NIV application for patients with sleep-related breathing disorders

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Sleep-Related Breathing Disorders

TABLE 3] Sleep-Related Breathing Disorders

Disorder
OSA disorders
OSA, adult
OSA, pediatric
Central sleep apnea syndromes
Central sleep apnea with Cheyne-Stokes breathing
Central sleep apnea due to a medical disorder without Cheyne-Stokes breathing
Central sleep apnea due to high altitude periodic breathing
Central sleep apnea due to a medication or substance
Primary central sleep apnea
Primary central sleep apnea of infancy
Primary central sleep apnea of prematurity
Treatment-emergent central sleep apnea
Sleep-related hypoventilation disorders
Obesity hypoventilation syndrome
Congenital central alveolar hypoventilation syndrome
Late-onset central hypoventilation with hypothalamic dysfunction
Idiopathic central alveolar hypoventilation
Sleep-related hypoventilation due to a medication or substance
Sleep-related hypoventilation due to a medical disorder
Sleep-related hypoxemia disorder

International Classification of Sleep Disorder-3

NIV application in Obstructive Sleep apnea

Definition and epidemiology of OSA

- **Definition**
  - Disorder that is characterized by
    - Obstructive apneas
    - Hypopneas
    - Respiratory effort-related arousals (RERAs)

    => caused by repetitive complete or partial collapse of the upper airway during sleep

- **Epidemiology**
  - 15 - 30 % in males and 5 - 15 % in females

  (When defined as an apnea-hypopnea index [AHI] > five events per hour of sleep)

Sleep. 2021;44(7)

Diagnosis of OSA

Diagnosis obstructive sleep apnea

Sleep testing device	Index	Diagnostic criteria for OSA
Polysomnography*	AHI	AHI 5 to 14/hour sleep **plus** one or more sleep-associated conditions¶ **or** AHI ≥15/hour sleep
	RDI	RDI 5 to 14/hour sleep **plus** one or more sleep associated conditions¶ **or** RDI ≥15/hour sleep
Home sleep apnea device△	REI	REI ≥15/hour total recording time

For the diagnosis of OSA, respiratory events should be identified as primarily obstructive (ie, apneas, hypopneas, arousals that are associated with respiratory effort). These events are used to generate the following indices:

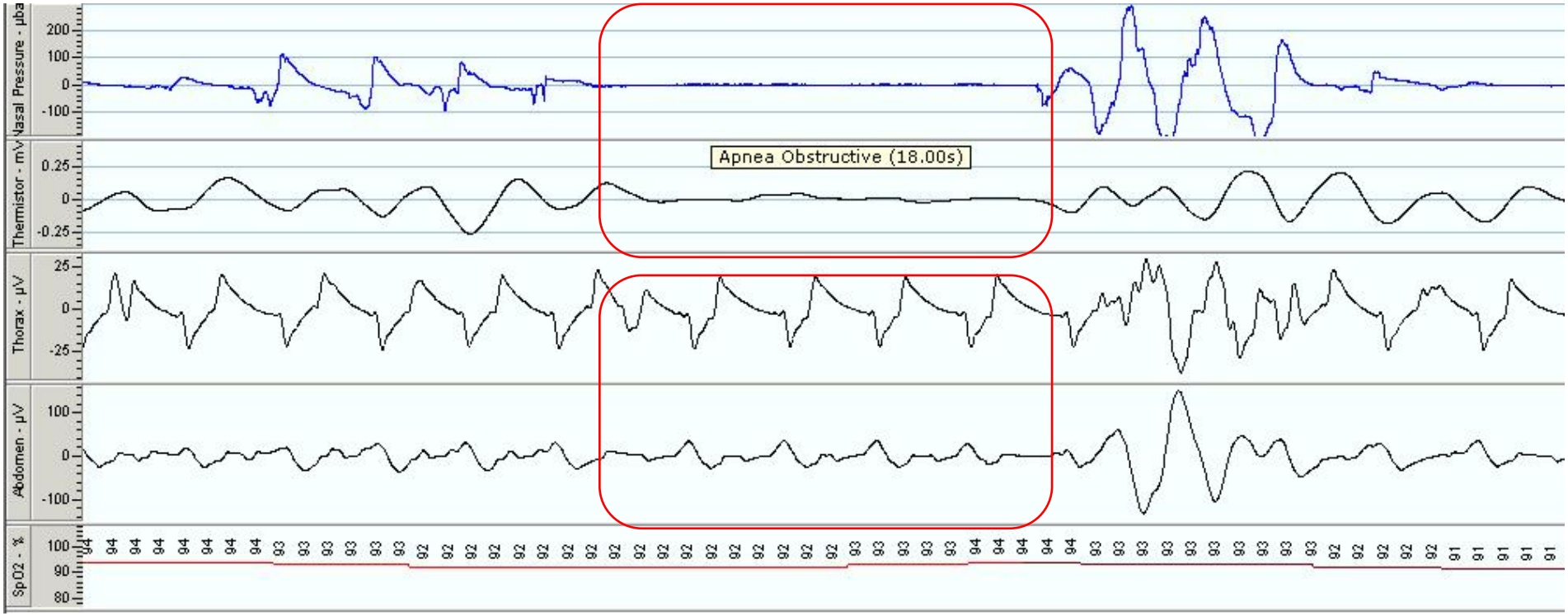
- AHI = (apneas + hypopneas / total sleep time in hours)
- RDI = (apneas + hypopneas + RERAs / total sleep time in hours)
- REI = (apneas + hypopneas / total recording time)

¶ Sleep-associated conditions:
•Sleepiness, fatigue, insomnia, or other symptoms leading to impaired sleep-related quality of life
•Waking up with breath holding, gasping, or choking
•Habitual snoring or breathing interruptions during sleep noted by a bed partner or other observer

AHI: apnea-hypopnea index;
RDI: respiratory disturbance index;
REI: respiratory event index;
RERA: respiratory effort-related arousals

Sleep. 2021;44(7)

Polysomnography of OSA



The absence of signal in the nasal pressure transducer and near absence of signal in the thermistor identifies the event as an apnea.
The continuing effort in the thoracic and abdominal leads indicates that it is an obstructive apnea.

Treatment of OSA
: Positive airway pressure(PAP) therapy

- The mainstay of therapy for adults with OSA

- Prevents respiratory events due to upper airway collapse (apneas, hypopneas) by maintaining a positive pharyngeal transmural pressure

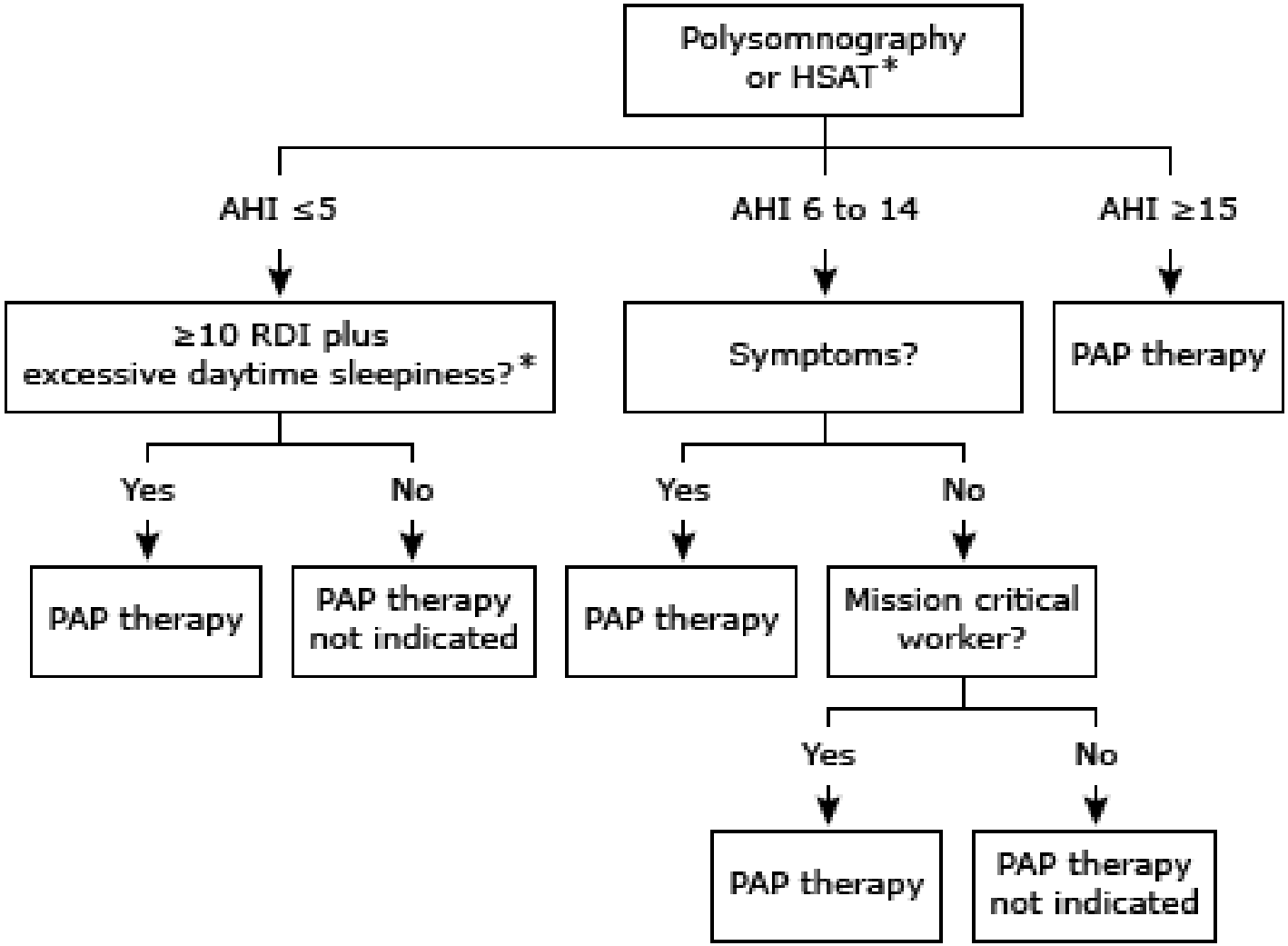
⇒ intraluminal pressure exceeds the surrounding pressure and by increasing end-expiratory lung volume

Lancet. 2014;383(9918):736. Epub 2013 Aug 2.

Positive airway pressure(PAP) therapy

- **Indications**
  - **AHI ≥15**
    - Even in the absence of symptoms, recommend PAP
    - Appears to be effective across a range of disease severities
    - Patients with severe OSA (AHI ≥30 events per hour) are most likely to benefit
  - **AHI >5 and <15 events per hour of sleep**
    - If symptoms, recommend PAP
    - Mission critical work (airline pilots, air traffic controllers, locomotive engineers, bus and truck drivers), even in the absence of clinical or physiologic sequelae attributable to OSA
  - **AHI ≤5 events per hour**
    - Increased number of respiratory effort-related arousals (RERAs) (≥10 per hour) and excessive daytime sleepiness

Am J Respir Crit Care Med. 2016 May;193(9):e37-54.



Am J Respir Crit Care Med. 2016 May;193(9):e37-54.

