness if there are no indications for any limitations The vitamin content of the food is essential, vitamins play a most important part in all the processes that take place in the growing body *The great therapeutic role of breast milk in the nursing period* cannot be overstressed, it is effective not only in treating digestive disorders but also against pyoderma, pyuria, and all manner of infectious processes, for instance, protracted pyelitis and pyodermatitis in bottle fed babies are soon overcome by giving the baby breast milk

The specificities of metabolism, notably fluid metabolism in young babies should not be overlooked The bodies of newborn and nursing infants contain relatively more water (75 per cent of body weight) than the adult body (60 per cent) Consequently *for normal functioning of all its organs the child's body requires a relatively larger amount of fluid*

Dehydration of the body (in toxic dyspepsia, for instance) easily leads to pathological states which are not observed under similar conditions in adults Therefore when taking care of a child in illness it is necessary to provide a sufficient *fluid intake*, all the more so since a young child does not complain of thirst In severe illnesses the child should be given small amounts (from a teaspoonful to a tablespoonful at a time) but frequently and regularly (every 10 15 minutes) of boiled water, tea with vitamins fruit juices physiological salt solution etc The total amount of fluid given in 24 hours should be no less than 600 to 1,000 ml, depending on the age and condition of the child

Further, the sick child requires *sunshine* and *pure, fresh air* The absence of these factors alone may lead to the development of grave diseases—rickets for instance Practice has shown the great importance of these factors in therapeutic treatment of children

The child should be out in the fresh air the whole day during any illness in the summer months, in the winter a porch is a good substitute, and the room or hospital ward should be well aired by opening the window or transom However chilling must always be avoided and the child should be kept warm by suitable clothing covering or hot water bags

The treatment of diverse diseases of childhood now includes the wide use of physical methods of treatment (physiotherapy) baths ultraviolet irradiation, diathermy, kinesitherapy, etc It is sufficient to point out the excellent results obtained with ultraviolet irradiation (artificial sunlight) of rickets patients (the antirachitic factor vitamin D is produced in the skin by the action of ultraviolet rays)

Chronic nutritional disorders of infancy (hypotrophy and atrophy) and all manner of protracted infections are successfully treated by *hemotherapy* i e , the intramuscular injection of 5 to 20 ml of the blood of one of the parents, *intravenous blood transfusions* are also given for these disorders as well as in certain cases of acute infections (severe forms of scarlet fever or diphtheria) diseases of the blood chronic nutritional disorders

Kinesitherapy, when property managed, stimulates muscular and nervous tonicity and corrects deformities (of the chest, for instance) in children of all ages, including infants.

Of recent years therapeutic agents that have become highly popular are *antibiotics* (penicillin, streptomycin, and others) and biogenic stimulators (tissue grafts), tissue therapy.

Finally, there is still another factor, more important in the treatment of children than of adults, that must be spoken of. This is *the psychic factor* which includes kindness, affection, and a considerate and tactful attitude to the sick child's complaints and desires. Only on this condition can the physician trust that all his instructions to the child will be carried out precisely and carefully. An ailing child frequently agrees even to unpleasant procedures if the doctor has won his confidence and admiration. The staff of children's hospitals or departments in general hospitals should strive to make the child's surroundings carry as little as possible of routine hospital stamp, the environment should be conducive to improving the child's emotional status by means of pleasing toys, games, pictures, etc. (i. e., stimulation of nervous tonicity).

It is essential for a favourable outcome of the disease to protect the child's emotions, to avoid all that might induce thoughts of irreparable harm to health, of the impossibility of becoming well again. The child should be kept in a cheerful mood, he must be convinced of the possibility of cure. Such a mood can be created only when the adults around the child (his parents, the medical staff) maintain an according mood themselves.

Not only the doctor, but the entire medical staff as well must cherish the child patient and try to make him feel himself at home throughout his stay at the hospital.

All the above listed factors—care of the child, physical methods, and psychotherapy—constitute what may be termed as *non-specific general treatment*. Its importance cannot be overestimated and it is indicated just as consistently for diseases for which there exist specific agents.

Specific therapy. The diseases for which specific treatment exists are not numerous. Malaria and syphilis in children are treated by the same specific drugs employed for adults (quinine, mercury preparations, penicillin, etc.), but there are also a number of specific serums which it will be well to mention. A striking achievement of medical science is the antitoxic antidiphtheria serum. This serum must be administered in all cases of diphtheria, even the very mildest. A lesser effect is obtained with the serums evolved against scarlet fever, dysentery, the meningococcus, and other infections, they are employed only upon definite indications (predominantly in toxic forms of the diseases).

Symptomatic treatment. In addition to the two above described forms of medical treatment for diseases of all ages there is also another important form of therapy, symptomatic treatment, i e , the elimination or mitigation of symptoms which are most severe and distressing to the patient, for instance, alleviation of a painful and frequently recurring cough which interferes with the patient's sleep, treatment of stomatitis that interferes with the intake of food, stimulation of weakened cardiac activity, etc The principles and methods of symptomatic treatment are generally the same for children and adults However, it should be pointed out that there is no need for haste in prescribing febrifuges for children even in cases of a very high temperature Children usually tolerate high bodily temperatures easier than adults do, in cases of diseases for the treatment of which there exist specific agents these agents are also the best febrifuges for instance, diphtheria toxoid for diphtheria and penicillin for scarlet fever and other diseases Frequently simple sponging of the body or a warm bath with a gradual decrease of the temperature of the water proves to be enough, such procedures lower the body temperature and stimulate the nervous system

Drug therapy In any case of disease, be it a gastrointestinal or nutritional disorder, an infection, or some other illness, the pediatrician must first of all institute the above forms of therapy, especially good nursing which, as we have said, is the basis of pediatric therapy However, many diseases of childhood cannot be treated without medicinal preparations We shall here restrict ourselves to several general observations, in so far as in childhood drug therapy takes a number of specific aspects

Drugs for children must be prescribed with greater caution than for adults, and only upon definite indications

For instance, the expectorants widely indicated for adult pneumonia (infusions of ipecac and senega) are not indicated for cases of pneumonia in infants Their administration is restricted to rare exceptions, as in early childhood inflammatory exudates are eliminated from the lungs by absorption and not by being coughed up with the expectorant, this is due to the anatomic and physiologic peculiarities of this age level (abundance of capillaries and lymphatic fissures) Exhaustive instructions on drug therapy for various diseases are given in manuals on children's diseases

Drug dosages A universally accepted principle for determining dosages is age The younger the child, the smaller the dose of any medicine prescribed for him Pediatricians of the preceding century worked out a dosage scheme based on age

Adults	1 dose
Child of 12 yrs	1/2 "
" " 6 yrs	1/4 "
" " 3 yrs	1/8 "
" under 1 yr	1/12 "

The majority of pediatricians and pharmacologists follow this scheme at present

Dosage according to age cannot be looked upon as being strictly scientific or perfect In order to obtain one and the same effect dosages should conform not only to age, but also to body weight, to weight of the organs for which the given drug has the greatest affinity, to the state of the central nervous system on which the reactivity of the body as a whole depends, and also to a number of other biological factors that are not always precisely concurrent with age Thus, sulfonamide and antibiotic dosages which are prescribed in accordance with the child's body weight are relatively larger for children than for adults

Many attempts have been made to evolve other schemes in which the chief point would be the actual weight of the child and certain other factors However, all these schemes are very complicated and their employment is associated with significant difficulties therefore none of them have been accepted in pediatrics

At the same time it must be acknowledged that it would be wrong to use the above scheme undiscriminatively Corrections must be made first of all for children whose physical development diverges more or less acutely from normal Moreover, clinical observations have shown that some drugs, given in precise accordance with age and weight of the child, still have a stronger effect on children than on adults Children are particularly sensitive to some alkaloids morphine, for instance, therefore morphine preparations are contraindicated in early childhood On the other hand, certain preparations are well tolerated by children even when given in doses exceeding the age norm, examples are chloral hydrate and atropine

In general the question of pediatric drug dosages is a very complicated matter that still awaits its final solution, in so far as the entire problem of age level reactivity, particularly to drugs, is not quite clear.

CHAPTER III

HYGIENIC PRINCIPLES IN REGIMEN AND UPBRINGING

Prof *Y. Dombrovskaya*

The hygienic regimen of children depends completely on the anatomy and physiology of the child Hence the essential principles of individual hygiene at different ages possess distinctions based on the reaction of the child to his environment, and on the effect of the environment on the physical and mental development of the child The period of *intrauterine development* is chiefly associated with the hygiene and health of the pregnant woman, this is a matter of profound concern of the maternity health centres

The hygiene of *the newborn baby* begins with his care directly after birth Since newborn infants are poorly adapted to the outer environment owing to the immaturity of their nervous systems (see Chapter V) favourable conditions have to be created for them by scrupulous asepsis, by providing for sufficient floor space in the infant wards (no less than 3 to 3 5 m^2 per baby), sufficient light, and an atmospheric temperature no lower than 22°C It is extremely important to have a sufficient supply of infant garments and diapers of good quality—soft cotton flannel and easy to wash cotton cloth that does not irritate the skin

The newborn s first toilet—tying the cord when pulsation ceases in it—is performed by the obstetrician Two clamps are placed on the cord, the first 12 15 cm from the umbilical ring, the second a little farther, the cord is wiped with alcohol, cut, and a sterile dressing is then wrapped around the remaining stump All these and subsequent manipulations are conducted with observance of strict asepsis To avoid chilling the infant while cleaning him he is placed on an inflatable rubber mattress containing warm water, and is warmed by an electric heat reflector *Eye disease* (gonorrhea) prophylaxis is performed at this time by instilling 1 drop of 2 per cent silver nitrate in the conjunctival sac It is important to remove the mucus and blood the infant's skin is covered with, and also the superficial layer of the vernix caseosa, by careful swabbing with sterile gauze napkins dipped in sterile mineral, olive, or sunflower-seed oil. It is not advisable to remove the vernix caseosa entirely as it protects the skin against irritation Infants with birth injuries should be handled as little as possible

The stump of the umbilical cord is treated with scrupulous care One of the most grave and dangerous diseases of the newborn, sepsis, sometimes develops owing to faulty asepsis and contamination of the umbilical wound (the navel) A sterile napkin is placed under the cord which is then tied at a distance of 2-3 cm from the umbilical ring, the excessive length of the stump is then cut off (with sterile scissors) 2-3 cm higher than the ligature, and the cut end is swabbed with alcohol One sterile napkin is placed around the remaining stump, another is used for securing the dressing After this the newborn infant is weighed, his crown heel length and head circumference are measured, he is attired in a short kimono, and a bracelet with a number is attached to his wrist, then he is wrapped up warmly (including head and arms) and transferred to the nursery, together with his developmental record

Every maternity home has on its staff physicians well acquainted with the anatomy and physiology of the newborn, and specially trained pediatric nurses Babies who have sustained birth injuries, or who have been born asphyxiated or prematurely are in need of special care This care includes not only indicated therapeutic treatment, but special feeding schedules as well

Cribs for the newborn should be high enough to provide for convenient diapering, a hair or dried grass mattress is placed in the crib, sheets, a waterproof and a light, warm blanket complete the bedding and bedclothes The hygienic toilet of the newborn consists of washing the diaper area with a stream of warm water, and swabbing the inguinal folds, the armpits, and the folds in the neck with sterile oil; the face and eyes are cleaned with a piece of cotton moistened in a 2 per cent solution of boric acid The dressing is kept on the cord until it sloughs, but the doctor and nursing staff should constantly check the condition of the navel Any unpleasant odour or redness around it require prompt attention If nursery conditions permit, infants whose cords have already withered and sloughed are bathed

Should an infant develop a purulent rash (pyoderma) it is imperative to isolate him, or at least to institute individual care, since any kind of coccus infection is dangerous for the newborn No less dangerous during this period are the penetration of infections through the mouth or respiratory passages, therefore the nursery staff, as well as the mother when nursing the infant, should wear gauze masks, and the nursery should be disinfected periodically by ultraviolet radiation, in addition to the most scrupulous cleaning and scrubbing

The body of the newborn cannot regulate its temperature in accordance with the environmental temperature owing to immaturity of the nervous system (thermoregulation and the vasomotor apparatus), consequently, it is dangerous to either chill or overheat such infants (see Chapter XXIV) Prophylaxis of the diseases of the newborn is based on proper care and regimen

Specific features of the regimen of the nursing infant Proper sanitary and hygienic measures, together with proper nutrition are conducive to the physical and mental development of the nursing baby, to the establishment of complex habits on which his future behaviour pattern is based

This means that a proper schedule must be established during the very first weeks of the infant's life at home alternation of feeding sleep, and waking hours are conducive to the establishment of conditioned reflexes

Adequate management and care of the infant build up the latter's resistance to environmental factors and to infections The chief health promoting measures are (1) proper environmental conditions and pedagogical management, (2) hardening the baby's body by inurement to environmental factors beginning with the first months of life, (3) suitable therapeutic physical exercises

Organization of the child's environment at home, and also in child-care and therapeutic establishments, consists first of all of arranging a 'children's corner' in the home or of a children's ward in the hospital Light, well aired, perfectly clean premises in the hospital, the lightest place in the home—such are the principal requirements Creches and hospitals for little children should be equipped with special furniture, playpens, and a slide (chute) and ladder for ambulant patients Free, active movements stimulate muscular tonicity and are conducive to the formation of motor habits, dexterity, and mental quickness

The walls of the nursery or children's corner should be decorated with bright pictures the child can understand Beginning with 3 months every baby should have his own toys A competent selection of toys of various shape and colours is an important educational factor Close contact between the child and the adult who cares for him maintains positive emotions in the child, and favours cheerfulness, an early formation of habits of personal neatness, and of timely reaction to the surroundings A baby who is handled with gentleness and kindness both in the hospital (nurses and attendants) and at home (parents and other relations) soon learns to smile in response Definite influences affecting the centres of vision and hearing are conducive to the formation of the second signal system

Every child should have his own towel, older children—their own toothbrushes etc This is not only a hygienic measure, it is also an educational factor in teaching the child to use things and to take care of them Besides pediatric nurses trained in medical care, the creche staffs also employ teacher nurses who supervise the daily schedules, the children's sleep and their waking hours.

Surveillance over the child's domestic life by specially appointed nurses from the local polyclinic (called patronage in Russian terminology) plays an important part in checking the child's domestic environment and upbringing

Hardening of the child's body should be instituted from the end of the first month of life For inurement to cold the window or transom are opened for some time, and the baby is kept in the cold room under warm covers In the winter he is taken outdoors when the atmospheric temperature is no lower than minus 5°C During the first months of life hardening to environmental temperature is also conducted at room temperature (no lower than 18°C), when the baby is changed he is left unclothed for 10 to 14 minutes In the winter babies younger than 6 months are taken outdoors for no longer than one hour at a time, but no less than twice a day, by the time the child is one year old he is taking two outings totalling 3 hours When the air outside goes down to minus 10 or 12°C it is not advisable to take out babies younger than 7 or 8 months In child care institutions for very young children the daily nap should be taken in the fresh air, on special sleeping porches, the children are placed in warm sleeping bags In the summer babies are taken outdoors from the very first days of their life

When the baby has learned to walk he should be provided with opportunities for outdoor activity (playing in sand with a ball, in the winter—sledding, etc)

As soon as the umbilical wound heals infants should be given a full *bath* daily, it is salubrious for children both younger and older than one year to be rinsed down with tepid water in the summer

Sun baths Children under one year of age are given sun baths when the temperature is no less than 18°C in the shade, it is recommended to sun them in places where the light is not too bright (preferably in a slightly tree shadowed area) for 10 to 20 minutes, and then to shower them with tepid water (at approximately 30°C) Water, air, and sun baths stimulate the complex system of skin receptors and increase the tonicity of the peripheral vessels, the stimuli so received are transmitted via nerve routes to the cerebral cortex, where they call forth a positive response that is diffused to the subcortical region and the centres of the autonomic nervous system

Clothing should not restrain the child in two weeks after birth babies may be wrapped so that their arms remain free Rompers (with the legs sewed up) and a warm shirt or sweater are the clothing recommended for the hours the baby older than 2 or 3 months is awake in the daytime As soon as the baby starts making his first steps he needs clothing convenient for walking—panties and stockings, a shirt and special footwear

Physical exercises are very important from the earliest stages of childhood, as they stimulate the muscles, strengthen the ligaments, deepen and normalize respiration, and have a favourable effect on blood circulation and metabolism Properly managed physical exercises favour normal gastrointestinal motility, improve the appetite, and, what is extremely important, have a positive effect on the child's mentality owing to his close contact with the person who conducts the exercises

Beginning with the second month of life a number of physical exercises are introduced in a gradual sequence First exercise the baby is laid on his back and his legs are massaged by bringing them to his abdomen in an alternating order ('bicycle) Second exercise the baby's arms are spread wide apart and then brought to his chest (coachman's motions') Exercise third the baby is placed stomach down on one hand and his feet are supported with the other ('swimmer's position') Fourth exercise the baby is laid on his back, his hands are grasped and he is pulled forward, while some resistance is applied to his feet

Children older than one year may already do a definite set of active exercises

The practical experience of infant homes has shown that properly organized environment, care and training are the means for raising sturdy, healthful children

Individual hygiene in *the preschool age* includes a greater degree of independence, of self service

In accordance with the child's requirements the level of educational measures also goes up, these measures should be directed at satisfying the child's inquisitiveness (the questioning age) A wider scope of physical exercises is introduced, the child's outdoor recreations now include sports (skiing, cycling)

Body hardening procedures should be done regularly *throughout the year* The child responds to irritation by cold by the constriction of the blood vessels in his skin The velocity and strength of the vascular contraction and dilalation are stimulated by inurement to cold (water and air procedures), conducted with sufficient frequency and regularity

Vasomotor regulation depends first of all on the state of the nervous system particularly of its highest section, the cerebral cortex N Krasnogorsky reports backwardness in the development of the cerebral cortex in undernourished and rachitic children, and states that their vascular cutaneous reactions are noticeably below normal These data stress the necessity of *gradual* inurement of the child to environmental factors Thus, water procedures should be started witb tepid water at 25 to 26°C, gradually bringing the temperature of the water down to 20 or even 18°C The same is true of outings and of sleeping with an open window or transom in the winter The nasal mucosa carries highly sensitive blood vessels therefore application of cold procedures without preliminary preparation leads to their acute constriction

Children of the preschool age should go in for sports throughout the year more extensively than younger children (outdoor bathing, cycling skiing, skating) During this stage of childhood proper management of active games and manual duties are very important

Nursery schools are an excellent preparation for school life, as they teach children discipline and self service However, at home children should also be around other children of their own age, they should do physical exercises and have their duties, and should be aided in their mental development

All school age children, but particularly the older ones, should follow a schedule in which lessons in class and homework alternate with sports and properly managed setting up exercises

The school doctor, teachers, and parents should outline schedules in which lessons outdoor recreation, homework, and sleep are all adequately accounted for

Physical exercises in school require the close supervision of the school doctor, it is essential to institute a well-planned complex of gym and sports that does not fatigue the children, but is conducive to intensification of metabolism and of the functions of all the bodily systems Here a prominent part is played by health promoting children's institutions of a general type, first among which come young pioneer summer camps Robust health, firm discipline, and sociability are the basic principles on which future citizens are brought up The school doctor periodically checks up on the health of pupils, working in close contact with the local children's polyclinic, schedules are individualized depending on health (additional free days for weak children etc)

The school doctor must be particularly attentive to schedules in forest schools for children with tuberculosis intoxication, and in sanatoriums and hospitals for children with rheumatic fever

CHAPTER IV

EXAMINATION OF THE CHILD

Prof. *V. Molchanov*

Methods employed in the examination of children differ from those employed in examining adults Pediatry uses all the methods of examination employed for adults, but in order to obtain correct and reliable results a special approach to the child is needed, and also knowledge of some specific methods of objective examination It is not uncommon for a physician who is very good at examining adult patients to feel lost when he is faced with a child patient

As in the case of adults, medical examination is made up of interrogation (for taking the pediatric history) and *physical examination*. Pediatric examination possesses certain specificities concerning both history and physical examination

INTERROGATION

Direct *interrogation* of the child patient is rarely reliable In children, even of the school age, the faculty of self observation is frequently absent or very little developed, and they are not capable of localizing their painful sensations They may often relegate pain in the throat to the mouth, pain in the chest to the abdomen while the navel is pointed out as being the site of all pains arising in the abdominal cavity Besides, the child is very susceptible to suggestion If he insistently asked, with an according intonation, whether a certain place is painful a positive answer may frequently be forthcoming, although there is actually no pain

Finally, it should be remembered that children may try to mislead the doctor on purpose

A child may deny the presence of an actually existing pain not wishing to be deprived of some pleasure or to be subjected to some dreaded examination Moreover, children with neuropathic and hysteric tendencies may simulate diseases

Consequently, the pediatrician is mostly obliged to base himself on information given by the mother or other person who has had care of the child, rather than on the information imparted by the patient himself.

In certain cases the questioning should be done in the child's absence

An observant mother when skillfully interrogated, may immediately provide the physician with valuable data for making the diagnosis and evaluating the case However, not all mothers are objective in presenting their observations to the doctor, very frequently the mother hastens to force her own opinion of the cause and nature of the disease on the doctor instead of giving him objective information The pediatrician has to be very tactful so as not to hurt her feelings by interrupting her story, on the one hand, and in order to obtain precise and brief answers to questions on the other

The general outline of the interrogation is the same as in examination of adult patients the data taken concern the child's development, previous illnesses, family diseases, family circumstances (income, living conditions), that is, the life history (anamnesis vitae) of the patient and the history of the development of the disease (anamnesis morbi) are elucidated Finally, the present condition of the patient (status praesens) is disclosed by questioning

However, there are a number of specific features associated with taking a pediatric history (anamnesis) on which we shall now dwell

1 The pediatrician takes the child's *name* and questions the mother on her opinion of what is wrong with the child The mother should be permitted to present the problem as she sees it, without interruption, otherwise she will later interfere with the examination by giving additional information

2 The diagnostic value of one and the same symptom varies extremely with the child's *age* Jaundice in the first month of life is a physiological occurrence the so called jaundice of the newborn, jaundice in the preschool and school age periods is mostly a symptom of epidemic hepatitis A combination of clinical findings which includes a high fever a cough, and a spotty rash should alert the doctor to the possibility of measles in children of six months and older, while measles does not ~~occur as a rule in babies younger than three~~ months Convulsions not associated with fever in the first year of life prevalently point to spasmophilia, while in the school age period a suspicion of epilepsy is elicited by their appearance

3 *The epidemiological surroundings* of the child are also very important It should be found out whether the child could have been exposed to some infection (contact with sick children) This is important not only for establishing the diagnosis in the given case, but also for prophylaxis, since the child may be in the latent period of some contagious disease and thus be a source of infection

1 *General outline of history or remote anamnesis* The history is taken with great detail the younger the child the more important it is to get as much information as possible on the pregnancy (ante natal health of the child), on delivery (natality), on the newborn (neonatal) period, and on nutrition, development and previous illnesses

Pregnancy and delivery The data taken should include information on the health of the mother during her pregnancy, on what diseases, if any, she had, on her occupation and working conditions, further, kind and duration of labour, type of delivery, state of baby at birth—did he cry immediately or was resuscitation required, was he asphyxiated, was he born at term or prematurety (in the latter case what was the cause of prematurity), birth weight

Difficult labour is accompanied by various kinds of birth injuries, such as hemorrhages, particularly into the brain, the latter leads to spastic hemiplegia or diplegia (Little's disease) Premature infants are frequently feeble, their resistance to harmful influences is insufficient, and they are susceptible to many diseases, particularly rickets The birth weight is an indication of prematurity and weakness of the infant

Diseases of the newborn The pediatrician examines the condition of the umbilicus, of the eyes, and of the skin for the presence of a rash or of jaundice, notes the nature of the rash

If the case concerns an infant in his first month of life suppurative inflammations of the umbilicus or of the skin may lead to sepsis Besides, the possibility of skin eruptions due to congenital syphilis should be taken into account

Nutrition during the first year of life The first thing to clarify is the type of nutrition (breast, formula, mixed), time of first introduction of solids and their type, if solids were given before time what was the reason, time of weaning

In cases of babies under one year of age interrogation concerning nutrition should be most exhaustive frequency of feedings, amount of food given at a single feeding and total daily amount, source of formulas (domestic preparation or the infant dairy kitchens) In general both the interrogation and the physical examination of nursing infants follow a special outline with which medical students become acquainted when taking their training in child health centres and in infant departments of hospitals

Developmental pattern in the first year of life The information sought includes weight gains (weight curve), time when baby first raised head, sat alone, pulled up, walked, did baby cease walking at any time, and if so, why, age of eruption of first teeth and number of teeth at one year, age when baby began understanding speech and when he began saying meaningful words and sentences

For the examiner to be able to evaluate the mother's answers correctly he must be conversant with the normal dynamics of the development of children and with all the physiological data set forth in subsequent chapters of this book

Tendency to recurrent diseases in the first year of life It should be ascertained whether the baby showed any tendencies towards diarrhea, coughs, rashes, or convulsions

Careful questioning should elucidate whether these diseases appeared without any visible causes, or whether they were provoked by slight or even insignificant causes These diseases do not include diarrheas precipitated by patent, coarse irregularities in nutrition, or rashes accompanying measles, scarlet fever, etc

Previous diseases, particularly acute infections, and child's endurance The diseases should be taken down in the sequence of their appearance, i e, during the first year of life, during the second, etc In cases when the physician did not himself attend the child during his illnesses he should endeavour by a number of leading questions to clarify the true nature of the disease, for instance, if the mother speaks of measles, the examiner should find out the details of the symptoms and also whether other children in the family, apartment, or house were similarly affected at the time By learning of the child's endurance of disease the physician gains some knowledge of his patient's resistance of the specificities of his reactions to infection and to other harmful influences

It is necessary to establish what type of preventive inoculations were done (against tuberculosis, smallpox, diphtheria, poliomyelitis) and when, how they were tolerated, was there any sign of the serum sickness

Family health The data taken includes the number of pregnancies the mother had and their termination (abortions, miscarriages, still births), how many children died, at what age and what was the cause of death If it becomes clear from the mother's answers that some of her pregnancies terminated in spontaneous miscarriages or stillbirths this should alert the physician to the possibility of syphilis Next the examiner finds out whether there are any other children in the family, their ages, and health are they under the surveillance of the special district tuberculosis clinic (dispensary) or of the antirheumatic fever office of the local polyclinic

Certain significance attaches to the present age of the parents, their age at marriage, the state of their health, the health of the closest relatives The diseases most important from this aspect are alcoholism, mental and nervous disorders, syphilis, malaria, rheumatic fever and, in particular, tuberculosis It is not sufficient to ask the mother whether she or the child's father have tuberculosis Mothers, even those who are obviously ill, frequently answer in the negative to such a question The actual state of health must be ascertained by additional leading questions For instance, was the mother ever sub-the mother and attempt to obtain as much information as possible by careful observation while the child sleeps

The first thing to note is *posture* A healthy infant lies on his back when asleep with his arms flexed and pressed to the chest the hands clenched into fists Children out of the nursing age take no definite position during sleep It is only during certain diseases that postures typical of the given disease are observed Thus, a child afflicted with meningitis usually lies on one side his legs bent in the knees and pressed to the abdomen, when a voluminous effusion is present in the pleural cavity the child lies on the affected side in cases of pan carditis a semi sitting position is preferred (Fig 2)

Fig 2 Posture of child with pancarditis

The next point of interest is *the colour and texture of the skin* a spotty rash concurrent with appropriate data obtained by interrogation (fever running nose a cough of 3 4 days duration) are grounds enough for diagnosing measles cyanotic lips and face evoke suspicion of a grave circulatory disturbance congenital heart defect

Further *the nature of the cough and of respiration* are elucidated Accelerated groaning respirations accompanied by flaring of the nostrils and a short cough are grounds for suspecting pneumonia

A peaceful state during sleep is a favourable moment for counting *the pulse and respiration* as even slight restlessness affects their rate

Pulse and respiration rates are important symptoms in certain diseases for instance slowness and arrhythmia of the pulse are characteristic of the initial stage of tuberculous meningitis and a relative slowness of the pulse is one of the symptoms of typhoid fever but these symptoms disappear when the child becomes restless ane cries

If the child is awake the physician should avoid anything that might cause apprehension as for instance looking at the child too intently approaching him too quickly talking loudly During the examination the pediatric patient should be distracted by some toy by playful talk While questioning the mother the examiner should observe the child carefully noting his reaction to the surroundings as with the sleeping patient the nature of his cough respiration etc should be observed

What the examiner does next depends on the age of the child When the patient is under two years of age all his clothing is removed immediately and the examination is conducted in the crib on the examining table or in the mother s lap Older children (preschool and school ages) may also be undressed at once or gradually as the examination progresses Gradual removal of clothing is particularly recommended for girls of the school and puberty ages in view of the modesty that appears at this age

The physician should not forget to examine the child s legs and feet the patient s stockings must be removed as otherwise certain conditions may be overlooked such as a nodular erythema on the legs that occasionally causes feverish chills or flatfoot or some other condition

The entire examination should be conducted in a manner least offensive to the child For this purpose it is sometimes advisable to distract the child by talk or a toy frequently the child becomes so engrossed in the process of the examination that he willingly lets himself be examined observing the doctor attentively and even trying to imitate what he does

Children with unstable nervous systems are often persistently resistant to medical examination The doctor s strict admonition sometimes has an unexpected favourable effect on them In exceptional cases the child has to be restrained during the examination

When examining *the throat* the physician should never allow himself to be persuaded by the child or by his parents to do the examination without a spoon or tongue blade He can calm the child by assuring him that the spoon or blade are needed for examining the teeth and not the throat the majority of children willingly agree to an examination of their teeth—if they haven t visited a dentist yet of course The method of examining the throat will be dwelt on in Chapter XVIII

Each pediatric case requires an individual approach and the success of the examination rests completely on the experience and skill of the examiner

A definite sequence is necessary in making the examination going from organ to organ We use the plan adopted in the Children's Clinic of the First Moscow Medical Institute However, the adopted sequence is frequently violated in pediatric examinations, as the physician has to adapt himself to the patient's mood, and, what is more important, the areas that are likely to be associated with pain or discomfort should usually be examined last Examination of the throat is the procedure children find most unpleasant, therefore it should also be done at the end of the examination

The details of examination of separate organs and systems are set forth in corresponding chapters

CHAPTER V

GENERAL FEATURES OF THE NERVOUS SYSTEM AND HIGHER NERVOUS ACTIVITY IN CHILDHOOD

Prof *Y Dombrovskaya*

The concept of nervism, of the entity of the organism and the influence of the environment as conceived by Ivan Pavlov is expressed most vividly in the neuro psychic development of the child, this development is associated with two points (a) gradualness of growth and differentiation of the separate elements of the central nervous system, the cerebral cortex in particular, (b) a gradual and uninterrupted equilibrium between all the bodily functions and the environmental conditions Stimuli arising from without may be of either a physiological or pathological nature

During illness the severity of the child's condition is determined by the degree of reactivity of his nervous system which is manifested, independent of the initial localization of the infection, by a complex clinical pattern of toxicosis—disturbance of consciousness convulsions or disturbances of muscular tonicity, cardiovascular and other vegetative disorders, etc Hence severe forms of pediatric diseases are frequently termed 'toxic" (toxic scarlet fever, toxic diphtheria, toxic pneumonia, toxic dyspepsia, etc) It may be assumed that the action of the toxins resolves first of all into overexcitation of the cerebral cortex a brief excitation is followed by diffused inhibition

The function of the higher sections of the central nervous system is inseparable from the activity of the peripheral receptor mechanisms

Receptors are end organs which receive stimuli and transmit them to the cerebral cortex Two types of receptors are recognized interoceptors which transmit stimuli from the visceral organs, and exteroceptors which transmit stimuli received from the external world

The exteroceptors include the peripheral sections of the sense organs (analysers) receptors of the vestibular apparatus skin receptors, taste receptors, olfactory, auditory, and optic receptors

Each analyser consists of three sections (1) the receptive (peripheral) part, (2) the conducting (intermediate) part, and (3) the cerebral (central) part.

Notwithstanding a certain specificity none of the analysers function in isolation for the cerebral cortex possesses not only the faculty of analysing but also of synthesizing It is thus clear that an imperative prerequisite for the analysing and synthesizing activities of the cerebral cortex is complete maturity of the cortical cells of the brain Owing to the immaturity of the child s nervous system both the conducting pathways and the cortical cells that receive the stimuli are functionally faulty although the external world is the source of multitudinous stimuli from the moment the baby is born

Upon coming into contact with the outer environment the infant has to react to it has to establish new links The unity of the organism and the environment is achieved by an uninterrupted equilibrium maintained between this system and the external world by the definite responses of the living system to stimuli arriving from without it (Ivan Pavlov) In the higher animals this process is predominantly enacted by the nervous system in the form of reflexes

The above equilibrium is attained by the activities of a number of mechanisms first among them is the system of extero and interoceptors then comes the system of humoral regulation i e metabolic displacements and alterations in the functions of the organs and finally the adaptative trophic function of the sympathetic nervous system *All these systems are under direct control of the cerebral cortex i e all the functions of the organism and its correlation with the environment are regulated by the nervous system* As defined by Pavlov this higher section governs all the bodily phenomena The complex behaviour pattern of man and the development of the higher nervous activity are completely tied up with the brain in particular with its cerebral hemispheres

Our exposition shows how great are the claims put on the nervous system of the newborn by adjustment in the first head to the influences of the outer world on his organism Such a continuous load on the newborn s functionally weak cerebral cortex brings the latter into a state of protracted inhibition the result of which is the almost continuous sleep of the newborn infant

ANATOMY AND PHYSIOLOGY OF THE NERVOUS SYSTEM OF CHILDREN

The nervous system of the newborn infant and of babies possesses a number of specific morphological features in so far as it is comparatively less mature and less differentiated than the other systems of the newborn These specific features underlie the entire life of the child and are the basis of his physical and mental development of his reactions to the outer world and to various harmful influences (germs etc)

The brain During the first stage of intrauterine life (the first four months) the cerebral cortex is not differentiated and it contains no myelinized fibres, by the end of the intrauterine period there are already seven layers of neurons in the cortex, arranged one above the other

Almost all the convolutions and fissures (gyri and sulci) the brain is to possess in later life are present at birth, but they are extremely underdeveloped The layers of the cerebral cortex are already almost completely formed at term, but differentiation of all the nerve cells occurs predominantly in the postnatal period (Fig 3) At the same

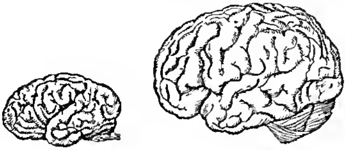

Fig 3 Brain of the newborn infant and bra n of adult

time the spinal cord the optic thalamus, and the corpus striatum are of a more mature structure The cerebellum is elongated and its sulci are weakly pronounced

It is only towards the end of the first year of life that the macro scopic structure of the baby's brain approaches that of an adult The brain gains intensively in weight following birth it weighs 360 370 g in the newborn about 600 g in the six month old and about 900 in the one year child The weight of the newborn's brain is one eighth of his body weight, in adults it is one fortieth

By nine months after birth the initial brain weight doubles be tween the first and third year it triples, and increases four- or fivefold by the time a person is twenty Differentiation of the brain matter (i e , of the nerve tissue, ganglionic cells and nerve fibres) is slower

Since the cortical layers of the brain of the newborn infant are little *differentiated the formation of the cortical centres is also immature* A particularly intensive development of the cerebral cortex takes place during the first three months after delivery A most characteristic point is the absence of dendrites (arboraceous branches) in the nerve cells (neurons) Principal differentiation of the nerve cells is completed by the age of 3 years, although the final termination of the process occurs only at 8 years (Fig 4) The conduction routes (with the exception of the pyramidal pathways) are sufficiently developed at birth, the pyramidal routes myelinize by the time the baby is 5 or 6 months old guished by diffuseness A certain tendency to diffusion of the tendon reflexes is retained in newborn infants and in babies of the first few months of life in the form of generalization and crossing an attempt to induce the patellar reflex in one leg results in contraction of all the muscles of both legs Positive Babinski s reflex (hyperextension of the great toe and flexion of other toes upon stroking of the sole) is physiological in children of the first two years of life, during the first two months of life clonus of the feet is occasionally also observed At the same time the reflexes of the abdominal wall are weakly pronounced in the first months of life The grasp reflex is quite peculiar stimulation of the palm of a baby s hand causes the fingers to flex the hand tightening into a fist Pain and tactile stimulation are not localized a prick or the touch of a hot or cold object induces a general motor reaction All these facts are confirmation of the insufficient functioning of the cerebrum of the immaturity of its analysing activities, and of the prevailing influence of the spinal cord and subcortical areas of the brain

Investigation of the physiological activity of *the brain* is the indisputable achievement of Russian physiology The psychic functions of the brain are based on the laws governing the higher nervous activity, laws which were established by Ivan Pavlov by the conditioned reflex method

The newborn infant is almost impervious to environmental stimulation as the effect of these irritants on his functionally immature cortex is excessive inducing in it a state of inhibition i e sleep

Although the cerebral cortex is functionally deficient and morphologically immature at birth the newborn infant possesses a number of inborn unconditioned reflexes *the food reflex* i e sucking and swallowing and *a defense* or *protective reflex* — winking the eye in a bright light

The basic process in the activity of the nervous system of the newborn is the congenital unconditioned food reflex — i e food dominant which is expressed by the inhibition of any other activity when the baby nurses The unconditioned reflex is induced by the stimulation food exerts on the taste apparatus, the excitation is translated into nerve impulses which are conducted over the nerve pathways to the medulla oblongata and from thence to the digestive glands Unconditioned reflexes are actually only conduction reflexes Unconditioned reflexes are retained after the removal of the cerebral cortex thus sucking is perfectly feasible in the absence of the cortex Towards the end of the first and in the second month of life *conditioned reflexes* first appear This is proof of the commencement of functional activity of the cerebral cortex which develops parallel to the maturation of its structure

The effect of irritants (signals) from the outer world in the formation of conditioned reflexes in children is wholly tied up with the baby s surroundings the care he is given his schedule The newly formed conditioned reflexes are not stable in children owing to the insufficient differentiation of their ganglionic cells, any recurrent intensive stimulation is the cause of the temporary extinction of the newly acquired reflexes Thus a child who finds himself in strange surroundings frequently loses the habits he has already acquired (complex conditioned reflexes), such as personal neatness and ability to feed himself, this is the result of overexcitation of the cortex by unusual impressions and the diffusion of this excitation The condition is manifested either by the child's continuous restlessness, or by inhibition, lassitude, and somnolence

Soviet physiologists have succeeded in establishing *the times of formation of conditioned reflexes* It has been proved by numerous experiments that conditioned reflex links may be formed in the first few weeks of life however, the newborn spends most of his time in sleep and therefore perception of irritants by his cerebral cortex is very weak

It has been proved that *a conditioned food reflex* may develop in the third week after birth preparation for nursing the infant, the changing of his diapers, or a definite position he is placed in for nursing resolve into a complex of peripheral stimuli and labyrinthine stimulation (tactile and vestibular analyzers), *the visual reflex to food* develops as early as the third or fourth month of life (the baby's reaction to his mother's preparation for nursing, or to a nursing bottle)

The sound analysing reflexes are formed somewhat later, and by the end of the first six months a definite number of already formed but still unstable reflexes are present (the first signal system)

The development of the higher nervous activity of the child is regulated to a great extent by the influence of the environment The sleep of the newborn alternates with a periodic reaction to his surroundings by the beginning of the second month the baby smiles, watches bright objects, in the third month voluntary movements of the arms and legs appear, and by the fifth month the child is able to hold things in his hands After six months babies begin taking an interest in their surroundings, they show a number of emotions (fear, joy), and recognize familiar faces *This marks the onset of the analysing activity of the cerebral cortex*

Towards the end of his first year of life the child not only perceives impressions arriving from without, owing to the establishment of conditioned reflex links but his cerebral cortex already commences its intricate analysing and synthesizing work As a result of the activity of the peripheral end organs—the receptors—and of the corresponding groups of nerve cells a gradual formation of the higher nervous activity of the child occurs The child displays definite tastes for certain foods, chooses his toys

Development of the specific function of the human brain—*speech*—begins in the eighth month of life Stimulation of the first signal system produces not only emotions of fear or joy, it also induces the

The nature of the child s sleep is extremely important in all stages of childhood

Sleep is a complex biological state the rhythmic alternation of sleep and wakefulness are an obligatory requirement of the body

According to the teachings of Ivan Pavlov sleep and internal inhibition are one and the same process associated with stimulation of the cortical cell

Having proved the great reactivity swift functional destructibility and rapid exhaustibility of the cortical cell (sentinel post of the organism) Pavlov formulated the important role played by protective inhibition this process prevents the continuation of excessive dangerous destruction of the cortical cell During its state of inhibition the cortical cell recovers its normal constituents Sleep is such an inhibitory state The duration of sleep is directly dependent on the age of the child infants under two months of age are in an almost continuous semi somnolent state owing to the diffuse inhibition of the functionally and morphologically immature cortex A certain sequence of wakefulness and sleep is established concurrently with cortical maturation in the first year of life sleep takes up 16 hours a day on the average including two naps in the daytime A powerful stimulus inducing the conditioned sleep reflex is fresh air children under one year of age usually soon fall asleep when taken outdoors The influence of the environmental temperature particularly in the winter resolves into increased stimulation of the exteroceptors and possibly also of the interoceptors by intensification of oxidation processes In healthy children sleep or inhibition occurs quite rapidly when the rules that play the part of conditioned reflexes are followed the child is put to bed at definite hours into his own bed undressed The child should never be burdened with too many impressions before bedtime as this will considerably delay the inhibition process Nervous children take a long time to fall asleep and their sleep is very light and frequently broken

The essence of sleep is cessation of the normal activity of the cerebral hemispheres followed by a slackening of the skeletal muscles Another plausible factor is the influence of various chemical irritants possibly the effect of protein metabolites on the grey matter of the brain

As the child becomes older his need for unbroken hours of sleep diminishes but up to the time he is five or six years old an additional nap in the daytime is a form of protective inhibition necessary for every healthy child Hospitals sanatoriums and young pioneer camps follow a similar purpose by their strict establishment of hours for rest or naps

The requirements of children in sleep vary with age between the ages of 2 and 3 years they need 14 to 16 hours from 4 to 6 years 12 14 hours and from 7 to 9 years 11 12 hours Many disturbances in the psychic and behaviour spheres of children are associated with violation of sleep schedules

EXAMINATION OF THE CHILD'S NERVOUS SYSTEM AND MENTALITY AND SYMPTOMATOLOGY OF THEIR MOST IMPORTANT DISEASES

The pediatrician must devote particular attention to examining the child's nervous system and mental status. He should be able to understand the significance of possible deviations from normal and only call on the aid of a specialist in exceptional cases.

Examination of the neuropsychic sphere of the child also consists of interrogation and physical examination.

Interrogation (Anamnesis)

Interrogation on the state of the nervous system and mentality of the child calls for great caution. When examining pediatric patients older than 4 or 5 years it is better to obtain details from the mother in the absence of the child, at the same time a circumstantial talk with the child will sometimes bring to light circumstances the mother knows nothing about (conduct at school, peer relationships, difficulties with lessons, etc.)

Interrogation of the mother should begin with questions pertaining to the very earliest stages of the child's life, i.e., antenatal development: what kind of pregnancy did the mother have, was she ill during that period; type of labour (precipitate or protracted). Both precipitate and protracted deliveries may be associated with injuries that result in subsequent lesions of either the peripheral or the central nervous system. The time of appearance of static functions should be taken into consideration, in so far as they are connected with the development of the brain, thus, the doctor should ascertain the time when the child first began holding up his head, sitting, standing, and walking, also when he began to understand and pronounce separate words and recognize the people around him. In the case of a preschool or school age child the patient's reaction to his surroundings, his family and peer relationships, his school work and behaviour should be elucidated. The mother should be asked whether the child has displayed any signs of cruelty, unsociability, unruliness. One of the most telling indices of the condition of the neuropsychic sphere is the child's sleep: how soon does he fall asleep, does he talk in his sleep, does he jump up suddenly during sleep, what kind of dreams does he have.

It must be emphasized that neuropsychic conditions and sleep problems have their origin in unfavourable environmental circumstances (faulty schedule and upbringing, overstrain due to too much mental work, to reading books unsuitable for the given age, particularly at bedtime, or to viewing too many films). It is also highly important to establish the child's reaction to febrile and other morbid conditions (convulsions attendant on elevated temperatures and on rickets in early childhood) headache its duration character and localization in older children (persistent headache paroxysms head ache in the morning or after school) The questions change depending on the disease therefore we only outline some general rules

Physical Examination

During interrogation of the mother and of the patient the pediatrician observes the child s reaction to his surroundings (indifference apathy somnolence unconsciousness coma excitation) his facial expression and gestures

Fig 5 Left s de paralys s of fac al nerve in ch ld of 16 months

The examination and a talk with the child may frequently reveal some psychic inhibition as well as defects of speech hearing reading or writing

The extremely large head in hydrocephaly or the small dimensions of the cranium in microcephaly are direct diagnostic indications No less typical are the puffy face and saddle nose of myxedema patients or the slanting eyes epicanthus thick tongue and open mouth in mongolism (Down s disease) Paralysis of the facial nerve may not be very noticeable in the quiescent state but is displayed when the child cries or bares his teeth (Fig 5)

Investigation of the functions of the nervous system must begin with *observation* of the patient his behaviour and posture (position of the child on his side with his legs flexed and head thrown back is typical of meningitis irregular twitching of the facial muscles and extremities are signs of chorea etc) (Fig 6) Sometimes the examination immediately reveals various degrees of atrophy of the extremities (infantile paralysis tuberculosis of the joints) or their decreased tonicity Observation is followed by examination of the sensitivity of the peripheral nerves by means of *palpation and pressure* applied along the run of the nerves and in the solar plexus Motor volume muscular strength and muscular coordination are likewise investigated at this time in older children

Fig 6 Meningitis in child of 2 years 9 months

The muscular strength of preschool or school age children is determined either by passive extension of a flexed extremity or by flexion of an extended extremity

Muscular coordination (static and motor) is examined in the case of very young children by observing the movements made by the child how he stands on his feet how he takes something into his hand Disturbance of static coordination displayed by tremor of extended hands and unsteadiness when standing is termed static ataxia (lack of muscular coordination in standing still or in fixed positions of the limbs) Dynamic or motor ataxia is expressed by inability to coordinate the muscles in walking (distorted gait) and in moving the arms and hands

When *determining muscular tonicity* (i e , the minimum tension of the quiescent muscle) the examiner should bear in mind the physiological hypertonicity (particularly of the flexor muscles) in the newborn and in infants in the first months of life

Increased muscular tonicity is observed as a pathological condition accompanying many lesions of the brain and of the spinal cord such as meningitis meningoencephalitis paralyses of cerebral origin in chronic disturbances of nutrition (hypotrophy and atrophy) hypertonia is not uncommonly observed as the result of functional disturbances in the cortex Muscular hypertonicity originating in the pyramidal tract is termed spastic hypertonia it is characterized by a springy resistance to passive manipulation Extrapyramidal muscular hypertonia—rigidity or increased plastic tonicity with a tendency to remain fixed in any position (fixation rigidity) is observed in cases of toxicosis spasmophilia and atrophy

Spasmophilia a disease presenting typical muscular hypertonia (tetany) is associated with changes in electrolyte metabolism (calcium deficiency) and changes in the regulatory influence of the cerebral

Fig 7 Spasmophilia Spasm of hands and feet in 13 month s baby

cortex on the subcortex The symptoms accompanying tetany besides general hypertonia are spasms prevalently of the hands and feet (carpopedal spasm accoucheur s hand) (Fig 7) of the facial muscles (fixed expression spasm of the ring muscle of the mouth or "carp mouth) Rigidity of the muscles of the neck and positive Kerning s sign are early symptoms of meningeal lesion causing irritation of the nerve roots

Decreased muscular tonicity (hypotonia atonia) is observed in children in cases of peripheral nerve lesions (diphtheritic paralyses)

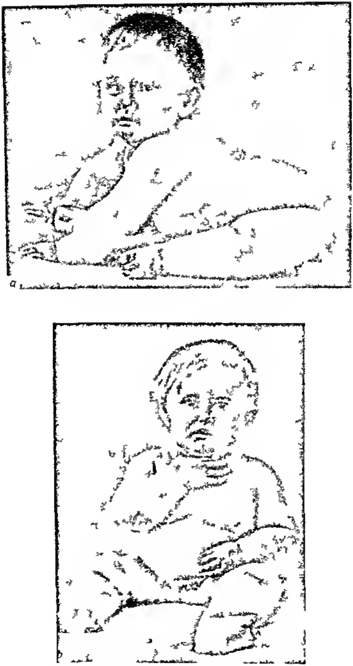

Fig 8 Hypotonia (*a*) and adiposity (*b*) following encephalitis in one year old baby

chorea, infantile paralysis with involvement of the cells of the anterior horns, rickets, mongolism, encephalitis) (Fig 8)

The examination also reveals *hyperkinesis*, i e, forced passive movements and involuntary contractions of the muscles (excessive voluntary and involuntary movements, associated with muscular spasm) The forms of hyperkinesis may vary considerably, including both convulsive movements of an isolated group of muscles (tics, nystagmus, tremor of an extremity, chorea), and diffuse hyperkinesis—convulsive states *Convulsive* states are quite frequent in children particularly in infancy, they are associated with organic processes occurring in the brain and also with toxicoses of bacterial and non bacterial origin Convulsive states are distinguished as clonic, tonic and clonicotonic The cause of the frequent association of convulsive states with infections is irritation of the brain this leads on the one hand, to defective regulation of the subcortical regions, and on the other to diffusion of the irritation received by the cortex through the system of interoceptors This diffusion proceeds both peripherally along the cortex and radially into the subcortical depths Severe toxicosis results in overstrain and exhaustion of the brain cells This, in its turn leads to a weakening and inhibition of the activity of the cerebral hemispheres causing intensification and random activity of the subcortical areas

The involuntary choreoathetoid movements of the newborn are a normal phenomenon associated with the morphological and functional immaturity of the cerebral cortex

A convulsive symptom complex, i e, tonic and clonic convulsions is observed in epilepsy, toxicoses and infections of the central nervous system (meningitis, meningoencephalitis), and occasionally in cases of pneumonia and of intestinal toxicoses The convulsions of *spasmophilia* are accompanied by laryngospasm, i e, a whistling inspiration (false croup laryngismus stridor) owing to inhalation difficulty and not uncommonly also by carpopedal spasm In children under two years of age spasmophilia frequently accompanies patent rickets, and is mostly observed in association with artificial nutrition and faulty schedules (carbohydrate diet, insufficient fresh air) that cause metabolic disturbances chiefly in electrolyte metabolism

Convulsions associated with infectious diseases (dysentery in babies, lobar pneumonia in older children) and intoxications (intestinal toxicosis) usually appear at the onset of the disease they are probably the result of the action of the toxins on corresponding receptors and the transmission of this irritation to the cerebral cortex Their occurrence is more frequent among excitable, neuropathic children

A number of diseases, unconnected with direct lesion of the central nervous system induce *a meningeal symptom complex* in children particularly in very young ones This complex is characteristic of meningitis, meningoencephalitis skull injuries infectious diseases and intoxications Most typical obvious meningeal symptoms are *the child s* *position* on one side, his head thrown back and his knees drawn up to the abdomen Any attempt to bend the head forward or straighten out the legs causes pain (irritation of the posterior roots)

Various degrees of *psychic changes* accompany such conditions in children (somnolence, lassitude, delirium, excitation) Consciousness is disturbed and the patient is not clearly aware of place or time Changes are observed in *muscular tonicity* positive Kerning's sign, rigidity of the muscles at the back of the neck, motor disturbances (pareses, various types of paralyses hyperkinesis)

Sensory disturbances are also manifested, taking the form of hyperesthesia of the skin, acute headache, increased visual sensitivity, periodic vomiting These symptoms are the result of hyperexcitation of the cortical analysers and increased intracranial pressure

Disorders of the autonomic nervous system are quite typical altered pupillary reflex, bradycardia, arrhythmia, disturbance of respiratory rhythm, constipation, red dermography, fulminant trophic disorders

All instances of obvious meningeal symptom complexes require examination of the cerebrospinal fluid, obtained by lumbar (spinal) puncture

For making *a lumbar puncture* the patient should be firmly restrained by an assistant in a lateral recumbent position, his head bent to the chest and legs drawn up to the abdomen The site of puncture is determined by drawing an imaginary line between the two iliac crests and using the intervertebral space above or below this line (the space between the III and IV or between the IV and V lumbar vertebrae) The lumbar puncture needle with stylet in place, is inserted in the midline of the space between the vertebral spines (found by palpation), the needle is held at an angle over the lower vertebra (i e , pointing a little towards the head, perpendicular to both planes of the back), and all rules of asepsis are observed The depth of puncture is 2 3 cm A distinct "give' is felt when the needle pierces the firm dura mater After the first drops of fluid have appeared the stylet (or hair mandrin in thinner needles) is removed and the escaping fluid, in volumes not exceeding 5 or 10 ml, is collected in a sterile test tube The pressure of the cerebrospinal fluid is gaged by means of a graduated glass tube attached to the needle, pressure is defined by the manner in which the fluid comes out of the needle (in drops, in a strong or weak stream) Normally the spinal fluid is clear and emerges in rarely spaced drops The protein value varies between 0 2 0 $3^0/_{00}$ Increased protein content is characteristic of inflammatory processes in the substance and meninges of the brain, while a decreased content is typical of hydrocephaly. Two tests are used for determining the globulin value of the spinal fluid The first is the Nonne Apelt test, a reaction with saturated ammonium sulfate the degree of turbidity is noted by crosses The second, Pandy's test, consists of adding one drop of the spinal fluid to one ml of saturated phenol in a test tube, inducing various degrees of cloudiness Only reflex following a brisk tap the leg remains in an extended state owing to tonic tension of the quadriceps muscle The tendon reflexes are increased in children with unstable nervous systems

A decrease of the tendon reflexes (hyporeflexia) or even their absence (areflexia) are observed in lesions of various parts of the reflex arc Areflexia appears in association with polyneuritis (of diphtheritic and other origin), lesions of the anterior and posterior nerve roots (meningitides), involvement of the grey matter of the spinal cord (epidemic infantile paralysis—acute anterior poliomyelitis), elevation of intracranial pressure, various types of meningitis, toxicosis, vitamin deficiencies, muscular atrophy

Cutaneous reflexes include the abdominal (upper, middle, and lower), the plantar and the cremasteric reflexes Cutaneous reflexes are best elicited by irritating the skin with some hard object (a match, the handle of a reflex or percussion hammer) Changes in these reflexes are associated with lesion of certain segments Diminished and absent cutaneous reflexes are observed in lesions of the pyramidal tract or of the spinal arc of a reflex However, diminution (or increase) of the cutaneous reflexes may be caused in children by general toxicoses, peritoneal diseases, neuroses with functional disorder of the gastrointestinal tract and cardiovascular system

The mucosal reflexes are the most unstable reflexes even in healthy children (diminished, absent, or increased faucial and corneal reflexes in children with heightened excitability)

Pathological reflexes are usually observed in lesions of the pyramidal tract (Babinski's sign, Rossolimo's reflex, Bekhterev's reflex, Oppenheim's reflex) Babinski s and Rossolimo s reflexes are physiological in children under one and a half years of age, i e , are encountered in healthy subjects

The state of the autonomic (vegetative) nervous system of the child is determined by examination of *the autonomic reflexes* and functional investigations of certain systems (the cardiovascular and digestive) Pharmacological tests are of considerably lower importance (tests with atropine and pilocarpine) When examining the autonomic nervous system the subjugation of the latter to the cerebral cortex must always be taken into account, hence, all the child's emotions (fear, sudden fright anxiety) may affect the results of the examination

The autonomic reflexes investigated are the *pupillary* reflex (dimensions of the pupil, its reaction to light), the *pilomotor* reflex (goose flesh) induced by both mechanical and thermal ~~irritation~~ (cooling), and *the vascular reaction* (vasomotor reflex) of the skin determined by the method of dermographism

Dermography (skin writing) consists of a response of the blood vessels of the skin to irritation caused by tracing the fingernail or a blunt instrument over the skin The type of dermography depends on the pressure exerted, and on the reactivity of the vessels and vasculomotor nerves No dermographic response is seen in undernourished children with dry and scaly skin Dermography is distinguished as *a local condition* limited to the sites of irritation and depending on the condition of the local capillaries, and as *a reflex condition* that goes beyond the site of irritation and is associated with the condition of the autonomic nervous system

The following types of dermography are recognized (1) red (dermographia rubra), (2) white (dermographia alba), (3) mixed, (4) elevated, or edematous A certain time lapses between the irritation of the skin and the appearance of the dermographic line (*the latent period*), the time between the appearance and disappearance of the line is termed *the obvious period*, this time is precisely noted in seconds *Red dermography* points to diminished vascular tone, it is particularly marked in meningitis, in toxicoses of intestinal origin, and also in pediatric patients with unstable nervous system, or in those who are subject to some autonomic disorder (excessive perspiration, tachycardia or bradycardia, functional disturbance of the gastrointestinal tract, etc)

White dermography is proof of increased vascular tonicity It is frequently observed in children with exudative diathesis and in cases of general hyperemia of the skin White dermography attends almost all cases of scarlet fever and is, indeed, one of the early signs of this disease Moreover, this symptom is of a certain prognostic value white dermography disappears when the patient's condition deteriorates, and appears again when the condition improves Acute red dermography is attended by the formation of wheals (edematous elevations) along the line (in scarlet fever and in cases of increased nervous excitability) An important symptom indicating the state of the autonomic nervous system is excessive perspiration (increased perspiration of the palms, soles, and axillary regions), and also acrocyanosis (coldness and blueness of the extremities, notably the hands)

Visceral reflexes. *The oculocardiac reflex* moderate gradually increasing pressure upon the eyeballs for a period of 30 seconds causes slowing of the heart rate, normally by 10 to 12 beats per minute A greater slowing of the pulse bespeaks increased vagus excitability.

Solar plexus reflex the heart rate is accelerated in response to pressure on the abdominal aorta in the area of the navel

In certain cases (suspicion of latent tetany or spasmophilia) it is essential to investigate the mechanical irritability of the muscles Thus, two typical signs of tetany are *Chvostek's sign* (the facial nerve sign)—contraction of the nasal wings or of the skin of the forehead in response to tapping of the cheek in front of the ear, and *Trousseau's sign*—carpophalangeal spasm elicited by compression of the upper arm

A still more trustworthy confirmation of the presence of tetany is obtained by studying the electrotonic effect, an altered condition of excitability of the nerves and muscles when in the electrotonic state, in spasmophilia a typical contraction of the muscles is elicited by a current below 5 A when a cathode circuit is interrupted Investigation of excitability to electric stimulation is very important for excluding the possibility of epilepsy

The radiographic method is quite salient in the examination of the nervous system, particularly cranial radiography (see Chapter XXV) In some cases electroencephalography gives valuable information concerning the localization of the lesion

The child's mental condition should be determined during the examination of the separate systems and when taking down the anamnesis First of all the pediatrician decides whether the patient's mental development corresponds to his age, this is done on the basis of the time when the child's first reactions to his surroundings appeared (he began to recognize his mother and other people around him, to smile), of his vocabulary, his literacy Mental backwardness is observed following birth injuries, diseases of the central nervous system (meningitis, encephalitis), congenital diseases (microcephaly), mongolism (Down s disease), myxedema, and also in cases of significant degrees of distrophy Occasionally a talk with the child will reveal the degree of mental backwardness (idiocy, imbecility, mental debility) There are certain plans for conducting the psychopathological examination of the pediatric patient depending on his age During the examination the pediatrician can establish disturbance of consciousness in a child who is severely ill The form of disturbance is frequently associated with the nature of the disease (somnolence in meningitis twilight state accompanying high fever, delirium in lobar pneumonia typhoid fevers and malaria, the stupor varying between twilight and comatose states caused by gastrointestinal toxicoses particularly in very young children, as well as by renal uremia and toxicoses of hepatic and diabetic origin)

While talking with the child patient and his mother the examiner notes all *behaviour disturbances* displayed by the patient Fidgeting and increased excitability are typical of children with nervous instability, lassitude, sullenness, and irritability are a transient symptom of severe forms of rickets Aggressiveness and malevolence are not unusual in epileptic children, but may also be the result of an erratic educational approach to emotionally unbalanced children Previous diseases of the central nervous system (meningitis and, particularly encephalitis) frequently leave sequelae in the form of various degrees of mental disorder—motor anxiety, quick temper, inability to concentrate on anything, rapid changes of mood

The child's upbringing and routine at home should always be taken into consideration when the state of his higher nervous activity is being judged Moreover, every protracted disease is attended by changes or retardation in mental development owing to functional disturbances in the cerebral cortex, in early childhood the most prominent causes are rickets and chronic nutritional disturbances

During the school-age period overstrain due to lessons, concurrent with an insufficient use of fresh air and neglect of sports frequently causes a protracted state of cortical inhibition, manifested by lassitude, changeability of mood, quick tears, and occasionally socially unacceptable conduct (untruthfulness, extreme egoism, and even a callous attitude to the parents), all these changes in disposition and behaviour are connected with inhibition of the regulatory influence of the cerebral cortex In adolescence (a period for which neuroendocrine disturbances are generally typical) prolonged overstrain, violation of proper daily routine, bad conditions at home owing to family discord, and less frequently acute mental shock may induce a definite clinical form of psychoneurotic disorder—*neurasthenia* According to Ivan Pavlov the processes of inhibition are impaired in the cerebral cortex in neurasthenia, while processes of excitation prevail, the rapid exhaustibility of the nerve cell and insufficient inhibition of its activity favour the onset of violent emotional reactions insomnia, night terrors, lack of self-control in relationships with other people, etc Neurasthenia is basically the result of the effect of a superirritant on the cerebral cortex The condition is characterized by a number of functional disturbances of the autonomic nervous system, the gastrointestinal tract (constipation, less frequently diarrhea) and the cardiovascular system (cardiac arrhythmia) All this indicates a diminution of the regulatory influence of the cortex on the functions of the internal organs The ordinary burden of school work is sometimes too much for the neurasthenic child. It is likewise prevalently in adolescence that *hysteria* is encountered The cause of hysteria is mostly the erratic management of particularly impressionable children with a weak type of nervous system The basis of hysteria is disturbance of the correlations of the cortical and subcortical areas with predominance of the subcortex The clinical symptoms of hysteria are hyperexcitability, unbalanced mood, egoism, imaginative tendencies, affected speech and behaviour Hysterical children frequently simulate some disease

Various types of hysteric conditions are encountered in pediatric practice, among them convulsive attacks, impairment of speech, sensory changes in various areas of the skin in the form of anesthesia or hyperesthesia, conditioned reflex vomiting, etc Certainty of the diagnosis is very important, the physician's closest attention is needed to differentiate hysterical symptoms from organic lesions of the nervous system.

Clinical Summary

Examination of the patient's psychoneurologic condition is an elaborate process that may, in the absence of sufficient experience, take some time and thus tire the patient It must be remembered that the child's cerebral cortex is easily fatigued, inducing a state of inhibition The latter is reflected in the result of the examination Therefore it is not advisable to make the entire examination at one time if the child shows signs of weariness, the examiner should strive to catch the interest of his young patient and give the examination the appearance of a game The investigation of tactile disturbances (hyperesthesia) should be repeated, in so far as such disturbances are of a subjective nature This is also in a certain degree true of examination of the autonomic nervous system when deviations from normal are considerable the examination should be repeated at various times of the day (before and after meals in a quiescent state after physical exertion), particularly in cases of excitable children and of children who are emotionally upset by hospitalization

The patient's condition permitting, it is preferable to examine him in a separate room after he has been left alone for some time to calm down

The conflict of the processes of excitation and inhibition in the cerebral cortex, i e , their collision (Ivan Pavlov), easily occurs when children find themselves in strange surroundings (in the hospital), particularly if the child has the opportunity of watching manipulations his neighbours are subjected to (taking of blood specimens, administration of injections) After a little time the child, even if he is in the preschool age period will become accustomed to the new surroundings and will calmly resign himself to all the procedures necessary for his examination The cerebral cortex controls the functions of many bodily systems, therefore lesion of the cortical mechanisms may cause dysfunctions that are not restricted to only one organ or system but involve a complex functional disturbance of many organs and systems of the body

All the above circumstances point to the need for creating optimal environmental conditions for the child in both therapeutic and health promoting establishments Hence the complex of therapeutic facilities includes an obligatory condition—the monotony of hospital life must be relieved by play, games and other beneficial distractions under the guidance of a teacher

No less important is the participation of the pediatrician in planning the daily domestic schedule of the schoolchild, ensuring proper alternation of lessons rest, and physical exercises

CHAPTER VI

THE ORGANS OF SENSE

Prof *D Lebedev*

In the teachings of Ivan Pavlov the sense organs are defined as peripheral receptors, specialized formations that convey signals from the outer world to the central nervous system Consequently, the sense organs are the peripheral parts of the analysers Besides the sense organs the analysers also include special receptors situated in the muscles and internal organs The proper functioning of signalization and of perception of the signals requires a sufficient degree of differentiation and maturity of the peripheral end receptors, absence of lesion in the conducting routes and an adequate development of corresponding cortical centres

It is not easy to examine the sense organs of children, especially of infants in the first months of life, since it is difficult to interpret the reactions that appear in children in response to stimulation It is particularly difficult to know how a very young child perceives sensations

Vision. One of the specific features of the organ of vision is *the physiologic photophobia* of the newborn during the first three weeks of life, when the infant's eyes are almost constantly shut Between the third and fifth week the baby's gaze rests on shining and bright objects for some short time (about 5 seconds), and for a longer time (several minutes) by the end of the second month In the first and second months after birth infants exhibit *physiologic strabismus*, and in the first month of life also absence of coordination between the movements of the eyeball and eyelids when the eye looks up or down the lid does not always follow its movements During this period *nystagmus* is also no uncommon occurrence *After three months healthy babies already consciously perceive what they are looking at* It is difficult to state whether or not infants under two months of age see The pupillary light reflexes and the conjunctival reflex are present in infants in the weeks directly following birth, the pupil is usually contracted in the early months of life, whereas at the age of 6 or 7 years it is somewhat larger than the pupil of adults Some practical importance likewise attaches to the fact that intensive skin stimulation does not always elicit pupillary dilatation in infants, and that these reactions to painful irritants are sometimes positive and sometimes negative in one and the same infant In preschool and school age children the pupillary reaction to light and to painful sensations differs very little from what is observed in adults Atropine and other drugs cause a lesser degree of pupillary dilatation in early childhood than they do at a later period of life, this is evidently associated with the immaturity of the vagus nerve

Babies younger than 3 or 4 months produce no tears when they cry The cause is not underdevelopment of the lacrimal glands, but immaturity of the nervous system

The insufficiency of tears owing to the small number of winking movements and the flabbiness of the eye closing reflex when the lids, lashes, or conjunctiva of infants are touched is often the cause of conjunctivitis

Examination of the eye is done as for adults

Symptomatology We shall here restrict ourselves to only those symptoms of ophthalmic pathology which are of certain value in the diagnosis of general diseases.

Strabismus, when not congenital or the result of an eye disease (sharp difference in the acuity of vision of both eyes, etc) is due to paralysis of the oculomotor nerve or the abducens nerve The latter is mostly observed following meningitis and diphtheria Paralysis of the oculomotor nerve is particularly characteristic of tuberculous meningitis, while accommodation paralysis is typical of diphtheria

Conjunctival hemorrhage is frequently noted in whooping cough

The position of the eyeballs is of some diagnostic value in hydrocephaly At all ages the upper eyelid normally covers part of the iris almost touching the pupil, while the lower lid touches on the lower rim of the iris In hydrocephaly the opposite is observed the lower lid covers part of the iris, while the upper lid only touches on the upper rim of the iris or does not even reach it, so that the upper part of the sclera may be visible in the form of a white strip between the margin of the upper lid and the rim of the iris

A similar phenomenon—a white strip of sclera visible between the upper lid and the upper rim of the iris particularly when the patient looks down (Graefe's sign), is typical of thyrotoxicosis This condition is also attended by exophthalmos—protrusion of the eyeballs (exophthalmic goiter) A more intensive and prevalently unilateral protrusion is observed with the growth of tumours or upon the formation of a retrobulbar abscess A lesser degree of exophthalmos may be an individual trait, or be due to adenoidal growths or other pathological processes or conditions leading to protracted disturbances of nasal respiration (see Chapter XV)

The pediatrician must know that physical or mental strain, severe diseases or operations may frequently be the cause of hypotonia of the lower lid in children and as a result a white strip of sclera is seen between its margin and the lower rim of the iris Concomitantly with other signs of fatigue (inadequate reaction to surroundings, rapid fatigability, unreasonableness, restlessness, etc) this phenomenon may serve as an objective indice of disturbances in the child's reactivity and functional abilities

Hearing. It is very difficult to decide whether the newborn infant hears or not. However, it has been noted that infants do definitely react to sounds in their second week of life the prolonged sound of a whistle makes them stop crying or making movements At four months a healthy baby already turns his head in the direction of a sound Children who are about one year old perceive sounds which are lower than any sounds adults hear, i e , their sense of hearing is finer

Anatomic features of the auditory organ In the first year of life the baby's external auditory canal possesses no bony part and consists only of skin and cartilage, moreover, it is much narrower than in adults During the first two months after birth the upper and lower walls of this canal almost touch, and its cross section is slit-shaped

Children, like adults, secrete cerumen (earwax), but it is of a looser consistency When babies wear warm caps or hoods that close the ears the earwax accumulating in the ear may liquefy still more and be discharged, simulating pus, the same may occur in the warm season of the year

The tympanic membrane (the eardrum) is situated almost horizontally, constituting an almost direct continuation of the upper wall of the external auditory meatus The narrowness of this canal and the position of the eardrum almost parallel to the optic axis makes otoscopy in infants very difficult *The tympanic membrane is thicker than in adults the eustachian (auditory) tube is shorter and wider*, favouring communication between the tympanic cavity and the nasopharynx Owing to this circumstance the stomach contents (following vomiting) and the mucus secreted during acute nasopharyngeal catarrh may easily penetrate into the middle ear and infect it, on the other hand, the exudate formed in the middle ear owing to otitis perforates the eardrum less frequently than is possible at a more advanced age as it usually is drained into the nasopharynx through the auditory tube without even causing any protrusion of the tympanic membrane *Hence otitis media may run a latent course in infancy*

The fact that ossification of the temporal bone is not complete in children and that the various parts it consists of have not knitted yet is of some medical significance, inflammatory processes arising in the cavity of the middle ear easily spread along these embryonic gaps and penetrate under the periosteum of the skull bones in the vicinity of the external ear (pinna), either in back or in front of it, causing *subperiosteal abscesses*

Mastoiditis is extremely rare in children under one year of age at this period the mastoid process is devoid of air cells containing only a cavity or antrum into which the inflammation may spread from the tympanic cavity causing *antritis* (also called maxillary sinusitis) A sufficiently well developed mastoid process with air cells only appears in the third year of life

Pediatric ear examination is conducted in the same manner as for adults A point to remember is that during otoscopy the outer ear of babies should be *pulled forward and down* but never back Every pediatrician should be able to perform an otoscopic examination

A very simple auxiliary procedure is the application of pressure to the tragus in the presence of otitis media the child feels pain and reacts accordingly To avoid mistakes the reactions obtained by equal pressure on the tragus and on the skull should be compared (in cases of nervous children) Sometimes otitis runs a latent course when even otoscopic examinations fail to show any characteristic changes in the tympanic membrane This is particularly frequent in the first year of life in such cases the disease is manifested only by general symptoms—elevated temperature restlessness loud crying the baby puts his hands to his head and pulls his ears It must be borne in mind that in infancy otitis media and antritis sometimes take the semblance of toxic dyspepsia usually with prevalence of vomiting over diarrhea and lead to the development of hypotrophy

Otitis is also frequently observed in association with nutritional disorders A point worth mentioning in this connection is that otitis even when complicated by suppurative osteomyelitis of the temporal bone may proceed without any elevation of temperature in weakened undernourished children

An auxiliary diagnostic symptom of otitis is enlargement of the superficial lymph nodes lying over the mastoid process Naturally these nodes may be enlarged owing to other causes such as involvement of the skin of the outer ear of the auditory meatus and of the areas of skin surrounding the outer ear in the temporal zone

Children of preschool and school age frequently complain of pain of shooting in the ear However it must be remembered that children who have had their eardrums pierced or who for some other reason are afraid of being examined by the doctor are apt to conceal their painful sensations in such cases otoscopy and pressure on the tragus will be an aid in making the diagnosis

Taste. In the majority of cases the infant is already born with some distinct sensations of taste he distinguishes sweet bitter acid substances Even premature infants born after seven months of gestation possess certain taste sensations At 4 5 months babies are already highly sensitive to taste reacting to any changes in their food The sense of taste in children of the preschool and school age levels differs little from that of adults

Smell (the olfactory sense). It may confidently be stated that even in the very first months of life infants perceive pungent odours like ammonia, vinegar or kerosene as unpleasant sensations and react accordingly It is chiefly the sensory endings of the trigeminal nerve that are stimulated by strong odours It is not clear how and when children begin to distinguish the more delicate odours that stimulate the ending of the olfactory nerve Investigations performed by the conditioned reflex method (N Krasnogorsky) have shown that after 7-8 months babies are quite able to distinguish weak odours as well as strong ones After one year they readily sniff at anything that smells good

Tactile sense. Newborn and nursing infants possess a sufficient degree of tactile sensitivity The areas most sensitive to touch are the eyes, forehead mouth, palms, and soles Thus, when an infant's palms are touched he clenches his hands so tightly over the object he feels that by pulling it it is possible to lift him out of his crib, when the sole is stroked dorsal flexion of the foot occurs, if an eyelid is touched the child shuts his eyes, etc Irritation of the skin elicits a general reaction manifested by restless motor activity Between the age of 3 and 7 months the baby is already capable of touching the precise site of irritation

Pain Children respond to painful sensations with both local and generalized reactions When his finger is pricked the child pulls away his hand and displays general restlessness However, the response to painful sensations is somewhat retarded in the newborn, and in sleeping children

Thermal sensations The reaction of infants to changes in environmental temperature is very strong When warm the small child calms down and stops crying when he finds himself in colder surroundings he begins to cry

CHAPTER VII

PHYSICAL DEVELOPMENT

Prof *D. Lebedev*

STATURE AND WEIGHT

Physical development of the child is evaluated by his crown-heel length (height or stature) and weight which are indices of the growth of the mass of his body, and by the degree of development of his functional abilities which depend on the differentiation and maturity of the cellular elements of the tissues and organs, especially on the functional faculties of the nervous system and the endocrines, the principal regulators of the entire bodily activity

Height The average crown heel length of a full term infant is 50 cm at birth Boys are usually a little larger than girls As regards subsequent growth it may be assumed that *the younger the child, the more intensive his growth*, i e, the dimensional gain of his body in the first year of life the child gains 20 25 cm in length, in the second year 10 cm, in the third 8 cm, and in the 4th and 5th years 4 6 cm a year Thus, the height of a child of five or six years (100 cm) is double that of his length at birth (50 cm), and by 14 or 15 years the birth length triples (150 cm) Length gains are most intensive in the first four months of life, when the infant gains 8 9 cm, in the following four months he gains 7 8 cm, and in the second half-year another 8 9 cm

Although height gains decrease as the child becomes older *there is no complete correlation between age and intensity of growth* Stature gains occur in waves The concept of the regular sequence of periods of "rounding out" and "pulling out" is widely used in medical and anthropologic literature It is considered that *the first "rounding out" period occurs between the ages of 1 and 4 years the first pulling out" between 5 and 7 years, the second "rounding out" between 8 and 10 years, the second "pulling out" between 11 and 15 years* However, such a concept is too schematic Actually one may only speak of the undulating nature of gains in height and in weight, and also note that at about the age of seven years and in the period of prepubertal development a child's height increases more rapidly than his weight does

Weight The child's weight is an important indice of physical development, particularly at early ages, however, the weight curve is subject to greater oscillations than the height curve, since it reflects various environmental circumstances, such as nutrition and diseases, to a much greater extent A full term infant weighs approximately 3,200 3,400 g at birth, and his crown heel length is 50 52 cm Boys are usually 120-125 g heavier than girls As a rule, firstborn babies weigh less than subsequent babies do

During the first 3 5 days following delivery the weight of the infant falls (physiological weight loss), this loss may attain 5 to 8 per cent of the initial weight (totalling 150 to 300 g) Weight losses exceeding 300 g are no longer physiological, but pathological After this postdelivery weight loss the infant begins to gain weight, and by something like the tenth day he attains his initial weight level

Physiological weight loss may be explained by an insufficient intake of water and food in the days directly following birth, and also by the excretion of the meconium and of urine, as well as of water through the skin and the lungs All this leads to the development of a negative balance—the prevalence of output over intake This weight loss may be avoided if the infant's nutrition is properly managed in the very first days of life

Generally speaking the laws governing weight gain are similar to those of height gain the younger the child the more intensively does he gain in weight An approximate idea of the increase in weight of a full term healthy infant in his first year of life may be presented by the following scheme by the end of the first month an infant gains 750 g, by the end of the second 700 g, in the third month 650 g, etc , the weight gain in every subsequent month is 50 g less than in the preceding month

The monthly weight gain is 800 g minus $50\times n$, where n is the number of months the baby has lived

To determine the baby's normal weight in any month of life the following formula may be used to the birth weight of the infant add the number of months he has lived (M) multiplied by the average month gain, for the first half year of life this will be 600 g, for the second 500g (weight$=3{,}200+M\times600$ or $+M\times500$)

Example an infant weighed 3,300 g at birth At the age of four months he weighed 4,300 g The average month gain for this age level is 600 g For a period of four months we multiply 600 by 4 and get 2,400 By adding this figure to the birth weight we get 5,700 Consequently, the baby's weight lag is $5{,}700-4{,}300=1{,}300$ g

A baby who weighed 2,500 g at birth weighs 9,000 g at eight months By multiplying the average monthly gain of this age 500 by 8 we get 4,000, and when we add this figure to the birth weight we get $4{,}000+$ $+2{,}500=6{,}500$ Consequently, the weight of this baby exceeds his age norm by 2,500 g

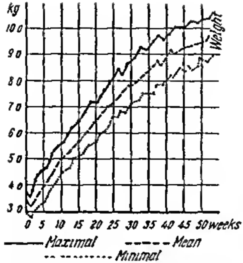

Fig 10 Normal range of variations in weight of infant during first year of life

The normal oscillations in the weight of babies younger than one year are shown in Fig 10

After one year the increase in weight proceeds at a slower rate The weight increase for the whole second year of life totals 2,500 3,500 g, i e , comprises approximately 200 g per month, while the subsequent yearly gain is about 1,500 2,000 g, growing to 5,000 8,000 g by puberty

To establish the approximate normal weight of a child between 1 and 12 years of age the average yearly gain is multiplied by the num ber of years the child has lived and the product is added to the one year weight of the child (after Maslov) This formula is not suitable for the puberty period, when the increase in weight is much greater

Consequently, *the following general outline of weight increase may be assumed children double their birth weight by 5 6 months* and triple it by one year, by 6-7 years the one year weight is doubled, and when the child is 13 14 years old he doubles his seven year weight*

Height, as we have already noted, *is doubled at the age of 5 years and tripled at 15*

However, a point to keep in mind is that all these figures are only approximate ones, showing average values which are most frequently observed Deviations from these values occur both as a result of dis-

* According to recent data the birth weight is doubled at 4 months in boys and at $4^1/_2$ months in girls

ease and in perfectly healthy children, the higher the age level, the more noticeable and frequent the deviations

The physical development of individuals and of child groups as a whole is evaluated by comparison with definite mean standards but these standards must not be looked upon as fixed and unchangeable The so-called developmental norm is not only a factor of climatic zones, it also changes in one and the same locality depending on times, on living conditions of the population and on other causes The following table of children's weights at various ages was computed by R Kogan (Moscow)

Table 1

Weight of Children in the First Years of Life (in g)

(Cited from R B Kogan 1956)

Age Level	Boys	Girls
1 mo	4 088 ± 35 6	3 876 ± 27 8
2 mos	5 166 ± 52 4	4 822 ± 51 6
3 ditto	6 104 ± 53 0	5 640 ± 56 7
4 ditto	6 914 ± 68 0	6 401 ± 57 9
5 ditto	7 600 ± 62 6	7 032 ± 63 7
6 ditto	8 166 ± 68 5	7 698 ± 60 5
7 ditto	8 696 ± 68 5	8 090 ± 87 3
8 ditto	9 268 ± 89 5	8 592 ± 90 7
9 ditto	9 703 ± 75 2	9 032 ± 96 7
10 ditto	9 956 ± 97 5	9 430 ± 114 6
11 ditto	10 210 ± 92 4	9 752 ± 116 8
12 ditto	10 500 ± 83 5	10 074 ± 109 8
1 yr 3 mos	11 182 ± 69 3	10 692 ± 79 1
1 ditto 6 ditto	11 798 ± 87 1	11 248 ± 93 5
2 yrs	12 712 ± 97 0	12 114 ± 102 9
3 ditto	14 642 ± *106* 0	14 260 ± *102* 0

(figures are slightly approximated)

For clinical purposes it is sufficient to know the mean values of every age level and to observe their change at subsequent ages

Other measurements besides height and weight that are important in the evaluation of physical development are breadth of the shoulders and circumference of the head The following approximate data will be found useful

1 *The shoulder breadth* of well developed children is approximately one fourth of their height in all stages of childhood

2 In the first year of life (Molchanov s data) *the circumference of the head* exceeds that of the chest by 1 to 3 cm, and in the newborn

it is 34 cm (the circumference of the chest is 32) by the age of 3 4 years both dimensions become equal subsequently the circumference of the chest becomes greater than the circumference of the head and the older the child the greater the difference

3 In the first year of life *the circumference of the chest* exceeds the baby s half height by 7 to 10 cm in seven year olds these dimensions are equal and later the chest circumference lags in children aged 12 13 the circumference of the chest is already 2 4 cm less than the half height and upon sexual maturation it again becomes several centimetres longer than the half height

In clinical practice it is highly important to know the dynamics of weight height and other dimensional gains of the body as the de gree of physical development gives some idea of the functional abili ties of the body as a whole and of its separate systems and organs conversely functional disturbances in the organs may lead to devia tions from normal physical development Therefore physical devel opment is often an indication of resistance and adaptability since normal physical development is usually attended by normal functions

Numerous formulas and indices have been proposed for evaluating the physical development of children and their nutritional state There is no need to dwell on them in detail as they are needed only in detailed anthropometric examinations but are of no great clinical value

Measurement of the height of older children is in no way different from the method of measuring the height of adults Ready made measuring boards are usually employed

The measuring board is an upright rack with centimetre gradua tions on it A small horizontal board (in the form of a muff) moves up and down it freely

The subject is placed so that the back of his head shoulder blades and buttocks touch the upright rack The head should be held so that the tragus of the ear and the outer corner of the eye are on a horizon tal level The horizontal board should fit closely to the head but not press on it It goes without saying that the child should be in his bare feet The measuring board may be replaced by any upright plane—a wall door etc A book or try square is substituted for the horizontal board Heights must always be measured in one and the same manner and the head must always be held in one and the same position

The crown heel length (the height) of infants is measured by means of a special horizontal measuring device a plank with two try squares for measuring the distance between the crown of the head and the soles of the feet The baby is placed on his back on this plank and the head try square is fixed touching the crown of the head the baby s legs are straightened out and pressed flat against the plank while the feet are flexed at right angles to the plank and the other try-square is pressed to the soles The distance between the two squares is the baby's length It is very easy to construct such a device, making the head piece stationary, while the foot piece moves on runners, a tape measure or a ruler is attached to the horizontal plank

Any system of scales is suitable for *weighing infants*, provided the baby can be placed on them in a recumbent position, and that their precision is 5 10 g Comparable results are obtained by weighing the baby in identical conditions If the weight of the baby's clothing is known, and is then subtracted from the total weight the baby need not be undressed for weighing Babies are weighed on a hungry stomach after they have passed water and had a bowel movement (either spontaneously or induced by an enema) A preliminary precaution is checking the accuracy of the scales

Older children are weighed on the scales used for adults

GROWTH AND DEVELOPMENT

The intensity of growth depends on a number of circumstances a great part of which are endogenous

The conditions surrounding prospective mothers affect the future development of the child Exogenous influences acting at this time may be the cause of changes in the fetus

Defects occurring in the sex cells of the parents prior to fertilization (in the phase of progenesis) may be reflected unfavourably in the entire process of gestation and postnatal development When the embryo is injured during the very earliest stages of its development, before the differentiation of the organs (in the stage of blastogenesis), we speak of blastophthoria (from the Greek words *blastos* meaning a germ, bud, shoot branch, and *phtheiro*, meaning to corrupt, to destroy) Finally, if the injury to the fetus occurs at a later stage of differentiation (over three months of gestation), after the organogenetic process (formation of the organs) has begun, the injury may be termed embryophthoria

The influence of exogenous factors on the development of the child is extremely variegated both in the matter of diffusion and of extent of the various resultant injuries, depending on the time of their action injuries sustained in the progenetic and blastogenetic stages result in a greater diffusion of the anomalies, injuries sustained during organogenesis are less diffused, frequently involving only one organ

Environment and living conditions have a telling effect on the child's development in postnatal life

Unfavourable conditions *after birth* are the cause of various diseases that result either in systemic dystrophy or in involvement of certain organs, the latter circumstance, in its turn, also affects the body as a whole

Thus we see that normal pregnancy hygienic regimen of the expectant mother timely obstetric aid adequate quantitative nutrition and proper care of the child are a guarantee of his normal development

However it would be wrong to consider the influence of exogenous and endogenous factors of development separately in isolation from one another A certain environmental factor may produce stable changes in the body that subsequently become an endogenous factor in its development For instance a brain injury occurring during delivery is purely exogenous in origin but it becomes an endogenous factor in the subsequent development of the child

After these general remarks we shall now discuss some of the particular moments that affect growth

Usually *increase of stature and of weight is not uniform* throughout the year at least in the preschool and school age periods and in perfectly healthy children at that The data reported by various authors show height and weight gains to be approximately equal during the winter months (November March) from March to August i e in the spring and summer height increases more rapidly while weight gains are smaller or may even cease altogether the highest weight gains occur in the August November period while increases in stature are much slower at this time The cause of such *seasonal oscillations in weight and height increases* is still not quite clear An important part is evidently played by diet as well as by the daily routine which changes in the various seasons of the year (duration of outdoor activities and degree of insolation)

Does *the prospective mother s nutrition* affect the development of her child? It is considered that this influence is not great and that during its intrauterine existence the future baby obtains everything it needs from the maternal organism However postmortems of newborn infants whose mothers nutrition was absolutely insufficient (severe and prolonged hunger) have shown that although the weight of these infants was within normal limits there were acute microscopic changes in the cartilaginous tissues and the endocrines particularly in the thymus gland which was found to be atrophied

Maternal diseases may be reflected in the development of the fetus It has been proved that rubella (German measles) infection in the first 3 4 months of pregnancy (and other virus infections as well but less frequently) leads to congenital heart defects in the child as well as to such congenital deformities as harelip cleft palate syndactyly spina bifida etc Similar results are most probably induced by various maternal intoxications in the first months of pregnancy

Postnatal environmental conditions also affect the child s development The development of bottle fed babies is usually inferior to that of breast fed babies It is not only weight and height gains that suffer but also the functional abilities of the body and its separate organs as well as the adaptability of the system to environmental alterations and its resistance to various harmful influences

Poor living conditions (crowded quarters, insufficient fresh air and light, poor care of the skin, etc.) usually lead to retardation in stature and weight. The prolonged intake of monotonous foods, as well as of foods which are deficient in the necessary nutritive ingredients (salts, vitamins, full value proteins), also has a great effect on the child's development. Animal experiments have shown that protracted nutrition of animals with food of inferior quality (chiefly as regards the protein component) induce stable irreversible changes in the body that do not clear up even when the animal is transferred to nutrition of full dietary value.

