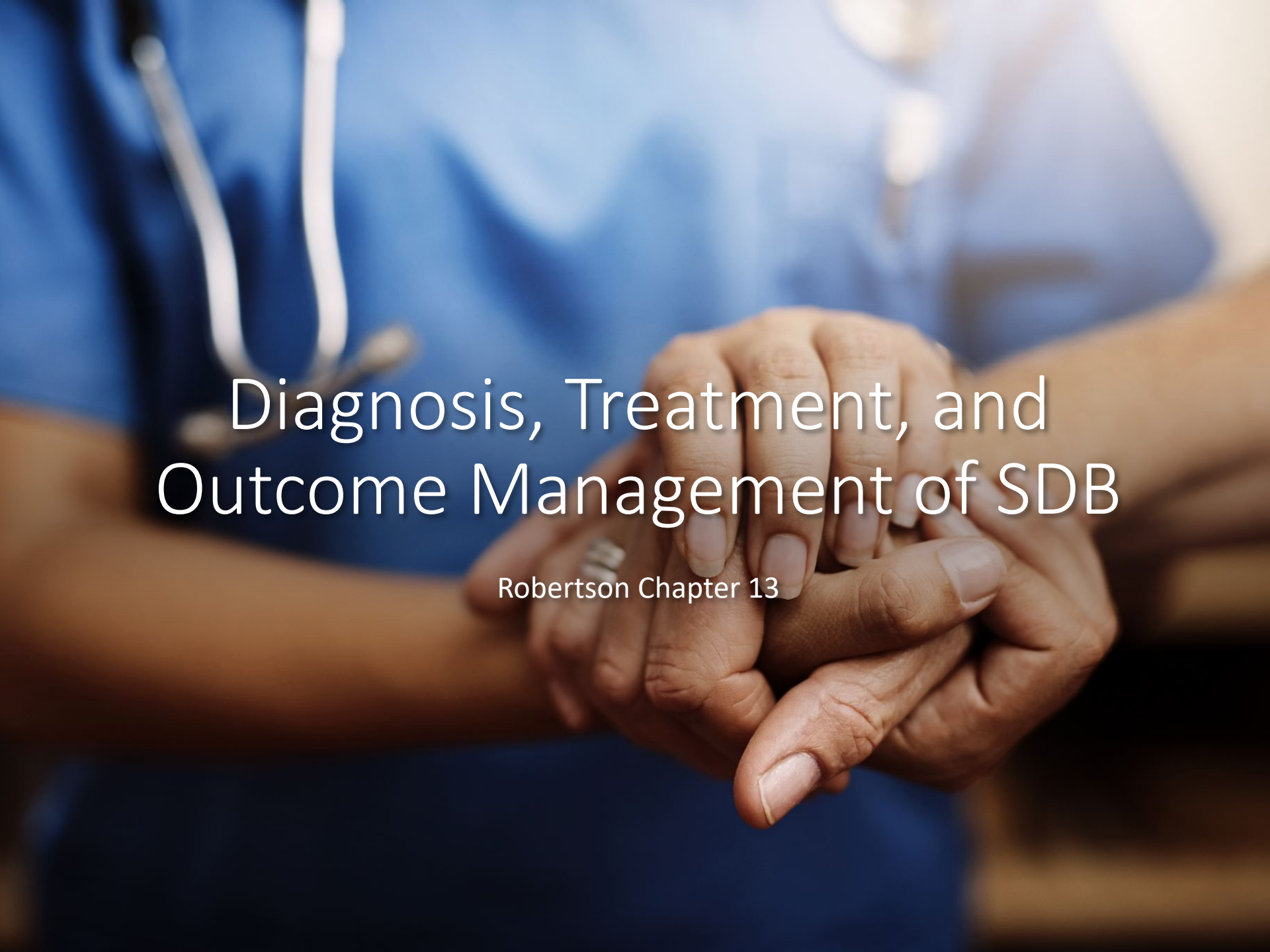


Diagnosis, Treatment, and Outcome Management of SDB

Robertson Chapter 13

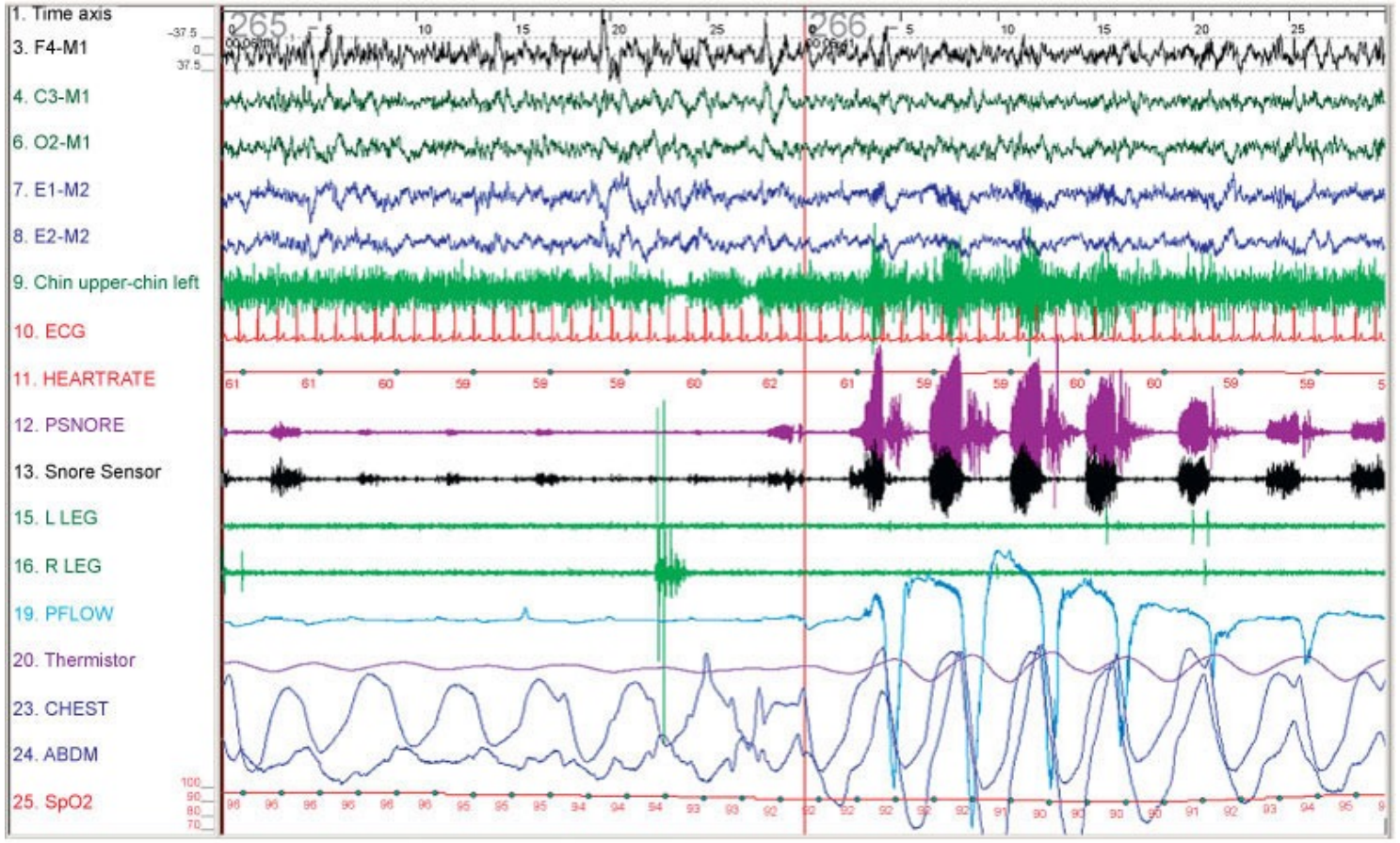
Introduction

- OSA = Most common diagnosis in sleep lab
- Up to 25% have at least mild-moderate SDB
- Since 1985, CPAP has been gold standard of treatment for OSA
- Split-night testing has grown in popularity
  - Usually sleep studies are 1 night diagnostic and 1 night titration
- Titration = Manual or auto manipulation of PAP setting to treat SDB
- CSA and complex apnea are challenges to treat
- Must have competent understanding of treatment options and be good at decision making

Respiratory Event Recognition

- Standardized acceptable recording mechanism for respiratory effort in sleep testing is RIP
- Gold standard for measuring respiratory effort is esophageal manometry
- Paradoxical breathing
  - Proper fit of RIP belts is essential for detecting paradoxical breathing
  - Polarity of belts must be adjusted during normal breathing to detect paradoxical breathing in sleep
  - Upper airway obstruction typically presents with paradoxical belt movements

