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SPECIAL ARTICLE

Clinical Guidelines for the Manual Titration of Positive Airway Pressure in Patients with Obstructive Sleep Apnea

Positive Airway Pressure Titration Task Force of the American Academy of Sleep Medicine

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Summary: Positive airway pressure (PAP) devices are used to treat patients with sleep related breathing disorders (SRBDs), including obstructive sleep apnea (OSA). After a patient is diagnosed with OSA, the current standard of practice involves performing attended polysomnography (PSG), during which positive airway pressure is adjusted throughout the recording period to determine the optimal pressure for maintaining upper airway patency. Continuous positive airway pressure (CPAP) and bilevel positive airway pressure (BPAP) represent the two forms of PAP that are manually titrated during PSG to determine the single fixed pressure of CPAP or the fixed inspiratory and expiratory positive airway pressures (IPAP and EPAP, respectively) of BPAP for subsequent nightly usage. A PAP Titration Task Force of the American Academy of Sleep Medicine reviewed the available literature. Based on this review, the Task Force developed these recommendations for conducting CPAP and BPAP titrations. Major recommendations are as follows: (1) All potential PAP titration candidates should receive adequate PAP education, hands-on demonstration, careful mask fitting, and acclimatization prior to titration. (2) CPAP (IPAP and/or EPAP for patients on BPAP) should be increased until the following obstructive respiratory events are eliminated (no specific order) or the recommended maximum CPAP (IPAP for patients on BPAP) is reached: apneas, hypopneas, respiratory effort-related arousals (RERAs), and snoring. (3) The recommended minimum starting CPAP should be 4 cm H_2O for pediatric and adult patients, and the recommended minimum starting IPAP and EPAP should be 8 cm H_2O and 4 cm H_2O, respectively, for pediatric and adult patients on BPAP. (4) The recommended maximum CPAP should be 15 cm H_2O (or recommended maximum IPAP of 20 cm H_2O if on BPAP) for patients <12 years, and 20 cm H_2O (or recommended maximum IPAP of 30 cm H_2O if on BPAP) for patients ≥12 years. (5) The recommended minimum IPAP-EPAP differential is 4 cm H_2O and the recommended maximum IPAP-EPAP differential is 10 cm H_2O (6) CPAP (IPAP and/or EPAP for patients on BPAP depending on the type of event) should be increased by at least 1 cm H_2O with an interval no shorter than 5 min, with the goal of eliminating obstructive respiratory events. (7) CPAP (IPAP and EPAP for patients on BPAP) should be increased from any CPAP (or IPAP) level if at least 1 obstructive apnea is observed for patients <12 years, or if at least 2 obstructive apneas are observed for patients ≥12 years. (8) CPAP (IPAP for patients on BPAP) should be increased from any CPAP (or IPAP) level if at least 1 hypopnea is observed for patients <12 years, or if at least 3 hypopneas are observed for patients ≥12 years. (9) CPAP (IPAP for patients on BPAP) should be increased from any CPAP (or IPAP) level if at least 3 RERAs are observed for patients <12 years, or if at least 5 RERAs are observed for patients ≥12 years. (10) CPAP (IPAP for patients on BPAP) may be increased from any CPAP (or IPAP) level if at least 1 min of loud or unambiguous snoring is observed for patients <12 years, or if at least 3 min of loud or unambiguous snoring are observed for patients ≥12 years. (11) The titration algorithm for split-night CPAP or BPAP titration studies should be identical to that of full-night CPAP or BPAP titration studies, respectively. (12) If the patient is uncomfortable or intolerant of high pressures on CPAP, the patient may be tried on BPAP. If there are continued obstructive respiratory events at 15 cm H_2O of CPAP during the titration study, the patient may be switched to BPAP. (13) The pressure of CPAP or BPAP selected for patient use following the titration study should reflect control of the patient's obstructive respiration by a low (preferably <5 per hour) respiratory disturbance index (RDI) at the selected pressure, a minimum sea level SpO_2 above 90% at the pressure, and with a leak within acceptable parameters at the pressure. (14) An optimal titration reduces RDI <5 for at least a 15-min duration and should include supine REM sleep at the selected pressure that is not continually interrupted by spontaneous arousals

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or awakenings. (15) A good titration reduces RDI ≤10 or by 50% if the baseline RDI <15 and should include supine REM sleep that is not continually interrupted by spontaneous arousals or awakenings at the selected pressure. (16) An adequate titration does not reduce the RDI ≤10 but reduces the RDI by 75% from baseline (especially in severe OSA patients), or one in which the titration grading criteria for optimal or good are met with the exception that supine REM sleep did not occur at the selected pressure. (17) An unacceptable titration is one that does not meet any one of the above grades. (18) A repeat PAP titration study should be considered if the initial titration does not achieve a grade of optimal or good and, if it is a split-night PSG study, it fails to meet AASM criteria (i.e., titration duration should be >3 hr).

Keywords: PAP; titration; continuous positive airway pressure; CPAP; bilevel positive airway pressure; BPAP; obstructive sleep apnea; sleep related breathing disorder; sleep disordered breathing

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1.0 INTRODUCTION

Positive airway pressure (PAP) is a standard treatment for patients with obstructive sleep apnea (OSA), a sleep related breathing disorder characterized by full or partial occlusion of the upper airway during sleep. Standard sleep medicine practice involves manual pressure adjustment by a sleep technologist during attended laboratory polysomnography (PSG) to eliminate obstructive respiratory-related events (apneas, hypopneas, respiratory effort-related arousals [RERAs], and snoring). A PAP delivery system consists of three main components: a PAP device; a nasal, oral, or oronasal interface (i.e., nasal mask, nasal pillows, full-face mask) held snug to the face by headgear; and a flexible hose that connects the device to the interface. A PAP device is basically an air pump (fan-driven or turbine system) that draws in external, filtered air and delivers pressurized airflow, which is adjustable by varying the pressure valve diameter or fan/turbine speed. PAP devices are divided into four basic types depending on their pressure delivery system: (1) continuous positive airway pressure (CPAP), which delivers a single, fixed pressure to the patient during the night; (2) bilevel positive airway pressure (BPAP), which delivers a higher inspiratory PAP (IPAP) than expiratory PAP (EPAP); (3) autotitrating positive airway pressure (APAP), which automatically increases CPAP or BPAP (IPAP/EPAP) as needed to maintain airway patency and then decreases the pressure if no abnormal respiratory events are detected within a set period of time; and (4) adaptive servoventilation (ASV), which uses a servocontroller that automatically adjusts pressure by breath-by-breath analysis to maintain a steady minute ventilation especially in heart failure patients with central sleep apnea and/or Cheyne-Stokes respiration.

A 2004 national survey of 196 board certified sleep physicians regarding APAP device prescriptions based upon point-prevalence estimates revealed that only 4% of PAP devices prescribed were APAP and that 30% of board certified sleep physicians reported having never prescribed APAP devices.[1] As more validation and reliability studies in diverse settings are being conducted, it is assumed that sleep medicine specialists are gradually becoming more accepting of the use of APAP devices.[2-4] Nevertheless, manual titration of CPAP or BPAP is currently the gold standard for selection of the optimal (effective) pressure for CPAP and BPAP (IPAP/EPAP), respectively, and the goal of this report was to develop recommendations that reflect current knowledge and practice of this procedure.

The American Academy of Sleep Medicine (AASM) has published practice parameters on the indications for PSG[5,6] (i.e., the utility of PSG for the diagnosis of sleep-related breathing disorders) and on the indications for CPAP and BPAP in the treatment of airway obstruction in OSA.[7] Lastly, in 2007, the AASM published a new scoring manual that defines the abnormal respiratory events (e.g., apneas, hypopneas, RERAs), which are used for PAP titration.[8] The present recommendations add to but do not modify any of these previously published guidelines and definitions.

2.0 METHODS

The AASM Board of Directors approved the development of PAP titration recommendations in April 2007, and approved the appointments of Task Force members in July 2007. An initial literature search was conducted by Drs. Alejandro Chediak and Vincenzo Novara on November 27, 2006 using the key words: CPAP initiation, CPAP titration, CPAP adjustment, PAP titration, bilevel positive pressure titration, bi-level pressure titration, BiPAP titration, and BiPAP adjustment. This search yielded 372 results, of which 26 relevant abstracts and articles were obtained and reviewed. Supplemental literature searches were conducted on June 29, 2007 and December 5, 2007 using the same key words as in the original search; an additional literature search was conducted on November 30, 2007 using the same key words plus the key word: children. These supplemental searches yielded an additional 82 results, of which 7 additional relevant articles were obtained and reviewed. All literature searches were computer-based using PubMed. The objective was to identify all studies that described PAP titration protocols and that were published in English from 1968 up to the date of the searches. Twenty-two additional relevant publications were obtained after reviewing the bibliographies of the publications collected through the original and supplemental searches. Lastly, the Task Force also reviewed PAP titration protocols developed by industry for background information; however, these protocols were not used to support the recommendations.

All relevant publications were assigned an evidence level based on the classification shown in Table 1.