Proper development of the entire system and its separate organs requires a ratio of work and recreation suitable to age level features, and nutrition adequate both in quality and quantity. It should be remembered that even the most interesting and attractive games and other activities may overexhaust the child.

According to certain authors premature infants with birth weights of approximately 1 500 g sometimes manifest a noticeable lag in both growth and weight for quite a long time—the greater the degree of prematurity the longer the period of backwardness. However, investigations carried out by the staff of the Pediatric Institute of the USSR Academy of Medical Sciences have proved that with sufficient nutrition and proper care even infants born long before term soon catch up with their coevals and subsequently do not differ from them. Even infants weighing less than 1,000 g survive and remain healthy.

Certain diseases, particularly congenital or acquired in early childhood, inhibit the growth and general development of the child, thus children with congenital or early developing heart disease, and with congenital or early acquired brain lesions usually lag behind their peers in both stature and weight.

Stable changes in the central nervous system undoubtedly affect the development of the functional abilities of the body, inhibiting the development of either one certain function or of various functions of the given organ, or else (this occurs most frequently) causing general psychomotor backwardness depending on the location of the brain lesion.

There is a widespread opinion that tuberculosis in childhood inhibits the patient's growth. This is not always so. Thus Y. Dombrovskaya, observing the development of children of tuberculous mothers in the consultation centre of the Pediatric Clinic of the First Medical Institute in Moscow found that 66 per cent of these children weighed above normal at birth, 20 per cent had normal weights and only 14 per cent weighed less than normal. The subsequent development of these children varied: some of them showed weight lags during the first year of life, others developed quite well and even weighed above normal. D. Lebedev observed child inmates of a number of forest schools and found that tuberculosis was accompanied by a tendency to inhibition of growth in breadth, while growth in length was unchanged, or frequently even accelerated—the asthenic type. However, it must be remembered that the formation of the asthenic physical type is typical not only of tuberculosis (chronic tuberculous intoxication), but also of other chronic and frequently recurring inflammatory processes, it is mostly observed in connection with chronic tonsillitis and adenoiditis, and also in cases of bronchiectasis which may induce the appearance of a similar pattern of chronic, but not tuberculous, intoxication

Together with the nervous system an important part in the normal physical and mental development of the child is played by the endocrines (the neurohumoral factor)

CHAPTER VIII

THE ENDOCRINE SYSTEM

Prof *D Lebedev*

Actually, it is not right to isolate the endocrine system into a separate chapter, since its functions in the body are closely correlated with the electrolyte constituents of the blood and the activity of the central and particularly the autonomic nervous systems, all these systems influence each other reciprocally, and they are functionally integral We shall not dwell here on the general endocrine system, nor on the general aspects of its correlations with the nervous system and the blood constituents, or the mutual effect of these systems on each other, we shall restrict ourselves to a brief exposition of their most salient features in childhood physiology and pathology

Our knowledge of the endocrine system in childhood is still far from complete As in adults the role of the endocrines is quite variegated in children it is associated with immunity (the adrenals) and with the reactivity of the central and peripheral nervous systems (the thyroid and sex glands) *the endocrine glands are especially important in children as regulators of metabolism, growth, and development*

However, the part they play in this respect is that of a subordinate functional organ The functions of the endocrine system are controlled by impulses arising in the nervous system All endocrine organs possess corresponding conducting nerves, while the centres are evidently situated prevalently in the centres of the diencephalon (between-brain) and the sympathetic nervous system, and the latter are in their turn subject to the regulating influence of the cerebral cortex

True, the nervous system is also affected by the activity of the endocrines The activities of these two metabolic regulators are interdependent and reciprocally regulated Many authors use the term 'neuroendocrine" or 'neurohumoral' system, thus stressing the exceptionally intimate and complex interrelations of these two systems

During the earliest period of intrauterine development the maternal hormones influence the growth of the embryo to a certain extent, but this growth is predominantly due to the energy of growth inherent in embryonic tissue In the later phases of prenatal life when the fetus already possesses its own endocrine glands the role of the latter is evidently limited, since the fetus receives hormones from the maternal organism Some authors hold that during the final months of intrauterine life an accumulation of hormones takes place in the fetus, analogous to the reserve of salts and vitamins on which the newborn exists in the first months of postnatal life These substances are also supplied with the mother's milk However that may be, in cases of congenital hypoplasia of any endocrine organ, the thyroid for instance, the first signs of its deficient function (congenital myxedema) appear only in the third or fourth month of life

Anatomic studies have shown the possibility of functional activity of the adrenal cortex, the thymus and the pituitary during the prenatal period During the first six months of postnatal life a great effect on the growth of the baby is evidently produced by the thymus while the role of the adrenals decreases in comparison with the prenatal period The function of the thyroid is intensified at approximately 5 6 months of age and the leading role of this gland is retained up to the time the baby is 2 2$^1/_2$ years old, at about 6 7 years the effect of the anterior lobe of the pituitary becomes noticeable During the prepubertal period the functional activity of the thyroid and pituitary glands intensifies but the leading role is played (particularly at puberty) by the sex glands as sexual maturation progresses these glands affect the functions of the organisms as a whole

The role of the endocrine glands as growth factors and of the closely associated autonomic nervous system in various periods of life has still to be clarified It should be borne in mind that the prevalence of any of the glands may only be assumed conditionally, since functional changes in any gland always lead to changes in the activity of all the other glands, owing to the close interrelations of the endocrines

We shall now turn to the morphological features, developmental dynamics and symptomatology of the diseases of certain of the endocrine glands in childhood

The microscopic structure of the thyroid gland of the newborn differs quite noticeably from that of adults The follicles are still unformed and a considerable part of the tissue consists of accumulations of epithelial cells divided into tobules by thin layers of connective tissue In some sites mature follicles and also small ones, just commencing their formation, may be discerned In general the picture resembles that of parenchymatous (hyperplastic) goiter and is evidence of the immaturity of the structure of the gland The follicular epithelium is higher than in subsequent periods of life, and there is a very little amount of faintly staining colloidal substance

The thyroid gland plays approximately the same role in the child as it does in the adult It is a powerful regulator of basal metabolism and of excitability of the central nervous system, particularly of the cerebral cortex The thyroid intensifies the function of the medullary layer of the adrenals and the tonicity of the sympathetic section of the autonomic nervous system Particular stress must be laid on the influence of the thyroid in childhood on nutrition of the skin, hair, and bones Deficient thyroid activity inhibits development of cartilage, thus suppressing the growth of the long bones

Without going into all the details of functional thyroid deficiency (athyreosis, hypothyroidism, myxedema) we shall only point out that this condition is characterized by backward mental and motor development, constipation, dryness and puffiness of the skin, increased sensitivity to cold, low basal metabolic rate, stunted growth Increased functional activity of the thyroid gland (hyperthyroidism, thyrotoxicosis Basedow's disease) is displayed by heightened reactivity, nervous excitability, tachycardia, excessive perspiration, involuntary tremor high basal metabolic rate, exophthalmos, tendency to diarrhea, enlargement of the thyroid gland (goiter), subfebrile temperature and wide palpebral fissure accompanied by Graefe's sign

Examination of the thyroid gland of children is conducted as for adults, the only difference is that in infancy, when the neck is very short while the subcutaneous tissues are more developed than in adults, only considerable enlargement of the thyroid gland may be discerned Palpation also shows either complete absence of the gland or its considerable reduction In these cases the trachea is felt with such ease that it is almost possible to count the cartilaginous rings it consists of An understanding of the function of the thyroid may be gained by investigation of basal metabolism which is increased in cases of hyperfunction and decreased in cases of hypofunction * Basal metabolism is explained in Chapter XXI

Another sign of thyroid hypofunction in childhood worth mentioning here is inhibition of the processes of ossification—the late appearance of ossification nuclei in the fine bones of the hands and feet Other symptoms of hypo and hyperthyroidism are the same as in adults

Adequate thyroid activity is already observable in a baby of 5 6 months By the age of two years the gland already functions quite clearly, since basal metabolism attains its peak at this time Enlargement of the thyroid may frequently be observed in the prepubertal and pubertal periods, particularly in girls and in the majority of cases there are no attendant symptoms of hyperfunction

It must be borne in mind that not every enlargement of the thyroid gland is accompanied by intensification of its activity

The relative weight of *the adrenals* of the fetus and of the newborn is much higher than in adults However, notwithstanding their weight the adrenals are still underdeveloped

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* Oscillation of the basal metabolic rate within a range of 10 per cent either way is considered normal An increase of more than 15 per cent is a sign of hyperthyroidism a decrease of no less than 15 20 per cent is a sign of hypothyroidism if there are no other contributive factors

During the first year of postnatal life a reconstruction of the internal layers of the cortical substance of the adrenals takes place, these layers are gradually replaced by medullary tissue which was very weakly expressed in the first days of the infant s life The process of adrenal reconstruction is completed when the child is approximately two years old The importance of these processes of adrenal differentiation has yet to be clarified

Functional disturbance of the adrenal medulla (the chromaffin substance) leads to a decrease of the secretion of epinephrine (adrenalin), and, consequently, to a decrease of arterial pressure Such a condition is frequently concomitant with the toxic form of diphtheria, owing to infection of the adrenal medulla with the diphtheria toxin

The functions of the adrenal cortex are not completely clear It has been proved to produce a number of hormones At present it is known that the adrenal cortex is associated with fluid and electrolyte metabolism Excessive secretion of the adrenal cortical hormone leads to retention of sodium and water and to intensification of potassium elimination The hormones of the adrenal cortex also affect carbohydrate and protein metabolism Preparations derived from these hormones (corticosteroids)—cortisone, prednisone and others—possess an anti inflammatory desensitizing action and increase resistance to various toxic effects, including bacterial toxins The adrenal cortical hormone is particularly important in combating the intoxication caused by toxic diphtheria Its content in the blood is evidently decreased in such cases, as may be concluded from the favourable therapeutic effect obtained by administration of corticosterone (together with vitamin C—ascorbic acid) in cases of toxic diphtheria, as well as from the histological changes observed during post mortem examinations of the adrenal cortex of children who have succumbed to toxic diphtheria, and in corresponding animal experiments (V Molchanov et al)

Hyperfunction of the adrenal cortex (adenoma, adenocarcinoma) leads to the development of an adrenogenital syndrome, formerly termed 'hirsutism" (see Chapter IX)

A pathological state concomitant with adrenal hypofunction is addisonism, a syndrome, manifested by adynamia (loss of strength) and bronzing of the skin, this condition is most frequently observed in tuberculosis of the adrenal cortex

Bilateral adrenal hemorrhages may be the cause of rapid death of the newborn (following pathological delivery) and of older children in cases of sepsis

The thymus gland It has been established beyond doubt that *the thymus attains its maximum weight by the period of sexual maturation, after which the weight decreases*

The growth of the thymus does not coincide with the general growth of the body its highest relative weight is observed at birth, while its subsequent growth lags behind the growth of the entire body

The physiological nature of the thymus gland is still not fully understood However, it was found that when tadpoles were fed with thymus gland they turned into gigantic creatures, but their metamorphosis into adult state was retarded Clinical observations provide grounds for assuming that the thymus acts as an inhibitor of the sex glands Reduction of the thymus gland during life has not been demonstrated since there are as yet no reliable methods for its investigation

Hypertrophy of the thymus gland is detected by increased dullness in the area of the left rim of the sternal manubrium, and likewise by x ray In some cases thymus hypertrophy is combined with concomitant hyperplasia of other lymphoid structures (the lymph nodes, spleen, solitary follicles of the intestine root of the tongue and the lymphatic ring surrounding the pharynx), and with inhibition of sexual development, the so called *status thymicolymphaticus* Such children are usually very stout, flabby and anemic, with hypoplastic genitals, and what is particularly important from the clinical viewpoint is that they sometimes die without any visible cause after administration of a narcotic or performance of some minor operation, the resistance of such children is lowered, hence increased morbidity and mortality owing to acute infections It is not infrequent for this anomaly to be combined with hypoplasia of the adrenal system

However that may be, the problem of status thymicolymphaticus still awaits its final solution

The pituitary gland (the hypophysis cerebri) is already sufficiently developed at birth Some characteristic age-level features of this gland are an abundance of chromophilous, particularly acidophilous (eosinophilous), cells in the anterior lobe in early childhood

The intermediate and posterior lobes of the pituitary have been recognized to secrete a number of hormones, a hormone that increases arterial pressure, a hormone that inhibits sexual development, and a hormone that effects protein and fat metabolism The hormones that have been isolated from the anterior lobe of the pituitary are the growth hormone, the gonadotrophic hormone (intensifying sex gland activity), and the adrenocorticotrophic hormone stimulating the adrenal cortex (ACTH) All these hormones act indirectly through metabolic centres in the diencephalon, and also to some extent by their inhibitory or activating effect on other glands The ties between the pituitary gland and the centres of the thalamus (diencephalon) are so close that many authors unite their functions and speak of the hypothalamic pituitary system and of hypothalamic pituitary syndromes (e g , diabetes insipidus)

Hyperfunction of the intermediate lobe of the pituitary, and to a certain extent of the posterior lobe as well (and, according to a number of authors, anterior lobe hypofunction), leads to adiposogenital dystrophy Some authors hold that hypofunction of the anterior lobe of the pituitary gland is the cause of Simmonds' disease (hypopituitary cachexia)—a progressive wastening of the body owing to metabolic disturbance Pathological conditions of the pituitary gland may be associated with its complete dysfunction, or with a partial disturbance of one or another of its functions It should be remembered that diseases of the diencephalon may induce symptoms characteristic of pituitary disease Pituitary lesion in childhood is accompanied by clinical findings other than observed in similar afflictions in adults Thus, various processes leading to hypofunction of the anterior lobe result in the development of hypophyseal nanism (pituitary dwarfism) in childhood

Hypertrophy and increased function of the anterior lobe of the pituitary in childhood does not usually lead to acromegaly, as in adults, but to a general increase of growth and weight—hypophyseal gigantism (see Chapter IX)

Of course, no direct examination of the pituitary gland is possible during life, its lesions may only be estimated by clinical findings The dimensions of the pituitary are judged by x ray pictures of the base of the brain showing the sella turcica in the depression in which the pituitary is situated When examining such x ray pictures there are certain points that must be remembered Firstly the dimensions of the sella turcica are subject to significant individual oscillations, and, secondly, age peculiarities must be taken into account—insufficient replacement of cartilage by bone makes it seem wider

The sex glands play a comparatively slight role in early childhood It is only in the period of sexual maturation that they come to the fore Besides the production of reproductive cells the sex glands also affect growth they accelerate the closure of the epiphyseal lines and thus arrest growth The sex glands increase basal metabolism stimulate muscular growth (in boys) accelerate growth of the larynx (change of voice during puberty), increase central nervous system tonicity and arterial pressure The appearance of the secondary sex characters is also connected with the activity of the sex glands development of the breasts in females, growth of the beard in males growth of pubic and axillary hair in both sexes

Interconnections with other endocrine organs are the same as in adults

An age characteristic connected with the function of the sex glands is the frequently observed *painful* enlargement of the mammary glands at the onset of sexual maturation This phenomenon is a perfectly normal one and it may also occasionally be observed in boys at puberty

Hypogonadism (retarded sexual maturation) induces a condition called eunuchoidism—increased height and span with disproportionately long extremities and absence or weak development of the secondary sex characters, accompanied by normal mental development

Precocious puberty is characterized by early functioning of the sex glands and early appearance of the secondary sex characters, and also by intensified growth and its early cessation, as a result such an individual is tall as a child and short as an adult

Enlargement of the mammary glands and secretion of colostrum in the newborn, as well as the occasionally observed discharge of blood from the vagina are due to the effect produced by the maternal sex hormones

The parathyroids (epithelial bodies) The most important anatomic feature of these glands is that in the first year of life they are devoid of oxyphilous cells the presence of the latter becomes pronounced at puberty The interstitial tissue of the parathyroids is developed very slightly The part these glands play in childhood is chiefly participation in calcium metabolism Parathyroid hypofunction leads to a fall of the calcium level, and hence to increased excitability of the nervous system Consequently, parathyroid hypofunction may be one of the causes of *spasmophilia* *

The physiological role of *the pineal body (epiphysis cerebri)* has still to be clarified There have been reports on premature development of the genitals, or precocious puberty owing to pineal hypofunction Hyperfunction may evidently cause retardation of sexual development and obesity However all this has still to be proved

The only thing to be said at this time concerning *the insulinoid apparatus* of children (the pancreas) is that it is morphologically developed already at birth and that it functions sufficiently

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* The function of the parathyroids may be evaluated by determining the calcium level in the blood (the normal level in a nursing baby is 10 11 mg per cent), and also on the basis of symptoms characteristic of latent spasmophilia—Chvostek s sign Erb s sign Trousseau s sign

CHAPTER IX

DISTURBANCES OF GROWTH AND DEVELOPMENT

Prof D Lebedev

In children disturbances of growth, i e, of the enlargement of the body, and of development, i e, of differentiation of the tissues and organs and the development of their functions, are usually concurrent Isolated statural disturbance without any disturbance of the process of development (e g, nanism), or isolated disturbance of development (e g, of speech ability) are comparatively rare We shall not dwell at present on the functional development of various organs or on the development of various powers and functions of the central nervous system

Several classifications have been proposed for disturbances of growth and development We consider that the classification proposed by V Molchanov is most suitable for clinicians

GROWTH DISTURBANCES CLASSIFICATION

In V Molchanov's monograph *Disturbances of Growth and Development in Children* the following classification of growth anomalies is proposed

I *Nanism and subnanism* (dwarfish stature)

A Disproportionate, i e, associated with more or less marked changes in the proportions of the entire body and its separate parts

(1) Chondrodystrophia
(2) Congenital bone fragility
(3) Rickets

B Proportionate, i e, with no noticeable disproportions of the body

(1) Primordial nanism—the miniature type

(2) Hypoplastic nanism
(3) Endocrine nanism
   (a) thyreogenic,
   (b) pituitary
(4) Dystrophic nanism
(5) Mixed and obscure forms
II *Gigantism and subgigantism*
A General gigantism
(1) Proportionate
(2) Disproportionate
   (a) pituitary or acromegalic,
   (b) hypogenital, or eunuchoid
B Partial gigantism

The causes of anomalies of stature and of development may be various In some cases there is a purely congenital anomaly caused by deficient primary formation of the organs—primordial nanism In other cases disturbances of growth and development are due to the influence of altered trophic impulses arising in the nervous system or the endocrines as, for instance, cerebral, endocrine, dystrophic, or other types of nanism Sometimes the cause of the disturbance may be an injury sustained by the growing organism owing to various changes in the surroundings deficient nutrition, severe diseases and toxicoses during prenatal and postnatal life (hypoplastic nanism)

Finally, the deformity may be due to mechanical factors Thus, many authors hold the amniotic band to be responsible for the congenital absence of the extremities or any of their segments

Nomenclature Prior to discussing the separate types of stature and developmental anomalies a few words must be said about terminology.

What deviations from average norms may be termed as gigantism, subgigantism nanism, or subnanism? There is no consensus of opinion concerning these conditions in adults It has been assumed that individuals whose stature is shorter than 120 cm are dwarfs, people taller than 190 cm are giants Naturally, these limits are only relative Their definition in children is more difficult, and such limits have actually not been established

All the varieties of pathologically short stature may be defined by one word—microsomia (from the Greek *micros*—small, and *soma*—body), meaning short stature, the greatest deviation is observed in dwarfs—nanosomia or nanism (*nanos* in Greek means dwarf), the deviations ranging between dwarfism and normal stature are called *subnanism* Extreme tallness is called gigantism, statures intermediate between normal height and gigantism are termed *subgigantism* We shall discuss some details of only certain disturbances of growth and development in children

Disproportionate nanism *Chondrodystrophia** The chief characteristic of this disease is that, as a result of suppression of bone growth the formation of bone from cartilage is defective, growth in length is inhibited while growth in breadth is little affected, owing to a relatively slight disturbance of the process of periosteal ossification

The clinical symptoms of chondrodystrophia are first of all shortness of the extremities (Fig 11) In typical cases the proximal sections of the extremities are shortened more than the distal sections

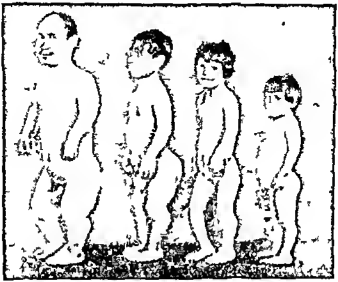


Fig 11 Chondrodystrophic family

the hand of these patients has a quite characteristic appearance—square with seemingly chopped off digits of equal length The head usually quite large frequently has prominent frontal and sincipital tubercles and the nose is saddle bridged In the lateral aspect the spinal column is devoid of normal curves in the thoracic and upper lumbar sections while it exhibits pronounced lordosis in the lower lumbar section hence the spine is board like Chondrodystrophia is frequently diagnosed as rickets owing to insufficient knowledge of

* From the Greek words *chondron* meaning cartilage *dys* a prefix meaning change for the worse and *trophia* (Latinized *trophe*)—nutrition Thus the term may be interpreted as disturbance of the nutrition of the cartilage

this anomaly by physicians, however, neither pathogenesis nor the anatomic changes in bone and cartilage, as well as clinical findings in chondrodystrophia, possess anything in common with rickets, as may be established by attentive examination of the child

In the overwhelming majority of cases chondrodystrophia is *a congenital disease*, in most cases death occurs before birth or soon after Survivals usually show no noticeable deviations from normal besides anomalies of stature and associated secondary changes

The etiology of chondrodystrophia is still not quite clear The familiar nature of the disease has been noted It has been assumed that chondrodystrophia is associated only with cartilage deficiencies This is not quite true, histological changes have been observed in the bone and muscular tissues, and it is not infrequent for various visceral lesions and other deformities to be present (particularly in extremely pronounced cases terminating lethally)

Congenital fragility of the bones (osteogenesis imperfecta or osteo psathyrosis The first term means imperfect bone formation, the second is derived from the Greek words *osteon* [bone] and *psathyrosis* [crum bling]) In this stature anomaly growth of the cartilage is normal, but the endosteal and periosteal processes of ossification are greatly disrupted, the production of bone tissue by the osteoblasts of the periosteum and endosteum is deficient, and the texture of the tissue so produced is not normal As a result the growth of the extremity in length is not affected, but its growth in breadth suffers and the shafts of the long bones (the diaphyses) are very thin At the same time the bone tissue is extremely fragile and possesses tendency for fractures As in chondrodystrophia, the extremities are shortened, but this shortening is of a secondary nature the result of the defective healing of fractures (Fig 12) The disease affects not only the bone tissue, it is a systemic disorder of the entire connective tissue Thus, owing to weak development of the scleral connective tissue the sclerae remain blue in older children, since the pigment of the vascular sheath of the eyeball is visible through the thin sclerae

Osteogenesis imperfecta is a disease of unknown *etiology* It develops prenatally, and the affected infants are born with multiple fractures Subsequently, if they survive, the slightest injury causes fracture

Notwithstanding some superficial similarity to rickets, the origin and anatomic pattern of bone fragility have *nothing in common with rickets* No specific treatment has to date been evolved

Rickets Fargone protracted rickets may result in retardation of growth However, most children who have had rickets in babyhood or early childhood usually differ little from their healthy peers by the time they start school But severe forms of rickets cause deformities and curvatures of various parts of the skeletal frame (the spinal column, the extremities), and as a result stature is much below normal

Fig 12 Osteogenes s imperfecta in 6 year old child

Proportionate nanism 1 *Primordial nanism—the miniature type* This form includes children born into low stature families They are delivered at term and do not differ from other children aside from their bodily dimensions

2 Ch ldren afflicted by *hypoplastic nanism* do not differ exter nally from the preceding group They are fully proportionate al though of low stature their birth length and weight are below normal and their subsequent heights and weights are also retarded in com parison with other children of the same age However in distinction from the preceding group *this stature anomaly is not congenital* Such children exhibit besides retardation of stature also late develop ment of motor and static functions of puberty development and of mentality Moreover their entire system presents a general develop mental insufficiency frequent deficiencies of the alimentary tract are observed also susceptibility to respiratory lesions and low re sistance to infectious diseases tuberculosis in particular The etiol ogy of the condition is not quite clear but blastular trauma may be suspected (injury in an early stage of embryonic development) In some cases when the retardation in stature and development levels out with time unfavourable environmental conditions were most

probably the contributive factors (deficient nutrition maternal disease etc)

3 *Endocrine nanism* Although many endocrine glands affect growth (the thymus pituitary thyroid sex glands etc) a more or less definite clinical characteristic is obtainable for only two forms of endocrine nanism thyreogenic and pituitary (hypophyseal)

(a) *Thyreogenic nanism (congenital myxedema)* The condition develops as a result of the absence (athyreosis) or deficient development of the thyroid gland (Fig 13) The clinical aspect of typical

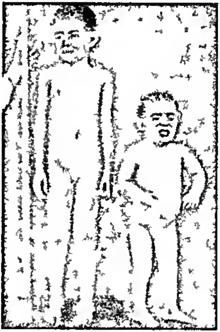


Fig 13 Right 7 year old child with thyreogenic nanism and myxedema Left normal child of same age

congenital myxedema is well known A point that must be borne in mind is that beginning doctors frequently diagnose myxedema as rickets since both diseases have several signs and symptoms in common protruding abdomen late eruption of teeth late closure of the fontanelles However a more thoughtful examination will easily bring to light symptoms not observed in rickets but characteristic of myxedema scaly skin absence of perspiration a thickening of the soft tissues (the term myxedema originates in the Greek *myxa*—mucus and *oidema*—swelling) that differs from ordinary edema by its jelly like consistency a large tongue pronounced mental retardation coarse sparse bristly hair a thick low voice subnormal temperature slow pulse constipation

Greater difficulty is encountered in diagnosing growth disturbances caused by thyroid hypofunction alone—*hypothyreosis* the stature of such children is below average, their skin is dry and cold to the touch, they exhibit tendencies to cyanosis and to constipation, their physical and mental development is retarded, they are sluggish, dull witted, devoid of initiative touchy, stubborn, and display a primitive reaction to their surroundings

In addition to congenital athyreoses and hypothyroidism, *acquired myxedema* is occasionally encountered This condition develops at a more advanced age owing to lesion of the thyroid gland following some infection Prognosis for these cases of extrauterine diseases of the thyroid gland is more favourable, and treatment with thyroid preparations is more effective Systematic ingestion of thyroid preparations renders the patient indistinguishable from healthy individuals particularly in the mental sphere Congenital myxedema presents lesser possibilities for *complete* elimination of all pathological features The most vivid symptom of overall inferiority of the organism is athyreosis Even systematic ingestion of thyroid preparations throughout life merely eliminates the severest symptoms of athyreosis acute intellectual inferiority and mental retardation of patients with congenital myxedema do not usually respond to thyroid treatment.

(b) *Pituitary (hypophyseal) nanism* Clinical findings short stature (even dwarfism), in some cases with infantile bodily proportions (short legs) more frequently the proportions corresponding to age level but the head is slightly enlarged The process of osteogenesis is retarded genital hypoplasia and delayed appearance or complete absence of secondary sex characters are observed The skin is soft and moist the hair is normal, intelligence and mentality are unaltered Excessive fat deposits are frequently noted in the area of the breasts hips and abdomen Premature wrinkling and creasing of the facial skin (senile appearance)—geroderma (from the Greek *geron*—old man and *derma*—skin) is common This condition is due to deficient function of the anterior lobe of the pituitary caused by its lesion No therapeutic effects are obtained with pituitary or sex gland preparations transplantation of the pituitary gland yields only a temporary effect

A frequently observed condition the pathogenesis of which is indeterminate, is *adiposogenital dystrophy* It is characterized by intensive development of the subcutaneous fat, particularly in the abdominal area, hips and breasts and concurrent hypoplasia of the genitals which is particularly noticeable in boys The disease becomes apparent only after the age of 5 6 years, prevalently at a still older age The physical stature of such children may be various—normal, increased decreased The cause of the anomaly in most cases is evidently pituitary dysfunction or disturbance of the trophic centres in the thalamus

4 *Dystrophic nanism* This term includes forms of short stature when the growth of a child born into a healthy family, and showing no visible deviations in bodily structure, is retarded under the influence of unfavourable exogenic factors (for instance, chronic infections, food of low dietary value over protracted periods, etc)

5 *Obscure and mixed forms* First among these conditions is *mongolism* (Down s disease)

The external aspect of a child afflicted with this disease is *remarkable* from the earliest age high cheekbones, slanting eyes, a narrow palpebral fissure, a small nose with a broad, flat bridge, a brachycephalic head, frequently strabismus, nystagmus, a large tongue, subnormal mentality, hyperflexion of the joints Such children are usually well-nourished, sometimes flabby and apathetic, more frequently their motor activity is intensified, although somewhat monotonous This form is often combined with other congenital developmental irregularities—inborn heart disease, polydactyly, cleft palate, harelip, etc Generally the viability of children with such anomalies of growth is low The majority of them do not live to their seventh birthday If they do survive until school age they are noticeably inferior to their peers and they cannot attend schools for normal children The condition should be known chiefly in order to be able to distinguish it from rickets and myxedema The etiology of mongolism is indeterminate It is probable that the disease is associated with retardation of the development of the brain cells The process involves both the endocrines and the central nervous system Endocrine therapy, particularly treatment with thyroid preparations is ineffective

Into this group may also be included such anomalies of physical growth in which there are indications of lesion of several endocrine glands, and also retardation of growth and development in children with diseases of the central nervous system, diabetes, congenital heart defect, diseases of the kidneys, etc

Gigantism and Subgigantism

Gigantism is encountered less frequently than dwarfish stature, its clinical forms are less variegated and response to therapy is still lower than in nanism

Proportionate gigantism This type (the exact opposite of the miniature type) is observed in individuals healthy in all other respects, and this tall stature is mostly a family characteristic

The form of *disproportionate gigantism* most frequently encountered is *pituitary gigantism*, the direct opposite of pituitary nanism Such children do not usually differ from their peers until the age of ten or twelve years They grow very rapidly in the prepubertal period, this growth is caused by the hyperfunction of the anterior lobe of the pituitary gland The anomaly is frequently combined with acromegalic symptoms, hence it is also called *acromegalic gigantism*

A less frequently observed condition is *hypogenital*, or *eunuchoid gigantism*, or, rather, subgigantism, since giant stature is usually not attained In these patients intensive growth ordinarily occurs in the prepubertal period The external aspect of the child changes gradually, he becomes long legged, since the bones of the legs grow most rapidly The muscles of such children are weakly developed, while the fat tissue is developed in excess, as are in some cases the secondary sex characters as well This anomaly is associated with late closure of the epiphyseal lines No treatment for these two forms of gigantism have yet been evolved

Partial gigantism is the enlargement of some separate part of the body—one leg or arm, or foot or hand, while *in distinction from elephantiasis* or edema this enlargement is due to the growth of both the soft tissues and the bones of the expanding part Occasionally *gigantism of half of the body* is observed, when one half of the body is comparatively larger than the other Several theories exist concerning *the genesis* of partial gigantism The most acceptable is the neurotrophic theory, according to which the anomaly is caused by disorders in corresponding sections of the autonomic nervous system (V Molchanov) Treatment is surgical (orthopedic)

DEVELOPMENTAL PATHOLOGY

General development of an individual may in some cases be *retarded*, and in other proceed at an *above average rate*, occasionally a selective deviation is noticed in the development of some discrete function—*discordance of development* Temporary retardation of the development of one or another function is frequently encountered in children in association with some severe disease sustained during the period of formation of the corresponding function Thus, the child may occasionally stop walking for a time, and forget how to talk if at the end of the first year of life or the beginning of the second he contracts pneumonia or a severe digestive disorder It must be borne in mind that a child raised in abnormal conditions (deficient upbringing and care) may show developmental retardation in the absence of any disease An overall more or less uniform and protracted retardation in the development of the entire body (stature mentality sexual maturation) is termed *infantilism* Infantilism falls into (1) congenital infantilism caused by injury to the embryo in early stages of its development, and (2) acquired infantilism following disease in early childhood (syphilis, tuberculosis)

An anomaly which is the reverse of infantilism is *precocity, early development*

Several varieties of precocity are recognized they differ from each other both in clinical findings and origin Sometimes early puberty is observed in infancy or early childhood, concomitant with intensive physical and mental development For this type of precocity, with its premature harmonious uniform development the old term, *pubertas praecox*, or *precocious puberty*, seems most suitable

Unilateral discordant precocious development is more frequent In some cases this condition is manifested only in the mental sphere These are the infant prodigies who, while remaining in their age level as concerns physical and sexual development, manifest unusual talents for mathematics, music etc This form of precocity may be termed *praecositas mentalis*, *precocious mentality* Its origin is still unclear In other cases the precocity is observed only in the somatic and sex spheres, while the psychic and emotional powers remain normal, or may even be retarded This anomaly is termed *macrogenitosomia praecox* in Latin

Pubertas praecox and macrogenitosomia praecox are first of all the result of gonadal tumours less frequently of pineal tumours, and in rare instances of lesions of the central nervous system and vegetative centres (hydrocephalus brain tumours)

Hirsutism (from the Latin word *hirsutus*—shaggy, hairy) is the former term for what is now called *the adrenogenital syndrome*, a peculiar form of disproportionate precocious development

This pathology is mostly observed in girls Rapid general growth commences at an age between two and twelve years, a characteristic feature is that the external genitalia show some similarity to the male organs owing to hypertrophy of the clitoris, an intensive growth of hair on the face is noted (beard and whiskers), and general hairiness of the entire body, the voice deepens becomes masculine, arterial pressure increases The development of the internal sex glands corresponds to the patient's true age, or may even be hypoplastic, menstruation is absent Mental development is normal The most frequent postmortem finding is adenoma or adenocarcinoma of *the adrenal cortex* Following timely removal of the tumour all symptoms of the disease disappear The viability of such children is usually low, death follows incidental infections

CHAPTER X

INDIVIDUAL QUALITIES AND CONSTITUTIONAL ANOMALIES

Prof *D Lebedev*

People living in identical conditions show various reactions to changes in these conditions

The cause of this difference lies in the individual traits of the given person, in his constitution (Latin *constitutio* from *constituere*—to fix)

The concept of constitution covers the total individuality of a person, including the cumulative effect of all his more or less constant inherited and acquired qualities and morphological and functional reactions to all environmental factors influencing his physical and emotional development

It must be remembered that not only acquired, but also inherited qualities may undergo significant changes under environmental influence The affirmation that constitution is a biological predestination of the individual is wrong

Ivan Pavlov proposed a division of all the variegated individual qualities of man and animals into several major groups on the basis of specific functional features of the central nervous system

According to the data reported by Pavlov all the variations of central nervous system reactivity may be brought down to the degree of functional abilities, to the power of the basic processes, excitation and inhibition Experimenting on dogs, Pavlov established that the nervous system of dogs of the strong, well balanced type is distinguished by a greater resistance to the effect of exogenous harmfulness and that neurotic states are more easily induced in dogs of the weak unbalanced type Pavlov and his school held that the same thing was true of humans

Although the problem of the significance of types of nervous activity is a very important one, particularly for pediatricians there are regrettably still no generally accepted accessible methods for their determination in man First attempts are being made in this direction

N Krasnogorsky divides children into four types on the basis of the ratio between cortical and subcortical centres

In the first and most superior type which Krasnogorsky has called the central well balanced type the subcortical functions are regulated and kept in balance by a strong cortex In such children the processes of both inhibition and excitation are intensive and conditioned reflexes are quickly established They easily adapt their emotions and instincts to changes in the environment they are capable of controlling their behaviour and of showing self restraint and perseverance These are strong willed children with high work efficiency This type resembles the strong balanced active type of Pavlov s classification

The second is the subcortical type The highly excitable subcortical nervous system is insufficiently controlled by the cortex instincts passions (affects) and emotions prevail over the conduct of such children positive conditioned effects are usually relatively weak in them and their inhibitory functions are also lowered Conditioned reflexes fade slowly (fixed habits) Oscillations in cortical activity are characteristic of such children with uneven moods and temperament who have no sufficient control of their instincts passions and emotions

The third is the cortical type In children of this type the subcortical functions are weakly expressed their excitability is decreased and easily exhausted although the cerebral cortex functions normally These children are dry untemperamental doctrinaires possessing no strong emotions although they may be quite gifted Their unconditional reactions are faint and the conditioned reflexes although easily formed are weakly fixed inhibitory conditioned reflexes are likewise formed easily

The fourth is the anergic or hypodynamic type It includes children with weak cortical and subcortical functions They are distinguished by low excitation of the nervous processes and rapid exhaustibility of these processes The children very soon cease reacting to stimuli as soon as the latter become more intensive and prolonged

The interconnections of the various tissues and organs and their qualitative and quantitative reactions to exogenous and endogenous stimuli are realized either directly through the nervous system or indirectly by the latter through the endocrinohumoral system hence in the final analysis the inherited (constitutional) qualities are due to the specific qualities of the nervous system The transmission of nerve impulses the regulation of the functions of various organs and tissues are conducted only through the nervous system the latter determines the force of the response of various parts of the body to exogenous and endogenous stimuli

Transitory deviations in the reactivity of the organism are not constitutional

It would be erroneous to conceive the inherited qualities of the child as something constant and unchangeable as completely established qualities that predestine the child s reactions to his surroundings throughout life In the process of growth and development of the human being a reconstruction of reactivity frequently occurs under the influence of prevalently exogenous factors

The teachings on individual constitutional qualities and anomalies are highly important in the clinical aspect of children s diseases in so far as these qualities affect the child s development and the course of the diseases he contracts

Inherited and acquired qualities are the cause of the different courses of one and the same disease in different children In a child with exudative diathesis pneumonia is protracted in a child whose nervous system is unbalanced this disease is superimposed by a number of neuropsychopatic symptoms Some oversight in the care of the skin of a child with exudative diathesis results in the appearance of very persistent dermatitis etc

CONSTITUTIONAL ANOMALIES AND DIATHESES

By far not all children react similarly to environmental stimuli some possess a greater resistance to various pathological and physiological irritants in others resistance is much lower stimuli inducing no visible reactions in the majority of children induce an extremely strong reaction in some This pathological reactivity may involve the body as a whole or it may prevail in certain systems or tissues which are thus susceptible to certain pathological processes and reactions Such a condition is termed diathesis

It is wrong to identify the concepts of diathesis and constitutional anomaly The latter is a wider concept which includes not only diathesis but also developmental morphological etc deviations from normal However it is often difficult to delineate strictly between constitutional anomaly and diathesis and therefore these terms have practically come to be synonyms

All forms of diathesis are characterized by periodic manifestations of certain symptoms these symptoms appear and disappear and physicians then speak of a latent or hidden phase of diathesis Under the influence of certain exogenous (and sometimes endogenous too) factors of the most diverse nature the hidden phase may pass into an obvious one

The clinical symptoms of diathesis appear as the result of the interaction of inherited or acquired individual qualities and the effect of exogenous stimuli

We shall now dwell on a number of diatheses of childhood

1 *Exudative diathesis* Its essential characteristic is the intensification of the reactivity of the skin and mucous membranes of the respiratory digestive and urinary tracts in response to the most diverse exogenous and endogenous stimuli The pathogenesis of exudative diathesis evidently comprises several components a definite part is played by inheritance which predetermines a specific pattern of physicochemical and metabolic processes the influence of the child s antenatal environment is a very important factor and still more essential is his postnatal environment An important part is played in this regard by nutrition and sensitization

It is very difficult in practice to establish the nature of the antigen which has caused the sensitization all the more so as in such children a nonspecific heightened reactivity may occasionally be discovered—parallergy Hence desensitization is very rarely employed in practice

The importance of sensitization is evidenced by the frequency of positive allergic skin reactions, the constancy of eosinophilia, and the disappearance of exudative diathesis and of other allergic conditions following dietary changes

Exudative diathesis is encountered very frequently, particularly among children under two years of age

One of the earliest clinical symptoms of exudative diathesis is *seborrhea of the scalp* and *milk scab* Seborrhea sometimes appears when a baby is 2 3 months old It is manifested by excessive activity of the sebaceous glands of the skin, chiefly on the scalp and in the area of the large fontanelle The sebum dries into crusts which reappear after removal Somewhat later the condition termed milk scab is encountered—a circumscribed redness of the cheeks accompanied by a thickening of the epidermis and the formation of tiny scales, eczema may subsequently develop in the area Besides this, patients with exudative diathesis easily develop *intertrigo* and *dermatitis* in the inguinal, perineal, and axillary areas, in the elbow bends, behind the ears, and in the folds of the neck (It must be remembered that dermatitis of this type may also be a symptom of fungal infection) At a later age, usually no earlier than 4 5 months, *strophulus* may develop, this is a form of miliaria which appears as red nodules on the extensor surfaces of the extremities and is accompanied by intensive itching In such children the reactivity of the mucosa of the respiratory passages is also heightened, as manifested by frequent catarrhs (rhinitis, pharyngitis, bronchitis, all of which are very tenacious and tend to relapse) *The digestive tract is likewise easily injured* the slightest irregularities in diet cause dyspepsia Reactivity of all the integuments (skin and mucous membranes) is not always simultaneous or of identical degrees, in some cases dermal symptoms of the nature of exudative diathesis may prevail, in others the respiratory mucosa suffers more, in still others the alimentary mucosa is involved, and finally, in some cases lesions of the urinary tract are observed

Increased reactivity of the skin and mucous membranes is in the majority of cases accompanied by *increased sensitivity of the neuropsychic sphere* The children become restless and irritable They display disorders of autonomic system tonicity the tonus of the vagus prevails over that of the sympathicus *Metabolism, particularly fluid metabolism, is labile, i e, instable,* hence the frequently observed seemingly causeless weight gains and losses

When speaking of exudative diathesis a few words must be said concerning scrofula Formerly scrofula was the term used for symptoms of exudative diathesis and lymphatism and for many symptoms of tuberculosis in childhood At present the term is used by some authors for designating a peculiar clinical pattern of tuberculosis observed in children affected with exudative diathesis

Scrofula involves the skin, mucous membranes, and lymphatics It includes chronic, frequently relapsing blepharitis and conjunctivitis (particularly of the phlyctenular type), persistent, chronic rhinitis with an abundant discharge that irritates the skin of the upper lip, chronic otitis Such children are afflicted by chronic upper respiratory catarrhs, and their submaxillary and cervical lymph nodes are enlarged Certain authours hold scrofuloderma, tuberculosis of the cervical lymph nodes and even tuberculous lesions of the bones to be symptoms of scrofula

Consequently this term covers both common chronic mucosal inflammations (due, most probably, to decreased immunity and also to neglectful care) and manifestations of exudative diathesis due to sensitization caused by various (mostly infectious) allergens as well as symptoms of tuberculosis per se and parallergic mucosal reactions

The theory of "scrofula' and its relations to lymphatism and exudative diathesis still awaits clarification and further development

The so called symptoms of exudative diathesis are only the most noticeable manifestations of the condition which is not restricted to the skin and mucous membranes alone, but involves the entire system

Upon birth an infant with exudative diathesis does not differ from other newborn A family history of irregular metabolism' may subsequently alert the physician to the possibility of exudative diathesis As the child grows signs of exudative diathesis become fainter and less frequent the first symptoms to disappear are seborrhea and milk scab (following the age of 9 12 months they are rare) then intertrigo and eczema become less frequent and only strophulus occasionally persists until the child is 5 or 6 years old (although the frequency of its symptoms becomes lower and lower) However, as the years elapse upper respiratory catarrhs become more frequent and all illnesses are accompanied by a greater involvement of the lymphatics—tonsillitis, pharyngitis, rhinitis and catarrhs of the nose and throat are attended by a greater vulnerability and more powerful reaction of the lymphatics

2 Some authors do not differentiate between *lymphatism* and exudative diathesis, while others consider it possible to single lymphatism out as a separate form since its chief characteristic is not so much ready involvement of the skin and mucosa as the powerful reaction of the lymphatic system, the tendency of the lymphatic structures to react by protracted hypertrophy to slight irritants of an infectious or non infectious nature In such children a pronounced enlargement of the tonsils and follicles in the root of the tongue the posterior wall of the pharynx and larynx, and of the adenoids is frequently noted, the spleen is often enlarged Many investigators note low immunity in such children Other noteworthy symptoms are a tendency to ad-

posity associated with a flabby and edematous (pasty) skin Heart involvement is not rare The muscles are flabby and weakly developed Some authors identify lymphatism with *status thymicolymphaticus*

3 *Neuroarthritism* is characterized by metabolic disorders (gout, obesity, extreme leanness formation of calculi, early arteriosclerosis), associated with various types of idiosyncrasy. At an early age these children manifest a changeable appetite, low resistance to unsuitable food uneven weight gains, unstable temperature, their mentality develops rapidly, but they are very irritable and neurotic The skin symptoms are the same as in exudative diathesis As the child becomes older the neuropsychic symptoms become more definite At the age of three or four years nutritional disorders occur (leanness or adiposity) and autonomic system findings are noted Sometimes the general condition and disposition deteriorates without any visible cause and after some time improvement occurs Purine rich foods intensify all the manifestations of this anomaly

4 Some authors speak of *a neuropathic constitution, of childhood neuropathy* when the neuropsychic reactions are either intensified or weakened We consider it more suitable to classify these conditions as the weak, unstable type of higher nervous activity forwarded by I Pavlov and N Krasnogorsky Such inherited qualities, in conjunction with a badly managed daily routine, high demands of the child's weakened emotional sphere and inadequate, insufficient rest and recreation favour the development of borderline neurotic disorders—phasic states

It must be pointed out that the enumerated forms of anomalies have been set forth rather sketchily and their isolation is somewhat artificial In reality a combination of the features of several types of inherited anomalies are always observed in one and the same child

CHAPTER XI

THE SKIN AND THE SUBCUTANEOUS ADIPOSE TISSUE

Prof V Molchanov

ANATOMY AND PHYSIOLOGY

The Skin

The skin of the child, particularly in the newborn stage and infancy, differs greatly from adult skin both structurally and functionally The details of this difference are not all clear, but the things we do know help us to understand and explain both the frequency of skin conditions in early childhood and some of their specific features

As in adults, the child s skin is divided into the following layers (1) *the epidermis* (scarfskin cuticle) which is in its turn divided into several layers the most important of which are the upper layer the stratum corneum and the lowest or basal layer, otherwise termed the stratum germinativum (2) *the derma or true skin* (corium cutis) which consists of a papillary and reticular layer (stratum papillare and stratum reticulare) under the skin lies the *subcutaneous or hypodermic tissue*

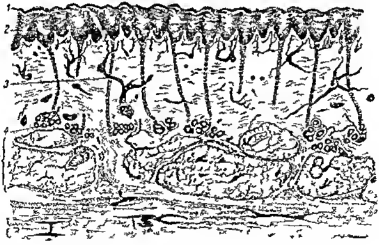


Fig 14 The skin of the newborn
1—epidermis 2—papillae 3—blood vessels 4—sweat glands 5—subcutaneous adipose tissue

In *the newborn* (Fig 14) ***the stratum corneum*** of the epidermis is very thin, it consists of 2 3 layers of keratinized loosely joined cells which are constantly being shed Conversely, the *basal*, or *germinative* layer, is well developed, in this layer an intensive growth of epithelial cells for replacing the sloughed off horny elements occurs *The basal membrane* between the epidermis and derma provides close cohesion between these layers, in adults it consists of closely interwoven connective tissue elastic fibres and protoplasmic projections of the epithelial cells This membrane is underdeveloped in the newborn, it is delicate and spongy owing to the weak development of the connective and elastic tissue, and therefore the cohesion between the epidermis and derma is very frail

The fibroelastic connective tissue in the base of *the derma* is poorly developed, and the same is true of the muscular fibres

Abundant vascularization with a dense network of wide capillaries is a characteristic feature of the skin of the newborn

The function of *the sebaceous glands* is already intensive in antenatal life, and continues so throughout the first postnatal year, sebum is discharged abundantly on the surface of the skin When delivered the newborn infant is covered with a cheesy deposit (vernix caseosa). On the other hand, *the sweat glands* do not function during the first 3 4 months of life, although some of them are already sufficiently developed at term their ducts being closed by epithelial cells The majority of investigators now hold the absence of functional activity of the sweat glands to be due to *the immaturity of the sweat secretion centres in the brain*

The hair on the scalp of the newborn is fully developed

The skin of the trunk particularly of the spine and shoulders, is covered with *lanugo*—fine, downy hair the lanugo is more prominent in premature infants than in full term babies During *the first year of postnatal life* the stratum corneum of the skin, as well as its connective tissue base, grows quite rapidly The prenatal lanuginous growth falls out during the first months after birth, and is replaced by hair that falls out and grows again repeatedly during the first year of life The capillaries retain their width for a protracted period of time, hence the delicate pinkiness of a baby's skin

The skin in other periods of childhood During *the period of sexual maturation*, owing to the autonomic and endocrine reconstruction of the entire system, a rapid growth of hair occurs on the face of boys, and in the axillary and pubic regions of both sexes, other features are increased vasomotor excitability of the skin (rapid change of colour), and intensive functioning of the sebaceous glands leading to plugging of their ducts with subsequent inflammation and suppuration (acne vulgaris)

Function of the skin One of the most important functions of the skin is *protection of the body against harmful mechanical and chemical influences*

In newborn and nursing infants the functional abilities of the skin in this regard are patently insufficient owing to morphological features (poor development of the stratum corneum, abundant capillary network). In comparison with the skin of adults the skin of young children is easily injured and its permeability to infections is higher. The same is true of the action of chemical irritants. Therefore, all manner of ointments containing irritating and easily absorbed substances (turpentine, mercury, etc.) should be avoided in early childhood.

The function of the skin is not restricted to protection against harmful mechanical and chemical agents. The skin is also one of the five organs of sense, it is through the skin that adaptation of the body to its environment is realized. The various environmental stimuli are conducted from the sensitive nerve mechanisms (the exteroceptors) along the nervous pathways (the afferent routes, from the word *affere*—to carry to) to the cerebral cortex, from there corresponding impulses are sent along the efferent conductors (from the word *effere*, to carry away) to the skin. In the newborn the nervous system, particularly the cortex and the brain centres, are immature, and therefore adjustment to environmental changes is poor. Herein lies one of the principal causes of the peculiar reactions of the newborn to environmental stimuli and his insufficient adaptability to environmental conditions.

This insufficiency is especially noticeable in *the thermoregulating function* of the skin. In newborn and nursing infants these functions are underdeveloped. Young children become chilled or overwarmed sooner than older children when the environmental temperature changes.

The skin is also *an organ of respiration*. In adults this function is negligible: their skin absorbs 800 times less oxygen than their lungs do.

In infants the respiratory functions of the skin are more important than in adults owing to the thinness of its stratum corneum and intensive blood circulation.

The skin produces a number of specific substances, such as *vitamins*, for instance. Thus, after exposure to ultraviolet rays vitamin D may be discovered in the skin.

The Subcutaneous Adipose Tissue

The development of *the subcutaneous adipose tissue* commences in the fifth month of antenatal life, by the end of the tenth lunar month the fetus loses its wrinkled appearance. Premature infants are thinner than full term babies, since the process of fat deposition is incomplete in them. In the full term newborn the adipose layer is well developed on the cheeks, hips, legs, and arms and poorly developed on the abdomen. In the period between six months and three years the deposition of adipose tissue is subject to oscillations, this process slows down or even ceases by the time the child is eight years old after which it recommences, it is more intensive in girls than in boys, particularly in the prepuberlal and puberlal periods

Chemical investigations of the subcutaneous adipose tissue of adults has shown it to contain 89 8 parts of oleic acid 8 18 parts of palmitic acid and 2 04 parts of stearic acid per 100 parts of insoluble fatty acids in children this tissue correspondingly contains 65 75 parts of oleic acid, 28 97 parts of palmitic acid, and 3 28 parts of stearic acid

The prevalence in the subcutaneous adipose tissue of solid fatty acids possessing a higher melting point lends this tissue a greater firmness in early childhood, and makes it solidify more readily when the environmental temperature is low. Herein we have a partial explanation of the pathogenesis of sclerema of the newborn (sclerema neonatorum s adiposum) As the child becomes older the subcutaneous adipose tissue becomes more abundant in fluid fatty acids

Clinical Summary

The above anatomical and physiological qualities clarify many of *the clinical features of the skin of newborn and nursing infants*

The skin of the newborn is ruddy owing to its powerful capillary network and delicate stratum corneum (*physiologic hyperemia'* or erythema neonatorum) The constant shedding of cornified cells creates a condition of *physiologic desquamation* while the intensified discharge of sebum is termed *seborrhea* In children particularly when they are susceptible to exudative processes a more or less thick crust is formed on the cheeks the so called *milk crust* (crusta lactea) Plugging of the sebaceous glands results in the appearance of small yellowish vesicles, milia They appear in large numbers on the nose and on the face

One and the same cause induces sharply differentiated clinical symptoms in newborn infants and in adults and older children For instance, staphylococcal infection of the skin produces *impetigo* in adults (superficial pustules with subsequent formation of crusts) In the newborn the same infection may produce large, flabby, rapidly rupturing bullae with cloudy contents, suppuration and the formation of crusts does not occur, since owing to the absence of cohesion between the derma and epidermis the latter is easily shed, baring the derma (the true skin) this condition is termed *pemphigus neonatorum*

A condition known as *dermatitis exfoliativa neonatorum* develops when the bullae are very numerous and a large area of skin is involved the disease is characterized by inflammation of the skin accompanied by a shedding of the epidermis in large or small scales It is not encountered in adults or children of a more advanced age

As has already been pointed out the immaturity of the stratum corneum and abundant vascularization makes *the skin of the newborn highly susceptible to abrasion and bacterial penetration*, particularly bacteria of the coccal group (staphylococci, streptococci) Many authors hold that the skin (and also the mucous membranes) of the newborn are more frequent inlets for an infection than is the umbilical wound, but that the inlet usually remains indeterminate owing to the absence of an inflammatory response at the site of ingress and in the local lymph nodes Taking all this into consideration it is the duty of the pediatrician to impress the mother and the nursing staff with the imperativeness of absolute cleanliness and asepsis in management of the newborn (washing hands before examining the infant, boiling his diapers and clothing, etc)

Excessive vulnerability is characteristic of the skin throughout the entire period of childhood This is partially due to irritation by urine, feces or vomitus Hence the frequency of various forms of dermatitis in the first year of life Indeed, not a single child is exempt from one or another lesion of the skin in the neonatal and infancy periods Such lesions are particularly frequent in the absence of proper care of the skin (diapers changed too rarely sloppy laundering) and also in children with exudative diathesis The physician should always bear in mind the immature heat regulating function of the skin of newborn and nursing infants and ensure that the babies are neither overcooled nor overwarmed

EXAMINATION OF THE SKIN AND SYMPTOMATOLOGY OF THE MOST IMPORTANT SKIN LESIONS

A point to remember is that *the various skin lesions are not isolated diseases of the skin alone* In the overwhelming majority of cases such lesions are only manifestations of general metabolic disturbances (e g, exudative diathesis), or of systemic diseases (various infections) And, conversely, diseases of the skin may affect the entire system Consequently in any skin disease examination must not be restricted to the skin alone, but all the organs and systems must be examined

Examination of the skin is commenced with interrogation after which a physical examination is made

Interrogation is aimed at eliciting certain information on the condition of the skin for instance, when did the condition appear, was itching or perspiration observed or is there any connection between the eruption of the rash and the ingestion of certain foods (eggs etc)

Objective physical examination The examination is conducted by (1) observation (2) palpation, (3) investigation of the fragility of the blood vessels, and (4) vascular reaction to mechanical irritation (dermographia)

Observation In visual observation attention is paid first of all to the colour of the skin Infants normally have a delicately pinkish skin Pathological changes of colour are very diverse, as we shall see below

1 *Pallor* Stable pallor with various tinges (yellowish, greenish) is seen in different forms of anemia and leukoses (leukemia), and occasionally also accompanies tuberculous intoxication and rheumatic fever However, paleness is by far not always a symptom of anemia, it may likewise be noted when the blood values are normal, owing to a spastic condition of the blood vessels or to their depth, and also in cases of renal edema and of edema of other origin (so called *false anemia*) Signs important in diagnosing true anemia are the condition of the conjunctiva of the eyelids and the mucosa of the lips

2 *Redness* 'Physiological erythema' of the newborn has already been mentioned A transient ruddiness of the cheeks is observed in various forms of pneumonia, typhoid, influenza, and other pyrexial diseases red spots of vasomotor origin appear following mechanical irritation of the skin or owing to mental stress and cerebral disorders. Constant redness accompanies burns (including sunburn) and phlegmon In general the child's skin reacts readily to environmental stimuli (baths, mustard plasters, etc) All these points must be clarified by interrogation

3 *Yellowness* Yellowness or icterus of the skin and conjunctiva is a reliable sign of the presence of bile pigments in the blood and tissues (jaundice) The yellow tinge becomes more vivid when the blood supply in tissues is decreased by pressure

As a rule yellowness of the skin is visible only in daylight illumination

Jaundice is encountered very frequently in the newborn, and its termination is favourable, hence the term physiological jaundice However, newborn infants are sometimes affected by a severe form of jaundice, icterus gravis neonatorum (a hemolytic disease of the newborn based on incompatibility of the maternal and infant's blood) In rare instances a severe and protracted jaundice appears which is due to defective development or absence of the biliary ducts This type of jaundice usually terminates lethally within several weeks or months A faint icteric colouring of the skin of the newborn may be a symptom of sepsis In older children jaundice is prevalently a symptom of infectious (epidemic) hepatitis (Botkin s disease) it is much less frequently a sign of cirrhosis, tumours, echinococcosis, or syphilis of the liver, and of sepsis

When infectious hepatitis is suspected the nature and colour of the stool and urine must always be ascertained (discoloured stool, beer coloured urine) Jaundice may also be caused by an increase in the decomposition of the erythrocytes owing to increased osmotic fragility of these cells (familial hemolytic icterus or jaundice—hereditary spherocytosis) Slight icterus of the sclerae may appear in cases of severe heart failure in the decompensation period it is then an unfavourable sign indicating severe disorders of the functional activity of the liver owing to portal stasis

Excessive consumption of carrots, tangerines and tomatoes causes the skin of young children to turn bright yellow, this colouring is the result of the deposition of the pigment carotene in the skin and subcutaneous adipose tissue, hence some authors term this condition *carotene icterus*, although it is more correct to call it "*carotene pigmentation*", in this condition the mucosa is not yellow and the colour of the urine is normal The yellowing is particularly pronounced on the palms, soles and face

4 *Blueness* Cyanosis, or blueness, may be *local*, it is most pronounced on the hands and feet In these cases the cyanosis is a sign of a local congestion of the venous blood The delimited cyanosis which involves one or both extremities or even only one or two digits and is absent in the summer, but always returns in the winter after even the briefest exposure to cold is caused either by disturbed vascular innervation, or by chilling (rigor)

General cyanosis of the entire body and mucosa is due to systemic circulatory disorders and indicates a severe lesion of the heart or lungs The quicker the cyanosis spreads, the graver the prognosis Rapidly spreading cyanosis is a threatening sign when it is due to constriction of the larynx in croup, spasm of the glottis, or presence of a foreign body, and also when it is the result of depression of cardiac activity in acute infections—scarlet fever, diphtheria, or pneumonia The cyanotic colouring spreads with relative slowness when the lungs are compressed by a pleuritic exudate However, cyanosis accompanying the rapid development of pyopneumothorax and hydropneumothorax may indicate grave danger to the child's life Acquired heart defects produce cyanosis only in the period of decompensation, concurrent with dyspnea and dropsy Certain congenital cardiac defects (constriction of the pulmonary artery, for instance) are attended by prolonged general cyanosis (morbus caeruleus, or maladie bleue) In the newborn cyanosis is seen in cases of severe asphyxiation

Very frequently circumscribed bluish red spots appear on the back of the head, on the face, and less frequently on the trunk of newborn and nursing infants, but disappear later without trace The spots are caused by a congenital local dilatation of the venous capillaries, the condition is termed *telangiectasis*

5 *Rashes* When examining patients attention must be paid to the rashes which are frequent in babies from birth throughout infancy They appear in the form of *intertrigo* in folds of the skin and in places where there is friction of adjacent parts, in the form of a diffused redness or papular *rash on the buttocks (erythema gluteale or diaper rash)* owing to irritation caused by urine and feces, and less frequently in the form of impetigo neonatorum following staphylococcic infection Sudamen, or miliaria crystallina, is not rare among infants, it appears as an eruption of pinhead reddish papules or vesicles containing a clear liquid and circumscribed by a narrow red rim

Exudative diathesis gives rise to different forms of eruptions *a nodular rash* with a red rim (strophulus and lichen urticatus), *urtica* *ria, eczema* (dry, weeping, intertriginous, squamosum, papulosum, seborrheicum), older children are affected by *prurigo*, the small, pale papules of which are most prominent on the extensor surfaces of the limbs All these eruptions are accompanied by intense itching, and the excoriations are frequently complicated by secondary suppurative infections in the form of *impetigo* The most prominent of the *pyogenic eruptions* is *pyoderma* Pyogenic pustules of various size and furuncles are frequently observed in infancy, older children are afflicted by impetigo The associations between impetigo and pemphigus neonatorum and dermatitis exfoliativa have already been spoken of Differentiation must be made between dermatitis exfoliativa and erythroderma desquamativa The latter is a generalized redness and abundant scaly eruption with seborrhea of the scalp, it affects babies between one and three months of age, its pathogenesis is undetermined

In childhood the prevalent parasitic eruption is *scabies* the favourite localization of the lesions is between the digits The most characteristic feature is the presence of 'runs" from 2 to 15 mm long, caused by the burrowing of the insect mite *Sarcoptes scabiei* through the superficial layers of skin, the skin above the runs is elevated in the form of vesicles and papules, as a result of itching excoriations in linear distribution are present, and these excoriations are subject to secondary infection—eczema and impetigo

In very early childhood the scabetic runs are not localized on the interdigital surface, but are spread all over the body, prevalently on the *lateral surfaces of the trunk*, face, and head, and their aspect is not typical owing to the thinness of the horny layer Owing to intensive vascularization secondary changes in the skin—exudative symptoms and pyogenic papules—are very marked The younger the child, the more difficult is diagnosis of scabies

The most important mycosis of childhood is *trichophytosis* (*ringworm*) The lesions may be located both on the body and on the scalp The clinical findings appear as small, lentil sized, reddened, gradually increasing spots circumscribed by elevated rims

In cases of hemorrhagic diathesis petechiae are observed on the skin—hemorrhagic spots of various shape and size *Meningococcemia* in children is frequently attended by *a stellate hemorrhagic rash*

Another type of skin eruption occasionally observed is *erythema nodosum* which appears on the legs below the knee in the form of tender nodules, these nodules are at first reddish, then they turn blue and yellow, i e , their coloration undergoes a series of changes typical of contusions caused by bruising The eruption of the nodules is accompanied by a high temperature which may be sustained for from one to three weeks The etiology is unknown The majority of pediatricians consider that erythema nodosum is an allergic symptom of a tuberculous infection, x ray examinations very frequently demonstrate a tuberculous infiltrale in the lungs concomitant with the eruption

In cases of fever of doubtful origin the entire body, including the legs, must be examined for erythema nodosum

Acute eruptive infectious diseases are extremely frequent in childhood measles, scarlet fever, rubella, chickenpox, less often typhus, typhoid, and other fevers The rashes in all these diseases are so typical that the diagnosis may be reached by observation of the skin alone The eruption of the serum sickness is very diversified, being predominantly of an urticarial nature

The most frequent skin lesions concomitant with chronic infections, namely *tuberculosis*, are *lupus vulgaris*, in older children usually localized on the face and limbs, *scrofuloderma* (tumour like formations subject to cheesy degeneration and suppurative liquefaction), *tuberculids* (large and small reddish brown papular nodules with relatively small necrotic centres) The rashes due to congenital *syphilis* are very diverse The characteristic roseolous rash is usually absent in infancy, frequent findings are maculo papular syphilids and pemphigus which in distinction from pemphigus neonatorum is formed on the palms and soles Diffuse infiltrates on the palms and soles (shiny, 'lacquered" soles) and on the face (stellate creases around the mouth) are also not rare Rheumatic fever occasionally produces an annular rash symptoms of hemorrhagic diathesis in the form of petechiae and hemorrhages of various sizes should alert the physician to the possibility of drug rash (dermatitis medicamentosa)

Another skin condition may be *desquamation* (branny following measles and scaly after scarlet fever, particularly prominent on the palms and soles) Desquamation is also caused by the use of various liniments inducing hyperemia, and it may be observed following a bath when a child has not had one for a long time A peculiar mottled pigmentation of the skin ("pellagroid skin', see Chapter XX) is frequently observed in emaciated children

6 Finally, when examining the skin attention must be paid to the presence of fine rounded, usually discrete, scars left by varicella (chickenpox), unevenly-shaped scars with scalloped edges localized in the corners of the mouth, around the anus, on the dorsal surface of the thighs and buttocks are left by syphilitic gummi, tuberculous lesions of the skin leave irregular stellate scars (lupus vulgaris, ruptured lesions of scrofuloderma and tuberculous lymphadenitis) The scars that remain after nonmembraneous impetiginoid diphtheria of the skin have indurated cyanotic rims with infiltrates

Palpation The dryness or moistness of the skin is discerned first of all by palpation Acute *dryness* is observed in ichthyosis, myxedema, sharp deterioration of nutrition in older children, and after a bath in children who have not been washed for a long time Increased moistness and excessive *perspiration* are typical of rickets hyperthyroidism (Basedow's disease or exophthalmic goiter), and of disturbances of the autonomic nervous system in the prepubertal period Excessive perspiration may lead to the formation of *miliaria* (prickly heat) in cases when the outlets of the sweat glands become plugged owing to swelling of the epithelium

Two qualities of the skin, elasticity and turgor, highly important in the pathology of childhood, are determined by palpation

Elasticity is determined by bunching the skin over the abdomen into folds (preferably in a longitudinal direction), if the folds are smoothed out rapidly resilience is normal, otherwise it is decreased Dehydration, or rapid loss of water by the body, leads to loss of skin elasticity Diarrheas of childhood (toxic dyspepsia or dysentery) may bring on a change in the elasticity of the skin within 24 hours

Turgor is the resistance felt when the skin and the soft tissues are pinched, turgescence is best examined on the inner surfaces of the thighs Acute and chronic nutritional disorders lower normal turgescence Disturbances of the turgor and elasticity of the skin are frequently concurrent but not always Fulminant dyspepsia in infants is accompanied by intensive vomiting and diarrhea, in such cases loss of elasticity may occur very soon without any noticeable disturbance of turgor (a large and rapid loss of fluid), conversely, chronic nutritional disorders in very young children are accompanied by visible changes in the turgor and relatively slight changes in the elasticity of the skin Consequently, *these two qualities of the skin are not identical* Loss of resilience serves as an indication for increasing fluid supply (physiological salt solution perorally or subcutaneously)

In childhood, particularly during the first days of life and in infancy, a certain degree of medical importance attaches to *sclerema* and *scleredema* Sclerema is a diffuse hardening (induration) of the skin of the calves, thighs, buttocks abdomen, and face The skin acquires a leathery appearance and does not pit under pressure The condition is characterized by inactivity, easy chilling subnormal temperature, acute deceleration of respiration and pulse Scleredema (sclerotic edema) is a disorder characterized by diffuse indurations of the skin, as in sclerema, and also by edema The skin is taut and shiny, but indentations remain after pressure has been applied by the fingers Some authors hold that sclerema is caused by (1) significant losses of fluid, (2) subsidence of bodily temperature, and (3) prevalence in the adipose tissue of stearic and palmitic acids which *harden more easily Other authors explain the formation of sclerema* by pathological changes in the colloid constituents of the tissue proteins