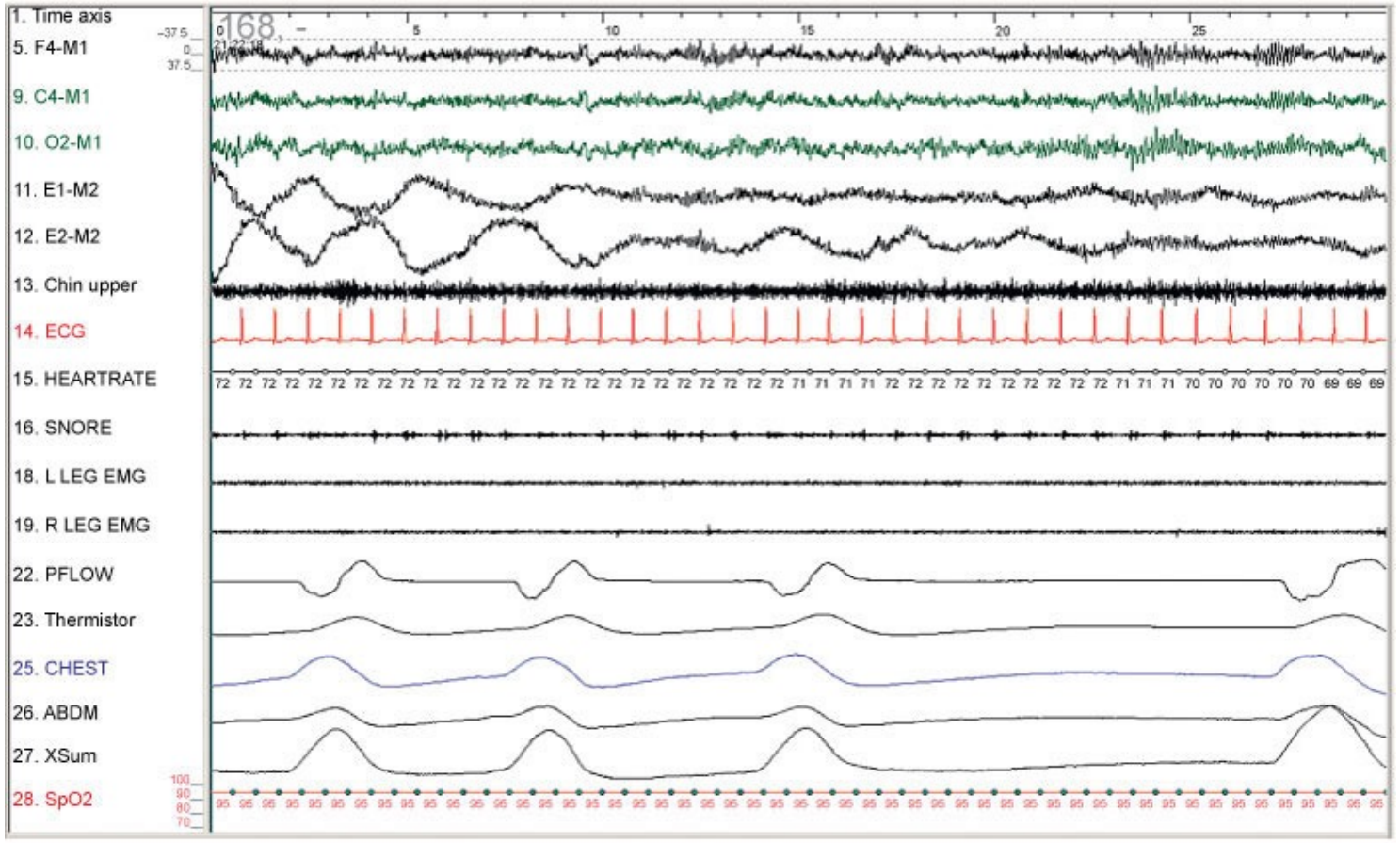
Paradoxical Breathing



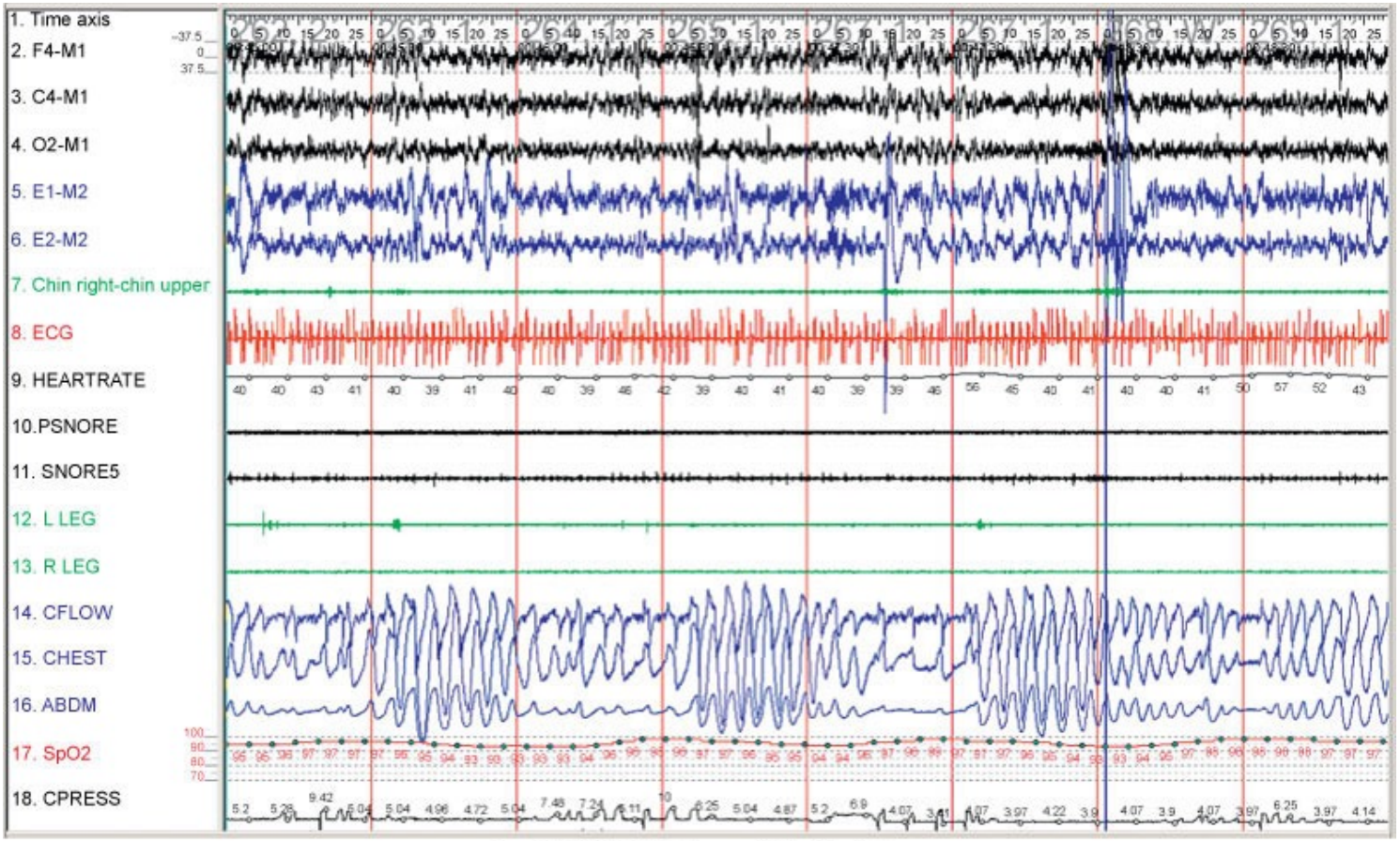
Central Apnea

- Little or no respiratory effort in addition to little or no airflow
- Common in patients with cardiovascular disease or on opioid medications
- Cheyne-Stokes respiration
  - Waxing and waning (or crescendo-decrescendo) pattern of breathing
  - May occur during wake and sleep
  - 45% of stable, optimally treated CHF patients have an AHI > 26
  - Treatment of SDB improves LV systolic function

