Original Articles

AN APGAR SCORE OF THREE OR LESS AT ONE MINUTE IS NOT DIAGNOSTIC OF BIRTH ASPHYXIA BUT IS A USEFUL SCREENING TEST FOR NEONATAL ENCEPHALOPATHY

M. Ellis, N. Manandhar*, D.S. Manandhar* and A.M. deL Costello

From *the Maternal and Infant Research Activities, Kathmandu, Nepal* and the Institute of Child Health, London, United Kingdom*

Reprint requests: Dr. Anthony Costello Center for International Child Health, Institute of Child Health, 30 Guilfoord St London WC1N1EH United Kingdom.

Manuscript received: September 23, *1997 Initial review completed October 21, 1997, Revision accepted December 6, 1997*

Objective: *To evaluate the relationship between an Apgar score of three or less at one minute of life and the subsequent risk of developing neonatal encephalopathy (NL)* ***Design.*** *Prospective* ***Setting*** *The principal maternity hospital of Kathmandu, Nepal, a low income country, where over 50% of the local population deliver* ***Methods*** *All liveborn infants over a 12 month period with a birthweight of 500 g or more were assessed by the Apgar scoring system at one minute of age All* torn *infants with neurological abnormalities presenting in the first day of life were systematically examined and described according to a conventionally defined encephalopathy grading system Major congenital malformations and neonatal infections were excluded* ***Results*** *Over 12 months there were 14,771 total births of a weight of 500g or more of which 14,371 were live births and 400 were stillbirths. Of 734 infants with 1 min Apgar of three or less, 91 developed NE The positive and negative predictive values of 1 min Apgar of three or less for NE were 11 4% and 99 9%, respectively The probability of developing NE lose from 0 6% (amongst all infants born at this hospital) to 11 2% (amongst infants born with a one minute Apgar of three or less)* ***Conclusions:*** *An Apgar score of* 3 *or less at one minute is a useful screening test for clinically significant birth asphyxia (NE) It over estimates by eight fold the scale of the birth asphyxia problem but identifies a high risk group requiring further observation of then neurological condition.*

Key words: *Apgar, Birth asphyxia, Neonatal encephalopathy.*

BIRTH asphyxia is an important cause of perinatal mortality and morbidity in developing countries(l) However, the definition of birth asphyxia is problematic(2) Most studies from developing countries report indirect measures of birth asphyxia, principally Apgar scores, which have been shown to have poor predictive power for the key outcomes of death and serious disability(3,4) The early neurological condition of the newborn is now recognized to be the best available indicator of significant preceding birth asphyxia(5) and the best predictor of both death and future disability(6).

A task force established by the World Federation of Neurology reviewed the

clinical definition of birth asphyxia and concluded that studies should aim to identify neonatal encephalopathy of early onset (NE), record the clinical signs and investigate the etiology as fully as is feasible and safe(7). We have done this for the first time in a developing country hospital setting and here compare the prevalence of birth asphyxia using this method as our gold standard with a conventional low Apgar score approach. Our aim was to evaluate the use of an Apgar score of three or less at one minute as a screening method for the detection of neonatal encephalopathy.

Subjects and Methods

Setting

The study population consisted of all infants born during a 12 month period (1995) at Prasuti Griha Maternity Hospital, Kathmandu. This is the major maternity hospital for the entire Kathmandu Valley, delivering over 14,000 women annually which we estimate to comprise 50% of all Kathmandu deliveries(8). There are poor communications with the hilly regions outside of the Kathmandu Valley. A recent audit showed less than 3% of the women delivering at Prasuti Griha were resident outside of the Kathmandu Valley. There is no functioning referral system for maternity cases in Nepal. The Hospital budget of £350,000 is supplemented by a modest user charge. It offers the most competitively priced institutional delivery service in the Valley. We therefore consider the population who deliver at Prasuti Griha hospital is broadly representative of the surrounding population.

Clinical Definitions

Formal operational criteria to grade the severity of encephalopathy in term infants were derived from the descriptions by Fenichel(9) and Levene *et al.* (10), modified in the light of more recent studies and are presented as *Table I.* These modifications incorporate the observations that mild NE

TABLE I–*Syndromic Diagnosis of Neonatal Encephalopathy*

	Grade 1 (mild)	Grade 2 (moderate)	Grade 3 (severe)
Conscious level	**Irritable/hyperalert**	**Lethargic**	**Comatose**
Tone	**Either**[a] Mildly abnormal (hypo/hyper)	**Moderately abnormal** (hypotonic or dissociated)	**Severely abnormal** (hypotonia)
Suck	**or**[b] Abnormal	**Poor**	**Absent**
Primitive reflexes	Exaggerated	**Depressed**	**Absent**
Seizures	**Absent**	Present	Present
Brain stem reflexes	**Normal**	**Normal**	**Impaired**
Respiration	Tachypneic	Occasional apneas	Severe apnea