Potential recommendations reflected evidence for reliability and validity as assessed by the Task Force following literature review, or comprised uncertainties in the literature that needed resolution by consensus. The Rand/UCLA Appropriateness Method[10] was selected as the consensus process for use by the Task Force given its use by the AASM Standards of Practice Committee (SPC) and the AASM Scoring Manual Task Forces, and also because the relative paucity of evidence warranted

Table 1—AASM Classification of Evidence

Evidence Levels	Study Design
I	Randomized well-designed trials with low alpha and beta error*
II	Randomized trials with high alpha and beta error*
III	Nonrandomized concurrently controlled studies
IV	Nonrandomized historically controlled studies
V	Case series

Adapted from Sackett[9]

*Alpha error refers to the probability (generally set at 95% or greater) that a significant outcome (e.g., $p < 0.05$) is not a result of chance occurrence. Beta error refers to the probability (generally set at 80% to 90% or greater) that a nonsignificant result (e.g., $p > 0.05$) is the correct conclusion of the study or studies. The estimation of beta error is generally the result of a power analysis. The power analysis includes a sample size analysis to project the size of the study population necessary to ensure that significant differences will be observed if actually present.

Table 2—AASM Levels of Recommendations

Term	Definition
Standard	This is a generally accepted patient care strategy that reflects a high degree of clinical certainty. The term standard generally implies the use of level I evidence that directly addresses the clinical issue, or overwhelming level II evidence.
Guideline	This is a patient care strategy that reflects a moderate degree of clinical certainty. The term guideline implies the use of level II evidence or a consensus of level III evidence.
Option	Recommendation with less evidence than guideline for which agreement was reached in a standardized consensus process based on available information.

Adapted from Eddy[11] and Iber et al.[8]

a formal consensus process. The first conference call of the Task Force was held on July 23, 2007 to discuss the consensus process and to develop a ballot comprised of possible recommendations. In order to encourage single recommendations, the ballots were constructed when possible to address mutually exclusive options. For balloting, the possible recommendations were rated on a 9-point scale for appropriateness and a 4-letter rank for specifying a judgment regarding whether the decision was being made on evidence vs. opinion. The "classic" definition of agreement was assessed using definitions from the RAND manual:

- Agreement for or against: No more than 2 Task Force members rate the indication outside the 3-point region (1-3, 4-6, 7-9) containing the median.
- Disagreement: At least 3 Task Force members rate the indication in the 1-3 region, and at least 3 Task Force members rate it in the 7-9 region.
- Indeterminate: Criteria are not met for agreement or disagreement.

The first round ballot was distributed to the Task Force on August 6, 2007 and was completed by September 1, 2007; Task Force members completed this round of voting individually without discussion. The first round ballot results were distributed to the Task Force on September 14, 2007. A conference call for the second round of voting was held on September 24, 2007, at which time there was discussion of the recommendations and the results of the first vote; consensus was achieved on all recommendations during this second round of voting. The recommendations in section 4.0 were developed based on the voting results and were subsequently reviewed by two outside reviewers, the Chair of the AASM Standards of Practice Committee, and the AASM Board of Directors. The Executive Committee of the AASM Board of Directors approved these recommendations on February 8, 2008.

All members of the Task Force and the Board of Directors completed detailed conflict-of-interest statements; none had Level 1 conflicts in the scope of their roles. Most participants in the development of this report are directors or members of sleep disorders centers, and many have substantial experience with PAP titration. These recommendations should not be considered inclusive of all proper methods of care or exclusive of other methods of care reasonably directed to obtaining the same results. The ultimate judgment regarding the propriety of any specific care must be made by the clinician in light of the individual circumstances presented by the patient and the availability of diagnostic and treatment options and resources.

The AASM expects these recommendations to have a positive impact upon the practice of sleep medicine, patient treatment outcomes, and health care costs. These recommendations reflect the state of knowledge at publication and will be reviewed, updated, and revised as new information becomes available. It is important to note that the recommendations published in this report are not practice parameters, since the majority of these recommendations do not achieve the evidence level of typical practice parameters. Instead, all recommendations were developed using the consensus process and the evidence grading was used only to indicate the level of evidence available to support the recommendations. AASM levels of recommendations (Table 2) are indicated in parentheses after recommendations that are based on published practice parameters; those recommendations that were not based on published parameters are labeled as "(Consensus)."

3.0 BACKGROUND

The manual titration of positive airway pressure has been conducted for over a quarter of a century,[12] yet no standardized protocols exist for this procedure.[13] 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; 22% of these centers did not have a written protocol.[14] The lack of standardization results in clinicians and technologists from different sleep laboratories developing their own protocols[15] or relying on protocols obtained from industry or other sleep laboratories. When a standardized protocol is implemented, the optimal pressure for CPAP can be reproducible; one study revealed a Spearman correlation coefficient of 0.89 for the optimal pressure selected for 2 consecutive CPAP titration nights in 50 patients with OSA.[16]

However, very few PAP titration protocols have been published in the literature, and there is a question as to what one would use or measure to advocate or support one particular protocol over another. Thus, the goal of this Task Force was the development of an evidence- and consensus-based standardized PAP titration protocol, with the underlying concept 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 side effects.[17]

The optimal pressure selected for an OSA patient during a PAP titration study is subject to interindividual variability, i.e., a pressure that controls the respiratory events of one patient may inadequately control those of another patient.[18] There are several factors that have been identified as potentially influencing optimal pressure, such as rapid eye movement (REM) sleep amounts,[19] the length of the soft palate,[18] and the degree of respiratory effort.[18] Additionally, one might reason that the level of optimal PAP is correlated with OSA severity and/or obesity; i.e., higher levels of PAP would be needed to control respiratory events in patients with severe OSA and/or those who are obese. However, this premise has not been consistently supported in the literature; although there are some studies demonstrating a good correlation between the level of optimal CPAP and the apnea-hypopnea index (AHI)[20,21] or obesity,[21] a significant correlation for optimal CPAP and AHI has been observed only in patients whose apneas are dependent on body position.[22] Mathematical equations incorporating measures of OSA severity (AHI) and obesity (i.e., body mass index and neck circumference) have been developed to predict the optimal level of CPAP[21,23,24] in order to theoretically achieve a higher rate of successful CPAP titrations by eliminating the need for multiple pressure changes at low pressure levels and to decrease the risk of insufficient time to perform an adequate titration study. However, two studies have independently failed to confirm the accuracy of these equations in predicting the prescribed CPAP level,[25-27] prompting the authors of one of these studies to comment that this failure "reaffirms the need for a CPAP titration study to prescribe the optimal therapy to the patient."[25]

Two types of PAP devices (CPAP and BPAP) are included in these titration recommendations, and BPAP as described in this report refers to BPAP set in spontaneous mode unless otherwise specified. Data regarding usefulness of other PAP device types or device features were not reviewed; although specific indications for adaptive servoventilation are discussed, a titration protocol for this device is not described since this type of ventilation was considered beyond the scope of this report. The recommendations in this report pertain only to nighttime PAP titration studies, although there is an emerging body of literature that indicates that diurnal and nocturnal titration results in comparable therapeutic pressures, equivalent resolution of sleep disordered breathing, and improvement in subjective sleepiness after 1-12 weeks of treatment, particularly for patients with severe OSA.[28-30]

This report uses the following terminology. Unless stated otherwise OSA is used synonymously with obstructive sleep apnea syndrome (OSAS), obstructive sleep apnea-hypopnea syndrome (OSAHS), and obstructive forms of either sleep disordered breathing (SDB) or sleep related breathing disorder (SRBDs). Other SRBDs are not addressed except when relevant to adaptive servoventilation treatment. The respiratory disturbance index (RDI) refers to the total of apneas, hypopneas, and RERAs per hour of sleep, and for this report, 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 OSA are defined according to following criteria in adults: mild, RDI 5 to ≤15; moderate, RDI 15 to 30; and severe, RDI >30.[31] In children <12 years of age: mild, RDI 1 to <5; moderate, RDI 5 to <10; and severe, RDI >10.[8,32-34]

4.0 RECOMMENDATIONS

The following are recommendations of the PAP Titration Task Force and the AASM Board of Directors. The scope of these PAP titration recommendations is restricted to adult (≥12 years) and pediatric (<12 years) patients with obstructive sleep apnea; these recommendations do not apply to patients with conditions such as neuromuscular disease or intrinsic lung disease. Summaries and evidence levels of published PAP titration protocols for adult and pediatric patients are listed in Tables 3a and 3b (see JCSM website: www.aasmnet.org/JCSM), respectively, and CPAP and BPAP titration algorithms for adult and pediatric patients during full- or split-night titration studies are depicted in Figures 1-4. The optimal setting for the titration of CPAP or BPAP is in an AASM-accredited sleep center or laboratory, with the titration protocol implemented by registered polysomnographic technologists and review of the titration study (including pressure selection) by a board certified sleep specialist. Additionally, the definitions, protocols, procedures, and indications for the diagnosis and management of OSA as specified in the AASM practice parameters for polysomnography[5] and PAP,[7] and the AASM Manual for the Scoring of Sleep and Associated Events[8] (i.e., respiratory rules) should be followed. It is understood that the recommendations for minimum and maximum PAP may be constrained by the specific PAP device used during the titration protocol. Lastly, the expectation of the Task Force is that these recommendations should not be followed in a "cookbook" manner; instead, sleep technologists and clinicians should combine their experience and judgment with the application of these recommendations to attain the best possible titration in any given patient.