Edema of the subcutaneous tissue in older children occurs either as a generalized edema of the body, or as localized edema on certain parts of the body Generalized edema may be caused by kidney or heart disorders, or may be of non protein origin, appearing under the effect of general emaciation (owing to protracted hungering, to diarrhea, and to vitamin deficiencies) *Acute edema of the face* is usually attendant on inflammatory processes in the skin and subcutaneous tissues, (erysipelas, eczema, mumps) *Chronic edema of the face* or of one extremity in young children is frequently a sequela of erysipelas in the site *Acute edema of the eyelids* may be a sign of ethmoiditis or of inflammation of the eye *Edema of the subcutaneous tissue of the cervical region* occurs in cases of mandibular periostitis palpation reveals a circumscribed, very tender thickening of the lower jaw In adenophlegmon a firm discoidal tumour closely attached to both skin and subcutaneous tissue is palpated A retropharyngeal abscess may likewise be accompanied by a swelling of the subcutaneous tissue of the neck In cases of *toxic diphtheria edema of the subcutaneous tissue of the cervical region* usually prevails considerably over enlargement of the glands, so that the latter are palpated with difficulty The cause of the swelling of the subcutaneous tissue of the neck in the latter two forms of edema is clarified by examination of the mouth and throat Various degrees of hypofunction of the thyroid gland are characterized by a dry scaly skin and, moreover, by myxedema, i e , *a mucous swelling* of the subcutaneous tissue, ordinarily most prominent on the neck and trunk This type of edema is not subject to pitting Moderate edema and pastiness of the skin over one half of the chest concomitant with symptoms of a pleuritic exudate indicate the pyogenic nature of the latter

A swelling with a great superficial resemblance to edema is *subcutaneous emphysema*, a condition caused by an accumulation of air (or gas) in the subcutaneous connective tissue Subcutaneous emphysema of the neck following tracheotomy begins in the vicinity of the tracheotomic wound A frequent cause of emphysema is rupture of the pulmonary alveoli owing to strenuous coughing, the air spreads along the interlobular connective tissue to the root of the lung and from there through the anterior mediastinum to the subcutaneous tissue of the neck and chest Subcutaneous emphysema may be induced by unskillful subcutaneous injections of serum, physiological salt solution, etc , if air is injected together with the liquid Subcutaneous emphysema is easily recognized by *the characteristic crackle, resembling the crunching of snow*, elicited by pressure applied to the skin When subcutaneous emphysema forms in the area of the chest the subcutaneous crackling may be confused with crepitation or with the sound caused by friction of the pleura

The fragility of the blood capillaries of the skin is determined by placing a rubber bandage on the patient's shoulder, when the bandage is removed (after 2 or 3 minutes) increased capillary fragility will be noted by the petechiae appearing in the elbow bend and on the forearm

Another method for determining capillary fragility a fold of skin (preferably on the anterior or lateral surface of the chest) is pinched between the thumbs and forefingers of both hands If a contusion remains after the skin is released it means that capillary fragility is increased Increased fragility is observed in cases of hemorrhagic diathesis and in scarlet fever, it is less pronounced in measles and other infectious eruptions

Dermographia is a response reaction of the skin to mechanical irritation caused by tracing the fingernail or a blunt instrument over it, the dermographic pattern depends on the degree of pressure and on the reactivity of the blood vessels and vasomotorial mechanisms A smooth delicate skin reacts more readily than a dry, coarse skin Dermographia may be either *local* when the reaction is limited only to the site of irritation and is conditioned chiefly by the state of the local capillaries, or *reflex* when it is associated with the state of the autonomic nervous system

The following forms of dermographia are distinguished (1) *red* (*d rubra*) (2) *white* (*d alba*), (3) *mixed*, when the red line along the line of scratch is flanked by two white lines, and (4) *elevated*, *exudative* or *edematous* The lapse of time between the irritation of the skin and the appearance of the response is called *the latent period*, while the time interval between the appearance of the dermographic line and its disappearance is called *the patent period*

Dermographia alba is frequently encountered in children, particularly children with exudative diathesis and also in various conditions associated with hyperemia of the skin, such as solar erythema (sunburn), for instance Dermographia alba is particularly marked in *scarlet fever*, being observed in 90 per cent of cases, and it has a prognostic significance when the patient's condition deteriorates it disappears or is faint, upon improvement it appears again

Dermographia rubra is usually very pronounced in meningitis and toxic dyspepsia

Exudative dermographia is occasionally seen in association with scarlet fever, and also when the excitability of the autonomic nervous system is increased

SYMPTOMATOLOGY OF THE MOST IMPORTANT PATHOLOGY OF THE SUBCUTANEOUS ADIPOSE TISSUE AND THE HAIR

The condition of a child is termed *normotrophia* or *eutrophia* when his nourishment is normal, his subcutaneous adipose tissue adequately developed, and his entire system functions normally It is characteristic of a normotrophic infant to have an abundant deposit of fat, particularly on the thighs, the inner surfaces of which carry 2 or 3 folds ("*physiologic creases*") Sometimes an excessive deposit of fat is observed, while in other cases the deposit is insufficient Excessive uniform deposition of fat, *adiposity*, may be caused by overfeeding and by inactivity, particularly when there is a tendency to adiposity Large deposits of fat in the area of the breasts, lower part of the abdomen, the hips and thighs are observed in adiposity of pituitary and cerebropituitary or genital origin

Various degrees of subnormal nutrition and deficient deposition of fat (hypotrophy) are observed The first degree, when the weight deficiency does not exceed 10 20 per cent, is characterized by a decrease of the adipose layer on the abdomen alone, this is *hypotrophy of the first degree* *The second degree of hypotrophy* (weight deficiency 20 to 40 per cent) is characterized by a disappearance of fat from the trunk and extremities as well as from the abdomen Complete or almost complete disappearance of the subcutaneous fat everywhere, even from the face and pubic region, is one of the features of the third group of disorders of nutrition, *atrophy*, in this condition the weight deficiency exceeds 40 per cent

Excessive growth of hair, *hypertrichosis*, is observed in scrofula tuberculosis, and occasionally following hydrocephaly (evidently owing to lesion of the autonomic nervous centres), after sun baths in cases of spina bifida occulta (a hidden defect in the closure of the spinal canal) in the lumbar region, and in hirsutism

Sparse growth and loss of hair is observed in endocrine disorders such as myxedema (dry, coarse hair), following infectious diseases and in vitamin deficiencies The scalp is frequently affected by trichophytosis, characterized by circular scaly patches of various sizes with partial loss of hair

CHAPTER XII

THE LYMPH NODES

Prof V Molchanov

The superficial lymph nodes are part of *the lymphatic system* which is comprised of glands in various parts of the body, lymphatic follicles in the mucous membranes (of the nasopharynx tongue intestine, etc) and the skin, and of infinitesimal lymphatic aggregations dispersed throughout the body and visible only by means of the microscope The lymphatic system also includes the thymus gland and the spleen

ANATOMY AND PHYSIOLOGY OF THE LYMPH NODES

Anatomy and developmental dynamics Our knowledge on the development of the lymph nodes is still insufficient However the majority of authors hold that *the common embryonal rudiments* of the separate groups of lymph nodes are formed at *the end of the second month of gestation* by concentration of undifferentiated connective tissue cellular elements which gradually develop into more differentiated reticular and lymphoid elements *Fully* developed lymph nodes may already be found in the *last months of gestation*

In *the newborn* the nodes are palpable (the cervical and inguinal nodes) in 50 per cent of cases according to Gundobin and in from 25 to 58 per cent of cases according to other authors Some authors have even found axillary and occipital lymph nodes in almost all full term infants Such a disparity is evidently not due to *the absence of the lymph nodes in part of the newborn but to the anatomic features of the nodes* at this age Indeed the parenchyma of the relatively voluminous lymph nodes of the newborn is abundant in lymphoid elements with a predominance of young forms The parenchyma possesses large lymph sinuses with endothelial cells, and a barely delineated terminal sinus at the same time connective tissue elements in the form of trabeculae and septa are almost completely absent The capsule of the lymph node is extremely thin and delicate *The entire cellular and connective tissue structure* of the lymph nodes of the newborn is quite immature in its development (Fig 15) Therefore, the node is not as clearly differentiated from the surrounding subcutaneous adipose tissue as it is in children of a more advanced age and in adults, and, consequently, it cannot always be palpated

The lymph nodes become palpable in the majority of children by *the end of the first year of life, or somewhat later,* their dimensions

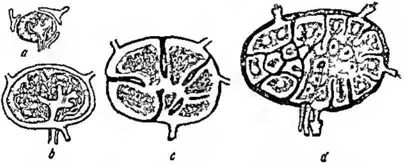


Fig 15 Development of central and peripheral lymph sinuses
a-d—node undifferentiated into nodules the cortical nodes and medullar cords are dotted the sinuses and blood vessels are black
g—trabecular network is seen on left network of medullar rays on right

sometimes attaining that of a lentil A further differentiation is concomitant with enlargement

By *3 years* the connective tissue capsule is pronounced, it contains reticular cells with faintly visible branching projections

At the age of 7 8 years a gradual intensification of connective tissue formations commences in the lymph node which at this time acquires a well defined reticular base Trabeculae are formed growing in definite directions to make up the framework of the node

By 12-13 years the structure of the lymph node is *completed* it has a well developed capsule trabeculae, follicles, the sinuses are narrower and the reticular tissue is less marked

In *the period of sexual maturation* the growth of the lymph nodes ceases, and they are subject to partial retrogression

Physiology The lymph nodes play a very prominent part in the child's life Their functions are extremely complex Their basic function, *participation in blood formation and the formation of lymphocytes* is undoubtedly mature already in the later months of gestation becoming particularly important in the first years of life, while *its role as a barrier against infections is negligible in the first months of life*

At this age the regional lymph nodes rarely react to the penetration of an infection into the skin

Owing to the underdeveloped barrier function of the lymph nodes, the immaturity of the central nervous system, weak resistance to infections, and low production of protective bodies the morbid process is not limited to the lymph nodes alone, but it involves the system as a whole Herein lies one of the reasons for *the more frequent and rapid development of generalized sepsis as compared with older children*

By one year or later the barrier function develops to such an extent that the lymph nodes already detain germs and frequently respond to the penetration of infection by inflammation with subsequent suppuration

In the period between 3 and 10 years enlargement of the lymph nodes and hyperplasia of other parts of the lymphatic system are particularly frequent The explanation must evidently be sought, on the one hand, in the anatomical and physiological features of the lymph nodes during this period of life a good blood supply, wide sinuses with an abundant reticular network which is conducive to slowing down the flow of the lymph, and also insufficient immunobiological resistance to the effect of various harmful factors On the other hand—and this needs to be emphasized in particular—children of the preschool and school ages are exposed more frequently than younger children to diverse harmful endogenous and exogenous influences It is therefore not surprising that superficial lymphadenitis, adenoiditis and tonsillitis are more frequent at this age, and that the follicular apparatus of the mucous membranes of the intestine, tongue, etc , is more marked

A general enlargement of all the lymph nodes is encountered in association with various infections and intoxications such as tuberculosis, syphilis, acute infectious diseases (scarlet fever), lesions of the skin and mucosa (scabies, prurigo, strophulus, etc), diseases of the blood Other factors contributive to enlargement of the lymph nodes are generalized nutritional disorders and diatheses (particularly exudative diathesis), certain avitaminoses, change of dietary habits (foods with high protein values), these symptoms are evidently associated with the participation of the lymph nodes in metabolic processes

As the child grows the important role of the lymph nodes in immunity becomes more and more noticeable, they undoubtedly acquire the ability of both detaining and destroying germs Therefore in older children and in adults pathogenic bacteria do not induce suppuration or the specific changes characteristic, for instance, of tuberculosis (caseation) in children of a younger age, although they do emerge in large numbers form the site of infection to the regional lymph nodes

Groups of lymph nodes. Among *the superficial lymph nodes* mainly the following *five groups* are accessible for examination (1) *nodes of the head and neck* (Fig 16) which are differentiated into (a) submaxillary nodes—under the corner of the lower jaw, (b) the submental nodes—usually one on each side, (c) the cervical nodes along the sternocleidomastoid muscle posteriorly and anteriorly, (d) the supraclavicular nodes in the supraclavicular depressions, (e) the mastoid and parotid nodes—in back of the ears on the mastoid process and in front of the ears on the parotid salivary gland, (f) the occipital lymph nodes, (2) *the axillary lymph nodes*, (3) *the cubital lymph nodes* in the sulcus of the biceps muscle in the elbow and higher, (4) *the thoracic lymph nodes* at the lower margin of the pectoralis major muscle, (5) *the inguinal lymph nodes*

In order to be able to determine the point of ingress of infection and the source of focal infections it is highly important to know *the localization of the lymph nodes and the directions of the afferent and*

Fig. 16 Lymph nodes of head and neck

a—submaxillary *b*—submental *c*—deep and superficial cervical nodes (situated anterior and posterior of m sternocleidomastodeus) *d*—supraclavian *e* mastoid *f*—occipital

efferent lymphatics, since it is at times impossible to detect any pathology in the site of penetration of the infection, while the regional lymph nodes are enlarged and tender, moreover, the development of the pathological process may have ended while the reaction in the lymph nodes is retained

The submaxillary nodes usually react to diseases of the mouth and fauces (stomatitis, lesions of the mucosa and skin of the lips, dental caries inflammatory process in the tonsils—tonsillitis)

The submental lymph node collects the lymph from the skin of the chin, the upper and lower lips and partially from the oral mucosa

The cervical nodes situated anteriorly to the sternocleidomastoid muscle principally in the superior carotid triangle, drain the lymph from the facial skin, the parotid salivary gland, and the mucous membranes of the nose, fauces, and part of the mouth Some authors call these and also the submaxillary nodes *tonsillar lymph nodes* in so far as they also drain lymph from the tonsils The deep cervical lymphatic chain, situated posteriorly to the sternocleidomastoid muscle prevalently in the inferior carotid triangle, collects the lymph from the nasopharynx and fauces, and partly from the mouth and the skin of the neck

The *supraclavicular* nodes collect lymph from the skin of the upper part of the chest and also from the pleura covering the apexes of the lungs

The *occipital* nodes collect lymph from the skin of the head and back of the neck

Diseases of the external auditory canal and of the middle ear and its appendages, as well as diseases of the pinna and the skin surrounding it, induce a swelling of the *mastoid* lymph nodes In cases of inflammatory processes in the area of the face and posterior part of the pinna the *parotid* lymph nodes become enlarged

The axillary lymph nodes collect lymph from almost the entire upper extremity

Only a small part of the lymphatics running from the III, IV, and V digits and from the skin of the inner margin of the wrist and forearm drain into *the cubital lymph nodes*

Enlargement of *the thoracic nodes* is a sign of lesion of the skin on the chest and breasts, and also of lesion of the pleura and lungs

All the lymphatic vessels of the skin and subcutaneous tissue of the lower extremities drain into *the inguinal nodes* These nodes likewise collect lymph from the lymphatic vessels in the skin of the lower abdomen, the buttocks, anus, genitals, and perineal area

Lesions of the organs of the thoracic and abdominal cavities involve corresponding regional lymph nodes into the process (the *bronchial, mesenteric, retroperitoneal,* etc , nodes)

Investigation of the lymph nodes No difficulties are encountered in the examination of the superficial lymph nodes, particularly in lean children, but a certain skill is necessary The nodes *most difficult to locate by palpation are the submental, axillary and cubital lymph nodes* The first are palpated by a light movement of the fingers from back to front near the median line of the submental area The axillary nodes are found by pressing the fingers as far as possible into the axillary hollow and from there proceeding downward along the chest The cubital lymph nodes may best be found by palpating the sulcus of the biceps in the elbow and higher, holding the arm bent in the elbow at a right angle The remaining groups of lymph nodes are easily palpated, in lean children they are even visible when ever so slightly enlarged (see Chapters XVI and XVIII for methods of investigation of the bronchial and mesenteric glands)

When examining the lymph nodes it is necessary to note the following (a) *dimensions* (the size of a pea, a cherry, etc), (b) *number* (nu merous, sparse, etc), (c) *consistency* (soft, resilient, firm), (d) *mobility*, (e) *relation to skin and subcutaneous connective tissue* (adherent or not), (f) *sensitivity* and *tenderness* to palpation

These properties of the lymph nodes differ depending on the nature of the pathological process and the causes inducing nodular enlargement In certain diseases (tuberculosis, lymphogranulomatosis) the findings in the superficial lymph nodes are so typical and characteristic that they may be employed for diagnosing the basic disorder Therefore the specialist in children's diseases must develop the ability of understanding the specificities of the lymph nodes

Unchanged and changed lymph nodes There exists no strictly definite criterion for deciding what constitutes lymph node normalcy The concept of 'normal nodes is very conditional and subjective Generally speaking, the nodes are normal if they are small (no larger than a pea), discrete, soft, mobile, do not cohere to the skin and among themselves, and are painless Usually the submental, thoracic supraclavicular and cubital lymph nodes are not palpable However, it is not rare for the dimensions of the superficial lymph nodes to be enlarged (to the size of a bean) and for their number to increase without any visible external cause in children with so called lymphatic diathesis or status thymicolymphaticus In these cases differentiation must be made from polyadenitis owing to chronic infections (tuberculosis syphilis) and acute or subacute moderate hyperplasia of these nodes in acute infections, the serum sickness, diseases of the blood etc

Symptomatology of the Most Important Diseases of the Lymph Nodes

Differentiation of acute and chronic diseases of the lymph nodes is necessary, although in both cases the pathological changes may concern either separate groups of nodes or the lymphatic system as a whole

Acute lymphadenitis The lymph nodes are enlarged to the size of a large bean in diseases such as measles, scarlet fever, the serum sickness they are soft, resilient frequently tender A definite localization of the swollen nodes is extremely typical of certain acute infectious diseases Thus, in diseases that set in with a sore throat (diphtheria scarlet fever) the nodes predominantly and first of all affected are the submental nodes and the nodes on the anterior surface of the sternocleidomastoid muscle, swelling of the occipital nodes is characteristic of rubella, the serum sickness first of all involves the regional lymph nodes and the sites of injection of the serum (as, for instance the inguinal nodes when the serum is injected into the buttocks or under the skin of the abdomen)

In acute diseases of separate groups of lymph nodes the latter may sometimes grow to the size of a hen's egg becoming hard and very painful in cases when the inflammation has involved the surrounding tissues (*periadenitis*) and also the subcutaneous connective tissue and the skin (*adenophlegmon*), the nodes become immobilized and coalesce with the skin In such nodes the inflammatory process usually terminates by the formation of an abscess

A condition that may be confused with acute lymphadenitis is parotitis—epidemic inflammation of the parotid salivary gland (mumps), particularly if the inflammation does not affect the parotid gland and affects only the submaxillary or submental salivary gland Parotitis is accompanied by the formation of a flat doughy swelling with indefinite contours in back of the mandibular joint under the pinna and in front of the tragus, this swelling is more easily seen than palpated its tenderness when pressed upon is usually slight, and changes in the skin are absent Parotitis is also occasionally confused with inflammatory swelling of the lymph node located on the parotid salivary gland

An acute or subacute enlargement of the cervical lymph nodes, predominantly of the nodes situated in front and in back of the sternocleidomastoid muscle, is characteristic of the disease known as *"glandular fever", which was first described by Nil Filatov* The process frequently involves other superficial lymph nodes, and also the nodes of the thoracic and abdominal cavities (mesenteric and others) An irregular fever, sometimes of an intermittent nature, may be sustained for several weeks The clinical findings are only a slight hyperemia of the fauces and slight enlargement of the liver and spleen Leukocytosis is prominent, frequently with a prevalence of lymphocytes (75 85 per cent) The etiology of the disease is unknown, it is possibly caused by various coccal bacteria, possibly by a virus infection, the infection evidently penetrates through the lymphatic ring surrounding the pharynx

Chronic lymphadenitis Among the chronic diseases involving the superficial lymph nodes *tuberculosis* takes first place, the clinical aspect of the lymph nodes and the role they play in tuberculous infection of children are currently better known for this than for other chronic diseases

Two forms of tuberculous lesions of the lymph nodes should be distinguished (1) a localized lesion of one or several groups of nodes and (2) a generalized disseminated lymphadenitis

In *localized* infections of a separate group of lymph nodes it is the cervical nodes which are most frequently enlarged (from the size of a hazel nut to that of an egg) (Fig 17) The nodes are very firm, they may coalesce with each other and the skin, after which they undergo caseous degeneration soften and rupture, forming fistulas that do not close for a long time Other symptoms of tuberculosis are concomitant

In *disseminated* tuberculous lymphadenitis the lymph nodes are small (from the size of a millet seed to that of a pea), *very firm* and *hard* (*sclerosis*) painless mobile, moreover, all the groups are usually palpated in large quantities A particular characteristic is palpation of the submental and cubital lymph nodes (in the absence at the given time and some time before it of any local cause for their enlargement)

Congenital syphilis produces a similar type of disseminated polyadenitis the most characteristic feature of which is enlargement of the cubital lymph nodes in newborn and nursing infants The cubital

Fig 17 Tuberculosis of the cervical lymph nodes in 12 year old girl

nodes are palpable in 80 to 90 per cent of children with congenital syphilis

In *lymphogranulomatosis* the lymph nodes principally the cervical nodes sometimes attain excessive dimension (Figs 18 and 19) All the groups of superficial nodes are involved in the process as well as the deep lymph nodes (of the mediastinum for instance) The nodes are generally resilient do not coalesce with each other and the skin are mobile and do not soften Enlargement of the spleen is a frequent concomitant finding An irregular undulant fever may be sustained for many months Final diagnosis is made on the basis of biopsy data since a similar picture may be produced in certain instances by tuberculosis lymphosarcomatosis syphilis

In *lymphosarcomatosis* the enlarged lymph nodes are moderately firm, and fused in groups; they grow very rapidly, showing a tendency for capsular growth into the surrounding tissues. The cervical,

Fig. 18. Lymphogranulomatosis in 9-year-old child (before treatment)

Fig. 19. Lymphogranulomatosis. Same child (after x-ray treatment)

mediastinal, and retroperitoneal lymph nodes are mostly involved. No definite blood pattern is observed.

When rapid enlargement of the lymph nodes occurs the possibility of *leukemia* should be thought of. The lymph nodes are usually multiple in the various forms of leukemia, and are located in the neck, axillary hollows, and inguinal area. Sometimes the nodes are very large, but they are mobile, soft, insensitive to pressure, and do not develop suppuration. Diagnosis is established by the blood picture.

CHAPTER XIII

THE MUSCULAR SYSTEM

Prof. *D. Lebedev*

ANATOMY

During the first months of life the histological structure of the muscles is distinguished by a lesser thickness of the muscle fibres, a more clearly defined interstitial tissue, and, chiefly, by an abundance of rounded nuclei in the muscular and interstitial connective tissue

Examination and symptomatology. The first thing to note in examining the child's muscular system is development, tonicity, strength, and the volume and nature of motor activity and mechanical excitability

The muscles are poorly developed in childhood, particularly in infancy It is not easy to establish the developmental condition of the muscles of young children owing to the presence of a well defined layer of subcutaneous adipose tissue Muscular increase becomes noticeable only after the age of five years, and it is particularly rapid during puberty development

In older children the muscular condition is established by observation, in younger children, particularly when they are stout and overnourished, by palpation Development of the muscles is associated with a number of factors—proper nourishment, undernourishment, emaciation due to some wasting diseases, family habits, the child's activity in general and in sports in particular, and also with inborn qualities

Atrophy of separate muscles or of groups of muscles is seen in cases of lesions of the nervous system (neuritis, poliomyelitis), of an adjacent joint, or in connection with prolonged inactivity of certain muscular groups (immobilizing bandages, etc) Diffuse muscular atrophy, frequently inconsistent with the anatomic correlations in the nervous system, is encountered in various forms of progressive muscular atrophy

Muscular *strength* of older children is established in the same manner as for adults, by means of the dynamometer, in infants it can only be approximated by determining the effort needed to oppose the child's spontaneous motor activity

Muscular *tonicity* is judged, firstly, by resistance to passive movements, and, secondly, by the consistency of the muscular tissue as determined by palpation Normally muscular development and tonicity are the same in symmetric sites Muscular hypertonicity with predominance of flexor tonus over extensor tonus in the extremities is characteristic of babies in their first months of life owing to specific features of innervation at this age level this is why infants usually flex their limbs when they are undiapered In the first year of life only sick babies straighten their legs in a recumbent position, like adults when waking or sleeping However, even in healthy babies muscular tonicity decreases somewhat during sleep and when the infant nurses, although prevalence of the flexor tonus is retained In children of a more advanced age this prevalence gradually decreases

In the preschool period of childhood muscular tonicity is lower than in adults In adolescents, and in the prepubertal period it is noticeably higher than in the younger school age and preschool age periods, and it is generally more marked in boys than in girls

Decrease or increase of tonicity in any separate group of muscles is a pathological condition

General *hypotonia* of the muscular system is concomitant with a number of diseases, such as rickets, chorea, and congenital myatonia, in progressive muscular dystrophy a gradual wasting and hypotonia of a number of muscles are observed in a definite sequence characteristic of various forms of this disease

Delimited hypotonia is usually due to lesion of the peripheral neuron (poliomyelitis, neuritis), when the corresponding muscles are hypotonic and atrophied

General hypertonia is the result of lesion of the central neuron (residual symptoms of encephalitis, birth injury, underdevelopment of the cortex, hydrocephalus, etc) In early childhood hypertonia and hypotonia are also frequently seen in cases of acute and chronic nutritional and digestive disorders, and in some infections (tetanus meningitis)

The cause of *delimited hypertonia* may arise in the muscles themselves—myositis (a very rare disease in childhood), but it is mostly due to lesion of the central neuron or of a corresponding joint or bone spastic tension of the abdominal walls in response to the most cautious palpation is typical of irritation and inflammation of the peritoneum Tension of the abdominal muscles is somewhat less in the presence of any process associated with tenderness to palpation Children with heightened sensitivity frequently display reflex tension of the abdominal muscles when the examiner is not careful enough, or when his hands are cold (as is the case with adults)

Muscular contracture is of one and the same etiologic origin in children and in adults Isolated tension of the cervical extensor muscles is observed during inflammation of the brain meninges (rigidity of the neck) *Trismus* i e , tonic spasm of the muscles of mastication, has the same effect as in adults

The motor activity of infants in their first months of life differs significantly from that of older children In the first 2 3 weeks after birth babies move their arms and legs very slowly their movements resemble those of a bug on its back trying to right itself These movements are regulated by the subcortical centres, since at this age the cerebral cortex is too immature Only at 4 5 6 months do the child's movements become faster and more vigorous, after the brain cortex begins functioning

The voluntary movements of babies who are just beginning to use their limbs are usually symmetric the child at first reaches out both hands and grasps objects that have caught his fancy, and only later begins taking things with one hand

Facial expression is frequently asymmetric in the first 2 3 months after birth, symmetry of expression comes later (see Chapter XV)

CHAPTER XIV

THE BONE SYSTEM

Prof *D Lebedev*

ANATOMY

The anatomical and physiological features of the skeletal frame in childhood resolve into the specific qualities of the bone tissue, of the bone as an organ, and of the skeleton as a whole

The osseous (bone) tissue in childhood is distinguished by a higher content of water and lesser percentage of solid constituents

Chemical constituents of the femur in the seventh month of intrauterine life 69 11 per cent water 13 2 per cent ash the respective figures at four years are 45 29 per cent and 21 59 per cent, analysis of the bone substance per se in the fetus shows it to contain 35 6 per cent water and 39 per cent ash at four years the respective values are 25 5 per cent and 47 15 per cent

The lesser mineral values favour a comparatively greater softness and resilience of children's bones to pressure and bending, and a lesser tendency to fractures Even in healthy children a slight contractability of the chest may be felt when it is pressed on

The energy of growth and bone regeneration is greater in childhood than in subsequent life, this is manifested by the shorter time needed for healing bone fractures as compared with adults, particularly elderly people The resistance of the child's bones to trauma and their elasticity is also greater

There are many *histological* distinctions between *the structure of the osseous tissue of children* and adults adult bones have a laminar structure, while in children (and to a still greater extent in the fetus) the structure is fibrous

The entire stroma of the bone is perforated by interlaced bundles of thick connective tissue fibres running in various directions marked laminar structure is rare In the child the arrangement of the osteocytes (bone cells) is more irregular and they are closely packed their shape varies but they are generally larger than in adults The processes of formation and resorption of bone tissue are much more vigorous the number of osteoblasts and osteoclasts is greater and Howship s lacunae are encountered more frequently The Haversian canals are somewhat wider their network is more marked owing to the greater vascularization of children's bones The periosteum is thick, with a particularly well defined internal layer

The bones attain adult structure very gradually The bones of 2 3 year olds already show some replacement of the fibrous tissue by the more regular laminar osseous structures

As regards the distinction of every separate bone as *an organ* it is noteworthy that whereas the long bones of adults are an entity in children they consist of several osseous parts divided by cartilaginous layers—the diaphysis (shaft) and usually two principal or occasionally several accessory epiphyses It is important to know of these accessory epiphyses in order to be able to distinguish the normal bone of a child from a comminuted fracture on an x ray picture

CLINICAL SUMMARY

Knowledge of the anatomical structure of the bones in childhood is an important point in understanding pathological conditions The presence in children s bones of cartilage dividing the epiphysis and diaphysis and in which a lively proliferation of the cells towards the diaphysis occurs the abundant vascularization and the structure of the vessels in the entire area of bone growth create anatomical conditions that favour bone inflammation osteomyelitis In older children *the osteomyelitic process* is generally located in the area of *the metaphysis* while *in the first two or three years of life* when the nuclei of ossification are formed it is prevalently situated in the *epiphyses* The differences between the clinical aspects of certain other diseases of early childhood are likewise to some extent due to the same qualities of the bones Thus in adults scurvy is not ordinarily accompanied by involvement of the diaphysis epiphysis border line characteristic of early childhood (Barlow s disease or Infantile scurvy) in early childhood rachitic rosaries and bracelets" are caused by rickets but osteomalacia in adults is not attended by such symptoms in early childhood syphilis leads to the development of osteochondritis on the margin between the epiphyseal cartilage and the bone while in children of a more advanced age and in adults it usually causes periostitis The greater frequency of subperiosteal fractures in infants is due to the greater thickness of the periosteum at this age

Sites of ossification appear in various parts of the skeletal framework of healthy children at a more or less definite time therefore ossification may serve as a guide for the approximate establishment of the child s age (Fig 20) Closure of the epiphyseal lines also occurs at a quite definite age Both things are easily established by radiography (see Chapter XXV)

In children *the bone marrow* occupies the entire bone cavity while in adults it is located only in the metaphyses and epiphyses

All *the joints* of the child articulate much more freely than in adults owing to weakness of the ligaments and muscles

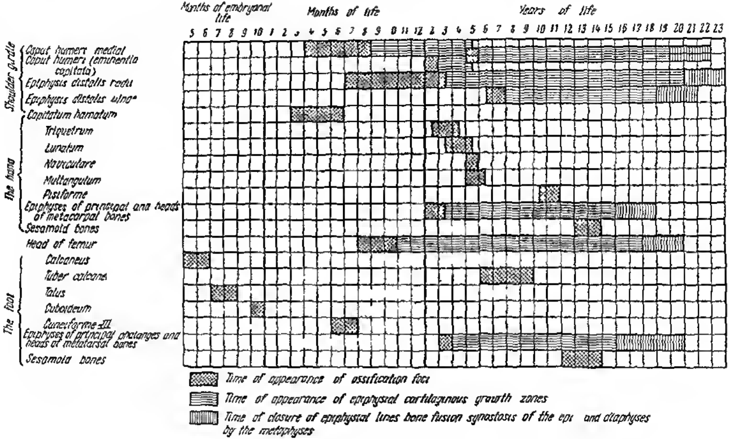


Fig 20 Time of appearance of foci of ossification (after Reinberg)

The Spinal Column and its Characteristics in Childhood

The spinal or vertebral column of the newborn is devoid of the curvatures characteristic of adult structure, in childhood it is almost straight, or, rather, generally convex in a dorsal direction (Fig 21) When the baby begins to hold up his head cervical lordosis appears,

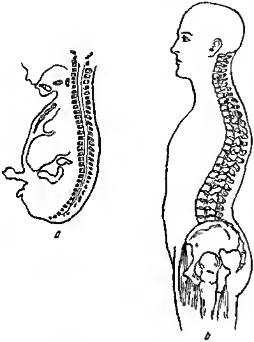


Fig 21 Spinal column of fetus (*a*) and of adult (*b*)

later (in the sixth month), when he begins to sit up, thoracic kyphosis develops, when the child learns to walk lumbar lordosis appears At first these curvatures are not stable, straightening out when the baby is in a recumbent position

Examination and symptomatology During examination of the spinal column attention should be paid to the following things when *observing* the child in the anterior aspect it may sometimes be noticed that one shoulder is higher than the other and one arm is closer to the trunk (when the arms hang freely) than the other, in this case the next thing to do is to establish whether the cause is scoliosis (lateral curvature of the spine) In early childhood marked degrees of scoliosis, as well as of kyphosis, are usually caused by rickets However, the cause may also be tuberculosis of the spine, *spondylitis*, which may likewise produce spinal deformation The distinction between them is that the spinal deformity in rachitic kyphosis is arched, while in tuberculous spondylitis it is angular The curvatures due to rickets are completely, or almost so, corrected when the child is lifted by his legs from a prone position But the aspect and stability of the spinal curvature are not grounds enough for establishing its nature, since angular and stable spinal deformities are also observed in severe forms of rickets In such cases diagnosis is substantiated by other symptoms of the corresponding disease

A spinal curvature of an entirely different origin is frequently observed in children of the school and preschool ages—the so called habitual or schoolroom kyphoscoliosis A similar tendency to spinal deformity, particularly in a sitting position, may often be observed in sick children and during convalescence from more or less severe diseases, and also in weak children whose domestic conditions are bad, in children who do not rest sufficiently, whose chairs and tables at school (or at home) are not suited to their stature, and who do not take enough physical exercise The formation of such habitual and schoolroom kyphoscolioses is due to insufficient tension and poor development of the muscles in general and the spinal muscles in particular, which is in its turn caused by *late rickets and/or faulty management of the child's routine* Therefore *the best preventive and curative agents* are provision of full-value nutrition, sufficient rest and sleep, and proper management of the schedule at school—alternation of classroom work with active games and gymnastics

In addition to lateral and posterior deformities of the spine there may also appear anterior curvatures, *lordoses* Cervical and lumbosacral lordosis is a physiological norm Lordosis is pathological when it is abnormally situated, or is very sharply pronounced The causes of lordosis are rickets and tuberculosis of the spinal column Lumbar lordosis is usually concomitant with double femur dislocation, contractures of the hip joint, and flatfoot, particularly in older children who spend much time on their feet Acute lumbar lordosis is quite characteristic of lesions of the longissimus muscles of the spine caused by poliomyelitis or progressive muscular dystrophy

When examining the spine its *mobility and tenderness* should be noted In early stages of tuberculosis of the spinal column, and also in cases when the lesion is located in sites of normal lordosis no visible deformation (i e , kyphosis) may be present, but the child is very careful of his back when moving The tenderness is established by percussion of the vertebral column

The Pelvic Girdle and Extremities

The pelvis The female pelvis is wider than the male pelvis In childhood these sex distinctions are not manifest, and it is only after the age of six, seven, or even more years that a greater development of the pelvis may be noted in girls When examining the child one should remember about rachitic lesions of the pelvis—rachitic or flat pelvis

During examination of the extremities attention should be directed to joint articulation (contractures, ankylosis, or, on the contrary, increased articulation, as in peripheral paralyses and rickets), to tenderness and pain, bone deformities (almost always of rachitic origin) It should be pointed out that in *the first months of life an apparent bowleggedness may frequently be observed* This is of no pathological value whatsoever and is not associated with true bone deformation, it is due to peculiarities in the development of the soft tissues

It must be borne in mind that during the first months of life flatfoot is normal The feet of babies who have not learned to walk yet are frequently turned in, this is likewise no pathology but simply an age characteristic

The next step in the examination is establishment of the dimensions of *the epiphyses* Large epiphyses with no signs of acute inflammation in the enlarged area are symptomatic of rickets

A pathological condition observed in the vicinity of the epiphyses is *syphilitic osteochondritis*, a distinctive process developing on the epiphyseal line If timely care is not taken this process may lead to separation of the epiphysis from the diaphysis under the effect of even slight trauma, resulting in pseudoparalysis of the affected extremity—*Parrot's disease*. Mostly the distal ends of the femur and, particularly, of the humerus are involved The child is unwilling to make active movements When passive movements are attempted sharp pain is induced

Another important question is that of *pain in the extremities* Pain which is induced by both active and passive movements, which is unstable, and which involves several joints simultaneously, travelling from one joint to another, should evoke suspicion of rheumatism, particularly when the joints are not only painful, but also swollen *Polyarthralgia* of a similar transient nature is occasionally observed in children with tuberculous or chronic toxicoses of tonsillar origin However, the diagnosis of polyarthralgia owing to tuberculous intoxication may only be established after the possibility of a rheumatic origin has been excluded

Polyarthritis may also be caused by infections such as gonorrhea, dysentery, or various cocci In such cases the lymph nodes adjacent to the involved joints are enlarged a contingency never associated with rheumatic or toxicosis polyarthritis

Pain in the legs—usually above and below the knees—is a sign of *flatfoot* and bowleg (genu varum) or knock knee (genu valgum) in children These pains usually appear at night, intensifying when the child has been on his feet a lot during the day The pains are conditioned by anatomic deficiencies in the structure of the joints and are not accompanied by any pain in the arms and hands—a factor of diagnostic value

Young doctors sometimes associate pain caused by polyneuralgia with lesion of the joints or epiphyses This mistake may easily be avoided if the extension of the nerve is investigated

Occasionally intensive pain may appear in the joints and in the muscles owing to various physical exertions

The Skull

In childhood the brain cranium is much more developed than the face bones, in distinction from adults This is due to the absence in babies of teeth which diverge the jaws, and to the immaturity of the nose and the nasal sinuses (Fig 22)

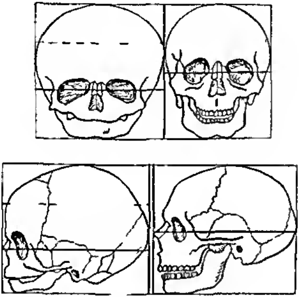


Fig 22 Skulls of newborn and adult depicted in same scale

The skull of a young child is characterized by the following features (Figs 23 and 24) it consists of bones divided by sutures, at the junctions of several bones there are gaps completely devoid of bone *the fontanelles Two lateral fontanelles* are situated on each side of the cranium (1) at the junction of the occipital, temporal and parietal bones and (2) at the junction of the frontal, parietal and temporal bones Normally these fontanelles close in the fetus at term or in the newborn infant during the first days of its life Later their presence is a sign of either immaturity or hydrocephaly *The small* or *posterior fontanelle* at the point of junction of the lambdoid and sagittal sutures is also closed at delivery in the majority of full term infants However, in approximately 20 per cent of the newborn it is still open

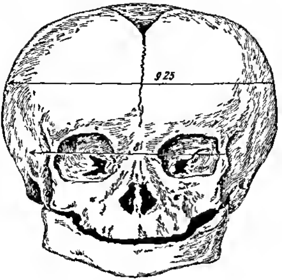


Fig 23 Skull of newborn infant, front view

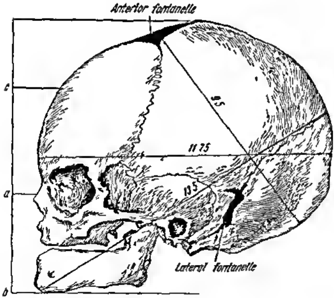


Fig 24 Skull of newborn infant, side view

The anterior or *great fontanelle* (at the junction of the frontal and parietal bones) is present after birth in full term infants normally its dimensions do not exceed 2 5 3 cm The dimensions are established by measuring the distance between the opposite sides of the fontanelle diagonal measurements must not be taken as it is difficult to decide where the suture ends and the fontanelle begins

Subsequently this fontanelle becomes smaller and usually closes between 15 and 18 months of age

The factors that *inhibit closure of the fontanelle* are first of all *rickets* and then hydrocephaly and myxedema. Premature closure is chiefly caused by microcephaly due to underdevelopment of the brain Besides these causes individual qualities are also highly important in perfectly healthy children the fontanelle may sometimes close earlier or later than is usual

Other features of the fontanelle must also be noted normally it breathes —oscillations of its surface concomitant with the child s respiration and pulse are quite clearly visible At the same time the fontanelle does not protrude beyond the level of the skull bones it only conveys a tactile sensation of moderate tension When a baby is afflicted by some febrile condition the fontanelle usually bulges slightly and its pulsation is stronger

When *intracranial pressure is significantly increased* (hydrocephaly inflammatory processes in the cranium) the fontanelle *bulges above the level of the skull bones* its tension increases greatly and its oscillations during respiration and pulsation decrease or disappear It should be remembered that the fontanelle of a healthy baby may become tense and bulge during crying spells

A decrease of intracranial pressure (lowered cardiac activity or general dehydration owing to large losses of fluid through vomiting or diarrhea) causes *the fontanelle to recede* becoming lower than the level of the skull bones the latter in such cases frequently override each other Acute cardiac weakness and dehydration (severe diarrhea and vomiting accompanied by deficient fluid intake) may cause the fontanelle to recede even in the presence of factors that usually induce an increase in intracranial pressure (meningitis) The fontanelle is larger in rickets and hydrocephaly

The sutures between the skull bones are easily palpated in healthy infants only during the newborn period If they are palpated subsequent to this period it is a sign of increased intracranial pressure When the bones of the skull of a healthy full term baby are palpated a hardness is felt over the middle part of each bone at their edges near the sutures and fontanelles the bones are yielding and resilient Resilience of the bones at some distance from the sutures when it seems that the bone is not hard but as yielding as parchment is observed in rickets the term for this condition is craniotabes It is particularly frequent in the occipital and parietal bones Palpation of the skull bones and sutures is done with both hands the thumbs held on the forehead, and the fingers probing the entire surface of the skull Certain age peculiarities of the temporal bone are of some practical value Thus, in children of five or six years there is a suture (fissura petrosquamosa), through which protrudes a connective tissue projection from the cavity of the middle ear to the brain meninges a suture between the mastoid process of the temporal bone and the squamous (posterior) portion of the occipital bone (sutura squamomastoidea) does not close until two years of age in 100 per cent of children, and in 40 per cent it is still present at ten years

The shape of the skull is normally round The deformation seen on the days immediately following birth is usually corrected within two to four days, this deformation is caused by molding of the head during delivery and overriding of the cranial bones permitted by the open sutures and fontanelles

Moreover, a soft, pasty swelling of the presenting portion of the scalp is seen in the newborn *caput succedaneum*—a serosanguineous infiltration of the soft tissues which resolves spontaneously within several days Another type of tumour may appear on the head subsequent to a more serious type of birth injury—*cephalhematoma*, an accumulation of blood between the periosteum and a skull bone which does not cross a suture line, in distinction from caput succedaneum which does A shape of head especially noticeable when

Fig 25 Caput natiforme

Fig 26 Tower head

observed from above is *caput quadratum* the rectangular head of rickets flattened upon the top and at the sides, with projecting occiput and prominent frontal bosses *Caput natiforme* (Fig 25) is only a greater degree of the same deformation of the skull (hot cross bun crown of the head), and it is usually also a sign of rickets *Tower skull* (oxycephaly) (Fig 26) is a frequent sign of congenital syphilis but may evidently be encountered in children not afflicted with this disease The anomaly is caused by premature closure of the coronal or lambdoid sutures and disturbance in the growth of the cranial bones

Pathological smallness of the head (*microcephaly*) is the result of congenital underdevelopment of the brain and early closure of the

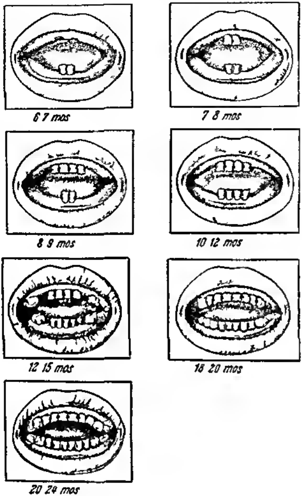


Fig 27 Eruption of milk teeth

fontanelles Enlargement of the head (*macrocephaly*) is observed in rickets and especially in hydrocephaly occasionally it is just an individual trait

The cause of enlargement of the head is determined in each given case by anamnestic data and examination Rachitic macrocephaly is ordinarily accompanied by other symptoms of rickets deformation of the chest bending of the extremities rachitic rosary (beading) muscular hypotonia anamnesis shows that the child was born healthy with a normally proportioned head (differentiation from congenital hydrocephaly) and did not have any acute diseases of the brain (differentiation from acquired hydrocephaly) The presence of hydrocephaly is witnessed by enlargement and tension of the fontanelle, not infrequently by separation of the skull bones pronounced mental backwardness, muscular hypertonia, especially manifested by spasms of the adductor muscles of the thigh

The teeth may as well also be mentioned here, although they are not entirely skeletal organs, however, their development is closely associated with skeletal development and deviations in their growth are frequently due to rickets

The newborn have no teeth or if they do it is only in very rare cases and these teeth soon fall out Healthy babies begin teething at the age of 6 7 months the first to erupt are the two lower central incisors between 8 and 12 months the other six incisors are cut Consequently *a one year old baby should have eight teeth* Between 12 and 15 months the first molars appear, between 18 and 20 months the cuspids, and between 22 and 24 months the second molars (Fig 27) *A two year old child has a full set of primary (deciduous) teeth* (20)

The order of eruption of the secondary or permanent teeth is as follows between 5 and 7 years the first permanent molars appear between 7 and 8 the central incisors, between 8 and 9 the lateral incisors between 10 and 11 the first premolars, between 11 and 12 the second premolars second molars and cuspids, and between 19 and 25 the third molars or wisdom teeth (sometimes the wisdom teeth never erupt at all)

However, occasionally the teeth cut out earlier or later than we have indicated The reason is not always a disease The disease mostly responsible for dentition delay is rickets Severe and protracted diseases such as prolonged and grave nutritional disorders, tuberculosis and other affections have but little effect on teething

Can teething be the cause of any grave systemic disorder?

This question is answered variously Some authors (their number is very small) still hold that teething may condition the appearance of spasms, febrile conditions etc Others consider that teething cannot cause any, even mild, ailments, since the growing tooth does not disrupt the tissue of the gums and such a physiological process cannot induce any systemic symptoms Finally, other authors—they are the majority—admit that in oversensitive children teething may sometimes be the cause of certain transient disorders (restless sleep slight elevations of temperature dyspepsia, etc)

It is of practical value to know what a newly erupted tooth should look like *Normally* there are three small sharp notches on its cutting surface (Fig 28) and the enamel is distributed evenly

The dental pathology worth mentioning here is the condition called *Hutchinson's teeth* observed in congenital syphilis the upper incisors are peg shaped with characteristic V shaped notches along the cut

Fig 28 Normal appearance of freshly erupted incisor two notches on cutting edge

ting edge Such teeth are frequently either larger or smaller than their neighbours

Other types of *dental dystrophy* (irregular situation non uniform size erosions enamel defects) indicate that during its formative period the tooth was affected by some trophic disorder owing to various reasons (syphilis rickets endocrine disorders tetany tuberculosis avitaminosis etc) However these types of dystrophy are of no specific diagnostic value

The Thorax

In the child *the thorax* has a number of singular features From birth and till the child is 1½ 2 years old his chest is barrel shaped its diameters being almost equal Later on the thorax flattens taking on its final shape by the time the child enters school

In the first year of life the ribs are almost at straight angles to the spinal column lying horizontally Subsequently the sternum to which the front ends of the ribs are attached descends so that by school age the front ends of the child s ribs slant downward as in adults Inhalation is difficult for young children owing to the structure of their chest it is effected by letting the diaphragm down while the ribs remain in the position of maximum inhalation

The ribs of young children are soft and resilient, bending easily when pressure is applied to the front and sides of the chest. Therefore a groove or sulcus corresponding to the attachment of the diaphragm—*Harrison's groove*—is quite noticeable during intensified inhalation (caused by nasal obstruction, stenosis, laryngeal spasm, pneumonia or atelectasis), disappearing during exhalation. Harrison's groove may become permanent owing to protracted respiratory obstruction (adenoids, chronic rhinitis) or rickets, when the bones become still softer.

Besides these bone deformations rickets may also be the cause of other deformations of the chest—*pigeon breast*, when the chest seems to be compressed laterally and the sternum and adjacent portions of the ribs become prominent. In cross section we should see an ace of hearts with its blunt point directed anteriorly. Another chest deformity is *cobbler's* (or *funnel*) *breast*, when the sternum, particularly its xiphoid process, is depressed. In cross section it would have the shape of an ace of hearts with its base turned forward.

The basic cause underlying the pathogenesis of these deformities is the softness of the ribs. Another important factor is prolonged obstruction of inhalation.

The growth of the ribs, and, consequently, the form of the chest are regulated by the state of the thoracic viscera. Thus, enlargement of the heart due to congenital or early cardiac defect leads to the formation of *a cardiac hump*—prominence of the portions of the thorax that are situated externally to the heart.

Cardiac hump should not be confused with the thoracic deformities caused by scoliosis.

Cicatrization of a lung associated with an abscess, gangrene, unilateral interstitial pneumonia, or following resection of a lung or its lobes may lead to a flattening of the corresponding side of the chest.

CHAPTER XV

GENERAL HABITUS OF THE CHILD

Prof. *D Lebedev*

Some data on the general habitus of the child were set forth in chapters I and VII, and also in the chapters dealing with the specificity of separate organs and systems In this chapter we consider it important to allot some space to features that were difficult to elaborate on in the above chapters, but which are important for the pediatrician

As has already been mentioned, the process of the child's growth and development does not involve the whole body and all its parts simultaneously and uniformly Some organs grow faster, the development of others is slower Hence the child's habitus (external appearance) is different at different age levels The head of the child is relatively larger than the head of an adult Thus in the newborn it takes up one fourth of his crown heel length while it is only one eighth of adult height

When examining a child attention should be paid to his *facial expression* not only during the first minute, but during the entire examination, the child's reaction to the doctor is also noted Healthy children, even in infancy, look lively and happy Illness produces a pained expression which is retained for a long time Observation of facial expression is an aid in gaining some insight into the mental and intellectual development of the child

When observing the face *the width of the palpebral fissure* should be noted Narrowing of this fissure is associated with drooping of the upper eyelid or with active contraction of the orbicularis oculi muscle (blepharospasm), observed in conjuctivitis keratitis, and other eye diseases accompanied by photophobia The palpebral fissure may be wider than normal owing to exophthalmos or paresis of the orbicularis oculi muscle The eyes of children recovering from some grave disease, or during a disease, may be very wide open owing to hypotonia of the orbiculari oculi Such wide open eyes may also be an individual trait of a healthy child when he is tired

The mouth of healthy children of all ages is closed and the lips are pressed together tightly, both during sleep and when they are awake An always open or half open mouth is an indication of either obstructed nasal respiration (acute or chronic rhinitis, adenoids obstruction of the nose by crusts or blood clots following nosebleed), or of acute mental backwardness (debility) of the child

Fig 29 Adenoid face

Blue rims under the eyes may be due to toxicoses (tuberculosis, helminthoses), or may be signs of the child's weakness of being overburdened by lessons, of insufficient use of fresh air as a result of mis managed schedule Puffiness of the eyelids frequently observed in children in the morning should alert to the possibility of kidney trouble, but it also occurs in healthy children in whom neither the heart, kidneys, nor blood are involved by any morbid process This symptom is evidently the result of some manner of change in the fluid metabolism or of disturbance of capillary permeability

Asymmetric facial expression—intensive contraction of the mimetic muscles on one side of the face, and delayed contraction of these mus cles or their complete paralysis on the other—are symptoms of pa ralysis of the facial nerve Asymmetry only in the lower part of the face indicates central paralysis of the facial nerve paralysis or pa resis of a complete half of the face (both upper and lower branches of the facial nerve) is conditioned by peripheral paralysis

Certain diagnostic value attaches to adenoid face (Fig 29) with its characteristic open mouthed appearance and wide open eyes The

Fig 30 Saddle nose

Fig 31 Normal low bridged nose in infancy

facial expression is also quite typical in myxedema, idiocy, mongolism, tetany (see corresponding chaplers)

The form of the nose should also be noted when observing the face saddle nose (Fig 30) is characteristic of congenital syphilis In infancy syphilitic deformation of the nose must be differentiated from the normal shape of the nose, with its low bridge (Fig 31)

CHAPTER XVI

THE RESPIRATORY ORGANS

Prof *Y Dombrovskaya*

In children the respiratory organs are distinguished not only by smaller dimensions (narrow lumens short windpipe) but also by immature (as compared with adults) differentiation of the tissues and cells comprising these organs Therefore the concept of the dynamics of development of the respiratory organs includes both an increase of components and their differentiation Immature differentiation and smallness of the respiratory organs are responsible for the frequency of diseases of these organs in children and have a great effect on the patterns of the diseases themselves The decisive factor in the clinical course and termination of respiratory diseases in children are the age level peculiarities of regulation of respiration The immature differentiation of the nervous system of young children is unfavourable for the process of nervous regulation particularly important in this regard is the immaturity of the cerebral cortex since it regulates the activities of the respiratory and vasomotor centres

ANATOMY

Upper Respiratory Tract Nose Nasopharynx, Fauces, and Larynx

The nose of very young children is relatively small and short and the same is true of the nasopharyngeal space since the visceral cranium is underdeveloped The nasal passages are narrow in the newborn and during the first months of life the lower nasal passage is almost absent—it is formed only at the age of four years As the bones of the face and the upper jaw grow and the teeth erupt the length and breadth of the nasal passages increase the choanas begin to grow rapidly attaining their complete development by the time the child is three years old The nasal mucosa is very delicate and intensively vascularized, the cavernous portion of the submucosa in the lower parts of the nasal cavity is undifferentiated, developing only by the age of 8 9 years and particularly during puberty The immaturity of the cavernous tissue in early childhood explains the rareness of nosebleed in very young children Nosebleed mostly appears during the period of puberty when the cavernous tissue attains its maximum development Owing to the narrowness of the nasal passages and the abundant vascularization of the mucous membrane even the slightest degree of hyperemia caused by a simple cold leads to constriction of the nasal passages in infants, making it difficult for the baby to suck, and sometimes even inducing acute dyspnea.

The paranasal sinuses are underdeveloped in early childhood The frontal sinus is absent in babies younger than 12 months, it is only delineated after two years, attaining its full development by 12-15 years The maxillary sinuses are present at birth, but they are very small, after the age of two years their dimensions greatly expand The ethmoid sinus is also present in the newborn, but its cells are very weakly differentiated The sphenoid sinus is absent at birth

Owing to the immature development of the paranasal sinuses in early childhood inflammatory processes do not spread from the nose and nasopharynx to the frontal and sphenoid sinuses, and very rarely do they involve the maxillary sinus

The nasopharynx and *the fauces* are directly continuous with the nasal passages The pharynx of the young child is relatively narrow and small. The lymphatic ring surrounding the pharynx is not clearly defined in the newborn both palatine tonsils are situated deep between the arches and when the throat is examined they are not visible before the end of the first year of life Another characteristic of the tonsils in early childhood is that their crypts and vessels are not well defined The low incidence of sore throat in babies during their first year of life is partly due to tonsillar immaturity As the child grows older his tonsils become larger owing to the growth of the lymphoid tissue, the latter attains its maximum development between the ages of 4 and 10 years, while by 14 or 15 years a process of resorption occurs Histologically the tonsils are closely related to the lymph nodes, they most probably have a certain protective function, reacting by hyperplasia of the lymphoid tissue to the penetration of germs, part of which is destroyed, owing, perhaps, to the abundant development of the reticuloendothelial system But part of the germs remain, finding a favourable nutritive medium in the deep tonsillar crypts, occasionally producing chronic inflammation of the tonsils (chronic tonsillitis) with subfebrility and toxicosis Hyperplasia of the palatine tonsils is accompanied by frequent tonsillitis and nasopharyngeal catarrh Clinical observations have shown the association between chronic tonsillitis and a number of diseases (frequent influenza, sore throat, rheumatic fever, etc) Pathological hypertrophy of the pharyngeal tonsil (*adenoids*) frequently obstructs the passage into the choanas and interferes with normal breathing The child breathes through his mouth snores at night his speech becomes nasal his hearing deteriorates The face takes on a characteristic mien (adenoid face) listless expression thick lips open mouth (see Chapter XV)

The child s *larynx* is funnel shaped its passage is narrower than in adults the cartilages are more yielding and delicate the false vocal folds and the mucous membrane are very tender with intensive vascularization The angle between the thyroid cartilages is rounded Prior to three years the shape and dimensions of the larynx are the same in boys and girls after this age the angle of junction between the thyroid cartilages becomes more acute in boys becoming particularly noticeable by seven years After ten years changes characteristic of the male larynx appear in boys In the first 6 7 years of life the glottis is relatively narrow in young children the respiratory portion of the larynx is not well defined its mucosa contains numerous glands The true vocal folds are shorter in infants than in older children to this is partly due the thin voice of children at this age The growth of the true vocal folds is particularly intensive during the first year of life and at the age of 14 15 years after 12 years the vocal folds of boys become longer than in girls

In childhood even not very marked inflammatory processes in the larynx cause respiratory trouble that may turn into true stenosis (croup) owing to the narrowness of the laryngeal passage and the abundant development of lymphoid tissue and blood vessels Heightened nerve reflex excitability in young children is also an important contributive factor

Lower Respiratory Organs Trachea Bronchi and Lungs

The trachea is usually funnel shaped in the first 4 5 months of life and its lumen is narrow The fibrous portion of the posterior wall is wider the walls and cartilages are softer the elastic tissue is poorly defined The trachea grows with the growth of the trunk its growth is most intensive in the first six months of life and then between the ages of 14 and 16 years In the newborn the upper end of the trachea is situated at the level of the 4th cervical vertebra gradually descending to the 7th cervical vertebra (in adults) Vascularization is intensive in the tracheal mucosa the latter is delicate and relatively dry *owing to immaturity of the mucosal glands These qualities of the tracheal mucosa coupled with the narrowness of the passage favour infective inflammatory processes and the easy development of stenosis*

The bronchi The trachea bifurcates into bronchial branches at the level of the 3rd thoracic vertebra in the newborn between two and six years the bifurcation is situated at the level of the 4th thoracic vertebra descending by adolescence to the level of the 5th The right bronchus is a direct continuation of the trachea the left branches off from its side Owing to this anatomic feature foreign bodies (buttons, sunflower seeds, pits) are mostly found in the right bronchus The bronchial passage is narrower than in adults, the elastic fibres are less defined, the cartilages are soft, while the mucosa is extensively vascularized hence inflammatory sites are formed sooner and the bronchial lumens become constricted more easily than in adults

The lungs Two important points in the process of development of the child's lungs are *differentiation* of the separate elements of the lung and *growth of the lung*

As in adults, the basic structural unit of the lung is the *acinus* consisting of a number of groups of alveoli (20 25) and respiratory bronchioles of the 1st 2nd and 3rd orders The interstitial pulmonary tissue of the young child is generally better developed and more vascularized than in adults, its capillaries and lymphatic sinuses are wider As a result, the lung of the child is less airy and more intensively blood saturated than the lung of the adult The lungs of infants and babies are poor in elastic tissue, particularly in the vicinity of the alveoli

The weak development of the elastic tissue is partially responsible for *the tendency of young children to develop atelectasis*, a condition likewise favoured by the limited excursions of the chest Atelectasis is formed with particular ease in the poorly ventilated posterior inferior sections of the lungs (owing to the fact that young babies are in a supine position almost all the time) where circulatory stasis easily develops And it is in these posterior inferior sections that the so called *paravertebral pneumonias* (see Chapter XXV) develop in emaciated children Moreover, faulty elasticity of the lung may likewise be associated with *the pulmonary emphysema that so readily appears in babies* as a result of severe whooping cough, and also the compensatory emphysema accompanying pneumonia

As the child grows the further differentiation of the pulmonary parenchyma resolves into a gradual histological development of all the acinal elements chiefly growth of the alveoli from the alveolar ducts instead of the saccular development characteristic of infants in the first months of life, and growth of the elastic tissue

Growth of the lungs is continuous with growth of the child and it is effected by increase of the alveolar volume *According to N Gundobin, the number of alveoli in the newborn is half of their number in the 12 year old and one third of their number in adults The diameter of the alveoli as defined on a desiccated lung also increases continuously* (from 0 05 mm in the newborn to 0 12 mm in the 3 to 4 year old and 0 17 mm in the 15 year old) *The lung grows most intensively during the first months of life and during the period of sexual maturation The overall volume of the lungs also increases quite rapidly in the newborn this volume is 65 67 ml by 8 years it increases eightfold by 12—tenfold and by 20 years it is twenty times that of the newborn*

The weight of the lungs, according to Gundobin, is $^1/_{34}$th to $^1/_{54}$th of the body weight, by 6 months it doubles, by 1 year triples, and by 12 years it is ten times greater than it was at birth. The weight of adult lungs is twentyfold of their birth weight. The right lung is one-fifth larger than the left.

Boundaries of the Lung and Its Lobes

Lung boundaries	front	Right lung: the IX rib on the axillary line, the V rib on the mammillary line. Left lung: the IX rib on the axillary line
	back	Both lungs at the level of the spinous process of the X-XI thoracic vertebrae
Boundaries of the pulmonary lobes	front	Right lung: above the IV rib the upper lobe, below the IV rib the middle lobe
	back	Both lungs: above the scapular spine the upper lobe, below the scapular spine the lower lobe

The lobes of the lung are divided by *interlobar fissures*: the great or principal oblique fissure separates the right upper and middle lobes from the lower lobe, the small horizontal fissure (fissura horizontalis) divides the upper and middle lobes. On the left lung there is, naturally, only one fissure. In young children the pulmonary fissures are frequently only faintly delineated in the form of notches on the lung surface. Owing to the proximity of the root of the lungs (hilus) a group of lymph nodes protrudes into the principal fissures on both sides, and may become the source of interlobar pleurisy by means of a perifocal process.

The division of each lung into ten segments is at present widely accepted. The doctrine of the segmentary structure of the lungs is very important in x-ray diagnosis, in therapy and surgery of pulmonary diseases.

The hilus of the lung contains the large bronchi and vessels, and also numerous lymph nodes. These nodes are connected with the other lymph nodes in the lungs and they therefore respond with a hyperplastic reaction to any inflammatory process in the lungs. The right hilus is higher than the left, it is situated at the level of the V or VI vertebra, the left hilus is between the V and VII vertebrae (Fig. 32).

The lymph nodes of the lungs consist of the following groups: (1) tracheobronchial, (2) bifurcational (in the bifurcation of the trachea), (3) bronchopulmonary, at the point of entrance of the bronchi into the lungs, and (4) nodes of the large vessels—superior, middle and inferior. The pulmonary lymph nodes communicate with other groups of lymph nodes—the mediastinal, supraclavicular, cervical, thoracic and others. In childhood the pulmonary, as well as all other lymph

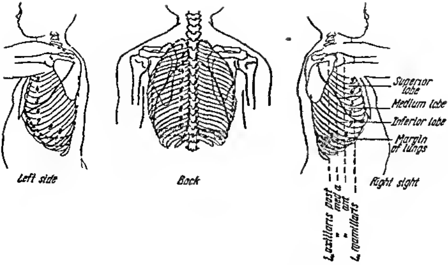


Fig 32 Margins of the lungs and of their lobes

nodes, are characterized by relatively wide sinuses, extensive vascularization weakly defined capsule, and numerous cellular elements All these features favour the development of reactive inflammatory processes The lymphatic systems of the lungs are very well developed in young children, and it is only at the age of 7 9 years that reverse development occurs The lymphatics in the different parts of the lung (pulmonary parenchyma bronchi, pleura) intercommunicate in the lung itself, and the total lymph flow is directed towards the hilus (Fig 33)

The pleura of the newborn and of infants is very thin, and is easily displaced by deep respiratory excursions and by accumulations of fluid The pleural cavity is a closed space included between the parietal and visceral layers of the pleura, and also by two visceral layers in the interlobar spaces The pleural sac is larger than the lungs, it has extra spaces, sinuses (costomediastinal, phrenicocostal) In young children the pleural cavity is extremely extensible owing to slack attachment of the parietal layers of the pleura

Any accumulation of fluid in the pleura of a young child easily provokes displacement of the mediastinal organs because of the tenderness and porosity of the surrounding connective tissue, the first organs to be displaced are the heart and the vena cava inferior Frequently observed acute circulatory disorders occurring in cases of pleural effusions may in part be due to this phenomenon

The presence of an exudate in the right pleural cavity causes displacement of the aorta, trachea large bronchi esophagus diaphragm and liver Consequently, *dextral effusions are more favourable for the development of functional disorders of a number of organs, the dis*

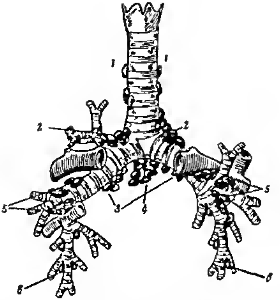


Fig 53 Topography of the mediastinal lymph nodes (scheme of Sukennikov modified by Yesipov)

1—paratracheal nodes 2—superior tracheobronchial nodes 3—inferior tracheobronchial nodes 4—bifurcation nodes 5—bronchopulmonic nodes of the first order 6—bronchopulmonic nodes of the second order

orders depend on altered position and displacement and sometimes also on the compression of the blood vessels of these organs

The mediastinum of children is relatively larger than in adults it is more pliant and resilient It contains numerous vessels nerves lymph nodes All this is loosely held together by a small amount of very porous celluloadipose tissue Anteriorly the mediastinum is restricted by the manubrium and body of the sternum posteriorly by the vertebral bodies (I XI thoracic) inferiorty by the diaphragm and laterally by the mediastinal layers of the pleura It is customary to divide the mediastinum into the anterior and posterior mediastinum and the anterior mediastinum in its turn into the superior and inferior mediastinum However this division is only conventional since all these parts of the mediastinum intercommunicate through *clefts and sinuses The superior mediastinum contains the thymus* which is loosely attached to the sternal manubrium some lymph nodes the trachea bronchi veins the ascending portion of the aorta and the recurrent and phrenic nerves the inferior mediastinum contains the heart pericardium vessels and nerves The posterior mediastinum contains the vagus and splanchnic nerves and part of the esophagus *Knowledge of the topography of the mediastinum is* *highly important in diagnosing the inflammatory processes that easily develop there*

The thorax of a healthy newborn (see Chapter XIV) is convex and relatively short lengthwise, its upper opening points directly upward, the jugular fossa is situated at the level of the VII cervical vertebra

The diaphragm plays an important part in the mechanism of respiration when it contracts its dome flattens, thus increasing the vertical dimension of the thoracic cavity The shallow respiration of the newborn is partly due to weak contraction of the diaphragm *All conditions interfering with the excursions of the diaphragm (intestinal meteorism, swallowed air, liver enlargement, etc) decrease the ventilation of the lungs*

Owing to anatomic features (horizontal position of the ribs, weakness of the respiratory muscles, etc) the respiratory excursions of the thorax of healthy infants are short and very limited, and the lungs do not expand completely during inspiration This explains the appearance of a number of physiological qualities characteristic of the respiration of the newborn

II PHYSIOLOGY OF RESPIRATION IN CHILDHOOD

Investigation of the outer features of breathing are important for determining the degree and form of respiratory failure in diseases of the respiratory organs and cardiovascular system The techniques employed include both simple methods (establishment of the frequency of respiration and of the pulse beat in a quiescent state and under definite physical loads, measurement of the chest and its movements during inspiration, expiration, and at rest, the breath holding test, and spirometry), and of the more complex methods calling for special equipment

The first and most important singularity of children s respiration is its *shallowness*

Depth of respiration, or *the absolute tidal volume* (the amount of air which is inhaled in an ordinary respiration) is much lower in the newborn than in any other subsequent period of life

Absolute Tidal Volume

(in ml) after Broca et al

Age level	
Newborn	15 20
6 mos	35-50
1 yr	60
2 yrs	up to 115
6 yrs	up to 130
11 yrs	160 175
14 yrs	225
Adults	500

The tidal volume increases gradually as the child becomes older, and its increase is quite noticeable when the child is restless The tidal volume is also associated with physical training becoming higher in children who go in for gymnastics and sports

Relative tidal volume (the amount of air inspired in one respiration per kg of body weight) is also lower in children than in adults

Relative Tidal Volume

(In ml)

From birth to 6 yrs	3 6
Adults	6 4

The shallowness of respiration of the newborn does not permit the lungs to expand fully during the first respiratory movements thus conditioning *physiological atelectasis* observed principally in the posterior inferior areas of the lungs The respiration of premature infants is still shallower owing to the specific features of their nervous system—extreme functional insufficiency of the respiratory centre and general immaturity of the nervous system This is why physiological atelectasis is particularly persistent in the premature and evidently favours the onset of pneumonia However notwithstanding the superficial nature of respiration the vital capacity (i e the tidal volume complemental air and reserve air) is relatively large this may in a great measure be explained by the pliancy of the thoracic walls

It is quite difficult to investigate the vital capacity of young children In older children (5 7 years of age) vital capacity is measured by spirometry (the volume of air that can be expelled from the lungs by the most forcible expiration after the deepest inspiration)

Vital Capacity of Different Age Levels

in (ml)

Age	
3 4 yrs	400 500
5 7 yrs	800 1 000
8-10 yrs	1 350 1 500
14 yrs	1 800 2 200
15 yrs	2 500
Adults	3 000 5 000

Vital capacity is higher in boys than in girls particularly in the prepubertal period

Frequency of respiration Since the oxygen requirements of young children are very great (high metabolic rate especially in gas exchange) the superficial nature of their respiration is compensated by frequency—the younger the child the faster he breathes

Age level	*Respirations per min*
Newborn	40 60
1 2 yrs	30 35
5 6 yrs	up to 25
10 yrs	18 20
Adults	15 16

The newborn infant is constantly short breathed—*physiological tachypnea of the newborn* Any disorder of the respiratory organs (rhinitis bronchitis and particularly pneumonia) causes the respiration rate to go up to 60 70 and even more respirations per minute In healthy children of all ages there are $3^1/_2$ 4 pulse beats to one respiration in the newborn $2^1/_2$-3

The tidal volume multiplied by the respiration rate is called *the minute tidal volume* or pulmonary ventilation The minute volume is a characteristic of the aeration of the lungs i e of the absorption of oxygen by the lungs Its absolute value is lower in children than in adults

Age	*in ml*
In the newborn	600 700
During the 1st year of life	1 500 2 000
In the 6 year old	3 000
In adults	6 000 8 000

The relative minute tidal volume (per 1 kg of body weight) is much higher in children than in adults owing to the frequency of respiration

Age	*ml/kg*
From birth to 3 years	200
At 11 years	150
In adults	100

Such a high relative minute tidal volume in children corresponds to the high basal metabolic rate at this period of life

The type of respiration from birth and throughout babyhood is abdominal or diaphragmatic after two years it becomes mixed and subsequently by the age of 8 10 years boys develop a prevalently abdominal type of respiration girls a costal and abdominal type The abdominal type of respiration in young children is conditioned by the limited excursions of the thorax owing to the horizontal position of the ribs the high level of the diaphragm and the large dimensions of the abdominal viscera

Respiratory rhythm is extremely unstable in the first months of an infant s life (a) the pauses between inspiration and expiration are not even (b) deep and shallow inspirations alternate These features are associated with the functional insufficiency of the immature respiratory centre and with the heightened excitability of the vagus receptors in the lungs and of the entire vagal system The same cause underlies the increase and decrease of muscular tension in the bronchi, causing constriction and dilatation of the latter.

The rate of gas exchange in the lungs is more intensive in children than in adults, it is effected by the diffusion of air through the alveoli For the maintenance of normal gas exchange the respiratory process in children as in adults, requires proper functioning of all three phases or stages of respiration (a) external respiration which is understood as the interchange of gases between the atmospheric (environmental) air and the air in the lungs by means of the alveoli (b) pulmonary respiration in which the interchange of gases between the blood and air occurs in the lungs, a process associated with the physicochemical diffusion of gases, (c) internal (tissue) respiration in which the exchange of gases between the systemic blood and tissues occurs

Respiration is *regulated* by the respiratory centre via several routes (1) through the reflex neuromuscular apparatus of the thorax and the system of pulmonary receptors connected with the vagus nerve, through stimulation of the pulmonary tissue caused by inspiration, inducing impulses which are transmitted to the central nervous system centripetally, (2) by a reflex route through the interoceptors of other organs, since the nervous system of the child always displays an integral reaction (3) through changes in the composition of the environmental and alveolar air, as the blood value of carbon dioxide and the concentration in it of hydrogen ions (pH) are an important factor in the regulation of the respiratory centre A close interrelationship exists between the entire mechanism of external respiration and the condition of the circulatory, alimentary, and hematopoietic systems The respiratory centre in the medulla oblongata is subject to constant regulation from the cerebral cortex

The automatism and rhythmicity of the activity of the respiratory centre are connected with the degree of maturity of the cerebral cortex, this explains the arrhythmic respiration of the newborn and the cessation of breathing (apnea) and cyanotic paroxysms in the premature

Because of their narrowness and the softness of the bronchial walls the air passages become constricted owing to the slightest catarrhal swelling The mobility and capacity of the chest are altered by thoracic deformations (rickets), and by marked meteorism which weakens the function of the diaphragm All the above causes tend to decrease pulmonary ventilation and disrupt external respiration The first and foremost cause of external breathing trouble is associated with bad (non physiological) environmental air (unaired or insufficiently aired living quarters)

Pulmonary respiration is just as easily disturbed by the abundance of blood vessels in the lungs and the rapid development of edema of the alveolar epithelium Thus, *oxygen insufficiency (hypoxemia and anoxemia) appears with much greater ease in babies than in older children or in adults*

Blood gas values differ in children and adults (Table 2)

Table 2

Gas Content in Arterial and Venous Blood
(in vol%)

	Carbon dioxide		Oxygen
Arterial blood	Infancy	41	15
	Preschool age	38 6-42 1	13 1-15 0
	School age	37 8-40	12 9 16
Venous blood	Infancy	47	8 3
	Preschool age	42-46	7 8
	School age	42-46	8 11 3

Only by the age of 10 15 years does the gas content attain normal adult values

Any decrease of the oxygen level in the blood is indivisible from oxygen deficiency in the tissues, i e hypoxia and anoxia The association between gas exchange and the acid base balance (see Chapter XXI) is especially close in childhood The air exhaled by the child contains much less carbon dioxide than the air exhaled by adults Respiratory exchange (alveolar ventilation) is the tidal volume multiplied by the number of respirations per unit of time its value does not differ greatly from adult values—4 5 litres in a child and 6 8 litres in an adult This depends on the higher rate of respiration in the child, notwithstanding the lower tidal volume The respiratory quotient, i e , the ratio of the volume of carbon dioxide given off to the volume of oxygen consumed (CO_2 O_2), is 0 7 in the newborn and 0 89 in the adult

The lower quotient in the newborn is associated with high oxygen consumption The rate of gas exchange drops during the hours immediately following birth, beginning with the second day it goes up, and already on the third day becomes normal A drop in the temperature of the environmental atmosphere induces intensification of gas exchange in the newborn, increase of oxygen consumption, and decrease of the respiratory quotient

Generally speaking, gas exchange is in close correlation with the acid base balance The oxygen deficiency that appears so easily in the blood and tissues aggravates the child's condition in pneumonia or diffused bronchitis

Clinical Summary

The above described *anatomophysiological specificities make respiratory conditions more difficult for the child as compared with adults*

The weakness of the excursions of the chest and the position of the ribs at almost right angles to the vertebral column result in incomplete expansion of the lungs and consequently in insufficient ventilation of all its portions particularly of the posterior inferior sections The abundant vascularization of the lungs and the almost constant horizontal position of the very young child are conducive to circulatory stasis in the posterior inferior sections of the lungs Hence the frequency of pneumonias in infants in their first months of life following diseases unaccompanied by upper respiratory catarrhs (paravertebral pneumonia) Insufficient differentiation of the pulmonary tissue particularly underdevelopment of the elastic tissue favours easy formation of atelectasis and this condition in its turn is conducive to inflammatory processes The shortness and narrowness of the windpipe abundant vascularization of its mucosa its tenderness and liability to trauma are conducive to the spreading of inflammatory processes from the upper respiratory passages to the lower therefore insignificant changes induce severe symptoms (stenosis) *All this explains to a certain extent the frequency and severe course of respiratory diseases particularly in babies in their first year of life*

A characteristic of pneumonias of early childhood is that they are generalized conditions of the entire body involving a number of systems (the nervous digestive cardiovascular etc) Environmental conditions (routine domestic conditions) are very important factors in the development of pneumonia in early childhood in so far as they affect the state of the oxidizing processes in the body But the leading part in determining the severity of the disease is played by the nervous system (severe or toxic forms of pneumonia) Thus pneumonias of early childhood are an illustrative confirmation of the principles of the teachings of Ivan Pavlov on the significance of the integral reaction of the organism on nervism and on the role of environment Some still unexplained anatomophysiological features of pulmonary pathology in children are the overwhelming prevalence in early childhood of lobular (bronchopneumonia) over lobar (croupous) forms of pneumonia It is very possible that an important part is also played by other insufficiently studied factors such as allergy for instance

INVESTIGATION AND SYMPTOMATOLOGY OF THE MOST IMPORTANT DISEASES OF THE RESPIRATORY ORGANS

Investigation of the child s respiratory organs consists of *interrogation and objective investigation*

1 Interrogation (we cite only the most important questions the mother is requested to answer) Is there any nose discharge? Does

the baby suck freely? If there is some discharge from the nose, then its nature should be described (admixture of blood, ichorous discharge, transparent discharge, dry rhinitis) Does the child breathe freely through the nose, or is he a mouth breather (during the day, at night)? Is there any odour from the nose? Does the child cough? Of what nature is the cough, if present (barking, hoarse, crowing, paroxysmal, dry, painful, moist)? When is the coughing more frequent, at night or during the day? Is the cough productive of sputum? What is the appearance of the sputum? Does vomiting occur with coughing? Are there any pains in the chest, sides, abdomen? How frequently does the child get upper respiratory catarrhs? Has he had pneumonia? Has there been exposure to tuberculosis or influenza?

