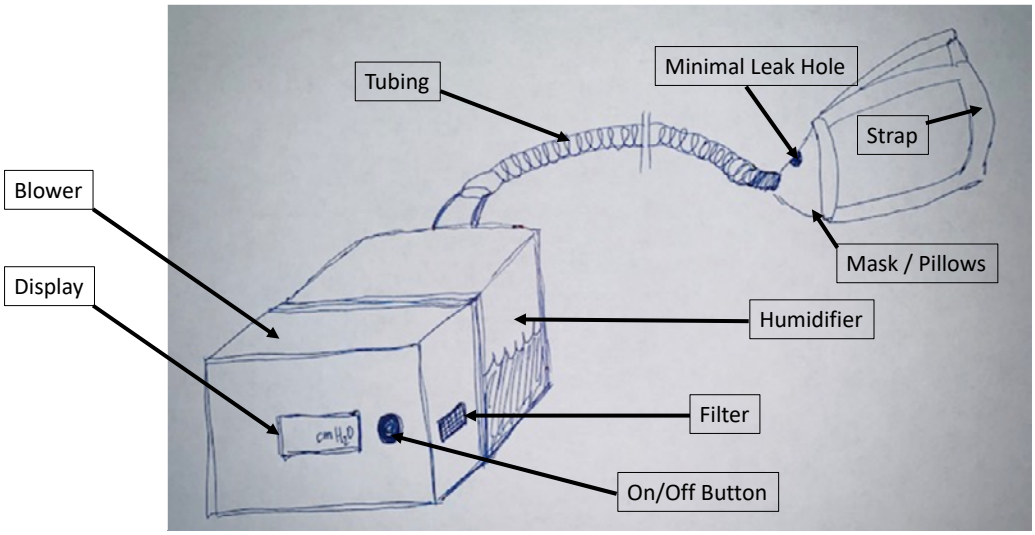
Difficult PAP Titrations

Nancy Collop
Emory University

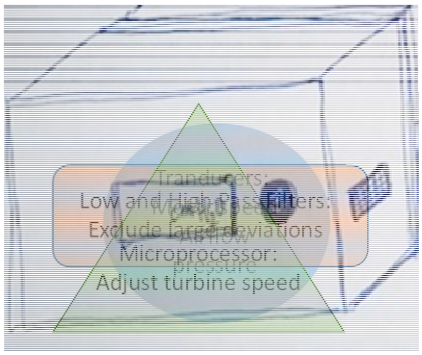
1

Anatomy of a PAP Device – Blows AIR !!



2

Inside Pandora's Box!!

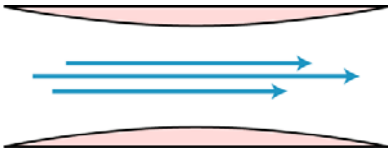


3

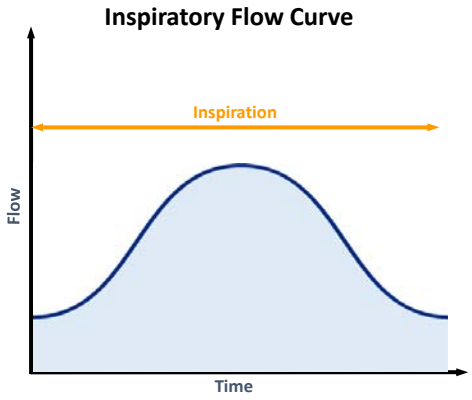
Mode(s)	Clinical Use
CPAP Auto-CPAP	OSA
Bilevel PAP (S)	OSA (CPAP failure, comfort)
Bilevel PAP (ST)	OSA with treatment-emergent CSA Obesity hypoventilation CSA due to neuromuscular disease
ASV	Comorbid OSA / CSA OSA with treatment-emergent CSA Ensure adequate ejection fraction (>45%)
AVAPS / IVAPS	Obesity hypoventilation syndrome Neuromuscular disease with daytime hypoventilation

4

Normal Airway



Open unrestricted airway



Unrestricted inspiratory flow time curve (rounded)

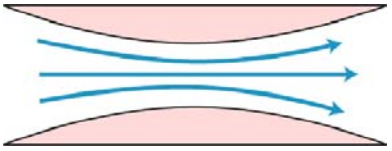
Slides courtesy Neil Freedman

5

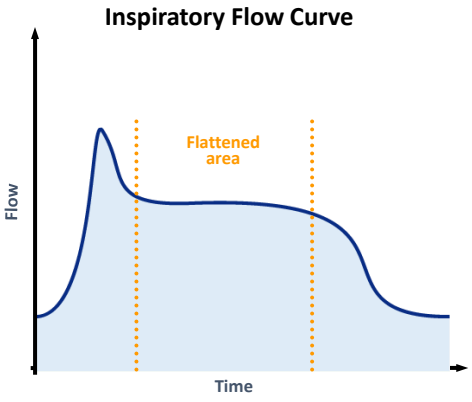
5

Inspiratory Flow Limitation

Patient's Airway



Silent partial obstruction



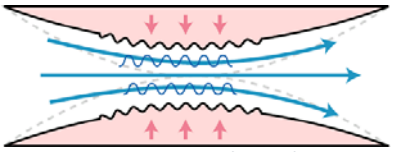
Flattened inspiratory flow time curve denoting partial obstruction

6

6

Snore

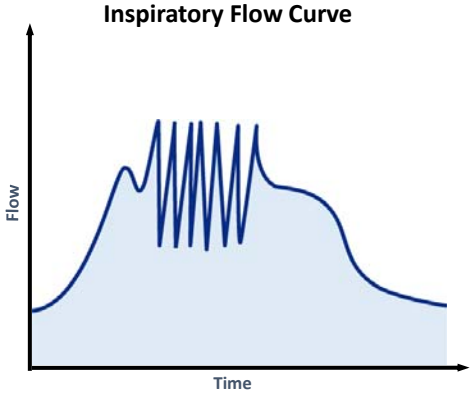
Patient's Airway



Vibrating airway (snoring)

Noisy partial obstruction

Inspiratory Flow Curve



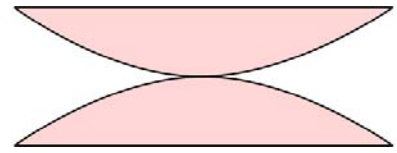
Snore superimposed on inspiratory flow time curve

7

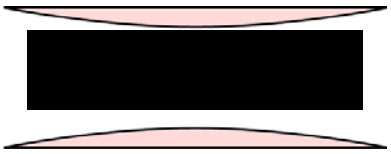
7

Apnea

Patient's Airway

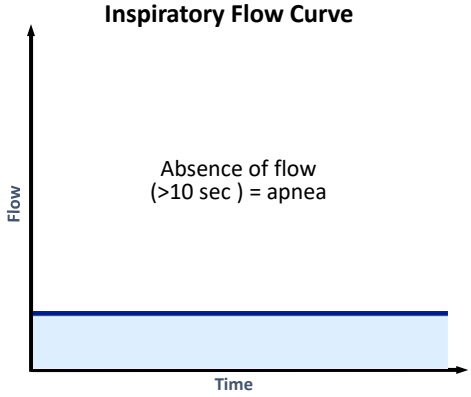


Complete airway collapse



Patent Airway without flow

Inspiratory Flow Curve

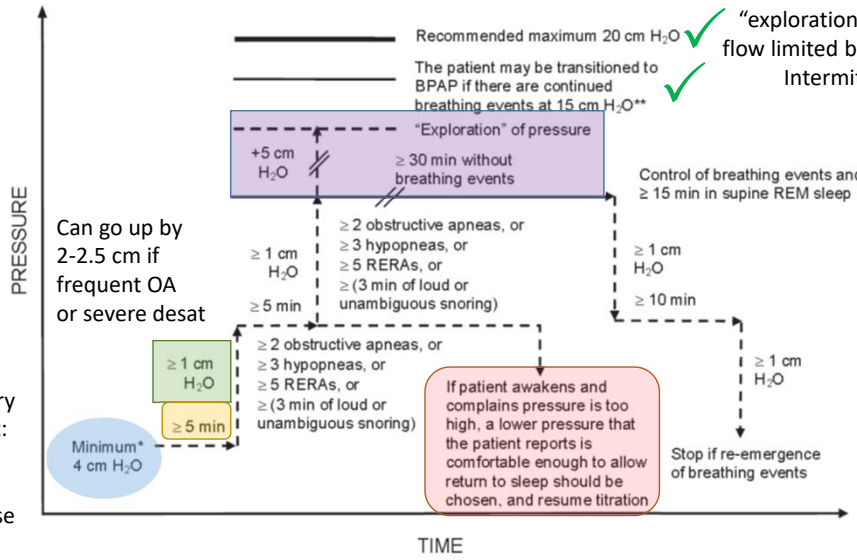


8

8

CPAP Titration Guideline

Journal of Clinical Sleep Medicine, Vol. 4, No. 2, 2008



"exploration" is for continued flow limited breathing, arousals, Intermittent snoring

