Manual Titration of Positive Airway Pressure in Patients with Obstructive Sleep Apnea

Alejandro D. Chediak, MD, FAASM, FACP, FACCP[a,b,*]

KEYWORDS

- Positive airway pressure • Titration
- Continuous positive airway pressure
- Bilevel positive airway pressure
- Obstructive sleep apnea
- Sleep-related breathing disorder
- Sleep-disordered breathing

Obstructive sleep apnea (OSA), a sleep-related breathing disorder characterized by full or partial occlusion of the upper airway during sleep, is treated most often by positive airway pressure (PAP) therapy. Standard sleep medicine practice involves manual pressure adjustment by a sleep technologist during attended laboratory polysomnography (PSG) designed to eliminate obstructive respiratory-related events (apneas, hypopneas, respiratory effort-related arousals [RERAs], and snoring). The manual titration of PAP has been conducted for over 25 years,[1] yet no standardized protocols exist for this procedure.[2] A survey of accredited sleep centers reviewed titration protocols from 51 accredited centers and found that the procedures described for PAP titration varied widely among the centers. Twenty-two percent of these centers did not have a written protocol.[3] The lack of standardization results in clinicians and technologists from different sleep laboratories developing their own protocols[4] or relying on protocols obtained from industry or other sleep laboratories. When a standardized protocol is implemented, the optimal pressure for continuous positive airway pressure (CPAP) can be reproducible; one study revealed a Spearman correlation coefficient of 0.89 for the optimal pressure selected for two consecutive CPAP titration nights in 50 patients who had OSA.[5] Published PAP titration protocols are scarce, however, and there is a question as to what one would use or measure to advocate or support one particular protocol over another. Given this gap, an American Academy of Sleep Medicine (AASM) Task Force was charged with developing an evidence- and consensus-based standardized PAP titration protocol. The task force chose as its premise that a successful titration is one in which there is an optimized trade-off between increasing pressure to yield efficacy in elimination of respiratory events and decreasing pressure to minimize emergence of pressure-related adverse effects.[6] The guidelines for CPAP titration provided in this treatment on the topic are often duplicative of the recommendations made by the AASM CPAP Titration Task Force, and the reader is directed to that manuscript for details pertaining to the scientific basis for a specific recommendation.[7]

Several factors have been identified as potentially influencing optimal pressure, such as rapid eye movement (REM) sleep amounts,[8] the length of the soft palate, and the degree of respiratory

[a] University of Miami at Mount Sinai Medical Center, 4300 Alton Road, Miami Beach, FL 33140, USA
[b] Miami Sleep Disorders Center, 7029 SW 61st Avenue, South Miami, FL 33143, USA
* School of Medicine, University of Miami at Mount Sinai, FL.
E-mail address: miamisleep@bellsouth.net

Sleep Med Clin 4 (2009) 443–453
doi:10.1016/j.jsmc.2009.04.012
1556-407X/09/$ – see front matter

effort.[9] Although there are some studies demonstrating reasonable correlation between the level of optimal CPAP and the apnea–hypopnea index (AHI)[10,11] or obesity,[11] a significant correlation for optimal CPAP and AHI has been observed only in patients whose apneas depend on body position.[12] Mathematical equations incorporating measures of OSA severity (AHI) and obesity (ie, body mass index [BMI] and neck circumference) developed to predict the optimal level of CPAP[11,13] have proven inaccurate in predicting the optimal CPAP level.[14,15] Hence, manual titration of PAP in the sleep laboratory remains the standard of care.

PAP delivery systems consist of three main components: a PAP device (a turbine- or fan-driven air pump), an interface (ie, nasal mask, nasal pillows, full-face mask) used to connect the subjects natural airway to the PAP device output, and a flexible hose that connects the PAP device to the interface. PAP devices are divided into four basic types depending on their pressure delivery system:

1. CPAP, which delivers a single, fixed pressure throughout the respiratory cycle
2. Bilevel positive airway pressure (BPAP), which delivers a higher PAP with inspiration (IPAP) than with expiration (EPAP)
3. Auto-titrating positive airway pressure (APAP), which, using a manufacturer specific paradigm, automatically alters CPAP or BPAP (IPAP/EPAP) intending to maintain airway patency
4. Adaptive servo-ventilation (ASV), which uses a servo-controller that automatically adjusts pressure to maintain steady minute ventilation

APAP device prescriptions account for only 4% of PAP devices prescribed, and in 2004, 30% of board-certified sleep physicians reported having never prescribed APAP devices.[16] Two types of PAP devices, CPAP and BPAP, will be discussed. As described in this article, BPAP refers to a BPAP device set in spontaneous mode unless otherwise specified. Data regarding usefulness of other PAP device types or device features including ASV will not be discussed. Unless specified otherwise, the information in this article pertains only to nighttime PAP titration studies. Manual titration of CPAP or BPAP is currently the gold standard for selecting the optimal (effective) pressure for CPAP and BPAP,