치료의 적응증 (보험)

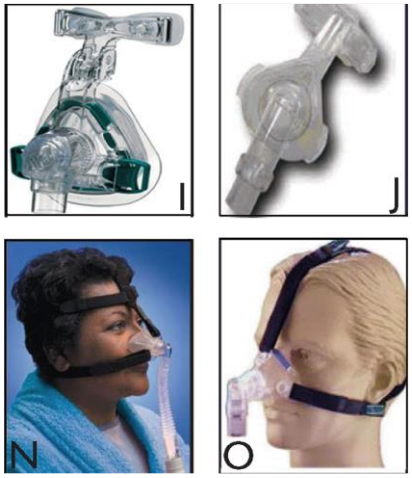
- 급여대상자 인정기준
  - **수면무호흡(G47.3)**, 신생아의 원발성 수면무호흡(P28.3), 신생아의 기타 무호흡(P28.4)의 상병으로 아래 진단기준에 해당되어 양압기가 필요하다고 전문의로부터 확진받은 자

  - **진단기준**
    - **제 I 형 수면다원검사(Level I) 결과**
      - 무호흡·저호흡 지수(AHI, Apnea Hypopnea Index)가 15 이상
      - 또는 10 이상이면서 다음의 어느 하나에 해당 할 것

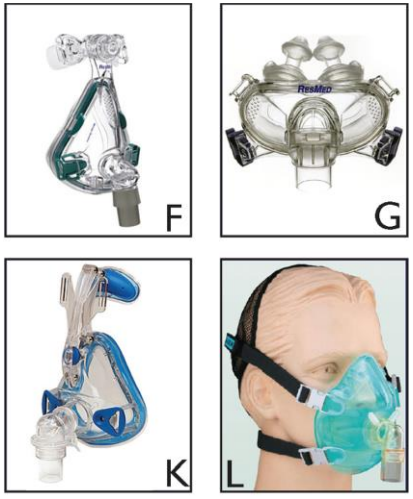
        1) 불면증, 2) 주간졸음, 3) 인지기능 감소, 4) 기분장애
      - 또는 5 이상이면서 다음의 어느 하나에 해당 할 것

        1) 고혈압, 2) 빈혈성 심장질환, 3) 뇌졸중 기왕력, 4) 산소포화도가 85% 미만

NIV interface



Nasal masks



Full face masks

Nasal mask—covers nose and not mouth

Advantages

- Possibility of speaking and drinking
- Allows cough
- Reduced danger of vomiting
- Minimum risk of asphyxia

Disadvantages

- Air leaks if mouth opens
- Possible nasal skin damage
- Needs patent nasal passages

Full face (or oronasal) mask—covers mouth and nose

Advantages

- Few air leaks
- Little cooperation required
- Can be adjusted for comfort

Disadvantages

- Vomiting
- Claustrophobia
- Possible nasal skin damage
- Speaking and coughing difficult

NIV interface

Nasal pillows

Nasal pillows or plugs—inserted into nostrils

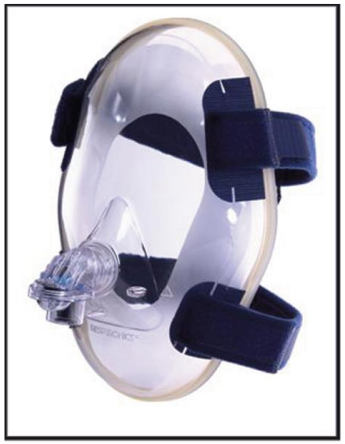
Advantages

- Can be applied as rotating strategy with other advantages of nasal masks
- Absence of nasal skin damage

Disadvantages

- Unreliable monitoring of expired tidal volume
- Inspiratory and expiratory air leaks
- Nasal irritation

Helmets



Full-face masks

Efficacy of PAP

- PAP compared with no therapy
  - High-quality evidence from RCTs and meta-analyses
  - Reduces the frequency of respiratory events during sleep, decreases daytime sleepiness, lowers the risk of crashes, and improves systemic BP, erectile dysfunction, symptoms of gastroesophageal reflux, glycemic control (in patents with diabetes), and quality of life
  - In severe OSA are most likely to benefit (AHI ≥30 events per hour)
  - The effect on cardiovascular events or mortality is less certain
  - Difference in therapeutic effect when oronasal rather than nasal masks are used is unclear

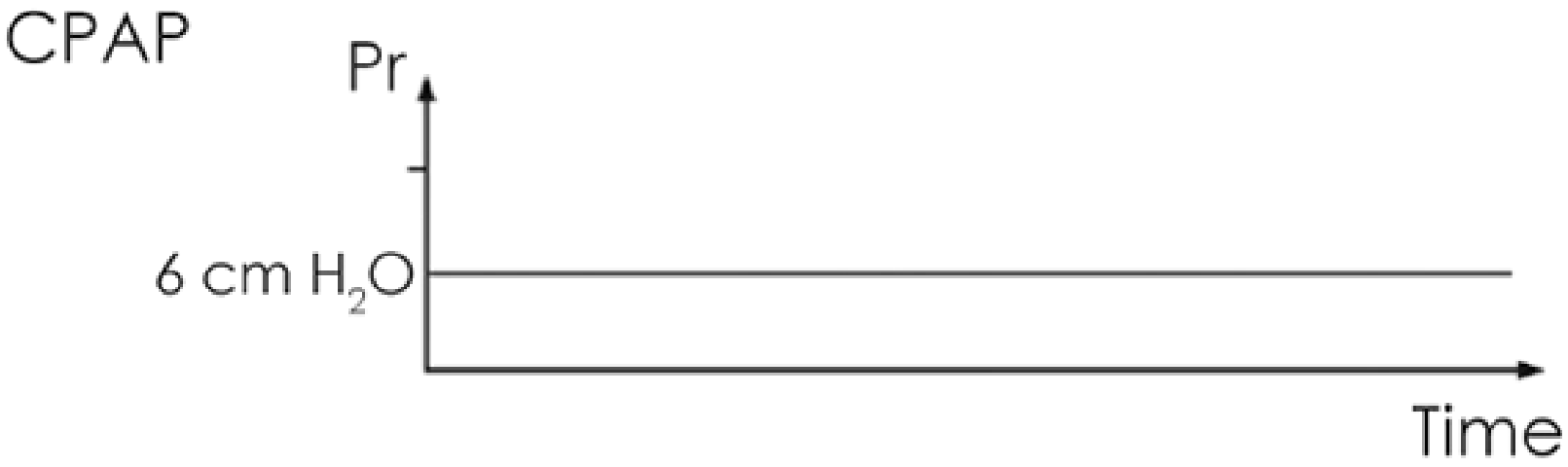
JAMA. 2012 May;307(20):2161-8
J Clin Sleep Med. 2019;15(2):301. Epub 2019 Feb 15

Mode selection, titration, initiation : Modes of PAP

- **Modes of PAP**
  - Fixed-level CPAP
  - Auto-titrating PAP (APAP)
  - Bilevel PAP (BPAP)
  - Adaptive servo-ventilation (ASV)

Mode selection, titration, initiation: CPAP

- **Fixed-level CPAP**
  - Delivers PAP at a level that remains constant throughout the respiratory cycle
  - The simplest mode, most extensively studied, and associated with the most clinical experience



J Clin Sleep Med. 2019;15(2):301. Epub 2019 Feb 15.

JCSM
Journal of Clinical Sleep Medicine

REVIEW ARTICLES

Treatment of Adult Obstructive Sleep Apnea With Positive Airway Pressure: An American Academy of Sleep Medicine Systematic Review, Meta-Analysis, and GRADE Assessment

Susheel P. Patil, MD, PhD[1]; Indu A. Ayappa, PhD[2]; Sean M. Caples, DO[3]; R. John Kimoff, MD[4]; Sanjay R. Patel, MD[5]; Christopher G. Harrod, MS[6]

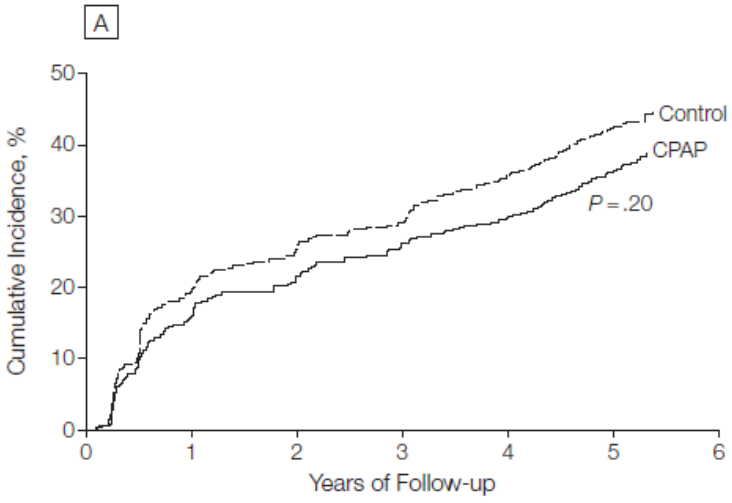
- In a 2019 meta-analysis from the AASM, compared with no therapy, CPAP had a significant impact on
  - OSA severity (-23 events per hour, 95% CI -29 to -18 events per hour),
  - Epworth Sleepiness Scale score (-2.4 points, 95% CI -2.8 to -1.9 points)
  - Nighttime systolic BP (-4.2 mmHg, 95% CI -6 to -2.5 mmHg), diastolic BP (-2.3 mmHg, 95% CI -3.7 to -0.9), and 24-hour mean BP (-2.6 mmHg, 95% CI -3.4 to -1.4 mmHg)
  - Positively impacted the rate of motor vehicle crashes (risk ratio 0.3, 95% CI 0.2-0.4) and quality of life
- CPAP had no impact on
  - Cardiovascular events (MI, stroke), mortality, neurocognitive function, mood, fasting glucose or hemoglobin A1C, left ventricular ejection fraction, or risk of hospitalization

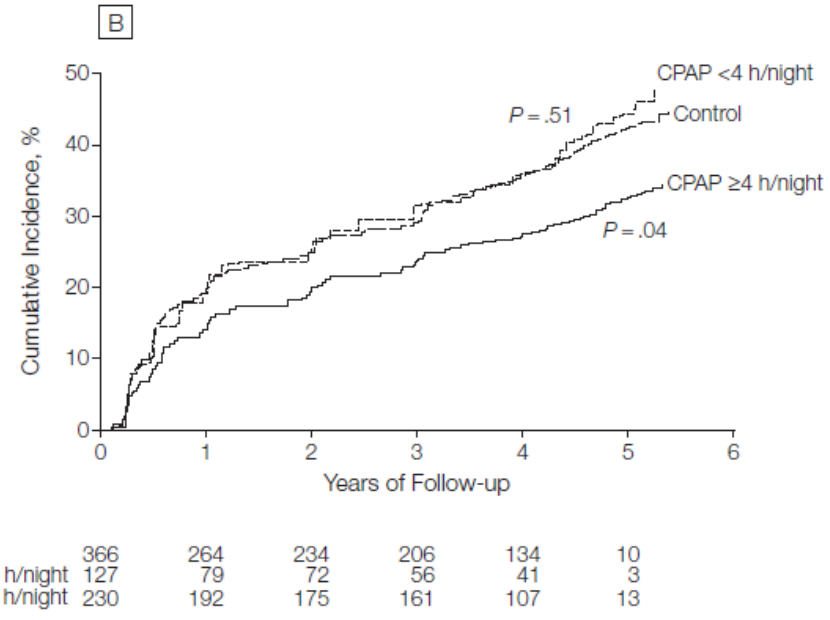
J Clin Sleep Med. 2019;15(2):301. Epub 2019 Feb 15.