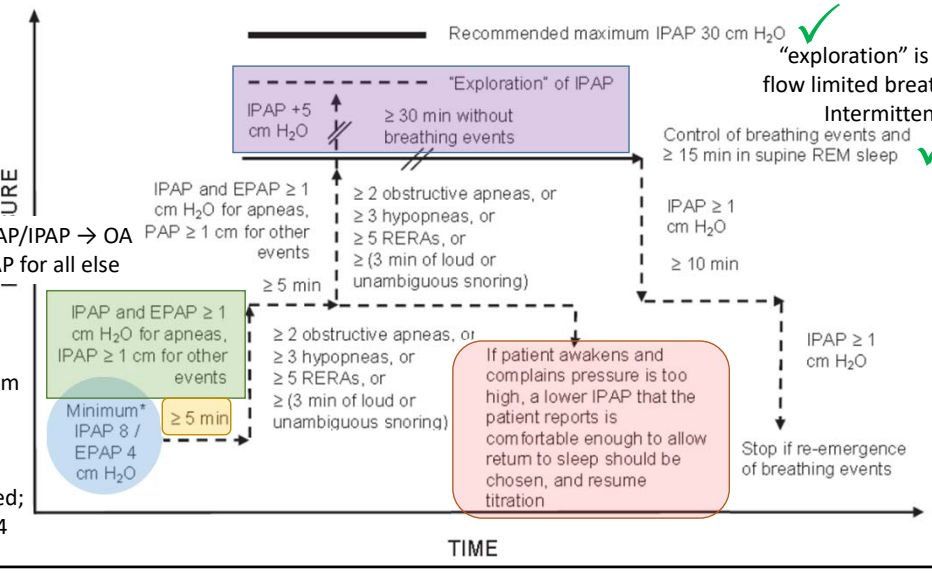
Can go up by 2-2.5 cm if frequent OA or severe desat

Discretionary Higher start:
Severe OSA
High BMI
Prior PAP use

9

Bilevel PAP Titration Guideline

Journal of Clinical Sleep Medicine, Vol. 4, No. 2, 2008



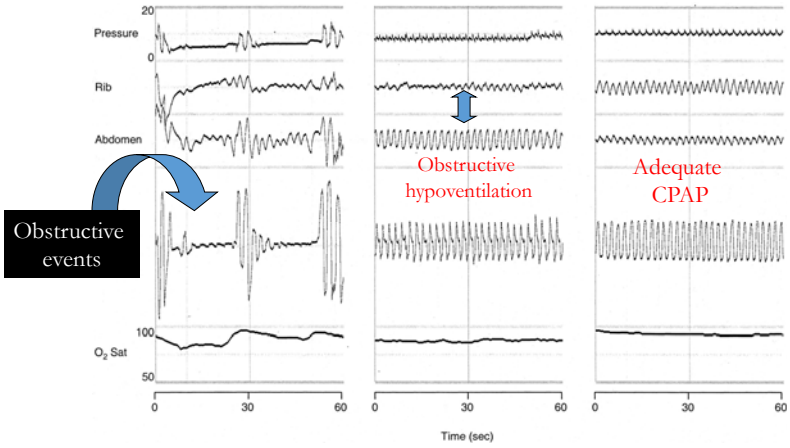
"exploration" is for continued flow limited breathing, arousals, Intermittent snoring

Increase EPAP/IPAP → OA
Increase IPAP for all else

If switching from CPAP to BPAP
Start EPAP at Pressure OAs Were eliminated;
Maintain PS = 4