2 Objective Investigation of the respiratory organs consists of (1) external examination of the nose, face, neck, and chest, (2) investigation of the respiratory movements, (3) palpation (4) percussion, (5) auscultation, (6) examination of the throat, and, occasionally, of the deeper respiratory passages, (7) laboratory tests, (8) x ray examination

Examination The objective investigation of the respiratory organs usually commences with external examination of the *face*, *nose*, and *chest*

External examination of the face is a means of discovering signs valuable in diagnosing respiratory diseases The first point is *cyanosis*—constant or transient, appearing when the child nurses or cries In babies the cyanosis may frequently be limited only to the triangular area formed by the nose and lips *Dilated nostrils* are an important sign of respiratory difficulty, pointing to disturbance of normal gas exchange

These signs may be enough for diagnosing pneumonia even when the data obtained by percussion and auscultation are not clear (so-called central pneumonia)

External examination of the nose shows the presence of *a nasal discharge*, a transparent, mucous discharge is usually observed in acute catarrhal conditions (influenza, rhinitis), a mucopurulent discharge with admixture of blood (*ichorous discharge*) is characteristic of syphilis and of diphtheria, and in the latter disease the ichorous discharge may appear from only one nostril, a sanguineous discharge *from one nostril may also be due to some foreign body in the nose* (a fruit pit, a seed, a button) A point to remember is that *nosebleed* appears quite easily in preschool agers owing to the tenderness of the nasal mucosa and its abundant vascularization Frequently repeated nosebleed may be a sign of hemophilia or of other manifestations of hemorrhagic diathesis Dry rhinitis accompanied by stertorous breathing in young children may be due to chronic inflammation of the mucosa accompanying congenital syphilis In older children *mouth-breathing*, particularly at night, is a symptom of adenoidal growths, the same is true of snoring during sleep *In the presence of an ichor-*

ous discharge from the nose a thorough examination of the nasal cavity is obligatory This examination often reveals the presence of a membrane on the nasal septum, enabling the pediatrician to diagnose diphtheria prior to the bacteriological investigation The examination is conducted in the following manner a nurse (or the mother) holds the child, wrapped up in a blanket, in her lap, the examiner sits down opposite the child, turns the latter's face to the light tilting the head back and lifting the end of the nose to look into the nasal passages

When the nostrils are blocked by nasal discharge or crusts they are cleaned with a swab of cotton dipped in a 2 per cent solution of boric acid

The throat should be examined last, otherwise the restlessness and crying provoked by this examination will interfere with the investigation

For the above reason external examination of the face and nose should be followed by *examination of the chest* The first things to note are any abnormalities in its anatomy, specifically rachitic deformations, but a more precise determination of these changes are made by palpation Caving of the chest on one side is observed in cases of chronic processes in the lungs accompanied by lesion of the interstitial tissue (chronic pneumonia, tuberculosis), the intercostal spaces are constricted on the affected side of the chest, the shoulder is lower, and the spine deformed, the convex portion of the curvature directed towards the healthy side, emphysema is usually observed on the healthy side owing to compensatory expansion of the unaffected lung

The younger the child the more rapid the constriction of the intercostal spaces and the formation of emphysema, this is prevalently due to the sparsity of elastic fibres in the lungs of very young children

Examination, and still more palpation of *the intercostal spaces* is very important since the protrusion and pastiness of the soft tissues on one side are a sign of the presence of pleural effusion Protrusion of one side of the thorax is seen in pneumothorax its retraction accompanies shrivelling lesions of the pleura The examiner should note the symmetricalness of the movements of the shoulder blades and of both halves of the thoracic cage (lagging of the affected side is characteristic of pneumonia and pleurisy) It is easier to establish lagging of one side of the chest during respiration by placing the fore fingers on the corners of the scapulae

During interrogation and examination the child s *voice, cry* and cough should also be observed

The child's voice is important in judging the state of the upper respiratory tract *Hoarseness* or loss of the voice (*aphonia*) is an indication of lesion of the laryngeal mucosa with involvement of the vocal folds The voice takes on *a nasal timbre* in chronic rhinitis and adenoiditis, retropharyngeal abscess, swelling of the tonsils, paresis of the soft palate (velum palatinum) following diphtheria. A low *harsh* voice is characteristic of myxedema.

The child's cry is also important. It is loud and lusty in a healthy newborn, and is only a feeble whine in the premature or asphyxiated infant. If the baby cries after he has been nursed, but milk is expressed from the mother's breast only with difficulty, he is evidently crying from hunger, however, in this case the precise amount of milk withdrawn by the baby in 24 hours must also be established (by weighing him before and after each feeding). A point to keep in mind is that hungering children pass water infrequently, and in small amounts, and that they are usually constipated. Dyspepsia causes paroxysmal crying bouts several times a day, while in the intervals the child is his usual happy self. This type of crying ceases as soon as the accumulated gas has escaped from the intestine and the bowels have been evacuated. Crying due to painful micturition is characterized by its appearance before the bladder is emptied, and its disappearance as soon as water has been passed. If the child's crying is suspected to be due to this cause urinalysis must be performed and the external genitalia examined (for phimosis or vulvitis). Inflammation in the ear causes the child to cry out suddenly, or to cry harder when the tragus of the ear is pressed, and while swallowing and sucking.

Loud and vigorous crying indicates that the baby is most probably not affected by pneumonia, pleurisy, or peritonitis, since children who have these diseases breathe very guardedly owing to pain during deep inhalations. Monotonous outcries are typical of the onset of hydrocephaly. Loud, periodic cries concomitant with general hyperesthesia and a number of other symptoms may be a sign of meningitis.

When a child cries loudly during bowel movements and is afraid of defecation he is evidently suffering from fissured anus.

A still more valuable diagnostic factor is the type of cough. Not only must the mother be questioned on the nature and duration of the cough, but the examiner must hear it himself. If the child cannot be got to cough voluntarily some artificial method must be used for producing it—irritation of the fauces or pressing the tracheal cartilages. Diagnosis may in some cases be determined by merely hearing a cough characteristic of a certain disease (croup, whooping cough).

Several types of cough are identified.

1. *A harsh, barking cough* that accompanies laryngeal catarrhs is characteristic of true and false croup (croupy cough). *True croup* is laryngeal diphtheria accompanied by the formation of membranes, while *false croup* (or spasmodic croup) is a catarrhal condition associated with the swelling of the laryngeal mucosa (laryngismus stridulus) in the area of the false vocal cords, it occurs in influenza, measles, or some type of chest cold. If the patient has a typical croupy cough the mother must be questioned closely concerning its duration,

respiratory trouble difficulty during inhalation and whether the child has been noticed to awake suddenly at night and jump up in his bed Gradual intensification of the cough with increasing inspiration difficulty is characteristic of true croup A sudden appearance of a croupy cough especially during the night, is mostly observed in cases of spasmodic croup An important thing to know is whether aphonia is present, since this is a symptom of true croup In false croup the voice is hoarse, but no aphonia develops

2 *A tormenting continuous dry cough* accompanies pharyngitis and tracheitis

3 *A moist cough* is symptomatic of bronchitis

4 In pneumonia *the cough is short and painful*, with grunting expirations

5 *A paroxysmal, crowing cough* is characteristic of pertussis (whooping cough) The examiner must find out when the cough first appeared, and whether the paroxysms precipitate vomiting An unmistakable sign of whooping cough in its acute period are the spells or bouts of many coughs one after the other in one breath when the child gets red in the face, and the spell ends in a crowing sound—the whoop, caused by a convulsive inspiration The whooping nature of the cough is sustained for a long time after pertussis and is intensified during any fresh disease of the respiratory tract (influenza) In pertussis the cough is usually harder at night, but other types of coughing are also intensified at this time (owing to close air, or to irritation of the upper respiratory passages by nasopharyngeal discharge in a recumbent position) It is symptomatic of whooping cough for the child to jump up in his sleep during a coughing spell, and in young children the expectoration of mucus In children who have already cut their teeth a fissure in the frenulum of the tongue caused by the incisors during the convulsive coughing is not rare

6 *A bitonal (double) cough* is a spasmodic cough with a coarse basic tone and a louder ringing overtone This type of cough is observed in cases of tuberculous lesion of the bronchial lymph nodes, it is most probably due to irritation of the coughing zone in the area of the bifurcation of the trachea caused by the enlarged lymph nodes

Respiration During the examination the child s respiration is likewise investigated its frequency rhythm the presence and nature of dyspnea, and the participation of the accessory muscles are noted

The respiration rate is counted with the hand placed on the child's chest or abdomen (if the patient is restless, the hand may be placed over the eye), preferably at the same time the pulse is measured, at the very beginning of the examination In evaluating the figures thus obtained all the factors affecting the respiration rate (particularly the child's restlessness or anxiety) must be taken into account *Tachypnea* or *abnormal frequency of respiration* is easily induced in the child by various conditions—anxiety, physical exertions, high temperature, respiratory diseases, diseases of the heart, etc

Bradypnea, or *a decreased breathing rate*, is rarely observed in children (in cases of diseases of the brain, in uremia)

The respiration rhythm is very liable to change in children Particular importance attaches to the Cheyne Stokes type of respiration, characterized by periods of apnea alternating with breathing that is at first very weak, then becomes stertorous, and then again weak (meningitis, other brain diseases, uremia)

A feature peculiar to childhood is a panting so called *"hunted animal" breath* manifested by a high frequency of uninterrupted respirations with deep inspirations, this type of breathing is observed in babies during severe disorders of the digestive organs (toxic dyspepsia), and in older children in a number of toxic conditions (diabetic coma, uremia, meningitis)

Dyspnea, or *shortness of breath*, occurs in children, as in adults, in three forms—inspiratory, expiratory, and mixed

Inspiratory dyspnea is characterized by laboured stertorous inhalation In children it is prevalently due to the liability of the upper respiratory passage to become obstructed (true and false croup laryngeal stenosis, foreign bodies, retropharyngeal abscess) The forced inspiration in dyspnea of this type is effected by vigorous contraction of the sternocleidomastoid muscle and of other auxiliary respiratory muscles

A whistling inspiration and a hoarse barking cough are so typical of croup that the condition may be diagnosed at a distance from the patient Tenseness of the sternocleidomastoid muscles is one of the symptoms of second degree laryngeal stenosis which requires surgical treatment (intubation, tracheotomy) Very significant is the retraction of the supraclavicular and jugular fossae, indicating difficulty in delivering air to the lungs owing to obstruction of the upper respiratory passages or the bronchi (croup, laryngeal edema) When the thorax is soft retraction of the ribs and of the lower tip of the sternum occurs In babies younger than 5 6 months a groove (*peripneumonic groove of Trousseau*) corresponding to the attachment of the diaphragm is usually seen on the anterior and lateral aspects of the chest In older children this groove becomes noticeable either with inspiration difficulties (pneumonia, laryngeal or tracheal stenosis), or when the ribs are too soft and pliant (severe forms of rickets) In rickets the ribs are particularly soft, so that a groove that does not disappear during exhalation (*Harrison's groove*) is usually observed along the insertion of the diaphragm

Various deformations of the spine (kyphosis, scoliosis, kyphoscoliosis) disrupt the normal excursions of the chest, decrease ventilation of the lungs and favour the formation of atelectasis *Rachitic deformations of the thorax have a particular influence on respiration*

In severe forms of rickets the ribs are laterally flattened, while the sternum is prominent—*pigeon breast* Flaring of the lower part of the thorax is also observed in rickets patients All these thoracic deformities decrease the capacity of the chest, restrict normal excursions, and impair pulmonary ventilation, thus promoting the formation of atelectasis and disturbances of pulmonary blood circulation As a result *rickets patients show an increased tendency to the contraction of repeated and protracted pneumonias*

A loud, bubbling, whistling inspiration, *inspiratory stridor*, is quite occasionally present in infants at birth, or it appears somewhat later during the first months of life (*congenital stridor*), it is probably caused by some anomaly in the anatomic structure of the larynx and epiglottis, and by insufficient firmness of their tissues

Expiratory dyspnea is characterized by difficult and usually prolonged expiration performed with the participation of the abdominal muscles This type of dyspnea attends constriction of the smaller bronchi and bronchioles which is caused by an accumulation of mucosal secretion, and also bronchial asthma, when in addition to the difficulty of penetration of air into the alveoli its emergence, owing to bronchial spasm, is just as difficult

A singular type of expiratory dyspnea is the so called *grunting dyspnea* of very young children (under 2 years), with significant enlargement of the bronchial and bifurcation lymph nodes and tuberculous infiltrates in the area of the root of the lungs— *expiratory grunting*" The condition is evidently associated with compression of the lower portion of the trachea and bronchi, so that free passage of air is possible only during inspiration

Mixed dyspnea is accompanied by *both inspiratory and expiratory difficulty* It is seen in lesions of the bronchi, lungs, pleura, diseases of the heart and failure of pulmonary circulation Mixed dyspnea is also observed in children with intensive meteorism, ascites and protruding abdomen caused by rickets The dyspnea should be studied not only while the patient is calmly lying in a recumbent position, but also when the position is changed and when the child cries, since inconsiderable degrees of dyspnea can only be discovered when the child is upset and restless

Palpation Visual examination of the chest is supplemented by palpation by which various pathological conditions may be detected Thus in thin rickety children *knobs*, or *beads* are frequently visible *along the sides of the chest where the bones of the ribs meet the cartilages—a rachitic rosary* In better nourished children this rosary is easily palpated when the finger is drawn along a rib particularly the lower ribs Palpation of the chest is also a means of detecting protrusion of the intercostal spaces and the edema and pastiness of the tissues observed in pleurisy with significant effusion Some authors describe a characteristic change in the skin associated with inflammations in the respiratory passages the skin is thicker (as discovered by pinching) on the affected side of the chest than on the unaffected side, owing to inflammatory edema of the soft tissues Moreover, rales may be detected by palpation, particularly when the smaller bronchi are affected (deep bronchitis) As has already been mentioned, tension of the sternocleidomastoid muscle in diphtheritic croup is a diagnostic factor in evaluating the severity of the stenosis In cases of diphtheritic croup a painful sensation is frequently induced by pressure on the laryngeal cartilages

The investigation of *vocal fremitus* is more difficult in children than in adults because of the weakness of the child's voice and the prevalence in it of thin tones Since it is impossible to get very young children to say the necessary words (seventy-three, seventy four) the presence of vocal fremitus must be detected when the child cries or coughs The establishment of the absence or presence of vocal fremitus (if feasible) is a valuable diagnostic symptom in differentiating a pleuritic exudate from pneumonia Sometimes interrogation and objective physical examination of a baby are indicative of pneumonia, while the localization of the process cannot be established by percussion or auscultation In such contingencies intensification of vocal fremitus on one or the other side of the chest when the child cries indicates where to took for the site of inflammation

Percussion Palpation is followed by percussion *The correct symmetric position of both parts of the thorax* is extremely important, since asymmetry may result in erratic changes in the percussive sounds—a dullness on the concave side A young child should be sitting up during percussion, the mother or a nurse supporting his head without letting him lean against her The patient is placed in a supine position for percussion of the anterior surface of the chest, and in a sitting position for percussion of the back (the tatter operation cannot be performed conveniently when the patient is recumbent, particularly in the presence of dyspnea)

Percussion is done by striking finger against finger, with the fingers of the left hand placed at right angles to the ribs, not along them *Percussion should be very light*, as the child's thorax vibrates very easily, making it difficult to detect changes in the sounds elicited by vigorous percussion *Direct percussion*, i e, striking the chest directly with a crooked finger, is also employed With the latter method the auditory sensation is supplemented by a tactile sensation Percussion is done over symmetric areas on both sides of the chest

Percussion of the lungs elicits various notes (1) *The clear vesicular resonance* contingent upon the existence of normal air containing lung vesicles (2) *Dull sounds of* various tones (a) *slightly dulled* over areas devoid of air (e g, infiltrates), (b) *absolutely flat sounds* over marked effusions (c) *dulled sound with tympanitic overtone* (3) *Tympanitic notes* of various timbres including bandbox resonance (emphysema, pulmonary cavities, pneumothorax)

When performing percussion of the lungs, particularly in babies it should be remembered that *a flatness unassociated with tissue pathology* may be encountered This flatness may be displayed as, firstly, a stable shortening of the sound on the right side under the scapular angle caused by meteorism and the high position of the liver associated with this condition (the liver goes down when percussion is done with the patient standing upright), secondly, the flatness may be due to sound changes depending on enlargement of the tracheobronchial nodes, the root of the lungs, and the thymus, and, thirdly, it may accompany loud crying in very young children owing to inspiratory dilation and extension of the lungs inspiratory percussion notes have a high tympanitic resonance, almost of a bandbox quality, while the expiratory percussion note elicited when the baby cries is flattened.

As regards diagnostic data, it is important to bear in mind that *percussion performed on very young children frequently elicits much less pathology than is actually present.* This is due to the fact that in early childhood pneumonia is prevalently of a lobular nature, with small inflammatory sites that do not at first affect the percussive notes as large infiltrates do. Moreover, owing to the sparsity of the elastic tissue compensatory emphysema develops in the pulmonary areas adjacent to the inflammatory sites with much greater ease than in adults.

Consequently, percussion frequently does not elicit the shortened sound characteristic of inflammatory sites.

In early childhood, particularly when the child is undernourished, *atelectosis* with subsequent inflammation is likely to develop *in the posterior inferior portions* of the lungs, where ventilation is not adequate. Hence percussion of these areas on both sides of the spinal column must be particularly exhaustive (to detect so called *paravertebral pneumonia*). The same applies to the *interscopular spaces* in so far as infiltrative processes in the lung are quite frequently generated in the root of the lung in the area of the lymph nodes.

In the presence of a large pleural effusion in older children a triangular area of dullness on the back on the unaffected side is detected by percussion (*the paravertebral triangle of Rauchfuss* also called *Grocco's triangle*) (Fig. 34). Its apex corresponds to the upper margin of the exudate, one side is formed by the vertebral column the base runs along the lower edge of the unaffected lung, while the hypotenuse descends to the outer rim of the basic line, forming a slightly curved (outward) line.

In older children an area of relative resonance is found in the low back near the spine in cases of pleurisy with significant effusion this area is called *Garland's triangle*. The clearness of the sound is associated with slackening of the pulmonary tissue.

When the effusion is in the left pleural cavity a percussive dullness is detected over *the semilunar space (Traube's space)* on the left anterior portion of the thorax overlying the stomach. This space is closed in from above by the cardiac dullness, below by the costal arch, and laterally by the liver and spleen. In pleurisy with effusion diagnostic value attaches to *the curve of Sokolov Damoiseau Ellis,* a curved line of dullness with its highest point in the postaxillary line, it is contingent on displacement of the lungs towards their root by the effusion

The percussor must strive to establish the precise boundary between the areas of dullness and normal tissue, as the expansion of the dullness is of diagnostic value (a dullness extending beyond the axillary line is characteristic of pleurisy with effusion) Of similar diagnostic

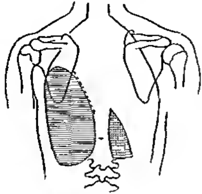


Fig 34

value is displacement of the heart by an exudate, since it is indicative of a considerable exudate

Percussion of the thymus. Although growth of the thymus does not cease until the age of 12-15 years its percussion yields more or less positive results only in children under 5 years of age, as the larger vessels are situated together with the thymus in the sternoclavicular area The percussive notes characteristic of the thymus are a dullness over the body of the sternum, on the left of the upper part of its manubrium, and over the first two intercostal spaces, not extending beyond the edge of the sternum, or extending no more than 0 5 1 cm to the left In cases of pathological enlargement of the thymus the dullness is predominant over the body of the sternum

Percussion of the bronchial lymph nodes. When conditions are normal the tracheal and tracheobronchial lymph nodes are not found by percussion, pathological enlargement of the nodes and changes in their consistency are determined by a number of diagnostic symptoms the most important of which we set forth below

1 *Koranyi's sign* a percussive dullness elicited by tapping the fingers over the spinous processes of the vertebral column, beginning with the IV thoracic vertebra and lower, indicating enlargement of

the bifurcation nodes, enlargement of the tracheobronchial nodes produces a dullness above the IV thoracic vertebra, when the bronchopulmonary nodes are enlarged a paravertebral dullness is detected on the level of the III V thoracic vertebrae, and also in the axilla

2 *Geibner's sign* enlargement of the bronchial lymph nodes causes percussive dullness and bronchial respiration in the area of the sternal manubrium

3 *D'Espine's sign* whispered voice sounds and bronchial respiration are heard in the spaces between the VII cervical and IV-V thoracic vertebrae along the spinal column

Diagnosis of bronchial lymph node enlargement is easier to establish in children than in adults owing to the lesser dimensions of the thorax and the greater reactivity of the lymphoid tissue, however, *it must be borne in mind that the above signs have only a relative value*

Auscultation. Auscultation of children's lungs is usually done by means of a *binaural stethoscope* (with two rubber tubes for conducting the sounds to both ears), an ordinary stethoscope (preferably a wooden one), or by the direct application of the ear to the patient's skin The stethoscope with rubber tubing calls for a certain degree of skill, it is especially convenient for auscultating restless young children and patients with infectious diseases When *an ordinary stethoscope is used close contact with the skin should be ensured by pressing its bell with the left hand* An ordinary stethoscope is more suitable for auscultation in cases of pleurisy, since the decreased respiration or fine sounds arising from friction of the pleura may not be detected owing to the length of the tubing of the binaural stethoscope The use of a phonendoscope is not advisable, since friction of the diaphragm of the instrument over the skin, coupled with lack of experience in the examiner and restlessness of the patient, may give rise to extraneous sounds Direct auscultation with the ear elicits extremely valuable data (sound of pleural friction), but some areas are unsuitable for such auscultation (the axilla the supraclavicular area) Direct auscultation is not employed in cases of infectious diseases

Auscultation, like percussion is more convenient to perform when the patient is sitting and, when very young, with his arms spread wide However, patients who are very ill may be auscultated in a recumbent position, since position is not as important in auscultation as in percussion Normally auscultation of a child should detect vesicular breath sounds, harsher and more exaggerated than in adults—*puerile respiration* This specificity of children's breathing is due to better conductivity of the thoracic walls, narrowness of the bronchi and shortness of the trachea Puerile respiration becomes quite distinct in children older than two years *In the first year of life the respiratory sounds seem feeble owing to sluggish participation of the muscles and shallowness of respiration*

Crying disturbs an inexperienced examiner during auscultation particularly if the child cries incessantly, without making deep inhalations But generally speaking, crying is an aid to investigating vocal fremitus and establishing the nature of the respiratory sounds and rales, since it promotes deep inspiration *Still, auscultation of the child when he is in calm state and breathes normally yields the most valuable information* (bronchial respiration, discrete rales) In cases when it proves impossible to get a small child to inhale deeply or cough tickling or pressing a finger lightly on the trachea may be resorted to

Auscultation is done over symmetrical sites on both lungs Attention should be concentrated on the following area (1) *the axillae*—early appearance of bronchial respiration in lobar pneumonia (2) *the paravertebral spaces*—frequent localization of bronchopneumonia in babies (3) *the space between the spinal column and scapulae* (area of the root of the lungs—onset of pneumonia and tuberculous infiltrates)

During pathological processes in the lungs the same changes as occur in adults are detected by auscultation but certain specific features are found in children

Breath sounds 1 *Bronchial respiration* is particularly clear in cases of infiltrative processes in the lungs (pneumonia, tuberculosis, pulmonary infarct), and also when the lung is compressed by an exudate and considerably enlarged bronchial lymph nodes

True bronchial respiration is not always auscultated during pneumonia in young children, *bronchophony* is more frequently found over the areas of inflammation The condition is associated with absence of focal condensation of the pulmonary tissue, since focal or lobular pneumonia is prevalent in early childhood

2 *Decreased vesicular respiration* and even its disappearance is observed in pleurisy with effusion It must be remembered that even when the pleural effusion is considerable breath sounds with bronchial overtones may still be detected in children, but vocal fremitus is decreased Another point to bear in mind is that *decreased breath sounds combined with painful inspiration* are characteristic of dry pleurisy, rib fractures, myositis, appendicitis and peritonitis The breath sounds may also be decreased by the presence of tuberculous infiltrates

3 *Amphoric respiration* Is very rare in children (lung caverns and other cavities)

Rales Pathological processes in the lungs generate rales of various types Owing to the vibratory qualities of the chest a distinct tactile sensation of the rales may be obtained in some cases by placing the hand on the chest The rales are mostly heard at the end of an inspiration therefore it is important to get the child to breathe deeply.

Dry whistling, loud rales of a transmissive nature are heard in laryngitis pharyngitis, bronchitis, emphysema in a number of bronchial lesions accompanied by exudation and constriction a drawn-out expiration and diffused rales are heard (asthma, bronchitis), the sibilant rales of bronchial asthma are heard from a distance

Moist rales of various force are auscultated in bronchitis, bronchopneumonia, and pulmonary edema Fine, clear rales indicate congestion of the pulmonary tissue, in such cases percussive dullness and bronchial respiration may be absent

It must be remembered that in the first months of life rales are detected with great difficulty owing to the feeble excursion of the chest Coughing and crying are in such cases diagnostic aids of considerably greater value

Pleural friction rub is auscultated as in adults

It must be pointed out that it is more difficult to detect a pleural exudate in a child than in an adult, as *complete cessation of respiration is rare* in older children decreased vesicular respiration is heard over the area of dullness in younger ones—bronchial respiration, or even bronchophony is detected, but dulled, as if coming from some distance.

Diagnosis is aided by physical observation (chest lag on the affected side), by palpation (flattening and protrusion of the intercostal spaces), by presence of the paravertebral triangle and also by disappearance of Traube's space in cases of left side pleurisy and cardiac displacement in children Heart displacement occurs more rapidly in children than in adults owing to the greater mobility of the mediastinum *In diagnosing a pleuritic exudate the most important symptom is absolute dullness of the breath sounds*

In early childhood suppurative pleurisy as a complication of pneumonia is more frequent than at subsequent ages When there are large accumulations of pus in the pleura chest tag on the affected side is already detected by objective observation, the skin is often edematous, and the intercostal spaces are flattened Even in the presence of a considerable exudate both bronchophony and moist although dulled, rales are heard Traube's space remains free in infants Consequently, *when diagnosing exudates more data are to be obtained by objective examination and percussion than by auscultation*

In the same manner auscultation and percussion of the child are frequently of small diagnostic value in cases of lesion of the lung tissue Importance is attached not only to the data obtained by percussion and auscultation but also to the external aspect and state of the child Thus, the detection of dry rales alone in the presence of dyspnea and obliteration of the margins of cardiac dullness due to emphysema of the anterior margins of the lungs, in association with the general aspect of the child, is frequently enough for diagnosing pulmonary lesion

The fauces Examination is commenced by investigation of the mucous membrane, the uvula, arches, and tonsils The child should be seated in a suitable position (his condition permitting) the nurse or mother seats the child wrapped to the neck in a blanket, in her lap, restrains his legs between her knees, and presses the child closely to her chest (Fig 35)

The child should face the light The examiner sits facing the child, fixates his head with the left hand, and with the right inserts a tongue blade into the patient's mouth, pressing firmly on the root of the tongue to make him open his mouth wide At times the child s nostrils have to be compressed to force him to open his mouth for breathing Should the child clench his teeth tight the tongue blade may be passed along the inside of the cheek to the place where the teeth end and thus be inserted into the oral cavity When the child opens his mouth a thorough examination of the oral cavity (mucous

Fig 35 Examination of the throat

membrane, teeth, tongue) is first made, and after that the tonsils and throat are examined Normally the faucial mucosa is smooth, shiny, bright pink Certain conditions affect it in a characteristic manner *a uniform fiery redness of the entire fauces and soft palate is symptomatic of scarlet fever, a red, infiltrated, uneven surface of the mucosa of the posterior surface of the throat is typical of pharyngitis which frequently generates a persistent cough, redness of the uvula and of the palatine arches is observed in influenza,* mucus on the posterior wall of the throat is an indication of chronic naso pharyngeal catarrh

The tonsils of children are sensitive organs that react to the pen etration of many infections Inflammation of the pharynx, fauces and tonsils—sore throat—is scientifically termed as pharyngitis, ton sillitis, or angina

In addition to having a generalized constitutional effect *sore throat* also causes breathing and swallowing difficulties and the enlargement of the cervical lymph nodes The following forms of sore throat are recognized (1) *catarrhal pharyngitis* or *acute angina* in which there are redness of the throat, swollen tonsils, pain on swallowing, (2) *lacunar tonsillitis* in which the crypts are patched with whitish elongated films, (3) *follicular tonsillitis* in which the crypts are involved and their contents project as yellowish white spots from the surface of the tonsil, (4) *diphtheritic pharyngitis* (suffocative angina, angina membranacea) which is characterized by the formation of a dirty-grey membrane or film over the mucous membranes of the nose and throat, and a fetid odour from the mouth (symptom of diphtheria), (5) *necrotic angina* (seen in scarlet fever), characterized by firm greyish membranes covering the tonsils, (6) *ulcerative fibrinous tonsillitis*, or, in Soviet medical terminology, *Simanovsky Rauchfuss angina*, (7) *gangrenous angina*, (8) *quinsy*, or *phlegmonous tonsillitis* is a tonsillar abscess with unilateral swelling of the tonsils and tonsillar arches and spasm of the masticatory muscles making it impossible to open the mouth A specific form of this type of sore throat is *retropharyngeal abscess* or *inflammation of the lymph nodes in the retropharyngeal space* which is accompanied by obstruction of nose-breathing, nasal voice, inspiratory dyspnea, excessive purulent nose discharge, and swelling of the posterior wall of the pharynx In addition to visual examination this condition calls for *palpation in order to establish swelling of the posterior wall of the pharynx and fluctuation* Enlargement and porosity of the tonsils are observed in cases of frequently recurring faucial catarrhs and in exudative diathesis Adenoidal enlargement is determined by a laryngologist but the pediatrician must know the most salient symptoms difficulty in breathing through the nose, snoring during sleep, half open mouth characteristic pinched facial expression, and considerable adenoidal growth

Investigation of the nasopharynx is extremely important in respiratory diseases A red, infiltrated mucosa secreting excessive mucus may be the source of a persistent cough in the absence of lesion of the deep respiratory passages Blood in the sputum may be due to blood passing from the nose to the posterior wall of the pharynx Swelling and fluctuation of the posterior wall of the pharynx (retropharyngeal abscess) may be the cause of inspiratory dyspnea Differential diagnosis between true and false croup is established by the presence of a characteristic grey film on the tonsils, palatine arches and posterior wall of the pharynx in diphtheria

Laboratory tests Usually children younger than six years do not cough up their sputum but swallow it The sputum is discharged with spasmodic coughs (whooping cough), or when the cough is of long standing (bronchiectasis) Therefore sputum to be tested is collected from the fauces, irritation of which causes the child to cough The feces and fasting stomach content (obtained by a stomach tube) are used for demonstrating tubercle bacilli and elastic fibres

The same types of sputum are seen in children as in adults *mucous sputum*, *purulent sputum* (in ruptured pulmonary abscesses) and *mucopurulent sputum* *Rusty sputum* (coloured by decomposition products of blood, typical of lobar pneumonia in adults, is rare in childhood, and is encountered only in older children But blood is quite frequently seen in the sputum (nosebleed, bleeding of the gums) In bronchiectasis an excessive quantity of sputum is secreted, and it has a characteristic offensive odour A foamy, coloured sputum is characteristic of lung bleeding Diagnostic pleural puncture and examination of the exudate are done according to general rules

Special investigations of the respiratory organs *Laryngoscopy and bronchoscopy* are resorted to when the presence of a foreign body or of an inflammatory process in the larynx or bronchi are suspected Notwithstanding the narrowness of the respiratory passages experienced otolaryngologists make wide use of these methods In pediatric practice bronchography is used for precise determination of the localization of bronchiectatic lesions prior to surgical intervention

Spirometry is the generally accepted method for investigating external respiratory function, the spirometer or gasometer is an instrument by means of which the vital capacity of the lungs is measured Before the investigation the child is told to exhale as much air as he can, and then inhale as deeply as possible, after which he exhales as forcibly as he can into the spirometric tube, the air thus expired defines the vital capacity of the lungs Spirometry is employed in mass medical examinations of schoolchildren before they leave for summer camps and upon their return from there Vital capacity increases with improvement of constitutional nutrition and of erratic posture (lordosis scoliosis, kyphosis), and it may serve as an indice of successful health promoting activities, together with weight and height gains and increase in chest circumference

CHAPTER XVII

THE ORGANS OF BLOOD CIRCULATION

Prof *D Lebedev*

PRENATAL BLOOD CIRCULATION

The lungs do not function prenatally therefore arterial blood containing oxygen and other nutritive substances is delivered to the fetus from the placenta through the umbilical cord The latter consists of the umbilical vessels embryonal connective tissue and an external amniotic sheath the umbilical vessels are two arteries along which venous blood flows from the fetus to the placenta and one vein which conducts the arterial blood from the placenta to the fetus

The umbilical vein carrying arterial blood from the placenta passes through the umbilical ring and reaches the lower border of the fetal liver branching out to the liver and portal vein and then as the duct of Arantius (ductus venosus) it joints the inferior vena cava (after birth the ductus venosus is obliterated becoming Arantius ligament while the obliterated umbilical vein is represented by the round ligament of the liver)

The inferior vena cava contains mixed blood arterial blood from the umbilical vein (delivered via the ductus venosus) and venous blood from the lower part of the body and from the liver The mixed blood flows from the inferior vena cava to the right atrium a special structure the eustachian or caval valve diverts the principal current from the right ventricle shunting it through the fetal foramen ovale into the left atrium

From the left atrium the blood runs into the left ventricle then to the aorta from whence it is carried to all the parts of the body the blood returns to the placenta through the umbilical arteries (Fig 36)

The right atrium also receives blood from the superior vena cava this blood is completely venous and it comes from the upper part of the body From the right atrium it flows into the right ventricle and from there into the pulmonary artery However since the lungs are in a collapsed state and do not function only a negligible amount of blood is delivered by the branches of the pulmonary artery to the lungs while the main mass is shunted from the pulmonary artery through Botallo s duct (ductus arteriosus) to the descending portion of the aorta i e it flows into the systemic circuit

Consequently the upper part of the body receives blood with a higher oxygen level than the lower part

Obliteration of the umbilical vessels commences with growth of the endothelium and connective tissue the muscular fibres of the vascular walls undergo degeneration and atrophy the elastic tissue either disappears or undergoes hyalin degeneration The process of obliteration usually terminates 6-8 weeks after birth sometimes later by 10 11 weeks The umbilical vein with its ductus venosus turns into the round and Arantius ligaments of the liver and the umbilical arteries into the vesicoumbilical ligament Obliteration of Botallo s duct begins directly after birth just as soon as the difference between the pressure in the aorta and in

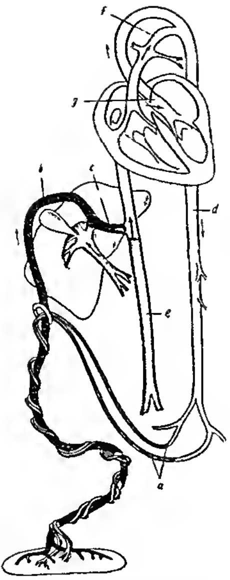


Fig 36 Fetal circulation

a — umbilical arteries, *b* — umbilical vein,
c — duct of Arantius (ductus venosus) *d* — aorta,
e — vena cava inferior, *f* — Botallo's duct (ductus arteriosus)
g — foramen ovale

the pulmonary artery falls to zero contraction of the muscular fibres occurs and then follows an extensive growth of the connective tissue in the internal vesicular wall

Closure of the foramen ovale in the septum between the atria is in most cases complete by the time the baby is between five and seven months old however *incomplete closure of the oval opening is no obstacle to normal circulation and* provokes no noticeable disorders in cardiac activity during life

ANATOMY AND PHYSIOLOGY OF THE CIRCULATORY ORGANS IN CHILDHOOD

The heart and blood vessels retain throughout childhood certain anatomic features that are reflected in the functional powers of the heart and in its pathology

The heart The entire *bulk of the heart is relatively greater in children than in adults* In the newborn the weight of the heart is 0 9 per cent of body weight while in adults it is only 0 5 per cent Newborn infants have 5 5 g of cardiac muscle per kg of body weight at the age of 13 16 years the proportion is 4 5 g/kg in adults it is only 4 g/kg

The initial weight of the heart (17 24 g) doubles approximately 6 7 months after birth triples between one and two years increases fourfold in the fifth year of life sixfold in the tenth year and elevenfold by 16 years of age

Thus we see that *increase in the heart weight lags behind increase in body weight* The energy of cardiac growth is higher in the first year of life between 7 and 14 years it slows down and again increases at puberty—i e cardiac growth is subject to the general laws of bodily growth

A comparison of the growth of the right and left parts of the heart shows a considerable right heart lag This lag becomes manifest when cardiovascular stress grows as for instance in pneumonia—in this disease the right heart is fatigued first

Both the growth of the different parts of the heart and other cardiac changes (cessation of placental circulation closure of the foramen ovale and of the ductus arteriosus motor development) are associated with the demands made on cardiac activity during life

The histological features of the cardiac muscle of newborn and nursing infants are specified by the slenderness of the bundles of muscular fibres and by their closer congregation The poorly developed connective tissue between the muscular bundles has a fine fibrous structure and is devoid of adipose cells The muscular cells of newborn and nursing infants are shorter and much thinner than the cells of adults and the cross striation becomes distinct only after one year of age The muscular cell nuclei have an elongated oval configuration with time they become longer gradually approaching the rod shape form of adults The total amount of nuclei is greater than in adults The elastic tissue in the atrioventricular orifices is poorly developed the younger the child the more abundant is cardiac vascularization and the lymphatics of the heart are also more defined in children than in adults The nerve ganglions are not fully developed Their differentiation ends by the age of 10 12 years

The blood vessels *The arteries of the child are relatively wider than in adults*, i e , as the individual grows older the arterial lumens become relatively narrower At the same time the capacity of the heart shows a relatively greater increase than that of the arterial lumens By the period of sexual maturation heart capacity increases almost twelvefold, while the circumference of the aorta is only tripled The left venous orifice is always smaller than the right

The capillaries are particularly wide in infancy In this period the width of the capillaries of the lungs, kidneys, skin, and intestine is absolutely greater than in subsequent periods of life

Contrarily, *the veins* of young children are relatively narrow, the diameter of their lumens is approximately the same as the diameter of the arterial lumens while in adults the lumens of the veins are twice as wide as the lumens of the arteries

A feature of the cardiovascular system in childhood is its *lesser impairment by use*, owing to the absence of a number of chronic infections and intoxications (nicotin alcohol etc).

The above explains the higher functional abilities of the child's heart as compared with adults (see further below)

Physiological features *The pulse* The rate at which the heart contracts in children is relatively high With time it becomes lower

Pulse Rate at Different Age Levels (per minute)

First 2-3 mos	140 120
7 12 mos	130 100
1 2 yrs	90 120
3 5 yrs	72 110
6 7 yrs	70 80

The schematic average norm is

Newborn infants	140
5 6 year olds	100
Older than 5 6 yrs	80 90
Adults	70 80

One respiration is accompanied by 3 5 4 heart beats The child's pulse rate is subject to marked oscillations as it is affected by crying restlessness, motor activity ingestion of food

Arterial pressure is relatively low in infants owing to the lower pumping force of the heart and the greater width of the vessels and also to the greater elasticity of the arterial walls Moreover arterial pressure is acutely affected by the heightened reflex excitability inherent in children at this age level

The method employed for measuring arterial pressure is the same for children and adults, the only difference being in the dimensions of the cuff used for compressing the arm

Data reported by various authors show the maximum blood pressure of newborn infants to be 66 76 mm mercury column, the minimum is 34-36 mm, in one year-olds the values are correspondingly 90 100 mm and 58 mm mercury column

According to V Molchanov, *the maximum arterial pressure in child hood is 80 plus the doubled number of years of life* Minimum pressure, as in adults, is from two thirds to one half of the maximum

Actually, however, the increase in blood pressure proceeds by un even jumps, and the weight of the child has also to be taken into account

Between the ages of one and four years arterial pressure is subject to little change, between six and ten years a more intensive increase is observed, with subsequent slowing down up to the period of sexual maturation when a new intensification in the increase of blood pressure commences The measurement of the arterial pressure of in fants is technically difficult

Of recent years the measurement of *mean arterial pressure* (see below) has been introduced into clinical practice

Clinical Summary

Blood circulation conditions are more favourable in children than in adults, the work capacity of the child's heart is generally higher A number of Soviet scientists (Kulyabko, Osinovsky, and others) have succeeded in inducing an infant heart to beat again after 9 to 30 hours following death, by passing Ringer s solution through it, a thing unfeasible with adult hearts Clinical observations also confirm the greater endurance of the heart in children For instance, during lobar pneumonia acute heart failure is less frequent among children than among adults, the critical subsidence of fever in acute infections in children is less frequently attended by collapse This is due, first of all, to the greater bulk of the heart, secondly, to the greater width of the vessels—consequently, to a lower resistance to the pumping power of the heart (arterial pressure is lower), thirdly, to the absence of a number of chronic infections and intoxications (nicotin, alcohol), and, finally, to the width of the capillaries, creating optimal conditions for nutrition of the growing organism

However, the width and abundance of capillary vessels in the organs favour congestion of the blood and microbial sedimentation For instance, one of the causes of the greater frequency of pneumonia (particularly of interstitial pneumonia) in infancy is the abundant vascularization of the lungs And this vascularization is also responsible for the localization in early childhood of acute osteomyelitis, in the epiphyses instead of the diaphyses

The cardiovascular system cannot be considered in isolation from the other systems of the body Its functions are in close interconnection with the activity of the entire organism—with the respiratory apparatus, the excretory organs, the composition of the blood, and the level of the diaphragm Communication is effected by sensory end organs situated in the vascular walls, these nerve endings are stimulated by changes in the chemical constituents of the blood (chemoreceptors), in arterial pressure (pressoreceptors), etc The interoceptors, upon receiving stimuli, forward them to corresponding nerve centres, and the latter send their impulses to the cardiac muscle These centres are also connected with the higher cortical formations It has been proved experimentally that the rate of the heart beats may be altered by the conditioned reflex influence of the cerebral cortex

The peripheral nerve conductors effecting cardiac innervation are the sympathetic and vagus nerves The development of the extracardiac nervous system is not complete at birth—the function of the sympathetic part is adequate, while that of the vagus is immature The function of reflex regulation of cardiac activity by the vagus nerve and its correlation with the sinocarotid area appears no earlier than at the age of $2^1/_2$ years, when the therapeutic effect of digitalis and respiratory arrhythmia may be observed in children Complete formation of the innervational apparatus of the heart occurs by the age of 7 8 years

Besides the inhibitory and stimulating nerves of the heart there also exist fibres affecting the force of cardiac contraction and of excitability and conductivity of the cardiac muscle The neural sensory organs in the heart also exercise a trophic function

Many details have still to be clarified concerning neural regulation of cardiac activity and vasomotorial functions in children especially in regard to infancy and the pubertal period

INVESTIGATION OF THE CARDIOVASCULAR SYSTEM AND SYMPTOMATOLOGY OF ITS MOST COMMON DISEASES

Before proceeding to the clinical study of the cardiovascular system it must be stressed that heart lesions have a drastic effect on the development and general state of the child, and on other organs and systems It is therefore imperative, when investigating the heart, to note statural and developmental backwardness (especially in cases of congenital or early heart lesions) the condition of the skin (cyanosis and edema), coldness of the extremities the general aspect of the extremities (clubbing of the digits), dyspnea, the liver condition, the function of the kidneys, etc Only by exhaustive investigation of the entire bodily system can a proper idea of the condition of the cardiovascular apparatus and its functional properties be gained

Clinical investigation of the cardiovascular system includes *interrogation and general physical examination*

In pediatric practice interrogation is much less productive than when dealing with adults Young children seldom complain of heart palpitations or pain In the heart The mother must be questioned concerning the time when the cyanosis first appeared its stability and intensification periods acceleration of heart rate when the child is bathed the time of appearance of the edema and whether the child can run as well as his playmates do

General physical examination consists of (1) physical examination (2) palpation (3) percussion (4) auscultation moreover, in some cases more delicate methods of special investigation are employed (roentgenoscopy sphygmo and electrocardiography)

Physical examination *Attention is concentrated on the shape of the thorax pulsation and cardiac impulse*

Severe lesions of the heart concomitant with its enlargement cause changes in the *configuration of the chest* represented by a bulging of the cardiac area—cardiac hump and *retraction of the cardiac area* a condition observed in pericardial fusion with the thoracic wall or displacement of the heart following long standing pleurisy Retraction in association with apical systole is observed in cases of obliterating pericarditis—so called *negative cardiac impulse*

Visible *pulsation* in addition to the apical area of the heart may be observed adjacent to the xiphoid process of the sternum in the substernal area and in the second or third intercostal space Pulsation in the substernal area is normally detected (low diaphragm) in children with a wide and short thorax it is patholog cal when it is the result of the enlargement of the right heart and its displacement At times pulsation in the substernal area is associated with pulsation of the aorta for instance in cases of failure of the aortal valves which is usually accompanied by pulsation of the cervical vessels as well

The cardiac impulse In childhood the position of the heart in the thorax is not quite the same as in adult life The high standing of the diaphragm causes the long axis of the heart to assume a less upright position in which its lower end is raised and displaced to the left This is why *the cardiac impulse in young children is detected in the fourth (instead of the fifth) intercostal space lateral of the mammillary line* As the child begins to walk and his diaphragm descends the heart also descends pivoting slightly to the median line the long axis becomes more upright approaching its adult position

The cardiac impulse shifts downward and medially by the age of 5 7 years it is already felt in the fifth intercostal space on the mammillary line In infancy the heart beat is frequently not so much seen as felt partly owing to its weakness and partly to the narrowness of the intercostal spaces Median position of the heart may be suspected if the beat is most distinct in the substernal area of a young child while the heart sounds are clearest over the sternum and the absolute cardiac dullness extends beyond the right margin of the sternum If the heart of a healthy child is displaced still further to the right, and the heart beat is palpated near the right margin of the sternum the possible displacement of the liver and spleen must be investigated (*situs inversus viscerum*)

In young children a diffuse, strong impulse may be the result of a congenital heart defect The tendency to develop cyanosis following the slightest cause (a light cough, crying) is still further confirmation of congenital heart disease, although no cardiac murmurs may be detected

Displacement of the cardiac impulse to the right is also contingent with right side lung collapse, left side exudative pleurisy, pneumothorax, tumours and echinococcosis of the left lung, thoracic deformation (pigeon breast, funnel breast), displacement outward and downward is observed in pericarditis and cardiac hypertrophy, upward displacement is a sign of ascites, meteorism, and of other factors that lift the diaphragm

Diffusion and intensification of the heart beat are associated with physical exertions and mental stress intoxications, or heart lesion; it is seen in children with unbalanced nervous systems and is frequent in the pubertal period and in anemic conditions However, cardiac failures and hypertrophy of the left ventricle are associated with a continuous strong resistant, elevated impulse, while its intensification is transient and jerky in neurotic children

Expansion and weakening of the impulse are observed in acute pericarditis, myocarditis, uncompensated heart failure, collapse, emphysema, adiposity, and also owing to narrow intercostal spaces and the retrocostal location of the apex of the heart, when it beats against a rib

Data obtained by external examination are supplemented by *palpation* which determines the strength of the cardiac impulse, the site of its greatest distinctness, and the focus of cardiac pain (in pericarditis) Cardiac failures generate a purring thrill

Percussion As has already been pointed out, the most suitable method of percussion in pediatric practice is by striking finger against finger

The following rules should be observed in percussing the heart

(1) the procedure is conducted from lung to heart, i e, from clear to dull sounds, as it is easier in this manner to detect where the flatness begins,

(2) light percussion is employed, as more forceful taps produce sounds in the surrounding pulmonary tissue

(3) percussion over the area of absolute dullness must be still lighter than over the area of relative dullness The borders of relative dullness show the actual dimensions of the heart The area of absolute dullness depends on how much of the heart is screened by the lungs Increased absolute dullness may be due to enlargement of the heart

and to collapse or displacement of the free margin of the lung A decreased area of absolute dullness is mostly observed in emphysema of the lungs, in cases of so called vicarious expansion, in pneumonia, and also in bronchial asthma and other toxicoallergic conditions (toxic dyspepsia, dysentery, etc)

Borders of cardiac dullness For greater convenience in determining the cardiac boundaries childhood may be subdivided into three periods from birth to 2 years, from 2 to 7 years, and from 7 to 12 years

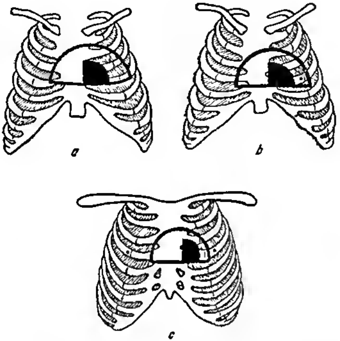


Fig 37. Margins of absolute (black areas) and relative cardiac dullness at different ages

a—from birth to 2 yrs, *b*—from 2 to 7 yrs *c*—from 7 to 12 yrs

of age (Fig 37) One should not forget that the boundaries of the heart do not depend on age alone, but also on the development and shape of the thorax The figures cited in Table 3 are merely of relative value When examining adipose children and girls in the pubertal period the midclavicular line is used instead of the mammillary line In addition to delineation of the cardiac boundaries the transverse diameter of the heart must likewise be ascertained (Table 3)

Expansion of the area of cardiac dullness is observed in hypertrophy and expansion of the heart fatty heart, cardiac lesions and exudative pericarditis, pulmonary collapse and thoracic deformation Left ventricular hypertrophy (*expansion of the heart leftward and downward*)

Table 3

Site of Cardiac Impulse and Borders of Cardiac Dullness
(after V Molchanov)

		0 2 yrs	2 7 yrs	7 12 yrs
Cardiac impulse		1 2 cm laterad of left mammillary line	1 cm laterad of left mammillary line	On mammillary line or 0 5 1 cm mediad of it
		Fourth intercostal space	Fifth intercostal space	
Absolute dullness	Upper border	III rib	Third intercostal space	IV rib
	Left (outer) border mediad of impulse	Between left mammillary and parasternal lines		
		Closer to mammillary line	In the middle	Closer to parasternal line
	Right (inner) border	Left margin of sternum		
	Transverse diameter of heart	2 3 cm	4 cm	5 5 5 cm
Relative dullness	Upper border	II rib	Second intercostal space	III rib
	Left border (laterad of impulse)	1 2 cm laterad of left mammillary line		On mammillary line
	Right border	Right parasternal line	Slightly mediad of right parasternal line	Midway between right parasternal line and right sternal margin or slightly closer to sternal margin
	Transverse diameter of heart	6 9 cm	8 12 cm	9 14 cm

accompanies cardioaortic diseases Right ventricular hypertrophy (*expansion* to the right) is seen in uncompensated cardiac disease, disturbances of pulmonary circulation (tuberculosis, pneumonia, pertussis), congenital heart lesion—particularly constriction of the pulmonary artery

Reduction of the area of relative dullness and of the dimensions of the heart (as revealed by the x ray) may be observed in states of shock and of certain allergic reactions, owing to a redistribution of the blood (congestion in the area of the portal vein and a decrease of the volume of blood in circulation)

A point to bear in mind is that thoracic deformations, especially pigeon breast, may be attended by *an apparent enlargement of the heart*, when the thorax borders on it laterally In cases of anterior mediastinum pathology the resultant shortening of the heart may coalesce with its dullness

In exudative pericarditis the shape of the heart resembles an isosceles triangle with its base on the diaphragm and its apex on the II and III ribs, the cardiohepatic angle is cut down Reduction of the absolute cardiac dullness occurs in pulmonary emphysema

Auscultation. Two basic sounds are heard on auscultation over the heart of a healthy child The first is coincident with the apex beat and it appears with systole, the second sound is attributed to the beginning of diastole A faint third sound is infrequently detected but it may be registered by means of phonocardiography (see lower) During auscultation the stethoscope should not be pressed too heavily on the child's chest, since this causes pain and weakens the heart sounds Auscultation of the heart is conducted when the patient is calm, and in various positions (recumbent, upright) The heart sounds are most distinct over the apex (the point of maximal impulse) and duller over the base of the heart A light accentuation on the second sound over the pulmonary artery is frequently observed in normal children of the school age and prepubertal periods Generally speaking, *the heart sounds of children are deeper in pitch than in adults, with the exception of infancy* During this first period of life the first sound is normally weak, even dull at times, loud heart sounds appear after the age of two years

Intensification of sounds is observed in all conditions attended with increased cardiac functions and high arterial pressure, the cardiac muscle functioning normally

The second sound is intensified over the aorta (accentuation of sound two) in conditions accompanied by increase of arterial pressure, such as collapsed kidney Accentuation of the second sound over the aorta may frequently be detected in a perfectly healthy child when the examination is conducted in a cold room The second sound is accentuated over the pulmonary artery in cases of right ventricular hypertrophy, acute or chronic pneumonia, emphysema, tuberculosis, pertussis, mitral valve defect—i e, in disturbances of pulmonary blood circulation, intensification of the second sound is physiological in the school age and prepubertal periods of childhood (see above)

Diminution of the heart sounds is observed in cardiac weakness, nutritional disorders, and in certain forms of congenital heart disease Its origin may be extracardiac—as a result of impaired conduction of the heart sounds to the thoracic surface (thickness of integuments, pulmonary emphysema), and also of the presence of transudates and exudates in the pericardial cavity Diminution of the first sound is caused by cardiac weakness, acute myocarditis, aortal stenosis and severe nutritional disturbances in infancy The second sound is reduced over the aorta in cardiac weakness and aortal stenosis, while its diminution over the pulmonary artery in congenital heart disease is a sign of stenosis of the pulmonary artery

Excessive pressure applied to the chest with the stethoscope reduces the heart sounds

In childhood the long and short pauses between the heart sounds are defined quite distinctly, therefore it is easy to differentiate the sounds

It is only in the newborn, particularly in premature infants, that it is difficult to differentiate the two sounds and that the pauses between them are of similar duration (*embryocardia*) Subsequent to 1 2 months of life embryocardia is a sign of pathology

In children of a more advanced age embryocardia is observed in severe lesions of the myocardium, in the majority of cases generating in acute infectious diseases most common of which are diphtheria and rheumatic fever carditis Embryocardia develops in association with reduction of the systolic volume, due either to a decrease of the cardiac systole, or to deficient delivery of blood to the heart as a result of vascular insufficiency, mostly both factors are concomitant

Actually, in addition to the identicalness of the first and second heart sounds and of the pauses between them, embryocardia is always attended by tachycardia The simple equality of the depth of the heart sounds and of the pauses between them in association with a normal rate, is termed pendulum rhythm Its presence may also be an indication of a grave lesion of the cardiovascular system

Arrhythmia is quite frequent in children, particularly during the prepubertal and pubertal periods

The same types of arrhythmia are encountered in children as in adults, and their pathogenesis is also the same In children sinus arrhythmia, synchronous with the acts of breathing prevails many investigators tend to consider it physiologic In the child with breathing arrhythmia the respiratory rhythm is not always uniform therefore it may be confused with extrasystole, or with arrhythmia detected owing to impaired sound conductivity In order to differentiate these two types of arrhythmia the study of the electrocardiogram is supplemented by a thorough investigation of the correlations be tween the seemingly devoid of any regularity arrhythmia and the res piratory changes

The basic properties of the heart muscle—its automatism, excita bility, conduction, and contractility—give rise to several types of arrhythmia (1) sinus changes in cardiac rhythm, (2) extrasystolic arrhythmia (3) paroxysmal tachycardia, (4) disturbed conduction (5) quiver and fibrillation of the atria—atrial or auricular fibrilla- tion, (6) alternating pulse, (7) nodal rhythm

1 *Sinus changes in cardiac rhythm* The sinoatrial node (node of Keith and Flack) is mostly dependent on extracardiac nerve impulses, generated by the vagus nerve and the sympathetic nervous system The clinical findings in sinus changes of cardiac rhythm are (a) sinus tachycardia when the pulse is regular, but its rate is increased to 120 130 beats per minute, (b) sinus bradycardia with a sharp decrease in the pulse rate, (c) breathing arrhythmia, also called physiolog ical arrhythmia owing to its frequency in children It is manifested by an increase in the number of pulse beats during inspiration and their decrease during expiration and in the breathing pause The ex planation of this type of arrhythmia lies in the fact that the sensory nerve endings in the lungs are stimulated during inspiration precip itating a reflex depression of vagal tonicity that leads to accelera- tion of the pulse rate during inspiration Breathing arrhythmia is particularly common among neurotic children is normal in healthy children during the period of sexual maturation, and is concomitant with bradycardia during recovery from acute infections

2 *Extrasystolic arrhythmia* is caused by the appearance of stimuli generating premature contractions as the result of a pathological impulse arising in the heart In accordance with the origin of this ectopic pacemaker sinusal, atrial, and ventricular extrasystoles are recognized Extrasystoles are detected by the appearance after a normal contraction of additional one or two contractions accompanied by a protracted pause Extrasystole arrhythmia is much less frequent among children than among adults, particularly in infancy Extra systoles are likewise observed in cases of functional disorders but they are more frequently symptoms of severe myocardial lesions

3 *Paroxysmal tachycardia* (racy heart) is closely related to extra systole it is manifested by paroxysms of rapid heart action in which the pulse rate goes up to 150 220 and the paroxysm may last from several minutes to several hours, or even weeks

4 *Disturbance of conduction* may arise along the entire length of the conduction system from the sinoatrial node to the Purkinje fibres The thus arising impediment either slows down the con duction of the impulse, causing partial heart block, or it effects a complete interruption between the different sections of the heart—*heart block* An extremely peculiar pattern is generated by heart block the rhythm of the atrial beat remains quite normal,

while the ventricular beat is slowed This type of heart block is seen in diphtheria, and less frequently in rheumatic lesion of the heart

Incomplete heart block is that in which the *PQ* interval of the electrocardiogram is prolonged, indicating slowed conduction of the impulse from the atria to the ventricles This prolongation may be stable, or it may gradually increase until the ventricle contracts before the impulse from the sinoatrial node reaches it The result is ventricular extrasystole

Inhibition of the conduction of the impulse in the ventricles—prolongation of systole—is displayed electrocardiographically by expansion of the "ventricular complex" *QRST*

Gallop rhythm is a peculiar form of arrhythmia, in which an extra sound occurs before the first sound, thus doubling it—systole gallop rhythm—producing *three sounds* Occasionally splitting or doubling of the second sound occurs

Gallop rhythm is observed in cachexia, nephritis, and in severe forms of rheumatic and diphtheritic myocarditis

5 *Atrial fibrillation* is characterized by heightened excitability accompanied by a marked decrease in impulse conduction and in the contractile function of the myocardium owing to this the normotopic excitation does not spread evenly and at normal rate in the atrial musculature Ectopic impulses arise in the atria from whence waves of excitation circulate along an undulating, variable irregular route they are called heterotopic impulses

Atrial fibrillation is sometimes seen in childhood in cases of mitral valve stenosis and in acute infections

6 *Alternating pulse* is caused by disturbance of the contractile function of the heart It is characterized by alternation of large and small pulse waves in cycles of equal length Alternating pulse occurs in childhood in association with acute and chronic intoxications and other processes favouring cardiac dystrophy and it is a sign of heart weakness

7 *Nodal rhythm* is a disturbance of cardiac rhythm when the impulses stimulating contraction are generated in the atrioventricular node (node of Aschoff and Tawara) instead of the sinoatrial node as is usual

Diagnostic differentiation of types of rhythm disturbance is based principally on the study of the electrocardiogram (ECG)

Murmurs Cardiac murmurs are adventitious sounds that may be heard over the region of the heart in addition to the heart sounds Cardiac murmurs are classified as *organic* murmurs originating in valvular failure or myocardial lesion and *inorganic or functional* murmurs unconnected with valvular or myocardial lesion It is generally considered that the *organic* murmurs caused by congenital heart lesions, and stable structural changes in the valves are shriller and louder, while those resulting from acquired heart lesions are low, blowing or whistling However, this is not quite so Acquired le sions mostly affect the left heart, congenital lesions—the right heart, and in this contingency the pulmonary artery is very frequently involved Diastolic and presystolic murmurs are rare in children younger than three years

The question of the mechanism giving rise to *functional murmurs* is still a subject of discussion, however, they may be divided in accordance with their origin

(1) murmurs depending on changes in blood constituents and circulatory rate,

(2) atonic and hypertonic murmurs conditioned by a weak or too strong contraction of the papillary muscles, in the first instance these muscles do not restrain the valves so that the latter bulge into the atrial cavity under the pressure of the blood, in the second instance the muscles contract too intensively, putting too much pull on the valvular cords, the latter become too tight and therefore contact between the valves is insufficient, the cause is faulty cardiac innervation,

(3) *murmurs depending on compression of the larger vessels (owing* to deformation of the thorax, tumours, or mediastinal, pleuritic, and pericardial adhesions),

(4) cardiopulmonary murmurs arising in the places where the heart is superimposed by the lungs, their period coincides with systole they are heard over the left ventricular area, and are intensified when the breath is held following inspiration

The chief difference between the functional murmurs heard in anemic children and organic murmurs is that the first are not accompanied by any other sign of cardiac lesion, they are almost always soft and blowing and coincide in time with systole, they become more marked with motor activity, and are usually attended by supraclavicular murmurs As the composition of the blood improves the murmurs diminish

Functional murmurs are rare in children younger than two years The extreme rareness of accidental murmurs in young children greatly enhances the diagnostic value of cardiac murmurs at this age Accidental murmurs are most distinct over the pulmonary artery, they rarely spread over the entire cardiac area, and never subdue the first sound

A loud *venous* murmur may at times be mistaken for an organic heart murmur, normally the venous murmur is heard only in the neck, at the posterior margin of the sternocleidomastoid muscle, near its attachment to the clavicle, in anemic children it is detected below the clavicle, at the second or even third rib The venous sound is intensified by factors accelerating blood circulation in the cervical veins during diastole, it may simulate the diastolic murmur produced in the aorta or pulmonary artery and thus lead to erroneous diagnosis of lesion of one or more of the semilunar valves Subclavian venous murmurs are likewise auscultated in children younger than two years They are distinguished from cardiac murmurs by their protracted nature, and although they are stronger during diastole they do not disappear in systole The strength of these sounds changes depending on the turn of the head Venous murmurs heard under the manubrium when the head is thrown back (Smith's symptom) arise owing to the pressure of an enlarged thymus or enlarged bronchial nodes on the vessels

Pericardial murmur has a scraping or crackling quality It frequently becomes stronger when the trunk is bent forward, or when the stethoscope is pressed too closely against the chest The murmur has no particular site, but it is mostly auscultated at the base of the heart over the sternum, in the vicinity of the third rib, or sometimes only over a limited area, it does not spread to the cervical vessels, and the cardiac sounds are often suppressed by it The appearance of this murmur does not coincide with either systole or diastole

Adventitious *pleuropericardial murmurs* synchronous with cardiac activity are occasionally heard over the left margin of the heart when there are inflammatory changes in the pleura

The adolescent or juvenile heart In the majority of cases percussion elicits cardiac enlargement due to the fact that either the growth of the heart has proceeded at a faster rate than the growth of the rest of the body, or, contrarily, the heart has lagged in growth and therefore secondary hypertrophy has occurred Moreover, some part is also played by disturbance of equilibrium in the endocrine autonomic system controlling heart activity, a condition frequent during the period of sexual maturation Factors that favour hypertrophy are mental or physical stress, and also thoracic deformation (such as pigeon breast) leading to cardiac and pulmonary dysfunction Some authors have described cardiac hypoplasia—hypoplastic heart Auscultation often elicits a systolic apical murmur Other frequent findings are increase in arterial pressure (physiological hypertension) palpitation rapid pulse rate, dyspnea, arrhythmia (particularly following stress), and headache in the frontal area during mental exertions A tendency to dizzy spells and fainting is mostly observed in girls

Some adolescents display a reaction to standing (orthostatic reaction) which verges on the pathologic, but is evidently of no serious import When they stand upright for some time, or sit without moving for protracted periods they develop a number of unpleasant sensations dizziness, precordial pressure pressure in the abdomen and legs an urge to change their position Forced prolonged standing may even cause fainting (orthostatic collapse) and vomiting The skin becomes pale, the hands cold and blue All the unpleasant subjective and objective vasomotor signs disappear rapidly after a period of lying down Such adolescents are subject to excessive perspiration, to salivation, and to red dermography, unbalanced personality traits are frequent—changeable moods, emotional instability

With time all these signs clear up and there is no need to pay any serious attention to them They are merely the result of a transient disturbance in the activity of the endocrines and autonomic nervous system, that is in its turn connected with dysfunction of the central nervous system Some part is also played by the above described discrepancies between the growth of the heart, vessels, and of the entire body It may prove quite difficult to establish differential diag nosis between juvenile heart and an organic lesion of the heart

Investigation of the vessels. The pulse of children is taken over the radial artery (at the wrist), preferably when the child is asleep but in any case when he is calm (since children are easily excited and the pulse rate goes up in such conditions) Normally the pulse is av eragely full and rhythmic, age level rates have been given above De viations from normal may be observed in rate, strength, tension, and rhythm

Increased pulse rate is observed when the child is excited, during muscular activity after meals, in the acute period of infectious dis eases (particularly during scarlet fever), in the terminal phase of tu berculous meningitis in hyperthyreosis In febrile conditions the elevation of the temperature by 1°C makes the pulse rate go up 15 20 beats

The pulse rate is decreased during sleep, in severe nutritional disor ders, in the initial phase of tuberculous meningitis, in typhoid fever, and during convalescence from acute infectious diseases, particularly scarlet fever and measles

A weak and frequent pulse is a sign of decreased cardiac activity The diagnostic value of this symptom is judged by concomitant find ings in other organs Coldness of the extremities expansion of the right heart, diminution of the heart sounds (particularly of the second sound), liver enlargement and cyanosis are bad signs Acute cardiac weakness is observed in diphtheria dysentery and in severe cases of acute infections and acute gastrointestinal diseases in infancy

A high tension pulse is seen in conditions when the activity of the left ventricle is intensified by the need for overcoming resistance in systemic circulation (spastic condition of the small arteries and capil laries in nephritis)

Arterial pressure is measured with the Riva Rocci sphygmomanom eter (equipped with a special cuff for children), by the sound method of Korotkov in which the brachial artery is auscultated, or by the Recklinghausen method of palpation of the radial artery (appearance or disappearance of the pulse in it)

To obtain reliable results in taking children's arterial pressure a special cuff, suitable to the child's age (stature), should be used

It has been found in practice that for children younger than two years the cuff should be 2 4 cm wide for children three to six years old 6 8 cm, and a 10 12 cm cuff is suitable for schoolchildren

Increased arterial pressure is observed in lung diseases, at the onset of infectious diseases, quite occasionally during convalescence from diphtheria and scarlet fever, when the child is excited, when he is under physical strain and especially in cases of nephritis Transient hypertension is frequent in adolescents

Decrease in arterial pressure is seen in acute nutritional disorders, the serum sickness, certain severe infections (e g, diphtheria), and in heart insufficiency

A progressive fall in arterial pressure is a poor prognostic sign

In recent years the determination of *mean arterial pressure* has been introduced into pediatric, as well as adult, practice in addition to measurement of maximum and minimum arterial pressure The mean arterial pressure is ordinarily not subject to oscillation, as it is not affected by the patient's excitation or by physical strain

Changes in mean arterial pressure are a sign of an organic lesion of the heart

Mean pressure is determined by an oscillograph which records the oscillations of the vascular wall under various degrees of compression of the artery by the cuff When the artery is compressed to complete impassability the waves are barely noticeable above the isoelectric level When pressure in the cuff is slightly less than maximal the first high amplitude wave appears When the pressure in the cuff is equal to the mean dynamic pressure in the artery the highest wave appears on the oscillogram When pressure in the cuff is equal to minimal pressure the waves decrease and then disappear consequently the pressure in the cuff at the time when the first noticeably increasing wave is registered corresponds to maximum pressure (Mx) The pressure coinciding with the largest wave corresponds to the mean dynamic pressure (My) Transition from large to small waves corresponds to minimal pressure (Mn) The dimension of the largest pulse wave the greatest oscillatory amplitude of the arterial wall which corresponds to the value of the mean pressure is called *the oscillatory index*

The value of the oscillatory index depends on the contractility of the heart on the diameter of the artery and to some extent on the tension of the latter Normally mean pressure varies with age

Newborn	50 58 mm Hg
3 7 yrs	73 77 mm Hg
8 14 yrs	81 86 mm Hg
Adults .	approximately 90 mm Hg

Characteristics recently introduced into medical practice for estimating the condition of the circulatory organs are venous pressure circulation time volume of blood in circulation and cardiac output

Venous pressure as measured with the Agekyan phlebotonometer is 60 100 mm in preschool and school age children It increases in right heart failure resistance to diastole compression of the venae cavae Left ventricular insufficiency does not affect venous pressure Ordinarily venous pressure decreases during deep inspiration and increases with expiration Excitement and crying will increase the venous pressure

In recent years bloodless measurement of venous pressure after the Waldman method has been introduced

Circulation time as determined by the histamine method is 14 17 seconds in children younger than two years between 2 and 6 years it is 15 seconds and from 6 to 12 years 17 26 seconds Other authors report 12 19 seconds for the 6 to 10 years age group 14 20 seconds for children between 11 and 13 and 16 21 seconds for those between 14 and 16 years The saccharin method gives the following values from 7 to 11 years 7-14 seconds, from 12 to 14 years 9 16 seconds Circulatory time in school agers, as determined by the lobeline method, is 4 to 8 *seconds*.