Central Apnea

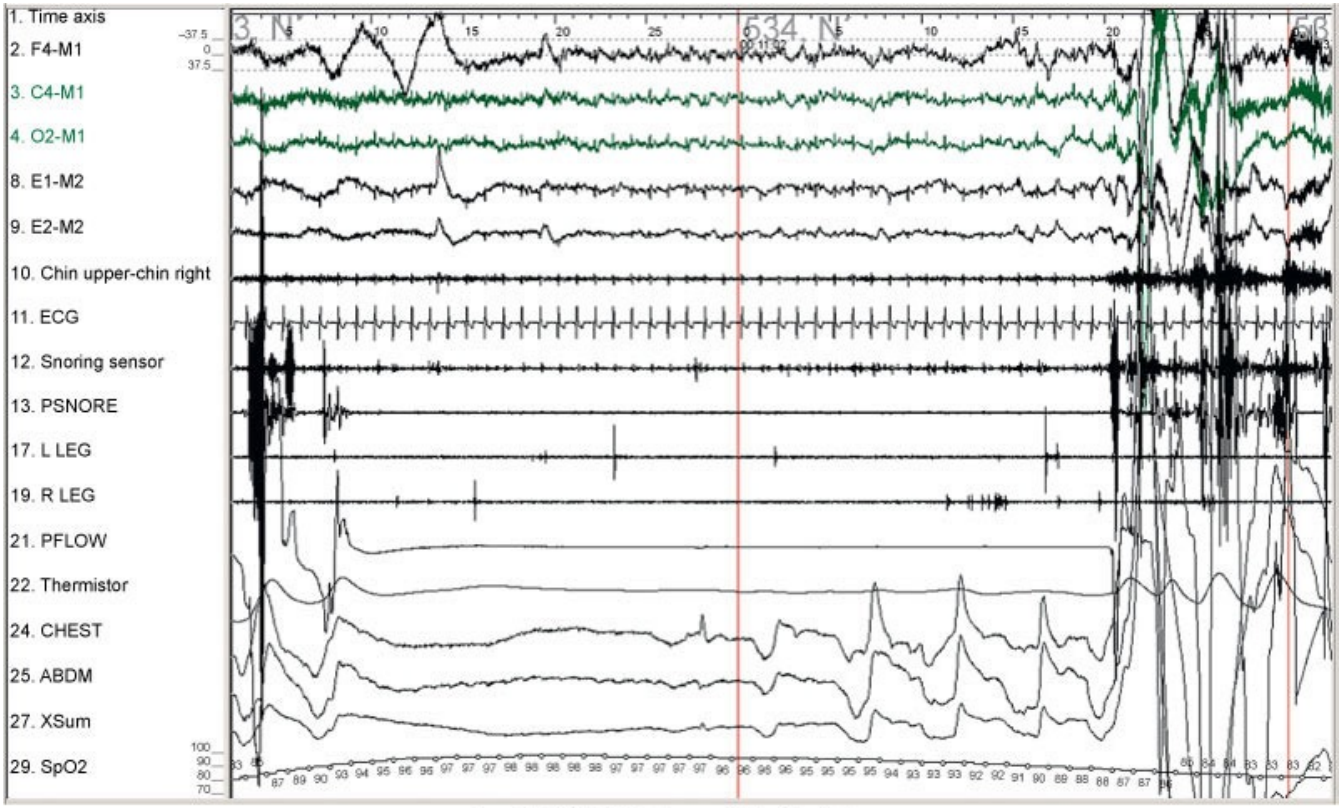


Cheyne-Stokes Respiration



Mixed Apnea

- Starts as central and converts to obstructive



Other Breathing Issues

- Hypopnea
  - Respiratory event lasting a minimum of 10 seconds with a ≥ 30% reduction in peak signal excursion compared to baseline and associated with a ≥ 3% (recommended rule) or ≥ 4% (CMS/acceptable rule) oxygen desaturation
- Noninvasive positive-pressure ventilation (NPPV)
  - Used for those with complicated breathing patterns due to restriction of thoracic ribcage in addition to upper airway obstruction
    - Examples: Significant obesity, neuromuscular disease

CPAP

- Identifying characteristics of OSA:
  - Loud snoring
  - Gasping for air
  - Disrupted sleep
  - Tiredness during waking hours
- PAP is most common treatment for resolving airway obstruction
  - CPAP is therapy of choice for SDB
- CPAP creates pneumatic splint for obstructed airway
- End exhalation is critical point in respiratory cycle where therapeutic levels of pressure must be applied

Partial Airway Obstruction

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CPAP

- Need to educate patient on SDB, his/her health due to SDB, and necessity of treatment
- Importance of therapy must be stressed to patient
- Compliance and adherence can be a challenge
  - Compliance = Measurement of specific usage determinants
  - Adherence = Extent to which patient continues the agreed-upon mode of PAP under limited supervision when faced with conflicting demands

Guidelines for Titrating CPAP

- AASM developed guidelines
  - Industry standard for CPAP titration
- Titration can be started at 4-5 cm H2O
  - Starting low can help prevent over-titration of less severe patients
- If patient has respiratory events, a 1-2 cm H2O increase helps to open the airway more and will decrease the number and severity of the events
- Continue to increase pressure to alleviate obstructive events

Titration Variations Based on Age

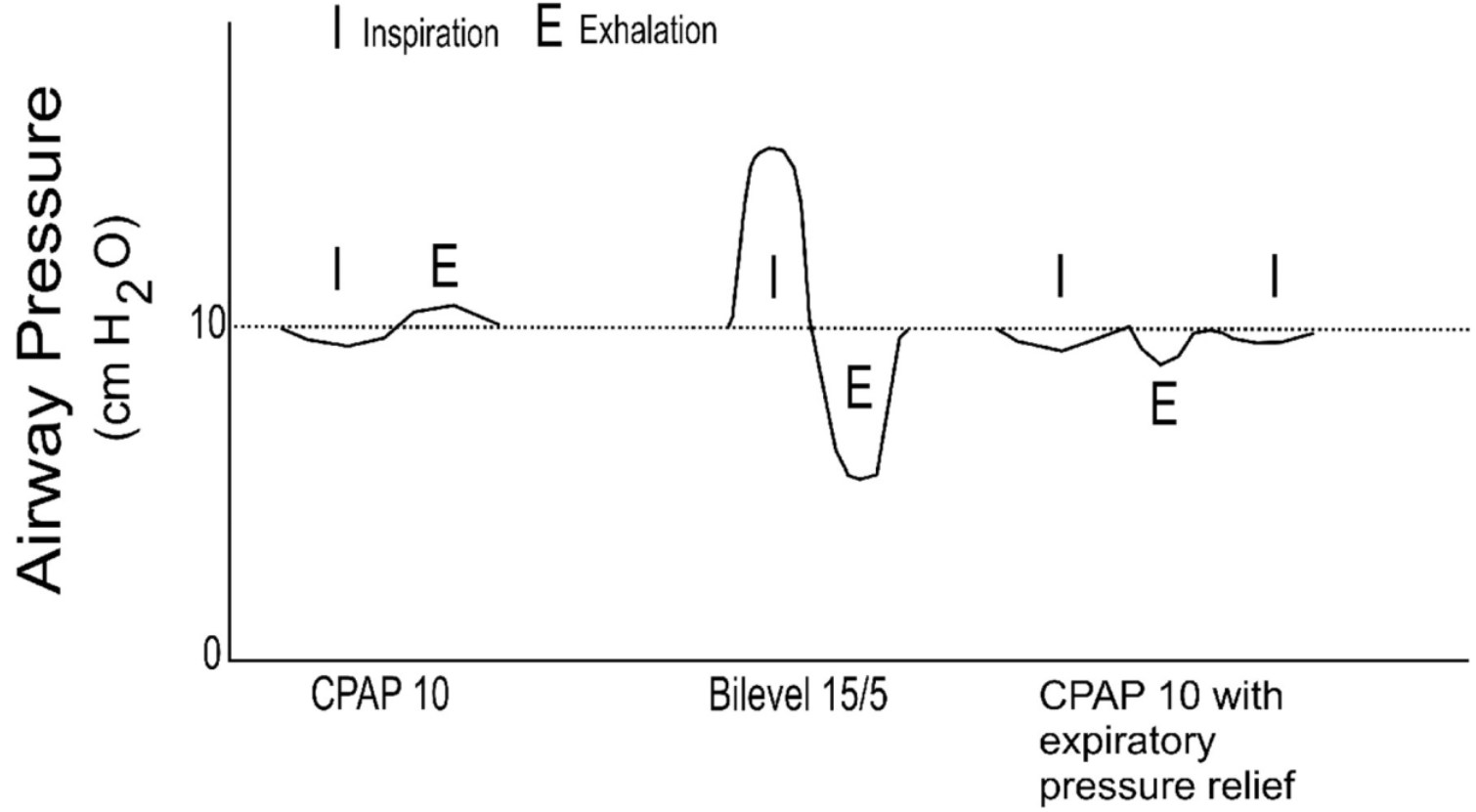
- AASM recommendations for adults (≥12 yrs):
  - Initial pressure of 4 cm H2O
    - Higher starting pressure can be used for elevated BMI or re-titrations
  - Maximum CPAP pressure of 20 cm H2O
  - 1 cm H2O increments following each 5-minute period should be continued until > 30 min observed without respiratory events
- AASM recommendations for patients <12 yrs:
  - Maximum CPAP pressure of 15 cm H2O