10

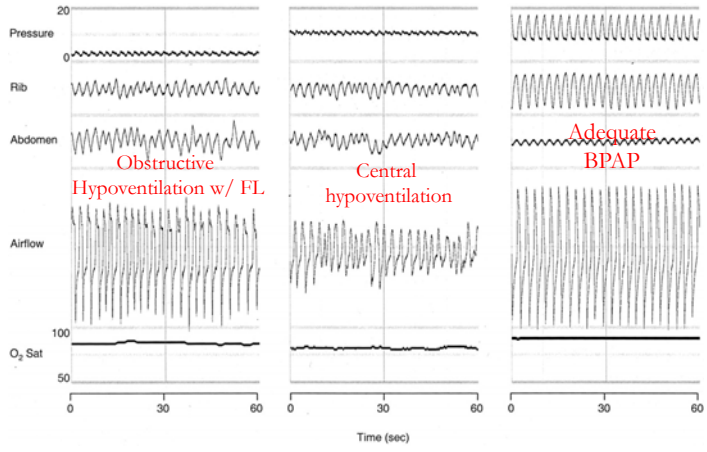
Data were obtained in a single patient



Berger, K. I. et al. Chest 2001;120:1231-1238

CHEST The Cardiopulmonary and Critical Care Journal

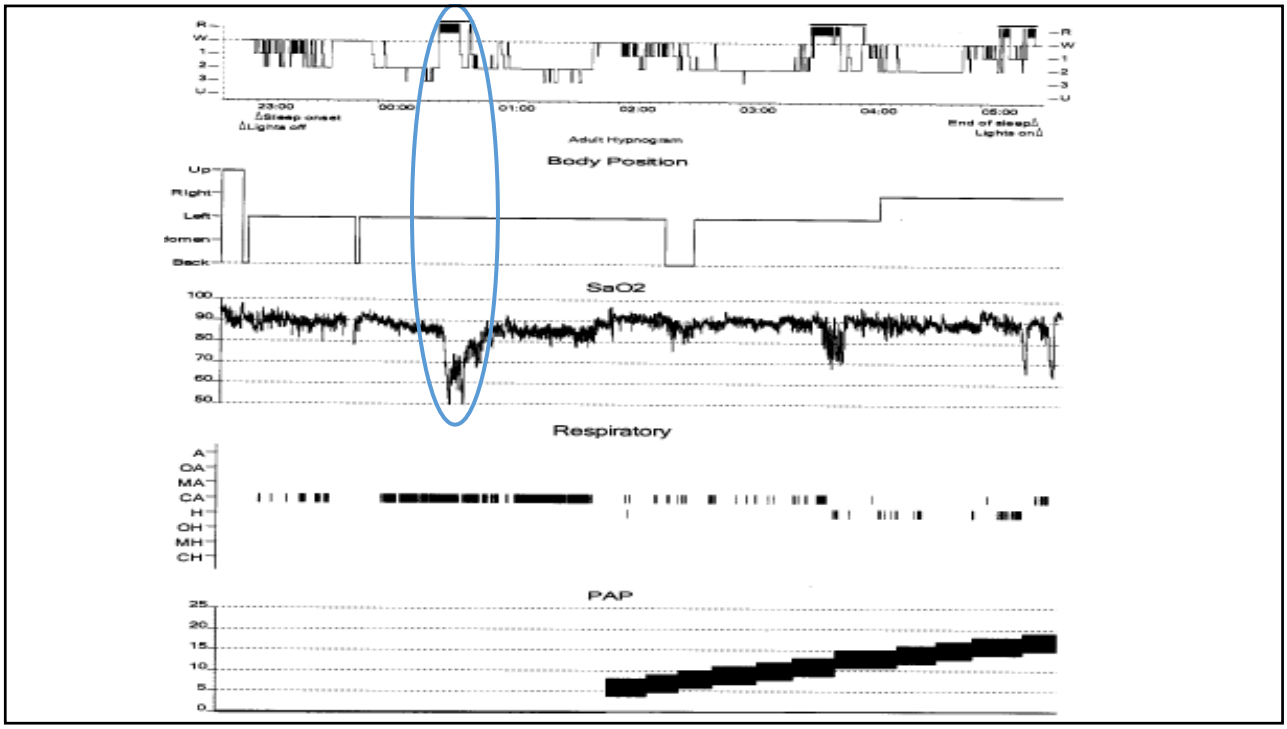
11



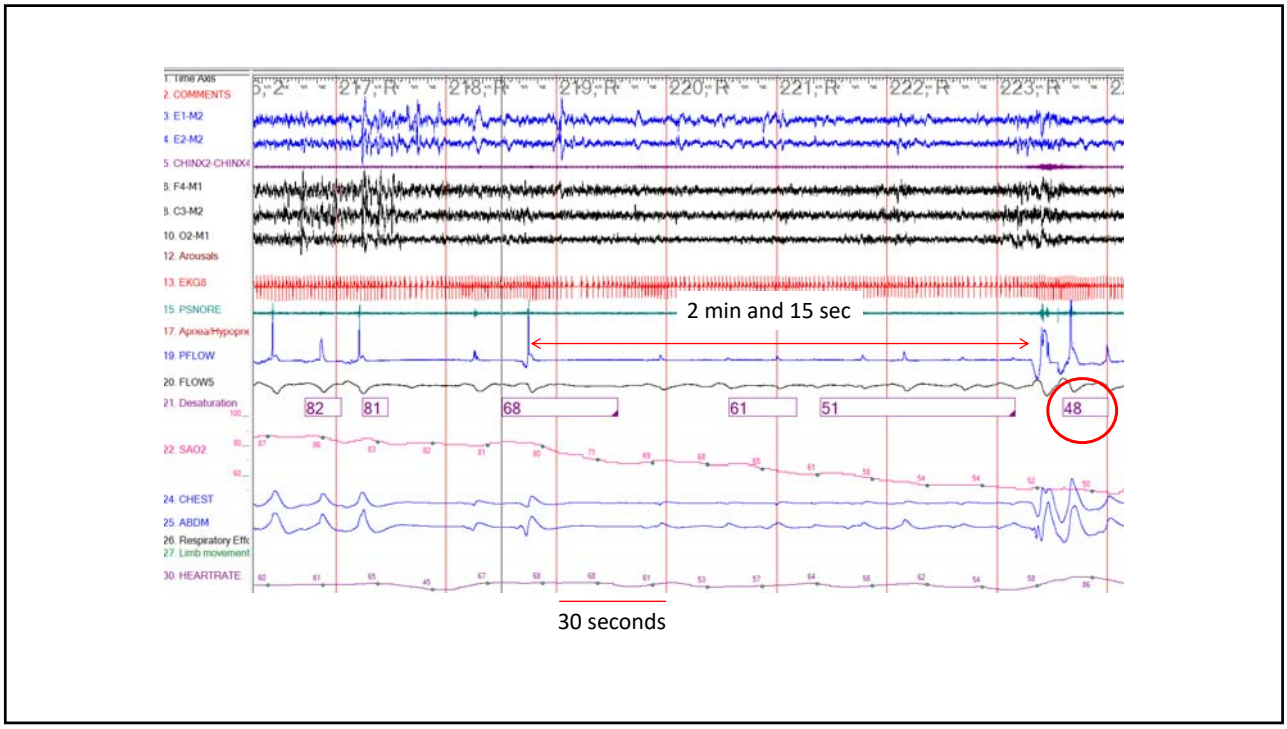
Berger, K. I. et al. Chest 2001;120:1231-1238

CHEST The Cardiopulmonary and Critical Care Journal

12


Adult Hypnogram
Body Position
Up
Right
Left
Back
SaO2
Respiratory
PAP

13


2 min and 15 sec
82
81
68
61
51
48
30 seconds

14

What is the cause of the prolonged sleep disordered breathing event?

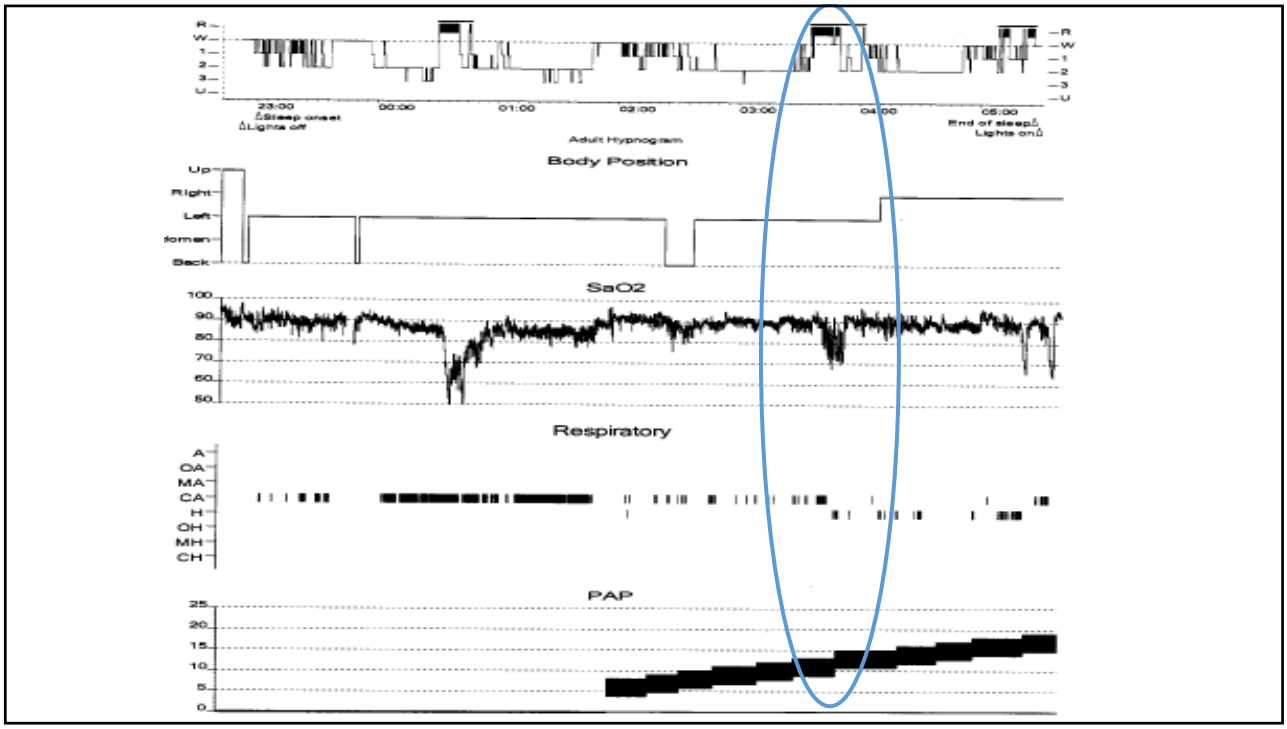
A. Excessive loop gain
B. Hypercapnia
C. REM related hypoventilation
D. Hypocapnia

15

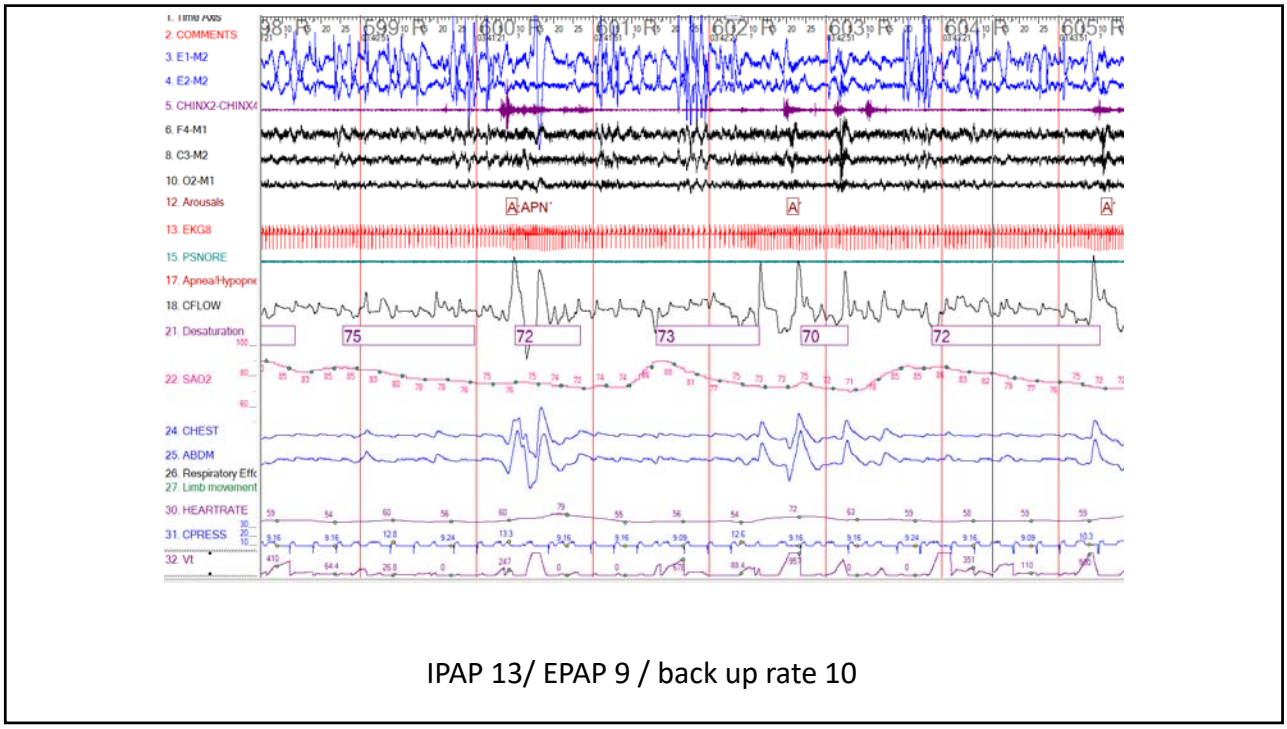
What is the cause of the prolonged sleep disordered breathing event?

A. Excessive loop gain
B. Hypercapnia
C. REM related hypoventilation
D. Hypocapnia

16



17



IPAP 13/ EPAP 9 / back up rate 10

18

What would you advise your sleep tech to do at this point?