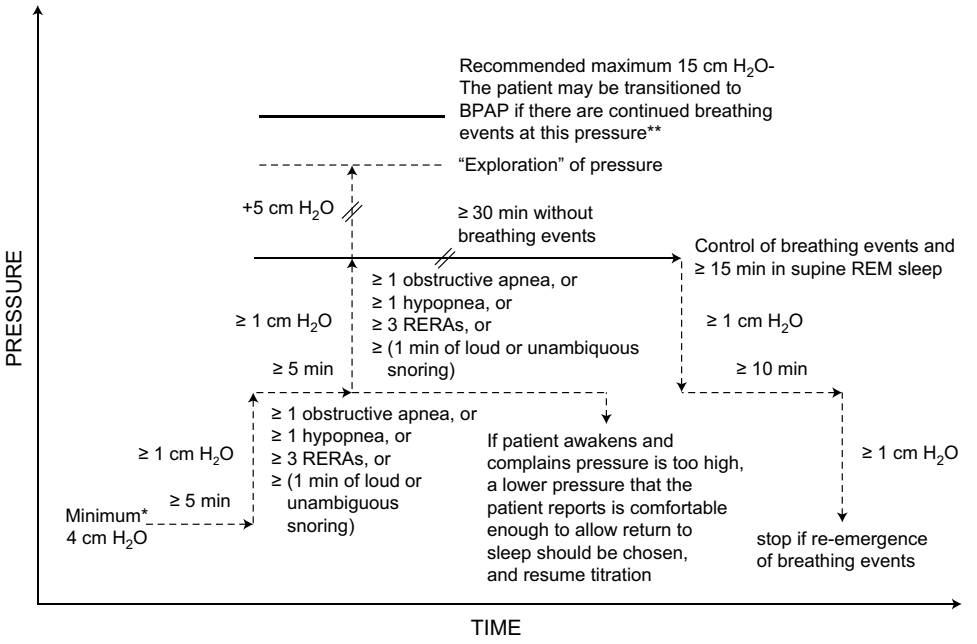

Fig. 1. Continuous positive airway pressure (CPAP) titration algorithm for patients younger than 12 years during full- or split-night titration studies. Note, upward titration at greater than or equal to 1 cm increments over greater than or equal to 5-minute periods is continued according to the breathing events observed until at least 30 minutes without breathing events is achieved. A higher starting CPAP may be selected for patients who have an elevated body mass index and for retitration studies (*). The patient also should be tried on bilevel positive airway pressure if he or she is uncomfortable or intolerant of high CPAP (**). (*From* Kushida CA, Chediak A, Berry R, et al. Clinical guidelines for the manual titration of positive airway pressure in patients with obstructive sleep apnea. J Clin Sleep Med 2008;4:157–71; with permission.)

and this article is limited to reflect current knowledge and practice of this procedure.

This article uses the following terminology. Unless stated otherwise, OSA is used synonymously with obstructive sleep apnea syndrome, obstructive sleep apnea–hypopnea syndrome, and obstructive forms of either sleep-disordered breathing or sleep-related breathing disorder. The scope of this work is restricted to adult (at least 12 years) and pediatric (younger than 12 years) patients who have OSA and does not apply to patients who have conditions such as neuromuscular disease or intrinsic lung disease. The respiratory disturbance index (RDI) refers to the total of apneas, hypopneas, and RERAs per hour of sleep, and for this article, this term is not synonymous with the AHI, which refers to the total of apneas and hypopneas per hour of sleep. Mild, moderate, and severe OSAs are defined according to following criteria in adults: mild, $5 \leq RDI \leq 15$; moderate, $15 \leq RDI \leq 30$; and severe, $RDI > 30$.[17] In children younger than 12 years of age, the criteria are as follows: mild, $1 \leq RDI < 5$; moderate, $5 < RDI < 10$; and severe, $RDI > 10$.[18,19]

GENERAL RECOMMENDATIONS FOR ADULT AND PEDIATRIC POSITIVE AIRWAY PRESSURE TITRATIONS

All potential PAP titration candidates (including those candidates where a split-night study is a possibility) should receive adequate PAP education, hands-on demonstration, careful mask fitting, and acclimatization before titration. Specific recommendations include:

- The indications, rationale for use, and adverse effects of PAP should be discussed in detail with the patient or caregiver *before* the PAP titration study.
- The patient should be fitted carefully for the interface with intent of maximizing comfort, compensating for significant nasal obstruction, and minimizing leak before the PAP titration.
- The patient should be acclimated to the PAP equipment (ie, wearing the interface with the pressure on) before lights off.[20,21]
- There should be several different types of PAP interfaces (ie, nasal mask, nasal pillows, full-face/oronasal mask) and