Scan for Author Video Interview

Effect of Continuous Positive Airway Pressure on the Incidence of Hypertension and Cardiovascular Events in Nonsleepy Patients With Obstructive Sleep Apnea

A Randomized Controlled Trial





- Multicenter, parallel-group, randomized controlled trial in 14 teaching hospitals in Spain
- CPAP compared with usual care did not result in a statistically significant reduction in the incidence of hypertension or cardiovascular events

JAMA. 2012;307:2161-2168

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 SEPTEMBER 8, 2016 VOL. 375 NO. 10

CPAP for Prevention of Cardiovascular Events in Obstructive Sleep Apnea

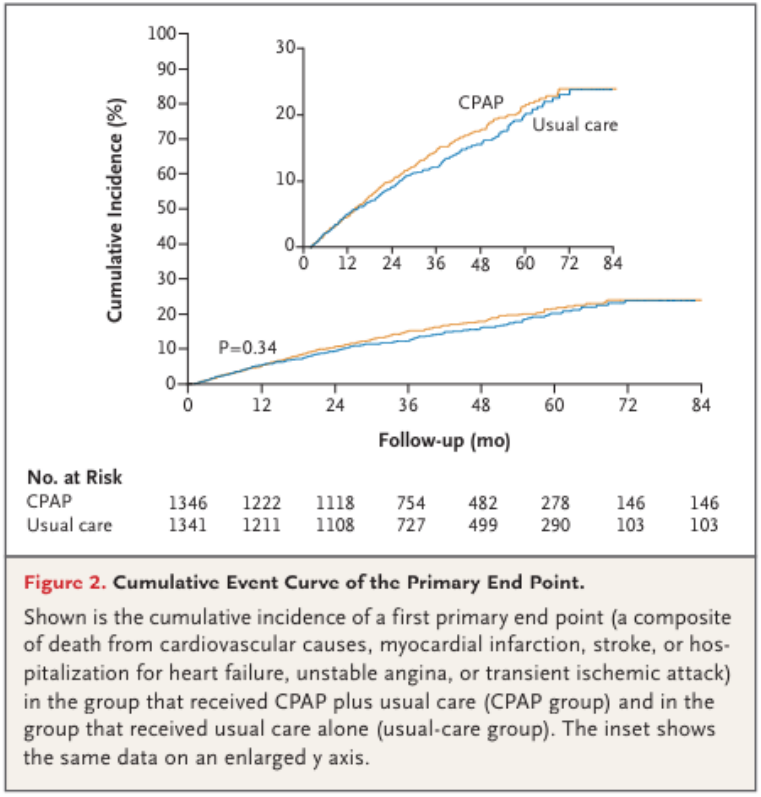


Figure 2. Cumulative Event Curve of the Primary End Point.

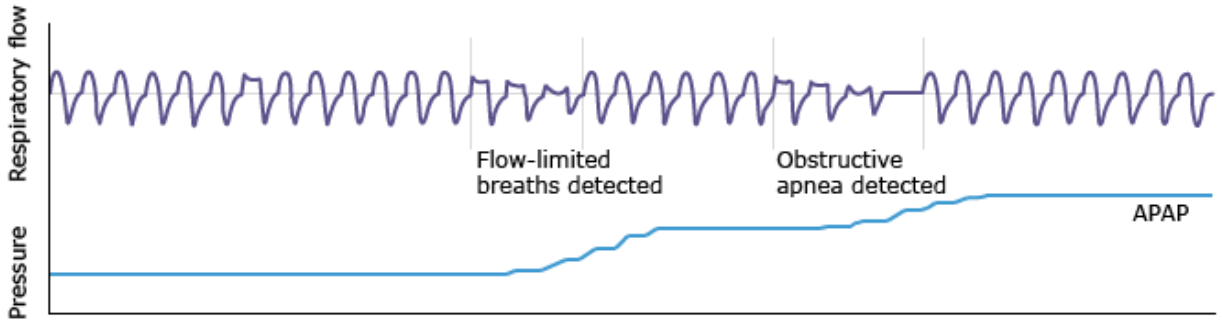
Shown is the cumulative incidence of a first primary end point (a composite of death from cardiovascular causes, myocardial infarction, stroke, or hospitalization for heart failure, unstable angina, or transient ischemic attack) in the group that received CPAP plus usual care (CPAP group) and in the group that received usual care alone (usual-care group). The inset shows the same data on an enlarged y axis.

- International, Multicenter, parallel-group, RCT
- 2717 eligible adults (45-75 years) who had moderate–to-severe OSA and coronary or cerebrovascular disease -> CPAP group vs. usual-care group
- CPAP therapy had no significant effect on the prevention of recurrent serious cardiovascular events

N Engl J Med 2016;375:919-31.

Mode selection, titration, initiation: APAP

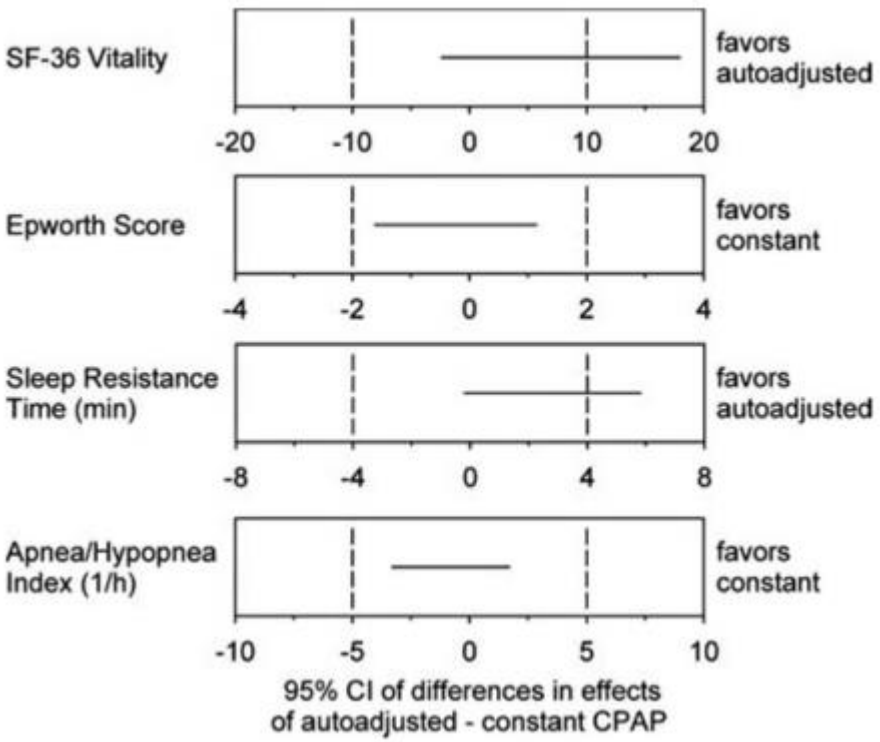
- **Auto-titrating PAP (APAP)**
  - Increases or decreases the level of PAP in response to a change in airflow, change in circuit pressure, or vibratory snore (signs that generally indicate that upper airway resistance has changed)
  - Increasingly used as an alternative in select patients with OSA, and has increased even more during the COVID-19 pandemic
  - Degree of improvement of major outcomes conferred by APAP and CPAP is similar



Upper waveform demonstrates normal respiratory airflow during sleep during which time no pressure is administered by the APAP device (lower waveform). Flow limitation and obstructive events are detected by the device and treated with positive airway pressure.

Equivalence of Autoadjusted and Constant Continuous Positive Airway Pressure in Home Treatment of Sleep Apnea*

Yvonne Nussbaumer, MD; Konrad E. Bloch, MD, FCCP; Therese Genser; and Robert Thurnheer, MD, FCCP



- Randomized, double-blind, controlled, cross-over trial
- 30 patients
- The effectiveness aCPAP in improving major outcomes was equivalent to cCPAP

Chest. 2006;129(3):638.

JCSM
Journal of Clinical Sleep Medicine

REVIEW ARTICLES

Treatment of Adult Obstructive Sleep Apnea With Positive Airway Pressure: An American Academy of Sleep Medicine Systematic Review, Meta-Analysis, and GRADE Assessment

Table S4. Summary of Findings Table for APAP-intiated PAP vs. In-lab-intiated PAP for the treatment of obstructive sleep apnea in adults

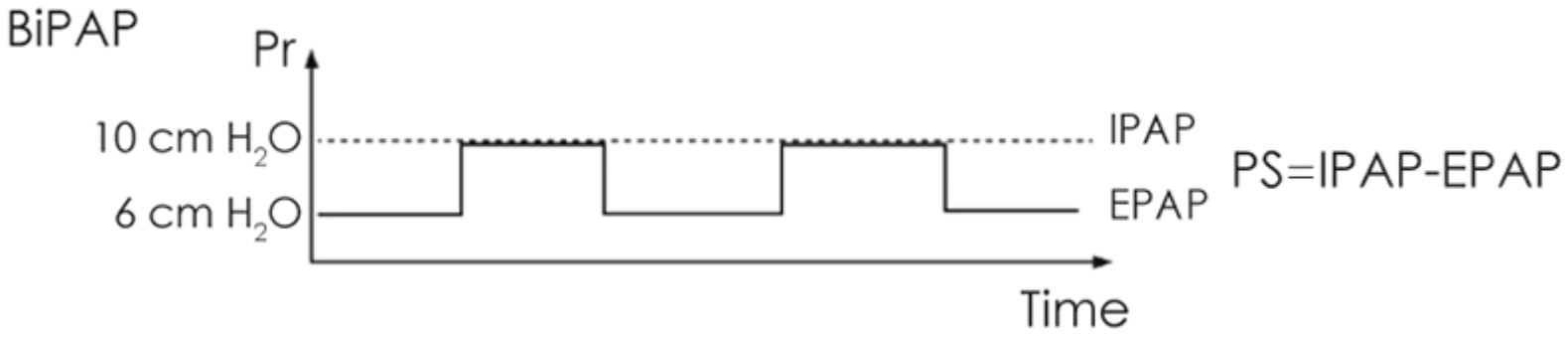
References: Antic 2009 (A); Berry 2008 (B); Cross 2006 (C); Kuna 2011 (D); McArdle 2010 (E); Mulgrew 2007 (F); Planes 2003 (G); Rosen 2012 (H); Chai-Coetzer 2013 (I); Hui 2017 (J)

Outcomes	Quality of the evidence (GRADE)	Anticipated absolute effects (95% CI) MD between APAP initiated PAP and in-lab initiated PAP	№ of participants (studies)
AHI	⊕⊕⊕⊕ HIGH	he mean AHI in the ambulatory PAP group was 3.3 (3.0). The mean AHI in the in-lab PAP group was 5.0 (4.8).The mean AHI in the APAP initiated group was 1.62 events/hr lower (2.94 lower to 0.3 lower)	170 (3 RCTs)[B,F,G]
Adherence (hrs/night)*	⊕⊕⊕⊕ HIGH	The mean adherence in the APAP initiated group was 0.09 hrs/night less (0.38 more to 0.56 less)	1211 (10 RCTs)[A-J]
Self-reported Sleepiness (ESS)*	⊕⊕⊕⊕ HIGH	The mean ESS score in the APAP initiated group was 0.04 points higher (0.46 lower to 0.55 higher)	1160 (9 RCTs)[A-H,J]
Sleep-related QOL* (FOSQ, SAQLI)	⊕⊕⊕◯ MODERATE ‡	The mean FOSQ/SAQLI score in the APAP initiated group was 0.06 standard deviations higher (0.09 lower to 0.20 higher)	773 (5 RCTs)[C,D,F,H,J]