The volume of blood in circulation from infancy and until the age of 5-7 years is 100 ml per kg of body weight in the preschool and early school age period it is 50 90 ml/kg, and in older children 50 92 ml/kg An increase of the volume of blood in circulation may occur owing to hydremia and intensive blood formation Decrease indicates retention of the blood in its depot

Cardiac output (or minute cardiac output) is understood as the volume of blood pumped out from the heart into the system in one minute, normally it should equal the volume of blood that flows back into the heart from the vessels It depends on the volume of circulating blood circulation time, and cardiac activity it increases with increase in rate and effort of cardiac contractions and decreases with their decrease

Cardiac output is approximately 350 ml in the newborn, increasing to 1,250 ml in the first year of life Between 1 and 5 years cardiac output is 1,250 1,800 ml, in children of 6 to 9 years it is 1,800 2,370 ml and in the period between 10 and 15 years 2 500 3,150 ml By the acetylene method of Grollman the mean cardiac output of the 5 to 9 year old child is 2,300 ml for 9 to 12 years it is 2,800 2 900 ml and for 13 to 16 years 3,800 ml

Other methods of investigations used are sphygmography—a graphic recording of the features of the pulse by means of an instrument the sphygmograph This method is used chiefly for children older than five years, its results are doubtful in younger children

An extremely valuable method in pediatric clinical practice is *electrocardiography* This method provides a means for determining delicate disturbances of cardiac activity inaccessible to ordinary clinical examination, such as various degrees of heart block and conduction disturbance in the branches of the conduction system, and various rhythmic disturbances associated with diphtheria and rheumatic fever

As we know, the electrocardiogram (ECG) is usually recorded on three standard limb leads Lead I is a combination of right and left arms, lead II of right arm and left leg, lead III of left arm and left leg A normal electrocardiogram shows *P*, *Q*, *R*, *S*, and *T* waves, in which *P* is caused by contraction of the atria, and the *Q*, *R*, *S*, and *T* waves are due to excitation of the ventricles Normally the *T* wave is always pointed upward from the isoelectric level and precedes the *P* wave by 0 15 seconds on the average Wave *R* is normally also always deflected upward on the electrocardiogram on all the leads, attaining its maximum height in lead II In infancy the amplitude of all the waves is noticeably lower than in older children Investi*gations of numerous healthy children of various age have shown that* the newborn display an acute downward deflection in lead I of the *S* wave which may even surpass the dimensions of the *R* wave, this feature begins to disappear in the later half of the first year of life, so that in a child of school age the *S* wave characteristic differs but little from that of the adult *S* wave (Figs 38 39)

Lately the three classic leads have been supplemented by several variating chest leads which permit reaching a more precise determination concerning the site of the cardiac lesion

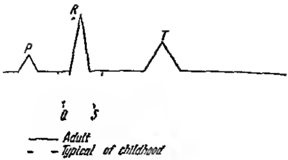


Fig 38 Schematic ECG of adult and child

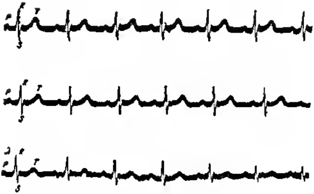


Fig 39 ECG of 5 year old child

There is no need to dwell here on the details of the ECG age variations since such data are included in all standard textbooks on pediatric diseases We shall likewise not discuss the factors conducive to ECG changes We merely wish to stress that the ECG is of diagnostic value only when its study is incorporated with data obtained by other methods of pediatric investigation One and the same ECG changes may be induced by various causes frequently of extracardial origin

Phonocardiography or the graphic recording of heart sounds and murmurs by electric reproduction is extremely helpful in examination of the heart owing to its objectivity

Recording by this method is possible even when the heart sounds and murmurs are not detected by the human ear The formation of both sounds and murmurs in the heart is accompanied by the arisal of oscillatory movements of diverse frequency in the heart its valves in the chordae and in the vascular walls The sounds incorporate oscillations ranging from 20 to 150 cycles per second the murmurs range from 100 to 3,000 c/s The human ear detects sounds within the range of 20 to 20,000 c/s, best of all sounds with frequencies of 1,000 to 2,000 c/s, its sensitivity to low frequency sounds (20-100 c/s) is very low, in old age the faculty of hearing the lower sounds diminishes still more This is why the objective method of recording sound oscillations is of undoubted value, all the more so since a recording is a document which can be compared with subsequently obtained data

Usually sound oscillations are recorded simultaneously with the ECG, on the same film or paper roll The shape of the phonocardiogram waves is quite variable, owing to a number of causes, partly technical, partly in connection with individual traits However, a general characteristic of typically normal phonocardiograms may be given in the following manner

The first sound, which reflects atrial and ventricular systole and is caused chiefly by the closure of the atrioventricular valves is represented in the recording by two portions, the first portion is generated by atrial systole and consists of 2 3 small waves followed by 3 5 high waves generated by the closure of the atrioventricular valves This basic part of the contour is followed by several small terminal waves *The atrial portion* does not coincide in time with wave *P* as might have been expected, but is coincident with the initial—ascending—limb of the *QRS* complex The second and basic portion of the first sound reflects the closure of the mitral (bicuspid) and tricuspid valves and corresponds to the descending limb of *QRS* located at a distance of 0 01 to 0 03 seconds from the top of *R* The inconstant waves adjacent to the principal portion are evidently associated with oscillations of the vascular walls caused by the flow of blood into them during systole The duration of the first sound is 0 1 0 15 seconds, and its frequency of oscillation is 20 200 c/s

The first sound is followed on the phonocardiogram by a straight or almost straight line representing the end of the *ST* interval and the entire *T* wave of the electrocardiogram The second sound appears within 0 01 0 05 seconds after the *T* wave, its duration is 0 05 to 0 08 seconds and its frequency is 50 150 c/s The second sound consists of 2 3 waves, usually of lower amplitude than those generated by sound one Sound two is attributed to the reverse flow of the blood at the beginning of diastole with resulting tension of the valves and walls of the aorta and pulmonary artery

An occasional *third sound* is not infrequently recorded 0 1 0 2 seconds after the second sound, it usually appears as one wave with a wide rounded top, sometimes it comes in two waves with a deflection between them The third sound is attributed to the opening of the atrioventricular valves and the beginning of ventricular diastole

Normally diastole produces a straight line, except for this occasional third sound

The values cited above are typically normal for adults In children they are lower, since the frequency of contraction is greater No age norms have yet been evolved

Heart *murmurs* differ from sound by a longer duration higher frequency (150 2 000 c s and even more) and greater uniformity between the amplitudes of the separate waves than is seen in sound recordings Phonocardiography has made it possible to detect the presence of murmurs inaccessible to human hearing

The phonocardiograph gives a more distinct idea than the ear can of the splitting and doubling of sounds, by its aid the formation of the presystolic murmur of mitral stenosis is detected before it can be heard by the ear Sounds and murmurs are usually recorded so that waves of various amplitude are 'filtered out separately This makes it possible to determine the frequency of oscillation of a given murmur It is important to remember that during subsequent examinations of the patient the data that are compared must be obtained under similar conditions and the sounds recorded from the same sites Factors to be taken into consideration as in ECG are meteorism displacement of the heart by breathing thickness of the soft tissues extent to which the heart is overlapped by the lungs presence of fluid in the pericardial and pleural cavities

Several illustrations (Figs 40 43) which will convey a better understanding of the clinical value of this method of examination are presented All the contours are recordings of different frequencies The upper line (*a*) is everywhere a lead I electrocardiogram while lines *b* *c* and *d* represent the phonocardiogram

Capillaroscopy—the microscopic examination (at magnifications of x40 to x100) of the cutaneous capillaries—is another method employed for establishing diagnosis of cardiovascular conditions

Thus in scarlet fever glomerulonephritis (a lesion of the kidneys) may be detected by spasm of the cutaneous capillaries several days preceding the appearance of characteristic changes in the urine and elevation of arterial pressure

In evaluating capillaroscopic data age features must also be taken into account Newborn infants (especially during the first three days of life) possess an extremely well defined subpapillary vascular network with a random arrangement of the transverse capillaries which are devoid of terminal loops owing to the absence of manifest cutaneous papillae Only by the end of the first month do small irregularly situated capillary loops appear After the middle of the second month of life the capillary loops are already demonstrable in the developing cutaneous papillae

The capillaroscopic picture in childhood is distinguished by the following features the younger the child the clearer is the subpapillary vascular network and the pinker the background the younger the child the more considerable is the number of wide short loops and the greater the irregularity of their arrangement The process of complete differentiation of the capillaries terminates at the age of 11 13 years

Capillaroscopy is an aid in early diagnosis thus cloudiness of the background indicates porosity of the vascular wall a pre edematous condition while extravasation is a sign of a still greater lesion of the vascular wall

Functional diagnosis of the heart In order to determine what physical strain a cardiac patient may be permitted at any time of his

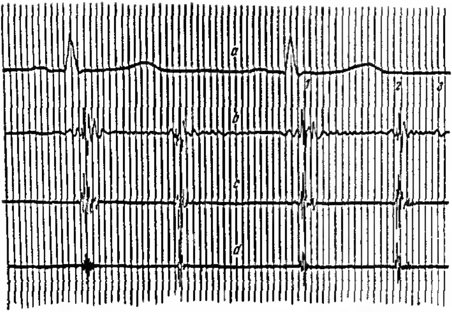


Fig. 40 ECG and phonocardiogram of healthy 7 year old girl

a—ECG lead I *b*—phonocardiogram 10 50 c/s range *c*—phonocardiogram 50 200 c/s range, *d*—phonocardiogram 200 600 c/s range *1*—first sound *2*—second sound *3*—third sound Amplification 1/20 Registered over apex of heart Each graduation on the time-recorder is equal to 0 02 seconds

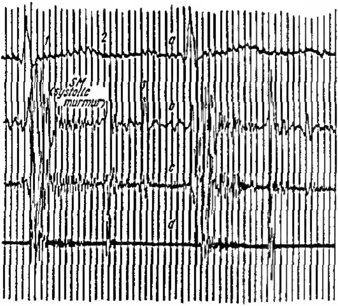


Fig 41 ECG (*a*) and phonocardiogram (*b, c, d*) of 6-year old boy during acute rheumatic myocarditis with no cardiac defect

1—first sound *2*—second sound, *3*—third sound *SM*—systolic murmur Amplification 1/20 Registered over apex of heart

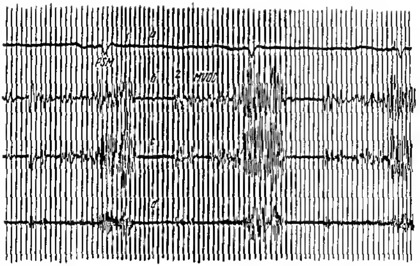


Fig 42 ECG (*a*) and phonocardiogram (*b, c, d*) of 12 year old girl with stenosis of the left atrioventricular opening

1—clicking first sound, 2—second sound *PSM*—presystolic murmur crescendo *MVOC*—mitral valve opening click Registered over apex of heart

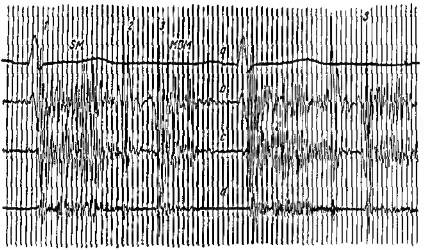


Fig 43 ECG (*a*) and phonocardiogram (*b, c, d*) of 12 year old girl with mitral valve defect

1—first sound *2*—second sound *3*—third sound *SM*—systolic murmur *MDM*—mesodiastolic murmur Amplification $^1/_{16}$ Registered over the fourth costal interspace left of the sternum disease the physician must understand the functional capacity of his patient s cardiovascular system and judge the adaptability of the heart to complemental strain Various methods are used for solving this problem

Clinical practice has shown that the following methods are most suitable

1 To decide whether the patient may be permitted to leave his bed the clinostatic test is used In healthy children the pulse rate and maximal blood pressure obtained when in an upright position differ very little from measurements taken in a recumbent position The pulse rate goes up no more than by 10 beats per minute Arterial pressure remains at the same level or increases by 3 5 mm A decrease in arterial pressure and an increase in the pulse rate by more than 10 beats per minute are an indication of lack of sufficient cardiac adaptability The disappearance of the accentuation of the second sound over the pulmonary artery when standing also points to a decreased functional ability of the heart

2 The degree of cardiac efficiency in the ambulant child may be judged by putting greater strain on the patient The method proposed by Gorinevsky is very adequate The patient does 60 springy jumps (3 4 cm high) within 30 seconds after which his pulse rate should normally increase by 25 30 per cent and return to normal in 2 3 minutes If the pulse rate increase is higher or if the return to normal occurs no earlier than in 5 minutes it is a sign of decreased functional ability

The Hench test consists of determination of the time interval during which the child can hold in his breath after making three deep respirations The reaction of the healthy child to this test varies with age

The approximate norms are a child of 5 6 years can stop his breath for 30 40 seconds a 7 8 year old can hold it for 40 50 seconds a 10 year old for 60 seconds and an adolescent may frequently be able to hold his breath for longer than one minute

This test is not suitable for children younger than 5 years

Naturatty when the above tests are evaluated several auxiliary factors must be taken into account Thus anemia pleural adhesions pulmonary fibrosis meteorism fatigue intensive motor activity directly preceding the examination untrained body—all these factors condition inferior results the same thing is observed when the examination is made directly following a meal In addition to the above factors the Hench test is affected by the child s tolerance his ability to overcome unpleasant sensations this test is thus also a test of will power

No final conclusions may be made on the basis of these or other tests They serve merely for orientation A finat conclusion concerning the resources of the cardiovascular system can only be reached after day by day observation of the child and exhaustive examination

When making an evaluation of the data obtained by an investigation of the cardiovascular system of the child one should not forget that this system is part of a constitutional whole, that it is in continuous intercommunication with numerous other organs and systems of the body This is why disorders of the blood circulatory organs frequently originate in dysfunction of other organs (respiratory system, kidneys, blood, etc) Intercommunication between systems and organs is maintained by excitation of the sensory receptors in the vascular walls by nerve impulses generated in other organs, and by the action of the endocrines through the blood In this regard there is a difference between the child and the adult, which is most noticeable during sexual maturation and in the period of life preceding the age of $2^1/_2$ 3 years Younger children (under $2^1/_2$ 3 years) still lack the function of the reflex mechanism by which vagal regulation of cardiac activity is maintained through the chemoreceptors of the sinocarotid zone

The practical import of this fact is that preparations of the type of digitalis show no inhibition of cardiac activity in children of this age

Symptomatology of the Most Important Heart Lesions

The principal symptoms of disturbed cardiac activity are the same in children and adults (they have already been mentioned) We shall now present the most prominent diseases of the heart and their symptoms

Myocarditis is accompanied by enlargement of the heart and a diffuse beat which is in most instances diminished and displaced outward and downward The heart sounds are dull, occasionally muffled and at times a systolic murmur may be detected as a result of relative (muscular) failure of the mitral valve The pulse is weak and rapid sometimes irregular In some cases gallop rhythm develops (diphtheria, rheumatic fever), as well as embryocardia, decrease of blood pressure, visceral blood congestion, hepatic enlargement and pain

Pericarditis Exudative pericarditis is accompanied by a dullness over an isosceles triangle with blunt angles, the cardiohepatic angle is flattened and the heart beat is not visible to the eye, the heart sounds are muffled and faint, epigastric pulsation is present, and the pulse is small, soft and weak

A pericardial friction sound is heard in the initial stages of pericarditis and also during suction of the effusion, cardiac hump develops quite rapidly, typical symptoms are shooting pains, a dry cough dyspnea, the patient feels more comfortable in a semi sitting position

Endocarditis The heart beat is intensified and diffuse A purring thrill is occasionally detected in the apical area In the initial stages a diminution and muffling of the second heart sound are noted while later on, depending on the site of the lesion, an apical murmur pre dominantly systolic, less frequently diastolic, is heard, the pulse is rapid, the temperature may be elevated.

The cardiac dullness is enlarged, but not very markedly—the enlargement occurs *first at the top, later to left and right*

Congenital heart lesions. We shall here dwell only on the symptomatology of congenital lesions which are particularly important in childhood

Congenital lesions rarely exist in a pure form, they are mostly combined lesions Their diagnosis during life is extremely difficult without the application of special methods of investigation

The most commonly observed lesion is *constriction of the pulmonary artery* Its signs are expansion of the cardiac margin to the right and hypertrophy of the right ventricle, systolic murmur left of the sternum in the second and third interspaces with no spread to the vessels The second sound of the pulmonary artery is extremely reduced Intensive cyanosis and clubbing of the digits are observed

This type of lesion is frequently combined with other defects, namely with patent interventricular septum or with patent ductus arteriosus The viability of children with pure constriction of the pulmonary artery is low

The following symptoms are characteristic of *patent ductus arteriosus* cardiac dullness to the left of the manubrium, a sharp systolic murmur spreading to the carotid arteries and the back accentuation of the second sound over the pulmonary artery, a purring thrill, general enlargement of the heart and in most cases absence of cyanosis

A plan for making a differential diagnosis between congenital and acquired murmurs is given in Table 4, and the congenital lesions that are most accessible for diagnosis are presented in Table 5

Abnormal communication between the two ventricles or patent interventricular septum (Tolochinov's and Roger's disease) is characterized by absence of cyanosis (in the majority of cases), a harsh systolic murmur over the sternum and in the back between the shoulder blades at the III and IV vertebrae The murmur does not spread to the vessels Cardiac configuration is usually only slightly affected, at times enlargement to the right and left is noted The dimensions of the defect are not decisive factors in the intensity of the murmur which may even be absent in cases of a very large defect (three chamber heart)

Patent foramen ovale of the heart is usually unaccompanied by any functional symptoms

Constriction and lesion of the tricuspid valve, as well as *displacement of the larger vessels* are comparatively rare

Congenital heart lesion is indicated by the detection of a murmur before the age of three years (acquired lesions are very rare at earlier ages, by its rasping, loud, harsh qualities, asphyxia at birth, and cyanosis from the first months of life, either of a constant nature or appearing when the child cries, and also by retardation of physical

Table 4

Differential Diagnosis of Congenital and Acquired Heart Murmurs

Diagnostic factors	Congenital murmurs	Acquired murmurs
Quality of murmur	Loud sharp, usually systolic	Usually lower, with a slight inspiratory quality, frequently blowing, whistling, mostly systolic
Localization of murmur	In site unusual for cardiac lesions, frequently of uniform strength everywhere, often detected over pulmonary artery	Precise site of maximum strength may almost always be detected, favourite site is the mitral valve
Conduction	Conducted to back	Conducted to back
Other cardiac symptoms	Heart only slightly enlarged to percussion Purring thrill absent in majority of cases, may occur owing to patent ductus arteriosus	Syndrome of definite cardiac lesion
Cyanosis	Definite tendency, sometimes extremely pronounced (constriction of pulmonary artery and aorta and vascular displacement produce particularly vivid cyanosis), may occasionally be absent (patent intraventricular septum) Frequent clubbing of the digits	Cyanosis never so intensive, usually concomitant with other signs of decompensation
Age	Usually apparent in period immediately following birth	Comparatively rare prior to 3 4 years of age
Anamnesis	Child gets blue from crying screaming nursing	Past history of rheumatic fever chorea, scarlet fever, frequent sore throat
Other signs	General retardation of physical development Other congenital developmental defects and deformities	

Table 5

Differential Diagnosis of Congenital Heart Lesions, Most Accessible to Diagnosis

	Patent interventricular septum (Tolochinov Roger disease)	Constriction of pulmonary artery	Patent ductus arteriosus
Dimensions of heart	Slight enlargement to right and left	Enlargement to right	Slight hypertrophy of both ventricles
Site of greatest strength of cardiac murmur	Systolic murmur to left of sternum in third intercostal space (not constantly), conduction to back	Systolic murmur at orifice of pulmonary artery (not necessarily) Conduction to back at top	Systolic murmur over upper third of sternum good conduction to back and carotid arteries
Accentuation of sound II over pulmonary artery	Distinct	Reduced	Very distinct
Cyanosis	Not necessarily	Acute, occasionally acute pallor	Absent or not constant
Specific symptoms	Synchronous pulsation of ventricles as detected by x ray Globular shape of heart Fair cardiac efficiency	Enlargement of heart to right and bulging of left arch to left on x ray picture Primary polycythemia infantilism	Mitral type of heart Intensive pulsation of arch of pulmonary artery Uneven pulse Tendency to congestive catarrhs Parasternal dullness in first and second intercostal spaces

development The above findings only point to congenital heart lesion, without any qualification of its precise localization

Roentgenologic data concomitant with congenital heart lesions are presented in chapter XXV

Auxiliary methods in topical diagnosis of congenital heart lesions. Recent years have witnessed the introduction on an ever increasing scale of surgical intervention for the correction of certain congenital (as well as acquired) cardiac lesions and developmental anomalies in the thoracic vessels Thus arose the need for precise topic diagnosis of such lesions Information obtained by percussion auscultation determination of the reserve power of the heart and ordinary x ray methods is now supplemented by *angiocardiography* which constitutes roentgenographic visualization of the thoracic vessels and the heart chambers after intravenous injection of radiopaque material The substance is injected into the cubital or jugular vein from whence it penetrates with the blood flow into the vena cava then into the right atrium pulmonary circulation and left heart

A sequence of x ray pictures shows the distribution and spread of the radiopaque material in the heart chambers and vessels (Fig 44*a* *b* *c* *d* After A Bakulev and Y Meshalkin)

Catheterization of the heart without the introduction of radiopaque material is employed for obtaining blood specimens from the different parts of the heart for investigation (determination of the O_2 and CO_2 levels) and for measuring the blood pressure in the separate chambers

Etiology and pathogenesis of congenital heart lesions There is as yet no unanimous opinion on the matter Some investigators hold congenital lesions to be the result of endocarditis sustained during fetal life others consider them the result of injury to the fetus inflicted by diverse harmful factors (intoxications infections erratic maternal nutrition during gestation) The association of congenital heart lesions with rubella (German measles) in the mother in the first trimester of pregnancy has at present been firmly established There are likewise grounds for assuming the possibility of the development of such lesions as a result of other maternal infections (predominantly viral) during this period of pregnancy Similar to other congenital deformities heart lesions may develop as a result of exposure of the mother to excessive radiation during the first 3 4 months of pregnancy

Circulatory failure There are two factors that may lead to circulatory failure—myocardial weakness and vasomotorial disorders that precipitate a redistribution of the blood supply so that the vessels of the visceral organs receive an excessive supply of blood while the vessels of the skin extremities and central nervous system are deficient in blood Such conditions are seen in syncope shock collapse

The patterns of pure vascular and cardiac insufficiency present the following distinguishing features

1 Cardiac patients are more comfortable when in a sitting position in vascular failure relief is obtained by lying down with the head lowered and feet raised

2 In heart insufficiency the veins of the skin neck and extremities are full in vascular failure they are in a collapsed state Venous pressure is increased in cardiac failure and reduced in vascular failure

Fig 44a Angyocardiogram of normal heart Frontal thoracic position

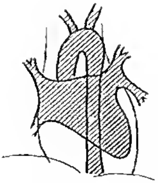


Fig 44b Angyocardiogram of normal heart Frontal thoracic position

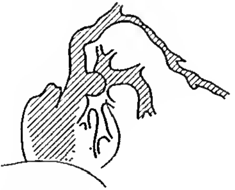
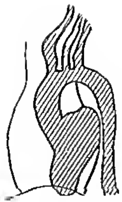


Fig. 44c Angyocardiogram of normal heart, Left oblique position



F g 44*d* Angyocardiogram **of normal heart** Left obl que pos t on

3 Cardiac failure is attended by dyspnea, failure that is purely vascular is accompanied by weak and shallow respiration

4 In collapse the heart is not enlarged

5 In collapse blood pressure is always significantly lowered, while in cardiac failure it is frequently increased

6 In collapse pallor appears, in cardiac failure cyanosis is seen

It must be remembered that in practice we usually have to deal with a combination of disorders, rather than with one isolated lesion

CHAPTER XVIII

THE DIGESTIVE ORGANS AND ABDOMINAL VISCERA

Prof Y Dombrovskaya

Digestion is one of the leading functions of the body in all periods of childhood particularly during the first years of life owing to the intensive processes of growth and development The works of the outstanding physiologist Ivan Pavlov in the field of physiology of digestion are the basis underlying the concepts of the separate links of the processes of digestion in the healthy body and the transition from disturbances of physiological processes to the formation of pathological processes Pediatricians must know these works of Pavlov since in childhood (particularly in infancy) gastrointestinal diseases are among the most common and dangerous ailments Pavlov s *Lectures on the Activity of the Principal Digestive Glands* were based on the leading principles of his doctrine the integral reaction of the organism the unity of the organism and its environment and nervism

One of the most important things in pediatrics is the study of the mechanism regulating the activity of the gastric glands The works of Ivan Pavlov have proved that gastric secretion acidity and enzymatic potency increase as the development of the complex conditioned reflexes and the maturation of the cerebral cortex proceed The specificity of the response to different food stimuli established by Pavlov is now the scientific basis for making up the dietary of the healthy and sick child Pavlov established the importance of appetite as the best stimulus of gastric secretory activity this point must be most prominent when the pediatrician plans the child s regimen The importance of rhythmicity in the ingestion of food which was proved by Pavlov is important not only in providing rational nutrition for the child it is just as important for his proper physical and mental development Meals at definite hours favour the formation of a complex reflex the fixation of which in a condition of cortical automatism calls for constant repetition The conditioned links formed in early childhood are labile and are easily extinguished or inhibited under the influence of external irritants owing to the morphological imma turity of the cerebral cortex The same is true of the instability of the physiological functions of the gastrointestinal tract in childhood

The digestive process as a whole at various age levels can only be understood on the basis of intimate knowledge of the principal anatomical and physiological features of the digestive organs of children

ANATOMY AND PHYSIOLOGY OF THE DIGESTIVE ORGANS AND ABDOMINAL VISCERA

The oral cavity is relatively small in infants, and its palatine convexity is not clearly defined, the tongue is relatively well developed and wide, as are the muscles of the lips Inside the cheeks there are well defined pads of fat (first described by Bichat), the buccal fat pads or sucking pads, the gums carry elevated ridges, and there are transverse folds in the mucosa of the lips *All these features are highly important for the act of sucking*

The oral mucosa is extremely delicate, somewhat dry, and possesses an abundant vascular network In the newborn white and yellowish nodules resembling tiny grains are seen on the median line of the palate—epithelial pearls or Bohn s nodules These pearls are cysts of the mucosal glands they disappear within the first weeks of life The delicacy of the baby's oral mucosa makes it extremely susceptible to injury, therefore *the mouth of a healthy baby should never be swabbed*

The secretion of saliva is very sparse in the newborn and throughout infancy, *the salivary glands* (submaxillary, sublingual, parotid) are in *an embryonic state in the newborn and lack differentiation* their terminal glandular vesicles are poorly defined, complete development is only attained in the third or fourth month of life, when the secretion of saliva increases and its diastase content goes up At this time the volume of saliva becomes one tenth to one fifth (and even more) of the amount of food ingested The sparse saliva secretion during the first months of life is most probably associated with the immature development of the cerebral cortex (see Chapter V) *The dryness of the oral mucosa is conditioned by the small quantity of saliva secreted And this dryness is also conducive to trauma* The reaction of the saliva is mostly neutral or even acid, less frequently—alkaline An amylolytic enzyme, ptyalin (ptyatase) is found in the saliva directly following birth Secretion of saliva is a purely reflex act depending on excitation of the mucosa and on brain centre activity A constant dribbling of saliva is observed at the age of 3 4 months (*physiological salivation*), this is because the baby has not yet learned to swallow his saliva Salivary secretion decreases in emaciated children, and also during acute febrile conditions, leading to dryness of the mucosa and its susceptibility to trauma

During the first months of life the child can take food only by sucking

The act of sucking, essentially an inborn reflex, is very complex, *it consists of three phases* (an active part in it is also played by the maternal breast, Fig 45) In *the first phase* (aspiration) the baby firmly grasps between his lips the nipple and part of the mammary areola, the tongue is pressed to the palate, the lower jaw goes down, and a vacuum is created in the mouth, the mammary areola, compressed by the jaws, loosens its tension, thus inducing active dilation of the mammary duct In *the second phase* (compression of the nipple) the milk delivered from the mammary gland flows into the mouth, this is accompanied by a concurrent activity of the tongue and soft

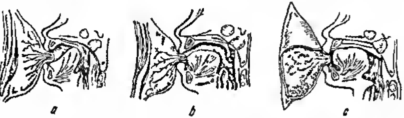


Fig 45 Consecutive phases in the act of sucking
a—aspiration *b*—compression of the nipple *c*—deglutition

palate *The third phase* is deglutition *The lips, tongue, buccal pads lower jaw and facial muscles* all participate in the act of sucking Although the sucking reflex is instinctive, still the functions of suck ing are strengthened by conditioned reflexes associated with the in gestion of food, changing the baby, a definite position at the breast and even the odour of milk are conditioned irritants This pertains likewise to bottle fed babies—the very look of the bottle awakens an urge for food in them When the baby is severely ill the conditioned stimuli lose their effect and the child's sucking activity decreases becoming extremely weak

The act of sucking becomes difficult when obstacles arising in the mother or child appear a flat or retracted nipple, harelip and cleft palate impossibility to breathe when the narrow nasal passages be come constricted owing to a cold, frequent coughing and dyspnea in pneumonia, ulcerative and inflammatory processes in the mouth finally, prematurity, birth injuries, underdevelopment or lesion of the nervous system may impair the sucking capacity The deglutitory reflex is also inborn, it is absent in premature infants and in infants with considerable central nervous system deficiencies

The esophagus of newborn and nursing infants is distinguished by an almost complete absence of glands, insufficiency of elastic and muscular tissue, and abundant vascularization *Its length in the newborn is 10 11 cm, by one year it grows to 12 cm, by five years to 16 cm* These data are of practical import, since when stomach tubes are needed their length is selected in accordance with the length of the esophagus

The stomach of full term newborn infants has a capacity of 30 35 ml at three months it is 100 ml and by one year it increases to 250 ml The fornix of the stomach is weakly defined the mucous membrane is relatively thick muscular development is moderate and the cardiac sphincter is in a rudimentary state The number of goblet cells and glands per unit of mucosal surface is less than in adults *This lack of differentiation in histological structure is retained up to the end of the 2nd year of life* The stomach is situated in the left epigastric area with its pylorus near the medium line However the position of the stomach in a child younger than one year approaches

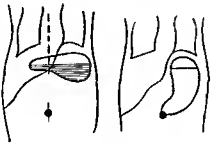


Fig 46 Shape of stomach in children under (left) and over (right) one year of age

the horizontal line and the concavity of the small curvature is directed to the back (Fig 46) After the child has begun to walk his stomach assumes a more vertical position Owing to muscular immaturity the stomach of nursing infants changes its shape when it is filled with food or when air penetrates into it Air is easily swallowed by the infant while he nurses particularly if he is an avid sucker and the maternal breast is tight This swallowing of air is termed *physiological aerophagia*

The above circumstance coupled with the immaturity of the cardiac sphincter and poor muscular development of the stomach is conducive to frequent regurgitation in infancy In older children the dimensions shape and situation of the stomach are likewise subject to easy change in association with the condition of the abdominal viscera the general nutritional state of the child and also the tonicity of his autonomic nervous system Constitutional features are likewise very important for instance a low and elongated stomach is frequently observed in asthenic subjects (see Chapter XXV)

Gastric motility in the child consists of peristalsis and periodic closure and dilation of the pylorus Disturbance of the function of gastric motility may be of either a hypotonic or hypertonic nature Hypotonia (decreased tension) is mostly seen in asthenic individuals predominantly girls in the pubertal period Increased muscular tension in the stomach occurs in children with heightened nervous excitability, particularly of the autonomic nervous system, in the form of cardiogastrospasm—spasm of the cardiac opening of the stomach accompanied by periodic pain in the substernal area, in nursing infants increased tonicity of the gastric muscles is prevalently of a local nature, appearing as pylorospasm—spasm of the outlet of the stomach In addition to general restlessness the condition precipitates projectile vomiting and inhibits weight gains

Contraction of the gastric muscle depends partly on vagal influence, and partly on the nerve plexuses situated between the muscular layers

Autonomic motor centres in the form of ganglia are also located in the muscular layers of the gastric wall A peculiar accumulation of ganglia is situated at the cardiac and pyloric openings of the stomach The autonomic innervation of the stomach is closely connected with the central nervous system through the branches of the vagus and of the sympathetic nervous system

The time intervals between stomach evacuations vary in infants depending on the type of food they receive the stomach of a breast fed baby is emptied within 2 3 hours after a feeding, in bottle fed babies nursed on cow's milk evacuation occurs in 3 4 hours, water leaves the stomach within 30 to 60 minutes Cow's milk remains in the stomach for a longer time because its protein content is higher than in mother s milk and, besides, the high lipase value of breast milk fat favours better digestion In general protein and fats retard evacuation of the stomach

The secretory function of the stomach. The works of Ivan Pavlov on the activity of the principal digestive glands are of extreme importance in the study of the specific features of the secretory function of the gastrointestinal tract These works were a most distinct demonstration of the regulating influence of the central nervous system on the secretory function of the gastrointestinal tract According to Pavlov, the secretory function of the stomach consists of two phases—the neural reflex and chemohumoral phases, in early childhood this activity displays numerous specific features associated with the developmental stage of the central nervous system A decisive influence on the power and quality of secretion is exercised by the quality of food ingested

The constituents of the gastric juice of an infant do not differ from those of an adult it contains hydrochloric acid, pepsin, rennin lipase Total acidity in the first year of life is 20 40 (60-70 per cent less than in adults) The level of free hydrochloric acid is determined 1 $1^1/_2$ hours after a feeding for breast fed infants and $2^1/_2$ 3 hours after a feeding for artificially fed babies, i e , its quantity depends on the kind of food ingested

Gastric digestion is established directly following birth in full term infants, in the premature it develops slowly The gastric juice of the newborn already contains all the usual constituents: enzymes (pepsin, rennin, lipase), lactic acid, hydrochloric acid, sodium chloride. Acidity increases with age, but it is subject to considerable variation depending on the child's nutrition, the state of his gastrointestinal tract, nature of food ingested, schedule, etc. In infants the pH of the gastric juice varies within the range of 5.8-3.8, with age the pH decreases, and in the digestive cycle of adults it varies between 1.5 and 2.0.

Total acidity (in ml) at various age levels, determined by means of $^{1}/_{10}$ N solution of KOH (potassium hydroxide) is

In the newborn	3-6
By end of first year .	15-20
During preschool period	30-35
Between 8 and 12 years	40-60

The child's gastric juice contains enzymes at birth, but the secretion of pepsin and rennin (formerly called lab ferment) and their potency are lower than at a more advanced age.

Gastric juice chemistry values in infancy (after M. Maslov)

	At one month	At one year
Total acidity	3-6-10 ml	12-21 ml
Free HCl	0.8-4.5 ml	4-10 ml
Pepsin	2-8 units	16-32 units
Rennin	32 units	256-512 units
Lipase	4.2-10.2 units	0-40 units

Thus we see that in infancy the functional deficiency of gastric secretion is quite distinct.

Any disturbance of the physiological status of the child (dyspepsia, hypotrophy) leads to a decrease in both gastric juice acidity and enzyme activity.

The increase in the acid number of the gastric juice and in enzymatic power observed as the child grows older may be explained according to the teachings of Ivan Pavlov, by three factors: (1) gradual formation of conditioned reflexes in response to food irritants, (2) increasing complexity of the child's dietary, in so far as there is a corresponding enzymatic action for each type of food, (3) development of the cerebral cortex. *Enzyme secretion depends on the food constituents and the state of the child: breast milk calls for enzymes of considerably lower potency than cow's milk, proteins intensify secretion, fats inhibit it; in healthy infants the digestive power of rennin averages 100, in an infant with acute symptoms of atrophy it is approximately 5.*

Stomach digestion consists of two phases: the first is coagulation of the milk, the second hydrolysis of the fats and digestion of casein. The separate food constituents are digested by different enzymes

Digestive potency varies in the various phases of digestion, pepsin activity increases particularly

Gastric juice is least acid when the infant is reared on breast milk, cow s milk requires the secretion of a much more active gastric juice (see Chapter XIX)

In the infant the first phase of digestion is milk coagulation, achieved by the action of rennin (or chymase), cow s milk coagulates at pH=6 0 6 5, breast milk at pH=5 0 The coagulation of breast milk proceeds slowly, with the formation of soft, fine flakes of whey and of paracasein calcium Splitting of fats (the second phase of digestion) in the stomach of nursing infants is very slight as the gastric juice has a low lipase content, and the lipase itself is not sufficiently active, secretion of the more active lipase of the pancreatic juice is deficient during the first months of life In breast milk the fat is emulsified, and, besides, breast milk itself has a high lipase content therefore *up to 50 per cent of the fats are split in the stomach of breast fed infants No fat hydrolysis occurs in the stomach of bottle fed babies*

In the newborn and during the first months of life the pancreas lacks differentiation, it is abundantly vascularized and poor in connective tissue Its weight in the newborn is 3 g, in a three months baby it weighs approximately 6 g, in adolescents 70 78 g and in adults 90 120 g The histological structure of the pancreas is similar to that of the parotid gland In both children and adults the pancreas possesses an endocrine function (it secretes insulin) and participates in the regulation of carbohydrate metabolism However, its chief function is the production of trypsin (an enzyme which hydrolyses protein) and of diastase and steapsin which hydrolyse carbohydrates and fats, the potency of the pancreatic enzymes grows with age

The investigations carried out by Ivan Pavlov and his school have completely clarified the mechanism of pancreatic secretion and have proved that concomitantly with the neural mechanism of pancreatic excitation there also exists a humoral, purely chemical, mechanism The acid gastric juice induces pancreatic secretion, but the activity of the pancreas is associated with the type of food ingested, the highest concentration of all the enzymes is induced by milk and fats, the least by meat Consequently, pancreatic juice contains all the enzymes necessary for digesting the child's principal food—milk and carbohydrates It is extremely important for the milk delivered from the stomach to the duodenum to have a definite acidity, as there is a close correlation between gastric and pancreatic secretion

The duodenal juice is a mixture of the secretions of the stomach intestine, pancreas, and liver (the enzymes amylase, lipase, trypsin) Changes in its colour depend on the admixture of bile Its quantity also changes in accordance with the nature of the excitant and the general state of the child any disease, particularly at an early age lowers the enzymatic potency of the duodenal juice and consequently impairs digestion and assimilation of food

The endocrine function of the pancreas is secretion of the hormone insulin. This hormone regulates carbohydrate metabolism, is conducive to the hydrolysis of sugar in the tissues and to the storage of glycogen in the liver, i.e., it regulates carbohydrate assimilation.

The absorptive function of the child's stomach is not very high; only a very small amount of electrolytes and sugar and also partly water and the products of protein hydrolysis is absorbed in the stomach. During recent years one of Pavlov's pupils, I. Razenkov demonstrated a new aspect of the physiological activity of the stomach—its faculty of eliminating from the blood proteins and the products of their hydrolysis, these products are subject to further disintegration, and are delivered into the organism in the form of amino acids. The main mass of food is delivered from the stomach to the intestine for assimilation.

The intestine of the infant is relatively longer than it is in adults. In the latter it is four times longer than the body length, in the infant—six times longer. The greatest relative length of the intestine is observed in the first year of life, then a relative shortening occurs up to the age of eight years, and afterwards the length gradually increases again. A more intensive growth of the large intestine is observed up to puberty. The average length of the intestine equals the tenfold sitting height, but generally speaking *the length of the intestine varies individually over a wide range*. The intestine of well nourished children is longer than in emaciated children, in rachitic patients it is also longer owing to atonicity of the intestinal walls. The rectum is relatively long, its mucosa and submucosa are loosely attached, hence the tendency to prolapse. The descending colon is larger than the ascending colon. The sigmoid colon and the sigmoid flexure are relatively long. The cecum and vermiform appendix are mobile. In children the situation of the vermiform appendix is frequently not typical, as it may be located posterior to the cecum and even in the true pelvis. The intestinal mucosa is well developed and abundantly vascularized, rich in cellular elements, very delicate, and contains a great number of lymph nodes and villi.

The intestine is innervated by the autonomic nervous system, by the vagus which stimulates intestinal motility and secretion, and by the sympathetic nerves which inhibit them. The intestine of the child, as that of the adult, exercises three functions—*digestion, motility, and absorption*. All three show certain specific traits in childhood. The process of intestinal *digestion* is activated by the secretion of the pancreas and liver, and by the intestinal juice. The principal digestion of food substances to an assimilable condition is connected with the activity of the pancreatic juice which contains three enzymes—trypsin, amylase and lipase. Although all these enzymes are present at birth they lack sufficient activity and subsequently their digestive potency increases as the child's dietary expands Least active is the lipolytic enzyme *The motor function* of the intestine (motility) consists of pendulum like movements of the intestine lengthwise and transversely (by which the ingested food is thoroughly mixed), and of peristaltic movements that favour propulsion of the food mass to the outlet of the intestine The large intestine is characterized by antiperistaltic motility conducive to thickening and shaping the fecal mass Intestinal motility is quite energetic in early childhood, therefore defecation is mostly of a reflex nature, from the end of the first year of life defecation becomes a voluntary act

The intestinal juice contains the majority of the enzymes at birth (enterokinase, erepsin amylase, lactase, maltase, invertin) Older children produce, in addition to the above, also lipase *In infancy the intestinal reaction is usually weakly acid or even neutral* The decrease of acidity in the content of the stomach as it is delivered into the intestine is due to the alkalinity of the intestinal juice and of the bile constituents, and also to the intensive process of absorption of the acid products of hydrolysis in the small intestine, it is in this portion of the intestine that protein is subjected to the action of trypsin and erepsin

Absorption is the principal function of the child's intestine Proteins are absorbed in the form of amino acids, and, possibly, to some extent in their unaltered form as well, particularly during the first months of life Carbohydrates when split, yield easily assimilated monosaccharides, fats are absorbed in the form of fatty acids

Consequently, the small intestine is the site of absorption of the products of protein, fat, and carbohydrate hydrolysis, and partly also of salts, the large intestine is the chief organ of absorption of iron, phosphorus, and alkalis In infancy fermentative processes are likewise predominant in the large intestine, while putrefaction is almost absent, the process of absorption in the large intestine is inferior in bottle fed infants, as in such cases insoluble saponaceous substances and phosphates are present in the content of the intestine The time it takes for the food to pass through the entire length of the intestine varies quite considerably in the newborn it is from 4 to 18 hours, in older children approximately 24 hours The duration of intestinal digestion in bottle fed babies is approximately 48 hours

During the first year of life the permeability of the intestinal epithelium to products of incomplete digestion, and particularly to germs is higher than at any later period of life

The liver is relatively very large in infancy It takes up 4 per cent of the body weight in the newborn, and 2 per cent in the adult The weight of the liver doubles by the age of ten months, and triples by three years An intensive growth of the organ is again observed in the prepubertal period, in accordance with this growth the vertical dullness of the liver increases progressively up to the age of 14 years Liver growth proceeds predominantly in breadth and thickness the length is doubled by the age of 10 12 years, while the thickness of both lobes doubles in half that time—by 5 6 years

The liver is innervated by the vagus and sympathetic nerves, it has its own receptors and is subject to cortical regulation In its turn the liver has a definite effect on the central nervous system, hence the varying severity of nervous system symptoms in infectious hepatitis (Botkin's disease), ranging from apathy or irritability to severe comatose conditions, convulsions, delirium The functional correlations between the liver and all the portions of the digestive tract are very close, and the liver is always involved in any gastrointestinal disease

In childhood the liver is extremely plethoric, the development of the hepatic cells is not completed until the age of 6 8 years There is not much connective tissue in the liver Plethora of the liver and lack of differentiation of its parenchyma are the cause of the rapid reaction of the liver (by enlargement) to a number of infections intoxications, and circulatory disturbances, and also of its rapid degeneration under the influence of infections and intoxications

Besides producing bile the function of the liver in the child's body is very diverse the liver is a barrier against numerous harmful endogenic and exogenic substances, as it neutralizes toxins delivered from the intestine owing to abnormal or deficient digestive activity, the liver is also a barrier against bacteria, and it plays an important part in various metabolic processes (of carbohydrates, protein, bile, fats, fluid, vitamins) In intrauterine life the liver is a blood forming organ, following birth the hematopoietic cells in it undergo disintegration

The liver is a temporary depot for many nutritive substances, chiefly for glycogen, and also for fat and protein these substances are delivered directly into the blood from the liver Certain of the cellular elements of the liver (Kupffer s cells, the endothelium of the hepatic sinusoids) are part of the reticuloendothelial system which possesses phagocytic functions and plays a prominent part in the metabolism of lipoids, iron, and cholesterol

The liver of the newborn is in a state of functional immaturity, owing to which part of the bile penetrates into the blood (bilirubinemia) this circumstance, coupled with rapid hemolysis of the red blood cells during the days immediately following birth, results in *the physiological jaundice of the newborn* This bilirubinemia is particularly marked in the fetus

The gallbladder of the newborn is small and narrow, by the age of two years it attains the margin of the liver Bile production commences in the second or third month of prenatal life, during the first few months of postnatal life bile production is comparatively low

Specific features of the bile in childhood (1) low bile acid value, (2) relative prevalence of taurocholic acid over glycocholic acid, the volume of which increases with age, (3) a high content of mucus, water and pigments Such a composition of the bile is advantageous for the child organism since the antiseptic properties of taurocholic acid are much stronger than those of glycocholic acid moreover taurocholic acid intensifies the production of pancreatic juice the enzymes of which are in especial demand owing to the abundance of fat and sugar in breast milk Bile intensified peristalsis in the large intestine emulsifies fats dissolves fatty acids

The spleen as in adults is situated between the IX and XI ribs but in infancy it is overlapped by the left lobe of the liver the fornix of the stomach and the small intestine a condition but seldom observed in adult life The newborn s spleen weighs $^1/_{80}$ of the adult spleen the birth weight of the spleen doubles by the time the baby is five months old and triples by one year It increases quite steadily in subsequent years up to the age of eight years 10 g are gained a year and after eight—6 g annually By ten years the spleen weighs ten times more than at birth

The morphological structure of the spleen in childhood possesses certain histological characteristics that resolve into the immature differentiation of this organ The trabeculae are finer than in adults and are abundant in cellular elements The development of the Malpighian corpuscles terminates at the age of three months by seven years splenic structure nowise differs from what is found in adults *The function of the spleen* is manifold it plays some part in digestion but its chief function is participation in blood formation particularly at an early age (see Chapter XVII) Like the liver the spleen is very sensitive to any infection or intoxication conditions to which it responds by enlargement Together with the liver the spleen is part of *the reticuloendothelial system* (the reticular cells of the spleen)

Attachment of the peritoneum to the abdominal walls is looser than in adult life The mesenteries are porous and easily retracted this is the cause of the frequency of hernia and occasionally of invagination particularly in infancy

Intestinal flora Two or three days following birth bacteria appear in the intestine of the newborn—the colon bacillus enterococci yeast flora all of which penetrate into the intestine from the air from the mother s nipples through various objects used in the care of the infant Subsequently the typical intestinal flora of breast fed babies includes *B bifidus B coli B proteus B lactis aerogenes* In bottle fed babies *B coli* (the colon bacillus) prevails In older children the make up of the intestinal flora is extremely variegated The arrangement of bacteria in the intestine is not uniform most of them locate in the rectum and colon their number is least in the duodenum and upper portions of the small intestine The stomach contains almost no bacteria at all

Importance of intestinal flora Many of the intestinal microorganisms produce enzymes that affect the food constituents and thus they par ticipate in the process of digestion Some bacteria increase carbohydrate fermentation, are conducive to saponification of fats, dissolve cellulose and synthesize vitamins of the B group and vitamin K However, when conditions of digestion change (decrease of enzymatic potency or inadequate food constituents) the hydrolytic action of the intestinal bacteria leads to the formation of abnormal products of hydrolysis of fats, protein, and carbohydrates, in consequence absorption of toxic products occurs

In sickness the intestinal flora changes, undergoes violent multiplication, toxicity increases, and the microorganisms work their way into portions of the intestine where they are not ordinarily found In these sections the food residue becomes infected, the toxic products of bacterial toxin decomposition are absorbed, and possibly the bacteria as well The action of the toxic products on the nervous system produces toxicosis The oral cavity of the newborn infant is also rapidly populated by bacteria from the outer surroundings—cocci, streptococci, representatives of yeast fungi This must be taken into consideration and the baby's mouth should be protected as best as possible against trauma Artificial feeding (cow's milk) is conducive to an intensive population of the entire gastrointestinal tract by bacteria, beginning with the mouth This is caused by the penetration of bacteria with the food, and by alteration in the enzymatic composition and bactericidal action of the digestive glands.

Clinical Summary

As we have seen, the digestive system of children is distinguished by a number of anatomical and physiological traits which are reflected both in the functional abilities of these organs and in the pathology of digestion and nutrition in early childhood In the first year of life the child's food requirements are relatively higher than in adults and older children The more intensive processes of acidification, the relatively longer intestine, and the heightened absorptive faculties of the intestinal mucosa are all conducive to satisfaction of these demands However, although at birth all the enzymes necessary for the process of digestion are present, *the functional ability of the digestive organs of the infant is limited* it is sufficient when the child is provided with definite physiological food that is with *breast milk* Before being given to the baby the milk of animals must be prepared for the process of digestion (dilution with plain or cereal water, milk formulas in which the fat or protein content is decreased, acidified formulas, etc) Even little deviations from normal in quantity or quality of the food may easily upset the functional activity of the digestive organs of babies and bring on digestive and nutritional disorders *Hence the high incidence of such disorders in infancy* It is only later in life, with maturation of the nervous system, that a more stable secretion is established in the gastrointestinal tract Digestive trouble in young children produces peculiar clinical patterns (for instance toxic dyspepsia), which are associated with the anatomical and physiological features of the digestive organs, with the specificities of the central nervous system, and with all the metabolic processes, digestive disorders are generally severe in early childhood, being one of the principal causes of child mortality in the first year of life

The child's organism is extremely sensitive to all manner of toxins that are frequently formed owing to disturbed digestion The first thing to be taken into account is the effect of the toxins on the system of intestinal receptors that transmit stimuli to the central nervous system But the humoral route open to toxins should not be disregarded This route is by way of the *intestinal wall*, so abundant in blood vessels and lymph nodes, which is *the first barrier against toxins and bacteria*, since the intestinal epithelium possesses the faculty of selective permeability for certain substances and detention of others When the epithelial function is disrupted toxic substances are delivered to the liver through the portal vein *The liver is the second barrier against toxins*, however, the lack of differentiation of the hepatic parenchyma favours rapid degeneration of its cells The disinfecting function of the liver is disrupted, and the toxins penetrate into the blood, inducing considerable disturbances in metabolism and in the functions of various systems and organs, first of all in the central nervous system

The normal physical development of the child is closely connected with the functions of his digestive organs any digestive trouble is quite rapidly reflected in systemic nutrition and metabolic pathology and such disturbances are in their turn accompanied by functional lesions in other organs and systems—the nervous respiratory and cardiovascular systems Consequently, diseases of the digestive tract may positively be classified as systemic diseases of childhood The prominent part played by the nervous system in these conditions is extremely distinct, since it determines the severity of the disease (intestinal toxicosis)

The child s environmental conditions (care, schedule, atmospheric temperature, hygiene) are extremely important etiologic factors in digestive diseases, in so far as disturbance of normal environmental conditions in early childhood rapidly involves the digestive functions

EXAMINATION OF THE DIGESTIVE ORGANS AND ABDOMINAL VISCERA AND SYMPTOMATOLOGY OF THEIR MOST COMMON DISEASES

Examination of the digestive and abdominal organs includes *interrogation* and *physical examination* Physical examination consists of (1) general examination, (2) palpation, (3) percussion, (4) laboratory investigation of vomitus, gastric and intestinal contents, feces, and functional test of the liver, (5) special methods of examination (x-ray and others).

Interrogation

The principal questions put to the mother concerning *an infant in arms* are is the baby breast- or bottle-fed or does he receive a mixed diet? How often is he put to the breast? Is he a vigorous sucker? For how long is he kept at the breast? Does he fall asleep after a feeding or become restless? How much milk does he withdraw in one feeding? Does any milk remain in the breast after he has nursed?

Matters to be clarified when the baby is on an artificial or mixed diet are when and what solids were first introduced, and in what manner? In which month of life? What milk formulas are given? Are they prepared by the mother herself or obtained from the local infant s dairy kitchen? Why were solids first added? (The usual time is at 5 6 months of age, earlier additions of solids are permissible in cases of maternal disease, lack of breast milk, mother occupied at work) How are the solids given (from a bottle or a spoon)? Does the baby throw up? What does he throw up, when, and how much? Character of regurgitation or vomiting (projectile vomiting accompanies pyloric spasm, eructation of air and/or regurgitation of food) Is vomiting precipitated by water? (Sign of toxic condition in the presence of diarrhea) Does vomiting occur in the intervals between feedings? Frequency of stools (2-4 bowel movements in 24 hours are normal for babies between 2 and 9 months of age) Colour of the movements, odour, consistency Does the baby strain (tenesmus)? Is blood or mucus observed in the feces? Does prolapse of the rectal mucosa occur?

Questions concerning *an older child* how many meals does the child have a day? What dishes are given? Is the child's appetite normal? (Lack of appetite is seen when meals are irregular and diet unsuitable, also in neurotic children, and during various diseases) An urge for food that may even turn into gluttony is observed in children with endocrine pathology, as, for instance, in precocious puberty, diabetes, etc)

Has the child any predilection for substances such as clay, coal, raw meat (the latter may be a source of tapeworm infestation)? If the appetite is poor, when did impairment occur? Does the child eat better in school or kindergarten (neurotic children and faulty upbringing)? Does vomiting occur (vomiting induced by forced feeding, neuropathic vomiting, acetonemic vomiting)? Is there any trouble in swallowing? Does the child chew properly? Does he complain of abdominal pain? When does the pain appear (during a meal or after)? Is the pain connected with any definite type of food (for instance, pain in the hepatic area after the ingestion of fat food)? Where does the child himself localize the pain (only older children)? How often are the bowels evacuated? In cases of constipation interrogation should clarify the child s schedule, the time he spends out in the fresh air, the sports, if any, he takes up, the food he eats (atonic constipation caused by sedentary life and by monotonous food deficient in roughage) Colour of stools, odour, consistency, admixture of blood or mucus? Have worms been observed in the stool? Is defecation painful? Does the child strain? Does prolapse of the rectal mucosa occur?

The above questions are only a general outline, a number of others arise in association with the nature of the child's disease

Physical Examination

General examination The tongue and oral cavity should be examined last, since the child may become restless and further examination be impeded

The child's *lips* together with the tongue, chin and cheeks participate in the complicated act of sucking, which frequently calls for considerable effort Therefore disturbances in sucking may be due to some defect in one of these organs Severe cases of harelip and cleft palate make sucking almost impossible but the child may sometimes take a rubber nipple quite easily, since no great effort is required for this Impossibility of opening the mouth (tetanus neonatorum), general feebleness, immaturity of the brain centres (prematurity asphyxia birth injury) may also cause the infant to refuse the breast During the first weeks of life the baby's lips may occasionally be the site of watery blisters, the result of irritation during sucking particularly if the breast is too tight Cracks on the lips particularly when accompanied by weeping excoriations in the corners of the mouth are a symptom of syphilis in infancy In older children (3 to 12 years—preschool and school age) infiltrates or cracks (perleche) may be observed in the corners of the mouth, formerly it was considered that these vesicles were contagious (staphylococci) At present it has been established that the condition, as well as certain other changes in the oral mucosa, are manifestations of vitamin B_2 (riboflavin) deficiency (see Chapter XX) Attention must be concentrated on herpes associated with pneumonia, on blueness of the lips (cyanotic lips are seen in heart lesions and asphyxia of various origin brightness accompanies severe gastrointestinal disorders) on their dryness or moistness on their thickness (the thick lips and open mouth of idiocy and myxedema) The inner surface of the lips is also examined in order to determine the condition of the mucous membrane (aphtha, thrush hyperemia with Filatov Koplik spots)

Examination of the lips is followed by *examination of the oral cavity*—the teeth tongue, mucosa of the throat, the tonsils and salivary glands

Mouth odour deserves particular attention the nature of this odour may sometimes indicate a disease not only of the mouth, but of the system as a whole A putrescent odour is typical of ulcerative stomatitis and sore throat, and of carious teeth In cases of acetonemic vomiting, severe gastrointestinal diseases, and diabetic coma an acetonic odour is quite typical, in bronchiectasis and pulmonary gangrene both the sputum and the exhaled air have a very offensive odour Toxic diphtheria produces a peculiar sickening-sweet smell from the mouth A bad odour from the mouth, particularly in the morning is mostly caused by chronic nasopharyngitis rather than by any gastrointestinal disease

The teeth—see Chapter XIV

The gums During examination a swelling of the gums may be noted, as well as porosity, redness, bleeding (avitaminosis hemorrhagic diathesis and a number of infections), coated mucosa (white films—thrush, greyish films—aphthous stomatitis, diphtheria)

The tongue The external appearance of the tongue is important Macroglossia (enlargement of the tongue) is seen in myxedema, when the tongue almost constantly protrudes from the mouth In digestive disorders and acute infections (typhoid, pneumonia) a white film coats the tongue Dryness of the tongue occurs in nasal obstruction (severe rhinitis) and grave systemic diseases (typhoid fever, dysentery, pneumonia, severe toxic dyspepsia in infancy) The appearance of the tongue in scarlet fever is quite typical—bright red, with prominent papillae—strawberry tongue A peculiar aspect is that of geographic tongue, with localized whitish and greyish thickenings of the epithelium (its occurrence is accepted as a sign of exudative diathesis) The tongue of emaciated, diarrheal children is frequently dark red, dryish, and smooth, with no sign of the papillae—magenta tongue, a sign of vitamin B_1 and B_2 deficiencies The marks left by the teeth sometimes prove useful for judging the nature of seizures the child may be subject to (tongue biting in epilepsy)

The frenulum of the tongue is frequently shortened at birth and in the first months of life, hence the characteristic clicking sound infants often make while nursing (a circumstance mothers frequently worry over) As a rule, this condition rapidly disappears without any interference Tongue-tie (ankyloglossia) is a congenital abnormality of the frenulum, interfering with the mobility of the tongue it is rarely observed An ulcer may form on the frenulum of the tongue in whooping cough (owing to abrasion by teeth)

In examination of *the mucous membrane of the oral cavity* the signs to be noted are colour (pale in anemia, yellowish in jaundice, red with excessive secretion in all manner of stomatitis—catarrhal, aphthous, and ulcerative, and also in bleeding and in hemorrhagic diathesis), films (a white coating in thrush) and membranes (in diphtheria) Measles is accompanied by a peculiar eruption in the mouth of reddish spots with whitish scales (Filatov's spots, also called Koplik's spots or sign) Very frequently aphthous ulcers appear on the buccal mucosa in the place where it is contiguous with the gums, therefore these places require the most careful attention In the second week of life newborn infants occasionally develop lentil-sized spots on the hard palate, one on each side of the median line (Bednar's aphthae) These spots are mucosal infiltrates with superficial ulceration, their appearance is the result of faulty care of the mouth (swabbing) In syphilis whitish spots or very superficial ulcers appear at times on the oral mucosa

Examination of the fauces—see Chapter XVI

In examination of *the salivary glands* (parotid, submaxillary, sublingual) attention is concentrated on their state—swelling of the parotid gland in parotitis (mumps), and sometimes also of the submaxillary and sublingual glands in this disease Other signs of parotitis are erythema, edema and elevation of the parotid duct above the mucosal surface

Examination of the abdomen commences with examination of its skin (see Chapter XI) and subcutaneous adipose layer It should be borne in mind that an excessive deposition of fat on the abdomen of endocrinopathic children (hypogenitalism) may frequently simulate abdominal enlargement

Dimension and shape of the abdomen Normally the abdomen is on the same level as the chest and does not protrude beyond the latter (after infancy), in infants the abdomen is slightly elevated over the level of the chest A number of pathological deviations are at times observed in the shape and size of the abdomen ***Large belly.*** The most frequent causes of abdominal enlargement are (1) *meteorism* resultant on acute and chronic dyspepsia and persistent constipation, meteorism owing to rough food, intestinal stenosis, depending on its location, induces either general meteorism (Hirschsprung's disease or megacolon, abdominal distention in intestinal paresis), or a local distention of the abdomen (pyloric stenosis—distention in the gastric area), (2) *hypotonia of the muscles* of the abdominal wall and *the smooth muscles* of the intestine observed in rickets (Fig 47), general muscular atrophy, so called intestinal infantilism which is attended by chronic diarrhea and retardation of physical development (Fig 48) (3) *accumulation of fluid* in the abdominal cavity in the form of (a) an inflammatory exudate produced by acute peritonitis or chronic tuberculous peritonitis (Fig 49) (b) a transudate—ascites which appears in cases of generalized dropsy (diseases of the kidneys and of the heart), local circulatory disturbances in the abdominal cavity (cirrhosis of the liver, rarer in children than in adults), (4) *abdominal tumours*—tumours of the liver, spleen lymph nodes of the adrenals sarcoma of the retroperitoneal and mesenteric lymph nodes, kidneys (Fig 50), or ovaries

The shape of the abdomen, as established during examination, is to a certain extent a clue to the cause of its enlargement

Shape of the abdomen In conditions such as rickets, meteorism and ascites a uniform enlargement of the abdominal curvature is noted

In tuberculous peritonitis the median portion of the abdomen is most prominent Unilateral enlargement of the abdomen is typical of tumours and paralyses of the abdominal muscles (infantile paralysis) In rachitic children in children with large bellies or children with chronic intestinal trouble a condition termed *pseudoascites* is observed with ascitic percussion findings It is caused on the one hand

Fig 47 Distention of abdomen in rickets

by intestinal atonia and meteorism and on the other by a considerable accumulation of fluid in the intestine Differentiation from true ascites is established by the instability of the percussive dullness and of fluctuation and disappearance of the dullness after evacuation of the intestine

Scaphoid or navicular abdomen is a belly with sunken walls presenting a concavity it is seen in starvation in underfed children in dysentery pylorostenosis tuberculous meningitis (Fig 51)

Other findings besides size and shape that are ascertained by examination of the abdomen are intestinal peristalsis the condition of

Fig 48 Right abdominal distention due to intestinal (celiac) infantilism in 4 year old child Left healthy little girl of same age

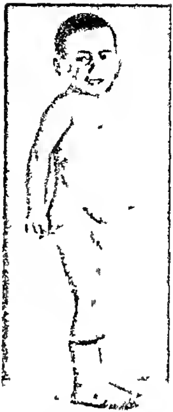


Fig 49 Abdominal distention caused by tuberculous peritonitis in child of $3^1/_2$ years

the navel possible divergence of the recti muscles and existence of hernia (umbilical inguinal)

Abdominal participation in the act of breathing is also determined by examination in cases of inflammatory processes in the peritoneum the normal infrathoracic type of respiration alters and respiration becomes thoracic

Normally intestinal *peristalsis* should not be visible during examination It is visible in children with poorly developed subcutaneous adipose tissue in emaciated children Peristaltic and antiperistaltic movements are seen in the epigastric and subcostal areas in infants in cases of constriction of the outlet of the stomach pyloric spasm or stenosis These movements occur from left to right and may be precipitated by the mechanical stimulation of the gastric walls through the abdominal integuments (Fig 52)

Intussusception, or the invagination or slipping of one part of the intestine into another produces intestinal obstruction, when peristalsis of separate loops of the intestine is seen (Fig 53)

The condition of the navel must be attended to in the first weeks of the infant's life Ordinarily the cord sloughs off on the 5 7th day of life, leaving an umbilical wound with a smooth surface The various diseases of the umbilicus include suppuration, ulceration, inflammation (omphalitis), phlegmon, granulation (frequently of a fungoid appearance), and diphtheria of the navel with a greyish film on the

Fig 50 Enlargement of abdomen caused by sarcoma of left kidney in 3 year old child

umbilical wound The development of the venous network in the area of the navel is an important diagnostic factor during the first weeks of life the condition even if the umbilical wound has healed, may be a sign of sepsis Faulty closure of the navel is the result of negligency and infection

Examination of the perianal area is a means of establishing the following (1) gaping anus and mucosal prolapse of the rectum in dysentery, (2) fissures of the anus causing painful defecation, (3) syphilitic papules at the junction of the skin and mucosa, (4) presence of pinworms, a cause of intense pruritus in the perianal area, particularly at night For examination of the anus the pediatric patient should be placed in the knee-elbow position, infants are examined while lying on a side Examination is supplemented by digital investigation through the rectum by this method rectal polyps, constriction of the rectum, accumulation of hard fecal matter or tumours are occasionally revealed

Palpation of the abdomen is performed with the child on his back The examiner places his hand (which should first be warmed) flat on the abdomen and presses in with three fingers, waiting for the child to exhale and thus loosen the abdominal muscles Pressure should be as deep as possible, and the patient's attention must be distracted somehow Palpation proceeds from the substernal area to the umbilical area then to the right and left iliac regions The condition of

Fig 51 Retracted abdomen in tuberculous meningitis in 4 year old child

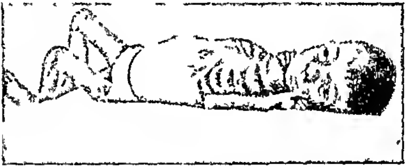


Fig 52 Visible gastric peristalsis in pyloric constriction

Fig 53 Visible peristalsis caused by intestinal intussusception in 4 month old baby

the skin, abdominal integuments, liver, stomach, and spleen is as certained as well as the tension of the abdominal integuments, the possible presence of infiltrates, fecal accumulations, tumours and spastic conditions of the entire intestine or of only certain parts of it in emaciated or tuberculous children the mesenteric lymph nodes are palpable

The abdominal integuments are formed by the skin, subcutaneous tissue, and the muscles *The tension of the abdominal muscles* may be either decreased or increased *Decreased tonicity* (hypotonia) is particularly frequent in rickets, if there is no considerable meteorism the hand may reach the spinal column, peristalsis and also a divergence of the recti muscles of the abdomen may be observed

Increased tonicity (hypertonia) or tense abdominal muscles is seen during inflammatory processes in the abdominal cavity, and in pyelitis

Percussion of the abdomen is a means for establishing the presence in the abdominal cavity of accumulations of fluid The flat places are dull to percussion, and the area of dullness alters with change of position, therefore the patient should be percussed both while standing upright and when lying down (on his back and on a side) The presence of fluid is indicated by fluctuation It should be noted whether the dullness to percussion shifts with a change of position (free fluid in hydremic edema, nephritis, heart lesions) The pediatrician must also bear in mind the possibility of adhesive peritonitis (tuberculous), a condition in which the existing adhesions cause the dullness originating in the exudate to retain its margins when the patient changes his position When fluid is suspected in the abdominal cavity the examination should be repeated on a fasting stomach or following an enema (to exclude pseudoascites)

EXAMINATION OF THE SEPARATE ABDOMINAL *VISCERA AND SYMPTOMATOLOGY OF DISEASES*

The stomach. The contours of the stomach can rarely be determined by examination and palpation alone Very light percussion is sometimes contributive to the determination of the margins of the stomach and its delimitation on the right and above from the liver, on the left from the lung and spleen and below from the intestines which are productive of a higher tympanitic resonance The part of the stomach bordered on by the heart, lungs and spleen is called the semilunar space (Traube's space), it is an important diagnostic factor for establishing the presence of a pleural exudate (see Chapter XVI) Distention and expansion of the stomach are occasionally visible to the eye Peristaltic and antiperistaltic movements of the stomach are seen in infancy when the pylorus is constricted (pylorospasm and pylorostenosis) Palpation of the stomach is a means for judging its fullness, tenderness, and presence of a tumour.

To be able to judge the normalcy of gastric activity the functions of the stomach must be studied, these functions are secretion, digestion, and motility The investigation includes laboratory examination of the vomitus and gastric contents and x ray examination

Vomiting may be due to diverse causes in childhood, and it is frequently a valuable diagnostic symptom Generally speaking children vomit more easily than adults do, and the younger the child, the easier does vomiting occur. Several types of vomiting are recognized (1) spitting up or regurgitation, (2) vomiting associated with gastrointestinal diseases, (3) merycism (rumination), (4) projectile vomiting in the first months of life owing to spasm or constriction of the pylorus, (5) neuropathic vomiting, (6) vomiting induced by coughing (pertussis), (7) vomiting associated with infectious diseases (scarlet fever and other), (8) reflex vomiting caused by stimulation of the peritoneum, (9) toxic vomiting caused by intoxications (uremia, diabetic coma, acetonemia), (10) vomiting of cerebral origin in meningitis, encephalitis, and brain tumours

Spitting up or regurgitation differs from other types of throwing up by the fact that it occurs in perfectly healthy children without any preliminary signs and without effort, i e, in the absence of tension of the abdominal press and of any change in the general condition of the child During the first months of life the baby often spits up uncurdled milk directly after nursing or, when some time has elapsed after the feeding—coagulated milk (frequently the cause is change of position, or rocking) The frequency of regurgitation and vomiting seen in babies is partly due to physiological aerophagia (swallowing of air), and partly to the weakness of the muscles at the entrance into the stomach *Persistent vomiting induced by every bit of food is typical of toxic dyspepsia*, which is attended—in addition to diarrhea—by systemic involvement loss of weight, impairment of cardiac activity dehydration, etc

A peculiar form of vomiting is *merycism (or rumination)*, when the food ejected into the mouth is again swallowed by the patient

Projectile vomiting in pylorospasm or pylorostenosis is usually accompanied by emaciation

Neurotic children frequently vomit without any visible deviations from normal in diet, and this vomiting is not infrequently accompanied by dyspepsia The cause of neuropathic vomiting is hyperesthesia of the mucosal lining of the stomach

Distinction should be made between vomiting and the ejection of food that has not reached the stomach, this is seen in cases of esophageal constriction (scars subsequent to burns, and tumours), paralysis of the soft palate after diphtheria, and also in tonsillitis or another type of sore throat owing to the impossibility of swallowing food

The character of the vomitus is a valuable diagnostic factor *Bloody* *vomit* is frequently a symptom of hemorrhagic diathesis in children, and it is seen in the newborn in the condition termed melena neonatorum, in umbilical hemorrhages, gastrointestinal hemorrhages, etc , owing to a septic infection, syphilis, and bleeding propensities Differentiation must be made between true bloody vomit (vomitus cruentus) and *false bloody vomit*—the admixture of blood to the vomitus in cases of fissured maternal nipples, and also when blood is swallowed during nosebleed and hemorrhagic conditions of other etiology *Coffee ground vomit* associated with toxic dyspepsia is a sign of hemorrhage in the mucous membrane of the stomach and is a poor prognostic symptom *Bilious* (greenish) vomit owes its colour to bile

The odour of the vomitus (usually sourish) is altered in bronchiectasis For evaluation of the digestive and motor powers of the stomach the vomitus should be subjected to microscopy, and its volume measured (retention of food, poor digestion of milk bread, etc) Parasitic worms (ascarids) may sometimes be found in the vomitus

By investigation of the stomach contents the functional activities of the stomach—*secretion, motility, and absorption*—are evaluated One hour after ingestion of a test meal the latter is removed from the stomach by means of a tube, and the subsequent chemical study is conducted in the same way as for adult patients Sedimentation of the gastric contents the presence of mucus, and the chemical constituents are noted The technique of insertion of the gastric tube is the same for older children as for adults, for infants Nelaton's catheter is used (the baby is in a recumbent position) The length of the tube corresponds to the length of the esophagus (see Chapter XVIII) The gastric contents either flow out of the tube freely or are aspirated with a syringe

The secretory function of the stomach is studied in the gastric juice The examination may be carried out by two methods (a) examination of one specimen of gastric juice, (b) examination of several specimens taken over definite intervals of time (fractional method)

For obtaining one specimen of gastric juice a thick rubber tube is used (as for adults), but the length of the child s esophagus must be taken into consideration First the contents of the fasting stomach are obtained, then the child is given a test meal (dry bread and tea), or 150 ml of water and 0 1 g of caffeine to stimulate the secretion of gastric juice It has been proposed to substitute the water and caffeine (the caffeine test) by 2 per cent rice water The histamine test (parenteral introduction of 1 1000 histamine) recommended for adults for stimulation of gastric secretion is rarely used for children

Fractional investigation of the gastric juice is done following a caffeine test meal, a narrow flexible tube is passed into the stomach after the meal, at 10 minute intervals small quantities of gastric content are withdrawn over a period of two hours, by means of a 10 ml syringe

Normally hydrochloric acid secretion increases gradually, for 40 minutes on the average, and then subsides The peak values for total acidity and free hydrochloric acid depend on the age of the child Fractional examination of the gastric juice may only be done with school age patients, since the procedure calls for a quiescent position for the duration of two hours, and is therefore rarely suitable for younger children The gastric juice is examined in the laboratory by the usual methods

Examination of the gastric juice of children yields the following (1) hyperchlorhydria, excessive secretion of hydrochloric acid (seen in gastric ulcers and neuropathy), (2) hypochlorhydria, diminished amount of hydrochloric acid In achylia, anemia, and severe nutritional disorders the remnants of food in the stomach contents are examined microscopically, a test for the presence of blood is done, etc Tubercle bacilli are searched for in the gastric contents of tuberculous children who swallow their sputum

Duodenal tubage is done with the patient lying down a thin tube (3-4 mm in diameter and about 40 cm long marked at 15, 20, and 25 cm) equipped with a silver olive shaped bulb is introduced into the stomach, from whence it slips into the duodenum After one to one and a half hours, when the 25 cm tube marking reaches the lips, an alkaline fluid, tinged with bile (the duodenal juice) is aspirated by means of a syringe affixed to the free end of the tube

As in adults, three portions of duodenal juice are distinguished Portion A consists of pancreatic juice, bile, and intestinal juice with an admixture of gastric juice, portion B is bile from the gallbladder, and portion C is predominantly bile from the hepatic duct with an admixture of pancreatic juice It is sometimes difficult to obtain B bile from children owing to insufficient dilation of the sphincter The introduction (through the tube) of 20 per cent magnesium sulfate accelerates the appearance of gallbladder bile

The duodenal juice of children, and particularly the B bile, may contain, in addition to cellular elements, protozoans—*Lamblia intestinalis* (syn *Giardia lamblia*) Their demonstration in freshly obtained duodenal juice may in some cases explain the etiology of abdominal pain (lambliasis cholecystitis) and even of protracted colitis (lambliasis colitis)

The liver. The examination of this organ begins with the study of its situation In cases of hepatic tumours or acute hepatitis in emaciated children a bulging of the liver in the right side of the abdomen is noticeable *Palpation of the liver should begin in the lower part of the abdomen*, under the navel, in order to be able to define the margin of the liver when it is considerably enlarged and lies low in the abdominal cavity Palpation is done with the tips of the fingers which are placed parallel to the right costal margin, pressure to the abdomen must be applied very carefully When palpation is conducted with the patient lying on his back the examiner determines the extent of protrusion of the liver beyond the subcostal rim, its consistency, shape, type of margin, tenderness The examination is frequently hampered by crying (when the patient is very young), and also by meteorism When the child cries loudly the physician waits, keeping his hands on the abdomen, and during inhalation he cautiously palpates the margin of the liver The surface of the liver may be smooth or knobby, its margin also varies (sharp or rounded edge, etc)—depending on the type of hepatic lesion *In infancy* the liver normally protrudes slightly from under the ribs

Percussion of the liver is performed by lightly tapping finger against finger, generally speaking, it is difficult to establish the borders of the liver owing to the thinness of its lower margin The upper margin of the liver is defined along the mammillary line in the fifth intercostal space the breadth of the liver increases up to the age of 12 years

Acute liver enlargement (parenchymatous swelling) concomitant with insignificant induration is frequently seen in children in connection with various infections and intoxications (particularly at early ages) In acute epidemic jaundice the liver is large, firm, tender, and its margin is considerably rounded *Chronic enlargement of the liver* is observed (1) in cirrhosis of the liver developing at an early age owing to syphilis, and at an older age in consequence of poly serositis, malaria, and also concurrently with splenic enlargement, owing to various causes (hepatosplenomegaly), the liver is indurated, its margin is sharp, in syphilis the liver is firm and knobby, (2) as a result of congestion of the blood in the liver in cases of heart lesions, pericarditis, weak cardiac activity, during many acute infections (diphtheria, scarlet fever), and pneumonia, particularly in babies, (3) in tumours of the liver (sarcoma, cysts), (4) in liver abscesses (acute pain in the liver when it is pressed upon), (5) in the presence of echinococci (caseworms) in the liver, effecting considerable enlargement of the organ, palpation elicits a smooth fluctuating cupola on the smooth surface of the liver (the caseworm) palpation is usually painless, but occasionally pain may be felt under pressure (6) congenital constriction of the cystic duct (congenital jaundice), such children usually succumb within the first three months, (7) in amyloid degeneration of the organs as a result of chronic suppurative processes, the liver is large and firm, but not painful, its margin is rounded, concurrent findings are an enlarged spleen and albuminuria (8) in kala azar (visceral leishmaniasis), (9) in diseases of the blood—leukemia and anemia, the spleen is enlarged, the blood is changed, the liver is large, firm, and painless (Fig 54), (10) in Banti's disease or syndrome—chronic congestive splenomegaly with cirrhosis of the liver

Acute atrophy of the liver—jaundice with toxicosis attended by acute diminution and tenderness of the liver

Liver function tests are carried out in the same manner as for adults Many methods have been proposed for determining the functional state of the liver, but they are all of relative value In pediatric clin

Fig 54 Enlargement of liver and spleen in leukemia

ical practice the values mostly determined are bilirubin in the blood, the bile acids and pigments urobilin and urobilinogen in the urine (the pigment function of the liver)

The functional ability of the liver in regard to *carbohydrate* metabolism is determined by the glucose tolerance method The fasting blood is first withdrawn for examination, and then the child is given glucose (or, still better, levulose) orally, 1 75 g per kg of body weight, in a glass of water, the blood is then drawn over 30 minute intervals for a period of two hours, and the sugar content is determined in each specimen A curve plotted by the obtained values is called the glycemic curve In normal conditions of the liver the curve returns to its fasting level in two hours, and its peak after ingestion is no higher than 50 per cent The contour of the glycemic curve is only an orientating factor in functional lesions of the liver, in so far this curve varies in healthy children, too However, the ascending limb of the curve characterizes the absorption of monosaccharides from the gastrointestinal tract Alterations of the liver function in disturbances of *fat metabolism* may be determined, to a certain extent, by the blood cholesterol value A number of tests have been proposed for the determination of the *disinfecting* function of the liver Of these the test most widely used among preschool and school age children is Quick s hippuric acid synthesis test it is based on the ability of the liver to synthesize hippuric acid from benzoic acid and glycine In diminution of the liver function the amount of hippuric acid excreted by the kidneys decreases The dose of sodium benzoate given the patient is 3 4 g the amount of hippuric acid eliminated in the urine in four hours is normally 75 per cent of the ingested sodium benzoate None of the proposed tests are an absolutely reliable method for cofirmation of liver dysfunction, since in children disease of the liver usually affects all its functions—the pigment, carbohydrate, protein, and disinfection functions

The spleen *is ordinarily examined by palpation and percussion* examination of the spleen provides definite indications only when its enlargement is excessive Palpation is usually conducted with the child lying on his back with his legs bent, and still better when lying on his right side *Palpation of the spleen should be started under the navel (like palpation of the liver)*, gradually travelling upward The spleen is palpated by pressing the fingers against the abdominal wall, it moves with respiration and when the child cries loudly In order to loosen the tension of the abdominal muscles older children are asked to breathe with the abdomen In young children examination of the spleen is impeded by meteorism and crying (accompanied by muscular tension of the abdomen), the child should in such cases be placed on his right side so that the trunk occupies an angle of 45° in regard to the bed, the area of the IX-XI ribs is fixated along the axillary line with the hand, and the fingers probe for the spleen Palpation indicates (1) the consistency of the spleen (in chronic diseases it is firmer than in acute conditions, the greatest degree of induration is seen in amyloidosis), (2) the dimension of the spleen (determined against displacement of its margin), (3) mobility, (4) tenderness

Even in adults *percussion* is less valuable than palpation, since merely the area of spleen adjacent to the thoracic wall is defined In children, particularly very young ones, accurate percussion of the spleen is associated with still greater difficulties owing to the high diaphragm, gastric and intestinal meteorism, and not so rarely encountered pulmonary emphysema Percussion should proceed along the midaxillary line with the child lying either on his back or on the right side Percussion should be very light, since the adjacency of air-containing organs makes the percussive sounds elicited from the spleen not completely dull, but only flattened In normal conditions the splenic dullness occupies an area from the IX to the XI rib, and should not go beyond the anterior axillary line

Splenomegaly (enlargement of the spleen) is observed in connection with (1) many acute infectious diseases, (2) chronic infections and intoxications (malaria, syphilis, leishmaniasis, tuberculosis, etc) (3) congestive and inflammatory processes in the liver (infectious jaundice, cirrhosis), (4) diseases of the blood (acute and chronic granulocytic leukemia, various forms of anemia, pseudoleukemia), (5) Banti's disease, (6) caseworm in the liver In many diseases enlargement of the spleen is concurrent with liver enlargement

Sometimes the liver and spleen are simultaneously involved (disease of the reticuloendothelium of the liver and spleen in consequence of disturbance of lipoid metabolism and the accumulation of lipoid in the hepatic and splenic cells), at other times the reaction of the spleen is secondary to the liver lesion In childhood dysfunctions of the liver and spleen are usually closely interrelated In children between 3 and 12 years of age splenohepatomegaly (enlargement of spleen and liver) of obscure etiology is occasionally observed

The intestine. Examination of the intestinal tract consists of examination of the abdomen and its palpation, and what is most important, of determination of intestinal functions by interrogation of the mother and examination of the child's stool Functional disturbances of the intestine may be manifested by both diarrhea and constipation. Some idea may be gained by the appearance of the feces, in addition to interrogation of the mother and of the child himself (older children) Examination of the feces provides data for judging of the activity of the intestine and also, to some extent, of the functions of the liver and pancreas, since all the parts of the digestive system and all the abdominal viscera are closely interconnected and no isolated functional disturbances occur in children

Feces The external appearance of the bowel excrements, their odour, colour and consistency all depend on a number of diverse factors, predominant among which are the age of the child, his dietary, the condition of his intestinal tract and liver, etc Feces consist of the undigested residue from food, intestinal secretion, and bacteria The upper portion of the intestine, from the stomach to the ileocecal valve (Bauhin's valve) is almost free of bacteria, while the cecum and colon always contain numerous bacteria in infancy—the colon bacillus Proteus and, at more advanced ages, numerous other bacteria as well *The bowel excrements voided by the newborn* during the first 3 4 days of life are called *the meconium*, it is a dark green, pasty homogenous mass which includes small, round, yellowish clots The meconium consists of desquamated epithelium mucus, bilirubin crystals, fat, and fatty acids with a very slight admixture of bacteria Nurslings fed exclusively on breast milk void one to three orange yellow, homogenous, sourish stools a day Microscopic examination reveals, besides epithelium and fat, also bacteria (prevailingly *B bifidus*). Bottle fed babies also have one to three movements a day but the consistency of these stools is thicker, giving the appearance of whitish yellow putty, and the reaction is alkaline, the feces contain saprophytes and bacteria of the genus *Escherichia* When flour is added to the baby's food, or he is given too much sugar, the colour of the stool becomes darker Greenish stools are often seen in slight digestive upsets in both breast and bottle fed babies the green is the result of the conversion of bilirubin to biliverdin

Microscopic examination of the feces is important for estimating the digestive function of the intestine, an abundance of muscular fibres droplets of neutral fat, and a large amount of fatty acids are grounds for suspecting pancreatic dysfunction and disruption of the process of saponification and absorption of fats This is prevailingly observed in cases of chronic or relapsing diarrhea In protracted diarrhea the rectoromanoscopic method is also applied for excluding the possibility of chronic dysentery This investigation however calls for special training

Pathology of bowel evacuation is manifested by the altered frequency, consistency, and odour of stools The following types of stools are recognized in early childhood

1. *Starvation stools* when the baby is put on a hunger-water diet for therapeutic purposes during acute gastrointestinal diseases, and also in cases when the child is underfed (mother cannot produce sufficient milk), the stool is sparse and dark coloured

2 *Dyspeptic stools in mild forms of dyspepsia* are greenish-yellow, with white lumps and mucus, and are voided 5 10 times a day The reaction is usually acid, the appearance of the stool is that of chopped eggs The white lumps consist chiefly of fat, salts and fatty acids, partly also of casein *In severe forms of dyspepsia (toxic dyspepsia) the bowel movements are very frequent, loose, watery, green, in the form of discrete flakes,* the reaction is weakly acid or alkaline