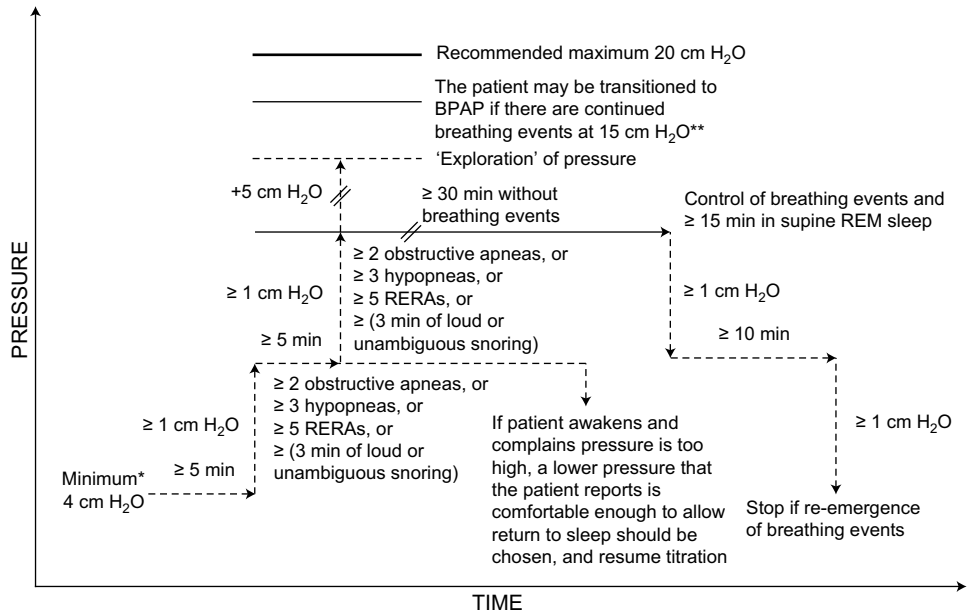

Fig. 2. Continuous positive airway pressure (CPAP) titration algorithm for patients greater than or equal to 12 years during full- or split-night titration studies. Note, upward titration at agreater than or equal to1-cm increments over greater than or equal to 5-minute periods is continued according to the breathing events observed until at least 30 minutes without breathing events are achieved. A higher starting CPAP may be selected for patients who have an elevated BMI and for retitration studies (*). The patient also should be tried on bilevel positive airway pressure if he or she is uncomfortable or intolerant of high CPAP (**). (*From* Kushida CA, Chediak A, Berry R, et al. Clinical guidelines for the manual titration of positive airway pressure in patients with obstructive sleep apnea. J Clin Sleep Med 2008;4:157–71; with permission.)

Box 1
Specific continuous positive airway pressure titration guidelines

The minimum starting CPAP should be 4 cm H_2O in pediatric and adult patients. A priori determination of CPAP cannot be supported by evidence. Nonetheless, a higher starting CPAP is sensible in retitration studies, in those who have very high BMI, and in cases where patients experience air hunger on lower doses of CPAP during the pretitration acclimation to CPAP.

The maximum CPAP should be 15 cm H_2O for patients younger than 12 years.

The maximum CPAP should be 20 cm H_2O for patients 12 years of age or older.

If there are continued obstructive respiratory events at 15 cm H_2O of CPAP for either adult or pediatric patients during the titration study, the patient may be switched to BPAP titration.

CPAP should be increased by at least 1 cm H_2O with an interval no shorter than 5 minutes, with the goal of eliminating obstructive respiratory events.

In patients younger than 12 years of age, increase CPAP as stipulated if:

At least one obstructive apnea is observed

At least one hypopnea is observed

At least three RERAs are observed

In patients 12 years of age or older, increase CPAP as stipulated if:

At least two obstructive apneas are observed

At least three hypopneas are observed

At least five RERAs are observed

CPAP may be increased by at least 1 cm H_2O with an interval no shorter than 5 minutes, with the goal of eliminating loud or unambiguous snoring after.

At least 1 minute of loud or unambiguous snoring in patients younger than 12 years

At least 3 minutes of loud or unambiguous snoring in patients 12 years of age or older

Exploration of CPAP pressure above the pressure at which control of obstructive respiratory events is achieved should not exceed 5 cm H_2O.

Elevated upper airway resistance with sleep disruption may persist despite selection of a pressure that eliminates apneas and hypopneas.[24,25]

A reduction in respiratory oscillations of esophageal pressure or resolution of inspiratory flattening on a flow–time curve in response to exploration with higher CPAP pressure may serve as surrogate markers of decreasing upper airway resistance. In this regard, CPAP exploration can have utility by increasing pressure by 2 cm H_2O but no higher than by 5 cm H_2O.[26]

Upward titration of the CPAP level to correct inspiratory flow limitation may be 2 to 5 cm H_2O higher than the level at which it reappears during downward titration, a phenomena explained by upper airway hysteresis.[26] Decreasing CPAP after controlling respiratory events (apneas, hypopneas, RERAs, and snoring) or up–down titration is an acceptable strategy employed to take advantage of upper airway hysteresis and allow for selection of a lower effective CPAP dose. Alternatively, an up-down-up CPAP titration paradigm, where pressure is increased in a stepwise fashion until respiratory events disappear then systematically decreased until respiratory abnormalities reappear (**Fig. 3**) followed by a reincrease in CPAP pressure to renormalize respiration, has been used to exploit the hysteresis effect.[27] If an up–down or up-down-up titration strategy is implemented:

At least one titration cycle (up–down or up-down-up) should be conducted.

At least 30 minutes without obstructive respiratory events should have passed before starting the titration cycle.

CPAP should be decreased by more than 1 cm H_2O with an interval no shorter than 10 minutes, until there is reemergence of obstructive respiratory events.

In up-down-up titration cycles, after completing the previously described CPAP reduction, CPAP pressure once again is increased in increments of 1 cm H_2O until respiratory events are corrected.

Complaints of excess pressure during the course of CPAP titration may be addressed by resuming the CPAP titration at a pressure at or just below that which the patient reports as uncomfortable.