J Clin Sleep Med. 2019 Feb 15;15(2):301-334

Mode selection, titration, initiation: BPAP

- **Bilevel PAP (BPAP)**
  - Delivers a preset inspiratory PAP (IPAP) and expiratory PAP (EPAP)
  - Degree of pressure support and consequently tidal volume is related to the difference between the IPAP and EPAP
  - No proven advantage to using BPAP instead of CPAP or APAP for the routine management of OSA



Am J Respir Crit Care Med. 1995;151(2 Pt 1):443

A Randomized, Double-blind Clinical Trial Comparing Continuous Positive Airway Pressure with a Novel Bilevel Pressure System for Treatment of Obstructive Sleep Apnea Syndrome

Peter C. Gay, MD; Daniel L Herold, RPSGT; Eric J Olson, MD

Table 2—Polysomnogram data from titration of CPAP and NBL in 27 patients

	CPAP	NBL
Optimal CPAP & baseline pressure (cm H_2O)	8.8 ± 1.1	8.9 ± 1.6
AHI (# / hour)	7.6 ± 11.9	3.7 ± 4.4
Arousal Index (#/hour)	16.5 ± 14.6	11.8 ± 5.8
Sleep Efficiency (%)	73.4 ± 15.0	84.4 ±14.4
Total Sleep Time (minutes)	115.2 ± 36.9	89.6 ± 42.5

No significant differences were noted between groups in the parameters presented (P = NS). CPAP, continuous positive airway pressure; NBL, novel bilevel pressure; AHI, apnea-hypopnea index

Table 3—Mean (± SD) self-assessment data of daytime sleepiness from 27 patients with obstructive sleep apnea syndrome

	CPAP	NBL
ESS		
Pretreatment	13.5 ± 3.4	14.2 ± 3.4
Posttreatment	8.0 ± 4.8	7.8 ± 3.8
FOSQ		
Pretreatment	88.4 ± 21.2	89.7 ± 11.1
Posttreatment	103.7 ± 18.4	107.2 ± 7.7

Pretreatment versus posttreatment self-assessment data regarding daytime sleepiness in 27 patients randomly assigned to receive treatment with continuous positive airway pressure (CPAP) or novel bilevel pressure (NBL). There were statistically significant reductions in the scores on the Epworth Sleepiness Scale and increases in the scores on the Functional Outcomes of Sleepiness Questionnaire ($P < 0.05$) of similar magnitude in both groups.

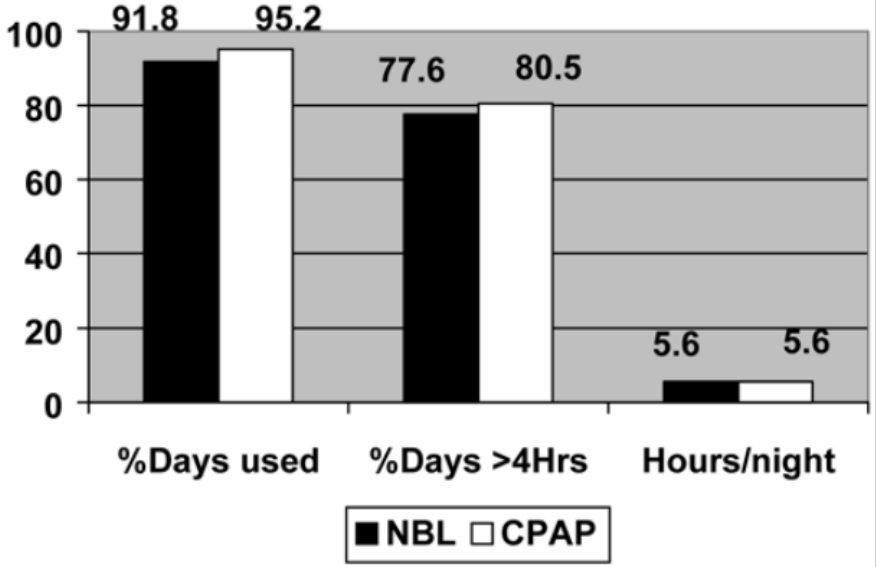


Figure 2—Compliance data downloaded from the device's inboard, pressure-actuated software for 27 patients randomly assigned to 30 days of treatment with continuous positive airway pressure (CPAP) or novel bilevel pressure (NBL). No significant differences were noted between groups in the 3 compliance parameters (P=NS). Percentage of days used equals number of days when any amount of use was recorded divided by total number of follow-up days.

Randomized, controlled, double-blind trial
22 patients

SLEEP 2003;26(7):864-9.

Treatment of Adult Obstructive Sleep Apnea With Positive Airway Pressure: An American Academy of Sleep Medicine Systematic Review, Meta-Analysis, and GRADE Assessment

BPAP vs. CPAP for the treatment of obstructive sleep apnea in adults

Figure S75. BPAP vs. CPAP (AHI, events/hr)

Study or Subgroup	BPAP Mean	BPAP SD	BPAP Total	CPAP Mean	CPAP SD	CPAP Total	Weight	Mean Difference IV, Random, 95% CI
Blau 2011	2.5	3.8	15	4.3	5.3	17	80.9%	-1.80 [-4.97, 1.37]
Gay 2003	3.7	4.4	12	7.6	11.9	15	19.1%	-3.90 [-10.42, 2.62]
Total (95% CI)			27			32	100.0%	**-2.20 [-5.05, 0.65]**

Heterogeneity: Tau² = 0.00; Chi² = 0.32, df = 1 (P = 0.57); I² = 0%
Test for overall effect: Z = 1.51 (P = 0.13)

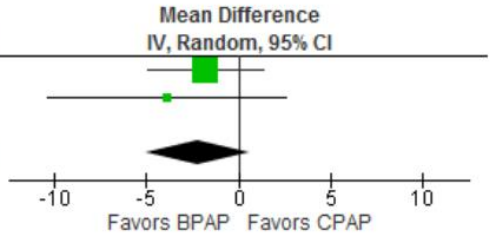
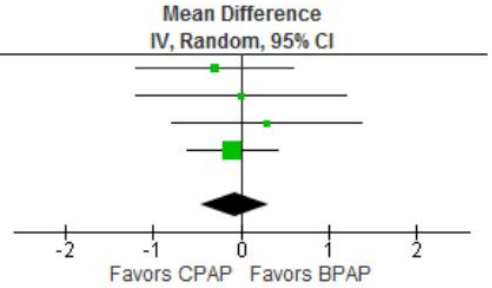


Figure S76. BPAP vs. CPAP (Adherence, hrs/night)*

Study or Subgroup	BPAP Mean	BPAP SD	BPAP Total	CPAP Mean	CPAP SD	CPAP Total	Weight	Mean Difference IV, Random, 95% CI
Blau 2011	5.3	1.5	15	5.6	1	17	19.1%	-0.30 [-1.20, 0.60]
Gay 2003	5.6	1.7	12	5.6	1.4	15	10.7%	0.00 [-1.19, 1.19]
Powell 2012	4.7	1.8	26	4.4	2	22	13.0%	0.30 [-0.78, 1.38]
Reeves-Hoche 1995	4.9	1.2	26	5	0.72	36	57.2%	-0.10 [-0.62, 0.42]
Total (95% CI)			79			90	100.0%	**-0.08 [-0.47, 0.32]**

Heterogeneity: Tau² = 0.00; Chi² = 0.73, df = 3 (P = 0.87); I² = 0%
Test for overall effect: Z = 0.38 (P = 0.71)

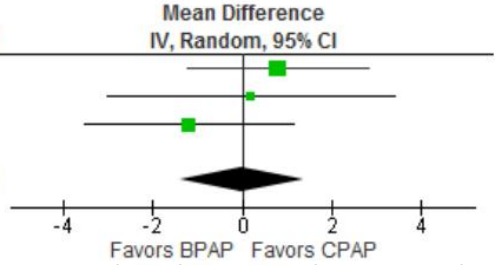


*Studies included patients who were previously untreated with PAP

Figure S77. BPAP vs. CPAP (ESS)*

Study or Subgroup	BPAP Mean	BPAP SD	BPAP Total	CPAP Mean	CPAP SD	CPAP Total	Weight	Mean Difference IV, Random, 95% CI
Blau 2011	7.6	2	15	6.8	3.7	17	46.8%	0.80 [-1.23, 2.83]
Gay 2003	8	4.8	15	7.8	3.8	12	18.3%	0.20 [-3.04, 3.44]
Powell 2012	6.9	4.4	22	8.1	3.8	26	34.9%	-1.20 [-3.55, 1.15]
Total (95% CI)			52			55	100.0%	**-0.01 [-1.40, 1.38]**

Heterogeneity: Tau² = 0.00; Chi² = 1.61, df = 2 (P = 0.45); I² = 0%
Test for overall effect: Z = 0.01 (P = 0.99)

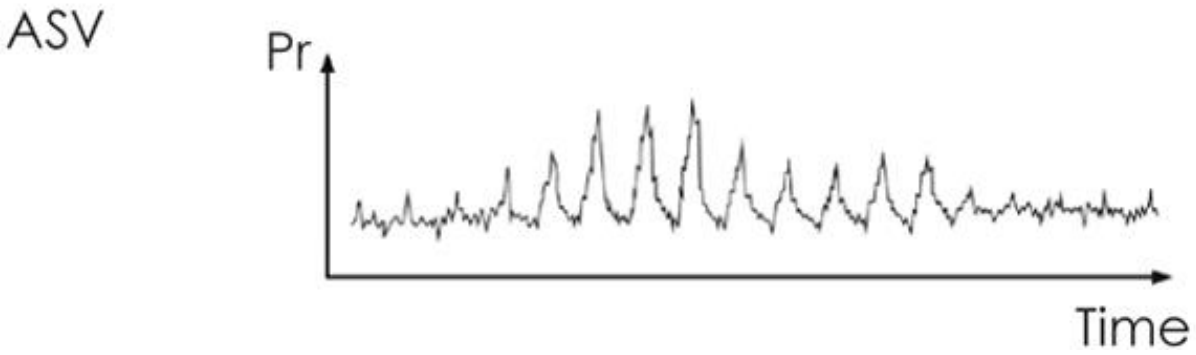


*Studies included patients who were previously untreated with PAP

J Clin Sleep Med. 2019 Feb 15;15(2):301-334

Mode selection, titration, initiation: ASV

- **Adaptive servo-ventilation (ASV)**
  - Varying amount of inspiratory pressure superimposed on a low level of CPAP
  - Helpful in patients who have OSA and concomitant central apneas
  - Caution should be exercised when using in patients with concomitant heart failure and a Cheyne-Stokes breathing pattern, specifically those with a left ventricular ejection fraction of less than 45 percent
    - Higher cardiovascular mortality in association with ASV



N Engl J Med. 2015;373(12):1095. Epub 2015 Sep 1.