Titration Guidelines

- Adults (≥ 12 years):
  - Increase if at least 2 obstructive apneas observed
  - Increase if at least 3 hypopneas observed
  - Increase if at least 5 RERAs observed
  - Increase if at least 3 minutes of loud or unambiguous snoring observed
- < 12 years:
  - Increase if at least 1 obstructive apnea observed
  - Increase if at least 1 hypopnea observed
  - Increase if at least 3 RERAs observed
  - Increase if at least 1 minute of loud or unambiguous snoring observed

Comfort Features for CPAP

- Ramp-delivered pressure increases
- Expiratory pressure relief
  - EPR on ResMed
  - C-Flex for Respironics



Potential Complications and Side Effects of CPAP

- Barotrauma = Pressure trauma to chest wall
- Epistaxis = Nosebleed
- Rhinorrhea = Runny nose
- Nasal bridge sore
- Skin irritation and breakdown
- Nasal drying
- Rhinitis and nasal congestion
- Aerophagia = Intake of air into stomach
- Central apnea

Types of CPAP Leaks

- Intentional leak = Controlled port leak
  - Washes out CO2 and prevents rebreathing
- Unintentional leak = Mouth leak or mask leak
  - Try to refit or readjust mask
  - Add chinstrap
  - Switch to full face mask
  - Increased risk of aerophagia, abdominal distention, and vomiting
  - Use heated humidification to reduce nasal resistance

Goals of a Proper Titration

- Observe all positions and sleep stages
- Resolve snoring
- Minimize arousals and cardiovascular effects
- Avoid excessive pressure
- See improvement in gas exchange and oxygenation

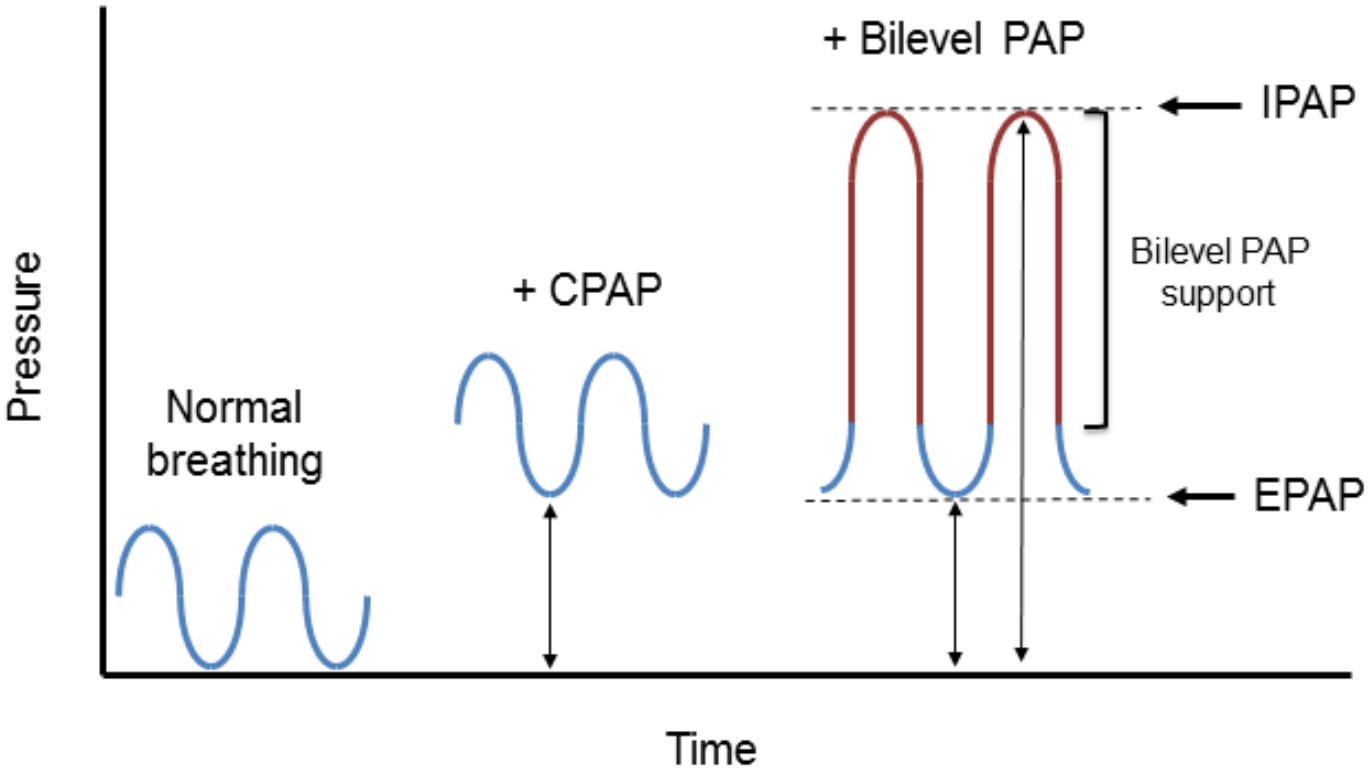
Not always possible

Complex Apnea

- Over-titration can cause CPAP emergent central apneas (complex apnea)
- Central apneas only present in titration
  - Not present in diagnostic study
- About 15% of SDB patient have this
- AASM recommends switching to BiPAP with backup rate

Spontaneous Bi-level PAP (BiPAP-S)

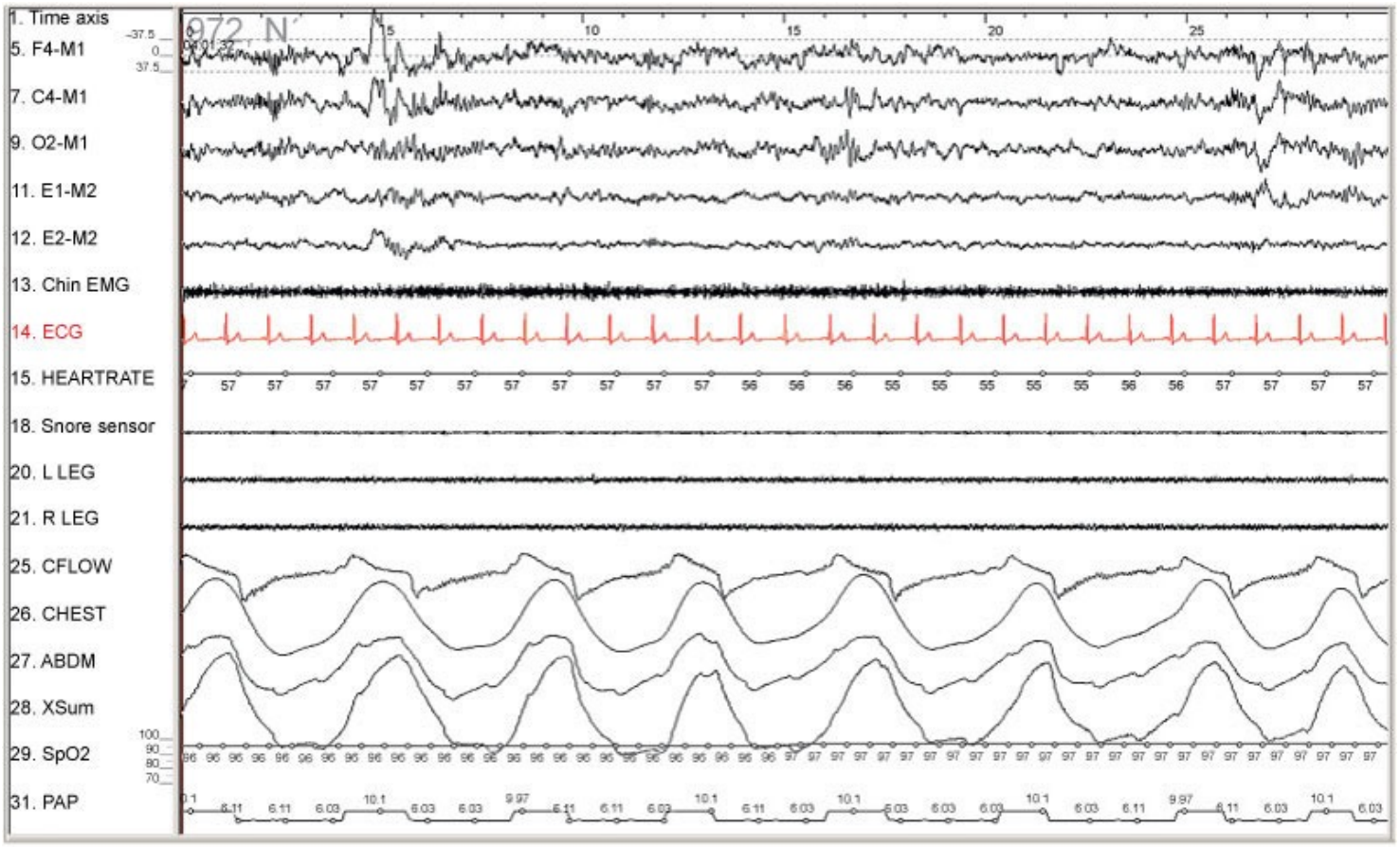
- Indications for transition from CPAP
  - Patient needs high therapeutic pressure
  - Persistent obstructive events once at CPAP of 15 cm H2O
  - Can't adjust to exhaling against CPAP pressure
  - CPAP caused increase in PCO2