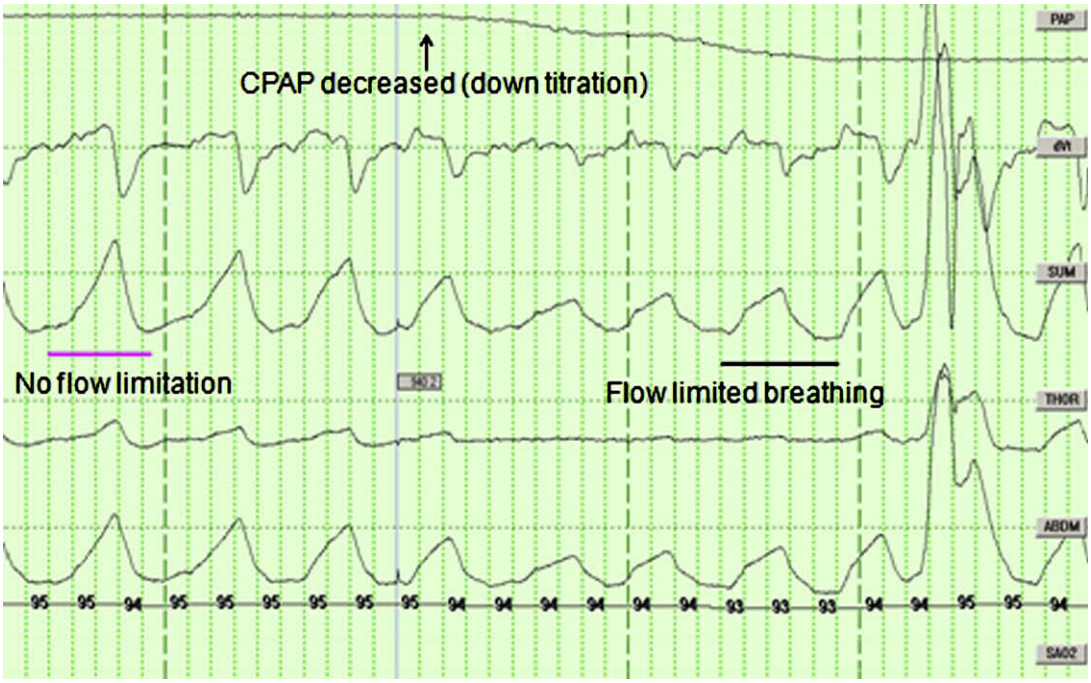

Fig. 3. Down titration phase of an up–down continuous positive airway pressure (CPAP) titration cycle. Note how flow becomes limited, and breath volume diminishes on abrupt reduction in CPAP pressure output, indicating insufficient treatment pressure at the lower CPAP pressure output. *Abbreviations:* ABDOM, abdominal contribution to breathing by respiratory inductive plethysmography (RIP); dVt, airflow derived by the instantaneous derivative of the tracing SUM (breath volume-time); PAP, positive airway pressure output; SAO_2, oxyhemoglobin saturation by pulse oximetry; SUM, breath volume derived by RIP; THOR, thoracic contribution to breathing by RIP.

accessories (chinstrap, heated humidifier) available if the patient encounters problems (eg, mouth leak, nasal congestion, or oronasal dryness) during the night.

- In patients who have combined insomnia and sleep apnea, a combination of daytime psychological and physiologic treatments before overnight PAP titration can facilitate acceptance of PAP titration[21]
- Because children have more problems adjusting to PAP than adults, additional steps may be required. Pediatric size interfaces should be available,[22] and behavioral modification techniques may be implemented to increase the tolerability and potential adherence to PAP equipment.[16,23]
- PAP assembly, optional equipment, importance of daily/nightly use, adherence issues, necessity of cleaning the equipment, and implications of the purchase/rental of the equipment (when applicable) should be discussed in detail with the patient or caregiver, preferably following the PAP titration study.

GUIDELINES FOR CONTINUOUS POSITIVE AIRWAY PRESSURE TITRATION

In full-night CPAP titration PSG and split-night PSG when CPAP is used in the titration arm of the study, CPAP should be increased until obstructive respiratory events are eliminated (apneas, hypopneas, RERAs, and snoring) or a recommended maximum CPAP is reached. Oxyhemoglobin desaturation–resaturation events occurring without associated obstructive respiratory events should not be considered in the decision to increase CPAP in pediatric and adult patients. Specific guidelines for pediatric and adult CPAP titrations are depicted in **Figs 1** and **2**, respectively, and in **Box 1**.

GUIDELINES FOR BILEVEL POSITIVE AIRWAY PRESSURE TITRATION

In general, BPAP is not more effective than CPAP, and the following guidelines should not be construed to imply otherwise (**Figs 4** and **5**). A patient may be tried on BPAP for intolerance of high pressures on CPAP and if there are continued obstructive respiratory events at 15 cm H_2O of CPAP in the course of