3 *In diseases of the large intestine* (colitis, dysentery) *a certain admixture of mucus and blood (depending on the severity of the condition) is present* in the stools, or the latter may consist exclusively of mucus and blood Bowel evacuation may be very frequent (10 to 60 times a day), and defecation is usually accompanied by tenesma

4 *In chronic enteritis evacuations are bulky, greyish, foul* A specific form is the frothy stool which resembles bowel evacuations seen in sprue (see Chapter XX)

5 *Evacuations in excessive milk diet are usually shaped, pale grey or pale yellow,* dryish, and foul, their reaction is alkaline (putrefactive processes) This is the saponaceous-fatty type of stool

6 A monotonous starchy diet, or excessive amounts of flour in the diet yield stools which are dark brown, watery, and often frothy as a result of intensive fermentation

In children of the older age groups the stool is usually shaped, and it is voided once or twice a day, a moderately fecal odour is present In constipation the stools are very hard, in spastic constipation sheep-dung stools are voided (small, round fecal masses) Foul, shaped stools are voided when there is an abundance of meat or milk in the diet Mucous, muco purulent, and muco sanguineous stools are typical of colitis and dysentery Blood in a shaped bowel movement may be due to anal fissures, hemorrhoids, rectal polyps, blood in the stool is sometimes encountered in cases of hemorrhagic diathesis A purely bloody discharge, in the absence of fecal masses or odour, sudden in appearance, attended by just as sudden prostration and meteorism is typical of intestinal *intussusception,* i e , the invagination or passage of one part of the intestine into another with resulting intestinal obstruction In infancy it is mostly the small intestine which invaginates into the large intestine, causing a bulging of the right part of the abdomen The comparatively high incidence of intussusception in early childhood is explained by the irregularity of peristalsis which depends on immaturity of the regulating mechanisms and also on the loose attachment of the cecum to the surrounding tissue The rectal discharge in intussusception consists exclusively of blood, with no admixture of excrements, and with no fecal odour whatsoever. The passage of gas is absent *By these symptoms intussusception is* *distinguished from acute colitis, in which the blood is mixed with mucus and feces* Valuable findings are elicited by palpation and examination of the abdomen The abdomen does not participate in respiration, and one part of it (mostly the right) is distended The presence of a resilient circumscribed swelling with restricted peristalsis is defined by palpation which causes sharp pain Developing intestinal intussusception is frequently erroneously diagnosed as acute colitis, and thus the time most auspicious for surgery is lost A particular type of evacuation is seen in mucous colitis (it has a number of synonyms, among them membranous colitis, chronic exudative enteritis, croupous colitis, etc), the condition is characterized by colicky pain during defecation, and the passage of mucus or membranous threads, ribbons, or masses It is frequently seen in children afflicted with exudative diathesis

The colour of the stool depends on its stercobilin content, on the nature of the food ingested, and also on ingestion of medicinal preparations An abundant meat dietary makes the feces darker than when vegetables or dairy products prevail Beet root lends the stool a dark red colour bilberries make it black, spinach—green Reduced iron (ferrum reductum) and bismuth colour the stools black, while santonin makes them yellowish red

Worms (helminths) *Various intestinal parasites and their ova* are voided in the stool Most prominent among them are (1) *pinworms (Enterobius vermicularis,* syn *Oxyuris vermicularis)*, small, thin worms about 1 5 cm long, encountered in great numbers in the bowel evacuations, the females crawl out of the anus, causing intensive itching, particularly at night Pinworms are most easily detected by an examination of the perianal area of the child when the itching appears The worms themselves look like short white threads, their eggs are ovoid with a grainy content, (2) *ascarids (Ascaris lumbricoides)*, pinkish roundworms 7-10 cm long, their ova have a scalloped shell, (3) *whipworms (Trichuris trichiura,* syn *Trichocephalus dispar)*, parasites with tapering anterior ends and thicker posterior parts, the ova of this worm are demonstrated in the feces, (4) *the dwarf tapeworm (Taenia nana)* which is only 1 2 cm long and has microscopic proglottids, its ova are ovoid, with a very thick shell, (5) *the pork (Taenia solium)* and *beef (Taenia saginata, Taeniarhynchus saginatus) tapeworms*, the segments of these two tapeworms are very similar, but the uterus of the pork tapeworm is less branched, the proglottids (segments) of the beef tapeworm are voided even without bowel evacuation a finding that is a diagnostic symptom, it is very important to establish during interrogation whether the child could have ingested raw meat, since the pork and beef tapeworms penetrate into the human body in the larval form of cysticerci, (6) *the broad* or *fish tapeworm (Diphyllobothrium latum)* is less frequently encountered discrete segments are found in the feces, the breadth of these proglottids is greater than their length, in distinction from the mature seg ments of other tapeworms, (7) protozoans which are not infrequently found in the feces are *Giardia lamblia (Lamblia intestinalis)*, seen as cysts and vegetative forms, the latter are demonstrable only in warm feces

Constipation. One of the symptoms of functional disturbance of the intestine is *constipation* It is observed as a transitory symptom in a number of infectious diseases, constipation is a valuable diagnostic sign in tuberculous meningitis, in this condition flabbiness of the abdominal muscles and caving of the abdomen are observed In early childhood habitual constipation is caused by faulty feeding (underfeeding or monotonous dairy dietary), or it may be a manifestation of intestinal atonia, of weak peristatsis

In all cases of constipation the mother should be questioned closely concerning the food the child eats *When undernourishment of an infant is suspected the quantity of milk he withdraws must be checked* (by weighing the baby before and after each feeding for 24 hours), and ascertaining the number of micturitions, infrequent micturition in association with constipation and loss of weight usually indicates hunger due to underfeeding Persistent constipation in early childhood is seen in cases of pylorostenosis and pylorospasm, Hirschsprung's disease, and also in constriction of the outer opening of the anus When persistent constipation is complained of it is necessary to make a digital examination of the rectum, in addition to examination of the anus *Constipation is less frequent in older children* than in young ones, owing to the greater variety of food such children have At this age constipation may also be due to faulty diet (abundance of milk or of food poor in cellulose which does not induce normal irritation of the intestinal walls) Constipation may quite occasionally appear subsequent to intestinal diseases (predominantly diseases of the large intestine attended by spastic conditions and ulceration—colitis, dysentery). Some children develop the habit of holding in their bowel movements, as a result of which distention of the lower part of the large intestine occurs and its muscular tension is disturbed The stool in such cases appears in the form of small hard, round masses

Abdominal pain. Children frequently complain of pain in the abdomen therefore it is important to clarify by exhaustive examination, the precise site and origin of this pain The pain may be localized in the skin of the abdomen, in its muscles, in the peritoneum, or in the abdominal viscera *Cutaneous hyperesthesia* is usually a manifestation of general hyperesthesia in meningitis, typhoid, etc *Muscular pain is often* observed in schoolchildren owing to too much exercise (football, skiing), and is ordinarily localized in the recti muscles of the abdomen (*gymnastic pain*) Similar pains are seen in children during pertussis as a result of the straining associated with coughing

Pain may be characterized as *diffused* or *circumscribed* Diffused pain is seen in peritoneal lesions, in dysentery, etc Circumscribed pain may provide valuable information for diagnosis, depending on its location pain in the cecal area with the most extreme tenderness in McBurney's point (i e, halfway between the umbilicus and the anterior superior iliac spine) increasing under pressure is symptomatic of appendicitis Complaints of pain in the substernal area after meals are not rare These pains are either dull, protracted, and accompanied by a sensation of heaviness in the stomach, or acute and paroxysmal. A tenderness is located by palpation in the substernal area or lower, near the umbilicus, the case history often shows diarrhea alternating with constipation

Investigations show that the acidity of the gastric juice usually diminishes with diarrhea and increases with constipation This irregularity in hydrochloric secretion is ordinarily based on dietary disturbances, particularly in schoolchildren owing to their indulging in snacks instead of meals, long intervals between the ingestion of food, too much food at one meal, sweets and starchy foods in excess Periodic pain that appears in the stomach following a meal, or some what later in the intestine, is seen in neurotic, excitable children afflicted with a number of disturbances of the autonomic nervous system, the pain is generated by spasms in different portions of the gastrointestinal tract (gastrospasm, cardiospasm, pylorospasm, duodenospasm, enterospasm) Such neurogenic motorial dysfunctions (dyskinesia) are confirmed by x ray examinations with radiopaque substances In diseases of the intestine pain (usually paroxysmal) is felt in different parts, depending on the nature of the disease Diffuse pain, accompanied by tenesmus, is typical of dysentery, a tenderness is detected by palpation in the umbilical area and along the course of the large intestine, in severe cases the entire abdomen is involved In catarrh of the small intestine the abdomen is distended, tender to the touch all over, and the pain is intensified by defecation Cholecystitis is characterized by the sudden appearance of sharp pain in the right part of the abdomen and the gallbladder area, the pain is increased by pressure Recurrent spasmodic abdominal pain is sometimes a primary symptom of tuberculous peritonitis Findings typical of tuberculous involvement of the peritoneum and omentum are tenderness of the abdomen to palpation, and the detection through the abdominal wall of band shaped indurations with sharply delineated margins Intussusception (invagination of one part of the intestine into another) a condition mostly observed in early infancy is characterized by the presence of a sausage shaped tumour, tender to palpation in the site of the invagination, peristalsis of separate intestinal loops is not infrequently observed It is important to know that a similar presence of hard, tender, mobile (or at times immobile) formations may be caused by retention of fecal masses in different parts of the intestine Diagnosis is clarified by repeated siphonage and cathartics (preferably saline laxatives or senna infusion)

During the school age and through adolescence nervous children frequently complain of pain predominantly localized in the umbilical area, this pain is erroneously termed *umbilical colic*, the greatest tenderness is observed along the median line in the area of the solar plexus Pain during defecation is caused by fissures or polyps in the anus In infancy abdominal pain with resultant restlessness is due to a considerable accumulation of gas—meteorism, the baby usually calms down after defecation or passing gas This pain frequently appears paroxysmally, at periodic intervals of time

It should be borne in mind that *children complain of pain in the obdomen in a number of disorders that are not located in the abdominal cavity* Thus the presenting complaint in tuberculosis of the spinal column is not infrequently abdominal pain which is intensified by physical exertion and acquires a paroxysmal nature at night Kidney colics (due to renal calculi) are accompanied by acute pain in the abdomen, referring to the back When there is suspicion of renal calculi (kidney stones) an x ray picture of the renal area must be made Children under 6 8 years of age complain of abdominal pain when they are affected by diseases of the lungs (especially in cases of lobular and lobar pneumonia) and of the pleura These painful sensations are interpreted as viscero visceral reflex pain Deep palpation of the abdomen will in such cases be found to be painless (to do this the child s attention must be distracted by a toy or by talk) Investigation per rectum is a valuable asset in determining the localization of pain-generating processes in the intestine (tumours infiltrates, polyps)

CHAPTER XIX

NOURISHMENT OF HEALTHY CHILDREN IN THE VARIOUS STAGES OF CHILDHOOD

Prof Y *Dombrovskaya*

Food plays a prominent part in the normal course of physiological processes in the child's body Not only the normal functions of separate organs and systems depend on proper nutrition, but also the general immunobiological reactivity of the child and, consequently, his power of resistance against disease causing factors and other harmful influences The child's vigorous growth, particularly during the first three years of life, the intensity of all his metabolic processes, the complex processes of differentiation of separate tissues and cells require both a sufficient amount of the basic food constituents and a certain proportion between them *A definite ratio between protein, fat, carbohydrate and mineral constituents is an essential requisite for normal processes of digestion and metabolism, and also for the physical and mental development of the child* Therefore the etiological concept of many acute and chronic pediatric diseases includes the alimentary factor, dietetics is therefore a most prominent therapeutic agent in the treatment of all ailments of childhood Heightened metabolic rate and intensive differentiation and maturing of tissue elements in the period of growth increase the bodily requirements in food calories and certain food ingredients, most prominent of which is protein

Hence the relative requirements in food constituents—protein, fat carbohydrates, vitamins, water and minerals—vary in the different age periods, as do their caloric values (Tables 6 and 7)

However, the figures in these tables are only average, and deviations in both directions are quite normal, all depending on the child's individual requirements his state of nourishment, the conditions he lives in, and the season of the year A well balanced diet with a sufficient amount of calories should be planned so that the calories falling to protein, fat, and carbohydrates are in a ratio of 1 2 3, proteins constitute 12 15 per cent of the total amount of calories, 50 per cent fall to fats in an infant's dietary, and 25 30 per cent in the rations of older children while carbohydrates should take up 36 to 60 per cent of the total amount of calories, depending on age Besides pro tein fat, carbohydrates minerals and water the child's dietary must include vitamins in amounts corresponding to his age, to the season, climate, and to a number of other factors

Table 6

Protein Fat, and Carbohydrate Requirements at Various Age Levels (per kg of body weight)

	Infancy (breast fed) up to 1 year*	1 5 yrs	5-10 yrs	10 15 yrs
		In grams		
Protein	1 5 2	3 5	2 5 3	2 2 5
Fat	3 5	2 5 3	1 5 2	1 5 1
Carbohydrates	10 12	10 12	10 15	10 12

* In artificial feeding the protein value is increased to 5 g/kg

Table 7

Caloric Requirements of Children at Different Age Levels

Age	Calories per kg of body-weight
Younger than 3 mos	130 125
3 to 6 mos	120 110
6 to 9 mos	110 100
9 to 12 mos	100 95
1 to $1^1/_2$ yrs	100-95
$1^1/_2$ to 3 yrs	100 85
3 to 6 yrs	approx 100
6 to 10 yrs	90
10 to 15 yrs	75

Taking all the above into consideration, it will be understood that the dietary of a healthy child at different age levels differs essen tially

FEEDING THE HEALTHY CHILD IN HIS FIRST YEAR OF LIFE

Breast Feeding (Natural Feeding)

The only natural, physiological food for babies in their first five six months of life is maternal breast milk A well managed campaign conducted by the mother and child welfare services in the USSR has resulted in up to 99 per cent of mothers nursing their newborn infants at the breast

Lactation Throughout pregnancy the mammary glands are affected by a number of hormones produced by the placenta the corpus luteum, the pituitary, and also possibly by the fetus itself Beginning with the second or third month of gestation a marked growth of the

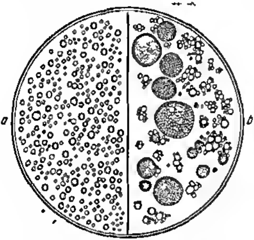


Fig 55 Human milk and colostrum (as seen under the microscope)
a—drops of fat in the milk b—colostrum bodies

breast occurs, and, moreover, it begins to produce its own secretion though very sparsely. During the first period of lactation in the 2 4 days following delivery, the mammary gland secretes colostrum a thick, yellowish, high protein fluid which curdles when boiled and contains, in addition to fat, also colostrum bodies (or corpuscles)—leukocytes containing fat globules (Fig 55)

Colostrum possesses a high caloric value (up to 1,500 calories) and a high specific gravity (1050 1060), its composition is close to that of the tissues of the newborn, thus constituting as it were, a transition from intrauterine nutrition to breast feeding On the fourth fifth day the colostrum changes, and then approximately until two weeks after birth the infant gets what is known as *transitory milk* which contains a high percentage of fat, and sometime later the real milk, with its more constant composition, comes in (Table 8)

The chemical composition of true human milk is not constant, changing even in one and the same mother at different times of the day, and before and after the baby is nursed Thus, the fat content is lower before the baby nurses than after Human milk has an approximate specific gravity of 1029, an amphoteric reaction, and a pH of 6 9-7 0, it contains an average 87 per cent of water

A distinguishing advantage of human milk as compared with cow's and goat's milk is its lower content of casein, a substance which is not easily digested (Table 9) The importance of this factor is understandable if we take into consideration the low acidity of the gastric juice of infants during the first few months of life But the principal distinction of human milk is the structure of its proteins, complex amino acid compounds (tryptophan, cystine, tyrosine, etc) The structure of these proteins is close to that of the proteins which compose the cells of the infant's body, this correlation undubitably enhances their assimilation and utilization for building up the body

Table 8

Composition of Human Colostrum and Milk
(in %)

	Protein	Sugar	Fat	Ash
Colostrum	5 8 2 25	4 1 7 59	4 2 83	0 31 0 48
Transitory milk	2 1 56	5 7 7 79	4 39 2 9	0 24 0 34
True milk	1 15 1 5	7 50	3 26-4	0 21 0 18

It is not only the difference in composition that makes breast milk superior to cow's or goat's milk The physicochemical properties are also highly important *The fat* of human milk is made up predominantly of liquid oleic acid and solid palmitic and stearic acids, and very little volatile fatty acids Such a composition favours assimilation of a high percentage of breast milk fats Upon the coagulation of human milk soft, fine curds are formed, this is also associated with the properties of the proteins and the reaction of the milk The factor most conducive to the rapid digestion and assimilation of breast milk fats is the high percentage in human milk of a number of enzymes (catalase, amylase, lipase), their content in the milk of animals is very low, and they are almost completely destroyed by boiling and pasteurization Breast milk contains almost 15 times more lipase and 100 times more amylase than cow's milk does

The sugar of human milk consists of beta lactose, a substance that inhibits the growth of the colon bacillus, while cow's milk contains alpha lactose which favours the growth of the colon bacillus, antagonist of acidophilous bacteria In breast fed infants the acidophilous intestinal bacilli possess the faculty of synthesizing the vitamin B complex

The content of *mineral substances* is 66 to 71 per cent less in human milk as compared with the milk of cows and goats However, the content of certain of the substances important for the organism (iron, copper, zinc) is much higher than in cow's or goat's milk Such basic cellular elements as *phosphorus* and *calcium* are assimilated twice as well (up to 70 per cent) with human milk as compared with cow's milk

An important biological feature of human milk is the presence in it of *antibodies* (*immune bodies*), that sustain the infant s immunity to a number of childhood infections during the first months of life, and also of hormones stimulating the growth and development of the child In human milk the antibodies are represented by both specific antibodies (antitoxins) and non specific bactericidal substances The latter include lysozyme which exerts an antiseptic action due to lysis of intestinal bacteria Breast milk also provides the infant in the first 2 3 months of life with a sufficient *amount of vitamins* (A B C)

Table 9

Composition and Properties of Milks
(in %)

	Species		
	Human	Cow	Goat
Protein (total amount)	1 1 5	3 3 5	3 5 4
Casein	0 6 1	3	3 8
Albumin and globulin	0 8	0 3	1 2
Lactose (milk sugar)	7	4 4 5	4 4
Fat	4	3 4	2 5
Protein nitrogen	0 12 0 17	0 5	0 43
Calcium	0 03	0 2	0 2
Phosphorus	0 05	0 24	0 28
Calories (per litre)	650 770	650 770	800

necessary for stimulation of metabolic processes It has been proved that the milk may be fortified with these vitamins by adding them to the mother s diet There is very little vitamin D in human milk but if the mother takes fish liver oil a certain amount of it appears in the milk (Table 10)

The infant s vitamin requirements are mostly satisfied by the vitamin content of breast milk (Table 11) if the mother s food contains enough, bottle fed babies do not get enough vitamins since most of them are destroyed by boiling and by the action of light

Table 10

Comparison of Vitamin Contents of Human and Cow's Milk (per 100 ml) (V Yefremov 1957)

	Vitamins					
	A in IU	B_1 in μg	B_2 in μg	PP (nicotinic acid) in mg	C in mg	D in IU
Human milk	250	20	40	2	3	5
Cow s milk	100	40	150	1	1	2

Table 11

Daily Vitamin Requirements of Breast Fed Infants

Vitamin	24 hour requirements of infants	Vitamin content in 500 ml of human milk
Vitamin A in mg	0 45	0 3
Vitamin A and carotene, in IU	1,500	1,2o0 1,500
Ascorbic acid, in mg	30	20 25
Thiamine (vitamin B_1) in mg	0 4	0 1
Riboflavin (vitamin B_2) in mg	0 6	0 25
Nicotinic acid (PP factor) in mg	4 0	0 9
Vitamin D in IU	500 1,000	2 30

Colostrum has a high content of vitamins A and B_1, nicotinic acid (PP factor), and ascorbic acid (vitamin C)

Another important point is that the breast milk supply is delivered to the baby in a practically sterile condition, while cow's milk is easily exposed to contamination

Consequently, the advantages of human milk over cow's milk lie in its physicochemical and biological properties that are close to those of the cells of the infant's body and have a favourable effect on the digestion and assimilation of the milk constituents

The breast fed infant is thus placed in especially favourable biological conditions, confirmation of this is the high resistance of these infants to infections, i e, the preservation and maintenance of the natural immunity conferred by the maternal organism, and the faculty of independent production of antibodies Infants deprived of breast milk during the first months of life do not possess such a high resistance

A healthy nursing mother produces up to 1 5 litres of milk in 24 hours Lactation is connected with the mother's age, with her living conditions, and with the slate of her nervous system The size and shape of the breast are much less important, exceptj for cases of immaturity of the mammary glands

The schedule and nutrition of the nursing mother need not differ essentially from what she was accuslomed to prior to her pregnancy Her food should provide a sufficient amount of protein, fat, carbohydrates, and vitamins, and the calories should lotal 3,200 3,500 The consumption of onions, garlic, and radish should be llmited, and no alcoholic beverages be taken at all The fluid intake (exclusive of liquid food) should nol exceed 1 5 2 litres, excessive drinking does nol intensify lactation, since the latler is a complicated process regulated by the nervous system and the hormones produced by a number of endocrine glands The volume of milk produced depends a great deal on proper nursing technique (pulling lhe baby to the breast at definite hours, complete evacualion of the breast, manual expression of any milk remaining after a feeding), and proper regimen of lhe mother (physical exercises, walks, work)

Ingredients important in the diel of lhe nursing molher are cooked and raw vegetables and also foods with a high vitamin B content (brown and black bread, brewer's and baker's yeast) Starchy and fat dishes should be avoided, sugar should be taken in sufficient amounts (honey, fruit preserves and jam) When the molher has food of full dielary value her milk generally contains enough vilamins, bul nursing mothers are advised to take some additional preparations of vilamin B_1, ascorbic acid, and fish liver oil (particularly during the winter months) The administration of preparations for intensifying lactalion per os and subcutaneously (mammin, for instance) does not yield any positive resulls

Breast Feeding Technique

The newborn is put to the breast 6 to 12 hours after delivery Premature and feeble infants, and also infants who have sustained birth injuries (forceps, asphyxia) are not put to the breast for 24 and even more hours They are given warm breast milk from a spoon or medicine dropper Sucking is an unconditioned inborn reflex therefore a healthy newborn infant will usually suck vigorously as soon as he is put to the breast Afler this firsl feeding he should be nursed every three hours during the day, with a six hour break at night seven feedings in all Strong eager suckers may be nursed less frequently, six times over intervals of $3^1/_2$ hours, with an eight hour break at night Premature and feeble infanls have to be fed more frequently, ten to twelve times in the 24 hour cycle

During the act of sucking the infant takes the nipple and areola into his mouth, lhe connection becomes almost airtight so that he can breathe only through his nose Therefore even a slight upper respiratory catarrh may be a grave obstacle to normal breast feeding

The baby should be put to only one breast at each feeding, a healthy infant is satiated after ten to twelve minutes of sucking The mother should take care that the baby does not swallow air while nursing, since it will cause regurgitation and restlessness To avoid this the mother should help the baby get the entire areola into his mouth by supporting the breast with the first two fingers, and compressing or flattening the areola a little with the thumb The mother nurses lying down while in the hospital, but later on she should nurse only while sitting up The breast should be washed with boiled water and dried with a piece of gauze before each feeding, and the nipple dried after feedings Soreness of the nipple is treated by the application of vaseline jelly or mineral oil The infant should not be kept at the breast for longer than 20 minutes The amount of milk extracted by the baby is checked by weighing him before and after nursing By compressing the breast it will be seen whether any milk remains in it The breasts of young mothers may be very tight, making it difficult for the baby to get his fill, in such cases it is advisable to express the remaining milk manually and give it to the baby from a spoon

Normal development is possible only when the baby is provided with a sufficient supply of breast milk An equation that approximately defines the volume of breast milk required by the infant in the first days of life has been evolved The required amount is found by multiplying 10 by the number of days of life and feedings per day (7) Thus, a five day infant should get 50 g of milk per feeding, or 350 g in 24 hours (50×7) As normal lactation is established and the real milk comes in the volume of milk withdrawn by the baby increases, but the number of feedings remains the same for three months (seven or six times in 24 hours) Healthy, well developing infants may be put on a five feedings schedule when they are 3 4 months old The best criterion of the sufficiency and good quality of the milk is proper weight gain, peacefulness, normal bowel evacuation, timely development of static and mental functions However, one should also be governed by the approximate values for breast milk requirements in the first nine months of life (Table 12)

Table 12

Breast Milk Requirements for Normal Development of Infants

Age	Amount of milk in regard to body weight
2 6 weeks	1/5
6 weeks - 4 mos	1/6
4 6 mos	1/7
6 9 mos	1/8

If calories be taken as a basis, then the amount of milk required in the above listed periods is calculated by the caloric requirements per kg of body weight, taking the caloric value of human milk to be 700 calories Thus, a three months baby weighing 5 kg requires approximately 600 calories per 24 hours, i e , about 840 ml of milk However, the total daily amount of milk ingested by the child must not exceed one litre

When the mother cannot nurse her baby he should be provided, at least partially, with breast milk obtained from another woman (donor milk) As a precaution such milk is pasteurized, a procedure which decreases the content in it of hormones, enzymes and vitamins Therefore the value of the human milk obtained at the special milk donor stations established at the child health centres is not equal to the value of milk obtained directly from the breast Moreover, the close contact established during nursing between mother and baby, as well as sensations derived from preparation for nursing have an undoubted favourable effect on the formation in the baby of a number of conditioned reflexes, i e , they are conducive to the development of the higher nervous activity

Milk donor stations that receive and dispense manually expressed breast milk are established at the children's polyclinics or dairy kitchens The nursing mother who offers her excessive milk is subjected to medical examination (for tuberculosis, syphilis, etc), and her milk is expressed into sterile bottles in the presence of a nurse, after this the milk is pasteurized and carefully protected against contamination

Introduction of Vitamins

After the baby is three months old he is given vitamin C (for increasing the oxidizing processes) in the form of freshly prepared vegetable and fruit juices, beginning with half a teaspoonful and ending with 8 10 teaspoonfuls a day The preferable juices are those in which the vitamin C content is highest At this age the baby is also given fish liver oil (particularly in the winter) which contains vitamins A and D at first only a few drops are given, and the amount is gradually brought up to 2 3 teaspoonfuls a day by the end of the year (see Chapter XX)

Solid Foods

During the first five or even six months of life the nutritional requirements of healthy babies are completely satisfied by breast milk complemented with vitamins In the following period the child s requirements in minerals and carbohydrates increase Like breast feedings, solids should be given at definite hours A baby of five or six months already reacts to the mere look of the preferred solid food, recognizes it (for instance, thin cereal) This is already a positive manifestation of the formation of a complex conditioned reflex associated with the development of the cerebral cortex The establishment of this reflex is attended by an intensification of the secretory and enzymatic functions of the digestive glands (psychological secretion) The first solid food on which the baby is started is thin cereal (gruel), 5 per cent wheat farina, prepared on diluted milk (2 parts milk and 1 part water) (The cereal should first be cooked in water and then whole milk added) The cereal is introduced gradually, beginning with 5 6 teaspoonfuls before one of the breast feedings, then bringing the amount up to 150 g and substituting the cereal for one breast feeding, berry or thin fruit starch puddings (kissel) are given soon after the cereal has been introduced Beginning with the seventh month the baby is given vegetable puree and raw grated apples After he is eight months old he should be getting meat broth, egg yolk, kefir, whole milk, and by the end of the first year forced meat balls, cooked or steamed The various solid foods are added gradually beginning with very small amounts with consideration for the baby s taste, the state of his gastrointestinal tract, weight gains, etc A single portion of food should not exceed 200 g An approximate dietary for babies between six and eleven months of life is presented in Table 13

The baby is *weaned from the breast* after all the forms of solids have been added to his diet, when the breast feedings have been cut down to no more than one or two a day A healthy baby may easily be weaned, without any harm to his condition by the end of his first year of life, but never in the hot season or when he is ill, if lactation has decreased it is better to wean the child in the spring but no earlier than at eight months

Approximate Times for Adding Most Common Solid Foods

5 per cent farina cereal (1 part water 2 parts milk)	5 6 months
Fruit or berry starch puddings (kissel)	5 months
10 per cent cereal on whole milk	6 months
Vegetable and fruit puree	6 7 months
Vegetable soups, meat broth	8 months
Forced meat	8 9 months
Steamed meat patties (quenelles)	by the end of the year

Breast feeding does not come up against any special *obstacles* Should the mother contract an acute infection (scarlet fever, diphtheria, typhoid) the baby must be isolated from her and taken off the breast If the mother remains at home the child is injected with normal human serum or the father's blood, in order to fortify his resistance to disease Other acute diseases, such as influenza, sore throat, pneumonia, are no obstacle to breast feeding, although they call for a certain amount of precautions (a mask over the mother's nose and mouth, isolation of the baby) to protect the child against infec-

Table 13

Approximate Plan for Feeding Babies up to 11 Months

Feeding hours	At 5 mos	At 6 mos	At 9 mos	At 11 mos
6 a m	*Breast*	*Breast*	*Breast*	*Breast*
10 a m	Breast Farina cereal approx 100 g	Cereals farina buckwheat oatmeal rubbed through a sieve on whole milk	Cereal any kind	Cereals
2 p m	Breast Vegetable or fruit juice	Vegetable purée soup Kissel or apple	Vegetable puree Yolk apple	Meat soup Forced meat vegetable puree brains liver Kissel
6 p m	Breast Kissel up to 100 g	Breast Kefir or grated apple	Kefir or pressed curds toast	Kefir or milk with toast
10 p m	Breast Up to 50 g of juice and 10 g of fish liver oil per day	Breast	Breast	Breast Pressed curds or apple puree toast

tion Mothers with active forms of tuberculosis, acute nephritis severe forms of diabetes and with mental diseases are not permitted to breast feed

Breast feeding difficulties may be connected with the anatomic structure of the mother's mammary glands One of the obstacles to breast feeding most common in the first months of the baby's life is due to *faulty nipples* (flat, retracted poorly developed) An attempt should be made at the women s health centre during pregnancy to eliminate such defects by gradually pulling the nipples out, a procedure which is continued during lactation

A tight breast is evacuated with difficulty, both by the baby when he sucks and by manual expression as a result the child does not get enough milk and the mother begins to think that she cannot produce enough In such cases it is sometimes helpful to press out a little milk before a feeding in order to decrease the tension in the breast

Many nursing mothers develop extremely painful *sore or cracked nipples* sometimes even accompanied by bleeding, nursing causes acute pain The condition calls for vigorous treatment (bathing the involved area in a strong solution of potassium permanganate, exposure to ultraviolet irradiation, application of 10 per cent silver nitrate and of lotions of penicillin in solutions containing 500,000 to 1,000,000 units per ml), at times it becomes necessary to feed the baby with milk expressed from the breast manually, or to use a special nipple shield, a glass cap with a rubber nipple attached to it (Fig 56) The appearance of these lesions may be avoided, to a certain extent,

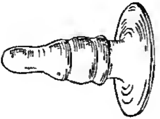


Fig 56 Glass nipple shield with rubber nipple

by observing proper breast-feeding techniques not merely the nipple, but the entire areola must be grasped by the baby's mouth

A serious impediment to breast feeding is mastitis, a condition that calls for immediate vigorous therapeutic intervention (antibiotics, cold to the affected breast, and elevation of the breast to the highest possible position) In cases of superficial mastitis breast feeding is sometimes continued, but in phlegmonous affections it has to be stopped

Deficient production of milk by the mother (hypolactation) is an obstacle to normal breast feeding In the majority of cases the deficiency is not primary (early hypolactation), but secondary, arising in connection with erratic management of breast feeding (particularly incomplete evacuation of the breast), and also with some disease of the mother and her faulty dietary

Obstacles to breast feeding depending on the infant are a feeble sucking reflex (prematurity, birth injury), and mouth and/or nose pathology—harelip, cleft palate, thrush, acute and chronic rhinitis, influenza In each individual case when the baby refuses to take the breast a thorough examination must be made of the child and of the mother's breast During severe illnesses babies do not take the breast, or if they do they suck very languidly, stopping frequently (temporary fading of the reflex)

It is not uncommon for young mothers who are nursing their first baby to complain of difficulties at the beginning the baby throws up, his weight gains are irregular or low

When the baby does not seem to be gaining enough the mother frequently begins to feed him irregularly, this causes, on the one hand, diminution of milk production, and on the other, it may induce a gastrointestinal disorder in the baby (alimentary dyspepsia) Too frequent nursing at the breast decreases the sucking powers of the child, and as a result the breast is insufficiently evacuated

Naturally, the mother becomes worried, and this in its turn may affect lactation In such cases the pediatrician and the patronage nurse must be very attentive and persistent in order to reassure the mother and help her establish normal breast feeding In certain cases (neurotic women) it is quite advisable to supplement the institution of a proper routine for the nursing mother (diet, sufficient sleep, outdoor walks) by sedatives (valerian, bromides, Adonis vernalis infusions)

Mixed Feeding in Infancy

When it has been established that the mother cannot produce enough milk and that weight gains are too low the baby is put on mixed feedings, that is, he is put to the breast or given donor milk from a bottle, and this food is supplemented by cow's milk formula Care must be taken that the baby obtains the necessary quantity of

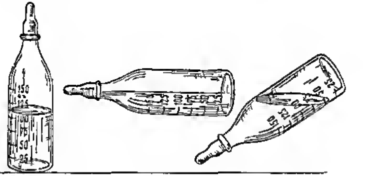


Fig 57 Position of bottle for nursing Correct on right, wrong in middle

breast milk, if not from his mother's breast then at least from a spoon or bottle When a 2 3 month old infant is given a formula out of bottle he may stop trying to suck the breast, particularly if this calls for great effort (for instance, when the mother's breast is very tight) The nipple holes should be very small (made with a red hot needle) otherwise the baby won't try to make any effort at sucking The position of the bottle during the feeding should be correct (Fig 57) When mixed feeding is instituted very early (in the second or third month) the complemental milk should at first be offered from a spoon The physician must do his best to supply the baby with donor milk if the mother cannot produce enough of her own, and it is only in extreme cases that the infant is put on mixed feedings.

It is much more advisable to give the 2-3 month old infant both the breast and the complemental milk at each feeding, gradually getting him used to other milk constituents. A sudden transfer of a young infant from breast feeding to mixed breast and bottle feeding is almost constantly attended by a gastrointestinal reaction since the digestive system is not adapted to the protein and fat of cow's milk, which are difficult to digest. In order to approach the composition of cow's milk to that of human milk it has to be specially prepared. These preparations are called formulas.

Formulas (nutritive mixtures) are designed for feeding healthy infants or for nutrition in illness (chiefly concerned with diseases of the gastrointestinal tract) or for physically feeble infants (therapeutic formulas).

Formulas are prepared with cow's milk. The milk should be of the very best quality, obtained from healthy animals which are under constant veterinary control, it should contain no less than 3.5 per cent fat, approximately 4.5 per cent sugar, its acidity should not exceed 20° (after the Turner method). Constant control of bacterial contamination of the milk is extremely important. The colon bacillus titer should not exceed 1:10, and no pathogenic flora should be demonstrable.

However, as has already been mentioned, even high quality certified cow's milk differs significantly from human milk, first of all by the biological properties of its protein. The proteins of cow's milk are alien to the infant body, while the breast milk proteins are homogenous with it. Moreover, in cow's milk the proportion between the protein, fat, and carbohydrates is not as favourable as in human milk (1:3:6).

Therefore formulas for the prolonged feeding of healthy infants (simple formulas) are prepared by diluting the milk predominantly with cereal waters (oatmeal, rice, buckwheat) in a 1:1 proportion (formula No 2, B rice, B oatmeal), or in a 2:1 proportion (formula No 3, C rice, C oatmeal). Such dilution diminishes the amount of protein difficult to digest, but it also lowers the fat content. However, 10 or 20 per cent of cream may be added to the formula, but no more than 20-30 ml per portion. To decrease the buffer action (i.e., the resistance of the proteins of cow's milk to digestion) the milk is acidified with lactic or hydrochloric acid. All the formulas contain 5 per cent (volumetric) of sugar. For children who gain weight slowly (on condition of absence of dyspeptic symptoms) it is recommended to give 50-100 ml of a butter flour formula, it is made by adding to the simple milk water formula (2:1) flour fried in butter (7 per cent).

In feeding healthy children whole milk and formulas are extensively replaced by kefir (milk fermented with kefir grains) diluted with rice and oatmeal water (B kefir, C kefir, i e, kefir diluted by half and by one third with cereal water) Such formulas are called fermentative mixtures Other formulas are prepared by acidifying whole milk with lactic acid bacteria (sourmilk), or by acidifying skimmed milk (buttermilk) The purpose of all manner of acid formulas is to inhibit the growth of the colon bacillus and facilitate digestion both by introduction of altered casein and by activation of the acid composition of the food, a problem dwelt on by Ivan Pavlov in his investigations Acid formulas are indicated for all acute and chronic gastrointestinal diseases, and also for prophylactic purposes in the hot time of the year, when the baby's gastric secretion decreases

When therapeutic formulas call for an increase of protein as a plastic material pressed curds are added, up to 2-3 per cent Such formulas are indicated for premature infants, and also for infants who are showing poor weight gains and have dyspeptic tendencies Preparation of all formulas requires strict cleanliness of bottles utensils, and all other equipment used The best thing to do is to obtain the formulas at the special dairy kitchens for babies, where specially trained staff prepare all the necessary formulas strictly according to prescription

When whole milk is given it is enough to just boil it In domestic conditions formulas are prepared in the Soxhlet apparatus a pail containing a special rack for 6 10 bottles This apparatus is used for sterilizing milk formulas The bottles, into which the formula has been poured, are stopped with corks or cotton plugs and placed in the rack, water is then poured into the pail, and it is heated to the boiling point, the bottles are left in the boiling water for 5 7 minutes The bottles with the sterilized formula are kept in a cold place before the baby is fed the bottle is warmed by placing it in warm water An ordinary pan may be used for this type of sterilization

Powdered milk is an excellent foundation for the preparation of various infant feeding formulas This milk, as well as powdered therapeutic nutritional formulas, is prepared commercially Powdered milk is particularly useful in areas where it is difficult to obtain fresh milk The composition of powdered milk is quite adequate for formula requirements

Composition of Powdered Milk
(in per cent)

Protein	21 26
Fat	21 28
Lactose	38 43
Minerals	6 8 6 2
Water	2 3
Calories	460 490 per litre

Vitamins A and B_1 are retained in powdered milk, but the content of vitamin C is much lower than in raw milk

Basic Rules for Artificial Feeding

Notwithstanding the most perfect methods employed in the preparation of food for the baby there is always danger of some gastrointestinal upset, since the enzymatic potency of the child's digestive tract cannot always cope with the assimilation of his food Therefore artificial feeding should always be started with simple sweet or acid formulas instead of with protein or fat fortified formulas Since the vitamin C contained in raw cow's milk is destroyed by heat bottle-fed babies must be given vegetable and fruit juices beginning with the age of two months In the Soviet Union almost all women give birth in maternity hospitals, where all the newborn infants who are not put on their mother's breast for some reason are provided with human milk obtained from other mothers or from the milk donor station During the first two months of life such babies are provided with a breast milk supply by the children's polyclinic or health centre In exclusive cases the newborn is given formula (milk diluted with cereal water in a 1 1 proportion with the addition of 5 per cent sugar—formula No 2 B) feedings are given 6 7 times a day Beginning with the end of the second month the infant is given the cream-enriched formula No 3, and also acidified formulas (kefir with cereal water, 1 · 1), the total number of feedings should not exceed five, since the slower digestion of cow's milk protein has to be taken into consideration If weight gains are low the caloric value of the food is cautiously increased by the addition of fat and carbohydrates (butter flour mixture) Cereals and kissel are started at five months, vegetable puree at six

Egg yolk may be added to the baby's diet beginning with the age of seven months (in soup or vegetables), whole egg after ten months (omlets, soft boiled egg) Some children develop skin eruptions after eating eggs, but yolk alone is well tolerated by almost all children

The volume of food required by bottle fed infants depends on a number of purely individual features Consequently, only a very approximate plan can be offered for artificial feeding

1 The daily amount of food should not exceed $^1/_6$ of the average weight of the baby, it must never be more than one litre

2 The average daily amount of milk should not exceed $^1/_{10}$ of the average weight of the baby

3 Bottle fed babies need 3 5 4 g/kg of protein, i e , more than breast fed infants do (cow's protein is more difficult to assimilate)

4 The caloric value of the food of bottle fed babies should be 10 15 per cent higher than that of breast fed babies

5 Bottle fed babies need approximately one feeding less than breast fed babies do

In addition to weight gains, the success of artificial feeding is indicated by the normal development of the mental and motor functions which is closely associated with the condition of the nervous

Table 14

Simple Formulas Used in Mixed and Artificial Feeding

Formula	Composition	Calories per 100 ml	Age when first given
A Sweet mixtures			
Formula No 2 or B rice B oatmeal	Milk and 5% rice or oat meal water in 1 1 pro portion *plus 5% sugar*	54 56	2 weeks
Formula No 3 or C rice C oatmeal	Milk and 5% rice or oat meal water in 2 1 pro portion plus 5% sugar	66	2 months
Formula No 2 or B rice B oatmeal with cream	Milk and 5% rice or oat meal water in 1 1 pro portion plus 5% sugar, plus 15% cream	76	2 weeks
Formula No 3 or C rice C oat meal with cream	Milk and 5% rice or oat-meal water in 2 1 pro-portion plus 5% sugar and 15% cream	88	2 months
B Acidified mixtures			
Buttermilk with 2% flour and 4% sugar		50 62	2nd month
B kefir	Kefir made from milk plus cereal water (rice oatmeal or buckwheat) in 1 1 proportion	56	3rd month
C kefir	Ditto in 2 1 proportion	66	4th month
C. Protein mixtures			
Pressed curds	Made from whole milk	190 195	From 1st month complemental to breast milk mix tures

Continued

Formula	Composition	Calories per 100 ml	Age when first given
Protein milk with 5% sugar		120 128	2nd month
	Butter flour mixtures		
Concentrated formula No 1	Formula No 2 plus 2 5% butter 2 5% flour and 3% sugar	95	2 months
Formula No 2	Formula No 3 plus 5% butter 5% flour and 6% sugar	144	3 months

system, particularly the cerebral cortex Proper hygienic management is exceptionally important for the well-being of artificially fed infants (see Chapter III), and particular emphasis is laid on regularly conducted physical exercises Stimulation of the corresponding receptors is conducive both to an increase in metabolic rate and to normal functioning of the cerebral cortex Since bottle-fed infants are more apt to develop rickets their resistance should be built up by the gradual introduction of fish liver oil, starting with 7 10 drops twice a day at two months, and bringing the amount up to 2 teaspoonfuls a day by four months

The formulas most commonly used in infant feeding, and their compositions, are presented in Tables 14 and 15

FEEDING CHILDREN AFTER ONE YEAR

Since a healthy baby usually has 8-10 teeth by the end of his first year of life his dietary must include some harder foods by that time The number of feedings should be decreased Between one and four years of age a child needs 3 3 5 g/kg of protein, 3 5 4 g/kg of fat, and 10 15 g/kg of carbohydrates The optimal ratio between protein, fat and carbohydrates is 1 1 5 3 5 Proper growth and development of the child require an obligatory minimum of full value animal proteins which contain some absolutely necessary plastic substances—amino acids (leucine, thyrosine, tryptophan), and also the vitamin B complex Besides meat, these amino acids and vitamins are contained in milk protein and in eggs A certain amount of some amino acids occurs in plants (legumes), but they cannot replace animal proteins, and therefore at least 50 per cent of the total protein requirements in the child's dietary must be represented by animal proteins

Table 15

Composition of Infant Foods Most Commonly Used (per 100 ml)

Formula	Protein	Fat	Carbo hydrates
	In grams		
Cow s milk whole	3 4	3 7	4 5
Formula No 2 50 ml milk 50 ml water 5 g sugar	1 7	1 8	6 5
Formula No 3 65 ml milk 35 ml water 5 g sugar	2 3	2 5	7 6
B rice B oatmeal 50 ml milk 50 ml cereal water 5 g sugar	1 7	1 8	7 5
C rice C oatmeal 100 ml milk 50 ml cereal water 5 g sugar	2 3	2 5	8 6
Cream formula 35 ml milk 50 ml water 15 ml of 10% cream 5 g sugar	1 7	2 6	7 4
Butter flour formula No 3 65 ml milk 35 ml water 5 g butter 5 g flour 5 g sugar	2 5	6 5	9 4
Buttermilk	3 4	0 5	4 0
Kefir	3 4	3 7	4 5
Wheat farina cereal 5%	2 2	1 9	10 2
Kissel thin starch pudding made with fruit or berry juice	—	—	12 2

Fats of full dietary value are cream butter, egg yolk and fish liver oil, which is given additionally

Carbohydrate requirements in children between one and four years of age are relatively high up to 2 years 50 per cent of the carbohydrates in the child's diet should be given in the form of sugar and honey and the other 50 per cent comes in bread cereals potatoes, vegetables

Besides protein fat, and carbohydrates the child's body requires a certain amount of minerals and vitamins Salts are sufficiently provided by a diversified diet which includes milk vegetables, bread meat fruit The basic sources of vitamins are vegetables and fruits (vitamin C), fish-liver oil (vitamin D), butter, egg yolk (vitamin A), vitamin preparations are prescribed only upon definite indications (see Chapter XX)

A lack of protein in the food leads to retardation of the child's growth and development, marked protein deficiency causes a nutritional disturbance, dystrophy, which is occasionally accompanied by non protein edema Dystrophy with edema, although not so pronounced, may also be seen in cases of protracted diarrhea, particularly when the patient receives a monotonous, "chary" carbohydrate diet

Lack of fat in the food leads to a decrease of the resistance to infections and other diseases, it may cause scaliness and dryness of the skin, fragility of the hair and nails, corneal diseases

Number of feedings: children younger than 2 years are given 4-5 meals a day, the number is brought down to 4 meals, two of which should be of higher caloric value than the others

In managing the nutrition of 4 to 7-year-olds the increasing carbo hydrate requirements should be taken into account, since the child becomes more active and spends more energy on muscular activity (games, running) The need for certain vitamins (C, the B complex) also grows accordingly

In the school-age period the rate of growth slows down, and there fore protein requirements per kg of body weight are also reduced (2 g/kg), but at puberty they again increase Fat requirements are also somewhat diminished in the school age period, but the need for carbohydrates remains high The ratio between protein, fat, and carbo hydrates in the preschool and school age periods are 1 1, 1 6 while in infancy the ratio is correspondingly 1 2 3 (see Table 16)

Table 16

Approximate Daily Protein, Carbohydrate and Fat Requirements of Children at Different Ages (in grams)

	1 4 yrs	4 7 yrs	7 12 yrs
Protein	*35 50*	*60 65*	*65 85*
Fat	45 50	50 55	50 100
Carbohydrates	170 180	250 275	350 500

The child should get most of his calories with breakfast (approximately 30 per cent) and the mid day meal (up to 45 per cent of the total daily needs)

The above norms are only approximate When making up the daily schedule one must take into account the child's taste, the condition of his digestive organs, and his state of nourishment Thus, children with tendencies to constipation should be given more vegetables, dark (black and brown) bread, and less meat, stout children need less starch, sweets and water All this comes under the heading of therapeutic dietetics

Milk contains the organic salts of calcium, it is a staple in the dietaries of children of all ages, but its amount should not exceed 500 ml for children under 4 years of age Part of it should be given in the form of acidified milk (sourmilk, kefir), particularly for children subject to constipation

Meat is started at the end of the first year of life, and is given 2 3 times a week in the form of forced meat balls and minced meat (chicken, veal, beef) Lean sorts of fish may also be given Beginning with the second year the child is ready for steamed meat patties or quenelles, cooked pike perch The fat sorts of meat and fish are poorly tolerated even by older children

Soups Children younger than four years are given vegetable soups and non fat meat soups to which vegetables are added

Eggs Children over one year of age are given whole eggs, but if the white causes itching or rash—only yolks

Fats are represented in the child's dietary chiefly by fat obtained from milk (butter, cream) Pork fat, lard, suet, and mutton fat are poorly tolerated by younger children

Fruits, berries, vegetables (green and yellow) are necessary in view of their mineral and vitamin content, and as roughage The vitamins are rapidly decomposed by processing therefore vegetables should be prepared just before serving, and not left to stand for lon in water after they have been pared, or left on the stove after they are cooked

All pungent and spicy foods, strong coffee, tea and all manner of alcoholic beverages are positively forbidden

An excellent stimulation to proper assimilation of food is a good appetite, in so far as the initial secretion of gastric juice (the psychological, or "priming" juice of Pavlov) is conditioned by the desire for food Appetite is maintained by observing a correct daily routine (fresh air, sleep), by abstaining from giving the child sweets bread milk, etc , between meals, and also by teaching him to feed himself independently as early as possible

The practice of creches and nursery schools shows that the child's appetite improves when he is among a group, and when he has been trained to be independent at meals Good appetite favours normal digestion of food, and this, in its turn, induces proper assimilation of the nutrient substances in the gastrointestinal tract and maintenance of normal metabolic equilibrium in the child's system

CHAPTER XX

VITAMINS AND VITAMIN DEFICIENCIES IN CHILDREN

Prof Y *Dombrovskaya*

In addition to protein, fat, carbohydrates and minerals the child s body needs vitamins for its proper development in all the periods of childhood

Back in 1880 a Russian physician, N Lunin, proved experimentally, on mice, that milk contains, besides its known constituents (fat, carbohydrates, protein) also some other substances without which the physiological development of the animal is impossible These substances were thirty years later called vitamins (Funk) Vitamins are extremely important factors in all vital processes, particularly in the growing organism they are closely related to the processes of growth and development, the functions of the nervous system, respiration, digestion, and the various forms of metabolism Vitamins heighten enzymatic activity and immunity, they regulate the processes of reduction and oxidation and the activity of the endocrine and hematopoietic systems, they are also conducive to the assimitation of the products of metabolism Thus vitamins are essentially regulators of vital processes, biocatalysts, i e, substances that stimulate these processes Vitamin deficiencies in the child s body (hypovitaminosis and avitaminosis) are mostly seen as polyavitaminosis—the lack of many vitamins However, in view of the specific physiological action of individual vitamins the absence or deficiency of a certain vitamin displays definite clinical features

Vitamin deficiencies may be due to the lack of these substances in the food supply (*exogenous hypovitaminosis*) or to their deficient assimilation owing to destruction in the digestive tract or poor absorption (*endogenous* or *secondary hypovitaminosis*) A relative vitamin deficiency may appear during a number of diseases in consequence of the heightened demands of the body The specific action of the separate vitamins is associated, to a great extent, with their properties

Vitamins fall into two basic groups fat soluble and water-soluble vitamins Best known among the fat soluble group are vitamins A, D, K, and E, among the water soluble group—the vitamin B complex and vitamin C

FAT-SOLUBLE VITAMINS

Vitamin A (the antixerophthalmic factor which prevents corneal xerosis, protects the skin, the anti infection factor, the growth vitamin) The multiform definitions of the properties of vitamin A indicate its multifarious activity in the organism Vitamin A is distributed in fats of animal origin, that is, in butter and egg yolk, beef and pork fats contain much less A particularly high percentage of vitamin A is found in fish-liver oil and liver The principal properties of vitamin A are (a) maintenance of an optimal nutritional level in the skin, conjunctiva, cornea, mucosal epithelium, nails, and hair, (b) regulation of sight adaptation, (c) stimulation of the processes of growth and weight gain, (d) maintenance of the immune properties of the organism, (e) participation in all metabolic processes, particularly in fat metabolism

The greater part of vitamin A is provided with the food in the form of provitamin A—carotene, a yellowish red vegetable pigment contained in a number of vegetables and fruits (carrots, tomatoes, tangerines, pumpkins) Provitamin A combines with the bile acids and is then absorbed in the intestine and the liver, under the action of the enzyme carotenase the provitamin is converted into vitamin A The formation of vitamin A from carotene occurs through oxidation [the conversion formula is $C_{40}H_{56}$ carotene $+2H_2O = 2C_{20}H_{29}OH$ (vitamin A)] However, this conversion requires a sufficient amount of fat in the food and normal functions of the liver and intestine When carotene is ingested in excess part of it is deposited in the skin, causing a yellowish pigmentation of the palms, soles, and even of the face (carotenemia) This carotene pigmentation is usually observed in children whose liver function is deficient The accumulation of vitamin A occurs in the liver, from which it emerges as required

Hypovitaminosis and avitaminosis A appear in the absence or insufficiency of full value fats with a high vitamin A content Avitaminosis A appears most rapidly in infancy At birth infants possess a certain store of vitamin A in the liver, but this store is depleted by the time the baby is 5 6 months old Breast feeding provides the infant with fat of full dietary value, and it, evidently, also satisfies the vitamin A requirements, fat deficiencies easily produce symptoms of hypovitaminosis A in bottle fed babies The first clinical manifestations of this dietary deficiency are dryness of the skin and sloughing of the epidermis, followed by disturbance of secretion of the mucosal glands, which is evidently due to constriction or even atrophy of the excretory ducts The result is dryness of the cornea (*prexerosis* and *xerosis*) and of the *mucosal lining of* the mouth Inhibition of weight gains and lowering of the child's resistance to disease are concurrent phenomena Hence the tendency to pyodermatosis, stomatitis, upper respiratory catarrhs, and acute infections In severe cases of avitaminosis A xerophthalmia may develop, the superimposition of a secondary infection turns it into keratomalacia (softening and perforation of the cornea) The drawn out courses of bronchitis and pneumonia concurrent with hypovitaminosis A are to a certain extent due to changes in the epithelium of the respiratory passages (metaplasia), while changes in the epithelium of the urine-excreting tract are conducive to the development of pyelitis Moreover protracted vitamin A deficiency in the diet of babies decreases all the metabolic processes and the functions of the endocrine glands In children of the preschool and school ages one of the early symptoms of vitamin A deficiency is reduction of dark adaptation (night blindness, nyctalopia), which is owing to disturbance in the formation of the visual purple (rhodopsin) with which sight adaptation is associated Keratinization of the follicles is noted on the skin, the sebaceous and sweat glands are gradually atrophied, and the skin acquires a typical appearance ("grater', "fish scales) It is held that a lack of vitamin A in the prepubertal period inhibits sexual maturation, but the same is true of protein deficiencies Vitamin A deficiency aggravates the course of tuberculosis, and have a particularly disastrous effect in measles and pertussis

Vitamin A requirement depends on age, dietary, season, and climate The development of hypovitaminosis A is closely interrelated with both the fat and protein content of the food a predominantly carbohydrate diet lacking in fats favours vitamin A deficiency

Vitamin D (the antirachitic factor) occurs rarely in nature, the content of this vitamin in the staple foods, including breast milk, is very low Its percentage is high in fish liver oil, liver, roe, egg yolk, and certain kinds of fish The vitamin is synthesized in the body from the sterols (precursors of vitamin D) contained in the skin The action of sunshine (ultraviolet rays) promotes the conversion of provitamin D into the active form, vitamin D_3, in this form it occurs in fish liver oil and in a few kinds of food Vitamin D_2 (calciferol) is produced by irradiation of ergosterol (contained in ergot, yeast, and other fungi) Vitamins D_2 and D_3 possess similar biological effects *In the body the active vitamin D regulates phosphorus and calcium metabolism, being conducive first of all to the assimilation in the bone tissue of the inorganic salts of phosphorus and calcium and to skeletal growth* Without vitamin D even excessive quantities of calcium or phosphorus salts are not assimilated in the body Moreover, this vitamin participates in the regulation of tissue respiration *The absence of vitamin D in the child's body produces rickets, and also spasmophilia or tetany.*

In rickets the bones are depleted of the salts of calcium and phosphorus, the calcium level of the blood remains almost normal, but the phosphorus content is reduced. This is conditioned by decreased assimilation of calcium salts. Normal values are 10 mg% of calcium salts and 5 mg% of phosphorus. In spasmophilia the calcium level is mostly reduced, causing increased excitability of the entire nervous system. Particularly severe forms of rickets are seen in connection with the coexistence of other vitamin deficiencies (A and the B complex). The activity of vitamin D preparations is measured in International Units (IU). 1 ml (30 drops) contains from 30 000 to 100 000 International Units, depending on the preparation. Vitamin D requirements depend on the season of the year, the method of feeding (breast or bottle) and general hygiene. Excessive ingestion of this vitamin (for instance, prolonged administration without prescription or too large doses) produces hypervitaminosis D, characterized by deposition of calcium salts in all the organs and tissues.

Vitamin K (the antihemorrhagic or coagulation factor) enhances blood clotting by increasing the prothrombin level (prothrombin is one of the factors in normal clotting).

Vitamin K is not very abundant in nature, its principal dietary source is cabbage (it also occurs in kale, cauliflower, spinach, tomatoes, and soybean oil). It is probably synthesized by the intestinal flora and then delivered to the liver. The vitamin K level in the body is judged on the basis of the blood prothrombin level. Physiological hypoprothrombinemia is seen in the newborn, which explains the appearance of a hemorrhagic condition in the newborn displayed by brain hemorrhage, umbilical and intestinal bleeding. Secondary hypoprothrombinemia is clearly manifest in diseases of the liver, especially in infectious jaundice, consequently, the determination of the blood prothrombin level is a certain criterion of the liver function.

Taken orally, vitamin K elevates the prothrombin level (the preparation is known in the Soviet Union as vicasol). For the newborn it is prescribed for a period of no more than three days.

Vitamin E (tocopherol) is the reproduction or antisterility vitamin. Its presence is necessary for the normal development of the embryo and fetus. The germ cells of grains, green plants (lettuce, alfalfa), milk and egg yolk are the chief dietary source of this vitamin. Experimentally lipoid metabolism is disrupted by vitamin E deficiency, as a result of which toxic products are formed, these products destroy the fetus in the gravid female and lead to testicular degeneration in the male. The association of vitamin E with lactation has not been sufficiently clarified.

Findings in experimental avitaminosis E are decrease of muscular tension, muscular dystrophy, adipose dystrophy or sclerosis of the cellular elements of the spinal cord, and demyelinization of the nerve fibres. On these grounds it has been attempted to use vitamin E in the treatment of patients affected by progressive muscular dystrophy.

WATER-SOLUBLE VITAMINS VITAMIN B COMPLEX, VITAMIN C AND VITAMIN P

The vitamin B complex includes as many as twenty separate components, for some of which the chemical structure and biological activity have been determined Vitamins of this group mostly occur concomitantly in a number of natural products, such as liver yeast, egg yolk, milk, meat

A quite exhaustive study has been made of the participation in physical processes of vitamins B_1 (thiamine), B_2 (riboflavin) and nicotinic acid (niacin, PP vitamin or factor), and of their deficiency symptoms As regards other constituents of the vitamin B complex, it must be noted that notwithstanding their presence in almost all of the systemic tissues (e g, pantothenic acid) and their participation in metabolic processes (biotin pyridoxine) no clear deficiency patterns have been evolved All the members of the vitamin B complex possess in common a certain similarity of action most of them participate in the regulation of the processes of reduction and oxidation, they are conducive to the assimilation of carbohydrates and proteins and are constituents of enzyme systems, they affect hematopoiesis, lymphopoiesis, and the formation of immune bodies But at the same time each one of them possesses a number of individual traits, so that deficiency of one member of the vitamin B complex may produce a definite clinical picture

Vitamin B_1 (thiamine) is also known as aneurin in connection with its principal deficiency symptom, the development of polyneuritis The importance of vitamin B_1 in the growing body is particularly high, since it is a constituent of the coenzyme cocarboxylase without which carbohydrate metabolism would be impossible The vitamin is absorbed in the intestine, and its depot is the liver Thiamine deficiency promotes the accumulation of intermediate products of carbohydrate metabolism, pyruvic and lactic acid with a subsequent disturbance of fat and protein metabolism Moreover, thiamine deficiency upsets the secretory motorial, and absorptive functions of the gastrointestinal tract True avitaminosis B_1 (beriberi) is exceptionally rare in the Soviet Union The leading findings in this disease are spastic paresis and in children, frequent edema, convulsions and aphonia A lack of thiamine in the diet (white bread, cereals) of young children may produce symptoms of hypovitaminosis B_1 in the form of edema carpopedal spasm (at times even convulsions), loss of appetite and, frequently, persistent constipation Such findings are indicative of considerable lesion of both the apparatus of neural regulation and of the cerebral cortex, a point that is confirmed by the very slow restoration of the child s mental abilities subsequent to the disappearance of thiamine deficiency symptoms A dietary increase of carbohydrates always increases the amount of vitamin B_1 required for their assimilation Manifestations of thiamine deficiency are not so vivid in schoolchildren, but nervous system involvement is also present Symptoms of this are rapid fatigue, irritability, vague pains in the muscles and along the nerve paths Subsequent findings are anorexia and achylia, and quite occasionally also cardiovascular disorders, such as arrhythmia and diminution of arterial pressure

Thiamine deficiency may likewise be endogenous in origin This occurs in cases of protracted diarrhea which is concurrent with reduced absorption (particularly in early childhood), and also in cases of faulty feeding, when the child is restricted to a monotonous carbohydrate diet Thiamine requirements depend on age season nutritional state, dietary, and condition of the gastrointestinal system

The principal dietary sources of vitamin B_1 are yeast (especially brewer s yeast) liver, egg yolk, and meat Milk, the staple food of babies, contains comparatively little thiamine (see Table 18), but it is synthesized additionally by the child s intestinal flora Whole grains are rich in thiamine, but its location is chiefly in the germ cells and outer portions of the grain (coarse or whole grain bread), there is almost none of it at all in the more expensive sorts of white bread (polished grain) The vitamin is resistant to heat

Vitamin B_2 (riboflavin) is a compound of the yellow pigment flavin with ribose (a pentose sugar), it occurs in almost all cells of the plant or animal world, and participates actively in cellular respiration (oxidation) as part of a respiratory enzyme

Riboflavin is absorbed in the upper portions of the intestine its chief depot is the liver and kidneys The clinical manifestations of ariboflavinosis (lack of vitamin B_2) have to date been studied insufficiently The most probable assumption is an association of this deficiency with cutaneous changes displayed by the appearance of symmetrically situated dry eczema prevalently on the flexor surfaces of the skin, and scaly desquamations on the face, typical symptoms are small ulcers in the corners of the mouth, salivation and a peculiar form of glossitis—sloughing of the epithelium of the tongue dryness, redness, loss of papillary structure (magenta red dry glossy tongue) Opacities, vascularization and the formation of phlyctenules are seen on the cornea Hypochromic anemia of a persistent nature is also quite typical The development of endogenous ariboflavinosis in cases of protracted diarrhea, particularly when the patient is kept on a chary non protein diet, is quite possible In children, particularly very young ones, this condition is accompanied by the development of a peculiar chronic relapsing diarrhea the stool is bulky, frothy, greyish, and foul By analogy with the symptoms of the tropical disease sprue (diarrhea alba) such stools are designated as sprue like' stools Its presence is attended by progressive anemia Apparently, intestinal infantilism (celiac disease), characterized by retardation of physical development, distended abdomen and periodic diarrhea, is associated with thiamine and riboflavin deficiencies These deficiencies induce disturbances of secretion and of fat and protein absorption, mucosal atrophy, endocrine hypofunction, and backwardness in mental development. Like thiamine, riboflavin evidently activates the processes of neural regulation. Clinical manifestations of vitamin B_2 deficiency include depression and persistent anorexia, disappearance of the cutaneous and tendon reflexes, and an appearance of tenderness along the nerves.

Notwithstanding the high requirements of the body in vitamin B_2, this demand is easily met by a well balanced dietary.

Vitamin PP (niacin or nicotinic acid) first derived its name from the words "pellagra preventive" (the PP factor). It is an obligatory dietary factor and a specific agent in the treatment of pellagra. The principal dietary sources of nicotinic acid and its amide are yeast, liver, meat, its content is less in dairy products, rye, and wheat.

Nicotinic acid is a constituent of all the cells of animal tissues; its content is particularly high in the liver, kidneys, and also in wheatgerm. The biological importance of nicotinic acid is especially great in the growing organism, since it is a coenzyme constituent and stimulates all the processes of cellular metabolism, acting as a catalyst in acid base metabolism. Nicotinic acid is a regulating factor in the complex metabolic processes that take place in the brain tissue; one of its early symptoms is mental depression, lassitude. Nicotinic acid has a characteristic vasodilatory effect on the smaller superficial blood vessels, it stimulates gastric secretion and increases the acidity of the gastric juice. The positive effect of nicotinic acid on blood clotting, and on erythrocyto- and leucocytopoiesis has been proved.

Prolonged nicotinic acid deficiency produces pellagra. True pellagra is characterized by dermatitis (hence the term pellagra, from *pell*—skin, and *agro*—rough), diarrhea, irritability and depression. Early symptoms of pellagra are diarrhea and mouth disturbances—acute hyperemia of the mucosa and tongue, salivation, and a specific pellagrous rash which appears predominantly on the outer surfaces of the hands and feet. It is held that pronounced true pellagra is characterized by three D's (diarrhea, dermatitis, depression). However, in practice *secondary endogenous nicotinic acid deficiency is more frequently observed, it is due to reduced absorption in chronic diarrhea and particularly in association with the low protein diet given in such cases.* The disease is manifested by a brownish skin pigmentation around the neck (a "tie", or "necklace") and on the hands and feet ("socks", "gloves"), mental depression, swelling and redness of the tongue, stomatitis. It has been proposed to call these symptoms pellagrous or pellagroid. A proper diet, abundant in protein (milk curds, meat) and nicotinic acid, as well as blood transfusion and the prescription of yeast, soon correct the condition. Usually nicotinic acid deficiency is coexistent with other vitamin B deficiencies (thiamine and riboflavin). Nicotinic acid requirements are dependent on age, energy of assimilation, and dietary.

Several other components of the vitamin-B complex are important in the physiology and pathology of childhood One of them is pantothenic acid (the "omnipresent" acid, from the Greek *pan*, *pantos*—all, complete) Accumulated data show that this acid occurs in all animal and plant cells, its chief dietary source is yeast, eggs, and liver There can be no question of its importance in carbohydrate metabolism in the growing organism, as well as of its participation in the regulation of the neural and endocrine functions (the adrenals) Of recent years the symptomatology of biotin deficiency has been studied Biotin is known under several synonyms, among them vitamin H (antiseborrheic vitamin), coenzyme R It has been attempted to interpret seborrheic eczema in children, i e, neurotrophic disorders, by the lack of this factor At present the B complex also includes choline, the derivative of which, acetylcholine, plays an important part in the chemical transmission of nerve impulses Choline is distributed in nature as a component of phospholipids (yolk, brain tissue) and it has a lipotropic effect, its deficiency is the cause of fatty degeneration of the liver

Wide use is currently being made of vitamin B_{12} and of folic acid in the treatment of a number of diseases

Vitamin B_{12} (antipernicious anemia factor) has been isolated from the liver It is very effective in the treatment of anemia, particularly of its pernicious form Vitamin B_{12} combines with the intrinsic factor of Castle produced by the pyloric portion of the stomach and yields an antianemic principle which stimulates blood formation The liver of ruminants is particularly abundant in vitamin B_{12} which is synthesized in their stomachs by bacteria

Folic acid (pteroylglutamic acid, vitamin B_c, green leaf factor) occurs in yeast and liver and has also been produced by synthesis It is employed clinically in treating certain severe forms of anemia and leukemia Folic acid is synthesized by the intestinal microflora

It has been firmly established that symptoms of vitamin B complex deficiency are closely connected with quantitative and qualitative dietary insufficiencies of protein This is particularly true of infants and babies with their high protein requirements Clinical practice and experimental data give grounds for affirming that the nervous system is most sensitive to the vitamin B complex deficiency in the body.

Vitamin C (ascorbic acid, antiscorbutic factor) is a specific agent for the treatment and prevention of scurvy It is widely distributed in nature in vegetables, fruits, berries, and the green parts of some plants The vitamin C content is particularly high in dog rose hips black currants, lemons (and other citrus fruits), and conifer needles

Ascorbic acid is a component of all the tissues and organs, but its content is particularly high in organs which are functionally most active—the adrenals, placenta, pituitary Its content in milk varies with season and cow fodder The ascorbic acid contained in foods is rapidly inactivated by light and heat and when kept in metal containers The biological properties of vitamin C are associated with its faculty of regulating reduction and oxidation processes, it is one of the most active reducing agents in the body, which stimulates the production of immune bodies, blood enzymes, endocrine and nervous activity, increases blood coagulation, raises resistance of the body to disease, and exerts a desensitizing effect in anaphylactic shock The daily ascorbic acid requirements of the child (per kg of body weight) are higher than those of adults Breast milk should be fortified with vitamin C by prescribing a diet high in vitamin C for the mother, from the third or fourth month of life breast fed babies should be given vegetable and fruit juices Babies who are raised on a mixed breast and bottle diet, or on the bottle alone, need juices earlier (see Chapter XIX) The average daily ascorbic acid requirement of children younger than seven years is 35 to 50 mg The percentage of ascorbic acid contained in the blood is 0 5 to 1 5 mg%, in mother's milk there is 3 to 7 mg%, depending on the season diet and schedule of the nursing mother Lack of vitamin C in the food leads to hypovitaminosis and avitaminosis C Avitaminosis C (scurvy) is in ordinary times rarely seen Its symptoms are bleeding of the gums, stomatitis, petechial skin rashes around the hair follicles (in distinction from hemorrhagic manifestations in hemorrhagic diathesis), and in severe cases also hemorrhagic infiltrations in the muscles, under the periosteum, and in the sclerae Persistent hypochromic anemia is typical

Scurvy of early childhood is manifested by subperiosteal hemorrhages along the diaphyses of the thigh and leg with bone fractures that are extremely painful when touched This type of scurvy, called infantile scurvy or the Moeller Barlow disease has been observed in the USA almost exclusively in babies fed on canned milk The Moeller Barlow disease is not infrequently seen in combination with severe rickets

Hypovitaminosis C is comparatively more frequent, and it may be of either exogenous (dietary deficiency) or endogenous origin (destruction of ascorbic acid in the gastrointestinal tract, reduced assimilation) Symptoms of vitamin C deficiency in the child are not very typical pallor, exhaustion, poor appetite, occasionally capillary fragility and bleeding of the gums Lack of vitamin C lowers the resistance of the body and may be the cause of a stable hypochromic anemia, particularly following gastrointestinal diseases, or in association with chronic colitis, pneumonia, or rickets

Vitamin P (citrin, permeability vitamin) is a group of substances called flavonoids (or bioflavonoids) that reduce capillary permeability and fragility and are conducive to fuller utilization of vitamin C in the body Hypovitaminosis P is attended by the appearance of multiple hemorrhages The vitamin P occurs in green tea leaves, in dog rose hips, in black currants, in grapes, lemons and buckwheat

Table 17

Lowest Daily Human Requirements in Vitamins

Subject	Vitamins							
	Vitamin A		carotene (mg)	B_1 (mg)	B_2 (mg)	C (mg)	PP (mg)	D (IU)
	IU	mg						
1 Adult								
(a) during moderate physical expenditures	3,300	1	2	2	2	50	15	
(b) during hard work	3 300	1	2	2 5	2	75	20	Up to 1 000
(c) during very hard work	3 000	1	2	3	2	100	25	
2 *Pregnant women*								
(5 8 mos of gestation)	6 600	2	4	2 5	2	75	20	500 1 000
3 Nursing mothers (up to 7 mos of lactation)	8 300	2 5	5	3	2	100	25	500 1 000
4 Children								
(a) under 7 yrs	3 300	1	2	1	2	30 35	15	500 1 000
(b) 7 to 14 yrs	3 300	1	2	1 5	2	50	15	500 1 000
(c) over 14 yrs	3 300	1	2	2	2	50	15	500 1 000

Note Human requirements in vitamin A are expressed in the table in three ways (1) in International Units (IU) (2) in milligrams of vitamin A and (3) in milligrams of carotene

One mg of vitamin A corresponds to 3 000 IU 1 mg of carotene (beta-carotene) equals 1 660 IU

One International Unit of vitamin D corresponds to 0 000025 mg of chemically pure vitamin D (calciferol)

One International Unit for expressing vitamin A activity corresponds to the activity of 0 0006 mg of carotene (beta carotene) or 0 0003 mg of vitamin A.