Spontaneous Bi-level PAP (BiPAP-S)

- Guidelines for BiPAP-S titration
  - Set separate IPAP and EPAP pressures
    - The greater the pressure support (IPAP-EPAP difference), the greater the VT
  - Starting pressure should be 8/4 cm H2O
    - Minimum IPAP-EPAP gap = 4 cm H2O
    - Maximum IPAP-EPAP gap = 10 cm H2O
    - Maximum IPAP pressure for patients < 12 yrs = 20 cm H2O
    - Maximum IPAP pressure for patients ≥ 12 yrs = 30 cm H2O
  - Goal = Reduce RDI to < 5 during at least 15 min of REM sleep in supine position

Spontaneous Bi-level PAP (BiPAP-S)



CSA, CSR, and Complex Apnea

- Patient needs time to adjust to each pressure change
  - Allow chemoreceptors time to reset
- If central apneas predominant in diagnostic study, titration approach may differ
- Goal of titration = Normalize minute ventilation, minimize exaggerated response to blood gas changes, and allow patient CO2 level and breathing pattern to stabilize

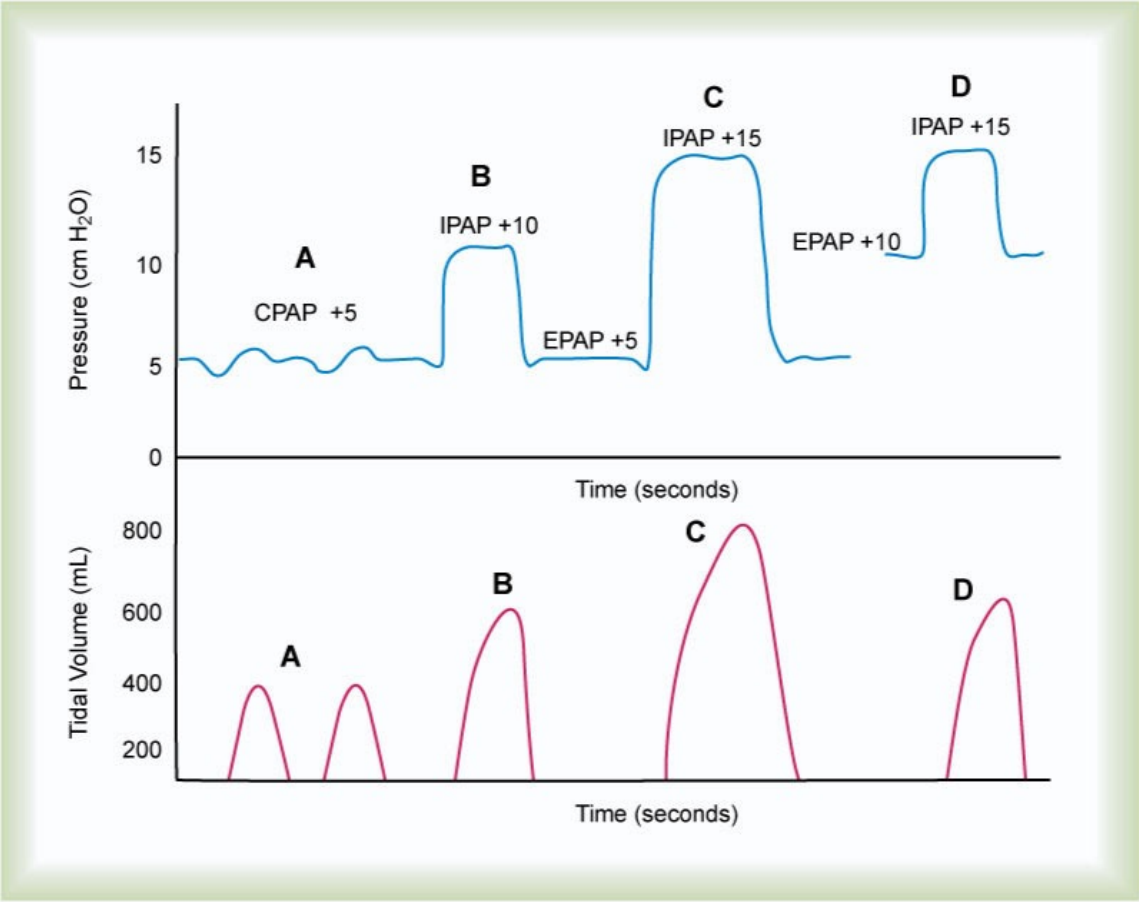
BiPAP as Noninvasive Ventilation for CSA

- Indications for use
  - 1st line of therapy for CSA may be BiPAP with a backup rate
  - 1st look to see if a low-level CPAP resolved obstructions to determine starting pressure
- Guidelines for titration
  - S/T mode on BiPAP = Breaths delivered are synchronized with spontaneous breathing until patient stops breathing and backup rate kicks in
    - Rate is set as timed breaths in the absence of spontaneous breathing
      - Usually set as 2 breaths below patient's resting RR while awake

BiPAP as Noninvasive Ventilation for CSA

- Guidelines for titration (continued)
  - Initial IPAP and EPAP may be higher for increased BMI, retitration, or air hunger
  - When switching from CPAP, set EPAP at titrated CPAP level that resolved obstructive events
  - Mask fit is critical for success of therapy

Comparison of CPAP to BiPAP



From Kacmarek RM, et al: Egan's fundamentals of respiratory care, *ed 10, St Louis, 2013, Elsevier.*

Adaptive Servo Ventilation

- Indications for use
  - Mode of ventilation used to treat Cheyne-Stokes breathing, complex sleep apnea, and other central forms of SDB
  - Dynamically increases pressure support, as needed on a breath-by-breath basis, to ensure target minute ventilation is achieved
  - Physician must decide whether to use ASV
  - Has been shown to be beneficial for patients with CSR associated with CHF, periodic breathing caused by idiopathic CSA, and opioid-induced CSA