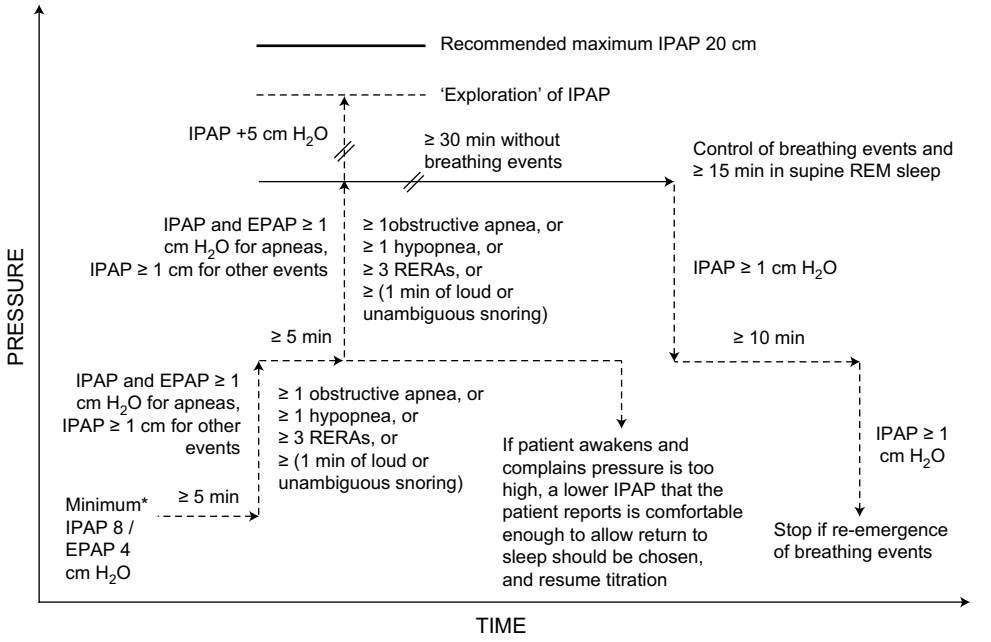

Fig. 4. Bilevel positive airway pressure (BPAP) titration algorithm for patients younger than 12 years during full- or split-night titration studies. Note, upward titration of inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP) greater than or equal to 1 cm H_2O for apneas and IPAP greater than or equal to 1 cm for other events over at least 5-minute periods is continued until at least 30 minutes without breathing events are 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. A higher starting IPAP and EPAP may be selected for patients who have an elevated BMI and for retitration studies (*). When transitioning from CPAP to BPAP, the minimum starting EPAP should be set at 4 cm H_2O or the CPAP level at which obstructive apneas were eliminated. An optimal minimum IPAP–EPAP differential is 4 cm H_2O, and an optimal maximum IPAP–EPAP differential is 10 cm H_2O. (*From* Kushida CA, Chediak A, Berry R, et al. Clinical guidelines for the manual titration of positive airway pressure in patients with obstructive sleep apnea. J Clin Sleep Med 2008;4:157–71; with permission.)

a CPAP titration. Efforts should be made to explore the cause of CPAP intolerance and to remedy the complaint before proceeding to BPAP titration. In full-night BPAP titration PSG and split-night PSG when BPAP is used in the titration arm of the study, BPAP should be increased until obstructive respiratory events are eliminated (apneas, hypopneas, RERAs, and snoring) or a recommended maximum IPAP is reached. The algorithm for split-night BPAP titration studies should be identical to that of full-night BPAP titration studies. Specific guidelines are listed in **Box 2**.

GUIDELINES FOR GRADING OF POSITIVE AIRWAY PRESSURE TITRATION STUDIES

The PAP settings prescribed following a titration study should reflect control of obstructive respiration by a low (preferably less than 5/h) RDI at the selected pressure, a minimum sea level oxyhemoglobin saturation (SaO_2) above 90% at the pressure, and with a leak within acceptable parameters at the pressure.

- An optimal titration is one that reduces RDI by less than 5 during at least 15 minutes of sleep and includes sustained supine REM sleep at the selected pressure.
- A good titration is one that: Reduces RDI by no more than 10 or by 50% if the baseline RDI is less than 15/h and includes sustained supine REM sleep at the selected pressure.
- An adequate titration is one that does not reduce the overnight RDI by less than or equal to 10/h but does reduce the RDI by 75% from baseline. Additionally, the titration grading criteria for optimal or good are met with the exception that supine REM sleep did not occur at the selected pressure.
- An unacceptable titration is one that does not meet any of the previously described criteria for optimal, good, or acceptable titrations.

IDENTIFYING AND MANAGING UNINTENTIONAL MASK LEAKS DURING POSITIVE AIRWAY PRESSURE TITRATION STUDIES

PAP mask refit or readjustment should be performed whenever any significant unintentional leak is observed.