Mode selection for titration of PAP : Initial mode and setting options

- **Setting of testing (home versus in-laboratory)**
  - In-laboratory PSG-based PAP titration is the traditional gold standard and preferred method of determining an effective level of PAP
  - Device type
    - Choice of the setting of testing is affected by the perceived appropriateness of a given patient for CPAP, BPAP, or APAP
      - Fixed-level CPAP
        - Titration in the sleep laboratory using PSG-based monitoring, thereby requiring an overnight stay
      - APAP
        - Utilize proprietary algorithms to resolve obstructive sleep-disordered breathing as detected by the device
        - Generally performed at home
      - BPAP
        - Attended in-laboratory PSG-monitored assessment is necessary

J Clin Sleep Med. 2019;15(2):335. Epub 2019 Feb 15.

Mode selection for titration of PAP : Initial mode and setting options

- Presence of complicating disorders or states that affect sleep
  - **Complicated OSA**
    - Generally require in-laboratory titration for fixed-level CPAP

Category	Examples
Pulmonary diseases	Severe COPD Chronic hypercapnic or hypoxemic respiratory failure
Cardiac diseases	Congestive heart failure
Neuromuscular diseases and hypoventilation syndromes	Central sleep apnea, obesity hypoventilation syndrome, neuromuscular diseases
Effects of drugs including substance use/abuse	Opioids, gabapentinoids, other respiratory depressants
Other conditions	Prior upper airway surgery

  - **Uncomplicated OSA**
    - Initial titration at home with APAP or in-laboratory CPAP titration

Mode selection for titration of PAP : Initial titration

- **Uncomplicated OSA**
  - To determine a fixed-level of CPAP, suggest that an attended in-laboratory CPAP titration with a fixed-level device (or an unattended in-home titration using an APAP device)
  - In-laboratory titrations are typically combined with a diagnostic polysomnogram
  - No substantial difference in efficacy between in-laboratory and in-home APAP titration strategies
  - BPAP devices are used to treat OSA patients
    - Fail or cannot tolerate CPAP
    - Complicated sleep-disordered breathing (central sleep apnea and/or hypoventilation syndromes)

J Clin Sleep Med. 2019;15(2):335. Epub 2019 Feb 15.

Mode selection for titration of PAP: Initial titration

- **Complicated OSA**
  - In-laboratory CPAP titration
  - BPAP may be initiated in select populations
    - Predominance of central sleep apnea or hypoventilation or in patients who fail CPAP

J Clin Sleep Med. 2019;15(2):335. Epub 2019 Feb 15.

Mode selection for titration of PAP: Initial titration

- **In-laboratory fixed-level CPAP titration**
  - Performed during a split- or full-night PSG study
  - Started at a low level (4 cm H_2O) and incrementally increased (1 to 2 cm H_2O increments) until there is no evidence of upper airway obstruction in all stages and sleeping positions
  - Optimal level of PAP
    - Reduces the respiratory disturbance index to <5 events per hour for at least 15 minutes, including during supine REM sleep
    - Sleep is not interrupted by spontaneous arousals or awakenings
  - Recommended maximum level of CPAP is 20 cm H_2O
  - Considering transitioning to bilevel PAP in spontaneous mode (BPAP-S) at CPAP levels of approximately 15 cm H_2O

J Clin Sleep Med. 2019;15(2):335. Epub 2019 Feb 15.

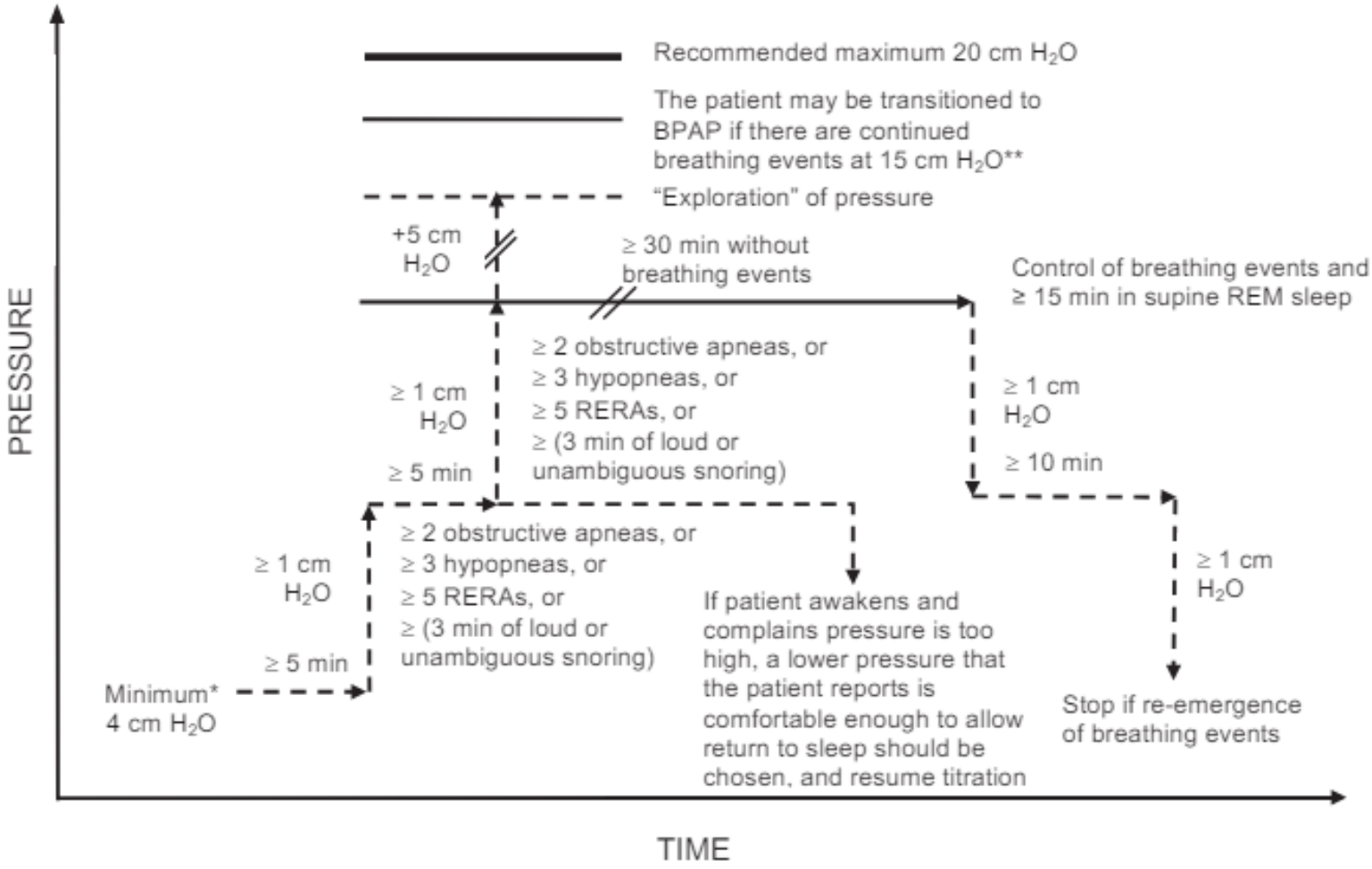


Figure 2—CPAP Titration Algorithm for Patients ≥12 years During Full- or Split-Night Titration Studies. Note: Upward titration at ≥ 1-cm increments over ≥ 5-min periods is continued according to the breathing events observed until ≥ 30 min without breathing events is achieved.

J Clin Sleep Med. 2008;4(2):157.

Mode selection for titration of PAP: Initial titration

- **At-home APAP titration**
  - Optimal method of titration with an APAP device is unclear
  - Gather device-downloaded data from a 7- to 14-day period of in-home APAP titration, employing a minimum and maximum pressure range of 5 to 20 cm H_2O.
  - Optimal fixed CPAP setting is typically the level of pressure at or below which obstructive events measured by the APAP device are eliminated for more than 90 or 95 percent of the time
  - Modern APAP devices report a respiratory event index (REI) that can be used to confirm the efficacy of the chosen pressure

J Clin Sleep Med. 2019;15(2):335. Epub 2019 Feb 15.

Mode selection for titration of PAP: Initial titration

- **In-laboratory BPAP-S**
  - Typically performed during an attended in-laboratory PSG-based study, preferably during a full night of sleep
  - IPAP and EPAP are usually started at 8 and 4 cm H_2O,
    => serially increased until frank obstructive apneas are eliminated
  - IPAP is titrated until obstructive hypopneas, respiratory effort-related arousals, and snoring are eliminated
  - The recommended IPAP-EPAP differential : 4 cm - 10 cm H_2O

J Clin Sleep Med. 2019;15(2):335. Epub 2019 Feb 15.