Adapted from Fenichel (9).
The features in bold must be as described to meet the minimum requirements for each grade.
Features not in bold may be present but are not required to make the syndrome assignation.
a/b: **Either** abnormal tone or abnormal suck should accompany altered conscious level to assign grade 1.

cases may have signs of increased as well as decreased tone(11), that seizures activity may not be clinically detectable(12) and that the inclusion of duration in the clinical definition of a grade renders the scheme contradictory(13). Inter-observer reliability of the grading system amongst five non-specialist assessors on 27 neurologically abnormal infants was tested. The kappa value, a measure of agreement where 1 indicates perfect agreement and 0 no agreement better than chance alone, was 0.87 for the scheme overall. These five assessors continued to perform the daily neurological grading of NE throughout the study period. The final assigned grade (1-mild, 2-moderate or 3-severe) as with Fenichel's scheme corresponded to the most severe encephalopathic state of the infant observed during the period of neurological abnormality.

An Apgar score of less than or equal to 3 at one minute of age was taken as the cut off for significant birth asphyxia following the World Health Organization International Classification of Disease (10th revision)(14). This is in line with National Neontatology Forum guidelines that "gasping and ineffective breathing or lack of breathing at 1 minute", which it is argued corresponds to an Apgar at 1 minute of 3 or less, arid "should be designated as birth asphyxia"(15).

Case Finding and Investigation

All newborn infants were routinely assessed and awarded Apgar scores at one and five minutes of age. This was done by the attending clinical staff, either a pediatrician or midwife. No special training was given since it was our intention to compare the routine measurement of Apgar scores with subsequent encephalopathy grading.

It is hospital policy to admit to Special Care Baby Unit (SCBU) all newborns with a one minute Apgar score less than or equal to three, those with a birth weight less than 2.0 kg and all sick infants. Over the study period 2,503 infants were admitted to SCBU, 17% of all deliveries. At the outset of the study period 1000 consecutive deliveries were checked on the routine post-natal wards for clinical signs of encephalopathy. No cases of NE who had not met the SCBU admission criteria were identified during this phase of the study. It was apparent that the broadly defined admission criteria for SCBU had already selected those infants at risk of developing NE and therefore subsequently only SCBU admissions were prospectively screened by daily neurological assessments.

All neurologically abnormal infants detected by screening were then formally examined following a standard examination protocol developed locally following the principles of neurological evaluation described by Amiel-Tison(16). The findings were recorded daily on a standard proforma. In suspected NE cases blood sugar was measured by glucose strip testing (BM stix and Reflolux-S meter) to eliminate hypoglycemia (blood glucose less than 2.6 mmol/L). If hypoglycemia was detected, corrective measures were taken and glucose estimation repeated until normoglycemia was achieved. Blood cultures were performed routinely and Grade 2/3 infants underwent lumbar puncture provided there was no evidence of raised intracranial pressure. Infection was defined by positive culture from either blood or cerebrospinal fluid. All suspected NE cases underwent early (first week) and late (six week) cranial ultrasound.

Any infant with a gestational age of more than 37 completed weeks [clinically assessed by the Parkin method(17)] 'with neurobehavioural evidence of encephalopathy at examination 6-24 hours after birth

was defined as a case of NE. Exclusion criteria were: (i) Severely dysmorphic infants with at least one major congenital abnormality; *(ii)* Infants with hepatosplenomegaly and cataracts indicative of intrauterine infection; *(Hi)* Infants with positive blood/CSF cultures; *(iv)* Infants whose neurological condition normalized when hypoglycemia was corrected; and *(v)* Preterm infants (less than 37 weeks). All mothers of case infants were interviewed for historical details and to explain the diagnosis and follow up procedures.

Data Analysis

All data was entered onsite into a computer database using Filemaker Pro v2.0, double-checked, and subsequently analyzed using Statview v4.1 and Stata 2.1.

Ethical Approval

Ethical approval was sought and given by both the Nepal Medical Research Council and the Institute of Child Health Ethics Committee, London.

Results

Study Population

During the study period there were 14,771 total births of a weight of 500 g or more of which 14,371 were live births and 400 were stillbirths. There were 254 neonatal deaths of a weight of 500 g or more prior to hospital discharge. This gives a perinatal mortality rate prior to hospital discharge of 44.3/1000 total births. Three infants of probable term gestation (> 2.0 kg birthweight) died following failed resuscitation efforts prior to admission to SCBU. These cases all had 1 min Apgar < 3 but did not survive to satisfy the NE case criteria. They do not therefore appear in the numerator of NE cases although we consider it likely that their rapid neonatal death was due to birth asphyxia.

Birth Prevalence ofLoiv Apgar Score

During the study period a total of 734 infants with a birthweight of 500 g or more had an Apgar score at 1 minute ($Apgar^1$) of three or less. Of these 548 (75%) had a birthweight of 2000 g or more. The data is presented stratified by birth weight in *Table II.*

Prevalence of NE

During the study period 96 infants met the case definition criteria for NE. Cranial ultrasound was either normal or diffusely echobright ('fuzzy' brain(18)) in all cases. Five of these cases were subsequently excluded because early neonatal blood culture was positive and we therefore assume their encephalopathy resulted from perinatal infection. This leaves a total of 91 cases of early neonatal encephalopathy in whom no cause other than birth asphyxia was evident. *Table III* presents NE grade data by $Apgar^1$ scores. Seven cases of NE (8%) had $Apgar^1 > 3$ including two cases who went on to develop a severe grade 3 NE. All of them had an $Apgar^1 < 7$.