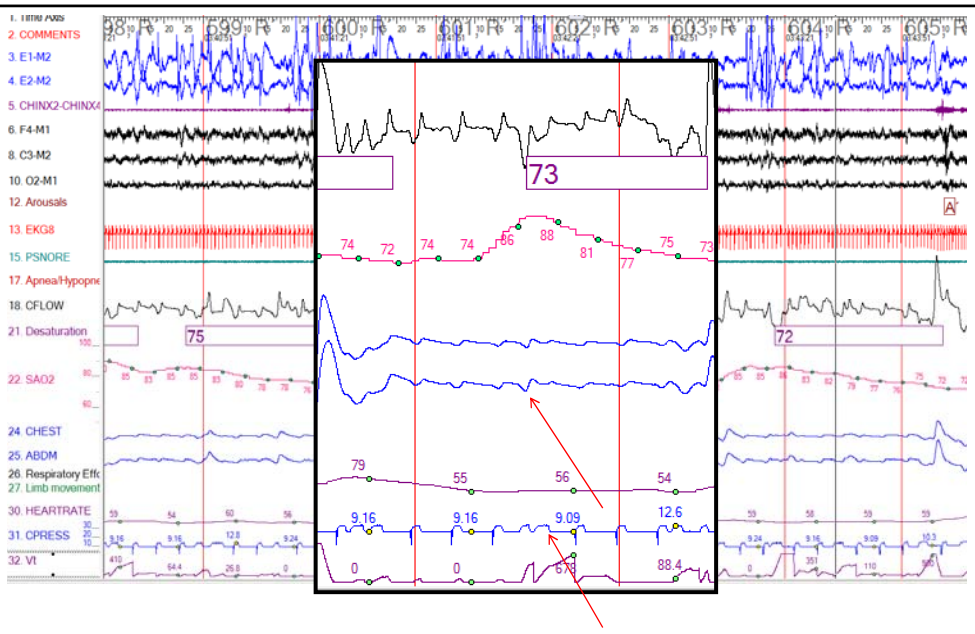
A. Increase IPAP only
B. Increase both EPAP and IPAP
C. Increase EPAP only
D. Increase back up rate

19

What would you advise your sleep tech to do at this point?

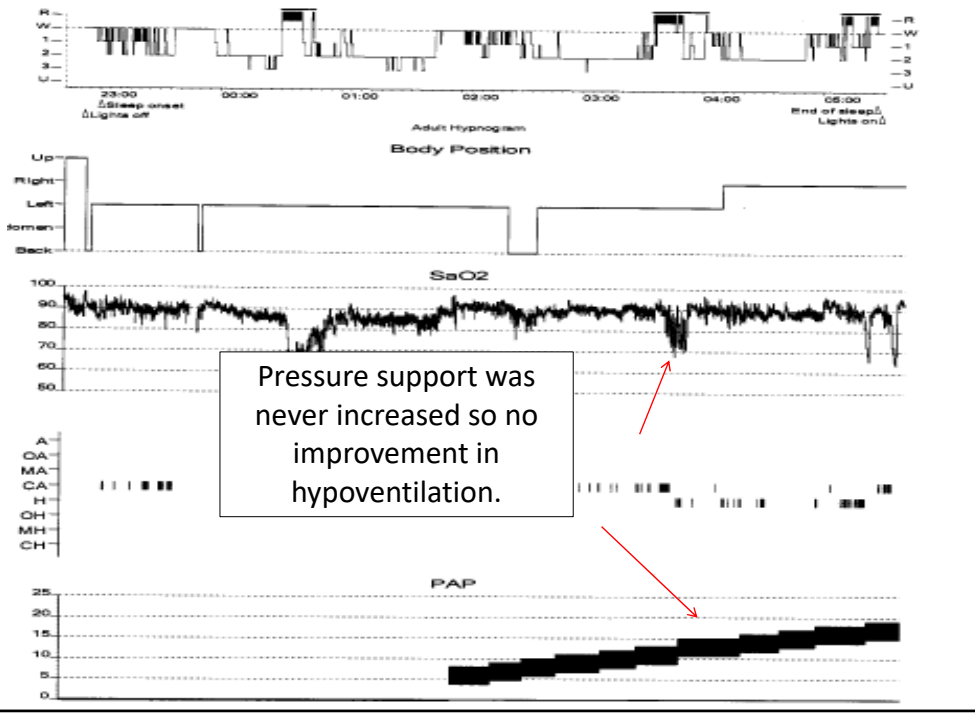
A. Increase IPAP only
B. Increase both EPAP and IPAP
C. Increase EPAP only
D. Increase back up rate

20



IPAP 13/ EPAP 9 / back up rate 10

21



Pressure support was never increased so no improvement in hypoventilation.

22

How do you treat HYPOVENTILATION?

1. INCREASE PRESSURE SUPPORT
2. INCREASE PRESSURE SUPPORT
3. INCREASE PRESSURE SUPPORT
4. INCREASE PRESSURE SUPPORT
5. INCREASE PRESSURE SUPPORT !!!!

23

How much pressure support?

- If possible, measure tidal volumes during PSG
- If not available, continue to increase PS until:
  - central apneas
  - maximum setting reached (25 – 30 cm H2O)*
  - Patient has risk for barotrauma

  * AASM recommends max of 20 cm H2O

24

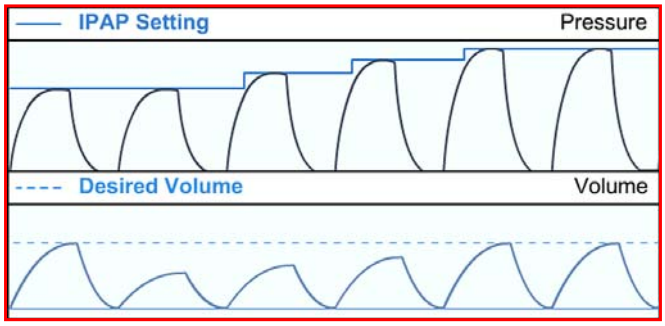
Using PAP/NIV in Obesity Hypoventilation Syndrome

- CPAP to treat obstructive events and flow limitation
- If persistent desats occur, not sawtoothing, (pay attention to REM) initiate BPAP
  - EPAP set at pressure required to eliminate obstructive apneas
  - IPAP set 4 cm above EPAP and increase as need to improve SpO_2
- If central apneas or persistent desats occur, add backup rate (set close to pt baseline rate)
- If SpO_2 remains low with BPAP – ST, add supplemental oxygen

25

Volume-Targeted Pressure Support

- AVAPS (Average Volume Assured Pressure Support)
  - Automatically adjusts IPAP to guarantee a target tidal volume



26

Adaptive Servoventilation vs. Average Volume-Assured Pressure Support

- ASV
  - Adds PS as necessary to maintain patient's breathing at level c/w recent past
- AVAPS / IVAPS
  - Acts mostly as a bilevel device
    - Attempts to provide a constant TV, adjusting PS
- ASV if breathing usually normal but fluctuates rapidly, AVAPS for breathing NOT normal at baseline

27

AVAPS (Respironics)

- Average volume assured pressure support

Parameter	Suggested Setting
Mode	AVAPS
EPAP	Set to Resolve OSA
IPAP min	Variable
IPAP max	25 cm H2O
Target TV	8 ml/kg
Inspiratory Time (Ti)	1.5
Rise Time	Variable
Resp Rate	2-3 below resting RR rate

IVAPS (Resmed)

- Intelligent volume assured pressure support

Parameter	Suggested Setting
Mode	IVAPS
EPAP	Set to Resolve OSA
IPAP min	Variable
IPAP max	25 cm H2O
Target TV	Based on height (See chart)
Inspiratory Time (Timin and max)	1.5
Rise Time	Variable
Resp Rate	Typically 12 to 15

28

AVAPS vs. bilevel PAP/ST in OHS

- RCT of 50 OHS patients to bilevel PAP/ST vs. AVAPS
  - 34% enrolled during an acute-on-chronic respiratory failure
- At three months there was no group differences in:
  - $PaCO_2$ and PaO_2
  - Epworth and QOL
  - Decrease in BMI
  - Improvement in FVC

Murphy PB et al. Thorax 2012 2012;67(8):727-34

29

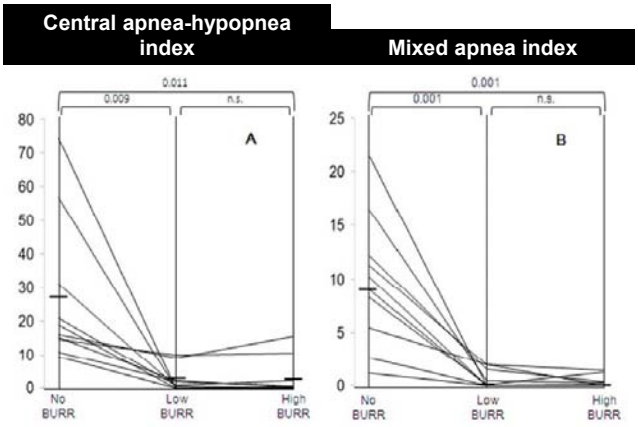
Need for a back-up rate with NIV in OHS

- 10 stable patients with OHS on long-term treatment with NIV with mean IPAP 20.5 and mean EPAP of 9 and back-up rate of 14
  - Patients had been previously titrated during an episode of acute-on-chronic resp failure
- Mean home adherence to therapy was 7.25 h/night
- 3 consecutive NIV PSGs with random order of modes
  - Spontaneous mode
  - Low back-up rate (11 breaths/min)
  - High back-up rate (20 breaths/min)