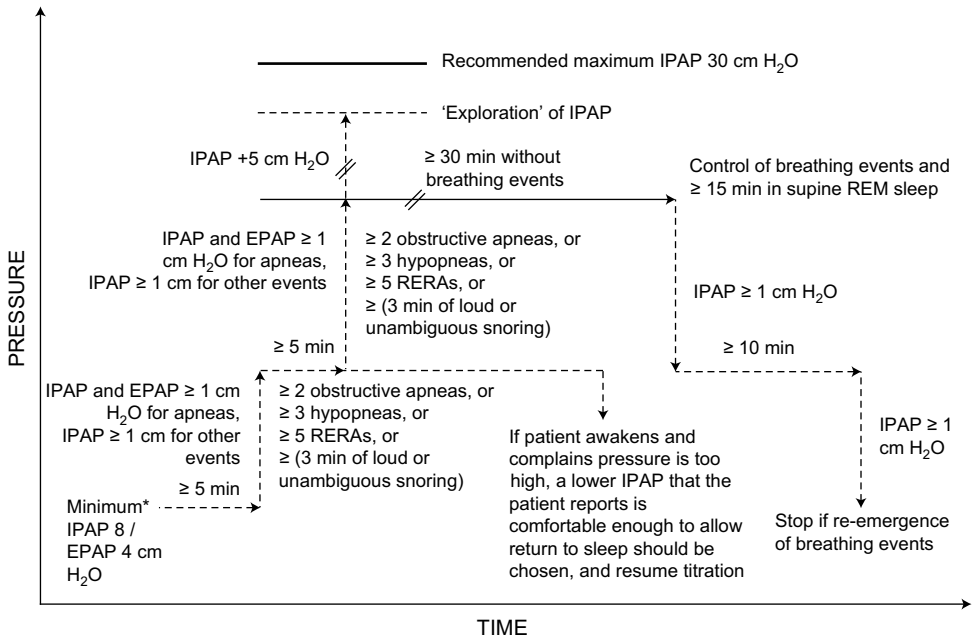

Fig. 5. Bilevel positive airway pressure (BPAP) titration algorithm for patients 12 years or older during full- or split-night titration studies. Note, upward titration of inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP) greater than or equal to 1 cm H_2O for apneas and IPAP greater than or equal to 1 cm for other events over at least 5-minute periods is continued until at least 30 minutes without breathing events are 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. A higher starting IPAP and EPAP may be selected for patients who have an elevated body mass index and for retitration studies (*). When transitioning from continuous positive airway pressure (CPAP) to BPAP, the minimum starting EPAP should be set at 4 cm H_2O or the CPAP level at which obstructive apneas were eliminated. An optimal minimum IPAP–EPAP differential is 4 cm H_2O, and an optimal maximum IPAP–EPAP differential is 10 cm H_2O. (*From* Kushida CA, Chediak A, Berry R, et al. Clinical guidelines for the manual titration of positive airway pressure in patients with obstructive sleep apnea. J Clin Sleep Med 2008;4:157–71; with permission.)

PAP mask air leakage can occur in several forms. The mask leak that washes out CO_2 and prevents rebreathing can be termed intentional leak, with the amount of intentional leak dependent on the interface used and the output pressure from the PAP device. Air unintentionally escaping by means of the mouth is called mouth leak, while air that escapes between the mask and the contact on the face or nose can be termed mask leak. A combination of intentional and unintentional leak can be termed total leak, and it is this latter value that most commercially available laboratory titration devices output to either a standalone monitor or plot directly on to the polygraph recording. Unintentional mask leak should be minimized by mask refit or readjustment, while unintentional mouth leak may be addressed by adding a chin strap to reduce mouth opening or by switching to a full-face/oronasal mask.[28,29]

The definition of a clinically significant leak during the course of PAP titration is difficult to define. A leak substantially higher than that recorded at a given pressure from a well-fitted mask in general may be considered unacceptable. The acceptable leak depends on the interface and the applied pressure. The notion that unintentional leak always will exceed intentional leak can be used for laboratories to derive a range of acceptable total leak for a specific PAP mask and pressure. **Table 1** shows the expected intentional leak of selected interfaces at a fixed pressure. The reader is encouraged to contact the individual PAP interface manufacturer to ascertain the intentional leak for other or new interfaces, the latter as they reach the marketplace. Laboratories are encouraged to use the manufacturer-specific leak–pressure relationship for a given interface and clinical judgment to develop laboratory-specific guidelines of acceptable total leak.

POSITIONAL AND SLEEP STAGE FACTORS

As defined earlier, for an optimal PAP titration, the patient should be recorded in supine REM sleep for at least 15 minutes at the designated optimal

Box 2
Specific bilevel positive airway pressure filtration guidelines

In pediatric and adult patients, the recommended minimum starting IPAP and EPAP should be 8 cm H_2O and 4 cm H_2O, respectively. A priori determination of IPAP and EPAP cannot be supported by evidence. Nonetheless, a higher starting IPAP or EPAP is sensible in retitration studies, in those who have very high BMI, and in cases where patients experience air hunger on lower doses of IPAP or EPAP during the pretitration acclimation to BPAP.

The maximum IPAP should be 20 cm H_2O for patients younger than 12 years.

The maximum IPAP should be 30 cm H_2O for patients 12 years of age or older.

The minimum IPAP–EPAP differential should be 4 cm H_2O

The maximum IPAP–EPAP differential should be 10 cm H_2O.

IPAP or EPAP (based on the type of obstructive respiratory event) should be increased by at least 1 cm H_2O apiece with an interval no shorter than 5 minutes, with the goal of eliminating obstructive respiratory events.

Obstructive apnea

In patients younger than12 years, increase IPAP and EPAP if at least one obstructive apnea is observed.

In patients 12 years of age or older, increase IPAP and EPAP if at least two obstructive apneas are observed.

Obstructive hypopnea

In patients younger than 12 years, increase IPAP if at least one hypopnea is observed.

In patients 12 years of age or older, increase IPAP if at least three hypopneas are observed.

RERA events

In patients younger than 12 years, increase IPAP if at least three RERAs are observed.

In patients 12 years of age or older, increase IPAP if at least five RERAs are observed.

Loud or unambiguous snoring

In patients younger than 12 years, one may increase IPAP if at least 1 minute of loud or unambiguous snoring is observed.

In patients 12 years of age or older, one may increase IPAP if at least 3 minutes of loud or unambiguous snoring are observed.

As described in the guidelines for CPAP titration, exploration of IPAP above the pressure at which control of abnormalities in respiratory parameters is achieved should not exceed 5 cm H_2O.