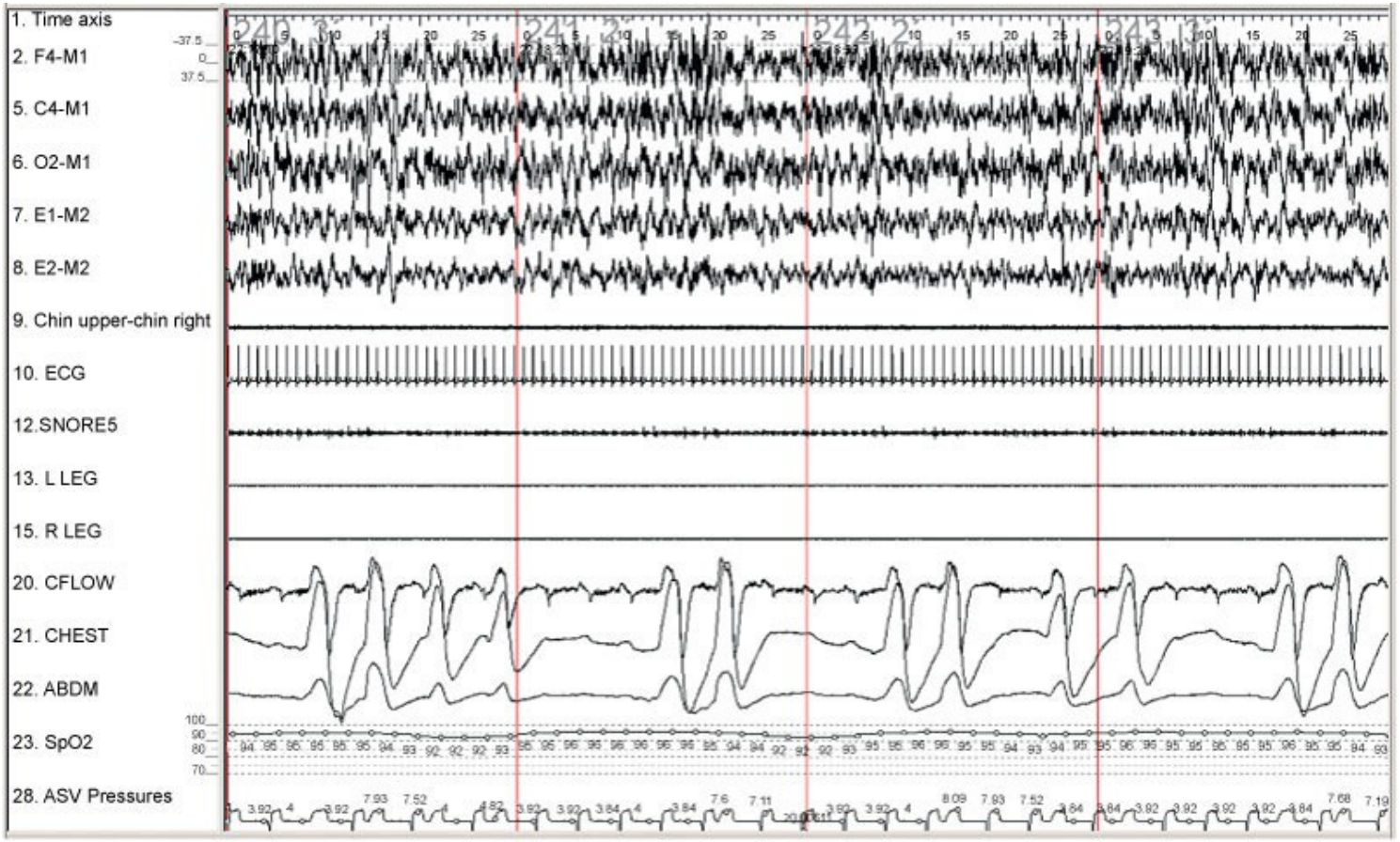
Adaptive Servo Ventilation

- Guidelines for titration
  - Uses a minimum end-expiratory pressure to control any component of upper airway obstruction, pressure support (PS) above the set expiratory pressure to increase spontaneous VT, and a back-up rate to supplement the patient's own breathing
  - Each device has their own algorithm
    - Philips Respironics BiPAP autoSV Automatic Servo Ventilation
      - Targets peak flow during a 4-min moving window and adjusts the delivered PS breath by breath as necessary
      - Automatically calculates back-up rate based on patient's spontaneous efforts
    - ResMed VPAP Adapt SV
      - Continuously calculates target minute ventilation by monitoring patient's RR and estimated VT
        - Target maintains 90% of patient's average minute ventilation by gradual variance and adaptation throughout night
        - Data is averaged over a 3-min window

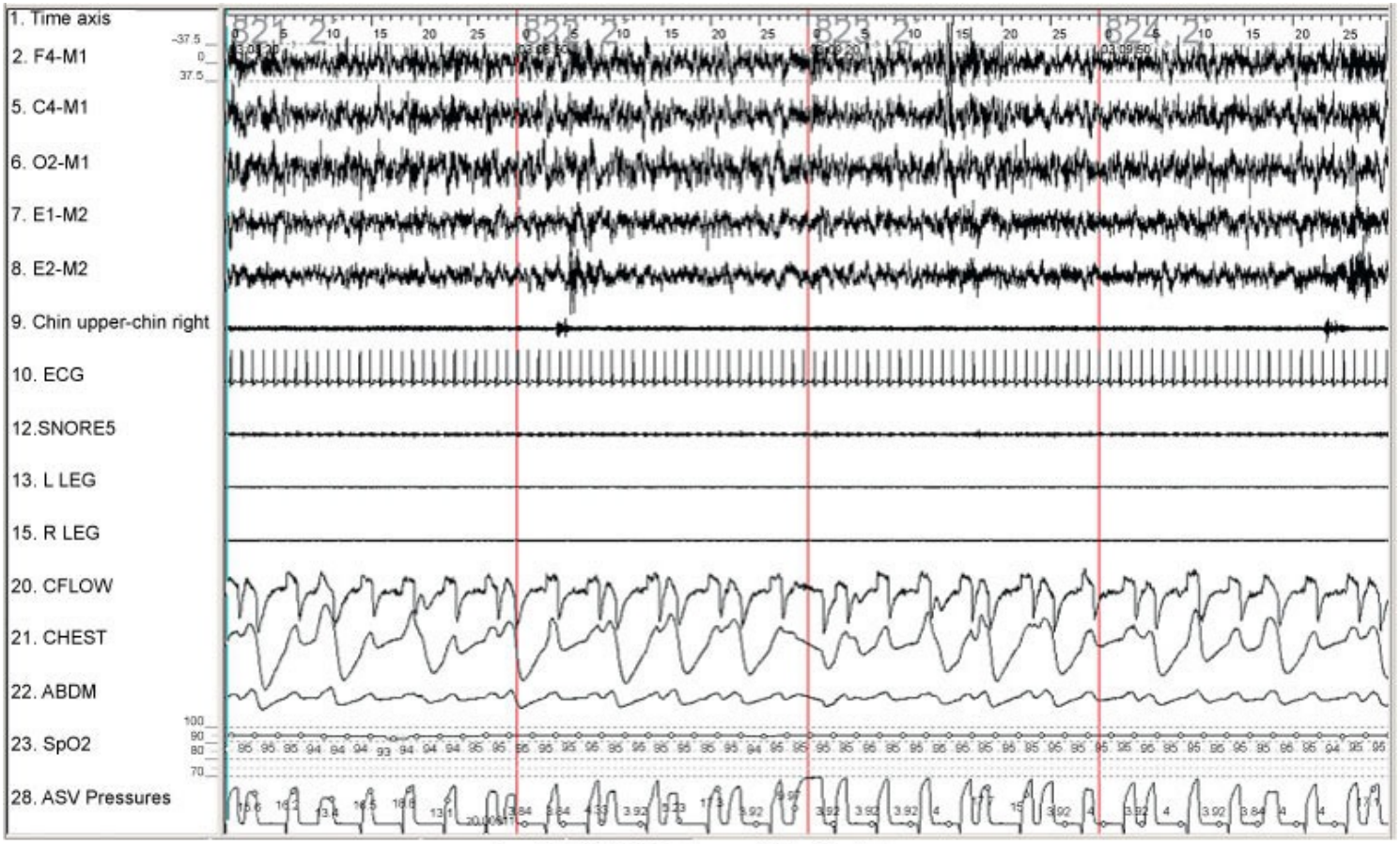
Adaptive Servo Ventilation

- Guidelines for titration (continued)
  - Tech must determine initial settings
    - Settings may be in physician's orders or tech's decision
- Treatment challenges
  - Must be patient during the process
  - Must have uninterrupted sleep opportunity to make sure patient properly responds
  - Need to be conservative with adjustments to EEP in response to obstructive events
  - Some patients fail all attempts at treatment
    - Known as "chemo-reflex modulated sleep apnea"
      - These patients demonstrate a hypocapneic breathing pattern
      - Use enhanced expiratory rebreathing space (EERS) to shift apnea threshold

ASV in Progress



Good ASV Progress Later in Night



NPPV in Complex Respiratory Diseases

- Chronic Hypoventilation Syndromes
  - Need ventilatory assistance during night to maintain an acceptable $PaCO_2$
  - Have respiratory compromise when awake too and this is intensified in sleep
- Indications for NPPV
  - Respiratory failure = $PaCO_2$ not maintained at or below 45 mm Hg and pH not maintained between 7.35-7.45
    - Have excessive work of breathing, respiratory muscle fatigue and dysfunction, inadequate alveolar ventilation, and severe hypoxemia
    - Metabolic system (renal system) retaining HCO_3^- to normalize pH
    - These patients are hypersensitive to supplemental O_2
      - May cause central apneas

NPPV in Complex Respiratory Diseases

- Goals of NPPV
  - Relieve the work of breathing, improve and stabilize gas exchange, improve duration and quality of sleep, prolong survival, and maximize QOL
  - When to increase backup rate:
    - When PaCO2 can't be kept in acceptable range without excessive IPAP
    - When tech concerned that required IPAP may cause barotrauma (bullous lung disease)
    - When tech concerned that necessary IPAP may cause patient intolerance
    - When central apneas emerge in absence of respiratory alkalosis
    - To decrease excessive spontaneous RR or work of breathing
    - To maintain PaCO2 between awake values and 10 mm Hg lower for hypercapnic patients, provided pH remains at or below 7.49