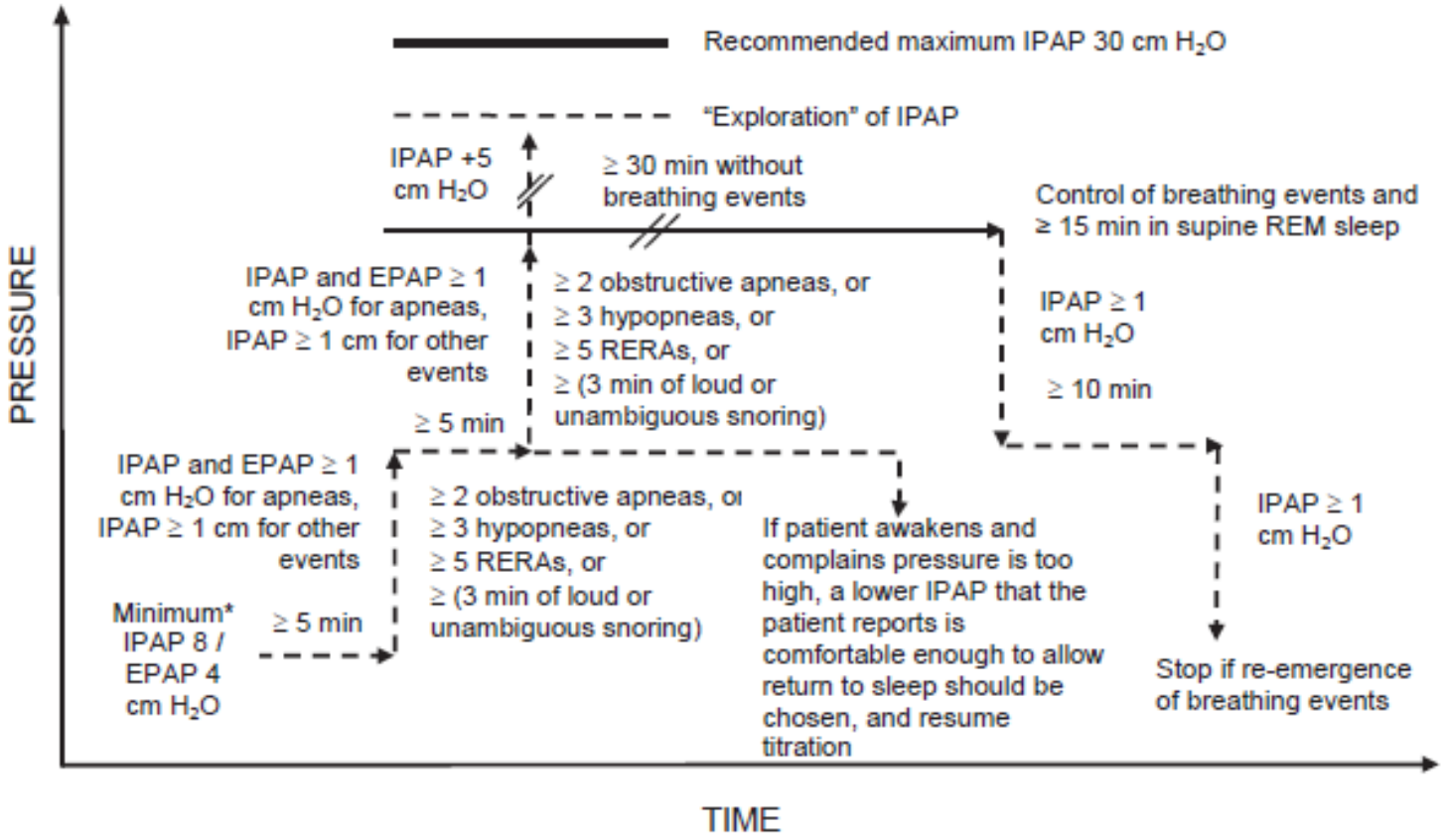


Figure 4—BPAP Titration Algorithm for Patients ≥12 years During Full- or Split-Night Titration Studies. Note: Upward titration of IPAP and EPAP ≥ 1 cm H2O for apneas and IPAP ≥ 1 cm for other events over ≥ 5-min periods is continued until ≥ 30 min without breathing events is achieved. A decrease in IPAP or setting BPAP in spontaneous-timed mode with backup rate may be helpful if treatment-emergent central apneas are observed.

Mode selection for titration of PAP: Follow-up

- **Follow-up after initial titration**
  - Titration data from the polysomnogram (from in-laboratory reports) or from the device (from in-home auto-titrating devices) should be examined
  - Should be assessed for residual symptoms and tolerance
    - Sensation of pressure, mask fit, nasal symptoms

J Clin Sleep Med. 2019;15(2):335. Epub 2019 Feb 15.

Mode selection for titration of PAP: Follow-up

- **Patients with optimal titration**
  - For those who can tolerate PAP and achieve optimal pressures during titration

  => PAP therapy should be initiated with follow-up in one to eight weeks

  - Uncomplicated OSA
    - Ongoing therapy is typically with CPAP or APAP
  - Complicated OSA
    - CPAP is the first-choice
    - BPAP is generally reserved for those who cannot tolerate or fail CPAP

J Clin Sleep Med. 2019;15(2):335. Epub 2019 Feb 15.

Mode selection for titration of PAP: Follow-up

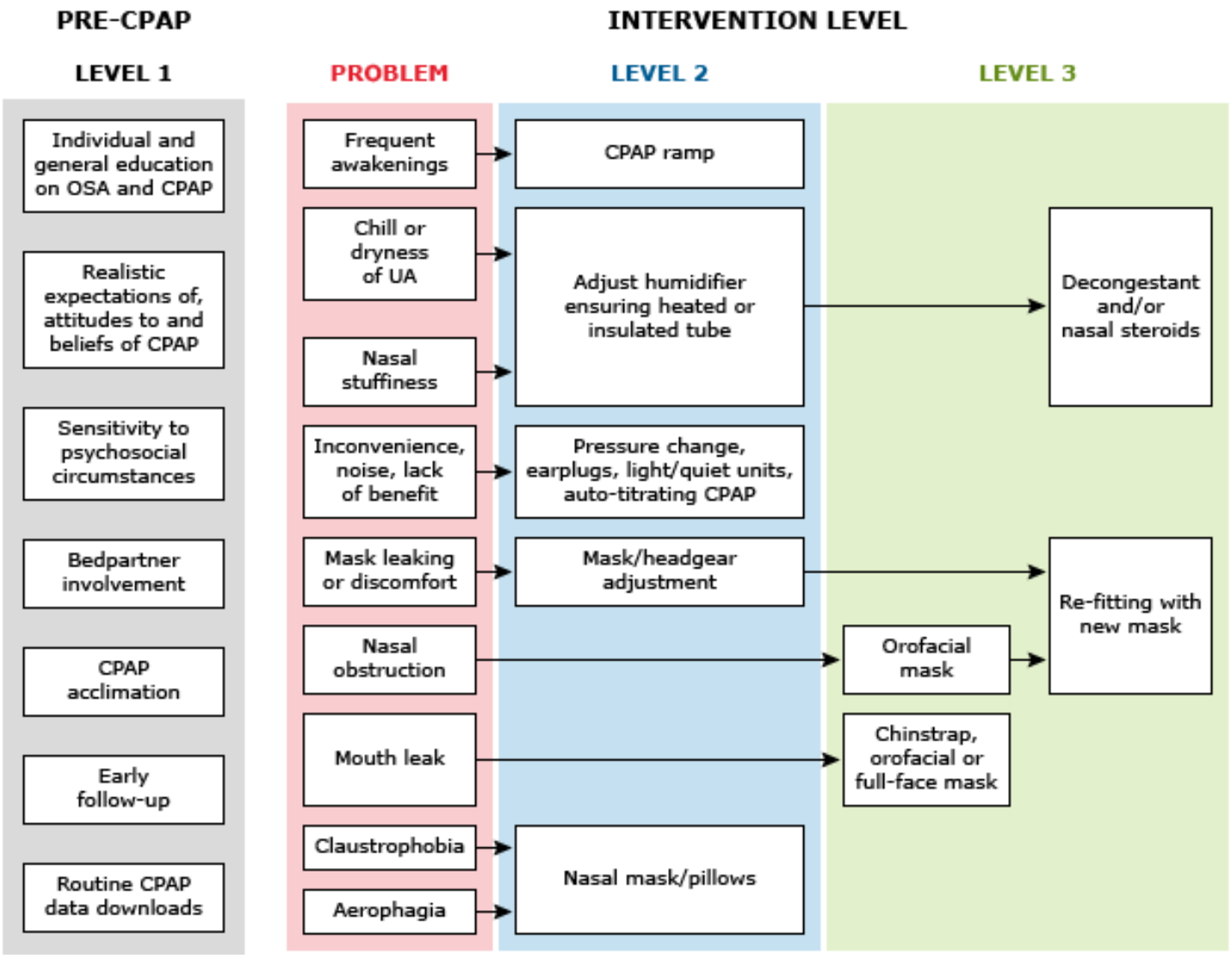
- **Patients with suboptimal titration**
  - For patients who are intolerant of a given level of CPAP, have residual symptoms of excessive daytime sleepiness or snoring, and/or have residual obstructive events observed on CPAP therapy at a pressure of ≥15 cm H_2O
  - Assess for potential etiologies that explain these phenomena
  - Undergo retitration, most often with the same modality
  - Should patients fail this strategy, suggest that BPAP titration (usually in the spontaneous mode) be administered in an attended in-laboratory PSG-monitored setting

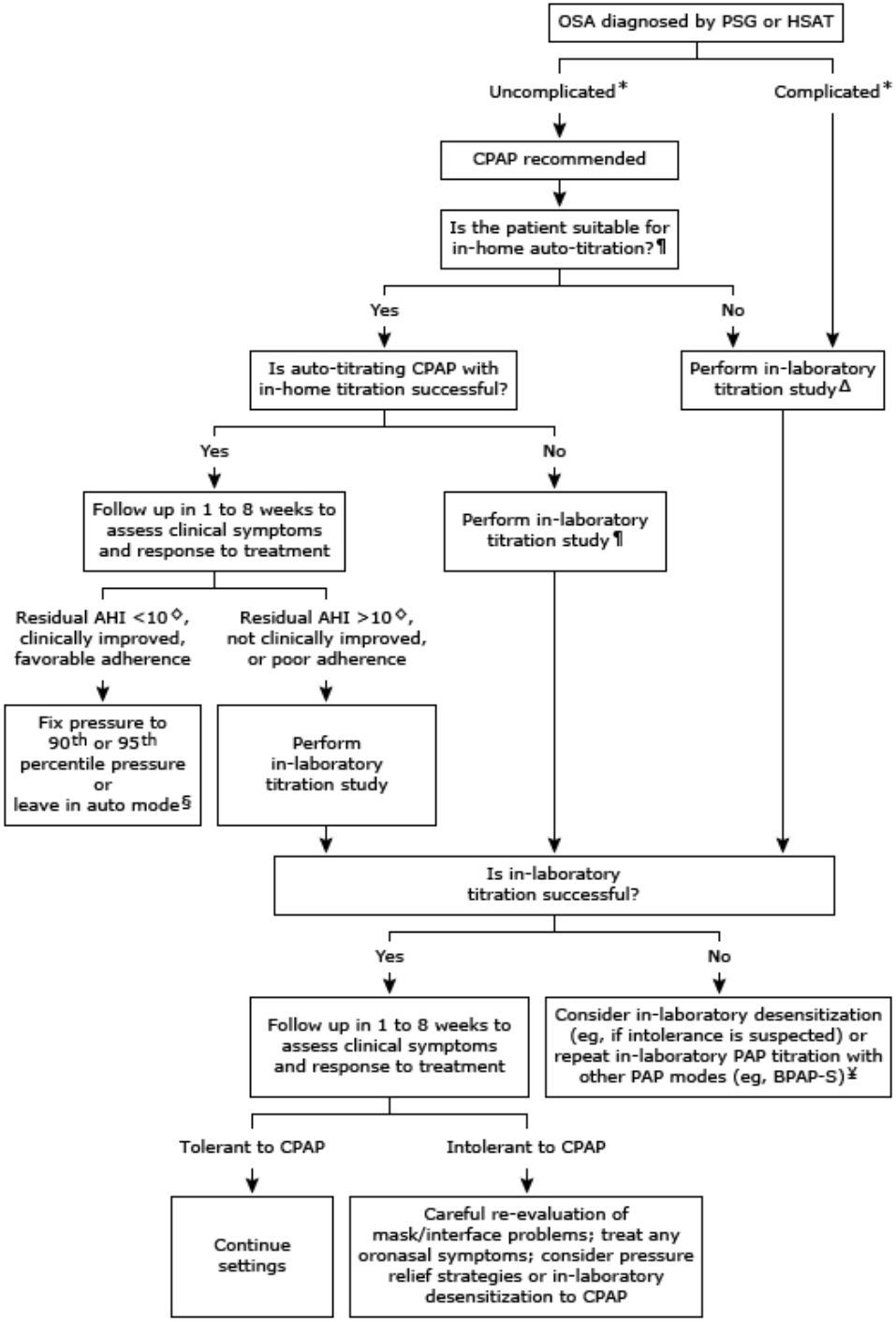
J Clin Sleep Med. 2019;15(2):335. Epub 2019 Feb 15.