Contal O, et al. Chest 2013;143(1):37-46

30

Central and Mixed events with / wo a BUR

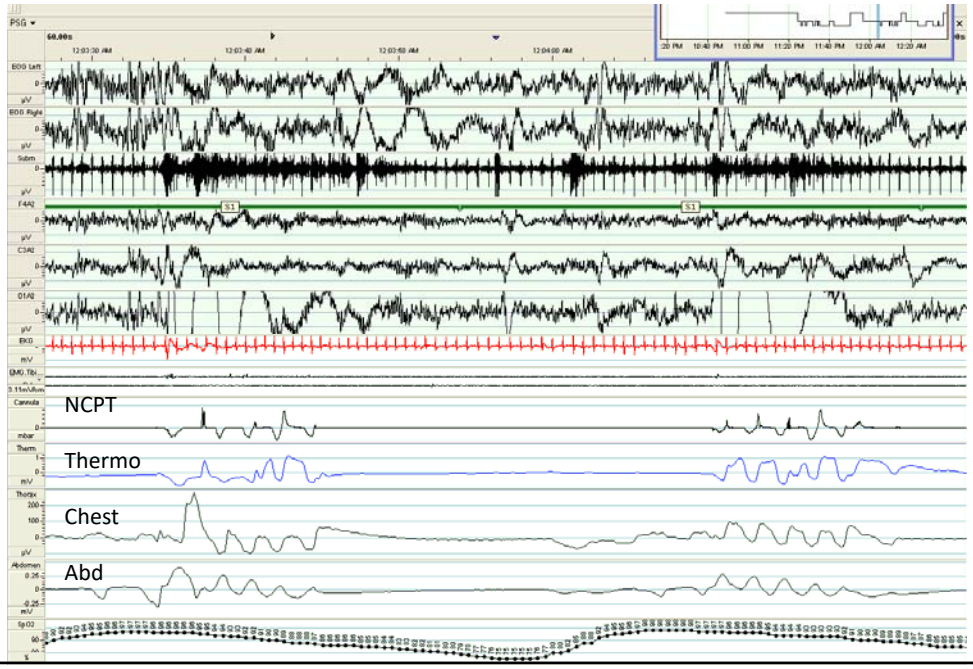


Patient ventilator asynchrony and comfort on ventilator not different in the three mode

Contal O, et al. Chest 2013;143(1):37-46

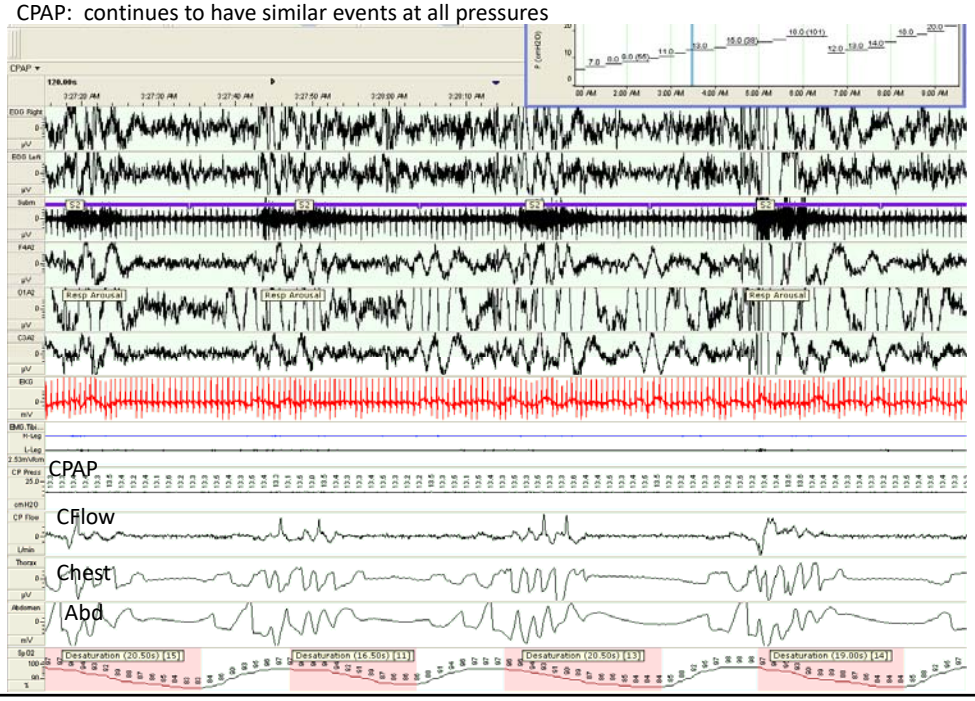
31

Baseline: has recurrent events as seen here



32

CPAP: continues to have similar events at all pressures



33

Central Sleep Apnea

Etiologies:

- Treatment Emergent
- Heart failure
- Stroke
- Opioid use
- Idiopathic

34

Treatment Emergent CSA (TECSA)

- Predominantly obstructive events on a diagnostic study with persistence or emergence of central events during PAP therapy
- Central events not better explained by another disorder
- Reported prevalence 2%-20%
- Significance and long term outcomes unknown

American Academy of Sleep Medicine. International classification of sleep disorders, 3rd ed. Darien IL: American Academy of Sleep Medicine, 2014

35

Treatment Emergent CSA (TECSA)

- Development of CSA during therapy for OSA
  - Unmasking previously-existing CSA
  - Overtitration of CPAP
    - Hering-Breuer reflex
  - More effective ventilation with relief of obstruction
- Can occur with other forms of therapy as well (eg OA)

Hoffman and Schulman, Chest 2012; 142(2): 517-22.

36

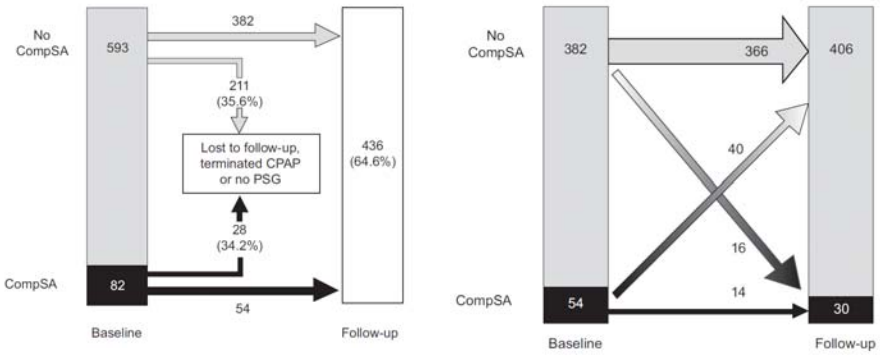
TECSA may go away or start with CPAP therapy

- Prospective study
- Utilized full PSG (no split nights, no HSAT)
- 675 pts
- Polysomnography
  - Baseline
  - On therapeutic CPAP
  - 3 months after CPAP therapy

Eur Respir J 2011;38:329-37

37

CompSAS may go away or start with CPAP therapy



Eur Respir J 2011;38:329-37

38

Natural History of TECSA

- Analysis of US telemonitoring device data at week 1 and week 13 after CPAP initiation
  - 3.5% of patients with CSA (≥5/h)
  - Of those 55% were transient, 25% persistent and 19.7% emergent
- Similar results seen in systematic review of literature:
  - 1/3 of patients with TECSA have persistence of TECSA
  - Up to 4% of patients without TECSA can develop delayed TECSA

Chest 2017 Oct;152(4):751-760
Ann Thorac Med 2018;13(2):86-91

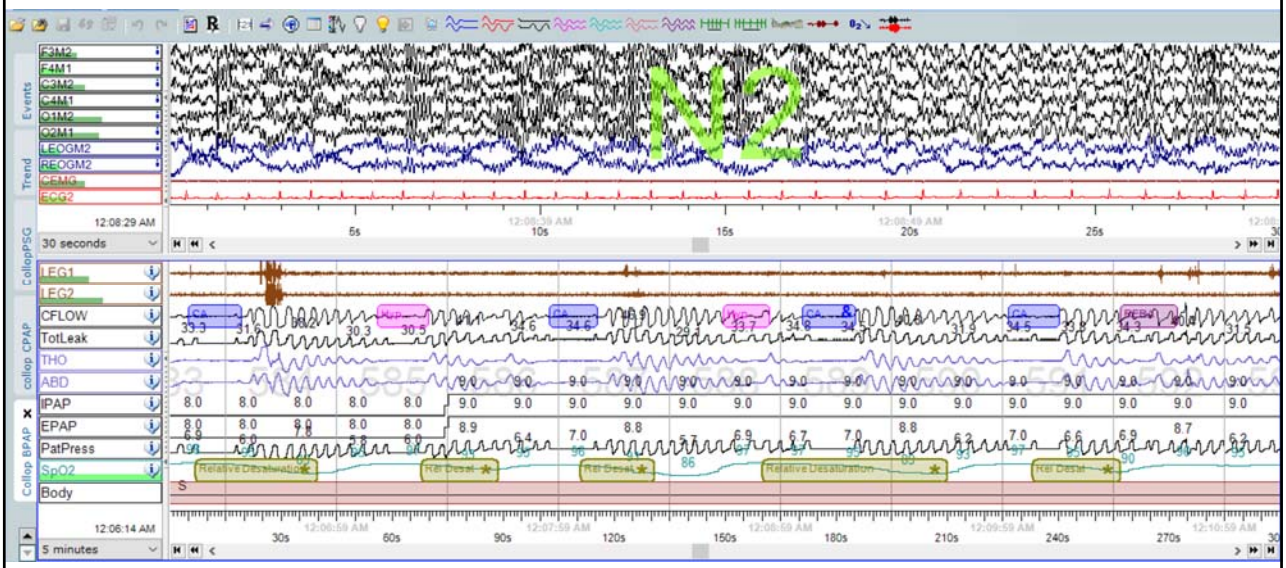
39

Case SM

- Underwent PSG for sleepiness and snoring
- H/O hypertension
- Baseline AHI 20; CAI 5
- Nadir SpO2 86%