Guidelines for Titration with NPPV

- Spontaneous Timed or Timed mode
  - Set RR at resting wake rate or lower
  - Adjust rate and IPAP based on ABG or surrogate measures of oxygenation and ventilation
    - To reduce elevated spontaneous RR
    - To reduce work of breathing
  - Adjust EPAP to eliminate upper airway obstruction
  - Adjust IPAP
    - To increase spontaneous breathing by increasing VT
    - To decrease PaCO2
    - To ventilate patient during central events

Guidelines for Titration with NPPV

- Inspiratory to Expiratory Ratio
  - Normal is 1:2
  - Patients with COPD may benefit from longer inspiratory time (1:3)

Special Considerations for Use of NPPV

- COPD and Overlap Syndrome
  - NPPV may be indicated
  - Overlap disorder = Patient has COPD and OSA, restrictive thoracic disorders, obesity hypoventilation, and other forms of hypoventilation, and neuromuscular disorders
  - Significantly affected by body position changes in sleep and by breathing changes in REM
- COPD
  - Often need longer I:E ratio (1:3 or 1:4)
  - When inspiratory flow rate (IFR) adjustable, increase IFR or peak IFR to deliver a shorter inspiratory time and longer expiratory time

Special Considerations for Use of NPPV

- Restrictive lung disease
  - A longer inspiratory time and shorter expiratory time (I:E = 1:1.5)
  - Rise time = Time in seconds to deliver IPAP max
    - Longer rise time makes inspiratory phase more sinusoidal and decreases flow rate
    - Adjusting rise time affects patient comfort
    - Adjusting rise time doesn't alter I:E ratio
- Sleep labs are starting to see more NPPV titrations
  - Must monitor CO2 levels with ETCO2 or TcPCO2 and oxygenation levels
  - Follow AASM guidelines

General Recommendations for NPPV

- Increase IPAP or EPAP, or both, to eliminate apneas, hypopneas, RERAs, and snoring
- Increase PS to maintain desired VT
- Increase PS if PaCO2 trends 10 mm Hg or more above desired PaCO2
- Increase PS if needed to provide respiratory muscle rest
- Increase PS if SpO2 remains below 90% for > 5 continuous minutes
- Supplemental O2 may be added if needed
- Monitor RR, VT, CO2, and SpO2
- Conditions Associated with Use of NPPV
  - Lung disease and end-stage COPD
  - Chronic alveolar hypoventilation syndromes

General Recommendations for NPPV

- Contraindications for NPPV
  - Unstable cardiorespiratory status
  - Uncooperative patient
  - Patient unable to protect airway because of impaired swallowing or cough
  - Recent facial, esophageal, or gastric surgery
  - Recent craniofacial trauma or burn
  - Anatomic lesions of upper airway
  - Excessive aerophagia that may result in vomiting, and aspiration
  - Extreme anxiety
  - Massive obesity
  - Copious secretions
  - Need for continuous or nearly continuous ventilatory assistance
  - Bullous lung disease
  - Hyperventilation
  - Hypoventilation
  - Night-to-night variability of need

Optimizing NPPV

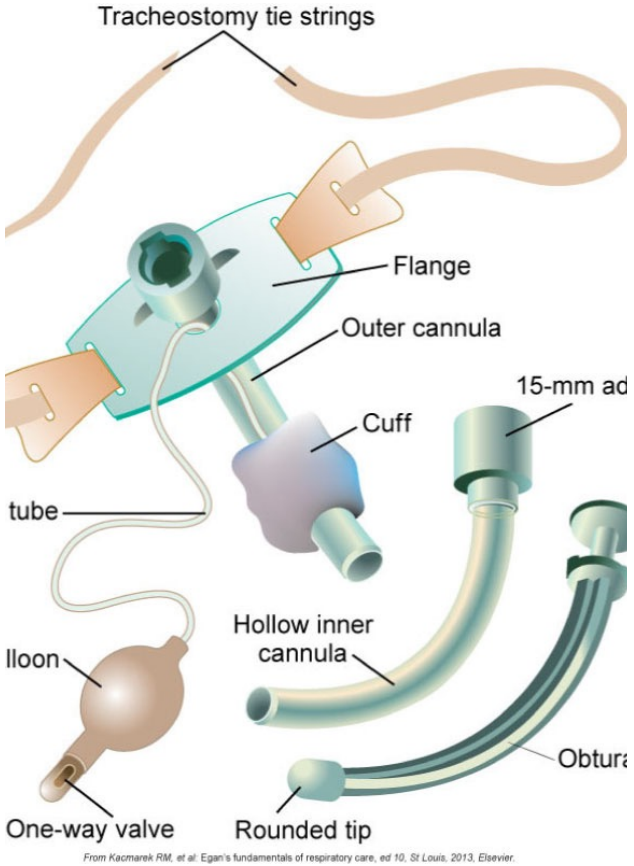
- Goal of BiPAP = Reduce chronically elevated $PaCO_2$ by increasing minute ventilation
  - May need BiPAP PS of > 8 cm H_2O
    - Neuromuscular disease patients may need ≥ 10 cm H_2O
- Improving patient comfort and synchrony is important for long-term adherence
  - Can adjust pressure relief and rise time
  - Mask leak must be in an acceptable range
  - Heated humidification will help with dryness

Supplemental O2

- AASM guidelines for use
  - Awake supine SpO2 is ≤ 88%
  - SpO2 during PAP titration remains ≤ 88% for 5 min in absence of respiratory events
    - Add 1 L of O2 and titrate up as needed to get SpO2 between 88% and 94%
      - Titrate in 15 min intervals
    - Connect O2 at the PAP device outlet
- Additional O2 may be detrimental to those with advanced respiratory disease due to compensated respiratory acidosis (chronic CO2 retention)
  - Start low (below 1 L) for these patients

Alternative Treatments for OSA

- Tracheostomy
  - Effective cure for OSA
  - Only used if can't use PAP and non-treatment is detrimental to patient's health
  - Advantages:
    - Provides patent airway
    - Obstruction bypassed
    - Upper airway bypassed
    - Work of breathing decreased
  - Disadvantages and risks:
    - Long-term risk of tracheal stenosis
    - Increased risk of infection
    - Secretion management
    - Social implications
    - Tracheostomy care
    - Procedure-related complications



Alternative Treatments for OSA

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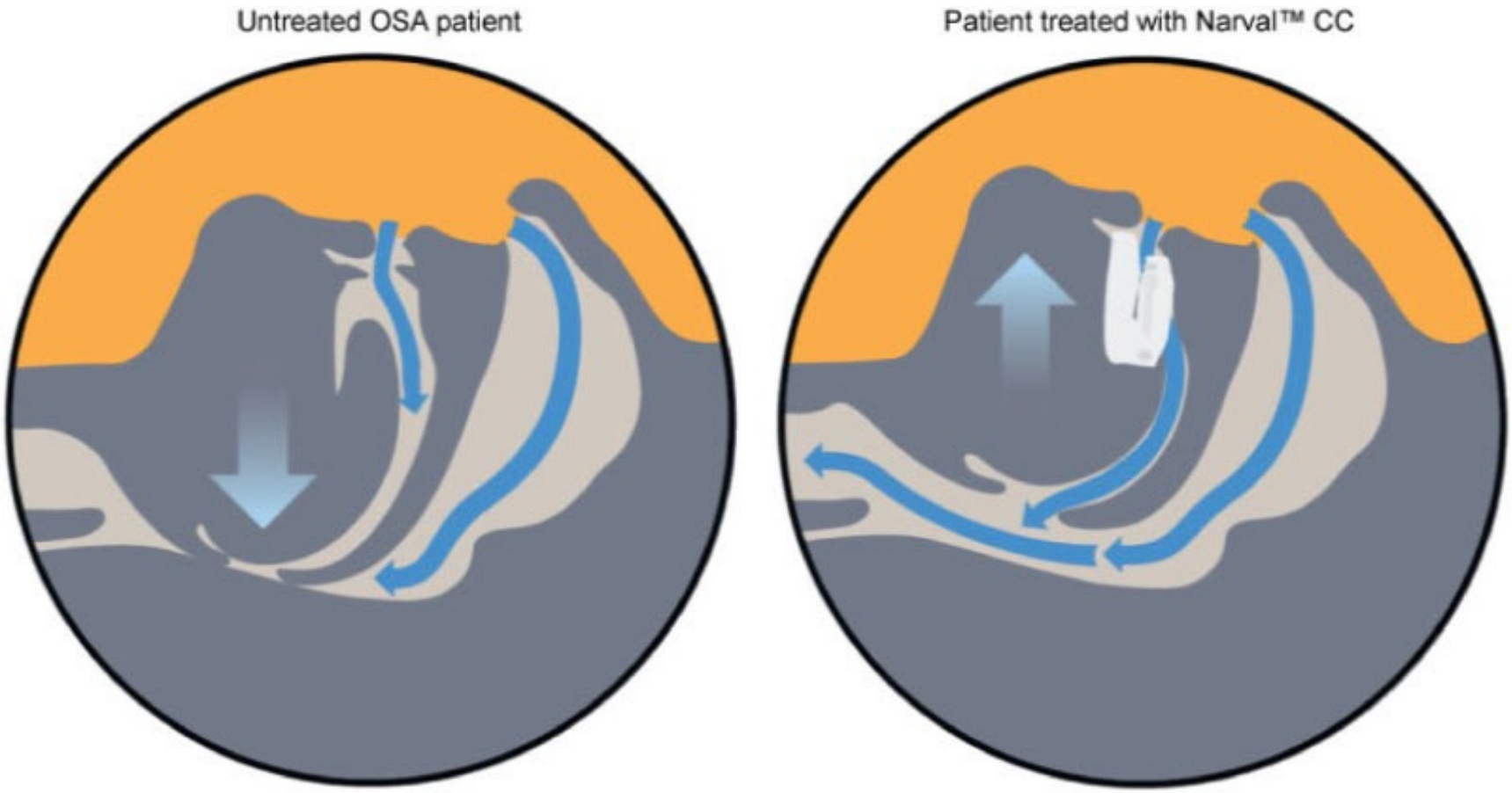
- Oral appliances
  - Treatment of choice for many patients
  - Advance the mandible and open the airway
  - Some also hold tongue forward
  - Less effective for those with severe OSA
  - Option for those with mild OSA
  - Must be custom fitted by dentist