4.1 General Recommendations for Conducting PAP Titration Studies in Pediatric or Adult Patients with Obstructive Sleep Apnea

4.1.1 All Potential PAP Titration Candidates (Including Those Candidates Prior to a Diagnostic Study Where the Clinical Suspicion of OSA is High and a Split-Night Study is a Possibility) Should Receive Adequate PAP Education, Hands-On Demonstration, Careful Mask Fitting, and Acclimatization Prior to Titration (Standard).

This recommendation is based on Standard-Level Recommendation 4.3.4 ("The addition of a systematic educational program is indicated to improve PAP utilization") in the 2006 practice parameters for the use of PAP devices[7] and consensus agreement by the PAP Titration Task Force. The Task Force recommends that

the indications, rationale for use, and side effects should be discussed in detail with the patient or caregiver preferably prior to the PAP titration study; parts and 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. The patient should be carefully fitted for the interface (i.e., nasal mask, nasal pillows, full-face/oronasal mask) with the goals of maximizing comfort, compensating for significant nasal obstruction, and minimizing leak prior to the PAP titration. There should be several different types of PAP interfaces (i.e., nasal mask, nasal pillows, full-face/oronasal mask) and accessories (chinstrap, heated humidifier) available if the patient encounters problems (e.g., mouth leak, nasal congestion, or oronasal dryness) during the night. The patient should be acclimated to the PAP equipment (i.e., wearing the interface with the pressure on) prior to "lights off."[35] For pediatric patients, in addition to the above, pediatric interfaces should be available[36] and behavioral modification techniques may be implemented to increase the tolerability and potential adherence to PAP equipment,[37-39] since children frequently have problems adjusting to PAP.

4.1.2 Recording the Airflow Signal Generated by the PAP Device or Estimating Airflow by Measurement of the Pressure Difference Between the Mask and the Outlet of the Machine Using a Pressure Transducer, with or without Square Root Transformation of the Signal, are Acceptable Methods for Detecting Apneas or Hypopneas (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and Consensus-Level Respiratory Rule 1.B (i.e., a nasal air pressure transducer with or without square root transformation of the signal is the preferred sensor for detection of airflow for identification of a hypopnea during diagnostic [non-PAP] PSG) in the AASM Scoring Manual.[8] However, during PAP titrations, the use of a standard nasal pressure sensor placed under the nares is problematic due to the difficulty in obtaining a good PAP mask seal since the tubing has to pass underneath the mask. Thus, estimation of airflow for detection of apneas or hypopneas by one of the two techniques specified above is acceptable; care should be exercised to ensure that the signal is accurately recorded. PAP devices designed for use in polysomnography generate a flow signal based on accurate flow sensors within the device and the majority also provide a signal reflecting an estimate of leak.

4.1.3 Nasal Airflow Obtained from a Thermistor or Thermocouple Placed Under the PAP Mask is not an Acceptable Method for Detecting Apneas or Hypopneas (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. An oronasal thermal sensor is the preferred primary sensor to detect absence of airflow for identification of an apnea during diagnostic (non-PAP) PSG.[8] However, it is not the preferred sensor to detect airflow for identification of a hypopnea (see Recommendation 4.1.2) and the placement of this sensor under a PAP mask for detection of airflow is not recommended.

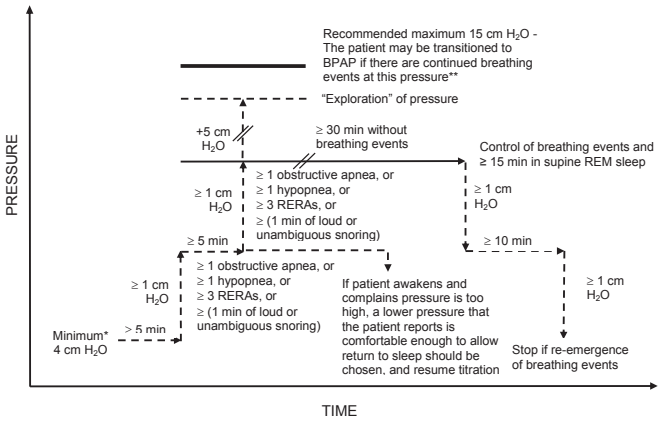

Figure 1—CPAP Titration Algorithm for Patients <12 years During Full- or Split-Night Titration Studies. Note: Upward titration at ≥ 1-cm increments over ≥ 5-min periods is continued according to the breathing events observed until ≥ 30 min without breathing events is achieved.
* A higher starting CPAP may be selected for patients with an elevated BMI and for retitration studies
** The patient should also be tried on BPAP if the patient is uncomfortable or intolerant of high CPAP

4.1.4 Respiratory Effort-Related Arousals May Be Estimated by Flattening of the Inspiratory Airflow Profile Associated with an Arousal When Airflow Changes Do Not Meet Criteria for apneas or Hypopneas (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. As specified in the AASM Scoring Manual, a respiratory effort-related arousal (RERA) in adults is defined as a sequence of breaths lasting at least 10 sec characterized by increasing respiratory effort or flattening of the nasal pressure waveform leading to an arousal from sleep when the sequence of breaths does not meet criteria for an apnea or hypopnea.[8] The scoring rules for pediatric RERAs when using a nasal pressure sensor requires a discernible fall in the amplitude of the signal from the sensor; a duration of at least 2 breath cycles; accompanying snoring, noisy breathing, elevation in the end-tidal CO_2, transcutaneous CO_2, or visual evidence of increased work of breathing; and termination by an arousal.[8] The contour of inspiratory flow tracing from a PAP system can be used to infer the presence of elevated upper airway resistance and flow limitation,[40,41] and this contour appears to be the simplest variable that best correlates with the lowest esophageal pressure during PAP titration.[42] For the assessment of respiratory effort during PAP titration, esophageal manometry or nasal pressure plus inductance plethysmography can be used in pediatric and adult patients, although the former technique may be more problematic given partial occlusion of one of the nares and difficulty obtaining a good PAP mask seal with the esophageal catheter and poorer adherence in the pediatric population.

4.1.5 Sawtooth Patterns in the Unfiltered Airflow or Mask Pressure Tracings and/or Detection of Vibration by Piezoelectric Transducers or Microphones Applied to the Neck are Acceptable Methods for Detecting Snoring (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. The output from most PAP de-

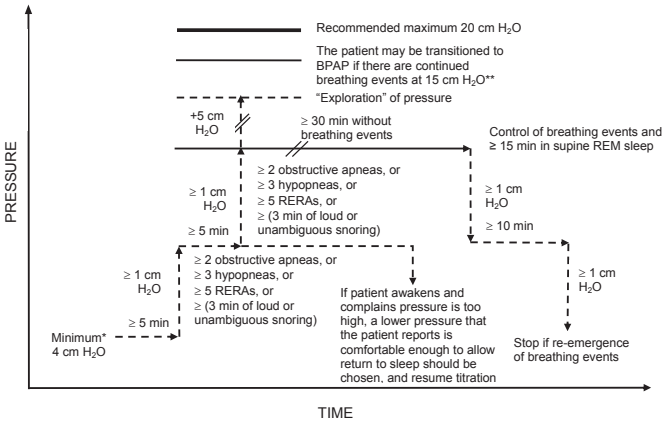

Figure 2—CPAP Titration Algorithm for Patients ≥12 years During Full- or Split-Night Titration Studies. Note: Upward titration at ≥ 1-cm increments over ≥ 5-min periods is continued according to the breathing events observed until ≥ 30 min without breathing events is achieved.
* A higher starting CPAP may be selected for patients with an elevated BMI and for retitration studies
** The patient should also be tried on BPAP if the patient is uncomfortable or intolerant of high CPAP

vices while accurate for assessing airflow and flow limitation is often too filtered or undersampled to display snoring.

4.2 Recommendations for Conducting CPAP Titration Studies in Pediatric or Adult Patients with Obstructive Sleep Apnea

4.2.1 General Recommendations for CPAP Titration Studies

4.2.1.1 CPAP should be increased until the following obstructive respiratory events are eliminated (no specific order) or the recommended maximum CPAP is reached: apneas, hypopneas, RERAs, and snoring (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and Guideline-Level evidence (3 level II studies,[43-45] 2 level III studies,[46,47] and 5 level V studies[42,48-51]). The Task Force recommends that SaO_2 desaturation-resaturation events occurring without associated obstructive respiratory events should not be considered in the decision to increase CPAP in pediatric and adult patients.

4.2.1.2 The recommended minimum starting CPAP should be 4 cm H_2O in pediatric and adult patients (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and Standard-Level evidence (1 level I study,[52] 4 level II studies,[44,45,53,54] 4 level III studies,[16,47,55,56] 2 level IV studies,[35,57] and 4 level V studies[49,58-60]).