Vitamin P preparations (rutin, catechols) are employed in the treatment of hemorrhagic diathesis capillary toxicosis, etc

As has already been pointed out, childhood hypovitaminoses are usually manifested as coexisting deficiencies of a number of vitamins (polyhypovitaminosis), but concomitant vitamin C and B deficiencies are most prevalent, particularly in infancy Consequently, the pediatrician must know the early symptoms of these deficiencies The leading albeit not very typical, symptom is the reaction of the nervous system manifested by restlessness, sleep disturbances alternating with somnolence caused by vitamin C deficiency, and depression, lassitude, and subsequent muscular hypertonia with spasmodic jerks

Vitamin Values in Staple Foods of Children
(after Prof V Bukin)

Vitamins / Foods	A	D	B_1	B_2	C	PP
		In milligrams per 100 grams of product (mg%)				
			Dairy Products			
*Milk human**	0 18 0 5	0 05 0 25	0 03 0 04	0 75	3.5 7 6	
Milk cow s	0 04 0 45	0 01 0 25	0 04 0 08	0 19 0 22	0 7 3 5	0 8 2 8
Cream	0 4 1 2	1 25	0 03	0		
Butter	0 4 12	1 8	0 09	0	0	
			Eggs			
Egg yolk	2 5 15 0	3 5 12 5	0 4 0 6	0 20 0 40	0	
Egg white	0	0	traces	0 19 0 23	0	
Whole egg	0 8 5 0	—	0 2	0 20 0 23	0	
			Meat Products			
Beef	0 12 1 25	—	0 12 0 24	0 19-0 37	0 9	7 7
Pullet	traces	—	0 18	0 13	—	7 3
Liver	5 4 12	1 12	0 27 0 48	3 0 3 7	20 40	21
Brain	0 03	—	0 15	0 25	16	5 1
			Vegetable Foods			
Whole wheat flour	—	—	0 4 0 7	—	—	
Ditto 75%	—	—	0 36	—	—	
Ditto 42%	—	—	0	—	—	
Oatmeal	—	—	0 5 0 8	0 06 0 1	—	1 8
Buckwheat	traces	—	0 6	—	—	
Rice	—	—	0 04 0 08	—		1 2
Fresh beans	0 6	—	0 06	0 09	15	4 0
Fresh peas	1 3 1 9	—	0 08 0 2	0 1 0 2	33	1 7
			Vegetables			
Cabbage	0 06	—	0 05	0 05	25 66	0 3
Cauliflower	0 04	—	0 2	0 05	50 75	
Spinach	6 15	—	0 2	0 4	16 40	1 7
Lettuce leaves	12	—	0 08	—	12 14	

* Comparative vitamin contents in human and cow s milk after V Yefremov 1957 See Table 10

Table 18 (Continued)

Foods \ Vitamins	A	D	B_1	B_2	C	PP
		In milligrams per 100 grams of product (mg%)				
Onion greens	3 75	—	—	—	127	
Onion bulbs	0	—	0 08	0 02	16 33	
Turnip	0	—	up to 0 1		10 20	
Carrots	0 2	—	0 06	0 03	25 30	0 5
Potatoes	0	—	0 08	0 02	5 8	1 2
Tomatoes	1 2 1 6	—	—	—	5	0 5
Watermelon	approx 1 0	—	0 06	0 03	5 10	
Pumpkin	5 0	—	0 06	0 04	25 50	1 7
Cucumber	0 08	—	0 06	0 02	8	—
Muskmelon	0 1	—	0 04	0 07	10 40	—
Fruits and Berries						
Dog rose hips	4 1			0 03	100-4 500	
Oranges	0 1 0 2	—	0 09	0 03	66	
Lemons	0 02	—	0 03		55	
Tangerines	0 2	—	0 09	0 03	40 50	
Apples	0 1	—	0 02	0 04	5 33	
Pears	traces	—	0 02	0 02	3 10	
Sour cherries	0 3-0 5	—	0 05	0 1	15	
Grapes	0 02	—	0 04	0 09	0 4 12	
Apricots	5 10	—	0 03	0 05	6	
Black currants	up to 2 0	—	—	—	105 400	
Red currants	traces	—	0 04	—	8 16	
Strawberries	0 4	—	0 02	traces	33 66	
Raspberries	0 3	—	0 02	—	12 25	
Cranberries	0 01	—	—	—	10 12	

and convulsions caused by hypovitaminosis B One of the early complaints made by the mother at the onset of rickets (hypovitaminosis D) is the child's excessive perspiration, sleep disturbances irritability These symptoms are likewise associated with irritation of both the central and autonomic nervous systems Prolonged dietary vitamin deficiencies inhibit the child s mental development, i e , his cortical functions (N Krasnogorsky)

Vitamin deficiencies (of both exogenous and endogenous origin) affect not only the nervous system, but also the closely interrelated functions of the endocrine glands The latter are regulated by the brain and the cortex Vivid confirmation of this was obtained by the study of cases where the leading lesion seemed to be located in certain of the endocrines, but autopsy showed considerable changes in the central nervous system The child obtains the required amount of vitamins when his dietary is properly balanced at all age levels (see Chapter XIX), while vitamin assimilation is regulated by the systemic processes of metabolism that depend to a great extent on proper hygienic regimen (fresh air, etc)

Consequently, *the child should be given vitamins in his food in accordance with his requirements* (Tables 17 and 18) *In addition to this pure vitamins* (vitamin C, vitamins B_1, B_2, nicotinic acid etc) *are given in definite dosages on medical indications Considering that infant food (including human and cow's milk) is poor in vitamin D this vitamin should be introduced orally in the form of fish liver oil or vitamin D beginning with 3 4 months of life* for the prevention of rickets

CHAPTER XXI

METABOLIC PROCESSES IN CHILDHOOD

Prof *Y Dombrovskaya*

THE CHEMICAL COMPOSITION OF THE CHILD S BODY

A direct continuation of the digestion of nutritive substances and their absorption in their altered form in the gastrointestinal tract is the process of cellular assimilation The intensive growth and development of the child call for a more rapid assimilation of the separate food constituents *This intensity of metabolic processes is the principal distinction of the growing organism* In order to comprehend a number of other specificities of metabolism in children it is first of all necessary to consider the peculiar chemical composition of the child organism (Table 19)

Table 19

Chemical Compos tion of the Child s Body at Different Ages
(data of various authors)

Age	Water	P o ein	Fa	Ash
	In pe cent			
Fetus 6 wks	97 5	—	—	0 001
Fetus 4 mos	91 3	5 21	0 51	0 99
Fetus 8 mos	82 9	10 40	2 44	2 8?
Newborn	74 1	11 60	9 1	2 55
Baby 56 days	70 1	14 ?9	13 1	2 73
Schoolch ld	65 9	16 80	10 5	5 6
Adult 32 yrs	59 0	15 00	21 0	5 0

It must be pointed out that the protein fat and water values at various age levels are subject to considerable deviations

It will be seen from Table 19 that (1) the body of the fetus consists predominantly of water and that as time passes desiccation of the body occurs (2) the total amount of protein increases chiefly in the middle of the intrauterine period of life, while the fat content grows towards the end of gestation, (3) the increase of mineral substances is particularly intensive during the prenatal period of skeletal development, and this rise is due in the main to an increase in calcium and phosphorus

It has lately been established that the content of vitamin C (ascorbic acid) and of the vitamin B complex is higher in the fetus and the newborn than in adults

Water is distributed differently in the child's body than in the adult body, there is less of it in the blood but much more in the muscles and brain Moreover, in the child the water is not bound up so closely in the cells as it is in adults, therefore in infancy a severe disease may cause the child to lose up to 300 400 g in weight daily (relatively very high figures) This must always be taken into account and a high fluid intake be prescribed for such patients

The chemical structure of the *fats* in the child's body likewise differs from that of the fats of adults (Table 20)

Table 20

Fat Constituents at Different Age Levels
(Dobatovkin and Langer)

Age	Solid acids (palmitic stearic)	Liquid acids (oleic)
	In per cent	
Fetus 10 mos	39 47	53 1
Infant 1 mo	27 48	65 1
Infant, 5 mos	19 94	73 5
Baby, 12 mos	18 22	74 1
Child 2 yrs	18 43	77 0
Child, 4 yrs	8 75	84 0
Adult	9 76	86 21

The *prevalence of solid fatty acids is conducive to the hardening* of the subcutaneous adipose tissue, a condition known as sclerema Sclerema is mostly seen on the legs and thighs of premature and newborn infants The condition is favoured by the high melting point of the adipose tissue of the newborn, as the child becomes older the melting point gradually diminishes, although not uniformly, in all the parts of the body

The tissues of the newborn have only a slight percentage of minerals (approximately 2 5 per cent), as time passes the mineral content increases and, moreover, the proportions between the individual ingredients change so that the amount of calcium and phosphorus, elements which are principally incorporated in the skeletal tissue, increases, while the amount of electrolytes (chloride, sodium) decreases

The chemical composition of the body of the fetus and the newborn is not stable since it is affected by the mother's diet during pregnancy, the state of her health, her living conditions and habits There is a close interrelationship between metabolism and the properties of the blood enzymes

The enzymes of the blood are catalysts of biochemical reactions occurring in the body, they are biological substances produced by the cell itself (intracellular enzymes or ferments) and possess a powerful specific effect Enzymatic activity is closely associated with the state *of the organism with the method of infant feeding, with age and* with general hygiene Thus the mother's living conditions and her habits are reflected not only in the activity of her own enzymes but also in the activity of the enzymes of the infant she nurses at her breast The activity of the principal blood enzymes—amylase lipase catalase—is reduced in premature and feeble infants During the first year of life enzymatic activity grows continuously in healthy babies, in disease particularly when the gastrointestinal tract is involved, it decreases (M Maslov) (Table 21)

Table 21

Enzymes Contained in the Blood of Healthy Babies in Their First Year of Life
(Tur Povurovskaya)

Mos of life / Enzyme	1	2	3	4	5	6	7 9	10	12
				in units					
Amylase	200	200	250 300	400	516 600	625	625 1 000	1 000	1 000
Lipase	26	23	35	40	40	42	44	46	49
Catalase	7 4	7 7	8 6	9 6	9 6	9 6	9 6 9 9	9 8	9 9

The enzyme levels in the blood of undernourished (hypotrophic) children are considerably reduced, which partly explains poor assimilation by such children of the nutritive substances necessary at this age

ENERGY METABOLISM IN CHILDREN

Energy metabolism occurs as a result of the conversion of the potential energy of food constituents into the basic physiological processes

As in adults, metabolism in children includes several consecutive phases absorption in the intestine, intracellular processes of assimi *lation, plastic processes of accumulation, and energy expenditures.* However, in distinction from adults part of the child's energy is expended on growth and deposition of substances, and this is one of the basic peculiarities of the growing body (Table 22)

Table 22

Distribution of Energy in Child and Adult Bodies

	Child	Adult
	In per cent	
Basal metabolism	60	60
Growth and deposition of substances	15	0
Specific dynamic effect of food	0 5	10
Energy expended on locomotion	15	25
Loss in excrements	5 10	5

Basal Metabolism

Basal metabolism is the minimum amount of energy expenditures necessary to maintain physiological processes in the body when it is at complete rest 12 hours after the intake of food Basal metabolism is measured in calories, and it is directly dependent on the state of the endocrine and autonomic nervous systems, and, hence, on cellular metabolism

Age	Basal metabolism expressed in calories per kg of body weight
Newborn	38 42
Infant, 2-4 weeks	44 46
Infant, 4 8 weeks	49
Infant, 8 12 weeks	54
Baby, $1^1/_2$ yrs	55 60
Child, 2 3 yrs	52
Child, 6 7 yrs	42
Child, 10 11 yrs	38
Child, 12 13 yrs	34
Adult	23

Daily basal metabolism is low during the days immediately following birth, then it gradually increases, and attains its highest values by the time the baby is one and a half years old, the daily basal metabolism of the newborn infant per square metre of body surface is 512 calories on the first day of life, by the end of the seventh day it becomes 702 calories, by the end of the first year 1,200 calories, and by the age of 14 years it goes down to 960 calories

Basal metabolism per kg of body weight is somewhat higher in boys up to 10-12 years than in girls In the period of sexual maturation basal metabolism increases, owing to the normal activity of the endocrines There is a certain correlation between basal metabolism and the content of adipose tissue in the body, since the activity of tissues of this type in energy processes is low Energy exchange is intensified by the intake of food, owing to the specific dynamic action of food (see Chapter VII)

The specific dynamic effect of food is defined as the energy needed for the digestion and assimilation of the food constituents in the gastrointestinal tract It is at its highest with protein and at its lowest with fat The specific dynamic effect of breast milk is insignificant during the first months of a breast fed baby's life, but even later the specific dynamic effect of food is only approximately half of what is seen in adults in children it takes up to 5 per cent of daily energy expenditures, in adults 10 12 per cent Basal metabolism is increased by the child's disposition, his activity, and restlessness during the examination Hunger has a greater effect on the basal metabolism of children than of adults

Energy expenditures on muscular activity are lower in children than in adults, particularly in early childhood, but when the child cries and is restless they rise sharply

Energy expenditures on growth and on the accumulation of substances are singularly high during the intrauterine period and in the first 2 3 months following birth (see Chapter VII) The intensive accumulation of body mass likewise increases excretory losses (bowel and bladder evacuation).

Fluid Metabolism

The body cannot do without water, especially in childhood, inasmuch as its percentage in the tissues of the child's body is so high *A sufficient intake of water (in accordance with bodily requirements) is imperative for the normal growth and development of the child* Water is essential not only for the increase of body mass but also for all the vital processes—thermoregulation, respiration, oxidation, etc

The above finds its confirmation in an analysis of the daily weight gains of young infants a 25 g gain is made up of 18 g of water, 3 g of protein and 3 g of fat, 1 g of minerals and a slight amount of glycogen

In the growing body all the tissues (although in various degrees) possess hydrophilism (affinity for water) Hydrophilism is determined by the intradermal injection of 0 2 g of normal saline solution (McClure Aldrich test) The younger the child, the more rapidly the vesicle formed owing to the injection is resolved in infancy it resolves in 30 minutes, at the age of one lo five years in 35 minutes, and in schoolchildren the process takes 50 minutes

The fluid requirements of the newborn are 150 200 ml per kg of body weight, during the nursing period up to 150 ml, by the end of the first year up to 90 ml, and by 12-13 years the child's body needs 40 50 ml of water per kg of weight

The rate of fluid metabolism is very high in the child, but it is easily disturbed by various factors The entire water in the child's body is in a state of constant redistribution—absorption in the small intestine and a reverse flow for the production of saliva and of gastric and intestinal juice Investigations of lhe rhythmic work of all the digestive glands in the absence of any delivery of food constituents or fluids have shown that a considerable amount of water is eliminated over and above the fluid intake, this water is contained in the solid foods and is formed in the intermediate processes of oxidation

Exchange of fluid between the tissues, blood, and intestine proceeds at a much higher rate than in adults, and the water ingested by the child travels the route from the intestine to the vascular system and back to the intestine no less than 3 5 times, i e , the fluid metabolism of a child who has ingested one litre of fluid is 3 or even 5 litres Fluid is eliminated from the body mainly by the kidneys (up to 60 per cent), and also through the intestine skin, and lungs (extrarenal elimination)

Two thirds of the extrarenal fluid losses occur through the skin and one third through respiration, the importance of these losses is greater in children than in adults Extrarenal losses grow under the effect of body temperature elevations undernourishment, increases in the atmospheric temperature, excessive clothing, restlessness, and a variety of other factors of exogenous and endogenous origin All this must be remembered, and the intake of fluids increased accordingly

Owing to the high rate of fluid metabolism water deficiencies caused by insufficient intake or by losses due to diarrhea vomiting, or even accelerated respiration promote dehydration (exsiccation) *and a grave systemic condition* (toxicosis), dehydration with large weight losses leads to febrility in the newborn (thirst fever) Children, like adults also have fluid depots in the blood, muscles, skin, and liver, but in children the fluid is easily redistributed

The regulation of fluid metabolism is influenced by a variety of factors the central nervous system (the subthalamic area), the autonomic and endocrine systems (the pituitary, predominantly its posterior lobe, the thyroid and pancreas) The entire capillary system of blood vessels is also one of the regulators of fluid metabolism The lability of fluid metabolism in infants is to a certain extent associated with the immature differentiation of the central nervous and endocrine systems This is why babies are so badly affected by water deficiencies, particularly during the warmest hours of the day or during febrile diseases

The urine output is negative during the first 3 4 months of the child's life but it becomes positive in the second trimester Urinary output is affected by the child's weight, his nutritional state, hygiene, dietary, and a number of other factors

A close connection exists between fluid metabolism and all the other forms of metabolism—carbohydrate, protein, mineral, fat and also the vitamin content of the body

Carbohydrates possess the highest water retaining capacities A prevalence of carbohydrates in the child's diet will cause a rapid but instable, gain in weight, since weight increases are associated with the retention of water which is insecurely linked to the tissues (hydrolability) When a child is kept on a restricted carbohydrate diet during the first year of his life he may develop a so called starchy disturbance of nutrition which is displayed by pallor and puffiness of the face, pasty tissues The "chary' carbohydrate diet given in association with protracted diarrhea (cereal water, toasted white bread, thin starch puddings) may produce *a non protein edema* which is in severe cases accompanied by generalized dropsy The most pertinent factor in the origin of this type of edema is protein deficiency and the vitamin B_1 deficiency concomitant with it

Minerals, particularly sodium chloride (NaCl) also possess a considerable water retaining action This property, as we know is the basis of the hypochloride and achloride (saltless) diets prescribed in cases of edema of renal and cardiac origin

The interactions of protein and fluid metabolism are much more complex Water is contained in the blood not only in a free state but also in linkage with proteins ("swelling water" is not a stable value) Moreover, an increase in the dietary protein induces increased water requirements

Fats are evidently of some aid to the cell in retaining water but they exercise no direct influence on this retention

Of late the importance of *vitamins* in the regulation of fluid metabolism has been greatly stressed, predominantly of the B group and vitamin C This influence is most probably indirect and is associated with the stimulation by vitamins of cellular metabolism, the functional activation of one of the principal fluid reservoirs, the liver, and the regulating effect on cardiovascular functions

Carbohydrate Metabolism

Carbohydrate metabolism in children is distinguished by a number of specific features, prevalently during the first years of life During the consecutive phases of digestion the carbohydrates are hydrolyzed into monosaccharides in the form of which they are absorbed in the small intestine (for the most part) and an insignificant amount is deposited in the muscles and liver in the form of glycogen *The principal designation of carbohydrates is the delivery of fuel which is utilized by the body for the production of heat and kinetic energy* Carbohydrates exert a definite influence on all forms of metabolism, and they maintain the acid base balance That is why in the first two years of life, when the processes of growth are most vigorous, carbohydrate assimilation and sugar tolerance are higher The frequently observed intensification of glycolysis may be looked upon as an indice of intensified growth in the child Intensified glycolysis raises the lactic acid level in the blood (up to 20 mg%), since lactic acid is formed by the hydrolysis of sugar Sugar occurs in the blood in the form of glucose the amount of which in fasting blood varies In infancy it is 70 90 mg% (high rate of glycolysis), in the pre school age 80 100 mg%, and from 12 to 14 years 95 to 120 mg%, which already approaches adult values The glucose level in the blood oscillates during the day, depending on intake of food and its composition, physical exertions, environmental temperature, and other factors

A study of the glycemic curve is of certain value in judging the condition of intermediate carbohydrate metabolism however, owing to the extreme lability of carbohydrate metabolism in childhood and the influence exerted on it by the other forms of metabolism the results obtained must be appraised with caution, taking into account the condition of the body as a whole The contours of the glycemic curve differ somewhat during the first years of life from what is observed in adult life its highest wave is lower, the height of the ascending limb, which reflects the condition of the gastrointestinal tract and of glycogenolysis changes in diseases of the liver acute intestinal catarrhs, etc The descending limb reflects glycogen formation, and its shape and height are subject to most frequent change

The blood sugar level is regulated by the nerve reflex and neurohumoral reaction of the sugar centre in the medulla oblongata A leading part in the mechanism of this regulation is also played by the endocrine system, first of all by the hormone of the pancreas, then that of the pituitary (the hormone of the anterior lobe), the adrenals, and the thyroid

Some part of the carbohydrates is hydrolyzed in the intestine owing to the fermentative processes caused by definite species of bacteria Lactose (milk sugar) is fermented most easily beet sugar not as easily, flour and rice are still less affected by fermentation During a number of intestinal diseases and dietary mismanagements excessive fermentation impairs absorption of the products of hydrolysis in the intestine and creates a favourable medium for bacteria

The carbohydrate requirements of a normally developing child are quite high, they should cover no less than 40 50 per cent of the total caloric requirements The nature of the carbohydrate is also important the only permissible carbohydrate in breast feeding is lactose, with the introduction of solids the child is given in addition to beet sugar also polysaccharides (cereal waters) The total quantity of carbohydrates per kg of body weight in the different stages of childhood varies between 8 and 15 g (see Chapter XIX)

An excessive intake of carbohydrates in association with protein and fat deficiencies produce a noticeable deterioration of immunity, in addition to the already mentioned 'starchy disturbance" of nutrition accompanied by pastiness and edema Moreover, as a result of the lack of vitamin A, which occurs in fats, periodic muscular hypertension develops, or it may be present constantly, and even tonic spasms are observed (protein and vitamin B_1 deficiencies)

Mineral (Electrolyte) Metabolism

The greater part of the elements of the Mendeleyev Table of chemical elements is contained in the body The most widely represented groups are (1) alkaline earth metals—calcium, magnesium, (2) alkaline metals—potassium, sodium, traces of lithium, (3) heavy metals—iron, zinc, manganese, aluminium, (4) metalloids—chiefly chlorides, and to a lesser extent iodine and fluorine

Sulfur and phosphorus are constituents of all cells The mineral composition of the cells and tissues differs essentially from that of the blood and lymph Some mineral substances (sulfur, phosphorus iron) are molecular constituents and are consequently necessary for the building of new tissues while others, in the form of dissolved salts or electrolytes, are dispersed in the tissue fluids and blood, playing an active part in many metabolic processes

As the child grows a redistribution of the different salts occurs, and minerals are concentrated in the skeletal system in the process of its development Human milk contains less mineral substances than cow's milk does, but these substances are much more efficiently utilized up to 50 per cent of the mineral intake is retained by breastfed babies, and only 15 per cent by babies raised on formula After the baby is 5 6 months old his mineral requirements grow rapidly and can no longer be met by what is supplied with the breast milk During the period of intensified growth a particular need in calcium appears, calcium is a bone constituent 97 per cent of which is inactive, and only 3 per cent active But calcium is not only necessary for the bones, it is essential in maintaining the integrity of the vascular epithelium and the normal functions of the cells of many tissues The blood serum of a healthy child contains 10 11 mg% of calcium, but this content varies with the seasons of the year, being lowest in the spring (effect of ultraviolet radiation) As has already been mentioned, notwithstanding the softness of the bones in rickets the calcium level of the blood is not perceptibly reduced (a decrease of calcium fixation in the bones occurs), a considerable diminution of the calcium level is seen only in association with spasmophilia

Calcium is fixated in the bones under the influence of a number of factors which include vitamin D, hormones secreted by the endocrine glands, and the stimulating effect of the vitamin B complex

In infancy calcium requirements are something like 0 2 g a day, in the school age period up to 1 g is required However, the relative calcium requirements are highest during the first year of life, and also possibly during the period of sexual maturation The principal dietary sources of calcium are milk (1 6 g of calcium per litre), cottage cheese (pressed curds), and also cabbage, carrots, turnips

Magnesium is also of some importance in growth Its content in breast milk covers the minimum requirements during the first six months of life Maximum requirements appear in the period of intensive growth—up to 13 mg/kg (adults need only 10 mg/kg)

All the cells of the body contain *potassium* and *sodium* in the form of salts *Sodium retention increases during the period of vigorous growth* (fetal life and first year of postnatal life), *therefore the sodium requirements of infants are relatively high* (up to 25 mg daily) potassium requirements are up to 30 mg Sodium and potassium dietary deficiencies inhibit the growth of experimental animals

Phosphorus is one of the most important anions in the regulation of metabolism its content in the blood serum (in the form of inorganic phosphorus) is 5 mg % and it is a constituent of all cells Dietary intake of phosphorus occurs in the form of organic compounds The assimilation of phosphorus calls for a definite ratio between this element and calcium, an optimal ratio is present in human and in cow s milk, but in breast feeding the greater part (up to 70 per cent) of phosphorus is retained in the body, while in bottle feeding approximately only about half of this quantity is retained The blood serum phosphorus value *is low in rachitic children* and moreover, the proportion between the calcium and phosphorus content may be greatly distorted

Sulfur is a constituent of all the food proteins—its amino acids The sulfur content is especially high in the amino acids needed for the growth and functions of the skin and its derivatives *Sulfur regulates nitrogen metabolism and is essential in protein synthesis*

Chlorides The skin is the principal depot of chlorides Chlorides are delivered to the body with food Breast fed babies retain a much higher percentage of chlorides than do artificially fed infants, particularly when the latter are kept on a carbohydrate diet *All gastrointestinal diseases associated with diarrhea and vomiting rapidly deplete the body of chlorides* (hypochloremia) Chlorides play an important part in maintaining the acid base equilibrium Children's blood contains something like 500 mg% of chlorides An excess of the blood chlorides may cause salt fever However, the blood cannot retain large quantities of sodium chloride, this is the function of the tissues and particularly of the muscles, skin intestine and lungs

An essential element for the formation of hemoglobin is *iron* Both human and cow's milk are poor in iron, some reserve iron is contained in the child's liver The iron contained in breast milk like other minerals, is utilized much more completely than iron contained in all other kinds of food but the body experiences an iron deficit beginning with the fourth or fifth month of life, when it therefore becomes necessary to introduce an additional quantity with vegetable and fruit juices, and later with vegetables too *Iron is not only closely linked with hemoglobin, it is also a catalyst of the oxidation processes occurring in the blood* Dietary deficiencies of iron associated with a monotonous milk diet lead to the development of anemia (alimentary anemia) Children's daily requirements in iron are 0 5 mg/kg

Consequently, the child's body contains a number of various mineral substances both the absolute content of individual elements and their proportions in relation to each other are important factors in maintaining at a constant level the internal chemical balance and the normal course of physiological processes Other elements (bromides fluorides, iodides copper zinc, cobalt) have a selective affinity for certain organs, although present only in traces the pituitary shows a high bromide percentage the thyroid is rich in iodine dental enamel in fluoride

Nitrogen (Protein) Metabolism

Protein is absolutely essential for the growing body, since it serves as plastic building material for the growth and development of the tissues *Therefore the nitrogen balance is positive in children while adults are in nitrogen equilibrium* The more intensive the child s growth, the greater the accumulation of protein in his body the greatest accumulation is seen in the muscles In breast feeding the proteins are almost complete assimilated, in artificial feeding assimilation is somewhat lower

The protein molecule consists of a series of amino acids, some of these amino acids must be introduced with food, and the tissue proteins are subsequently synthesized from them Such vitally essential amino acids include valine methionine, phenylalanine tryptophan histidine, leucine lysine, tyrosine The biological value of food is determined by its content of proteins of full dietary value As has already been pointed out, 10 15 per cent of the daily caloric requirements should be covered by protein Breast fed infants receive an average of 1 2 g/kg of protein (see Chapter XIX), bottle fed infants get 3 4 g/kg, and in subsequent life the requirements diminish coming down to 1 5 2 g/kg by the age of 15 years The normal development of the child calls for an optimal amount of protein Protracted pro tein deficiency in the diet *causes* retardation of growth and a decrease in immunity.

There is a close connection between the retention in the body of nitrogenous substances and the dietary content of other ingredients. the optimal ratio between the protein, fat, and carbohydrates in the first years of the child's life is 1 : 2 . 3-3 5 Carbohydrate intake increases protein retention, fats decrease it

The amino acids not utilized for plastic purposes are deaminated in the liver with the formation of ammonia, and then urea and other nitrogenous compounds which are excreted with the urine

The greater part of nitrogenous substances is eliminated from the body in the form of urea, in infancy (with breast-feeding), when growth is extremely intensive, urea production is much lower than in adults, while *the amount of ammonia* per kg of body weight is greater owing to a certain degree of alkalipenia dependent on an insufficiency of alkalis which are utilized by the child's body for building purposes

The output of *uric acid* is higher in the newborn period of infancy, hence the development of the condition known as uric acid infarct, in the form of deposits of uric acid salts in the kidneys This high elimination of uric acid continues for 2 3 weeks after birth, its origin is most probably endogenous, originating in the high intake of protein and the sloughing of the intestinal epithelium Subsequently the amount of uric acid per kg of body weight gradually decreases in connection with the more complete utilization of protein, and by the age of 12 years it attains a daily value of 0 7 g/kg (0 8 g/kg in adults) However, infants eliminate approximately 4 times more uric acid per kg of weight than adults do It is considered physiologic for the urine of a child (especially at night) of 5 6 years of age to contain, in addition to creatinine, also *creatine* (in adults only creatinine is present) There is considerably less creatinine in the urine of children than in that of adults, this is evidently associated with the lesser mass of muscular tissue, inasmuch as creatinine is formed from the muscular creatine The existence in children of creatinuria is evidently the result of the peculiarities of metabolism in childhood

Fat Metabolism

Fats are constituents of the child's tissues, they are also present in supplemental or reserve depots of fat in the subcutaneous adipose tissue and the omentum These reserves are utilized by the body in conditions of dietary deficiencies (in quality or quantity) *The principal function of fat in the child's body is that of fuel, a source of energy* The body uses fats together with carbohydrates, therefore fat metabolism is closely interrelated with carbohydrate metabolism, this may probably be explained by a certain common route of nervous and humoral regulation of carbohydrate and fat metabolism

Fat requirements depend on age. Thus, infants use up to 4.5 g of fat per kg of body weight, children aged from 2 to 6 years use 3-3.5 g/kg, from 6 to 10 years 2.3 g/kg, and older than ten years—1-3 g/kg. Fat covers over 50 per cent of the total caloric requirements of the child. *Both the quantity and the quality of the fat intake are important.* Fats of full dietary value are those which contain phosphatides, lipoids and vitamins (fresh butter, egg yolk, fish liver oil).

Fats are carriers of vitamins A and D. Together with protein, fats are imperative for the formation of immune bodies and are highly important in digestion. In the small intestine the action of the lipolytic enzymes hydrolyzes fats into glycerol and fatty acids, the action of alkalis converts them into soaps (saponification). The glycerol and soap are absorbed through the intestinal wall, converting into neutral fats which are delivered by the lymph through the thoracic duct into the blood, where a high percentage is used up as fuel. This is why *alimentary lipemia* is observed in children after the ingestion of food (on the average in 3.5 hours).

The fats contained in breast milk are almost completely assimilated (up to 98 per cent), while only 85 per cent of the fats of cow's milk are assimilated. The unused fat (on the average up to 10 per cent) is eliminated from the body in the stool. In the case of breast fed babies the amount of insoluble fatty soaps is much lower than with bottle feeding. The values of neutral fats and free fatty acids are likewise much higher in artificial feeding. *The appearance, colour and odour of the feces of bottle fed babies are due to the high fat content*—pasty clay coloured saponaceous fatty stools. This type of stool is associated with an increased elimination of calcium and magnesium and is not infrequently an early symptom of acid base equilibrium disturbances. This is why excessive amounts of fat in the diet may cause acid base imbalance in the form of acidosis. During their first year of life children are particularly sensitive to deprivation of fat, a protracted absence of fat in the food induces the development of a peculiar form of dystrophy characterized by retardation of growth and lesions of the skin, mucous membranes, hair, and nails (see Chapter XX). Normal assimilation of fats calls for a definite ratio between them and the other dietary constituents (see Chapter XIX).

SUMMARY ON METABOLIC PROPERTIES OF THE GROWING BODY

The insufficient nervous system function of regulation associated with its immaturity conditions an extreme metabolic lability in early childhood. Hence all harmful influences of both exogenous and endogenous origin (diseases, diet faulty in quantity or quality, faulty child care hygiene in the form of overwarming or insufficient fresh air) change the courses of metabolic processes, as is demonstrated most vividly during the first year of life

For the maintenance of optimal metabolic levels it is extremely important to consider all the child's dietary requirements in accordance with his age

Besides the nervous system, a regulating factor in all forms of metabolism at all ages is the endocrine system, between which and the nervous system there exists an extremely close correlationship (neural and endocrine regulation), each age level is characterized by specific features in this respect (see Chapter VIII)

CHAPTER XXII

THE UROGENITAL ORGANS

Prof V Molchanov

ANATOMY AND PHYSIOLOGY OF THE URINARY TRACT

The kidneys The weight of the kidney of a newborn infant is relatively higher than in an adult constituting about $^1/_{100}$ of body weight while in adults the kidney weight is $^1/_{200}$ of the body weight

The weight of the kidney in a newborn infant averages 11 12 g it doubles by 5 6 months trebles by 12 months and increases tenfold by 15 years Towards the age of 5 years the weight of the kidney reaches 55 65 g at 12 years—100 g an adult kidney weighs 150 g The growth of the kidney is irregular its most intensive growth is observed during the first year of life the second period of intensive growth is during puberty *The growth of the kidney usually follows the growth of the body*

Topography The higher relative weight and size of the kidneys of young children are the cause of their situation (in respect to adjacent organs) differing from what is seen in adults

The younger the child the higher lies the upper extremity (extremitas superior) of the kidney In a newborn infant the upper extremity of the kidney is situated at the level of the lower margin of the XI thoracic vertebra in a one year old child it is at the level of the lower margin of the XII thoracic vertebra and by the age of two it occupies the same position as in adults i e corresponds to the level of the I lumbar vertebra

The younger the child the lower is the lower extremity (extremitas inferior) of the kidney From birth and throughout infancy the lower extremity of the kidney is situated on the level of the IV lumbar vertebra below the crista iliaca in children of two years and older it is almost always above the crista iliaca The right kidney is situated 0 5 1 cm lower than the left one

Pediatricians must know the peculiarities of kidney topography in infants Owing to their considerably lower position and their greater relative size *normal kidneys are palpated with greater ease in children under two years than at a more advanced age*

Structure At birth the kidneys of newborn infants are as a rule lobular In most cases *lobulation* disappears during the second year of life, sometimes later The renal cortex lacks differentiation in the newborn and develops gradually as the child grows older The uriniferous tubules are also underdeveloped during the first months of life, especially the tubules in the peripheral layer of the kidney

The function of the kidney and urine formation. The kidney is a complicated organ Its principal functional elements are the *malpighian glomeruli* (renal corpuscles) and *uriniferous* or *renal tubules* Previously their functions were held to be isolated from each other currently their interdependence is becoming more and more evident *These elements of the kidney together with their blood vessels constitute a functional unit* which acts as a physiological entity and as such an entity exhibits pathological symptoms True, in pathological conditions prevalent affections and dysfunctions either of the corpuscles or of the tubules are not infrequent, but usually both these elements of the kidney suffer simultaneously

Excretion is the main function of the kidneys and urinary organs Through the kidneys the body eliminates water and mineral and organic substances The kidney, being a most important excretory organ plays a leading part in the maintenance of osmotic and acid base equilibrium and in the elimination of nitrogenous and other metabolic waste products

It has been established of late that the kidneys are also endocrine glands, in certain conditions (impaired blood circulation in the organ) they secrete into the blood *renin, a hormone* which raises arterial pressure

The functions of the separate elements of the kidney and its functional connections with other organs and systems, as well as with metabolic processes are not quite clear However, physico chemical processes occurring in tissues undoubtedly influence renal functions through their effect on fluid metabolism

Theory of urine formation. There are several concepts concerning the mechanism of the excretory function of the kidneys At present the theory of filtration and reabsorption is most widely accepted According to this theory, a so called *provisory* urine is first formed in the renal corpuscles, this *precursor* of urine is filtrated from the blood, and it is formed in great quantities, selective reabsorption occurs in the tubules, different substances being reabsorbed in different degrees some of them penetrate the walls of the renal tubules very easily, others only in small quantities, and some do not pass through at all The passage of substances through the wall of the tubules depends on their concentration in the blood plasma on the volume of a filtrate, on the concentration index, i e , the ratio of the urine to the given substance, and on the ability of a substance to pass through the tubular walls The urine remaining in the renal tubules after this process of reabsorption is called the *definitive* urine

The process of urine formation is very complicated, the renal function is also a complex process involving a number of other bodily functions In its turn, the renal function is influenced by various systems and organs Therefore *pathological processes in the kidneys should not be regarded as isolated local lesions of these organs alone* they involve or are more or less influenced by the nervous system (central and peripheral), cardiovascular and lymphatic systems, endocrine glands, etc

The experimental data obtained by the Pavlov school have proved the regulating influence of the central nervous system on kidney functions If a large amount of fluid is introduced through a gastric fistula into an experimental animal's stomach the fact of the introduction alone evokes increased renal activity (conditioned diuresis) On the other hand, conventionally induced polyuria immediately turns into anuria under the influence of pain stimulation (conditioned anuria) It has long been known that hypnotic suggestion may provoke the excretion of the same volume of urine as that produced spontaneously (K Bykov)

In childhood, especially in its early stages, the renal functions are more intensive than in adult life due to more vigorous metabolic processes, particularly more intensive fluid metabolism

The renal pelves and ureters The renal pelves and ureters of newborn infants and babies are relatively broad, their walls are hypotonic due to immaturity of the muscles and elastic fibres As the pelvis develops it becomes relatively narrower and the ureter becomes less twisted The length of an ureter of a newborn infant averages $^1/_4$ of an adult ureter (6 to 7 cm), the left ureter being somewhat longer than the right one The length of the ureters increases in parallel with the growth of the body *The ureteral diameter of young children relatively and sometimes even absolutely exceeds that of adults* In infants under one year of age the ureter bends sharply at the level of the linea innominata above which it dilates

Histologically, a characteristic feature of the ureters in early childhood is *poor development of ureteral elastic and muscular tissue*

Greater convolution, immaturity of elastic and muscular tissue and the recurvature of the ureters condition *the retention of urine*, which is conducive to the appearance of pathological processes in the renal pelves (pyelitis, hydronephrosis, pyonephrosis)

The urinary bladder *The urinary bladder of a newborn infant is situated higher* than in older children and adults, partially protruding into the abdominal cavity When *the bladder is full*, this protrusion is considerable so that *it may sometimes easily be palpated at the level of the umbilicus and even higher* As the child grows older his bladder gradually descends into the pelvic cavity The rate of bladder growth during the first 3 4 years is uniform subsequent growth is less rapid

Microscopic examination of the walls of the bladder shows good mucosal development and immaturity of the muscular tissue and elastic fibres

The growth of the bladder occurs mainly by development of the muscular layer and elastic fibres

When emptied *the bladder of young children is fusi- or pyriform* Subsequently it begins to round, in schoolgirls it has a roundish form while in boys it remains oval elongated throughout life When full the bladder becomes rounded in children and adults alike

The capacity of the urinary bladder in a newborn infant is approximately 50 ml (according to N Gundobin) by the age of three months this capacity doubles at one year it increases fourfold and at the age of 9 10 years it averages 600 900 ml Bladder capacity depends not only on anatomical but also on physiological factors and varies greatly in accordance with these factors When the child is asleep the muscles of the bladder relax thus greatly increasing bladder capacity

The nerves of the bladder branch off from the hypogastric plexus (plexus hypogastricus) and from the *III* and *IV* sacral nerves to form the vesical plexus (plexus vesicalis) Bladder functions are innervated by three nerve centres one of which (a reflex centre) is in the spinal cord and the other two (reflex and voluntary centres) are in the brain

The urethra in boys is more markedly curved than in adults In a newborn infant it is 5 6 cm long its length increases gradually as the child grows older In the pubertal period the length of the canal rapidly grows from 6 to 12 cm (in adults it measures from 14 to 18 cm)

The plication of the urethral mucous membrane (tunica mucosa) is less defined in children than in adults *Microscopic examinations* show poorly developed urethral papillae and connective tissue in the deep lamina of the tunica mucosa and an abundance in the latter of cellular elements the elastic fibres are immature

The length of the urethral canal in the female newborn is 0 8 1 cm in a 16 year old girl it is 3 3 cm and in women from 3 to 6 cm Its gaping external orifice (orificium urethrae externum) has a smooth anterior edge, while the posterior edge is covered with villi which to some extent, prevent the penetration of infections into the canal at the age of 1 2 years the external orifice grows narrower and by 12 it has collapsed into a mere slit

Since the urethral canal in girls is rather short and is situated near the anus it is very accesible to infection (*B coli communis*) To avoid the penetration of infection from the anus the perineal areas of baby girls should be washed and dried from front to back and not vice versa

Urine The average 24 hour volume of urine passed *by adults is*]1 500 1 800 ml The volume of each micturition ranges between 150 and 400 ml The number of micturitions is 5 to 8 a day About 60 70 per cent of the fluid intake of an adult is excreted as urine through the kidneys In an adult 15 000 g of urine contain 60 g of solid matter which consists of 35 g of organic and 25 g of inorganic compounds

During the first days of *the newborn s* life the amount of urine its composition and the frequency of micturition have certain specific features The volume of urine passed during the first days of life is very limited, some babies do not urinate at all during the first 24 hours or urinate very little during the first 3-4 days, depending on the fluid intake

The solid contents of the urine in the newborn period also differ from what is seen at a later period, the concentration of the urine is higher during the first 2 3 days of life The ratio of the solid matter also differs The uric acid content varies greatly during the first days of life, its relative percentage and absolute quantity being 2 3 times higher than in subsequent infancy The relative and absolute content of urea increases with every day, but its percentage decreases The amount of chlorides and phosphates also increases with every day (see Chapter XXI)

Micturition In the first months of life urination is involuntary However, beginning with the 5th or 6th month, i e , when a conditioned reflex for urination may be formed the baby should be trained to evacuate his bladder over a potty Other conditioned reflexes as mentioned above, begin to form much earlier, at $1^1/_2$ or 2 months (see Chapter V) At the age of 6 months the child, if trained properly, does not wet himself spontaneously when in a wakeful state but some children may continue night bed wetting up to the third year of life A number of factors— exciting games anxiety, fear—may cause involuntary bladder evacuation even in older children The formation of hygienic habits in a child depends also on his physical and mental development, if his development is retarded, the formation of hygienic habits is also inhibited

As a rule, infants pass urine about 15 times in 24 hours, the diurnal volume depends on many factors mainly the quality and quantity of their food the greater the fluid intake, the more urine is voided Environmental temperature is also important in a cold room the infant wets himself more frequently and his kidneys excrete more of his water intake, while in a warm room less urine is voided since the elimination of water from the organism in respiration and through the skin is more intensive

Bottle fed babies void somewhat greater amounts of urine than breast fed infants do

The volumes of urine voided with separate micturitions vary greatly Average volumes (in ml) are

Newborn infants	10- 50 ml
1 year-olds	50 100 ml
5 year olds	90 200 ml
10 year olds	150 250 ml
15 year olds	200 300 ml

The diurnal (24 hour) volume of urine is also extremely variable (Table 23)

Table 23

Diurnal Values of Urine
(in ml)

Age	Volume	Age	Volume
1 month	300	4 yrs	900
6 12 mos	600	5 6 yrs	1 000
2 yrs	700	10 yrs	1 500
3 yrs	800	13 yrs	1 500 1 800

The following formula may be used *to determine the approximate volume of urine* passed by the child during 24 hours to 600 *(the average daily volume of urine passed by a one year old child) add 100 multiplied by the number of years of the child s life minus 1* For instance the formula for a five year old child would be 600+(100×4) 600+ +400=1 000

The specific gravity of the urine is lower in young infants than in adults it is as high as 1006 1018 during the first few days of life then drops to 1003 1005 and becomes higher again as the child grows older In children 2 to 5 years old it is 1009 1016 The low specific gravity of the urine of infants cannot be regarded as a sign of renal concentration insufficiency When the fluid intake is drastically limited (pylorospasm) or water loss due to vomiting or diarrhea is great the specific gravity of the urine of infants may rise to 1020 1030

The urine of children shows a slight acid *reaction* but it may be neutral or even alkaline especially when vegetable foods are introduced into the child s diet

EXAMINATION OF THE URINARY ORGANS

Examination of the kidneys is performed by *palpation* the child lying on his back or on his side with his legs flexed Both hands are used in the examination one hand applied posteriorly to the lumbar region pushes the kidney forward in the direction of the other hand which palpates it through the abdominal wall For older children the following method may be used when the kidney is not palpable in a recumbent position from a standing position with his arms at his sides the child is asked to bend the upper part of his trunk to an almost straight angle the examiner palpates the kidneys bimanually in this position

As has already been pointed out the kidneys of healthy infants are often palpable since at this age the kidneys are relatively large and their position is lower than at a more advanced age while the ribs are more horizontal After two years the kidneys are palpable only when enlarged In rare cases, the kidneys are palpable in older children owing to downward displacement of all the viscera

During palpation of the kidney attention should be directed to its size, its surface features, its consistency, and tenderness Knobbiness and firmness are observed in cases of tumours, fluctuation is a sign of hydronephrosis or cysts, tenderness is noted in presence of pyelitis and kidney stones Tenderness to taps in the small of the back (*Pasternatsky's symptom*) is most frequently a sign of an inflammatory process in the kidney or perirenal connective tissue, or of the presence of renal calculi

Of great importance in the examination of the kidney is *roentgenography* X-ray examination of the kidney may be direct, i e , when an x ray picture is made with no previous introduction of a radio paque medium This method is used to detect stones and foreign bodies, as well as to determine the size and shape of the kidney Another method of x ray examination is *pyelography* in which the picture is taken after the introduction into the bladder or intravenously of some contrast medium—abrodil (skiodan), uroselectan or sergosin This method is used to determine the dimensions and shape of the renal pelves, the position of and changes in the ureters, and pathological changes in the urinary bladder and the urethra

Examination of the bladder. The bladder of the newborn and young children is very accessible to *palpation*, since it protrudes slightly from the true pelvis, it is especially easy to palpate when full In some cases the enlarged bladder is noticeable due to the protrusion of the lower part of the abdomen *Percussion* produces a flat sound above the symphysis pubis and palpation reveals a smooth, elongated fluctuating tumescence Bladder enlargement is often associated with lesions of the nervous system (meningitis, etc), severe rectal tenesma in dysentery, spastic contractions of the sphincter of the bladder (sphincter vesicae) followed by urine retention are observed in the presence of anal fissures Urinary calculi may also be the cause of urine retention

A very important method of bladder examination used in addition to observation, percussion and palpation is cystoscopy *Cystoscopy* is a means for performing visual examination of the inner surface of the bladder A special cystoscope is used for catheterizing the ureters (*ureteroscopy*) *Chromocystoscopy** is a means for determining the excretory function of each kidney separately

In female babies cystoscopy may be applied beginning with the third month of life, in male infants at a more advanced age

The collection of urine specimens is not difficult in older children but is far from easy in infants, especially girls Various methods are

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* Cystoscopic observation of the urinary flow from the ureters following intravenous administration of indigo carmine which stains the urine

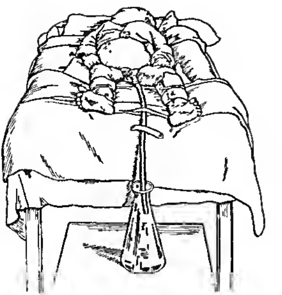

Fig 58 Urine collection in female infant

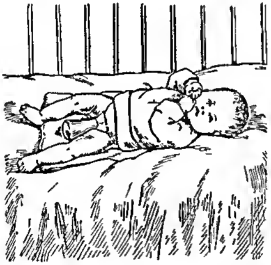

Fig 59 Urine collection in male infant

employed for this purpose One end of a rubber tube is immersed into the neck of a small conical flask the other end of the tube is attached with strips of adhesive tape to the perineal and pubic area so that the urethral orifice is enclosed in the mouth of the tube (Fig 58) No rubber tube is needed for urine collection in boys (Fig 59) and instead of the flask a test tube is used There are also more simple methods A thoroughly clean rubber bed pan with a small tray a plate or a saucer in the middle are placed under the child At times especially if the child has not urinated recently it is enough to uncover his abdomen because cooling of the bladder area has a reflex effect on micturition A finger pressed against the top of the bladder the edge of which is prominent above the symphysis rapidly induces a flow of urine No matter what method is employed in urine collection care should be taken to avoid contamination with discharge from the external genitalia Consequently *it is necessary to wash the genitals prior to urine collection* This is particularly important when dealing with girls since owing to vulvitis their urine may become contaminated with a purulent discharge from the rima pudendi Sterile urine is obtained by catheterization with soft rubber catheters The genitals must be washed and the catheter sterilized before collecting the urine to avoid infection Catheterization is resorted to only in exceptional cases

Tests of renal function are the same for children and adults but the age of the child should be taken into account

Excretory test the child is given (on an empty stomach and in accordance with his age) a certain amount of water—600 800 or 1 000 ml (averagely the number of hundreds of millimetres should correspond to the number of years of the child s life) The child drinks this water in portions during 15 to 30 minutes Specimen collection is performed at hourly intervals and the specific gravity of the urine is determined If the function is normal the whole amount of water ingested is eliminated in 4 hours the specific gravity of the urine in this case drops to 1000 1001 In impaired excretory function of the kidneys the ingested water is not excreted in 4 nor sometimes even in 24 hours

Concentration test This is a test of kidney function wherein the normal ability of the kidneys to secrete solid matter—to concentrate or dilute urine—is measured The child is deprived of all fluid for 24 hours and his urine is collected every 2 3 hours the specific gravity and volume of each specimen is determined If the concentration ability is normal the specific gravity will increase with each new specimen of urine while the volume of urine diminishes In 6 to 10 hours the specific gravity attains the high level of 1028 1030 The specific gravity of urine excreted by the kidneys in cases of impaired concentration function does not exceed 1020 1025

Both of these tests may be performed on one and the same day in the morning the child is given the specified amount of water his urine is collected and its specific gravity is determined every hour, during the second half of the day the child is given only dry food urine collection and specific gravity measurement is also done every hour

Zimnitsky's test is one in which the volume of urine and its specific gravity are determined while the child is on his usual diet and schedule (with no extra load) on the basis of the daily water intake The urine is collected every three hours (day and night) its specific gravity volume and if necessary the content of chlorides and urea are determined in every specimen The urine output is as a rule higher during the day than by night two thirds or even three fourths of the diurnal urine are passed during the daytime With the kidneys functioning normally the volume of urine passed and its specific gravity vary from specimen to specimen while in pathology the difference is negligible (fixed specific gravity)

Sodium chloride ($NaCl$) secretion is tested on the basis of a salt balance established in the following manner the child is given a definite amount of table salt in his food and then from 4 to 10 g of salt are added to the same amount of food salted as before The urine is collected every 2 3 hours and its salt content is determined Normally the whole amount of salt is eliminated within 24 hours and the first specimens contain the greater part of the salt In functional pathology of the kidneys the secretion of salt takes a longer time—48 hours or even more

Rehberg's test for creatinine determines renal corpuscular filtration and tubular absorption Since nitrogen metabolism is considerably higher in children than in adults this test requires no additional introduction of creatinine The test is performed as follows the urine accumulated for a definite space of time (1 $1^1/_2$ hours) is collected and the minute urine output (u) is established 30 45 minutes after the beginning of the test 2 5 5 ml of blood is withdrawn from a vein and the creatinine content is determined in the blood and urine

The ratio of creatinine in the urine to its content in the blood in milligram per cent constitutes the concentration quotient of creatinine (C_{kg}) Corpuscular or minute filtration (F) is the product of the creatinine concentration quotient (C_{kg}) multiplied by the minute urine output (u) $F = C_{kg} \cdot u$

The percentage of corpuscular filtrate (F) reabsorbed in the tubules is the tubular reabsorption value (R) It is calculated by the following formula $R = \frac{(F - U)\,100}{F}$

SYMPTOMATOLOGY OF URINARY TRACT DISEASES

Various pathological conditions arising in the kidneys themselves and in other visceral organs as well as diverse metabolic disturbances are promptly reflected in the excretory function of the kidneys This is manifested by the appearance of various symptoms, by deviations from normal in urine composition and volume, and by urination trouble. We shall here dwell only on the symptoms most pertinent to the pathology of childhood.

Translucency and colour. Normally urine is a clear, amber coloured liquid. On standing it may become cloudy or turbid owing to precipitation of salts and multiplication of bacteria. Turbidity may likewise be caused by diverse pathological elements—erythrocytes, leukocytes, mucus, casts, and sloughed epithelium of the kidneys and other urinary organs. In the presence of such pathological processes the urine is turbid directly after it is voided, and a simultaneous change of colour also occurs. Dark red urine (meat slops) is seen in glomerulonephritis owing to a considerable admixture of blood, the presence of bilirubin in association with diseases of the liver makes the urine beer coloured, and its foam (when a specimen is shaken in a test tube) is then yellow. A colourless, transparent urine suggests diabetes insipidus (drastic deterioration of the renal function of concentration of solids). The colour of the urine is also affected by certain medicinal preparations (santonin, pyramidon) and vegetable pigments.

Urine output. *Polyuria*—the passage of excessive quantities of urine—may be the result of an increased fluid intake, or a symptom of diabetes (both mellitus and insipidus). In diabetes the daily urine output may attain a 6-10 litre volume or even more. Polyuria is also a usual finding during reconvalescence following febrile conditions, and it is common during the reabsorption of edemas and absorption of transudates. As mentioned above, the central nervous system also greatly influences urinary output as well as renal functions in general.

A diminution in the daily output of urine is called *oliguria* and the total suppression of urinary passage—*anuria*. In some cases the passage of urine is impeded by failure of the kidney to produce it, in others, by the presence of obstacles to the flow in the urinary tract (stones, constrictions, tumours), and also by spasm due to innervation disorders (anuria spastica).

Oliguria of the newborn is a physiological condition. Its main cause is insufficient water intake but congenital defects in the urinary tract may also be responsible.

Retention of urine may occur in dehydration due to vomiting or diarrhea, and also in association with meningitis and various lesions of the brain and spinal cord.

Urination. Reduced passage of urine is often concomitant with *painful urination*, a condition called *dysuria*. Dysuria attends uric acid infarct of the newborn, inflammation of the prepuce (posthitis and acroposthitis) and of the glans penis, and inflammatory processes in the urethra and the urinary bladder. In girls painful urination may be a symptom of vulvitis or vulvovaginitis. Strongly acid concentrated urine may irritate the urethral mucosa and so cause pain on urination (gravel).

Dysuria is particularly acute in cases of urinary calculi, besides the acute pain experienced by the patient, an interruption in the flow of urine sometimes occurs

Abnormally frequent micturition (pollakiuria) is a physiological condition in young children, and common in pathological conditions associated with irritation and inflammation of the bladder, stones in the bladder, and inflammation of the urethra

Frequent micturition during the night (*nycturia*), is sometimes seen in children It is observed in nephrocirrhosis, tuberculosis of the bladder or the kidney, and in cardiovascular diseases

Urinary incontinence (enuresis) may be a temporary, transitory symptom of inflammatory processes in the urinary tract, of epileptic conditions, and of severe febrile diseases marked by disturbed consciousness It may be a more persistent, even constant, symptom in lesions of the central nervous system, in myelitis, and in developmental anomalies of the urogenital tract

As a constant and long standing symptom, urinary incontinence in older children is very distressing both for the child and for the people around him In some cases involuntary discharge of the urine occurs only at night (*nocturnal enuresis*), in others, also in the daytime (*diurnal enuresis*) Urinary incontinence attends innervation disorders of the bladder caused by neuropathy, hysteria and other functional anomalies in the central nervous system Structural defects in the lumbosacral region of the spinal canal, for instance spina bifida occulta (a defect in the closure of the vertebral arches) are less frequent causes of this condition An x ray examination of the spine is necessary to detect such anomalies

Urine composition *Uric acid salts* The formation of concentrated urine with a high percentage of uric acid crystals (*uric acid infarct*) is not infrequently observed in *the newborns* during their first days of life Postmortem examinations have shown uric acid infarct in 26 per cent of infants who succumbed during delivery and in 39 40 per cent of those who died soon after birth

Uric acid infarct is clinically manifested by reddish yellow spots on the diapers and loud crying before each micturition The condition is the result of an excessive formation of uric acid owing to increased disintegration of cellular elements

Albuminuria Protein is very frequently found in the urine of the newborn (up to $25^0/_{00}$)—*albuminuria of the newborn*

Albuminuria following physical stress Protein may appear in the urine of older children, most probably owing to the low resistance of the capillary endothelium in the renal carpuscles, and also as a result of chemical changes in the blood (accumulation of acid substances) The condition is observed subsequent to strenuous physical exercise, races, etc

Orthostatic albuminuria During the school age period and adolescence children frequently exhibit periodic and protracted albuminuria, sometimes with a high protein content, which, however, appears only when the child is in an upright position (i e, in the day time) It is easily induced by an artificial lordosis causing circulatory disorders in the kidneys *The state of the vasomotor system of the kidneys* is a leading factor in this condition Hence the frequency of orthostatic albuminuria in the school age and prepubertal periods when the stability of the vasomotor system is low, subject to changes in the autonomic endocrine system

Toxic albuminuria Acute infections, digestive disorders and serum sickness are not infrequently attended by a transient passage of protein containing urine

A moderate albuminuria with small numbers of casts and erythrocytes in association with intact renal functions, is sometimes observed in childhood The condition may persist for years It is called *pedonephritis*, i e, children s nephritis, it is generated by focal changes in the kidneys and may develop into a severe kidney disease

Glomerulonephritis is characterized by a moderate protein content (up to 1‰) The protein level in *nephrosis* patients is considerably higher (up to 3‰), it is particularly high in amyloid degeneration of the kidney Inflammatory processes in the renal pelves or the bladder raise the urine protein levels negligibly

Pus A point to bear in mind is that the urine may be contaminated by pus from the external sex organs (the condition is termed *pseudo pyuria*), in cases of vulvovaginitis in girls and of balanitis in boys Therefore the genital area of the child should be thoroughly washed prior to urine collection

Blood Blood in the urine (*hemoturia*) is always seen in glomerulo nephritis the intensity of the colour depends on the amount of blood, and it ranges from pink to reddish brown (meat slops), and becomes turbid Blood also occurs in the urine in association with other diseases, including renal tuberculosis neoplasmatic growths, bladder and/or kidney stones, and it may likewise be a symptom of hemorrhagic diathesis

Solitary erythrocytes are frequent findings in the urine of children (erythrocyturia minima—the presence of exceedingly small numbers of erythrocytes) This condition is evidently of no pathological value

Hemoglobin Sometimes the urine of children is stained red by hemoglobin, the red pigment of blood (*hemoglobinuria*) This condition is caused by the decomposition of great numbers of red blood corpuscles and is observed in cases of paroxysmal hemoglobinuria and also of poisoning with potassium chlorate (Berthollet s salt), phosphorus, morel mushrooms, hydrogen arsenide or phenylhydrazine

Organisms Great numbers of organisms (*bacteriuria*) sometimes occur in just voided urine Bacteriuria is seen in cystitis or pyelitis, and in some cases it is attended by no clinical manifestations at all

Bilirubin, urobilin, indican In conditions attended by the absorption of bile into the blood vessels (jaundice of various etiology) the urine is stained greenish or yellow by the bile pigments, and the foam produced by shaking in a test tube is yellow In all febrile conditions the urine is of a concentrated dark-yellow or dark red colour owing to the presence in it of urobilin, indican and other substances *Urobilin* is found in hepatic diseases, scarlet fever, pneumonia and other infectious diseases *Indican* is associated with constipation, putrefaction of protein substances in the intestine, and suppurative processes (peritonitis, pleurisy)

Drugs The urine is stained red by certain medicinal preparations, such as rhubarb, senna, or pyramidon, santonin makes it greenish-yellow, and streptocid—yellow

Sugar The presence of sugar in the urine (*glycosuria*) suggests diabetes mellitus, however, an excessive sugar intake will frequently raise the sugar level in the urine of children. This pertains in particular to infants whose food is rich in sugar, the sugar found in the urine is of the same type as is contained in the food Urinalysis performed during acute digestive disorders (toxic dyspepsia) often reveals sugar irrespective of its content in the food, sugar is also found in the urine during severe infectious diseases

Acetone Other urine pathology meriting attention is the presence of acetone *Acetonuria* is observed in grave nutritional disorders, particularly in association with absence or deficiency of carbohydrates, as a symptom of acidosis, in diabetes, in febrile conditions, and in association with the periodic vomiting to which older children are sometimes subject

The diazo reaction of the urine is positive in children affected by typhus fever, measles, lymphogranulomatosis, miliary tuberculosis and other diseases

Uremia Uremia is a toxic condition caused by the retention in the body of waste products of nitrogen metabolism which should ordinarily be eliminated by the kidneys (urea, uric acid, creatinine, creatine), and of sodium chloride and water Failure of the kidneys (owing to some renal lesion) to maintain an optimal balance between these substances in the body results in their concentration in the blood and tissues, which may lead to uremia In childhood the type of uremia most frequently encountered is *eclamptic uremia* which is evidently the result of a retention of water and chlorides in the tissues, inducing edema and dysfunction The condition prevalently affects the central nervous system (edema of the brain) *Azotemic uremia* is less frequent in children, its cause is the retention in the blood of nitrogenous substances, inducing autointoxication of the body

THE GENITAL ORGANS OF BOYS

The testicles of male infants have usually already descended into the scrotum at birth, however, it may happen that one or both testicles are not in the scrotum (*monorchism* and *cryptorchism*), but some-where on their way to it in the groin or inside the abdomen (most frequently in the inguinal region). When the child's skin is chilled his scrotum will contract into wrinkles while the testicles are jerked up into the groin and become almost impalpable. The same thing occurs when the scrotum is touched owing to the reflex action of the cremasteric muscles. Therefore examination of the testes should commence with an attempt to move the testicle down into the scrotum along the inguinal canal.

Testicular growth is very slow during the first ten years of life while the epididymides are relatively larger than at a more advanced age. The epididymis-testicle weight ratio in newborn males is 1 : 2, in adults it is 1 : 9. Rapid testicular growth occurs between 12 and 15 years: the testicle of a 15-year-old boy weighs seven times more than it does in a boy of 7-10 years. The pubertal period begins at this time and it ends by the age of 20.

Development of all the sex organs generally occurs between 12 and 15 years. Although *the seminal vesicles* are quite well defined in the newborn they contain only indifferent sex cells and large embryonal seminal cells. Very little change occurs until the boy attains puberty, at what time the seminal vesicles already contain mature spermatozoa.

A condition which is not rare in the first year of a child's life is *hydrocele*, the accumulation of fluid in the sac of the tunica vaginalis of the testis; the fluid is prevalently serous, less frequently fibrinous and very rarely purulent. Hydrocele should not be confused with *inguinal hernia*. Hernias are absolutely opaque to light and are easily replaced in the inguinal canal (the replacement is accompanied by a peculiar rumble); a hydrocele cannot be pushed up into the groin and it is translucent. Inflammatory processes in the testicles and their epididymides are associated with infectious diseases (tuberculosis, syphilis, mumps). *Mumps* occurring in the prepubertal and pubertal periods (more frequently in boys, less frequently in girls) may be accompanied by *an acute inflammation of the sex glands* (*orchitis, oophoritis*) owing to which atrophy of the gland and subsequent sterility are possible.

The penis (male copulative organ) is characterized in childhood by the following features: the corpora cavernosa are smaller, the connective tissue and muscle bundles are thinner than in adults and their fibres are poorly defined. The prepuce is much longer than the glans penis, its orifice is constricted (*physiological phimosis*) by adhesion of its folds so that the foreskin cannot be retracted to uncover the glans penis, but the condition is corrected as the child grows older. By the age of 5-10 years retraction is usually completely free.

Smegma, the substance secreted by the sebaceous glands of the prepuce, often accumulates between the prepuce and glans penis; this may cause irritation or even inflammation of the prepuce (*posthitis, balanitis*). Retraction of the foreskin beyond the glans penis may cause compression of the body of the organ, leading to a congestion of blood and swelling of the glans penis This condition is called *paraphimosis*, reduction of the glans penis requires medical aid

The growth of the penis is at first slow, but it proceeds very rapidly in the pubertal period

The prostate. During the first years of life the prostate grows very slowly, its intensive growth begins at the age of 10 11 years and is most rapid between 14 and 16 At this period it weighs 10 times more than it does one month after birth, and is twice as long and broad Its full development is attained at the age of 20 25

In very young children the prostate is globular, towards the age of 11 it flattens and at 16 becomes cordiform It is always softer in children than in adults The prostate produces a specific secretion—a watery, milky fluid with an alkaline or amphoteric reaction and a characteristic odour This secretion increases the activity of the spermatozoa

THE GENITAL ORGANS OF GIRLS

The external sex organs. In a full term well nourished female newborn the labia majora are well developed and almost cover the labia minora, while in immature and underdeveloped babies they do not cover the labia minora completely and the rima pudendi is gaping

The vagina grows gradually with age, but its growth is slow up to 11-12 years after which it becomes more rapid It is 3 cm long in a one month old infant, 4 4 5 cm in a ten year old girl and 6 7 cm long at the age of 13

The internal sex organs. *The uterus* of a newborn female infant is relatively larger than in subsequent years, the cervix uteri is longer than the corpus uteri As the girl child grows older the uterine walls become thicker, the corpus uteri increases in size and the cervix becomes smaller than the uterus The length of the uterus of a female newborn is 3 3 5 cm, its growth is very slow and irregular up to the age of 10 years, at 11 years an intensive growth of the uterus starts so that by 15 16 years it is almost as large as the adult woman's uterus If the growth and general development of the girl is retarded by some cause the growth of the uterus is also inhibited In such cases a condition known as *infantile uterus* is found in adult women

The ovaries at the moment of birth are fully defined, but their form changes with development the shape of the ovary is cylindrical in the newborn and becomes ovoid after the child attains the age of 8 10 years The graafian or vesicular follicles are mature even in fetuses during the last months of gestation, but regular ovulation sets in only after the girl has attained puberty, when the follicles rupture, and the process is accompanied by periodic bleeding from the uterus (menstruation)

SYMPTOMATOLOGY OF DISEASES OF THE GENITAL ORGANS

The following phenomena are sometimes observed in *the newborn* the mammary glands of both male and female babies swell and discharge a whitish fluid resembling colostrum In boys edema of the scrotum and hydrocele of one or both lesticles are observed, in girls a swelling, edema and redness of the labia majora, labia minora and clitoris occur, with a white mucous discharge from the vagina (vaginal mucus and epithelial cells of the sex organs) In some cases the mucous discharge of the female newborn contains varying amounts of blood (pseudomenstruation) These phenomena are sustained for the duration of 2 15 days and are called *"sex crises of the newborn"* They are evidently caused by the maternal sex hormones penetrating into the felus lhrough the placenta *This vaginal bleeding in female newborn infants should not be confused with true precocious menstruation* which accompanies precocious sexual maturalion (pubertas praecox and macrogenitosomia praecox), an extremely rare occurrence in the newborn (see Chapter IX)

Mucous or mucopurulent vaginal discharges are not infrequently observed in the newborn period and later, this discharge is often caused by mild catarrhal conditions of the external sex organs in the absence of any infection particularly in girls with tendencies for exudative diathesis

Vaginal discharge may also appear during severe infectious diseases (measles, scarlet fever, chickenpox, etc), or may be caused by mechanical irritation (masturbation, pinworms) The term for the condition is *nonspecific vulvovaginites* They are generated by various bacteria—the colon bacillus, staphylococci, cocci, etc However, the possibility of vulvovaginitis of a specifically gonorrheal nature should be borne in mind A final diagnosis of *gonorrheal vulvovaginitis* is established on the basis of laboratory confirmation of the presence of the etiologic agent, *Neisseria gonorrhoeae* Lesions of the external genitalia caused by the diphtheria bacillus are not at all rare (*diphtheritic vulvovaginitis*) The characteristic diphtheritic membranes may sometimes be absent the disease is manifested by a purulent discharge The final diagnosis of this condition also requires bacteriological confirmation

CHAPTER XXIII

BLOOD AND BLOOD FORMATION

Prof *D Lebedev*

Human blood consists of a liquid part—the plasma which is a mixture of true and colloid solutions and of formed elements suspended in it, the erythrocytes leukocytes and thrombocytes (blood platelets)

The blood is the internal medium of the body, which supplies all the organs and tissues with food, oxygen, and the various antibodies, enzymes and hormones that participate in the regulation of the activity of the organs The blood receives metabolic waste products for subsequent elimination from the body, and it circulates toxic substances of various origin

Hence we see how important it is to know the specific features of blood chemistry values and blood morphology pertinent to different age levels

When studying the data obtained by various blood tests a point to keep in mind is that changes in the blood are not contingent on the functional state of the hematopoietic organs alone, but also on the condition of a number of other organs and systems

No great difference is noticed between the blood values of healthy children at different ages except for the newborn period when some condensation of the blood is seen

The basic blood values are drawn up in Table 24

PHYSICOCHEMICAL PROPERTIES OF THE BLOOD

Amount The total amount of blood of an adult is equal to approximately 5 5 5 per cent of his body weight The relative amount of blood in the child is higher, and the younger the child, the higher it is In the newborn the amount of blood equals 10 5 19 5 per cent of the body weight in later infancy it is 9 12 5 per cent (10 11 per cent on the average), in the school age period—approximately 7 per cent of body weight

Table 24

Normal Blood Values

Chemical constituents	Blood	Plasma serum	Erythrocytes	
Water	75 85%	90 92%	57 69%	
Solid residue	15 25%	8 10%	32 43%	
Protein (total value)	12 5 21 9%	6 8%		
Fibrinogen		0 1 0 4%		
Globulin		1 5 3 12%		
Albumin		3 8 5 5%		Protein quotient $\frac{\text{albumin}}{\text{globulin}} = 1\ 5\ 2\ 5$
Nitrogen nonprotein	6-45 mg%	18 40 mg%	38 55 mg%	Deviations dependent on dietary composition bladder elimination and liver function
Uric acid	0 8-4 mg%	2 4 mg%		Raised in presence of liver hypofunction and intensive disintegration of nuclei
Urea	13 30 mg%	20 50 mg%	17 28 mg%	
Sugar (glucose)	70 120 mg%	98 120 mg%	100 121 mg%	
Cholesterol	160 220 mg%	120 200 mg%	170 240 mg%	
Bilirubin		0 2 1 mg%		
Sodium	170 220 mg%	280 350 mg%		
Phosphorus (total)	37 50 mg%	7 13 mg%	58 100 mg%	
Phosphorus inorganic	2 5 3 mg%	5 7 mg%	3 4 8 6 mg%	
Calcium	5 9 mg%	8 12 mg%		
Amylase	100 1 000 u			
Lipase	25 55 u			In infancy
Catalase	7 5 9 9 u			
Trypsin inhibitor	140 230 u			
Phosphatase	5 11 u			

Coagulation, bleeding time erythrocyte sedimentation rate (ESR) are not different in infants and older children from what is seen in adults The coagulation time (by the Burker method) does not exceed 4 $5^1/_2$ minutes When the Sitkovsky Yegorov method is applied clotting commences in $^1/_2$ $2^1/_2$ minutes and ends in $2^1/_4$ $4^1/_2$ minutes bleeding time (by Duke's test) is 2-4 minutes the ESR is 4 10 mm/hr The blood values of the newborn are somewhat different Thus, coagulation time may be up to 10 minutes and in cases of jaundice still longer The ESR of the newborn is delayed—approximately 2 mm/hr (by Panchenkov's method)

Osmotic fragility, or the erythrocyle fragility test, is a measure of the resistance of red blood cells to osmotic hemolysis in hypotonic salt solution of graded dilutions In infancy maximum osmotic fragility corresponds to 0 36-0 4 per cent NaCl, minimum fragility to 0 48-0 52 per cent NaCl At a more advanced age the maximum is 0 36 0 4 per cent NaCl, and the minimum 0 44 0 48 per cent NaCl

THE FORMED ELEMENTS OF THE BLOOD

Development of the hematopoietic system and specific features of blood formation in children In the early stages of embryonic development the *first sites of hematopoiesis* appear in *the blood islands* which are masses of condensed splanchnic mesenchyma in the wall of the yolk sac Towards the end of the first and beginning of the second month of gestation hematopoiesis (formation of both red and white blood cells) is already observed in the embryo itself, mainly in the liver, and beginning with the third or fourth month in the spleen as well The hematopoietic function of the liver is most intensive during the fifth month of intrauterine life after which it gradually declines and ceases at term Splenic hematopoiesis ceases somewhat earlier At the beginning of the fourth month of gestation the skeletal tissue and bone marrow are formed, this is when bone marrow blood formation first appears gradually becoming more and more prominent while production of the formed elements of the blood in the spleen and liver fades into the background The lymphatic system of the embryo develops later than the myeloid system Erythrocytes and granulocytes (granular leukocytes) are already present in the circulation of a 2 months embryo, but lymphocytes are still absent The development of the lymphatic system commences at the end of the second month, after which lymphocytes are formed After birth the development of the lymphatic tissue continues, and it functions vigorously, especially during the first years of the child's life As has been pointed out, the formation of erythrocytes and leukocytes in the splenic pulp gradually ceases by the end of intrauterine life, as the splenic lymph nodules or corpuscles (also called malpighian bodies or corpuscles) develop the spleen becomes an organ in which lymphocytes and other lymphoid formations are produced As regards all other formed elements (erythrocytes, leukocytes, blood platelets)—the spleen is the site of their destruction

The reticuloendothelial system (*RES*) is a term denoting the reticular tissue in the lymph nodes, bone marrow and spleen, as well as Kupffer s (star) cells of the liver, the endothelium of the venous sinuses of the spleen, the lymph nodes in the bone marrow and adrenal cortex, and also the connective tissue histiocytes The reticuloendothelial system plays an important part in metabolic processes, in immunity, and to a certain extent in the formation of the bile pigments Moreover, it has been established that the principal hematopoietic organs in the healthy body are the reticular tissue of the bone marrow, lymph nodes and spleen The increase of the rate of blood regeneration associated with pathology activates the potential hematopoietic function of the reticulo endothelial elements of other organs and tissues Extramedullary hematopoiesis (i e blood formation occurring outside the bone marrow) appears first of all and proceeds most rapidly, in the liver, then in the spleen, it may appear in the kidneys, in muscular tissue, and elsewhere

However, not all the problems pertaining to hematopoiesis are clear

It has been established, beyond doubt, that during postnatal life the bone marrow produces erythrocytes, granulocytes blood platelets, and monocytes, the lymphocytes are produced in the lymph nodes, spleen, the intestinal follicles and Peyer s patches (aggregate nodules), and in other lymphoid formations

The entire hematopoietic system of children is characterized by extreme lability and susceptibility to the slightest exogenous influences Diminution of the hemoglobin value and of the erythrocyte count, the appearance of immature red blood elements, high white blood counts (leukocytosis) accompanied by the appearance in the peripheral blood of young cells are much more widespread among children than among adults, and the development of such pathology is much more rapid The appearance of extramedullary sites of blood formation, and at times even a complete return to the extramedullary embryonal type of hematopoiesis in children may be caused not only by severe anemia and leukemia as in adults, but also, as is frequently the case, by various infections, intoxications, and other harmful factors (bronchopneumonia, acute pyogenic meningitis, pyelitis, or otitis in infants)

The younger the child, the more drastic are the pathological changes in hematopoiesis, reflected in the quatity and quantity of the formed elements of the peripheral blood Evidently, the high reactivity and the restorative and proliferative properties of the tissues characteristic of this age are responsible Undoubtedly, the autonomic-endocrine system participates in the regulation of hematopoietic processes, in addition to the effect of the pathological stimulation of blood formation The autonomic nervous system is extremely labile in childhood Of course, this, too, is reflected in the lability of blood formation in childhood

Hematopoiesis and the redistribution of the formed elements of the blood, like all other bodily functions, are invariably dependent on impulses arising in the cerebral cortex This point pediatricians must take into account beginning with the school age, and perhaps even earlier

The importance of the central nervous system in the regulation of hematopoiesis during the first months of life has not been ascertained to date

PROPERTIES OF THE BLOOD AT VARIOUS AGE LEVELS

Fetal blood. During the late period of intrauterine life the blood is distinguished by a high hemoglobin content, an increased number of macrocytic erythrocytes, nucleated forms (erythroblasts and normoblasts), and a marked prevalence of young forms of leukocytes Some authors, moreover, note a high percentage of normocytes and lymphocytes

Blood of the premature infant. The blood of premature infants shows a much higher tendency to individual deviations than any of the other age groups of childhood Statistics based on published data show the *hemoglobin* content to vary between 100 and 120 per cent, the red blood count—between 4 5 and 7 million *The white blood count* is in the majority of cases somewhat *lower* than in infants delivered at term However a number of authors report higher hemoglobin and red and white blood counts The number of *blood platelets* (thrombocytes) is, according to some authors slightly reduced, and according to others on the contrary, increased Such contradictory data may be explained by the wide range of individual deviations in the amounts of formed elements contained in the blood of the premature

The drop of hemoglobin and red cells that follows birth is much faster in premature than in full term infants, therefore a quite considerable *anemia* develops by the age of approximately 2 5 months, to gradually clear up by the end of the first year Consensus of opinion is that even when good care and nutrition are provided the hemoglobin level of premature infants 2 5 months after birth varies between 30 and 50 per cent, and the red blood count—between 2 and 3 million *Anemia of the premature is partly the result of an insufficient store* of iron in the body of the fetus, since premature delivery stops the process of accumulation of iron in the fetal liver However, a more important reason is probably the immaturity of the hematopoietic system itself in the premature, or at least its inferior ability of assimilating iron, an element requisite for the formation of the blood- Confirmation is found in the fact that even an excessive dietary intake of iron does not always correct the anemia of prematurity

Blood of the newborn infant. *The red blood count* (number of erythrocytes per cubic millimetre of blood) equals 5 7 million during the first two days following birth, but by the 14th day it usually drops to 4 million *The hemoglobin* level during the first two days may be as high as 100-140 per cent, falling to 80-100 per cent by the end of the 14th day After a transient rise (6 12 hours) a reduction of the hemoglobin content and the red blood count begins, so that by two weeks of life the levels are 80-100 per cent hemoglobin and 4 5 million erythrocytes As a result the colour index which at first is equal to slightly more than unity becomes 1 0 or even somewhat lower Erythrocytes of unequal size circulate in the blood of the newborn, a state termed *anisocytosis* which is most distinctly expressed by the presence of *macrocytes*, abnormally targe erythrocytes with high hemoglobin contents

The number of polychromatophilic erythrocytes observed in thick smear studies is up to 40 per field of vision during the first week, but by the end of the second week it is already no more than normal, 1-2 per field of vision The number of *reticulocytes* (immature or young erythrocytes with a granular network which stains supravitally) is from 50 to 100 per 1,000 mature erythrocytes during the first days following birth, their number also drops rapidly, so that by 10 15 days of life only 5 to 10 reticulocytes are counted for every thousand erythrocytes During the first hours of life a considerable number of *normoblasts* (nucleated red blood cells) is found in the blood (a mean of 3 per 100 leukocytes), however, by the end of the first week they are usually no longer found in the peripheral blood

Osmotic fragility The blood of the newborn contains erythrocytes with elevated and with reduced osmotic fragility Some authors affirm that both minimum and maximum fragility are elevated in the newborn

The erythrocyte sedimentation rate (ESR) of the newborn likewise calls for further investigation However, the majority of authors hold that it is somewhat slower than in adults beginning with the age of two months the ESR rises, and throughout subsequent childhood is the same as in adults, i e , 8 10 mm/h after Panchenkov's method

The number of *blood platelets* varies considerably during the first days of life, from 100,000 to 200,000 per cubic millimetre, subsequently it becomes about 200,000 300,000 per cubic millimetre of blood

The picture of the *white blood* is quite singular in the newborn During the first 8 12 hours following delivery the number of leucocytes is as high as 25,000 30,000 per cu mm, this is concomitant with *neutrophilic leucocytosis* and a distinct *regenerative shift to left*, i e , *the presence of many immature neutrophils* in the peripheral blood By the 10-15th day the white count has gradually dropped to an average 10,000 12,000, the immature cells, as a rule, disappear almost completely from the peripheral blood while the primary neutrophilosis is replaced by lymphocytosis Thus, the differential blood count in the newborn is characterized by the presence of a great number of immature red and white cells, an indication of the vigorous activity of the hematopoietic system *The differential white count of the newborn* (except for the first few days after birth) is characterized by a stable lymphocytosis, both relative and absolute A gradual increase in the number of lymphocytes begins in the very first days of life attaining 50 60 per cent by the fifth day, this level is sustained throughout infancy, at the same time the number of neutrophils is gradually reduced to 30 per cent Curves plotted against changes in the numbers of neutrophils and lymphocytes intersect at some time

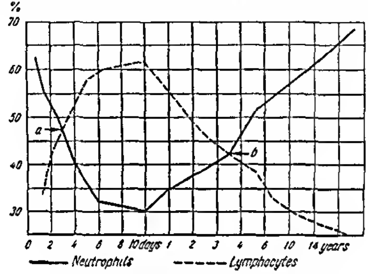

Fig 60 Neutrophil and lymphocyte counts (in per cents) in the different stages of childhood

a—first intersection b—second intersection

between the second and fourth days of life (according to some investigators—between the fifth and sixth days), indicating an increase in lymphocytes and decrease in neutrophils an occurrence that has been called *the first intersection* Subsequently, in the third fourth year of life (Gundobin reports the 4 5th year), a considerable reduction in the number of lymphocytes takes place while the number of neutrophils grows The respective curves intersect again—the second intersection (Fig 60)

The coagulation (clotting) and bleeding times in the newborn period are almost indistinguishable from adult norms coagulation time (by Burker s method) is 5 $5^1/_2$ minutes, bleeding time (Duke s test) is 1 3 minutes *Clot retraction time is normal*

In addition to the compositional characteristics of the blood it must be pointed out that *the total volume of blood of children, particularly newborn, is relatively higher than in adults*

Various investigators offer diverse interpretations for the higher relative amount of blood in the newborn and for its higher hemoglobin erythrocyte and leukocyte values Some authors see the explanation in the fact that during parturition part of the placental blood passes into the infant s body therefore the later the cord is clamped the greater is the amount of blood which flows into the new born baby According to the opinion of other authors the high hemoglobin and red and white cell levels in the newborn are caused by maternal hormones the hormones circulating in the body of the pregnant woman and stimulating her hematopoietic system penetrate into the body of the fetus and thus stimulate its hematopoietic organs The delivery of these hormones into the infant s blood ceases after birth and therefore a rapid drop of the hemoglobin erythrocytes and leukocytes occurs

Recent publications deal with the problem from the viewpoint of metabolism in the given case prevalently gas metabolism Stud es of fetal blood have established that throughout intrauterine life the fetus is in a state of oxygen deficiency Such deficiency is reflected in the processes of blood formation inducing intensive erythropoiesis (a phenomenon analogous to chronic mountain s ckness) A sharp change in gas metabolism occurs after birth the oxygen deficiency is eliminated so that the production of erythrocytes decreases considerably and the composition of the blood changes accordingly

It is possible that the change in the metabolic processes which occurs at the moment of birth induces *intensive disintegration of the erythrocytes* the clinical manifestation of which is jaundice Some authors consider that another factor conducive to the appearance of jaundice in the newborn is immaturity of the liver which is evidently not capable of rapidly eliminating from the body the products of disintegration of the blood elements at the time of their intensive destruction These products irritate the hematopoietic organs thus inducing according to such authors, high neutrophil counts in the newborn

Blood in infancy A number of investigators hold that it is extremely difficult to obtain a precise picture of the blood of an infant, since the activity of his hematopoietic system is susceptible to the slightest exogenous and endogenous factors (crying fretting feeding mild infection) frequently impossible to account for However that may be there exist *a number of characteristic features of the blood during infancy* The red blood count rates 4 4 5 million the hemoglobin level is 80 to 72 per cent and it easily drops to 55 per cent so that the colour index stays below unity Consequently the red blood cells are insufficiently saturated with hemoglobin i e they are hypochromic (according to Nikolayev the red blood count in children under two years of age is 5 6 million according to Tur it is 4 4 6 million both these authors rate hemoglobin at 70 80 per cent) Anisocytosis is quite marked The reticulocytes do not number more than 5 6 per 1 000 normal erythrocytes although during the period of physiological anemia up to 20‰ may be found No nucleated erythrocytes (normoblasts) are usually seen The maximum and minimum osmotic fragility of the erythrocytes is slightly elevated in comparison with the newborn period The blood platelet count varies between 200 000 and 300 000 per cu mm Coagulation bleeding time and clot retraction are almost no different from what is normal in adults The white count is usually 10 000 12 500 in infants Shift to the left

i. e., the presence of young neutrophils, as has already been pointed out, is corrected at the beginning of infancy and appears again only in the presence of some irritation of the bone marrow that accelerates the emergence into the blood stream and formation of leukocytes. *The differential white count retains its characteristic lymphocytosis* which is sustained at the level of 50 per cent throughout the first two years of life, while the neutrophil count varies within a range of 35-40 per cent during this period.