Exploiting hysteresis during BPAP titration has not been reported. Therefore, specific guidelines for up–down and up-down-up BPAP titration strategies are not offered.

Complaints of excess pressure during the course of BPAP titration may be addressed by resuming the BPAP titration at an IPAP or EPAP pressure at or just below that which the patient reported as uncomfortable.

If central apneas emerge in the course of BPAP titration, a decrease in IPAP or setting BPAP in spontaneous-timed (ST) mode with backup rate may be helpful.

pressure. If the patient is in REM sleep but not in the supine position while at the designated optimal pressure, the patient may be awakened and instructed to lie in the supine position.

Optimal CPAP in the supine position may exceed optimal CPAP while sleeping in the lateral position by 2 cm. This relationship is applicable in REM and non-REM (NREM) sleep, in obese and nonobese subjects and in those younger and older than 60 years.[30] Because treatment-emergent central sleep apnea is more likely to occur in NREM sleep, it is also important to evaluate patients at the designated optimal pressure during NREM sleep.[31–34] Because sleep efficiency is the sole independent PSG parameter that predicts PAP adherence, the decision to awaken the

Table 1
Intentional leak at various pressures (cm H_2O) for selected positive airway pressure interfaces

(a) Intentional leak of selected ResMed interfaces (L/min)[a]

	Extranasal			Intranasal		Mirage Full-Face/Oronasal		
Pressure	Mirage Micro	Mirage Activa	Ultra Mirage II	Swift LT	Swift II	Liberty	Quattro	Ultra
4	19.2	19.2	18.3	20.3	20.3	22.1	22.1	22.1
6	23.7	23.7	24.1	25.2	25.2	27.6	27.6	27.6
8	27.7	27.7	29.4	29.4	29.4	32.3	32.3	32.3
10	31.2	31.2	34.3	33.2	33.2	36.6	36.6	36.6
12	34.4	34.4	38.4	36.7	36.7	40.5	40.5	40.5
14	37.4	37.4	42.6	39.9	39.9	43.5	43.5	43.5
16	40.2	40.2	46.3	42.9	42.9	47.8	47.8	47.8
18	42.8	42.8	49.9	45.8	45.8	51.1	51.1	51.1
20	45.4	45.4	53.1	48.6	48.6	54.3	54.3	54.3

(b) Intentional leak of selected Respironics interfaces (L/min)[b]

	Extranasal					Intranasal	Full-Face/Oronasal	
Pressure	ComfortGel	ComfortSelect	ComfortClassic	Profile Lite	Simplicity	OptiLife	ComfortFull 2	ComfortGel Full[c]
5	17.9	17.9	17.9	17.9	15.6	16.1	18.6	17
10	25.5	25.5	25.5	25.5	22.4	23.1	27.5	26
15	31.4	31.4	31.4	31.4	27.5	28.7	34.2	33
20	36.7	36.7	36.7	36.7	31.9	33.7	39.7	40
25	41.1	41.1	41.1	41.1	35.7	37.9	44.2	45
30	45	45	45	45	39.2	41.7	48.4	50

[a] *From* http://www.resmed.com/en-us/assets/documents/product/102648-pressure-vs-flow-mask-flow-generator-settings-usa-eng.pdf.
[b] *From* http://sleepapnea.respironics.com/PDF/LeakRate.pdf.
[c] *From* ComfortGel (Murrysville, Pennsylvania) FULL instructions for use.

patient to sample supine REM must be considered in the light of potentially altering the value of sleep efficiency as a predictor of long-term PAP use.

SUMMARY

PAP therapy continues to be the most widely prescribed treatment for adult OSA, and PAP increasingly is offered to pediatric patients who have OSA. The current standard of practice involves performing attended PSG for the manual titration of PAP therapy. This article set out to provide a practical framework by which to manually titrate PAP therapy (CPAP and BPAP) during a laboratory PSG. Most of the recommendations and guidelines within this treatment on PAP titration have been derived by consensus with reliance on the relatively sparse available evidence for scientific review. The interested reader is referred to the AASM Positive Airway Pressure Titration Task Force publication[1] for details regarding the evidence-based and consensus findings behind the recommended approach for the manual titration of PAP during attended in-laboratory PSG.