4.2.1.3 The recommended maximum CPAP should be 15 cm H_2O for patients <12 years and 20 cm H_2O for patients ≥12 years (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and Option-Level evidence (1 level II study[53] [adult patients], 1 level III study[61] [adult patients], 2 level V studies[40,62] [adult and pediatric patients]). 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 (see Recommendation 4.3.1.1)

4.2.1.4 Methodology to determine CPAP a priori has insufficient evidence, although a higher starting CPAP may be selected for patients with an elevated body mass index and for retitration studies (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and Option-Level evidence (1 level III study that found that the amount of CPAP pressure was correlated with body mass index at baseline [$\rho = 0.32$, $p < 0.001$][20] and 1 level V study that indicates that body mass indices were significantly higher in patients who required higher CPAP levels to abolish their apnea[21]).

4.2.2 Full Night CPAP Titration Studies

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

This recommendation is based on consensus agreement by the PAP Titration Task Force and Standard-Level evidence (2 level I studies,[52,63] 7 level II studies,[43,44,53,54,64-66] 8 level III studies,[16,46,47,55,56,61,67,68] 5 level IV studies,[25,35,57,69,70] 21 level V studies,[18,21,24,42,48,49,51,59,60,62,71-81]). The studies reported pressure increments of 1-2.5 cm H_2O, and 11 of these studies[16,25,26,42,43,52,55,56,59,74,77] specify a time duration ≥5 min. There are insufficient data to recommend increasing CPAP by increments of more than 2.5 cm H_2O.

4.2.2.2 CPAP should be increased (according to the criterion in Recommendation 4.2.2.1) if at least 1 obstructive apnea is observed for patients <12 years or if at least 2 obstructive apneas are observed for patients ≥12 years (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. A lower pressure is required to treat apneas compared to the pressure required to treat other respiratory events.[82]

4.2.2.3 CPAP should be increased (according to the criterion in Recommendation 4.2.2.1) if at least 1 hypopnea is observed for patients <12 years or if at least 3 hypopneas are observed for patients ≥12 years (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force.

4.2.2.4 CPAP should be increased (according to the criterion Recommendation 4.2.2.1) if at least 3 RERAs are observed for patients <12 years or if at least 5 RERAs are observed for patients ≥12 years (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force.

4.2.2.5 CPAP may be increased (according to the criterion in Recommendation 4.2.2.1) if at least 1 min of loud or unambiguous snoring is observed for patients <12 years or if at least 3 min of loud or unambiguous snoring are observed for patients ≥12 years (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. The utility of titrating CPAP to eliminate snoring was demonstrated in a limited study of non-apneic patients. Although a minority of these patients accepted CPAP use and their subsequent CPAP adherence was poor, 73% of these patients nevertheless reported improvement in their subjective daytime sleepiness after using CPAP for a six-month period.[83]

4.2.2.6 "Exploration" of CPAP above the pressure at which control of abnormalities in respiratory parameters is achieved should not exceed 5 cm H_2O (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. CPAP exploration does have utility; upper airway resistance can be four times normal despite selection of a pressure that eliminates apneas and hypopneas,[42] and this residual high airway resistance can lead to repetitive arousals and insomnia.[84] Reduction of this resistance has been demonstrated by increasing pressure until esophageal pressure swings (if measured) or the shape of the inspiratory flow limitation curve are normalized,[40,84,85] or by increasing pressure by 2 cm H_2O[17] but no higher than by 5 cm H_2O.

4.2.2.7 If the patient awakens and complains that the pressure is too high, the pressure should be restarted at a lower pressure, chosen as one that the patient reports is comfortable enough to allow return to sleep (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force.

4.2.2.8 "Down" titration is not required but may be considered as an option (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and Option-Level evidence (2 level III studies[16,47]). A "down" titration is recommended due to the "hysteresis" phenomenon:[40] during upward titration the PAP level at which flow limitation disappears is 2-5 cm H_2O higher than the level at which it reappears during downward titration. If a "down" titration is implemented, the Task Force recommends at least one "up-down" CPAP titration (1 cycle) should be conducted during the night. It should be conducted when at least 30 min has elapsed without obstructive respiratory events. CPAP should be decreased by more than 1 cm H_2O with an interval no shorter than 10 min, until there is reemergence of obstructive respiratory events. There is also limited evidence that an "up-down-up" titration protocol should be considered.[49] One study with 85 OSA patients used a CPAP protocol in which the pressure was increased by 1 cm H_2O in a stepwise fashion until respiratory events disappeared (effective pressure 1, $Peff_1$); the pressure level was then decreased by increments of 1 cm H_2O until respiratory abnormalities reappeared. The pressure was re-

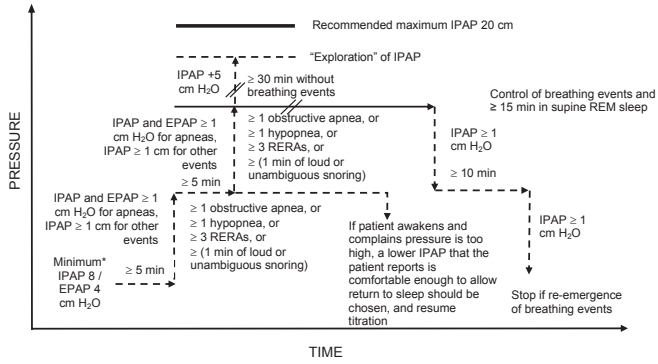

Figure 3—BPAP Titration Algorithm for Patients <12 years During Full- or Split-Night Titration Studies. Note: Upward titration of IPAP and EPAP ≥ 1 cm H2O for apneas and IPAP ≥ 1 cm for other events over ≥ 5-min periods is continued until ≥ 30 min without breathing events is achieved. A decrease in IPAP or setting BPAP in spontaneous-timed mode with backup rate may be helpful if treatment-emergent central apneas are observed.
* A higher starting IPAP and EPAP may be selected for patients with an elevated BMI and for retitration studies. When transitioning from CPAP to BPAP, the minimum starting EPAP should be set at 4 cm H2O or the CPAP level at which obstructive apneas were eliminated. An optimal minimum IPAP-EPAP differential is 4 cm H2O and an optimal maximum IPAP-EPAP differential is 10 cm H2O.

increased by increments of 1 cm H_2O to normalize respiration ($Peff_2$). The pressure obtained after the "down" titration had to be re-increased in 79 patients due to snoring (n = 26), flow limitations associated with arousals (n = 32), obstructive hypopneas (n = 19), and obstructive apneas (n = 2). The $Peff_2$ level was significantly lower than $Peff_1$ with a mean difference of 0.6 (1.5) cm H_2O (95% confidence interval, 0.29-0.93).

4.2.3 Split-Night CPAP Titration Studies

4.2.3.1 The titration algorithm for split-night CPAP titration studies should be identical to that of full-night CPAP titration studies (Guideline).

This recommendation is based on Guideline-Level Recommendation 4.2.1 ("A full-night, attended polysomnography performed in the laboratory is the preferred approach for titration to determine optimal positive airway pressure; however, split-night, diagnostic-titration studies are usually adequate") in the 2006 practice parameters for the use of PAP devices[7] and consensus agreement by the PAP Titration Task Force. Studies that have compared adequacy of prescribed pressure, CPAP adherence, and patient acceptance have found no significant differences for adult patients undergoing full-night vs. split-night CPAP titration studies,[46,69,86-88] with the possible exception that pressures determined from split-night studies may be lower for patients with mild-to-moderate OSA who may not manifest the maximal severity of their condition during the first portion of the night.[25,73] It may be prudent to increase CPAP at larger increments (i.e., 2 or 2.5 cm H_2O) given the shorter CPAP titration duration in split-night vs. full-night studies. Of note, there are

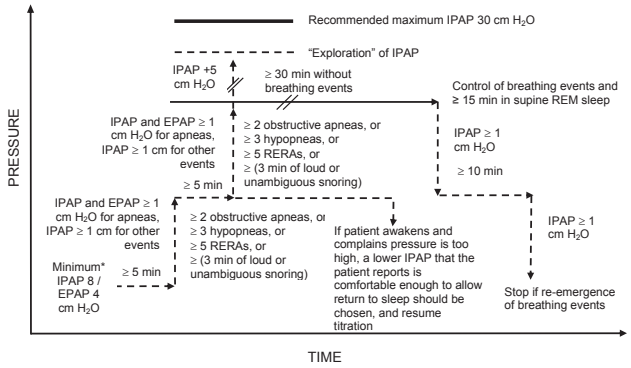

Figure 4—BPAP Titration Algorithm for Patients ≥12 years During Full- or Split-Night Titration Studies. Note: Upward titration of IPAP and EPAP ≥ 1 cm H2O for apneas and IPAP ≥ 1 cm for other events over ≥ 5-min periods is continued until ≥ 30 min without breathing events is achieved. A decrease in IPAP or setting BPAP in spontaneous-timed mode with backup rate may be helpful if treatment-emergent central apneas are observed.
* A higher starting IPAP and EPAP may be selected for patients with an elevated BMI and for retitration studies. When transitioning from CPAP to BPAP, the minimum starting EPAP should be set at 4 cm H2O or the CPAP level at which obstructive apneas were eliminated. An optimal minimum IPAP-EPAP differential is 4 cm H2O and an optimal maximum IPAP-EPAP differential is 10 cm H2O.

insufficient data to make any recommendations for split-night CPAP titration studies in children <12 years.