Follow-up

- **Follow-up goals**
  - Resolution of the signs and symptoms
  - Improvement in sleep quality
  - Normalization of the AHI and oxyhemoglobin saturation levels

Follow-up


PRE-CPAP
INTERVENTION LEVEL
LEVEL 1
PROBLEM
LEVEL 2
LEVEL 3
Individual and general education on OSA and CPAP
Realistic expectations of, attitudes to and beliefs of CPAP
Sensitivity to psychosocial circumstances
Bedpartner involvement
CPAP acclimation
Early follow-up
Routine CPAP data downloads
Frequent awakenings
CPAP ramp
Chill or dryness of UA
Nasal stuffiness
Adjust humidifier ensuring heated or insulated tube
Decongestant and/or nasal steroids
Inconvenience, noise, lack of benefit
Pressure change, earplugs, light/quiet units, auto-titrating CPAP
Mask leaking or discomfort
Mask/headgear adjustment
Re-fitting with new mask
Nasal obstruction
Orofacial mask
Mouth leak
Chinstrap, orofacial or full-face mask
Claustrophobia
Aerophagia
Nasal mask/pillows


OSA diagnosed by PSG or HSAT
Uncomplicated*
Complicated*
CPAP recommended
Is the patient suitable for in-home auto-titration?¶
Yes
No
Is auto-titrating CPAP with in-home titration successful?
Perform in-laboratory titration study Δ
Yes
No
Follow up in 1 to 8 weeks to assess clinical symptoms and response to treatment
Perform in-laboratory titration study ¶
Residual AHI <10 ◇, clinically improved, favorable adherence
Residual AHI >10 ◇, not clinically improved, or poor adherence
Fix pressure to 90th or 95th percentile pressure or leave in auto mode§
Perform in-laboratory titration study
Is in-laboratory titration successful?
Yes
No
Follow up in 1 to 8 weeks to assess clinical symptoms and response to treatment
Consider in-laboratory desensitization (eg, if intolerance is suspected) or repeat in-laboratory PAP titration with other PAP modes (eg, BPAP-S)¥
Tolerant to CPAP
Intolerant to CPAP
Continue settings
Careful re-evaluation of mask/interface problems; treat any oronasal symptoms; consider pressure relief strategies or in-laboratory desensitization to CPAP

NIV application in Central sleep apnea

Definition and epidemiology of CSA

- A disorder characterized by repetitive cessation or decrease of both airflow and ventilatory effort during sleep

- **Classification**
  - Primary idiopathic CSA
  - Secondary CSA
    - Cheyne-Stokes breathing
    - Medical condition
    - Drug or substance
    - High altitude periodic breathing

- **Epidemiology**
  - Uncommon in the general population
    - Adults aged 40 years and older, the overall prevalence of CSA was 0.9 percent
  - Prevalence is higher among older adults, males, and those with certain comorbid conditions, such as heart failure or stroke

American Academy of Sleep Medicine. International Classification of Sleep Disorders, 3rd ed, American Academy of Sleep Medicine, 2014.

Diagnosis of CSA

- **Primary CSA**
  - PSG reveals ≥5 central apneas and/or central hypopneas per hour of sleep
  - Central apneas plus central hypopneas is >50 percent of the total number of apneas and hypopneas
  - No evidence of Cheyne-Stokes breathing
  - The patient reports sleepiness, awakening short of breath, witnessed apneas or difficulty initiating or maintaining sleep, frequent awakenings or nonrestorative sleep
  - No evidence of daytime or nocturnal hypoventilation
  - Not better explained by another current sleep disorder, medical disorder, medication, or substance use

American Academy of Sleep Medicine. International Classification of Sleep Disorders, 3rd ed, text revision, American Academy of Sleep Medicine, 2023.

Diagnosis of CSA

- **CSA with Cheyne-Stokes breathing**
  - PSG reveals ≥5 central apneas and/or central hypopneas per hour of sleep
  - At least three consecutive central apneas and/or central hypopneas separated by a crescendo-decrescendo change in breathing amplitude with a cycle length of ≥40 seconds (Cheyne-Stokes breathing pattern)
  - Central apneas and/or central hypopneas is >50 percent of the total number of apneas and hypopneas.
  - The patient reports sleepiness, awakening short of breath, witnessed apneas or difficulty initiating or maintaining sleep, frequent awakenings or nonrestorative sleep
  - The patient has atrial fibrillation/flutter, congestive heart failure, or a neurological disorder
  - Not better explained by another current sleep disorder, medical disorder, medication, or substance use

American Academy of Sleep Medicine. International Classification of Sleep Disorders, 3rd ed, text revision, American Academy of Sleep Medicine, 2023.

Diagnosis of CSA

- **CSA due to high altitude periodic breathing**
  - Breathing disturbance occurs at high altitude
    - Typically at least 2500 meters, although some individuals may exhibit the disorder at altitudes as low as 1500 meters
  - The patient reports sleepiness, awakening short of breath, witnessed apneas or difficulty initiating or maintaining sleep, frequent awakenings or nonrestorative sleep
  - Witnessed periodic breathing, or PSG if performed at altitude reveals recurrent central apneas or hypopneas with a frequency of ≥5 events per hour
  - Not better explained by another current sleep disorder, medical disorder, medication, or substance use

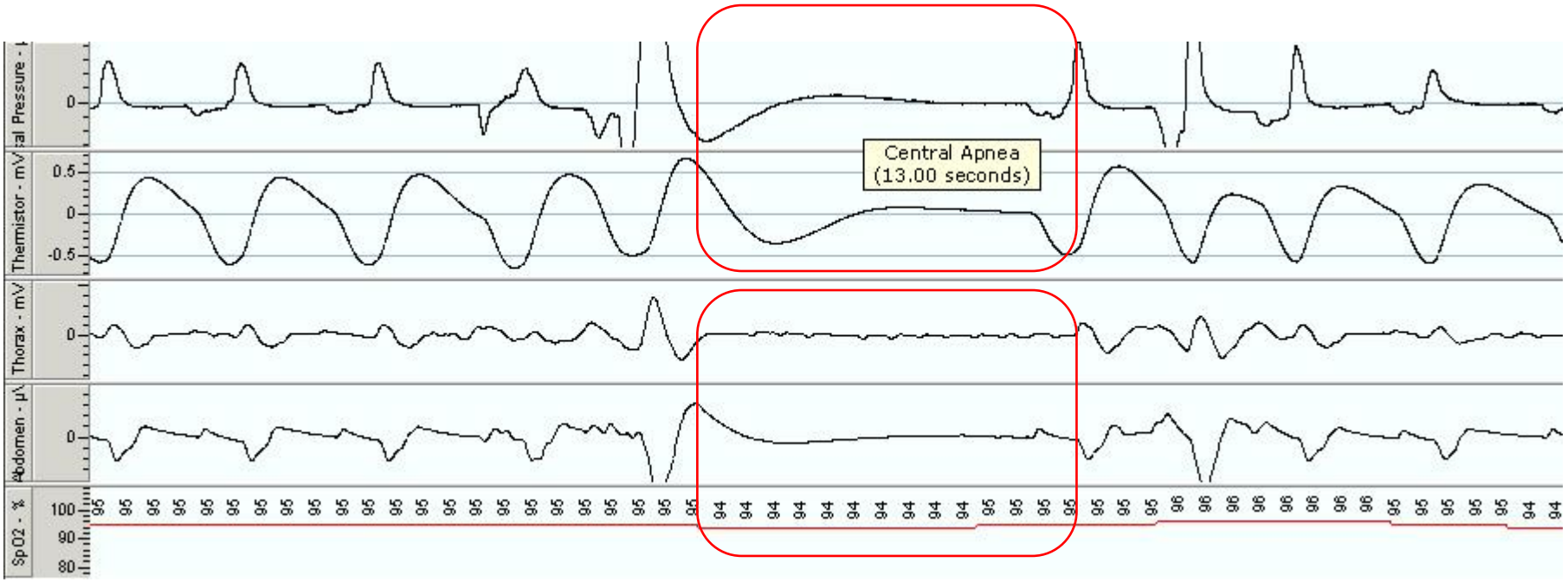
American Academy of Sleep Medicine. International Classification of Sleep Disorders, 3rd ed, text revision, American Academy of Sleep Medicine, 2023.

Diagnosis of CSA

- **CSA due to a medication or substance**
  - Taking an opioid, ticagrelor, or other medication known to impact respiratory control
  - The patient reports sleepiness, awakening short of breath, witnessed apneas or difficulty initiating or maintaining sleep, frequent awakenings or nonrestorative sleep
  - PSG reveals ≥5 central apneas and/or central hypopneas per hour of sleep
  - Central apneas plus central hypopneas is >50 percent of the total number of apneas and hypopneas
  - Not better explained by another current sleep disorder, medical disorder, medication, or substance use

American Academy of Sleep Medicine. International Classification of Sleep Disorders, 3rd ed, text revision, American Academy of Sleep Medicine, 2023.

Polysomnography of CSA



The absence of signal in either of the airflow leads indicates that this is an apnea
the absence of respiratory effort in either the thoracic or abdominal effort leads identifies this as a central apnea

Treatment of CSA

- **Goals of therapy**
  - Initial treatment should be directed at any condition that may be causing or exacerbating the CSA
  - If persists despite such therapy, CSA-specific therapies are indicated for patients with symptoms or significant physiological sequelae attributable to CSA
    - Daytime sleepiness, prolonged or repetitive oxyhemoglobin desaturation during sleep

Sleep. 2012;35(1):17. Epub 2012 Jan 1.

Treatment of CSA

- **Hyperventilation-related CSA**
  - Includes primary CSA, CSA associated with Cheyne-Stokes breathing, a medical condition such as heart failure, or high-altitude periodic breathing
  - CPAP in CSA
    - Preferred first-line therapy for symptomatic patients
    - Reduces the frequency of central apneas, by preventing pharyngeal airway narrowing and occlusion during a central apnea
  - Supplemental oxygen during sleep

Sleep. 2012;35(1):17. Epub 2012 Jan 1.

Treatment of CSA

- CSA due to heart failure with reduced ejection fraction (Patients with ejection fraction ≤40 percent)
  - Recommend not initiating adaptive servo-ventilation (ASV) in patients
  - Suggest not using bilevel positive airway pressure (BPAP) with a back-up rate in these patients, based on the analogous mechanism of effect between ASV and BPAP with a back-up rate

Sleep. 2012;35(1):17. Epub 2012 Jan 1.