REFERENCES

1. Juhasz J. The fine art of CPAP titration—will it ever become obsolete? Sleep Breath 2007;11:65–7.
2. Stepanski EJ. The need for a standardized CPAP titration protocol and follow-up procedures. J Clin Sleep Med 2005;1:311.
3. Stepanski EJ, Dull R, Basner RC. CPAP titration protocols among accredited sleep disorders centers. J Sleep Res 1996;25:374.
4. Mokhlesi B, Tulaimat A. Recent advances in obesity hypoventilation syndrome. Chest 2007;132:1322–6.
5. Weist GH, Fuchs FS, Harsch IA, et al. Reproducibility of a standardized titration procedure for the initiation of continuous positive airway pressure therapy in patients with obstructive sleep apnoea. Respiration 2001;68:145–50.
6. Berthon-Jones M, Lawrence S, Sullivan CE, et al. Nasal continuous positive airway pressure treatment: current realities and future. Sleep 1996; 19(Suppl 9):S131–5.
7. Kushida CA, Chediak AD, Berry RB, et al. Clinical guidelines for the manual titration of positive airway pressure in patients with obstructive sleep apnea. J Clin Sleep Med 2008;4:157–71.
8. Sullivan CE, Issa FG, Berthon-Jones M, et al. Home treatment of obstructive sleep apnoea with continuous positive airway pressure applied to a nose-mask. Bull Eur Physiopathol Respir 1984;20:49–54.
9. Sforza E, Krieger J, Bacon W, et al. Determinates up effective continuous positive airway pressure in obstructive sleep apnea. Role of respiratory effort. Am J Respir Crit Care Med 1995;151:1852–6.
10. Nino-Murcia G, McCann CC, Bliwise DL, et al. Compliance and side effects in sleep apnea patients treated with nasal continuous positive airway pressure. West J Med 1989;150:165–9.
11. Miljeteig H, Hoffstein V. Determinants of continuous positive airway pressure level for treatment of obstructive sleep apnea. Am Rev Respir Dis 1993;147:1526–30.
12. Pevernagie DA, Shepherd JW Jr. Relations between sleep stage, posture and effective nasal CPAP levels in OSA. Sleep 1992;5:162–7.
13. Hoffstein V, Mateika S. Predicting nasal continuous positive airway pressure. Am J Respir Crit Care Med 1994;150:486–8.
14. Rowley JA, Tarbichi AG, Badr MS. The use of a predicted CPAP equation improves CPAP titration success. Sleep Breath 2005;9:26–32.
15. Gokcebay N, Hirshkowitz M. Optimal CPAP: titration versus. formula. Sleep 1997;20:237–8.
16. Slifer KJ, Kruglak D, Benore E, et al. Behavioral training for increasing preschool children's adherence with positive airway pressure: a preliminary study. Behav Sleep Med 2007;5:147–75.
17. Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques and clinical research. The report of an American Academy of Sleep Medicine Task Force. Sleep 1999;22:667–89.
18. Iber C, et al. The AASM manual for the scoring of sleep and associated events: rules, terminology and technical specifications. 2. Westchester (NY): American Academy of Sleep Medicine; 2007.
19. Montgomery-Downs HE, O'Brien LM, Gulliver TE, et al. Polysomnographic characteristics in normal preschool and early school-aged children. Pediatrics 2006;117:741–53.
20. Silva RS, Truksinas V, de Mello-Fujita L, et al. An orientation session improves objective sleep quality and mask acceptance during positive airway pressure titration. Sleep Breath 2008;12:85–9.
21. Krakow B, Ulibarri V, Melendrez D, et al. A daytime, abbreviated cardiorespiratory sleep study (CPT 95807-52) to acclimate insomnia patients with sleep disordered breathing to positive airway pressure (PAP-NAP). J Clin Sleep Med 2008;4:212–22.
22. Marcus CL, Ward SL, Mallory GB, et al. Use of nasal continuous positive airway pressure as treatment of childhood obstructive sleep apnea. J Pediatr 1995; 127:88–94.
23. Rains JC. Treatment of obstructive sleep apnea in pediatric patients. Behavioral intervention for compliance with nasal continuous positive airway pressure. Clin Pediatr (Phila) 1995;35:535–41.
24. Montserrat JM, et al. Time-course of stepwise CPAP titration. Behavior of respiratory and neurological variables. Am J Respir Crit Care Med 1995;152:1854–9.

25. Guilleminault C, Stoohs R, Clerk A, et al. A cause of excessive daytime sleepiness. The upper airways resistance syndrome. Chest 1993;104:781–7.
26. Condos R, Norman RG, Krishnasamy I, et al. Flow limitation as a noninvasive assessment of residual upper-airway resistance during continuous positive airway pressure therapy of obstructive sleep apnea. Am J Respir Crit Care Med 1994;150:475–80.
27. Bureau MP, Series F. Comparison of two in-laboratory titration methods to determine effective pressure levels in patients with obstructive sleep apnoea. Thorax 2000;55:741–5.
28. Schwartz AR, Kacmarek RM, Hess DR. Factors affecting oxygen delivery with bilevel positive airway pressure. Respir Care 2004;49:270–5.
29. Berry RB. Medical therapy. In: Johnson JT, Gluckman JL, Sanders MH, editors. Obstructive sleep apnea. London: Martin Dunniz; 2002. p. 89–118.
30. Oksenberg A, Silverberg DS, Arons E, et al. The sleep supine position has a major effect on optimal nasal continuous positive airway pressure: relationship with rapid eye movements and non-rapid eye movements sleep, body mass index, respiratory disturbance index, and age. Chest 1999;116:1000–6.
31. Gilmartin GS, Daly RW, Thomas RJ. Recognition and management of complex sleep-disordered breathing. Curr Opin Pulm Med 2005;11:485–93.
32. Hoheisel GB, Teschler H. Clinical parameters for the prescription of minimally effective CPAP for the treatment of obstructive sleep apnea. Am J Respir Crit Care Med 1994;149:A496.
33. Goodwin JL, Kaemingk KL, Fregosi RF, et al. Clinical outcomes associated with sleep-disordered breathing in Caucasian and Hispanic children—the Tucson Children's Assessment of Sleep Apnea study (TuCASA). Sleep 2003;26:587–91.
34. Montserrat JM, Alarcon A, Lloberes P, et al. Adequacy of prescribing nasal continuous positive airway pressure therapy for sleep apnoea/hypopnoea syndrome on the basis of nighttime respiratory recording variables. Thorax 1995;50:967–71.