4.3 Recommendations for Conducting Bilevel PAP (BPAP) Titration Studies in Pediatric or Adult Patients with Obstructive Sleep Apnea

4.3.1 General Recommendations for BPAP Titration Studies

4.3.1.1 If the patient is uncomfortable or intolerant of high pressures on CPAP, the patient may be tried on BPAP. If there are continued obstructive respiratory events at 15 cm H_2O of CPAP during the titration study, the patient may be switched to BPAP (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and Option-Level evidence (1 level IV study[40] and 1 level V study[62]). However, this recommendation does not imply that BPAP is more effective than CPAP at maintaining upper airway patency. Additionally, efforts should be made to explore why the patient is uncomfortable or intolerant of high pressures on CPAP and to remedy the situation before trying the patient on BPAP.

4.3.1.2 BPAP (IPAP and/or EPAP, depending on the type of obstructive respiratory event) should be increased until the following events are eliminated (no specific order) or the recommended maximum IPAP is reached: apneas, hypopneas, RERAs, and snoring (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and Guideline-Level evidence (1 level I study[52] and 1 level III study[46]). The Task Force recommends that SaO_2 desaturation-resaturation events occurring without associated obstructive respiratory events should not be considered in the decision to increase IPAP and/or EPAP in pediatric and adult patients.

4.3.1.3 The recommended minimum starting IPAP and EPAP should be 8 cm H_2O and 4 cm H_2O, respectively, in pediatric and adult patients (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and Guideline-Level evidence (1 level I study[52] for the minimum starting EPAP in adult patients). In addition, when switching from CPAP to BPAP, the Task Force recommends that the minimum starting EPAP should be set at 4 cm H_2O or the CPAP level at which obstructive apneas were eliminated.

4.3.1.4 The recommended maximum IPAP should be 20 cm H_2O for patients <12 years or 30 cm H_2O for patients ≥12 years (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. There is also evidence from the critical care literature indicating that an excess of 30 cm H_2O of upper airway pressure may increase the risk for barotrauma and other morbidities.[89,90]

4.3.1.5 Methodology to determine IPAP or EPAP a priori has insufficient evidence, although a higher starting IPAP or EPAP may be selected for patients with an elevated BMI and for retitration studies (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. As in the case of CPAP, a higher starting IPAP or EPAP may be needed for patients with an elevated BMI (see Recommendation 4.2.1.4).

4.3.1.6 The recommended minimum IPAP-EPAP differential is 4 cm H_2O and the recommended maximum IPAP-EPAP differential is 10 cm H_2O (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and Guideline-Level evidence (1 level I study[52] for the minimum IPAP-EPAP differential in adult patients).

4.3.2 Full-Night BPAP Titration Studies

4.3.2.1 IPAP and/or EPAP (depending 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 min, with the goal of eliminating obstructive respiratory events (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and Guideline-Level evidence (1 level II study,[66] 1 level III study,[46] and 2 level V studies[71,74]).

4.3.2.2 IPAP and EPAP should be increased (according to the criterion in Recommendation 4.3.2.1) if at least 1 obstructive apnea is observed for patients <12 years or if at least 2 obstructive apneas are observed for patients ≥12 years (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. As in the case of CPAP, a lower pressure is required to treat apneas compared to the pressure required to treat other respiratory events (see Recommendation 4.2.2.2); however, there is 1 level II study[53] and 1 level V study[71] that used increases in both IPAP and EPAP to eliminate apneas.

4.3.2.3 IPAP should be increased (according to the criterion in Recommendation 4.3.2.1) if at least 1 hypopnea is observed for patients <12 years or if at least 3 hypopneas are observed for patients ≥12 years (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force.

4.3.2.4 IPAP should be increased (according to the criterion in Recommendation 4.3.2.1) if at least 3 RERAs are observed for patients <12 years or if at least 5 RERAs are observed for patients ≥12 years (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force.

4.3.2.5 IPAP may be increased (according to the criterion in Recommendation 4.3.2.1) if at least 1 min of loud or unambiguous snoring is observed for patients <12 years or if at least 3 min of loud or unambiguous snoring are observed for patients ≥12 years (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. As in the case of CPAP, the utility of titrating PAP to treat snoring may be reflected in improvement in patients' subjective daytime sleepiness (see Recommendation 4.2.2.5).

4.3.2.6 "Exploration" of IPAP above the pressure at which control of abnormalities in respiratory parameters is achieved should not exceed 5 cm H_2O (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. As in the case of CPAP, IPAP exploration does have utility (see Recommendation 4.2.2.6).

4.3.2.7 If the patient awakens and complains that the pressure is too high, the pressure should be restarted at a lower IPAP, chosen as one that the patient reports is comfortable enough to allow return to sleep (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force.

4.3.2.8 A decrease in IPAP or setting BPAP in spontaneous-timed (ST) mode with backup rate may be helpful if treatment-emergent central apneas (i.e., complex sleep apnea) are observed during the titration study (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force.

4.3.2.9 "Down" titration is not required but may be considered as an option (Consensus).

This recommendation and the following protocol is based on consensus agreement by the PAP Titration Task Force. As in the case of CPAP, a "down" titration is recommended for BPAP due to the "hysteresis" phenomenon[40] (see Recommendation 4.2.2.8). If a "down" titration is implemented, the Task Force recommends at least one "up-down" BPAP titration (1 cycle) should be conducted during the night. "Down" titration of IPAP and EPAP is conducted when at least 30 min has elapsed without obstructive respiratory events. IPAP should be decreased by at least 1 cm H_2O with an interval no shorter than 10 min, until there is reemergence of obstructive respiratory events. There is also limited evidence that an "up-down-up" titration protocol should be considered for CPAP[49] (see Recommendation 4.2.2.8); an "up-down-up" titration protocol should also be similarly considered for BPAP.

4.3.3 Split-Night BPAP Titration Studies

4.3.3.1 The titration algorithm for split-night BPAP titration studies should be identical to that of full-night BPAP titration studies (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. A full-night, attended polysomnography performed in the laboratory is the preferred approach for titration to determine optimal positive airway pressure; however, split-night, diagnostic-titration studies are usually adequate (Recommendation 4.2.1 [Guideline] in the practice parameters for the use of CPAP and BPAP devices published in 2006).[91] Unfortunately, studies comparing factors such as patient acceptance, adequacy of prescribed IPAP/EPAP, and adherence to BPAP for patients undergoing full-night vs. split-night BPAP titration studies do not exist. It may be prudent to increase IPAP and EPAP at larger increments (i.e., 2 or 2.5 cm H_2O) given the shorter BPAP titration duration in split-night vs. full-night studies. Of note, there are insufficient data to make any recommendations for split-night BPAP titration studies in children <12 years.

4.4 Important Considerations for PAP Titration Studies in Pediatric or Adult Patients with Obstructive Sleep Apnea

4.4.1 Acceptable PAP Titration Study

4.4.1.1 The CPAP or BPAP selected for patient use following the titration study should reflect control of the patient's obstructive respiration by a low (preferably <5 per hour) RDI at the selected pressure, a minimum sea level SpO_2 above 90% at the pressure, and with a leak within acceptable parameters at the pressure (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. See Recommendation 4.4.3.2 for description of leak within acceptable parameters.

4.4.1.2 Grading system: An optimal titration reduces RDI <5 per hour for at least a 15-min duration and should include supine REM sleep at the selected pressure that is not continually interrupted by spontaneous arousals or awakenings (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and the grading system proposed by Hirshkowitz and Sharafkhaneh.[91]

4.4.1.3 Grading system: A good titration reduces the overnight RDI ≤10 per hour or by 50% if the baseline RDI <15 per hour and should include supine REM sleep that is not continually interrupted by spontaneous arousals or awakenings at the selected pressure (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and the grading system proposed by Hirshkowitz and Sharafkhaneh.[91]

4.4.1.4 Grading system: An adequate titration is one that does not reduce the overnight RDI ≤10 per hour but does reduce the RDI by 75% from baseline (especially in severe OSA patients), or one in which the titration grading criteria for optimal or good are met with the exception that supine REM sleep did not occur at the selected pressure (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and the grading system proposed by Hirshkowitz and Sharafkhaneh.[91]

4.4.1.5 Grading system: An unacceptable titration is one that does not meet any one of the above grades (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force and the grading system proposed by Hirshkowitz and Sharafkhaneh.[91]

4.4.2 Repeat PAP Titration Study

4.4.2.1 A repeat PAP titration study should be considered if the initial titration does not achieve a grade of optimal or good and, if it is a split-night PSG study, it fails to meet AASM criteria (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. As per split-night study criteria in the AASM practice parameters for the indications for PSG[5]: (a) an AHI of at least 40 is documented during a minimum of 2 hours of diagnostic PSG. Split-night studies may sometimes be considered at an AHI of 20 to 40, based on clinical judgment (e.g., if there are also repetitive long obstructions and major desaturations). However, at AHI values below 40, determination of CPAP pressure requirements, based on split-night studies, may be less accurate than in full-night calibrations. (b) CPAP titration is carried out for more than 3 hours (because respiratory events can worsen as the night progresses). (c) PSG documents that CPAP eliminates or nearly eliminates the respiratory events during REM and NREM sleep, including REM sleep with the patient in the supine position. (d) A second full night of PSG for CPAP titration is performed if the diagnosis of a SRBD is confirmed but criteria (b) and (c) are not met.