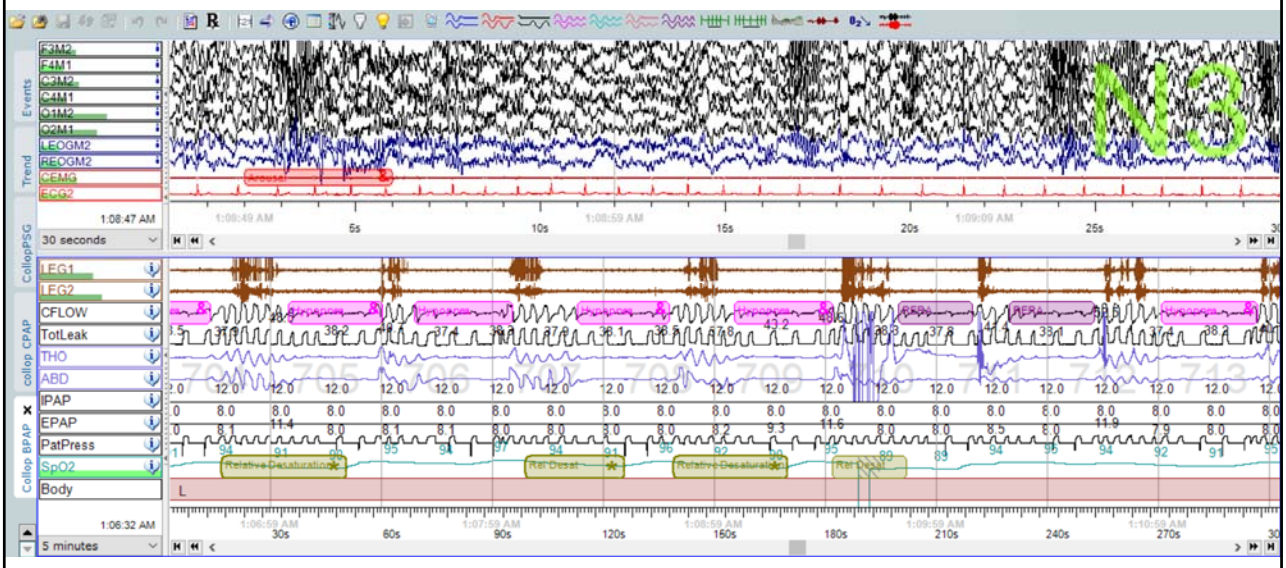
40

On CPAP to start (9)



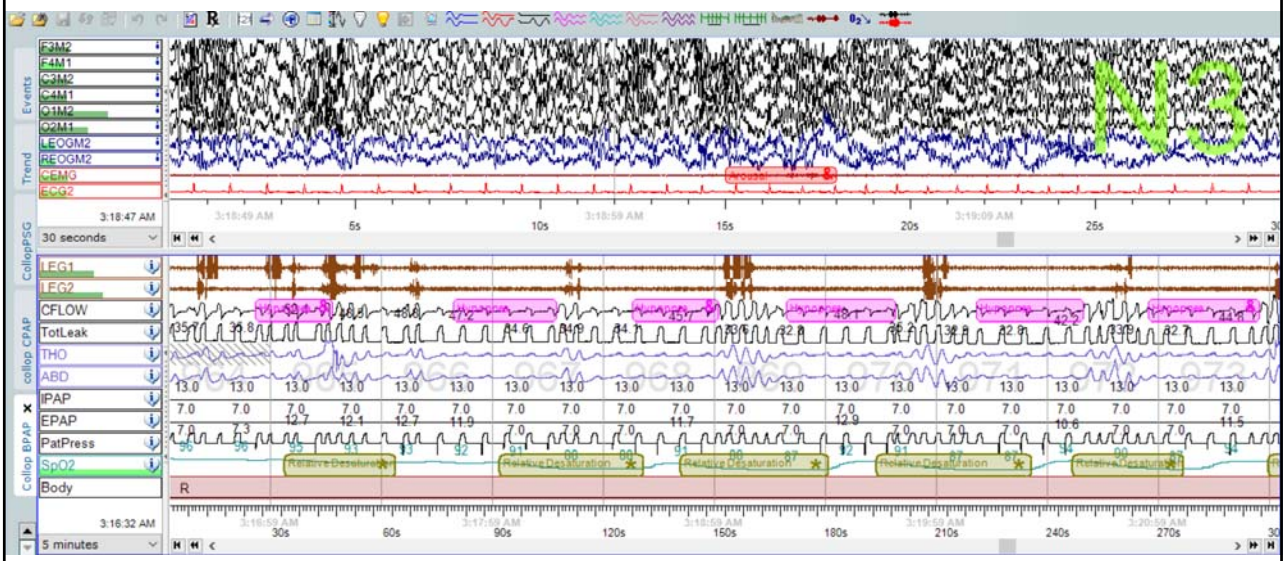
41

Switched to bi-level PAP with BUR (12/8, BUR 12)



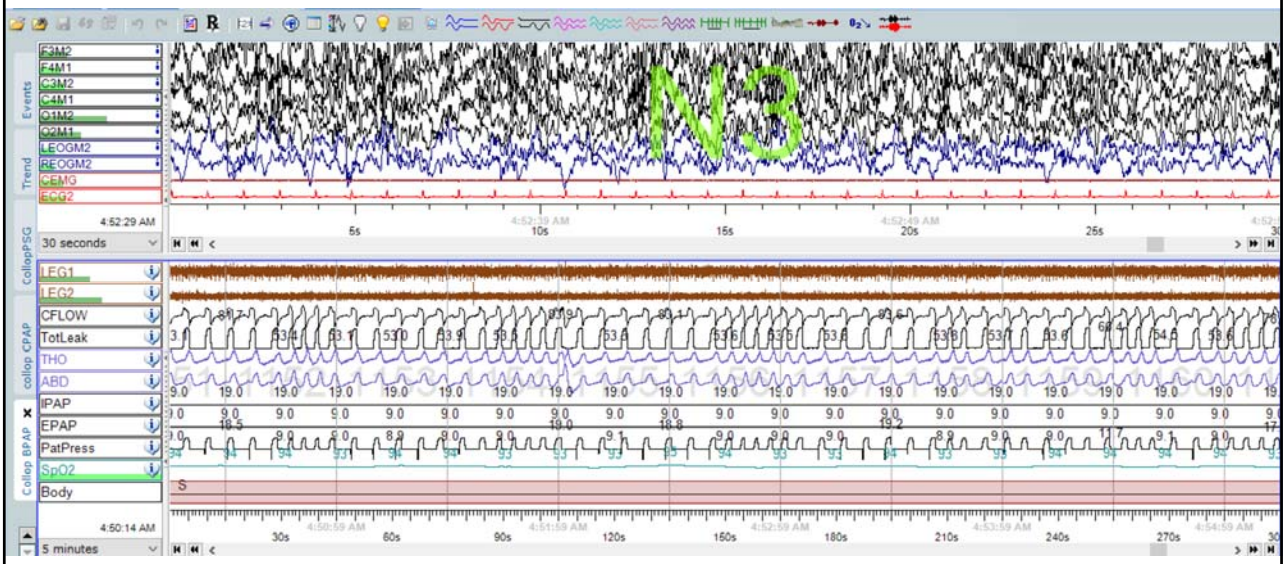
42

Continue to increase bilevel PAP (13/7)



43

Continue to increase bilevel PAP (19/9, BUR 12)



44

Why is back up rate important?

- If patient does not initiate a breath within a time window the device triggers a breath within a set time window.
- Example- Patient set up at BR-10
- Time window to initiate breath or cycle time= 60/BR)=60/10=6 secs.
- Also important to determine IPAP time. (IPAP time/Ti is usually 30% or 40% of the cycle time).