Oral Appliances



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Surgical Procedures

- UPPP with maxillomandibular advancement has shown good results for many patients
- First line of treatment for pediatric OSA = Adenotonsillectomy
  - Beneficial in 75% to 100% of children, even with increased BMI

Outcome Management for PAP

- PAP is foreign to the human body
- If patient sees improvement, more likely to use it
- Some side effects may be seen
  - Congestion, runny nose, ear pressure, facial soreness, pressure discomfort, skin breakdown, claustrophobia, anxiety, and aerophagia
- Education is key to dealing with side effects
- Clinical sleep educator is new role to help with PAP compliance
  - Educates PAP user and family
  - Shows benefits of therapy

Efficacy Monitoring

- PAP usage can now be remotely monitored thanks to wireless and wired monitoring technology through secure websites and servers compliant with HIPAA privacy requirements
- Allows clinicians real-time access to data
  - This allows clinicians to contact the patient with solutions to problems and issues and update their PCP if changes in therapy are needed
- Effect of heated humidification and nasal congestion
  - Nasal resistance makes PAP hard to tolerate
  - Heated humidification reduces nasal resistance
  - A heated wire circuit can help with significant nasal issues

Wireless Monitoring of PAP

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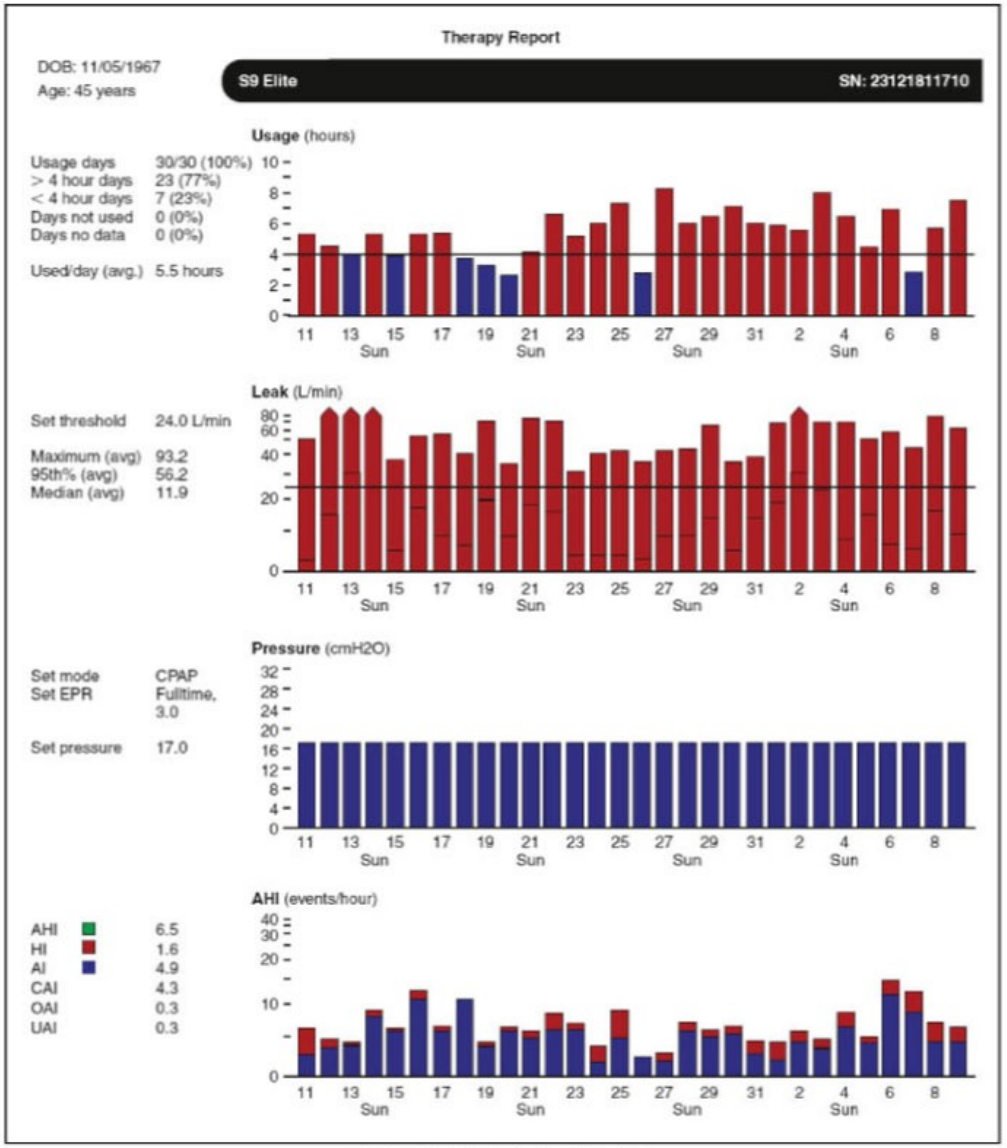
PAP Report from Respironics



Courtesy Philips Respironics, Inc., Andover, MA.

PAP Report from ResMed

Compliance Report

Age: 43 years

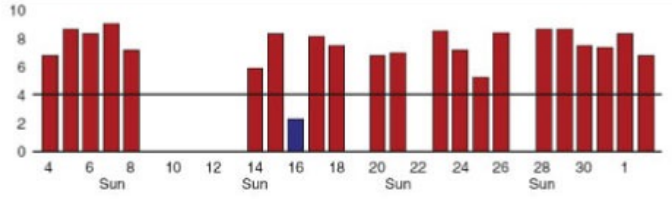
30 day compliance	10/04/2012 - 11/02/2012
Compliance met	Yes
Compliance percentage	70%

Usage	10/04/2012 - 11/02/2012
Usage days	**22/30 days (73%)**
>= 4 hours	**21 days (70%)**
< 4 hours	**1 days (3%)**
Usage hours	164 hours 11 minutes
Average usage (total days)	5 hours 28 minutes
Average usage (days used)	7 hours 28 minutes
Median usage (days used)	7 hours 38 minutes

S9 AutoSet	
Serial number	23121535174
Mode	AutoSet
Minimum pressure	4 cmH2O
Maximum pressure	12 cmH2O
EPR	Fulltime
EPR level	2

Therapy						
Pressure - cmH2O	Median:	9.1	95th percentile:	11.3	Maximum:	11.8
Leaks - L/min	Median:	4.5	95th percentile:	13.5	Maximum:	25.0
Events per hour	A1:	0.7	HI:	0.0	AHI:	0.7
Apnea index	Central:	0.3	Obstructive:	0.3	Unknown:	0.0

Usage (hours)



Data from ResMed Corp., San Diego, California. resmedialibrary.com.

Unintentional Leak

- Must address unintentional leaks
- Sometimes need to refit or readjust the mask
- Add a chin strap to help mouth leak
- Switch to full face mask for mouth leak
- Increased heated humidification may resolve the leak over time
- Requires time to address and patience