4.4.3 Leak and Comfort

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

This recommendation is based on consensus agreement by the PAP Titration Task Force. Leakage can occur in several forms. Intentional leak is the controlled leak from the port on mask interfaces that washes out CO_2 and prevents rebreathing. Unintentional leak is characterized as a "mouth leak" (i.e., pressurized air escaping via the mouth when a nasal mask is used) or "mask leak" between the mask and the face (i.e., pressurized air escaping between the mask and the face when a nasal mask or full-face/oronasal mask is used). Unintentional leak can be minimized by mask refit or readjustment, and, in the case of "mouth leak", addition of a chinstrap to reduce mouth opening or switching to a full-face/oronasal mask may be beneficial.[92,93] A study examining the effects of mask leak on the efficacy of BPAP therapy reported that the patients showed improved oxygenation, decreased arousal index, and increased REM sleep when this leak was minimized.[94]

4.4.3.2 There is insufficient evidence for what constitutes a clinically significant leak given mask fit and other factors; however, in general, an unacceptable leak for PAP is one that is substantially higher than the leak recorded at a given pressure from a well-fitted, applied, and secured interface. The acceptable leak will always exceed the intentional leak, which depends on the applied pressure and interface type. The intentional leak vs. pressure relationship is usually supplied by the manufacturer of each interface (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. The intentional leak of all interfaces increases as pressure increases. The exact amount of leak also varies with the type of interface. This makes identification of what constitutes an unacceptable leak value very difficult. Clinical judgment based on laboratory-specific criteria or the leak vs. pressure relationship supplied by the manufacturer for a given interface is recommended. A sudden increase in leak without a pressure change should alert the technologist to a possible increase in mask/mouth leak.

4.4.3.3 Pressure waveform modification technologies may improve patient comfort and adherence with PAP (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. Complaints of a sensation of exhaling against a high pressure were reported by approximately 20% of patients receiving CPAP,[95] and it is possible that the pressure reduction during expiration on pressure-relief CPAP is

more comfortable for those patients who require a higher CPAP pressure. These new technologies have had limited testing but have potential utility in patient acceptance and utilization of PAP.[43,58,96-99]

4.4.4 Positional and Sleep Stage Factors

4.4.4.1 Ideally, the patient should be recorded in supine REM sleep for at least 15 min at the designated optimal pressure during the PAP titration study. 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 (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. Optimal CPAP has been defined as the highest pressure obtained during REM sleep with the patient having slept in the supine position.[55] Since 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.[100] There is evidence that the optimal CPAP level in the supine position is greater than 2 cm H_2O higher than the optimal CPAP needed while sleeping in the lateral position, both in REM and NREM sleep, in obese and nonobese subjects and in those younger and older than 60 years.[50] However, the decision to awaken the patient to obtain a PSG sample of supine REM must be carefully considered, since it is important that the patient be allowed to obtain adequate sleep during the titration study. This point may be supported by research demonstrating that an increase in sleep efficiency (SE) during CPAP titration compared to the diagnostic night was found to be the only significant predictor of objectively measured CPAP adherence after controlling for indices of OSA severity and sleep quality during the diagnostic night. Specifically, patients who had their SE increase used their machines an average of 2 hours more per night than those who did not have their SE increase.[101]

4.4.5 Supplemental Oxygen

4.4.5.1 Supplemental O_2 should be added during the PAP titration when, prior to the PAP titration, the patient's awake supine SpO_2 while breathing room air is ≤88%. Supplemental O_2 may also be added during the PAP titration when SpO_2 is ≤88% for ≥5 minutes in the absence of obstructive respiratory events. In both instances, supplemental O_2 should be introduced at 1 L/min and titrated upwards to achieve a target SpO_2 between 88% and 94% (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. The above recommendation is made with the understanding that pulse oximetry can overestimate the actual arterial oxygen saturation in some circumstances and that the effective inspired oxygen concentration can fall if machine flow increases due to higher leak. A slightly higher goal than 88% (90%-94%) might be prudent in some circumstances.

4.4.5.2 The minimum starting O_2 rate should be 1 L/min (both pediatric and adult patients) (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force.

4.4.5.3 O_2 rate should be increased by 1 L/min, with an interval no shorter than 15 min, until SpO_2 is between 88% and 94% (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. Similar to Recommendation 4.4.5.1, a slightly higher goal than 88% (90%-94%) might be prudent in some circumstances.

4.4.5.4 Optimally, supplemental O_2 should be connected to the PAP device outlet (using a T-connector) (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. When O_2 is introduced directly into a PAP mask, the O_2 does not have time or space to mix well with the high flow coming from the tubing, which leads to highly variable O_2 concentrations inside the mask. However, when O_2 is introduced into the tubing near the PAP device rather than directly into the mask, more constant O_2 delivery to patients using PAP would be expected.[102]

4.4.5.5 "Weaning" down of O_2 supplementation by employing BPAP or by further increasing IPAP (if BPAP was already instituted and if the patient tolerates the higher inspiratory pressures) can be attempted (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. However, there is evidence from bench testing and limited human studies that measured O_2 concentration with supplemental O_2 is lower with higher CPAP, or in the case of BPAP, higher IPAP and EPAP levels, regardless of the difference between IPAP and EPAP levels.[93,102] Anything that increases machine flow (room air) has the potential to reduce the effective O_2 concentration for a given supplemental O_2 flow.

4.4.6 Adaptive Servoventilation

4.4.6.1 Adaptive servoventilation may be considered if the patient is observed to have Cheyne-Stokes respiration or if treatment-emergent central sleep apnea (i.e., complex sleep apnea) during the titration study is not eliminated by down titration of pressure (Consensus).

This recommendation is based on consensus agreement by the PAP Titration Task Force. Adaptive servoventilation is a new therapy that provides an expiratory positive airway pressure and inspiratory pressure support which is servocontrolled, based on the detection of Cheyne-Stokes respiration,[103] with a backup respiratory rate. There is controversy as to what complex sleep apnea represents,[104,105] but in one study, adaptive servoventilation has been shown to decrease respiratory events and improve objective sleep measures in patients with central sleep apnea/Cheyne-Stokes respiration, mixed sleep apnea, and complex sleep apnea.[106]

4.4.7 Follow-up After the PAP Titration Study

4.4.7.1 PAP usage should be objectively monitored to help assure utilization (Standard).

This recommendation is based on consensus agreement by the PAP Titration Task Force, and is a slight modification of Standard-Level Recommendation 4.3.1 in the 2006 practice parameters for the use of PAP devices[7]; the current recommendation reflects objective monitoring of PAP (i.e., CPAP and BPAP), rather than only CPAP, usage.

4.4.7.2 Troubleshooting of problems encountered while on PAP, management of side effects, and methods to increase adherence should be a part of the close follow-up of the patient on PAP (Standard).

This recommendation is based on consensus agreement by the PAP Titration Task Force, and is a modification of Standard-Level Recommendation 4.4.1 ("Close follow-up for PAP usage and problems in patients with OSA by appropriately trained health care providers is indicated to establish effective utilization patterns and remediate problems, if needed. This is especially important during the first few weeks of PAP use.") in the 2006 practice parameters for the use of PAP devices.[7] CPAP use is improved by contact with health care providers (either clinic physician appointment or specialist nurse home visit).[107] However, newer approaches may represent alternatives to current practices; the use of telemedicine support (i.e., Internet-based informational support and feedback for problems experienced with CPAP use) resulted in equivalent use, functional status, and patient satisfaction at 30 days compared to traditional follow-up care.[108] Skipping the use of CPAP for 2 or more nights within the first week of treatment signals potential nonadherence and highlights the need for close follow-up during this particularly vulnerable period of usage.[109] This is especially important since it is estimated that worldwide 5%-50% of OSA patients recommended for CPAP either reject or discontinue its use within the first week.[110]

5.0 FUTURE RESEARCH

Additional work is needed with respect to the following:

1. Further outcome studies comparing manual PAP titration studies vs. autotitrating PAP devices with respect to OSA severity and diverse patient populations.
2. Assessment of the reliability of selection of optimal pressure following PAP titration studies and the stability of the selected optimal pressure across successive PAP titration studies is needed.
3. Clinically significant thresholds for unintentional leak from the mouth or mask need to be identified.
4. Finally, advances in the technology for improving patient comfort and adherence to PAP devices are sorely needed.