45

ASV for TECSA SUMMARY

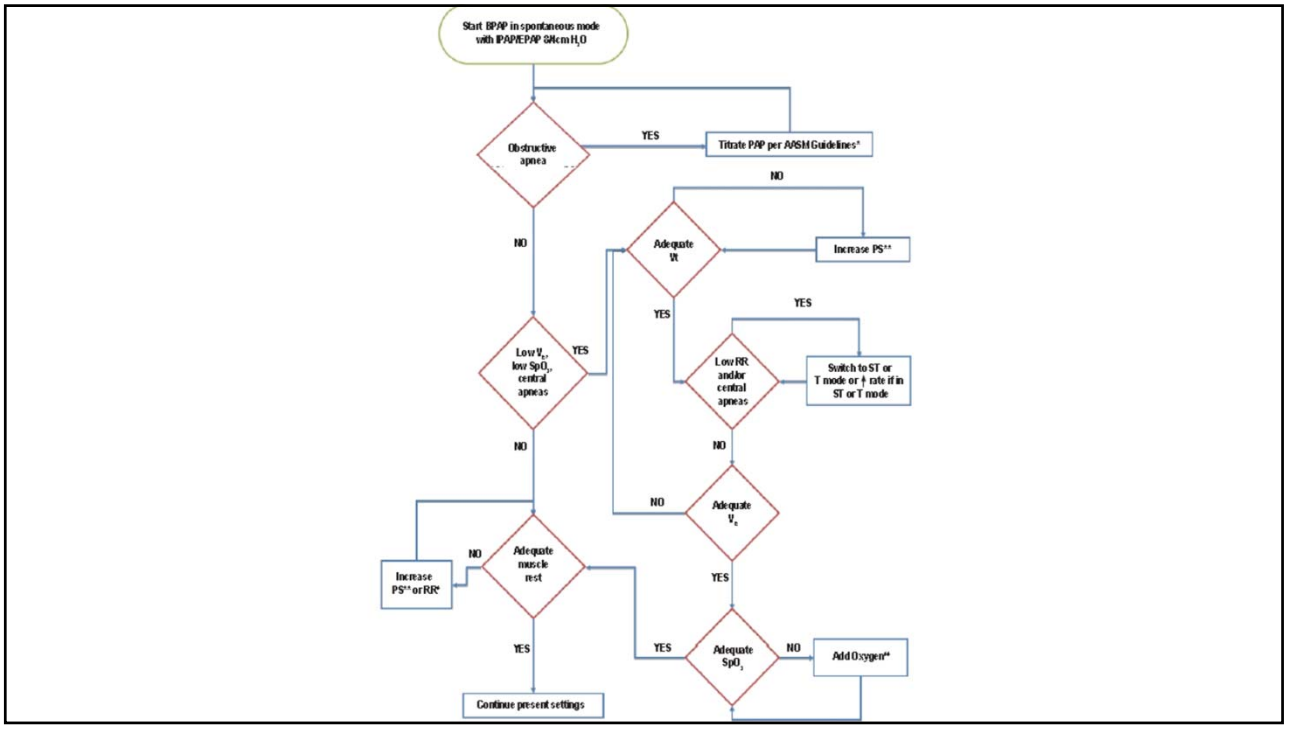
- TECSA is rare and usually transient
- Long term effects unknown but can lead to symptoms
- Optimizing PAP therapy to control TECSA improves sx
- ASV should be attempted in persistent TECSA despite CPAP

46

Bilevel PAP with Backup Rate vs ASV for CSA

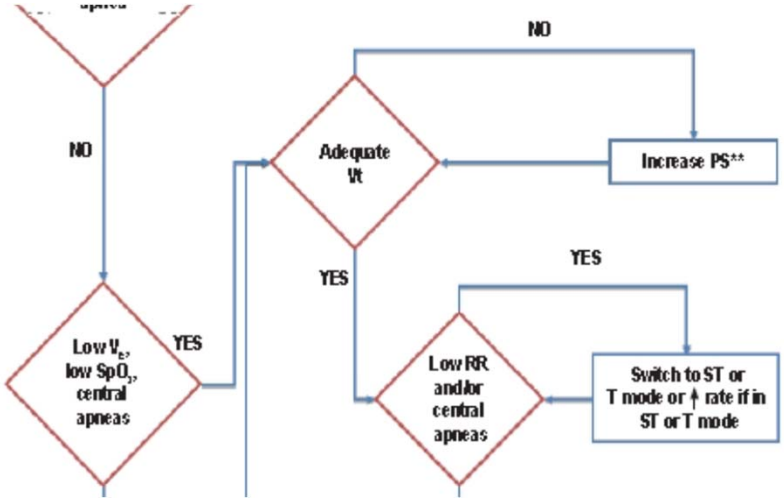
- Adaptive servoventilation works best for Periodic Breathing / CSR
- Bilevel PAP / BUR may be used in:
  - Primary CSA
  - Opioid induced CSA
  - CHF with low ejection fraction
  - Obesity hypoventilation syndrome
  - Neuromuscular / Spinal cord injury patients unable to trigger inspiration

47



48

For Central apneas: BUR should be set at 2 breaths/min below stable rate (≥ 10 breaths per minute)