TABLE II *Low One Minute Apgar (≤ 3) by Birth Weight (n=734)*

Birth weight (g)	Frequency with low Apgar(< 3) No (%)
500 999	13 (2)
1000-1499	68 (9)
1500-1999	93 (13)
2000-2499	183 (25)
2500-2999	223 (30)
3000 or above	142 (19)
Missing birth weight data	12 (2)
Total	734

Low Apgar Score As A Screening Test For NE

Table IV describes the qualities of the one minute Apgar score as a test for NE. For the purposes of evaluation we are here using NE as the gold standard measure of birth asphyxia(19).

Discussion

We have demonstrated that in a setting representative of non-referral hospitals throughout South Asia, the current definition of severe birth asphyxia used by WHO identifies a population eight times greater in magnitude than the population of term infants manifesting neonatal encephalopathy not attributable to other causes. The vast majority (92%) of NE cases had an Apgar^1 < 3 and all had an Apgar^1 < 7.

Given a high patient to staff ratio and rapid patient turnover, it is possible that a few mild cases of NE escaped detection. However, moderate or severe NE is **not** a subtle syndrome and following birth asphyxia always presents within 24 hours of birth(9). Therefore the discrepancy is unlikely to be significantly explained by under reporting of NE in this population.

TABLE III *NE Grade By One Minute Apgar Score (n=91)*

NE Grade	Apgar^1 ≤ 3	Apgar^1 4-7
Mild (n=30)	28/30	2/30
Moderate (n=36)	33/36	3/36
Severe (n=25)	23/25	2/25
All NE (n=91)	84/91	7/91

TABLE IV– *One Minute Apgar Score ≤ 3 As A Test for NE*

	NE	No NE	Total
Apgar^1</=3	84	650	734
Apgar^1>3	7	13630	13637
Total	91	14280	14371

Sensitivity 92 3%, Specificity 95 4%, LR+ 20 06, LR- 0 08,, Positive predictive value 11 4%, Negative predictive value 99 9%, Prevalence 0 63, Pre-test odds 0 0063, Post-test odds 0 126, and Post-test probability 0 112

Although there is significant inter-observer variation in Apgar scoring, it remains a useful indicator of the newborn's general condition especially at the lower extremes(20). There are two groups of newborns who may. have a low early Apgar but do not develop NE. Firstly, there is a large group of term infants depressed immediately after birth who rapidly improve. This transient depression in the first minutes of life is not associated with later neuro-development sequelae(6). Over *75%* of the non encephalopathic cases with low one minute Apgar in this series had a birthweight of 2.0 Kg or more and are likely to have been of term gestation.

The second group are preterm infants who may have a low Apgar score due **to** the immaturity of their responses(20). This does not indicate brain injury due to birth asphyxia. Less than 25% of this series had a birthweight less than 2 kgs and are likely to have been significantly premature. Perinatal brain injury in premature infants is generally anatomically different from that seen in term infants following birth asphyxia and is thought to largely occur after delivery(21). Interventions to improve outcome for this group of infants are likely to differ from those aimed at the prevention of asphyxia in term infants. Therefore a measure of the prevalence of birth asphyxia should not simply amalgamate all infants with reduced responses in the first minutes of life.

Levene and colleagues compared Apgar scores and what they termed post-

asphyxial encephalopathy (PAE) in 126 infants in a UK hospital setting(10). They found that 29 of 126 cases of PAE (23%) had an Apgar^1>3. The comparable proportion from the present study is rather less (8%); Levene's study gives no data on the overall prevalence of low Apgar in their hospital.

Kumari and colleagues report a large series of Apgar scores from an Indian district hospital in 35,959 infants born in one of four years between 1981-88. They found 3.4% newborns had Apgar^1 <3(22) and 7.6% Apgar^1 < 7. Of These 41% had a birth weight less than 2000 g. A multicenter study of Apgar scores in Africa reported that 22.6% of 4268 deliveries in central hospitals had a 5 min Apgar < 7(23). Both these studies inferred that these large numbers of infants had suffered significant birth asphyxia.

We have shown that early Apgar scores overestimate the scale of the problem of significant birth asphyxia as indicated by NE but remain a useful screening test in busy units. Our data suggests that an admission policy for special care selecting all infants with a one minute Apgar of three or less will select approximately 5% of all deliveries and will include almost all cases of NE.

Acknowledgements

This work has only been possible with the support of the Directors and staff of Prasuti Griha Maternity Hospital. The MIRA project has enjoyed support from Overseas Development Administration and the NE project has been generously funded by the Wellcome Trust.

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