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Evidence Table 3a—PAP titration protocols in Adults

First Author (yr), Reference (superscript), Evidence Level	Number/Male (# or %)/Age (yr)/ BMI (kg/m^2)/ Baseline AHI or RDI	PAP Type	Study Aims	Titration Protocol
Baltzan (2006)[48] V	101/M 75/age mean 54.3/BMI mean 34.7/AHI mean 57.3	CPAP	Estimation of prevalence of persistent OSA and to explore the parameters possibly capable of discriminating these patients	Pressure raised by 1 cm H_2O increments to maximum of 20 cm H_2O until all apneas, hypopneas, SpO_2 desaturations, snoring, inspiratory flow limitation, and RERAs are absent; if severe desaturations persisted despite extinction of apneas and hypopneas, supplemental O_2 bled into the respiratory circuit at or near the mask
Behbehani (1998)[54] II	31/M 26/age mean 51.00/BMI mean 35.82/AHI mean 55.2	CPAP vs. APAP	Comparison of the performances of APAP vs. CPAP	Started CPAP at 4-6 cm H_2O, increased at 1-2 cm H_2O increments whenever the patient experienced full or partial obstruction, respectively; after each pressure increase, the pressure was left unchanged for ≥2 min prior to another pressure increase; the pressure increases ceased when all partial and complete obstructions were eliminated for all sleep stages and body positions
Berry (1991)[75] V (randomized to 2 different ethanol concentrations; PAP not randomized)	10/M 10/age mean 56.0/BMI mean NA/AHI mean 3.6	CPAP	Assessment of the effect of moderate ethanol ingestion in patients being treated with CPAP for moderate-to-severe OSA	P_{eff} determined by slowly increasing the level of CPAP in 1- to 2-cm H_2O increments until apneas, hypopneas, and desaturations were abolished
Berry (2006)[51] V (randomized to zolpidem vs. placebo; PAP not randomized)	16/M 14/age mean 49.4/BMI mean 36.1/Zolpidem Group AHI Mean 2.7/Placebo Group AHI Mean 4.8	CPAP	Assessment of the effect of zolpidem on the efficacy of CPAP for the treatment of OSA	P_{eff} required to prevent apnea, hypopnea, snoring, and respiratory arousals in all body positions and sleep stages was determined by slowly increasing the level of CPAP in 1- to 2-cm H_2O increments
Bureau (2000)[49] V	85/M 74/age mean 50.0/BMI mean 37.3/AHI mean 40.5 (n = 42)	CPAP	Quantification of the difference in the initial and final effective pressure when the titration study takes into account these possible changes in the effective pressure level	Initial CPAP setting of 4 cm H_2O, increased at 1 cm H_2O increments until obstructive apnea, hypopnea, snoring, and flow-limited breathing associated with arousals disappeared (P_{eff1}); pressure then reduced by 1 cm H_2O increments every 2-5 min (providing P_{eff1} ≥6 cm H_2O and recording time required to reach P_{eff1} <5/hr) until one of the respiratory abnormalities reappeared or the minimal pressure level (4 cm H_2O) was reached; pressure then increased again by 1 cm H_2O every time a new obstructive event appeared until they disappeared (P_{eff2}) and this pressure was applied for the rest of the night; subjects needed to achieve REM sleep and sleeping supine
Derderian (1988)[61] III	CPAP Group: 7/M 7/age mean 59.3/BMI mean 27.8 (calculated from data table)/ AHI mean NA/AI mean 40.7; Control Group: 7/M 7/age mean NA/BMI mean NA/AHI mean NA	CPAP	Assessment of the psychologic mood changes associated with sleep restoration before and two months after treatment with CPAP in patients with OSA	Started CPAP at 5 cm H_2O, progressively increased in 2.5 cm H_2O increments up to a maximum permissible pressure of 15 cm H_2O; reversal of apnea, a marked decrease in the number of episodes of apnea (<5/ hr), decreased episodes of disordered breathing, or a lack of CPAP tolerance were used as endpoints in the determination of the appropriate pressure to be used

First Author (yr), Reference (superscript), Evidence Level	Number/Male (# or %)/Age (yr)/ BMI (kg/m^2)/ Baseline AHI or RDI	PAP Type	Study Aims	Titration Protocol
Farré (1998)[58] V	9/M 9/age mean 50/BMI mean 35/ AHI mean 62	Flow-dependent PAP	Design and assessment of flow-dependent PAP	Started CPAP at 4 cm H_2O, progressively increased once well-established N2 sleep was achieved to determine P_{eff}, which in patients was defined as the one required to avoid arousals, apneas, hypopneas, and flow limitation as detected by the flow curve
Fietze (2007)[56] III	CPAP Group: 11/M 10/age mean 51.8/BMI mean 29.4/AHI mean 40.4; APAP Group: 10/M10/age mean 56.9/BMI mean 32.6/AHI mean 43.3	CPAP vs. APAP	Evaluation of the efficacy of attended APAP titration in a randomized crossover study compared with manual CPAP titration over 2 nights where the sequence of the titration mode was changed	Started CPAP at 4 cm H_2O, stepwise increased in 1 cm H_2O increments every 10-20 min with the occurrence of apneas or hypopneas, O_2 drops <3% or RERAs until P_{eff} achieved
Fleury (1994)[77] V	31/M 25/age mean 53.35/BMI mean 31.32/AHI mean 63.62	CPAP	Assessment of the acute and long-term compliance with CPAP set up during a single-night PSG in patients with severe OSA	Started CPAP at 3 cm H_2O, increased at 1 cm H_2O increments every 10 min with the occurrence of abnormal breathing events; P_{eff} defined as an AHI reduction to <10 in all the sleep stages, including REM sleep in the dorsal decubitus position; P_{eff} was determined by the sleep technologist during the sleep study and confirmed by the sleep study physician after completion of the study; follow-up and treatment adherence was evaluated at home after 1 mo and then every 4 mo by a nurse
Gay (2003)[63] I	27/M 22/CPAP Group: 15/M NA/ age mean 45.1/ BMI mean 34.1/ AHI mean 46.1; PRBPAP Group: 12/M NA/age mean 43.6/BMI mean 36.6/AHI mean 41.8	CPAP vs. PRBPAP	Determination of efficacy, objective adherence, and self-assessment data from OSA patients treated with CPAP or a novel BPAP (PRBPAP) therapy	Started CPAP at 5 cm H_2O, increased at 1 cm H_2O increments until snoring and RERAs were abolished and AHI <5; CPAP titration was considered complete ("optimal CPAP" level obtained) when the patient obtained NREM and REM sleep in a lateral decubitus position and at least 20 min of sleep, preferably with REM, in the supine position; the device was then seamlessly switched to PRBPAP which did not result in arousal of the patient; the P_{eff} became the P_{base} at the beginning of the PRBPAP titration. The $Gain_{exp}$ was then titrated in 1-2 step increments until there was reemergence of respiratory events or arousals, at which time the $Gain_{exp}$ (adjustable negative expiratory gain) was returned to the previous setting 1-2 steps prior to this setting; the peak IPAP ($IPAP_{max}$) was 5 cm H_2O above P_{base} to prevent excessive inspiratory pressure exposure that might lead to unwanted arousals, The $IPAP_{min}$ was targeted to allow approximately 2 cm H_2O above the P_{base}, primarily in response to an assessment made of the quality of the inspiratory flow profile; the adjustable inspiratory gain ($Gain_{insp}$) was gradually increased incrementally such that the actual $IPAP_{max}$ was 2 cm H_2O above the P_{base} for the majority of breaths; during expiration, the $EPAP_{min}$ (lowest allowable drop in the early expiratory pressure) was 5-7 cm H_2O, and the $Gain_{exp}$ was adjusted such that a 2-4 cm H_2O early expiratory pressure drop occurred during the majority of breaths