In various publications the period of infancy is occasionally termed as the period of *physiological anemia* in consequence of the relatively low hemoglobin level and patent hypochromia. The most probable explanation is that the growing body puts increased demands on the hematopoietic system, and also that during this period the synthesis of hemoglobin does not keep up with erythrocyte formation, inasmuch as the hematopoietic organs of the child evidently do not have at their disposal sufficient amounts of protein and iron to draw on for the production of hemoglobin. During the first year of life the child uses the iron stored in his liver during the terminal months of intrauterine life, any delivery of iron with food is extremely restricted owing to the specificity of nutrition during infancy (both breast milk and cow's milk are low in iron).

Blood of children from 2 to 6 years. Between the ages of 2 and 6 years the hemoglobin level is 72-80 per cent, the red blood count is to 4.5 million, with 2-3 per cent reticulocytes, the colour index is lower than unity—0.85-0.95. Anisocytosis is marked. The white count gradually diminishes, becoming 8,000-8,500 by the age of 6 years.

The presence of juvenile forms is not featured in the blood picture of this age level. As has already been stated, the number of lymphocytes gradually decreases, going down to 40-35 per cent by the age of 5-7 years, that is, becoming equal to the number of neutrophils. From this time on *the nature of the differential white count changes, as the number of lymphocytes gradually diminishes and the number of neutrophils grows* (second intersection). This increase in the amount of neutrophils and decrease in that of lymphocytes continues, so that the differential count gradually approaches the normal adult pattern.

Blood of children between 6 and 14 years. The composition of the *blood at this period is approximately the same as in the preceding* period. The red blood count averages 4.5-4.8 million, the hemoglobin is 78-86 per cent, and the anisocytosis gradually disappears. The leukocyte count continues to fall, and by 14 years of age it is 7,000-7,500. *The differential white count is characterized by a further rise in the number of neutrophils and a drop of lymphocytes*: by 14 years the count shows 60-65 per cent neutrophils and 25-30 per cent lymphocytes.

The blood of adolescents. The red blood count in the years of 14 to 18 remains approximately the same as in children of the school age, i. e., 4.5-5 million. The hemoglobin, according to some authors, is at a high level, 80-97 per cent, according to others it is much lower—

60 75 per cent The white count is 6,000-7,500 The cause of such marked deviations in the hemoglobin level during adolescence is not clear, it is possibly associated in some way with the reconstruction of the endocrine autonomic system and with the intensive growth observed during this period Stabilization of the hemoglobin and erythrocyte values, and of the proportion of the various types of leukocytes occurs only subsequent to the period of sexual maturation

The morphological characteristics of the blood of children of various ages (mean values) are presented in Table 25

Hemoglobin percentages are given according to the Sahli method Currently the hemoglobin value is more frequently calculated in grams per 100 ml of blood, i e, in g% In the Soviet ГС 2 hemometer 100 graduations on the scale (100 per cent) correspond to a content of 16 67 g of hemoglobin per 100 ml of blood

SYMPTOMATOLOGY OF BLOOD CHANGES

Quantitative changes In the red blood The increase in the number of erythrocytes (*polyglobulia*) may be either true or false

1 *True polyglobulia* is associated with intensification of bone marrow activity, It is observed (a) in the newborn, (b) in children with congenital heart disease, (c) in all forms of dyspnea, (d) at high altitudes, (e) in polycythemia

True increase of the number of erythrocytes Is a disease characterized by a high hemoglobin (100 150 per cent, in rare cases 200), high red count (5 10 million), and considerable growth of the myeloid tissue in the bone marrow, liver and spleen The disease is rare in children (observed at the age of 4 5 years) Prognosis is poor As in adults, the disease in children is manifested by an intensive cutaneous hyperemia, chiefly of the face and arms, the mucous membranes acquire a singular purplish tinge Older children complain of headache, dizziness and of a feeling of congestion in the head Occasionally the spleen is enlarged

2 *False transien tpolyglobulia* occurs as a result of condensation of the blood due to considerable fluid losses (a) in cases of acute dyspepsia, dysentery, and certain severe infections, (b) in excessive perspiration, (c) in insufficient fluid intake

Reduced red blood counts and hemoglobin levels (conditions corresponding to the clinical concept of *anemia*) are observed in the following instances

1 Reduction of the bone marrow function (a) contingent on the action of various emaciating factors leading to decreased hematopoiesis owing to emaciation of the bone marrow (starvation, faulty diet, infection, protracted intoxication, growth of tumours in various organs)—hypoplastic anemia, (b) in congenital inferiority of the hematopoietic system, for instance anemia of prematurity, (c) as a result

Table 25

Picture of Blood at Various Ages

Age	Hemoglobin, % (Sahli method)	Erythrocytes: total amount per cu mm	Erythrocytes: with supravital granular structure, %	Total white count per cu mm	Differential white count (%): neutrophils: Total	Myelocytes	Juvenile cells	Band cells	Polymorphonuclear cells	lymphocytes: Total	Large	Small and medium	Monocytes	Eosinophils	Basophils	Türk's cells	Blood platelets
1-2 mos	84	4,450,000	7.0	12,100	25.0	0.0	0.5	2.5	22.0	61.5	4.0	57.5	10.0	2.5	0.5	0.5	231,000
3-4 mos	76	4,260,000	5.0	11,890	27.5	0.0	1.0	3.5	23.0	59.0	3.5	55.5	10.0	2.5	0.5	0.5	241,000
5-8 mos	78	4,550,000	5.0	10,900	27.0	0.0	0.5	3.5	23.0	58.5	3.5	55.0	10.6	3.0	0.5	0.5	232,400
7-8 mos	77	4,560,000	5.0	11,580	26.0	0.0	0.5	3.0	22.5	60.0	3.0	57.0	11.0	2.0	0.5	0.5	225,600
9-10 mos	79	4,790,000	5.0	12,300	25.5	0.0	1.0	3.5	22.0	61.5	3.5	58.0	9.0	2.0	0.5	0.5	235,000
11-12 mos	75	4,670,000	5.0	10,500	32.0	0.0	0.0	3.5	28.5	54.5	4.0	50.5	11.5	1.5	0.5	0.0	243,000
2-3 yrs	78	4,760,000	3.5	11,000	35.5	0.0	0.5	3.5	32.5	51.5	2.0	49.5	10.0	1.5	0.5	0.0	
4-5 yrs	80	4,890,000	2.8	10,200	45.0	0.0	0.5	4.0	40.5	44.5	3.0	41.5	9.0	1.0	0.5	0.0	
6-7 yrs	80	4,890,000	2.6	10,600	46.5	0.0	0.25	3.5	42.75	42.0	1.5	40.5	9.5	1.5	0.5	0.0	200,000
8-9 yrs	81	4,840,000	2.6	9,880	49.5	0.0	0.25	3.5	45.75	39.5	2.5	37.0	8.5	2.0	0.5	0.0	300,000
10-11 yrs	85	4,910,000	2.3	8,200	51.0	0.0	0.0	2.5	48.5	35.5	1.5	35.0	9.5	2.5	0.5	0.0	
12-13 yrs	82	5,120,000	2.3	8,100	53.5	0.0	0.25	2.5	50.75	35.0	2.5	32.5	8.5	2.5	0.5	0.0	
14-15 yrs	86	4,980,000	2.3	7,650	60.5	0.0	0.0	2.5	58.0	28.0	1.0	27.0	9.0	2.0	0.5	0.0	

of the destruction of the bone marrow by tumours or the development of the pathological process in the bone marrow itself (carcinomatosis, sarcomatosis, osteosclerosis, and also syphilitic sclerosis)—myelopathic anemia

2 The number of erythrocytes may be reduced owing to increased expenditure (a) in acute and chronic bleeding (b) as a result of hemorrhagic diathesis, (c) during certain toxicoinfectious processes that cause a considerable increase in the rate of erythrocyte disintegration (severe form of acute or chronic infections, worms, malaria, etc), (d) when the erythrocytes themselves are inferior (familial hemolytic jaundice)

It must be added that symptoms of anemia appear in cases when production does not compensate the increasing destruction of the blood elements Moreover, *anemia is often associated with the concomitant interaction of several of the cited causes* a sign of intensive disintegration of the erythrocytes is a rise in the level of the bile pigments of the blood and of urobilin in the urine Reduced erythrocyte regeneration is indicated by a drop in the number of reticulocytes in the blood Data obtained by a study of bone marrow specimens (obtained by puncture) are likewise of some value

Pseudoanemia Pallor of the skin not dependent on reduction of the hemoglobin level and red blood count is mostly observed in children of the preschool and school ages it is called false or pseudoanemia The same symptoms may be seen in infants The pallor in such cases is due to depth of the capillary network, or to vascular spasm

Qualitative changes in the red blood. Changes in the quality of the blood elements—appearance of primary or not quite mature cells, appearance of degenerative forms—are indicative of changes occurring in the process of blood formation

Megaloblasts are the embryonal precursors of the megalocytes, they are not encountered in normal blood and are present in the blood of the embryo during the very earliest stages of development The appearance of megaloblasts or megalocytes in the peripheral blood is a sign of a return to the embryonal type of blood formation Owing to the peculiar features of the child's hematopoietic system sporadic megaloblasts appear in the blood during various mild forms of anemia associated with alimentary disturbances, infection, etc This is not as important in childhood (particularly early childhood) as in adult life

Erythroblasts and normoblasts are immature nucleated forms of red blood cells (the precursors of erythrocytes in the bone marrow) Normally the peripheral blood does not contain these forms, except for the newborn period, when their presence is normal, as has already been explained In subsequent periods of life the emergence of erythroblasts and normoblasts into the circulation is looked upon as an indication of intensified bone marrow activity associated with output of immature forms into the blood stream under the effect of pathological stimulation

Polychromatophils are the regenerative juvenile form of erythrocytes which stain a light violet with the usual Romanovsky Giemsa stain, they appear in the peripheral blood in increased numbers during active erythrocylopoiesis

Increased reticulocyte counts The reticulocyles are immature forms of the red blood cells, young erythrocytes with a granular or filamentous network which stains supravitally (usually with brilliant cresyl blue). An increase in their amount is an indication of intensive bone marrow function Normally the blood of children, beginning with infancy, contains 5 6 reticulocytes per 1,000 mature erylhrocytes During intensive erylhropoiesis their number increases and may grow to 100 per 1,000, or even more Inversely, inhibition of bone marrow activity induces a decrease in the number of these cells

The appearance of macrocytes, large erylhrocytes intensively saturated with hemoglobin, is a sign of healthy regeneration of the blood

Hyperchromia is displayed by the appearance of considerably enlarged hemoglobin saturated erythrocytes, the colour index becomes equal to unity or somewhat higher owing to the high hemoglobin con tent in the separate erythrocytes, although the total hemoglobin and red blood values, particularly in cases of megalocytic hyperchromia, are usually considerably reduced *A macrocytic type of hyperchromia develops as the result* of a hyperplastic process in the bone marrow induced by intensive stimulation (large blood losses, hemolysis) and is an indice of healthy regeneration It is normally observed in the blood of the newborn A megalocytic type of hyperchromia is a sign of distorted hematopoiesis and is observed in children in certain severe forms of anemia, and in pernicious anemia in adults

Hypochromia Reduced hemoglobin levels concomilant with a rel atively high red blood count are manifesled by a significant decrease in the saturation of the erythrocytes with hemoglobin The colour index* becomes much lower than unity, for instance, if the hemoglo bin is 45 per cent and the red count 3 5 million the colour index will be $\frac{45}{35\times 2}=0\ 64$ An insignificant hypochromia is observed in infancy as a physiological process associated with the specific features of metabolism and nutrition during this period A more considerable hypochromia conditioned by pathological factors is usually accompanied by anisocytosis and poikilocytosis, i e , the appearance of abnormal red blood cells—pseudomicrocyles, and pseudomacrocytes (shrivelled and swollen erythrocytes), and poikilocytes (large irregularly shaped erythrocytes), it is a symplom of bone marrow functional deficiency which is observed in many types of hypochromic anemia A particularly pronounced hypochromia is characteristic of

* The colour index is calculated by dividing the hemoglobin value (in per cent) by double the first two figures in the red count (if the count is less than one million the first figure alone is doubled)

There are certain forms of leukemia in which the changes in the peripheral blood are insignificant, but the bone marrow is the scene of meta and hyperplasia typical of true leukemia

Leukoses are occasionally confused with leukemoid reactions which are characterized by a significant leukocytosis in the peripheral blood accompanied by the delivery into it of immature forms of leukocytes, down to the myeloblasts The absence of forms intermediate between mature and immature white blood cells is typical of leukosis, while in leukemoid reactions these forms are present In all doubtful cases bone marrow puncture must be performed and the bone marrow studied The clinical picture of leukemia is consistent with that of an acute infectious disease Leukemia is an extremely grave disease the etiology of which is not clear

Besides determination of the total number of leukocytes, estimation of the *nuclear shift of neutrophils* is highty important Shift to the left (increased number of young forms of leukocytes) is a sign of accelerated production of white blood cells The concomitant presence of shift to left and neutrophilosis is a favourable prognostic symptom Prognosis is less favourable when the shift to the left is unattended by any increase in the total white count, or when leukocytosis without any shift to the left is recorded Evidently, the neutrophils most active functionally are those that contain 2 3 segments and a clearly staining nucleus Pycnotic nuclei, as well as toxic granules" in the cytoplasm, are a grave sign of the severity of the intoxication

Lymphocytosis The absolute and relative increase of the number of lymphocytes circulating in the peripherat blood is a stable physiological condition throughout infancy and early childhood In pathological cases a lymphocyte increase is extremely typical of certain acute and chronic infectious diseases, among them rubella (German measles), pertussis (whooping cough), typhoid fever at the height of the disease and during convalescence, certain forms of glandular fever, tonsillitis with a lymphocytic reaction Especially high lymphocyte counts (both absolute and relative) are observed in lymphatic leukemia, and also in case of the so called *lymphocytic reactions in children*, mostly encountered in whooping cough

Lymphocytic reaction This peculiar reaction of the hematopoietic system is rarely observed, it usually develops in response to an acute or subacute infection, principally in adolescents The rise in the total white count is accompanied by a sharp rise of the lymphocyte count, up to 50 70 per cent Prognosis is quite favourable

Monocytosis A transient increase in the number of monocytes precedes the crisis and is maintained during it in certain acute infections, and it also occurs in malaria, measles, tuberculosis and infectious mononucleosis

Eosinophilia, or an increase in the number of eosinophils, is observed in numerous pathological conditions Normally the blood con tains 2-4 per cent of eosinophils, in some pathological conditions the amount goes up to 20-30 per cent, or even more. Eosinophilia occurs in children with exudative diathesis, particularly when it is very pronounced, in bronchial asthma, the serum sickness, anaphylactic states, scarlet fever, leukemia, certain cases of lymphogranulomatosis, and in all types of worm diseases. In trichinosis the eosinophil level may attain 70 per cent.

Basophilia. Normally the basophil count does not exceed 0.5-1 per cent. A rise is observed in association with acute and chronic leukemia, lymphogranulomatosis, polycythemia, pernicious anemia.

Leukopenia—diminution of the number of leukocytes, is a characteristic symptom of certain infections (typhoid fever, measles, rubella), and also of aleukia. Aleukia is a disease that (like leukosis) is accompanied by severe lesion of the entire hematopoietic system, during which the total leukocyte count in the peripheral blood is reduced notwithstanding a pronounced shift to the left. In sepsis, suppurative processes, and pneumonia leukopenia is an indication of depression of the hematopoietic organs and is therefore an unfavourable prognostic sign.

Reduction of the white blood count in the peripheral blood is conditioned by:

(1) hypofunction of the bone marrow caused by certain infections or owing to injury of the sites of blood formation effected by some chemical poisons (arsenic, benzene) or exposure to ionizing radiation (x-rays, radium),

(2) lesion of the myeloid tissue (agranulocytosis): *agranulocytic angina* is a most severe disease accompanied by a sharp drop of the leukocyte count (to several hundred per ml of blood) and almost complete disappearance of the neutrophils. The etiology of the disease is not known, fatty degeneration of the red hematopoietic bone marrow in the long bones is observed.

Pseudoleukopenia is contingent on an unequal distribution of the blood in the capillary network, for instance, as a result of spasm of the cutaneous vessels caused by chilling of the skin.

Neutropenia. Reduction in the number of neutrophils is usually attendant on leukopenia and is a sign of a severe form of infection or sepsis. Absolute neutropenia is characteristic of agranulocytosis and aleukia.

Lymphopenia. Reduction of the number of lymphocytes is observed in certain infectious diseases in association with neutrophilic leukocytosis. Absolute lymphopenia is seen in lymphogranulomatosis, lymphosarcomatosis, and certain forms of myelosis.

Monocytopenia. Reduction of the number of monocytes is noted in severe septic and infectious processes, in pernicious anemia, myelosis, and lymphadenitis.

Eosinopenia. A decrease of the number of eosinophils in the peripheral blood is observed in the majority of acute infections during their development and at maximum height of the process, and also at the onset of exacerbations of chronic infections Eosinopenia is particularly typical of typhoid fever, measles, pneumonia, septicemia aggravation of tuberculosis and rheumatic fever As the process subsides the eosinophil count returns to normal Complete absence of eosinophils is a sign of severity of the process

It is frequently necessary to gain a clearer idea of the absolute numbers of the separate forms of leukocytes Thus, the total and differential counts may easily lead to erratic conclusions in cases when the general increase or decrease of leukocyte counts is prevalently due to certain types of cells without any change in the absolute number of others For this purpose it has been proposed to define the absolute numbers of the individual types of white blood cells

Qualitative changes in the white blood High leukocytosis is not rarely accompanied by marked *shifts to the left*, i e , by *the appearance in the circulating blood of primary and immature elements* of the white blood, such high white counts indicate activation in the processes of delivery of the blood cells from the bone marrow, or of pathological changes in leukopoiesis The blood picture may show the presence of myeloblasts—the youngest of the precursor cells of the granulocytic series, or of the next intermediate forms of granulocytes—promyelocytes myelocytes, and juvenile neutrophils The appearance of these cells is usually concurrent with a considerable rise in the total leukocyte count, and, as has already been stated, is encountered in children in a number of infectious and suppurative diseases The presence of immature elements in the blood notwithstanding the low total leukocyte count is a characteristic symptom of *aleukemic myelosis*

Drastic changes in the white and red blood observed in children in certain types of anemia (von Jaksch's anemia or infantile pseudoleukemic anemia), pneumonia, dysentery, inflammatory and suppurative processes, and skin diseases are frequently the result of a so called myeloid reaction which easily appears in childhood owing to the instability of the hematopoietic system These changes evidently differ from the irreversible changes occurring in the myeloid tissue during leukemia chiefly by the rapid normalization of the blood with recovery from the primary disease that induced the violent reaction in the hematopoietic system

True leukemia is differentiated from the leukemoid reaction on the basis of bone marrow studies The myeloid reaction is never accompanied by such a rejuvenescence of the bone marrow as occurs in leukemia

Table 26 gives an idea of the age characteristics typical of bone marrow cellular composition

Besides the regenerative elements of the blood that appear during various pathological processes the appearance of degenerative elements may also occur—giant or diminutive neutrophils, or neutro-

Bone Marrow Picture of Various Ages

Age \ Cellular forms (%)	Micromyeloblasts	Myeloblasts	Neutrophilic promyelocytes	Neutrophilic myelocytes	Juvenile neutrophils (metamyelocytes)	Neutrophilic band cells	Polymorphonuclear neutrophils	Eosinophilic myelocytes	Mature eosinophils	Basophils	Promegaloblasts	Megaloblasts	Normoblasts	Reticulocytes	Megakaryocytes	Monocytes	Histiocytes	Plasmacytes
2 mos	63 9	1 0	1 6	6 6	3 0	4 7	0 1	1 6	0 1	—	5 8	1 4	9 7	0 3	0 2	—	—	—
5 mos	38 6	2 6	4 0	10 6	9 6	9 8	3 6	0 2	0 2	0 2	3 4	2 4	14 1	0 6	0 3	0 2	—	—
1 yr	33 3	11 3	4 1	6 1	11 1	12 2	3 0	2 6	0 6	—	1 0	3 2	10 5	0 5	0 1	—	0 2	0 2
3 yrs	19 2	4 7	8 5	10 8	11 3	13 1	9 2	1 1	2 5	—	1 0	2 3	16 3	—	—	—	—	—
6 yrs	7 0	4 0	3 4	8 0	8 7	26 0	19 9	3 6	1 6	—	3 2	3 2	11 3	0 1	—	0 5	—	0 5

phils containing toxic granules in their cytoplasm, or having pycnotic nuclei The appearance of degenerative white blood cells was called the degenerative *shift to the left* by Schilling

Toxic granulation of the leukocytes The appearance of neutrophils containing toxic granules in their cytoplasm is due solely to pathological processes Evidently, changes occurring in the cytoplasm of the neutrophils are phenomena of a reactive nature caused by the action of toxins which alter the chemistry of the cell

Giant neutrophils The appearance of giant neutrophils is a positive indication of pathology in the processes of formation and maturation of the leukocytes

Plasmacytes are characterized by a relatively larger size, markedly basophilic cytoplasm, vacuoles, and a large distinctly outlined nucleus which is mostly eccentric. The appearance of these cells is a sign of pathological stimulation of the hematopoietic tissues, it is prevalently observed in children during infectious processes—measles, rubella, pneumonia, meningitis

Blood platelets The number of blood platelets is normally 200,000 300,000

Thrombocytosis—an increase in the number of blood platelets (thrombocytes) is typical of many infectious diseases (pneumonia, rheumatic fever, etc).

Thrombopenia—reduction of the platelet count is observed in severe forms of anemia, leukemia, Werlhof's disease (idiopathic thrombocytopenic purpura)

Giant platelets In some cases the size of the platelets is subject to change The appearance in the blood of abnormally large platelets indicates the pathological nature of their maturation in the bone marrow (severe forms of anemia, leukemia, certain types of infection).

A dynamic study of the *erythrocyte sedimentation rate* is of high diagnostic value in determining the reaction of the body to infection Acceleration of the ESR points to an aggravation of the infection, inhibition is a sign of improvement, of subsidence of the pathological process However, there are exceptions from this general rule Thus the ESR does not change perceptibly in whooping cough, increasing only with the development of complications Prognosis is grave when the drop of the ESR is concomitant with an aggravation of the general condition of the patient (areactive ESR)

The erythrocyte sedimentation rate may be accelerated in the absence of any infection—in cases of severe anemia, high blood pressure, malignant tumours Physical stress may occasionally induce a transient acceleration of the ESR The same is true of emotional stress During recent years there has appeared an increasing interest in studies of the sedimentation rate during graduated time intervals—fractional ESR.

CHAPTER XXIV

BODY TEMPERATURE

Prof V *Molchanov*

Thermoregulation and its Specific Features in Childhood

Adult human beings maintain their body temperature at an almost constant level irrespective of fluctuations in environmental temperature, and are therefore said to be *homeothermal* (from the Greek *homos*—the same, uniform similar) This constant level is maintained by special mechanisms which regulate heat production and emission, thus strictly balancing the two processes

The concepts of chemical and physical thermoregulation differ

Chemical thermoregulation is the control of heat production Heat is produced in the course of the complex chemical processes involved in protein fat, and carbohydrate metabolism The production of heat occurs in all the cells of the body, but the principal producers are the large digestive glands in the abdominal cavity, the liver, and also the muscles during muscular activity

Physical thermoregulation is regulation of heat emission It is effected by physical processes—radiation and convection of heat and evaporation of water from the surface of the body Heat dissipation is effected mainly by the skin Dilatation of the cutaneous blood vessels causes an influx of blood and an intensified dissipation of heat by convection and radiation, vasoconstriction produces a reverse effect The evaporation of sweat is another source of heat emission Heat is also dissipated through respiration by the warming of the inhaled air and the evaporation of water by the lungs

Both forms of thermoregulation are co ordinated by the thermo regulating centres in the brain The contemporary physiologic concept of the thermoregulation centre incorporates a whole system of subordinated and mutually co ordinating centres These centres are situated in the hypothalamus, particularly around the tuber cinereum To them are subjected the vascular, sudoriferous respiratory metabolic, and other centres The highest centre of thermoregulation to which all the above mentioned centres are subordinate is the cerebral

However when heat regulation disorders are observed in older children it should be borne in mind that disorders in the vegetative endocrine system inducing thermoregulatory disturbances are not infrequent in the prepubertal period

Taking the temperature of infants by the axillary method presents great difficulties and is impossible in malnourished (atrophic) babies In babies the rectal method is preferable Rectal temperatures are taken with the baby on his stomach across the mother s (or nurse s) knees or with him lying on his side on a bed with his knees drawn up In the latter position the hips are restrained by the left hand while the right hand gently inserts the thermometer its bulb coated with vaseline about 5 6 cm into the rectum The thermometer is kept in as long as the column of mercury goes up the measurement is completed when the mercury column remains at the same level from 30 seconds to 1 minute The whole procedure takes 4 5 minutes Taking the temperature in the groin is less convenient in infants since it takes at least 10 15 minutes In older children the axillary temperature is taken in the same way as in adults for 10 15 minutes With younger children care should be taken that the bulb of the thermometer is held tight in the armpit In certain cases for example when malingering is suspected (see lower) rectal temperatures are taken in older children too

Normal temperature The temperature of the fetus is 0 2 0 3° higher than that of the mother This temperature persists in the newborn only for a short time immediately following delivery and then rapidly subsides by 1° and more In the normal newborn a subnormal temperature is sustained for 2 3 days while in feeble infants for 5 7 days The explanation is evidently to be found in the newborn s peculiarity—a slow development of the ability for adaptation to the conditions of extrauterine life

The normal rectal temperature of an infant is about 37°C varying from 36 8 in the morning hours to 37 2 37 4 in the evening (for 4 to 6 hours) This temperature (about 37°C) with negligible changes not exceeding 0 3 0 5° through the 24 hour cycle is considered typical of a healthy infant However such *monothermia* (from the Greek *monos*—single) is comparatively rare and is observed in absolutely healthy breast fed babies in conditions of ideal nursery care As a rule variations in the temperature of young children during 24 hours and during longer periods are considerably greater than in adults because changes in various external conditions rest and movement sleep and wakefulness and especially crying hunger and the intake of food—are reflected in the bodily temperature of the child more rapidly and emphatically than in adults owing to the imperfection of the thermal regulatory apparatus Therefore *lability or instability of the bodily temperature is a characteristic of infancy*

During the subsequent periods of childhood the temperature remains the same with a possible tendency to slight decrease

It is of practical importance to know *the difference between the rectal and axillary temperatures* It is usually considered to be equal to 0 3 0 5°, which is true in the overwhelming majority of cases However, the difference may be greater in certain cases depending, firstly, on individual properties of the child and, secondly, on his state at the time the temperature is taken (following a resting spell or immediately after running, or other physical exertions) Physical stress causes a greater rise in the rectal temperature, so that the difference may prove to be 1° or even more

Deviations from normal *Hypothermia* (a condition when the body temperature is lower than normal) is extremely frequent in premature infants, a drop of their temperature to 30°C and lower is usually well tolerated Cases have been described when premature infants survived after their body temperature had fallen to 24 22°C when timely measures were taken for warming them A subnormal temperature is typical of starvation, pylorostenosis, congenital heart lesions and hypothyreosis The chief cause is a low metabolic rate as a result of which any warming of the body produces only a temporary effect In undernourishment the temperature returns to normal quite rapidly following an increase in the amount of food especially when sugar is added

Abnormally high body temperatures (*hyperthermia or fever*) are commonly more frequent in children than in adults The causes are variable the above mentioned physiological properties, the frequency of infectious or non infectious diseases

What is the highest temperature compatible with the child s viability?

This question is very difficult to answer Children apparently tolerate very high temperatures worse than very low temperatures In febrile conditions it is not only the high temperature which produces unfavourable effects on the course of vital processes, but also the products of impaired intermediate metabolism and the activity of micro-organisms An exceptional case has been described of an extremely high temperature in scarlet fever (43 6°C) after which the child did recuperate

Elevations of temperature in infancy owing to non-infectious causes. Among the various forms of hyperthermia characteristic exclusively of infancy *the transitory fever* of the newborn or dehydration fever must be mentioned first (Fig 61) This fever (38 39 5°C) is rather a frequent occurrence (it affects from 15 to 20 per cent of the newborn) and is not accompanied by any pathological symptoms The appearance of fever on the 2nd to 5th day of life is commonly associated with the highest physiological weight loss, its incidence is higher during summer heat Transitional fever is caused by an inadequate fluid intake (dehydration) and rapid improvement is effected by oral administration of water Therefore the transitory fever of the newborn is also called *thirst fever* However, thirst fever also occurs in later infancy, particularly in undernourished (hypotrophic) infants in consequence of severe limitations of the fluid intake

Infants may also be affected by *various types of alimentary fever*—elevated temperature induced by an increased introduction of proteins (*protein fever*, Fig 62), table salt (*salt fever*) or sugar In all such cases the instability of the metabolic processes and inadequacy of the heat regulating mechanism are the factors conducive to the febrility Insufficient fluid intake also favours the appearance of

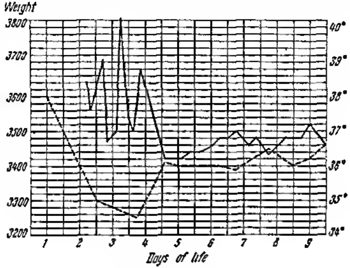

Fig 61 Transitory fever of the newborn

hyperthermia, while an abundant administration of fluids eliminates it (*relative thirst fever*)

Overheating due to excessive external warmth, careless application of hot water bags, too much clothing or covering during the hot months of the year may all lead to a considerable rise of temperature (up to 40°C) not only in the premature, but also in the normal newborn and even in older infants This condition is sometimes attended by severe general disorders—restlessness, convulsions Elimination of the causes promoting overheating and a cool bath rapidly bring the temperature back to normal

Infectious fevers and their specific features In children of all age levels, as well as in adults, infectious fevers are a most frequent occurrence The following types of fever are distinguished (1) continued fever (febris continua) as, for example, in lobar pneumonia, (2) remittent fever (febris remittens) associated with various infectious diseases, (3) intermittent fever (febris intermittens), as in malaria or pyemia, (4) recurrent or relapsing fever (febris recurrens) as seen in spirillum fever (recurrent fever) this latter type of fever differs from intermittent fever by longer remissions to normal between paroxysms (5) irregulary remittent fever *The temperature curve is an extremely valuable diagnostic sign* in so far as in most cases a definite type of fever is produced by definite infectious diseases

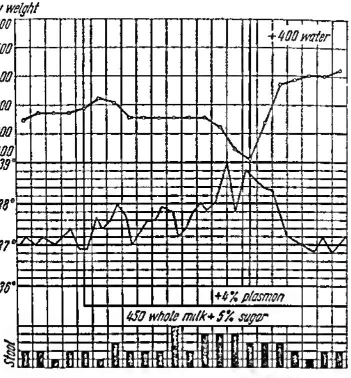

Fig 62 Protein fe er and its subsidence follo ving the administration of water

Among the infectious diseases of childhood *scarlet fever* for instance is characterized by a rapid rise of temperature to 39 40°C which is sustained for 4 5 days and then gradually decreases (by lysis) beginning with the 5th day attaining a final return to normal by the 7th to 9th day of the disease In *measles* the temperature is elevated on the first two days of the prodromal period after which it subsides sometimes to normal levels on the 3rd or 4th day a drastic rise to 40°C and higher occurs with the first appearance of the rash and a constant level is maintained throughout the entire eruptive period resolution by crisis occurs on the 4th or 5th day following the appearance of the rash In distinction from adults children often exhibit an absence of regularity in their temperature curves and *the younger the child the more pronounced are the deviations from the temperature curve typical of any given infectious disease* Infectious diseases of infancy (scarlet fever, measles) are often accompanied by atypical temperature curves In typhoid fever the period of constant temperature is sometimes absent and what is then observed is an initial period of gradual elevation of the temperature directly followed by a period of intermittent fever

It is noteworthy that *an intermittent fever is sometimes found in children suffering from diseases that have nothing in common with malaria or pyemia*, it has been observed in certain cases of lobar pneumonia, particularly in early childhood unaccompanied by any signs of purulent processes, in glandular fever and in some other diseases

Acute fevers of uncertain etiology. The cause of the elevated temperatures observed in various diseases of childhood may sometimes remain obscure for longer periods of time than in adults Hence, any febrile condition in children necessitates a most thoughtful and comprehensive investigation thorough and detailed interrogation, examination of the entire surface of the body *(not infrequently erythema nodosum on the lower parts of the legs is missed)* and of the ears (*latent otitis*), urinalysis (*pyelitis*), repeated percussion and auscultation and if possible, x ray examination of the lungs (*limited foci in the roots of the lungs*) Examination of the fauces should not be overlooked sometimes even older children do not complain of pain in the throat while the examination discovers *tonsillitis* pharyngitis, *adenoiditis* (mucopurulent discharge on the posterior pharyngeal wall) and at times, more serious diseases, such as *diphtheria* There are cases however, in which the true cause of the fever becomes clear only after the temperature has subsided Otitis for example, becomes evident following the appearance of a purulent discharge from the ears This is conditioned by the morphological peculiarities of the ear in young children (see Chapter VI), so that even an experienced specialist may at times not be able to detect any signs of middle ear inflammation

Protracted fevers An elevated temperature, usually subfebrile (37 5 38°C) and at times even higher (39° and more) may persist for many weeks and even months, while the determination of any definite diagnosis is not always possible The type of fever may vary more or less constant, slightly remittent, distinctly intermittent irregular etc The causes are also varied In some cases the fever is caused by inflammatory processes in various organs latent otitis and mastoiditis, inflammation in the paranasal sinuses, adenoiditis unattended or attended with enlargement of the cervical lymph nodes, *glandular fever*, appendicitis and many other afflictions, in other cases it is due to generalized infections—malaria, septicemia tuberculosis, etc The diseases which may be productive of protracted fever are too numerous to be cited here

Some forms of *tuberculosis* in children (miliary tuberculosis infiltrations in the region of the pulmonary roots or bronchial lymph nodes, dry pleurisy) do not produce any clear objective symptoms besides elevated temperature for quite a while The general state of the child remains satisfactory. The disease is often diagnosed as paratyphoid, up to the appearance of meningeal symptoms in cases of miliary tuberculosis or distinct pulmonary lesions in cases of infiltrative processes in the lungs However, even in these cases the true cause of the fever may be timely established if a comprehensive examination (x ray, tuberculin test) is made

Non-infectious elevations of temperature in older children Theoretically, the possibility of considerable rises in temperature due to non infectious causes affecting the thermoregulatory centres cannot be rejected Cases have been reported of long standing febrile conditions due to tumours in the region of the diencephalon and the tuber cinereum, prolonged and considerable rises in temperature have been observed in children as a result of a cerebral hemorrhage sustained at birth Non-infectious elevations of temperature in infants have already been dwelt upon However, protracted elevations of temperature, commonly subfebrite (up to 38°C), are sometimes observed in schoolchildren and adolescents, when comprehensive examinations and prolonged observation definitely exclude the existence of any pathological process, local or general In the overwhelming majority of cases such children display various neuropathic, particularly vegetative functional disorders marked by unsteady pulse, functional transient heart murmurs, cold cyanotic fingers, perspiration headache of a migrainous type (neural arthritic diathesis), general nervous excitability and rapid fatigability, at times endocrine disorders (hyperthyreosis, precocious puberty) are also found

In some cases subfebrite temperatures appear independently, as it were with no preceding morbidity, and are noticed incidentally, in others the subfebritity is the sequel of some infectious disease—influenza, sore throat, measles, scarlet fever or other diseases associated with very high temperatures All symptoms of infection disappear, but a subfebrite temperature is either sustained for an indefinitely long time (many months and even years) or appears periodically This temperature retains the pattern common to normal temperature, being lower in the morning and higher in the evening, it may grow very high if some infectious disease is contracted

Children tolerate habitual subfebrile temperatures easily, and only occasionally complain of an aggravation of their usual unpleasant sensations during the evening elevations—headache, sweating, etc Objectively neither the blood (normal blood picture and ESR) nor any other organs are affected At times skilled questioning will elicit the familial character of the protracted subfebrility (mother or other relatives inclined to this condition)

In most cases the true cause of the subfebrile temperature remains obscure even after it has subsided, functional disorders of the cardiovascular system prompt the diagnosis of "endocarditis", more often than not the condition is labelled "tuberculous bronchadenitis' despite negative tuberculin tests, especially when the x-ray examination presents a common finding—enlarged, although calcified, bronchial lymph nodes

In the meantime, notwithstanding the persistent elevation of the temperature no new data for confirming the diagnosis are available, the patient grows and develops, his state and behaviour are normal The only reasonable thing to do is for the physician to advise the parents to stop taking the temperature, to stop worrying about it, and, particularly to avoid attracting the patient's attention to it

Such an elevated temperature which practically differs in no way from normal in respect to its influence on the organism, should be regarded simply as a shift of the bodily temperature to a higher level owing to instability of the autonomic nervous system its thermoregulatory centres in particular This condition is called *thermoneurosis or non infectious pyrexia in a child with an unbalanced nervous system*

However, to establish such a diagnosis the following two conditions are necessary first, the presence of any chronic infection or other pathological processes which might provoke the appearance of a prolonged subfebrile temperature must be excluded by the most thorough examination and investigation of the patient, and by protracted observation, the presence of an old abated process (for example enlarged calcified bronchial lymph nodes) cannot undermine the diagnosis of neurogenic hyperthermia, secondly, the pyrexial condition must be definitely confirmed and the possibility of malingering on the part of the patient be excluded Pediatricians should bear in mind such possibilities which practice shows to be not infrequent and not easy to discover To exclude malingering, the axillary and rectal temperatures should be taken simultaneously

A protracted subfebrile temperature of infectious etiology in adults is distinguished from neurogenic hyperthermia by the administration of pyramidon (1 2 g in the course of the day), pyramidon brings febrility of an infectious origin down to normal but does not affect that of neurogenic etiology The efficacy of this method in children has not been sufficiently tested to date Moreover, pediatricians should always keep in mind the most important factor—the mental state of the patient As K Bykov says in his book *The Cerebral Cortex and the Internal Organs*, insufficient attention to the patient s mentality has led and always leads to an incomplete and imperfect diagnosis, to erratic prognosis, and to incapable treatment And moreover, a neglectful attitude to the mental state of the patient may lay the foundation for the superimposition of new diseases and then instead of healing the physician will be the cause of a new disease, as was already pointed out long ago by the father of medicine, Hippocrates

CHAPTER XXV

RADIOLOGY IN PEDIATRICS

Dr *M. Kurbatova*, Candidate of Medical Sciences

GENERAL FEATURES

An important clinical method employed in the study of childhood physiology and pathology is the use of the x ray

Investigations of the features peculiar to x ray diagnosis in childhood have provided medical science with a means for observing numerous physiological and pathological processes occurring in the growing organism *in their dynamic development*, such processes include the appearance of ossification centres in the bones, the depression or activation of this process during the different periods of childhood, rarefaction of the bone structure contingent on chronic malnutrition, the different stages of rickets, various forms of osteochondral pathology, and diseases of the thoracic viscera—diverse types of pneumonia in early and later childhood, pleurisy, heart disease

The use of *contrast mediums* (radiopaque substances) in pediatrics is possible in the very first weeks of life The method has been found valuable in diagnosing the nature of processes associated with pylorospasm and pylorostenosis, and in older children for clarifying a number of dyskinetic disorders of the gastrointestinal tract in the course of their development, for the investigation of gallbladder function by means of cholecystography, for the establishment of the precise nature of congenital heart defects by angyocardiography, for identifying urinary tract pathology by pyelography

There are a number of specific points associated with the use of the x-ray in pediatrics

The radiologist must acquaint himself with the clinical data and case history to gain a thorough understanding of the patient before commencing the examination

The type of examination resorted to most frequently is examination of the chest A number of various devices have been proposed for immobilization of the pediatric patient—special chairs and bags, or boards fitting into a vise for restraining babies in a horizontal position behind the screen

However, since these devices frequently interfere with the conduction of multiplane examinations of the chest it has been found useful in clinical practice for an assistant (medical personnel or a parent) to hold the baby's arms in an uplifted position, his head resting against the assistant's left arm, while the radiologist restrains the legs (which are wrapped in a diaper).

Every pediatrician must be conversant with the principles of x ray diagnostics in children, i e, he must have a thorough understanding of the indications for such examinations and be able to evaluate the resultant data. However, it must be emphasized that clinical diagnosis is based first of all on data derived from the clinical examination of the patient.

RADIOLOGIC INVESTIGATION OF THE BONE SYSTEM

The x ray method is basic in the study of normal and pathological osteology, and, indeed, comprises an entire section which has been called x ray osteology.

The skeleton of the child differs from the adult skeleton not only in size, but also in its morphological differentiation (see Chapter XIV), particularly in regard to the cartilaginous content, the level of which is inverse to the child's age. Hence, the x ray depiction of the child's skeleton presents a peculiar picture. Owing to its low specific gravity the cartilaginous tissue absorbs the x rays in the same manner as the soft tissues do, therefore cartilaginous sites produce no shadow on the x ray depiction.

The cartilaginous layers adjacent to bone surfaces are seen on the radiograph as empty spaces or free gaps, the younger the child the wider are these gaps in the joints.

The embryonal skeleton consists entirely of cartilage and leaves no shadow on the x ray picture (radiograph or roentgenogram). As the embryo grows centres of ossification appear in different points of the cartilaginous skeleton, these centres expand occupying more and more of the skeletal system.

At term ossification has already occurred in all the diaphyses while the epiphyses, with some slight exceptions (for instance, the lower femoral epiphysis), consist of cartilage and are seen as free spaces or gaps on the radiograph. The small cancellous carpal bones and the epiphyseal centres of ossification in the bones of the forearm foot and phalanges are also absent in the picture.

As the child grows centres of ossification appear in the epiphyses of the long bones and in the small bones of the arm, wrist, foot fingers, and toes, and this is distinctly reflected in the x ray picture.

By puberty ossification of the entire skeletal system has occurred, and only between the epiphyses and diaphyses of the long bones there remains a layer of epiphyseal cartilage at the expense of which the growth of the bones in length proceeds (endochondral or enchondral bone growth)

The process of enchondral growth, as followed up by radiography, is normally directed from the epiphyseal cartilage to the diaphysis. A dense layer is deposited in the region of the metaphysis on the margin of the epiphyseal cartilage, seen on the radiograph as a dense narrow band, the zone of preliminary calcification

Thus, a radiograph of the joints and extremities of normal bones of children presents a typical picture

1 The epiphyseal centre of ossification, divided by a dark narrow cartilaginous layer from the dense band in the metaphysis—the zone of preliminary ossification

2 The above mentioned epiphyseal cartilage which separates the epiphysis and metaphysis

3 The metaphysis, with its typical latticed structure of cancellous bone, demarcated at the distal end by a dense band, the zone of preliminary calcification

Considerable numbers of ossification centres are situated in some parts of the child s skeletal system—for instance, there are six separate centres in the bones of the elbow joint

A motley picture is presented by the pelvic girdle in childhood, divided as it is by a number of cartilaginous layers. As the child becomes older the ossification centres expand, while the cartilaginous layer isolating them from the metaphysis becomes narrower, finally, with the synostosis of the epiphyses and metaphyses the meta-epiphyseal gaps disappear completely, a sign of cessation of growth

The so called bone age of the child is estimated on the basis of the developmental state of the bone system, the times of appearance of centres of ossification in the epiphyses of the various bones and of synostosis between the epiphyses and metaphyses, and the termination of skeletal ossification

Delayed appearance of centres of ossification (retarded bone age) is observed in association with endocrine disturbances characterized by hypofunction of the thyroid, thymus, anterior pituitary lobe, and sex glands

Early appearance of centres of ossification (increased bone age) is seen in precocious puberty and in association with hyperfunction of the thyroid and adrenal cortex

Distortion of the order of ossification, i e , a disturbance in the usual sequence observed in the appearance of centres of ossification with development of symptoms is prevalently contingent on endocrine dysfunctions (hypothyreosis, hypopituitarism, infantilism)

Symptomatology of the most important diseases of the skeletal system. The features peculiar to x ray symptomatology of pediatric bone diseases are predominantly associated with the fact that the majority of x ray changes occur in the site of the most active growth of the bone, the region of the epiphyseal cartilages—in the epiphysis and metaphysis Therefore the radiologist s attention should be centred in these areas of the child's skeletal system

Rickets The x ray symptoms of rickets are most pronounced in the epiphyses, i e , in the abundantly vascularized areas they are manifested by changes in the epiphyseal ends of the bones and also in abnormal radiolucency of the bone structure

The skeletal changes occurring in rickets based on depletion of the bones of calcium consist chiefly of a depression or complete cessation of the processes of calcification in the bone areas of growth The zone of preliminary calcification thins out until it finally disappears altogether Instead of normal bone tissue osteoid tissue devoid of calcium salts develops at the distal end of the metaphyses and vascularization increases Thus a rachitic zone is formed adjacent to the epiphyseal cartilage in the metaphysis this rachitic zone consists of remnants of cartilage of osteoid tissue and of branching capillaries

The zone involves a considerable portion of the distal end of the metaphysis sometimes as wide as 1 5 cm The transverse expansion of this zone leads to a thickening of the junction ends of the bones (rachitic beads rosary or bracelets)

The osteoid tissue produces no shadow on the radiograph and the rachitic zone is presented by increasing unevenly serrated gaps between the epiphysis and metaphysis The ends of the metaphysis grow in width and the x ray picture shows the goblet shaped expansions typ cal of rickets

The expanding rachitic zone of osteoid tissue growth is responsible for the growth of the bones in length

As the condition improves calcium salts are deposited in the growing bone A new zone of preliminary calcification appears in the site of enchondral growth at the end of the osteoid zone of the metaphysis It is first seen in the form of minute calcium salt inclus ons which later fuse to form a continuous thin dense layer separating the osteoid tissue of the metaphysis from the epiphyseal cartilage

Owing to mineral deficiencies rickety bones are soft and pliant so that they bend easily producing various deformations (of the legs thighs spine etc) An x ray examination of a rachitic child will show a more or less distinct rarefaction of the bone structure and the formation of beads on the ribs at the junctions with their cartilages and in the epiphyseal zones of bone growth caused by growth of the osteoid tissue

Fractures sustained in early and preschool childhood are primarily subperosteal since during this period of life the periosteum is quite thick and when fractures occur it remains intact restraining the bone fragments and thus displacements are avoided (greenstick fracture)

The bone fragments frequently cohere closely, and as a result the fracture may look like a fissure The presence of fracture and bone displacement is determined by taking x ray pictures in two planes

Tuberculosis of the bones a disease not infrequent in childhood shows a definite x ray pattern

The process mostly involves the bone at the border of epiphyseal cartilage and the first symptom of tuberculosis in these cases is a certain rarefaction of the bone structure in the contiguous parts of the bone liquefaction of the tissue wasting of bone and subsequent constriction of the arthrous gap

Such local wasting of the bone tissue in the absence of any distinct periosteal reaction is a characteristic symptom of tuberculous lesion of the bones Usually only one joint is affected X ray changes in the joint are observed much later than clinical findings (approximately 3 weeks later) this is why x ray examinations performed in the initial period of the disease frequently produce negative results a matter not to be forgotten by the pediatrician

When suspicion arises of a tuberculous lesion in the bone the x ray examination must be repeated several times over 3 week intervals and x ray pictures taken in two planes (of the spine joints and extremities)

An exception is constituted by spina ventosa—multiple tuberculous infection of the long bones of the hands and feet The skin over the involved areas is always edematous and hyperemic

On the radiograph the affected phalanges are distended their bone structure is destroyed at times to almost complete liquefaction with a thin layer of bone tissue left at the outer margins of the bones

The developmental dynamics of childhood *osteopathia caused by nutritional disorders* is at times detected by clinico radiologic examinations The leading symptom is systemic osteoporosis The bones of the extremities are thin and delicate with thinned out cortical layers and coarsely looped rarified stroma In distinction from the osteoporosis of rickets the growth zone in the long bones of the extremities in malnutrition osteoporosis is always clearly visible while the epiphyseal centres of ossification are also porous with coarse trabecular structure

Syphilitic lesion of the bones is revealed in the newborn as a systemic affection of all the tubular bones of the extremities Increase in the deposition of calcium in the cartilaginous cells is noted, and the process of physiological resolution of the cartilage is depressed

Syphilitic osteochondritis prevatently involves the distal metaphyses of the legs and forearms The younger the infant the more prominent are these enchondral changes in babies older than 6 8 months such lesions are less frequent and the leading symptom is then excessive thickening of the bones and massive sometimes laminar periosteal deposits along the entire length of the tubular bones of the extremities

RADIOLOGIC EXAMINATION OF THE THORACIC VISCERA

As seen in x ray examinations, the thorax of young children differs from what is seen in adults The anteroposterior and transverse dimensions are almost equal the ribs run horizontally The thorax is so resilient and pliant that many morbid processes, even acute ones have a telling effect on its shape, causing greater or lesser changes in it

Radiologic examination of the thoracic viscera includes radioscopy (fluoroscopy), radiography, and, on special indications also bronchography tomography and kymography The motion of the ribs the heart beat the radiolucency of the lungs on inspiration and other points are seen on the screen, and the radiologist is also enabled to establish the topography of the organs and their correlationships in physiology and pathology by examining the patient in different planes

The x ray examination of young children calls for no extremely powerful" equipment, an adequate examination of children of any age can be performed by means of any modern x ray equipment, given a certain degree of radiologic skill and proper technical conditions

In radiography the main thing is to catch the proper moment for exposing the film, and to obtain a sufficiently clear image, since even a slight movement of the patient may distort the picture of the chest

The lungs X ray examination of the lungs in early childhood necessitates the observance of certain technical requirements owing to the number of unfavourable factors which may be present The radiologist must possess special knowledge in x ray diagnostics of the lungs The lungs of infants contain less air and more blood in comparison with adult lungs

Normally radiolucency of the lungs of an infant is low and a diffuse, almost homogenous pattern is produced This is due to the minute structure of the image which is not detected on the screen and is frequently not even revealed by the radiograph

During the first two years of life delivery of blood to the lungs is subject to very marked variations depending on changes in the respiratory phases and on crying Therefore the normal pulmonary pattern of an infant is distinguished by extreme changeability and shows great deviations in the different phases of respiration The normal pattern is that which is observed during inspiration when the blood content of the lungs is lowest and the air content highest The pulmonary tissue is more transparent airy and the contrast range of its pattern increases

In the expiratory phase when both cupolas of the diaphragm rise to high levels and the pulmonary vessels fill up with blood conditions for diagnosis are unfavourable A particularly unfavourable moment is the infant s crying during the protracted and tense inspiration which accompanies the crying the diaphragm is raised the median shadow produced by the heart and large vessels expands owing to venous congestion and covers the lungs thus constricting their visible area The radiologist must take this into account and wait until the baby calms down before making a radioscopic examination or taking an x ray picture or he should at least try to take the picture (or observe the image) during inspiration

In early childhood the mediastinal organs—the heart large vessels and thymus—are much larger as compared with thoracic capacity than in later life This too has an unfavourable effect on the x ray examination since the expansive mediastinal shadow covers the greater part of the lungs thus constricting the areas accessible for examination This is especially true of infants during the first few months of life in such cases as a rule thoracic radiography is done with the infant on his back in a horizontal position and therefore the image of the posterior parts of the ribs is more distinct than that of the anterior parts partially covering the pulmonary tissue

X-ray diagnosis of lung diseases The majority of lung diseases encountered in childhood are characterized by alveolar effusions and consolidation of the pulmonary tissue seen on the screen in the shape of discrete dark spots corresponding to the shape and size of the sites of consolidation These dense shadows—particularly when observed in motion—are the leading x ray symptom of inflammatory processes in the lungs

X ray examinations of young children during various pathological conditions, particularly conditions accompanied by toxicosis frequently reveal vicarious emphysema In emphysema the pulmonary fields are excessively radiolucent, the diaphragm is low and its excursion during respiration is almost absent Excessive distention of the lungs may interfere with the true depiction of the existent changes, especially in cases of diffuse nodular consolidations, since minute sites may fail to produce a shadow against the background of the abnormally radiolucent pulmonary tissue

In marked emphysema of the lungs intensive coughing may lead to rupture of the alveoli and the accumulation of air in the pleural cavity, the mediastinum and under the skin

On the x ray such alveolar ruptures (pneumatocele, pneumocele) may simulate lung cavitations

The formation of pneumothorax causes the affected side to become abnormally radiolucent, with no pulmonary contours, while the mediastinum is displaced towards the opposite side, the diaphragm is low and flat, paradoxical motions of the diaphragm are frequently observed during respiration, and the outlines of the collapsed lung may be discerned at its root

Another feature typical of pulmonary inflammations in infancy is atelectasis which, when considerable, may produce a large shadow

The atelectatic complication produces a number of peculiar x ray symptoms owing to the reduced volume of the lung the mediastinum is displaced towards the affected side, the thorax caves, the diaphragm is elevated on the same side

1 *Acute pneumonia in infancy* Pneumonitic processes in infants are usually localized in the region of the root of the lung, in the posterior paravertebral space Therefore the x ray examination of infants should be concentrated on the hilus of the lung and adjacent areas, as well as on the regions contiguous with the spinal column — the paravertebral spaces

The location of the infiltrated pneumonitic area in a long band like area in the posterior sections of the lung is characteristic, occurring predominantly on the upper part of the right paravertebral space

The radiograph carries a clear depiction of a thin line of more or less intensive shadow on the pulmonary field running lengthwise along the spinal column, mostly from the apex to the root of the lung, where the shadow is usually intensified

In double pneumonia such lines appear on both sides of the spinal column (bilateral paravertebral pneumonia)

When evaluating radiographic data it must be remembered that a shadow at the hilus of the lungs does not always signify that the process is localized namely in this area—it may just as well be in back or in front of the root of the lung

Diffuse focal pneumonia is characterized by the appearance of multiple minute foci of infiltration distributed over a large area of one or, more frequently, of both lungs In babies this form of pneumonia is easier to detect by radiography, since the above mentioned symptoms are missed in radioscopy owing to the low contrast range and delicacy of the minute pattern of the stroma

The radiographic film shows the greater part of both lungs to be studded with small foci of consolidation of irregular shape and blurred contour These foci are denser in the central areas of the lungs

The fusion of the discrete foci occurring in bronchopneumonia in infants promotes a formation of extensive areas of greater or lesser consolidation—infiltrates occupying large portions of the lung or the entire lung in the massive form of the disease The process is usually not restricted to one lobe of a lung, the foci of consolidation are prevalently localized in the lower median sections of both lungs

The leading x ray symptom of this form of pneumonia is a uniform, more or less intensive shadow with a motley structural pattern

The mottled, irregular nature of lobular pneumonic processes is reflected on successful radiographs

2 *Protracted and recurrent pneumonia in the first years of life* The aggravation of the bronchopneumonic processes that may complicate measles or whooping cough is usually also associated with involvement of the interstitial pulmonary tissues and with a spread of the process along the peribronchial lymphatics This form is called peribronchial or interstitial pneumonia (M Skvortzov)

The coarse pattern of the bronchiat vascular network and of the peribronchial cord is distinctly revealed by x-ray examination, the discovery of interlobar stria is also not rare Another finding is a peculiar honeycomb pattern of the pulmonary tissue caused by an en capsulating form of peribronchitis in association with small *emphysematous* foci

In children under two years of age a subsequent distention of the smaller bronchi occurs, prevalently in the upper and medial parts of the lungs, x ray examinations of older children show distention of the lumens of the small bronchi in the transverse and cross planes in the area of the internal sinuses of the lower medial sections of the lungs, with considerable mural consolidations of the developing bronchiectatic type

In cases of protracted pneumonia fibrinous exudates are seen along the clefts between the lobes of the lungs Their resolution is extremely slow and they are subsequently detected during x ray examinations for a long period of time as intertobar adhesions

3 *Pneumonia of the newborn and premature* The form most frequently observed in such infants is interstitial pneumonia It is characterized by the absence of bronchopneumonic foci and the prevalence of peri lobular and perialveolar changes in the form of a vesicular pattern of the pulmonary tissue, delicate infiltrations of the hilar regions of the lungs, localized in the majority of cases in the base of the right upper lobe and the lower mediat parts of both lungs

The delicate vesicular pattern of the lung tissue of the newborn is not conducive to the detection of changes in the interstitial stroma, but even so interstitial processes are marked by (1) pronounced vesicular pattern of the perilobulites and perialveolites (2) delicate infiltrated areas in the hilar sections of the lungs with no lymph node enlargement (3) distention of vascular cords concurrent with the presence of emphysema (4) absence of any marked bronchitic changes (5) absence of bronchopneumonic foci (N Panov)

4 *Lobar and pseudolobar forms of pneumonia* During x ray examinations lobar pneumonia presents a clear picture when the greater part of the lobe is involved in the process A clear image is obtained of a dense shadow which corresponds to the infiltrate and is sharply delineated by the interlobar cleft However similar symptoms may also be observed in massive lobular pneumonia (bronchopneumonia) but in the latter case the fusing sites do not usually involve the entire lobe they are localized in one large site in some part of the lobe and the condition is called focal or pseudolobar pneumonia The resolution of such forms of pneumonia occurs gradually During the period of retrogressive development of the pneumonic infiltrate areas of bullous emphysema are not rarely observed these areas are formed by rupture of the alveoli caused by intensive coughing they may disappear just as rapidly as they appear

The clinical and radiologic recovery of the child after pneumonia is not simultaneous when clinical findings already show the child to be healthy x ray examinations will still present characteristic symptoms of lung consolidation

Pleurisy Pleurisy with effusion is determined radiologically by a characteristic line showing the upper limit of a pleuritic effusion known as Sokolov s curve Damoiseau s curve or Ellis curve an S shaped curve occupying a triangular space in the lower lateral section of the lung its apex contiguous with the distended root of the lung

The Sokolov Damoiseau Ellis curve may be detected when the volume of the pleuritic effusion is no lower than 200 ml

Adhesive pleurisy is diagnosed by exhaustive x ray investigation it is revealed in the shape of a shadow covering the entire surface of the lung

Encapsulated pleurisy—walled off pockets of exudate in the pleural space—is established in the phase of organization of pleurisy with effusion and is usually detected by multiplane examination in the form of a hornet s nest on the lateral side of the chest

Tuberculosis of the lungs X ray diagnosis of pulmonary tuberculosis in children is a difficult matter Changes in the lung tissue typical of tuberculosis may likewise be observed in pneumonia and in other lung diseases

The radiologist can gain a clear understanding of the nature of the disease by complementing the x ray findings with previously obtained clinical data

The primary focus may not always be discovered during the x ray investigation since small freshly formed foci are not always revealed by fluoroscopy or radiography New foci produce a weak, delicate shadow the outlines of which become clearer with time and with the retrogressive development of the process

The area of the primary focus becomes particularly distinct following its calcification, when clearcut, dense foci of consolidation of variable shape and form appear in the lung tissue In the subsequent stage of petrification (Ghon s primary focus or lesion, Ghon tubercle) these firm usually rounded shadows are frequently seen throughout the patient s whole life

The primary tuberculous complex comprises the Ghon tubercle and the accompanying regional lymph node involvement in the root of the lung in the form of a lymphatic network connecting both formations

In children under three years of age calcified primary foci are rarely encountered It is not infrequent for the bifurcation lymph nodes to be involved in the process, to find them the child must be examined in the first and second oblique positions

When the primary focus in young children develops no healing tendency the tuberculous process spreads rapidly over large areas of the lungs the x ray picture is then blurred and densely shadowed, its outlines irregular—development of caseous pneumonia Such extensive shadows are not typical of caseous pneumonia until disintegration occurs and a cavern is formed, the latter is seen by means of the x ray as a radiolucent cavity surrounded by a denser rim

Cavities with effusions are not revealed in children by x ray examination

In cases of a bronchogenous spread of the tuberculous process the finely diffused nodules and consolidations frequently arranged in groups, present a mottled pattern of fusing spots of various size on the affected area of lung tissue (the so-called 'picture of melting snow'), the diversity of the pulmonary pattern is particularly vivid in the presence of multiple small cavities which create an exceptional contrast

When the infection spreads through the blood a miliary pulmonary process is generated The areas of the lungs are studded with small evenly arranged spots—nodules of equal size

Eosinophilic pneumonitis is an allergic condition observed mostly in the hilar region of the lungs, it is attended by eosinophilia in the peripheral blood Such infiltrates are transitory, and their course is benign Their appearance is associated with a peculiar sensitization of the organism owing to certain factors (chronic tuberculous intoxication, bronchial asthma, ascariasis), this sensitization involves local vascular hyperergy or vasomotor edema which is frequently accompanied by eosinophilia of the blood The allergenic substances may be various odours, that of hay, for instance, or of old books, fur, spring pollen, etc

Pneumonomycosis (candidomycosis) does not, as a rule, present any definite clinical radiologic pattern. The x-ray changes observed in the lungs are extremely multiform and variable. Large foci of infiltrative lesions (frequently with necrosis) may be observed at the same time as small foci of a diffuse nature, and the motley appearance is intensified by areas of developing emphysema and involvement of the interstitial tissue. No particular reaction is usually noted at the root of the lung.

The changes occurring in the lung tissue in pneumonomycosis are characterized by tenacity and long duration, in distinction from ordinary bronchopneumonia.

Bullous (vesicular) emphysema (pneumocele) is not infrequent in infants during recovery from focal pneumonia or bronchopneumonia and likewise during pneumonia as a result of the rupture of the septa between the alveoli in the loose interstitial tissue of the lung (in whooping cough, measles).

Bullous emphysema, i.e. the formation of air-containing cavities in the lung, runs an asymptomatic course and is only detected during x-ray examinations in the form of rounded cavities of various size in the pulmonary tissue; these cavities disappear gradually without any treatment.

Foreign bodies in the respiratory passages are encountered more frequently in children than in adults.

For the most part the foreign body passes through the trachea and lodges in one of the chief bronchi where it may remain for a considerable time without producing any marked clinical or radiologic symptoms, particularly when the body is soft and does not absorb x-rays.

Attention must be paid to indirect x-ray symptoms conditioned by the presence of a foreign body in the air passages. If such a body is lodged in one of the bronchi the constriction or obstruction of the latter with the formation of atelectasis of the corresponding area of the lung will cause the lung to throw a dark shadow on the fluorescent screen while the diaphragm stands at a high level and displays almost no motion during respiration. The displacement of the mediastinum towards the atelectatic side during inspiration is quite clearly defined (the Holzknecht-Jakobson sign).

X-ray examination of the heart. Investigation of the heart of the child by radiologic methods includes several procedures—radioscopy, radiography, examinations with contrast mediums (angyocardiography), orthodiagraphy, kymography, etc.

A summary radioscopic examination of the thoracic and abdominal cavities must be made prior to radioscopy of the heart; this preliminary examination establishes whether any deformities of the thorax or spinal column exist, determines the bone structure of the ribs and their position, and likewise the position and mobility of both domes of the diaphragm, the state of all the sinuses and of the mediastinum.

During the first months of life enlargement of the thymus is not infrequent, and this introduces considerable diversion in the configuration of the mediat shadow thrown by the heart predominantly in the area of the vascular bundle

The shape approximate dimensions and beat of the heart are usually determined by radioscopy in the direct and oblique positions it must be noted that the position of the child s heart changes quite easily depending on various factors (height of the domes of the diaphragm mediastinal displacement etc) therefore the configuration of the juvenile heart should never be described as mitral or aortal such descriptions only bring confusion into the clinical examination without adding anything definite or essential to diagnosis

For precise determination of the size of the child s heart the method of teleradiography is resorted to when the tube is at some distance (2 metres) from the body (to avoid distortion) However in children younger than six years the difference between the changes in the teleradiographic outlines of the heart and the usual radiographic picture are insignificant which is possibly owing to the relatively greater dimensions of the heart in early childhood

In consequence of the high standing of the diaphragm in the first two years of life the apex of the heart is lifted and the heart assumes a recumbent position The large vessels are short and wide at this age During inspiration and when the baby cries the superior vena cava distends and the shadow thrown by the large vessels becomes broader

The heart of new-born and older infants occupies a median position and occasionally its greater part lies on the right side At this age the outlines of the heart are clearly visible since the pericardium carries no fat deposits yet The typically rounded shape of the heart with its poorly developed arches is explained by the anatomic interrelationships of its cavities this medially situated relatively large cardiac shadow interferes with examination of the lungs in the median sections of the thorax—the hilar regions

Static changes as well as changes in the correlations of the visceral organs occurring in the second year of life are the cause of a lesser protrusion of the median shadow beyond the right margin of the sternum the left ventricle grows rapidly the apex of the heart occupies a lower position and the shape and position of the heart begin to resemble what is seen in adult life by the age of seven years the outline of the cardiac shadow as seen by means of the x ray differs little in shape and configuration from the adult heart During the period of sexual maturation growth of the heart lags somewhat in comparison with the general growth of the child and the shape and outline acquire a number of specific features that have given rise to the term juvenile or adolescent heart During this period of intensified growth the heart as seen during x ray examinations looks small occupies a median position and its form resembles a falling drop

During this period considerable protrusion of the arch of the left pulmonary artery is observed a condition that clears up by the time complete development of the heart has occurred, when, as a result of the gradual development of the left ventricle, the angle at the orifice of the arch of the pulmonary artery flattens out and the arch attains the usual adult size

Hypertrophic juvenile heart with considerable enlargement of the left ventricle, or at times even of both ventricles, is more frequent in boys than in girls, and is observed in association with strenuous physical exertions In this condition the apex of the heart is definitely rounded, massive, and clearly outlined

Congenital heart lesions are rarely observed in isolation, diverse variations and combinations of defects are more usual

Congenital heart defects without cyanosis

Patent ductus arteriosus—an anomaly in which the fetal blood shunt (ductus arteriosus Botallo s duct) does not become obliterated after birth The radiological symptoms are pronounced protrusion and vigorous pulsation of the pulmonary artery and also considerable enlargement of the right ventricle particularly in the right oblique position

Ventricular septal defect (Tolochinov s and Roger s disease) When the defect is not great the x ray configuration of the heart may be unchanged, a considerable defect causes the heart to assume a globular shape owing to enlargement of both ventricles The distended right ventricle displaces the right atrium to the right and upward going beyond the lower part of the right lower arch where its pulsation may be observed on the fluoroscopic screen

Aortic isthmus stenosis (coarctation of the aorta) is caused by constriction between the subclavian artery and the ductus arteriosus On the x ray the ascending portion of the aorta is unfolded dilated elongated and its arch is considerably straightened out or even straight The seeming broadness of the vascular bundle is created by the innominate carotid and subclavian arteries The narrow descending portion of the aorta may be visualized in oblique positions below the area of constriction

Congenital heart defects with early cyanosis

Stenosis of the pulmonary artery (relative) usually combines with some other developmental anomaly of the heart, such as patent ductus arteriosus or ventricular septal defect X ray findings constitute right ventricular hypertrophy with distention to the right side the right ventricle is prominent both on the dextral outline of the heart, occupying its lower part, and on the left outline above the arch of the left ventricle

A sharp protrusion of the arch of the pulmonary artery is also visible on the left margin of the heart its vigorous pulsation is seen distinctly in both the direct and left oblique positions

Tetralogy of Fallot (pulmonary stenosis with interventricular septal defect) is a complex anomaly incorporating four concomitant congenital defects (a) stenosis of the orifice of the pulmonary artery, (b) dextroposition of the aorta (c) a high ventricular septal defect, and (d) hypertrophy of the right ventricle

Transposition of the great vessels is usually combined with other malformations and x ray findings are characterized by blurred indefinite shadows thrown by the aorta

Dextrocardia This anomaly is not important clinically, but during x ray examinations it is immediately detected

Catheterization of the heart and the use of contrast substances for gaining more precise data on topic and local cardiac pathology during the clinical investigation of such patients are methods the use of which is constantly expanding The radiopaque substance cardiognost used in these examinations contains up to 70 per cent iodine and great caution must be observed in its use, following a preliminary careful preparation of the patient

Acquired heart defects present the same x ray findings in children as in adults The changed outline of the malformed heart as visualized by means of the x ray is caused by the unequal enlargement of the cardiac cavities and circulatory fail ures conditioned by the lesion This is why the x ray findings typical of a given lesion appear only after the changes have become so great that they already affect the shape of the heart

Owing to the above the initial stages of endocarditis are ordinarily not detect ed during x ray examinations and the typical picture is visualized on the screen only following the appearance of stable changes in the form of the heart

RADIOLOGIC EXAMINATION OF THE ABDOMINAL VISCERA

The child is usually given a purging enema on the evening preced ing the examination, and another on the morning of the examination, on a fasting stomach

Boiling water is poured into the radiopaque substance (barium sulfate, 50 g, and 150 ml of water), optimal homogeneity is attained by using pulverized barium sulfate (100 g of the powder to 160 ml of water)

The examination of the stomach and intestine must be preceded by a summary radioscopic examination of the chest and abdominal cavity, and only after this has been done the child is given several gulps of the suspension in order to outline the image of the mucous membrane on the screen

After this a more detailed study of the esophagus is made, during which spastic contractions in some part of it may be detected Thus, in cardiospasm the first portions of the barium sulfate will pass the esophagus freely, and then an abrupt stop will occur at the cardia sometimes for several minutes sometimes for a longer time after which sudden passage is effected

The stomach. In childhood the shape of the stomach varies consid erably A particular instability is observed in babies and in children of the preschool age in whom the position of the stomach is high and horizontal owing to the more or less marked meteorism usual at these age levels

The plicae of the mucous membrane of the stomach are outlined quite clearly directly after the first portions of the barium sulfate have been swallowed, with the exception of instances of accumulation of gastric mucus

A vivid image of the mucosal folds is obtained on the screen or on the x ray close ups when dosed pressure is applied at the moment of observation or exposure (through a special tube or rubber bulb), the folds then appear in the form of 2 3, or sometimes even four clearly defined lengthwise bands running parallel with the lesser curvature of the stomach from the cardia to the pylorus, at times these folds may be very thin and delicate, at times thick and coarse

Examination of the surface of the gastric mucosa is associated with many difficulties in early childhood, besides, it has been proved by morphological studies that mucosal plication is very poorly developed in children under the age of two years

The contours of the mucous membrane change during the different phases of digestion from a smooth and even surface to an intricate pattern

The actual state of the gastric mucosa is determined after exhaustive x ray examination an imperative component of which is also radioscopy of the patient in a recumbent position (trochoscopy) the entire x ray unit with the patient standing behind the screen pressed against the back panel is tilted backwards to an angle of 30° and the examination is repeated

Occasionally the position of the stomach of a young child may be determined without the introduction of any radiopaque medium owing to the physiological meteorism present in the intestines particularly in the colon

The widely distended intestinal loops are conducive to visualization of the margins of the liver spleen and full stomach However this type of examination of the stomach of the child may be resorted to only for general orientation (determination of the presence of contents in a fasting stomach correlation of the stomach and the adjacent organs existence of coarse morphological changes etc)

X ray examination of the gastrointestinal tract includes evaluations of the functional abilities of various portions of this tract as well as of their shape and position topography of the mucosal lining etc All this is possible only with the introduction of radiopaque substances

During the first year and more particularly the first months of life a condition termed aerophagia is observed it is characterized by a large air bubble in the baby s stomach In infancy the stomach is pear shaped and the shape easily changes depending on the baby s position gastric muscular tonicity is low in consequence of which the stomach is easily distended however it does not descend as in adults but seems flattened out in the abdominal cavity reaching almost from the left to the right lateral wall

In older children the lower border of the stomach normally lies approximately 3 cm above the horizontal line of the iliac crest in atonia of the stomach in older children a downward displacement is observed chiefly of the pyloric portion of the stomach and partly of the duodenum in such cases the latter does not look so much sunken as distended and unfolded along the horizontal axis to the right

Evacuation of the stomach content is usually rapid, beginning 5 to 7 minutes after the introduction of the barium sulfate, a considerable acceleration of the rate of evacuation or on the contrary a longer retention of the contrast substance may be observed in various disturbances of the motor functions of the stomach associated with evacuation

On the average the stomach is free of the ingested barium sulfate suspension in $2^1/_2$ 3 hours, but evacuation may occur as soon as in 1 $1^1/_2$ hours or even less time, while at times the suspension may be retained in the stomach for 4 and more hours

A protracted (up to 24 hours) detention of the barium sulfate suspension in the stomach is observed in cases of pylorostenosis The x ray findings in this condition are a distended stomach which retains the contrast medium for a long period of time and deep intensive peristalsis of the stomach In pylorospasm the contrast medium is detained in the stomach intermittently, and for relatively short intervals

Gastritis X-ray findings are a coarse topography of the thickened (up to 1 cm) folds of the gastric mucosa, which are occasionally broken owing to the accumulation of the barium sulfate in the form of small lumps As a result serrated, irregular outlines of the gastric mucosa are visualized along the greater curvature of the stomach

Gastric ulcer shows definite x ray symptoms in the clinical pattern of adults

In childhood the condition is more frequently recognized radiologically in the form of what is known as pre ulcerative states coarse outline of the mucosa, spastic contraction of some parts of the stomach and duodenum, finally, 'barium spots are visible in the sites of superficial erosion of the mucosa subsequent to stomach evacuation

The duodenum is often difficult to find in young children owing to the peculiar position of the stomach which is frequently flattened out

In older children the bulb of the duodenum is approximately of the same shape as in adults, and the plication of its mucosa is directly continuous with the longitudinal folds of the gastric mucosa

A periodic, uniform filling of the bulb of the duodenum with the contrast substance usually occurs quite rapidly, various types of dyskinesia in this section are observed in association with various degrees of malnutrition, prevalently in young children

The small intestine. The contrast substance is usually distributed evenly in the loops of the small intestine, showing up its delicate feathery pattern Optimal visibility is attained 40 minutes after the oral introduction of the barium sulfate Normally the feathery pattern of the circular folds of the mucous membrane of the small intestine (valves of Kerckring, plicae circulares) is quite distinct

The study of the different sections may be deepened by means of close-up radiographs

The large intestine. For examination of the colon the contrast substance is introduced both by mouth and with an enema

Four to five hours following oral intake the barium sulfate fills out the cecum and the ascending colon, in 12 to 24 hours the entire contrast substance is in the sigmoid flexure and the rectal ampulla In 48 hours only traces of barium sulfate are detected in the large intestine

Considerable variations in the period of evacuation of the large intestine are observed in children with dyskinetic trouble at times only traces of the barium sulfate can be found in this section of the intestine 24 hours after its administration, while in other instances all the sections of the colon are still filled with barium sulfate 48 hours following administration

The colon, when filled out with the barium sulfate taken per os, shows characteristic pouches or haustra in the transverse section, which are not so clearly defined in the ascending and descending parts This section of the intestine presents a wreath like shape, and it is very pliant its position is influenced by various conditions The image of the mucous membrane of the large intestine becomes quite distinct after the administration of a barium sulfate enema the surface outline shows a characteristic pattern consisting of alternating small longitudinal and transverse plicae, the haustral structure is well defined

Examination of the descending part of the colon, particularly when pathology of the sigmoid section is suspected, is performed exclusively by the irrigoradioscopic method wherein the contrast medium is introduced rectally under control of the fluoroscope after a preliminary purging enema *1 $1\frac{1}{2}$ litres of water containing 100 250* g of barium sulfate is injected through the rectum under slight pressure, with the child lying on his back By this method clear images of the shape and position of the different sections of the large intestine are obtained, but the haustral pattern is lost

Following bowel evacuation the outline of the mucous membrane of all the sections of the large intestine is usually well defined

Care must be taken not to introduce too great amounts of liquid (for instance, in megacolon when the capacity of the intestine is as high as 4 6 litres), no more than 1 1 5 litres of the barium sulfate suspension should be injected as the introduction of greater amounts of liquid may produce shock in the child.

INDEX

A

D

T