Continuous Positive Airway Pressure for Central Sleep Apnea and Heart Failure

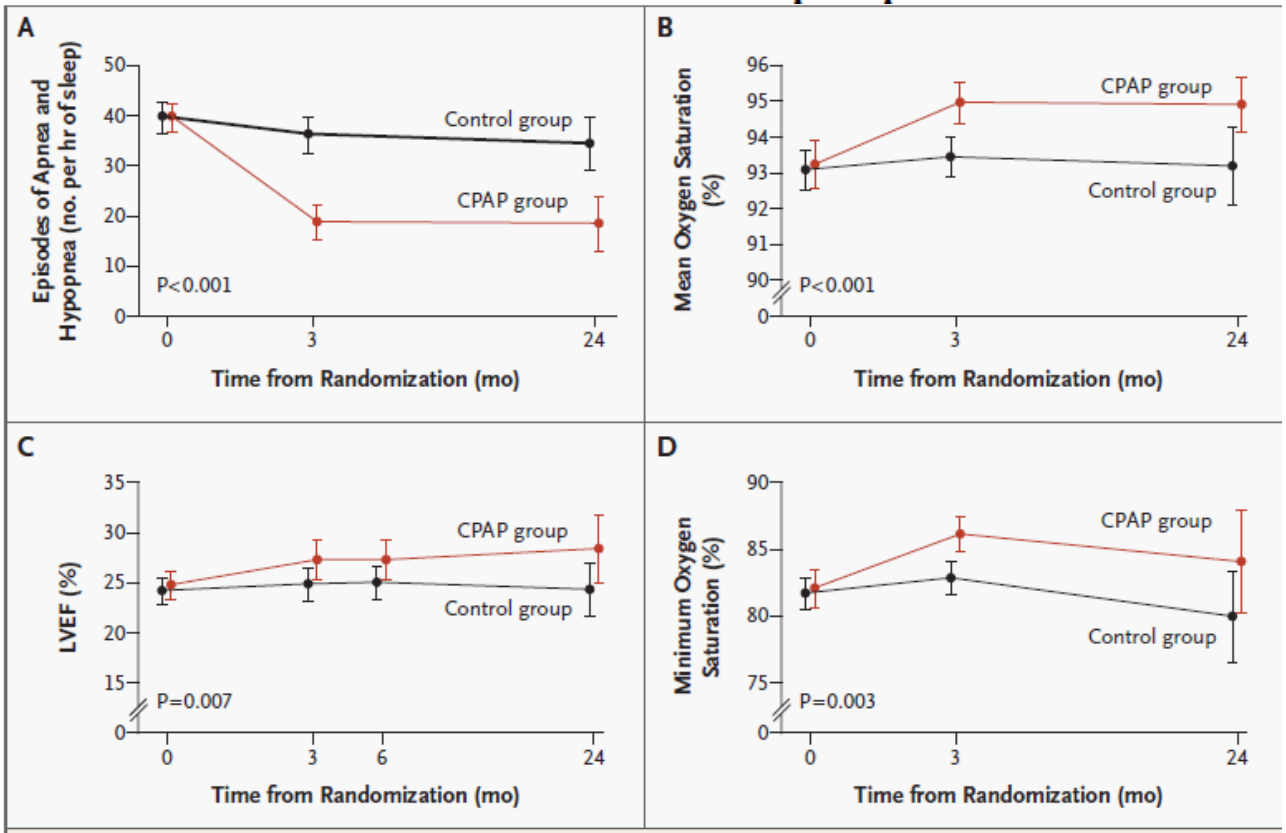


Figure 1. Effect of CPAP on the Frequency of Episodes of Apnea and Hypopnea, Mean and Minimal Nocturnal Oxygen Saturation, and Left Ventricular Ejection Fraction.

CPAP resulted in significant long-term reductions in the number of episodes of apnea and hypopnea per hour of sleep (Panel A) and increases in the mean nocturnal oxygen saturation (Panel B), the LVEF (Panel C), and the minimum nocturnal oxygen saturation (Panel D). P values represent time–treatment interactions over the period of the entire trial (corresponding values for effects at three months appear in the Results section). Circles represent means, and I bars represent 95 percent confidence intervals.

- RCT, 11 centers in Canada
- 258 patients with heart failure and CSA

-> CPAP vs. no CPAP

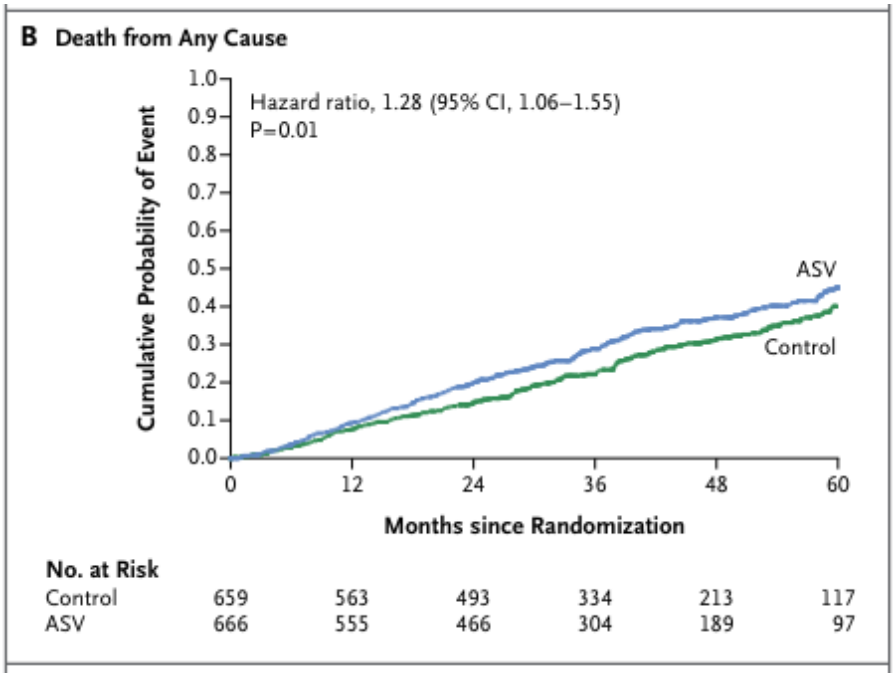
- CPAP attenuated CSA, improved nocturnal oxygenation, increased EF, and increased the distance walked in six minutes,
- Did not affect survival

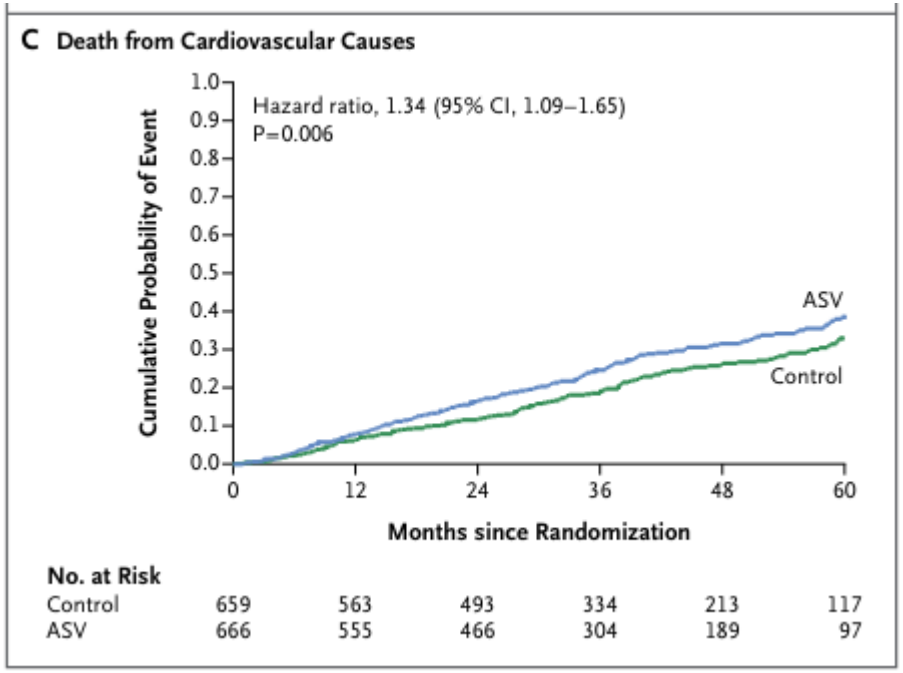
N Engl J Med. 2005;353(19):2025.

Adaptive Servo-Ventilation for Central Sleep Apnea in Systolic Heart Failure

Tre

Martin R. Cowie, M.D., Holger Woehrle, M.D., Karl Wegscheider, Ph.D., Christiane Angermann, M.D., Marie-Pia d'Ortho, M.D., Ph.D., Erland Erdmann, M.D., Patrick Levy, M.D., Ph.D., Anita K. Simonds, M.D., Virend K. Somers, M.D., Ph.D., Faiez Zannad, M.D., Ph.D., and Helmut Teschler, M.D.





- International, multicental, RCT, 1325 patients 22 years of age or older and had symptomatic chronic heart failure and reduced EF (<45%), AHI ≥ 15, predominance of central events -> ASV group vs. control group
- All-cause mortality and cardiovascular mortality were significantly higher in the ASV group than in the control group

N Engl J Med 2015;373:1095-105.

Treatment of CSA

- Symptomatic patients who are already using and tolerating ASV for CSA
  - Individualize decisions about ongoing therapy and discuss the risk of increased mortality observed in a trial of ASV in patients with reduced ejection fraction

- Patients with a preserved ejection fraction (>40 percent) who do not tolerate CPAP for CSA
  - ASV and BPAP with a back-up respiratory rate remain reasonable second-line modes of ventilation

J Clin Sleep Med. 2019;15(2):301. Epub 2019 Feb 15.

Treatment of CSA

- **Adaptive servo-ventilation (ASV) in CSA**
  - Heart failure with preserved ejection fraction, primary CSA, treatment-emergent CSA
    - In patients who are responding to therapy and have failed prior CPAP
- **Bilevel positive airway pressure (BPAP) in CSA**
  - Be considered for the treatment of CSA if there is no response to CPAP
  - Back-up respiratory rate is required if BPAP is used for the treatment of central apnea
    - BPAP in the spontaneous mode (without a back-up rate) may induce hypocapnia and hence exacerbate central apnea

J Clin Sleep Med. 2016;12(5):757. Epub 2016 May 15

Treatment of CSA

- For symptomatic patients with hyperventilation-related CSA who do not tolerate PAP
  - Suggest supplemental oxygen during sleep
  - If oxygen is not available or effective, trial of acetazolamide

J Clin Sleep Med. 2019;15(2):301. Epub 2019 Feb 15.

Treatment of CSA

- **Hypoventilation-related CSA**
  - CSA due to central nervous system or neuromuscular disease
  - Individualized based on the underlying etiology
  - In most of these disorders, BPAP with a back-up rate is a first-line therapy

J Clin Sleep Med. 2019;15(2):301. Epub 2019 Feb 15.

Treatment-emergent Central Sleep Apnea (TE-CSA)

- 1–5% with OSA develops CSAs upon introduction of treatments that restore airway patency, including CPAP, oral appliance, and surgery

- Some experts continue CPAP therapy after an initial "failed" titration for two to three months
  - If TE-CSA has not resolved, CPAP may be continued at a suboptimal level

  => ASV or rarely, BPAP-S/T mode, may be chosen

- Other experts, prefer ASV if CPAP is acutely not able to resolve complex sleep-disordered breathing to AHI <5
  - Based on limited data, ASV seems to be superior to BPAP-S/T in acutely resolving TE-CSA

Sleep. 2007;30(4):468.

Summary

- **OSA**
  - **Indications for PAP**
    - AHI ≥15, AHI >5 and <15: Symptoms, Mission critical work,

      AHI ≤5: Increased number of RERAs (≥10 per hour) and excessive daytime sleepiness
  - **Mode selection**
    - Fixed-level CPAP : First-line
    - BPAP: Uncomplicated OSA who fail or do not tolerate CPAP, Complicated sleep-disordered breathing (central sleep apnea and/or hypoventilation syndromes)
    - ASV: OSA and comcomitant central apnea
- **CSA**
  - **Hyperventilation-related CSA**
    - CPAP: Preferred first-line therapy for symptomatic patients
    - CSA due to heart failure with reduced EF: Not initiation ASV or BPAP
    - ASV: Heart failure with preserved EF, primary CSA, treatment-emergent CSA (failed prior CPAP)
    - BPAP: no response to CPAP, back-up respiratory rate is required
  - **Hypoventilation-related CSA**
    - BPAP with a back-up rate is a first-line therapy

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