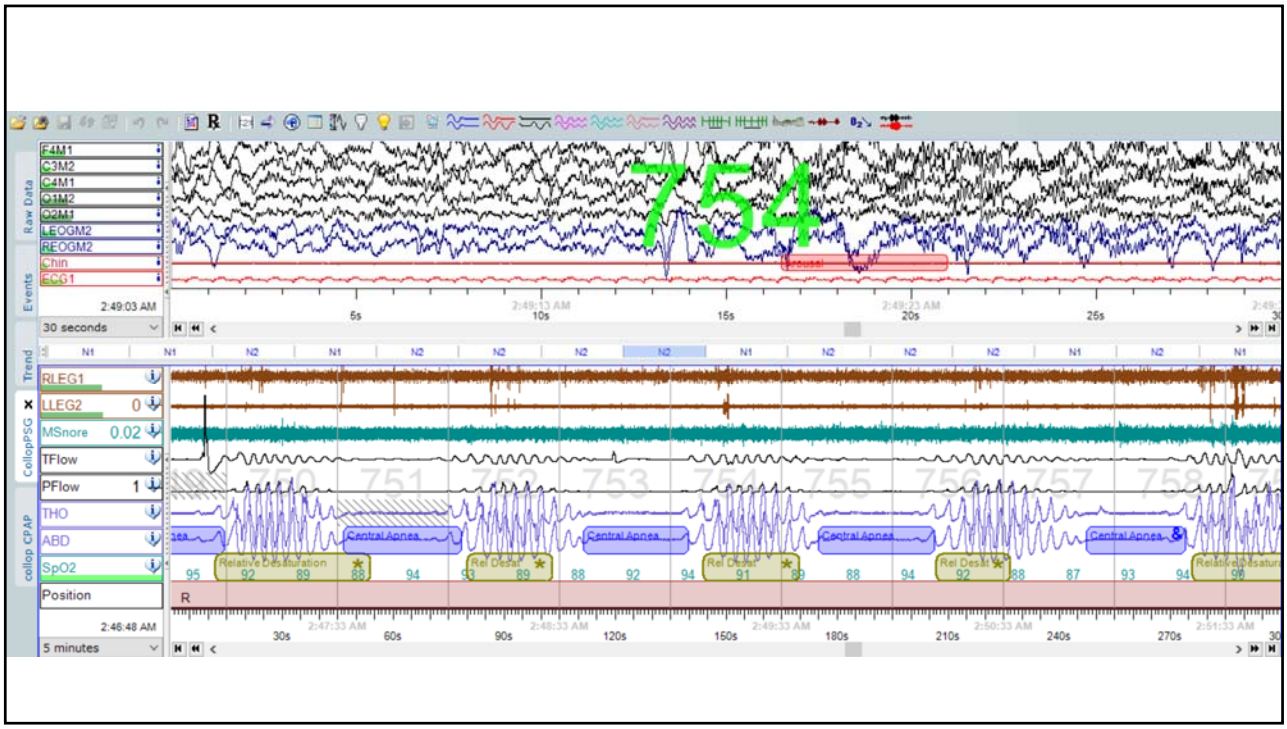


49

Case SC

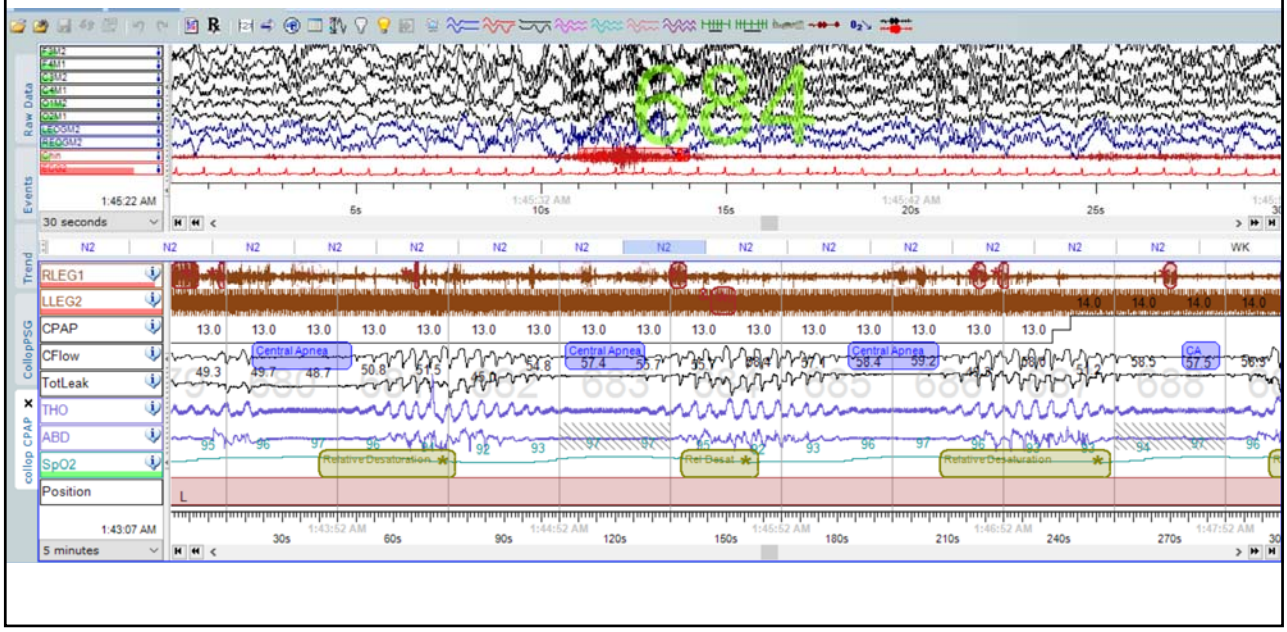
- h/o afib, sick sinus syndrome, pacemaker, HFpEF, TIA
- Underwent PSG for snoring, sleepiness, poor sleep
- Baseline AHI =51.7, CAI 21.3
- Nadir SpO2 83%

50



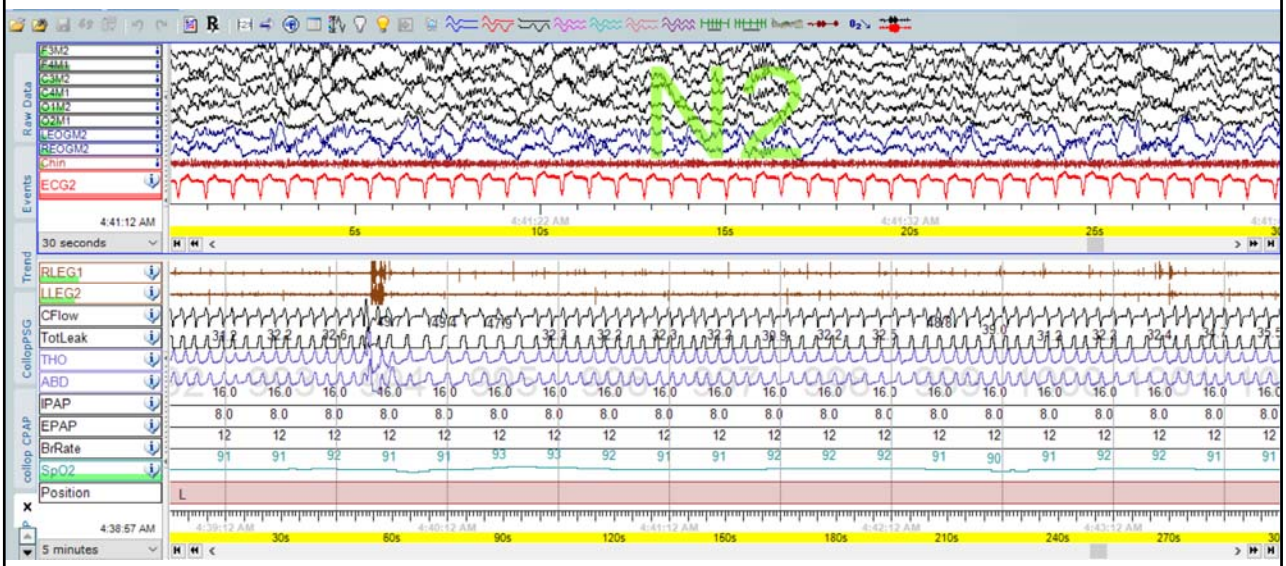
51

Returns for PAP Titration



52

Switched to bilevel PAP with BUR



53

Adaptive Servoventilation (ASV)

- Non invasive automated Bilevel Positive Airway Pressure Device
- Aims to stabilize respiratory drive by varying amount of pressure support
- Also called anticyclical ventilation (to patient's own respiratory drive)

54

ASV: how does it work?

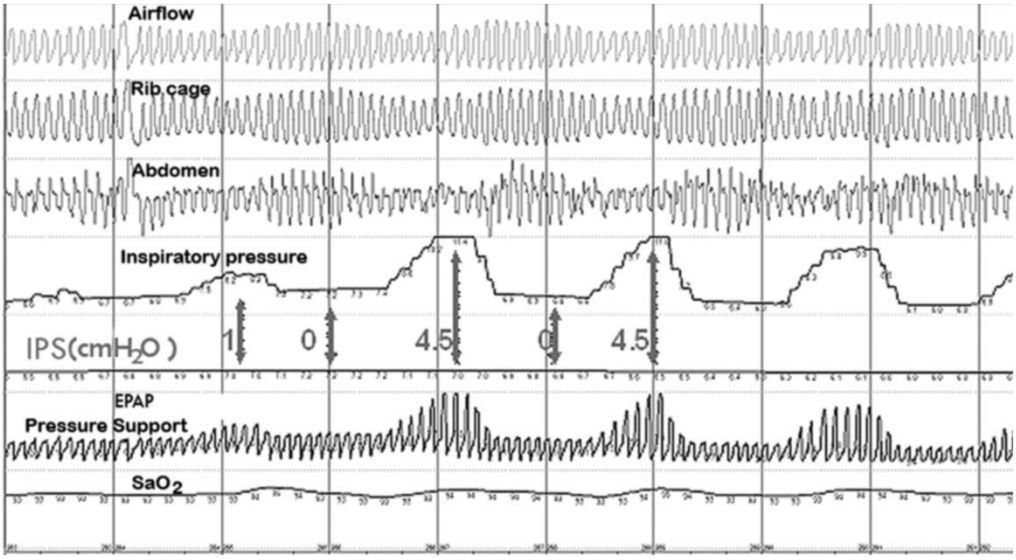
- Continuously tracks patient's airflow (3-4 minute window)
- Calculates average weighted minute ventilation (Resmed) or peak flow (Respironics)
- Device adjusts respiratory parameters to maintain 90% of calculated MV or peak flow

55

ASV: how does it work?

- EPAP, set or auto titrating: maintains upper airway patency
- Variable pressure support (PS min, PS max): targets 90%-95% of minute ventilation/peak flow to stabilize ventilatory drive
- Back-up rate: kicks in during central sleep apnea (CSA) events to maintain ventilation and stabilize drive

56



CHEST 2014; 146 (2): 514 - 523

57

Comparing Device Settings

	Aircurve 10 ASV (Resmed)	Dreamstation BiPAP auto SV (Respironics)
Target parameter	Average weighted MV (3 min)	Average weighted peak insp. flow (4 min)
Threshold	90% MV	95% peak flow
Max Pressure	25 cm of water	30 cm of water
Min/Max EPAP range	4-15 cm of water	4-25 cm of water
Min PS	0-6 cm of water	0-5 cm of water
Max PS	5-20 cm of water	0-26 cm of water
RR	Auto (15 bpm)	Off, auto or range 4-30 bpm
Apnea	MV drop ≥75% for≥10s	Flow drop ≥80%
Hypopnea	MV drop ≥50% for ≥10s	Flow drop ≥40%
Rise time	Automatic	Levels 0-3

58

Indications

- Hypocapnic or eucapnic CSA
  - Treatment emergent CSA (TECSA)
  - CSA in Heart Failure with preserved Ejection Fraction (HFpEF)
  - Opioid related CSA (O-CSA)

59

Contraindications

- Predominant CSA in Heart Failure with reduced EF <45%
- Hypoventilation (OHS, NM disease, Restrictive lung dz, chest wall deformities, moderate-severe COPD)

60

ASV Titration Protocol

- Changed from **EPAP 5-15 cm H2O, PS 0-15 cm H2O**
- EPAPmin at 4cm H2O; set EPAPmax at 10cm H2O; set PSmin to 0cm H2O; set PSmax to 15cm H2O; Max Pressure to 25cm H2O; Rate to "Auto"
- Set Bi-Flex to 2 (this may be adjusted further to improve patient comfort) Note: If the patient is having difficulty with pressure tolerance, increase BiFlex to 3.
- Increase EPAP min by 2cm H2O if **recurrent** obstructive apneas are present or the patient feels that the pressure is inadequate; limit =10cm H2O; wait a minimum of 20 minutes to assess effect before making another change
- If obstructive apnea still persists after EPAP min is at 10cm H2O, increase the EPAPmax to 15 cm H2O
- Increase PSmin by 2 cm H2O for hypopneas and RERAs to a max of 10 cm H2O.
- Observe for **unresolved** central apneas; Auto Rate targets the patient's spontaneous breathing rate, but technologists should observe for potential inadequate breathing rates;. If central apneas are noted, set fixed rate to a minimum of 12 bpm or 2 below the resting wake respiratory rate
- If the device is not appear to be sensing correctly, go in the room to check for mask leaks.

61