First Author (yr), Reference (superscript), Evidence Level	Number/Male (# or %)/Age (yr)/ BMI (kg/m^2)/ Baseline AHI or RDI	PAP Type	Study Aims	Titration Protocol
Gokcebay (1996,[26] 1997[27]) V	219/M 184/age mean 48/BMI mean NA/AHI mean 39	CPAP	CPAP prediction equations[21,23,24] tested in pre- and with-equation groups	Started CPAP at 3-5 cm H_2O, gradually increased after ≥15 min of sleep at each pressure during early low-pressure titration with the goal of eliminating respiratory events; when a pressure that eliminated respiratory events was reached, it was maintained unless obstructive events recurred; if respiratory events recurred, the pressure was then adjusted further; REM sleep had to be observed at a pressure to be considered optimal; it was extremely rare that a patient would sleep at optimal pressure <1/hr; optimal CPAP was determined by the sleep specialist only after reviewing the entire night's data
Hedner (1995)[78] V	12/M 10/age mean 54/BMI mean 33.26 (calculated from data table)/ AHI mean NA	CPAP	Assessment of the effects of long-term CPAP therapy on sympathetic activity, cardiac structure, and blood pressure	CPAP pressure resulting in complete alleviation of sleep disordered breathing events was determined after consecutive pressure increments of 0.5 cm H_2O; the therapeutic effect of CPAP was routinely reinvestigated at 3, 12, and 24 mo after treatment initiation, and <5% of the initial number of apnea events were allowed without pressure adjustment
Hers (1997)[70] IV	27/M 26/age mean 49/BMI mean 33/ AHI mean NA (desaturation index [# of ≥4% desaturations/hr of sleep] mean 51.2)	CPAP	Assessment of whether CPAP therapy applied for a few hr at the beginning of the night had any residual effect on OSA severity during the ensuing hrs of unassisted nocturnal sleep in newly diagnosed OSA patients	Patients had 2-3 nights on CPAP at low pressure (5 cm H_2O) for habituation and adaptation to the interface device; during the second PSG with CPAP, the pressure was increased in 1 cm H_2O increments in order to suppress snoring, movement arousals, apneas, and/ or hypopneas; after about 4 hr of treatment, CPAP was discontinued, the mask was withdrawn, and the patients were allowed to fall asleep again
Hoffstein (1994)[24] V	26/M 21/age NA/ BMI mean 32.7/ AHI mean 48.3	CPAP	Validation of equation for prediction of optimal CPAP level[21] in a prospective group of OSA patients returning for a CPAP titration study	Started CPAP at level predicted from the equation; if AHI <10, the pressure was reduced in 1 cm H_2O increments until AHI >10; if with CPAP level equal to the CPAP predicted level, AHI >10, CPAP was increased in 1 cm H_2O increments until AHI <10; optimal CPAP defined as the lowest pressure at which AHI <10
Hoffstein (2001)[76] V	441/M 370/age mean 51/BMI mean 33.6/AHI mean 47	CPAP	Comparison of pressures required to abolish apneas with pressures required to abolish snoring	Started CPAP at level predicted from an equation[72]; the pressure was increased (or decreased) in increments of 1 cm H_2O depending on whether the AHI was higher (or lower) than 10; once the pressure at which AHI <10 was achieved, further increments in pressure were dictated by the technologist's perception of snoring; the study was terminated when snoring was abolished, when the lowest pressure of 2 cm H_2O was reached or when the highest pressure of 16 cm H_2O was reached; BPAP was considered at CPAP >16 cm H_2O

First Author (yr), Reference (superscript), Evidence Level	Number/Male (# or %)/Age (yr)/ BMI (kg/m^2)/ Baseline AHI or RDI	PAP Type	Study Aims	Titration Protocol
Jokic (1998)[47] III	Part 1 (single-blind crossover study in OSA patients): 10/M 7/age mean 52.4/BMI mean 38/AHI mean 99; Part 2 (comparison with controls): 10/M NA/age mean 52.3/BMI mean 38.1/AHI mean 85	CPAP	Comparison of the CPAP requirement at time of diagnosis, after 2 wk, and after 4 wk of CPAP therapy, in patients with severe OSA and assessment of whether any alteration in CPAP requirement over the first 4 wk of CPAP therapy would influence daytime alertness, subjective sleepiness, or mood	Started CPAP at 4 cm H_2O, increased at 2 cm H_2O increments to eliminate gross obstructive apneas and hypopneas, and then 1 cm H_2O adjustments (up or down) were made with sleep stage and position until the minimum CPAP necessary to eliminate respiratory arousals (obstructive apneas and hypopneas and repetitive snoring-associated arousals) had been carefully defined
Juhász (2001)[99] II	12/M NA/age mean 48.83/BMI mean 34.52/RDI mean 82.9	Proportional PAP	Assessment of proportional positive airway pressure to optimize airway pressure for the therapy of OSA	Established P_{eff} to abolish apneas and hypopneas and then an expiratory pressure relief (2-3 cm H_2O) to facilitate exhalation; after ensuring that no further occlusion occurred, the base pressure was gradually decreased to a minimally effective expiratory level with a synchronous adjustment of the inspiratory pressure difference over the base pressure to maintain the effective maximal inspiratory pressure
Lloberes (2004)[55] III	93/M 69/age means 53.9-58.6/ BMI means 31.1-32.0/AHI means 49.8-55.2	CPAP (night vs. day) vs. APAP	Comparison of the effectiveness of conventional vs. manual or automatic daytime CPAP titration in unselected patients with OSA	After patients achieved stable sleep, pressure increased from 4 cm H_2O in increments of 1 cm H_2O about every 10 min until apneas, hypopneas, snoring, and desaturations disappeared; pressure then slowly decreased until events resumed to ascertain lowest effective pressure; also ensured patient had achieved REM sleep and was in the supine position
Lloberes (1996)[45] II	20/M NA/age mean 50/BMI mean 31.7/AHI mean 53.3	CPAP vs. APAP	Assessment of the value of APAP titration as an alternative method to conventional PSG-controlled CPAP titration for predicting future fixed-level CPAP needs in patients with OSA in whom treatment has been indicated	After 45 min, when patients had achieved stable sleep, CPAP was started at 4 cm H_2O, progressively increased at 1 cm H_2O increments lasting 3-5 min each, until apnea, hypopnea, snoring, thoracoabdominal paradox, and arousals disappeared; supine position and at least 2 REM sleep periods were registered; after CPAP pressure required to stabilize the upper airway was achieved, it was reduced in steps of 1 cm H_2O until the respiratory events or snoring resumed; CPAP level was measured at end-expiration, immediately before the reappearance of abnormal respiratory events; P_{eff} defined as the highest pressure obtained during REM sleep with the patient having slept in the supine position
Lopez-Campos (2007)[57] IV	Split-Night CPAP Group: 87/M NA/ age mean 55/ BMI mean 34/ AHI mean 52; Formula CPAP Group: 113/M NA/age mean 57/ BMI mean 33/AHI mean 43	CPAP	Assessment of CPAP success in controlling OSA symptoms and adverse effects by two titration methods: split-night PSG or use of an equation for prediction of optimal CPAP level[21]	Split-Night CPAP Group: Started CPAP at 4 cm H_2O, increased at 1 cm H_2O increments every 5 min until apneas disappeared; thereafter, CPAP increased by 1 cm H_2O increments every 10 min until hypopneas, flow limitation, and snoring disappeared. Formula CPAP Group: Started CPAP at 4-6 cm H_2O; following a few min of adaptation, CPAP pressure was progressively increased by 1 cm H_2O increments every 5-10 min, depending on patient tolerance, until the Initial pressure estimated using prediction equation[21] was achieved

First Author (yr), Reference (superscript), Evidence Level	Number/Male (# or %)/Age (yr)/ BMI (kg/m^2)/ Baseline AHI or RDI	PAP Type	Study Aims	Titration Protocol
McArdle (2000)[111] IV	Split-Night CPAP Group: 46/M 80%/ age mean 50/ BMI mean 34/ AHI mean 49; Full-Night CPAP Group: 92/M 83%/ age mean 49/BMI mean 32/AHI mean 49	CPAP	Determination of the value of split-night vs. full-night CPAP titration studies	CPAP titration was performed to obtain the minimum pressure that normalized the breathing pattern and minimized EEG arousals; all patients received an educational intervention prior to their studies, which involved an explanation of OSA and CPAP treatment, an educational video and mask fitting from a wide range of mask types as well as 20 min spent acclimatizing to CPAP during the day; for patients booked for a split-night study, it was explained that CPAP treatment was likely to be needed, and, if so, would be initiated during the night
McEvoy (1984)[112] III	12/M 9/age mean 55.8 (calculated from data table)/ BMI mean NA/ AHI mean NA/AI mean 35.1	CPAP	Evaluation of whether CPAP would be equally effective in patients with early and advanced OSA; how acceptable it would be to patients as long-term therapy; if regular CPAP use would produce OSA reversal; if long-term CPAP use results in adverse side effects	Started CPAP between 5 and 8 cm H_2O; if this pressure was insufficient to maintain upper airway patency, pressure was increased up to 10 cm H_2O; higher pressures were not used
Meurice (1998)[65] II	Group I (P_{eff} suppressed snoring, apnea, hypopnea, and flow limitation): 9/M 9/ age mean 56/BMI mean 34.8/AHI mean 56.9; Group II (P_{eff} suppressed snoring, apnea, and hypopnea): 9/M 9/ age mean 53/BMI mean 31.0/AHI mean 60.4	CPAP	Prospective comparison of the efficiency of 2 different CPAP settings: 1st mode–pressure that suppressed snoring, apnea, and hypopnea, 2nd mode–pressure that normalized these events and abolished flow limitation	CPAP titrated according to the two different modes (see Study Aims); pressure level increased in steps of 1 cm H_2O; regression of snoring assessed according to disappearance of fluttering on the inspiratory flow signal and systematically confirmed by the technologist; respiratory cycles classified as flow-limited according to a breath-by-breath analysis when the nasal inspiratory flow signal became maximal and plateaued while the esophageal pressure still increased; both pressure levels were determined during the first sleep cycle that included REM sleep, while patients were in the supine position; during the rest of the titration night, the pressure level was increased until not more than 3 consecutive respiratory cycles with snoring or flow limitation were observed
Miljeteig (1993)[21] V	208/M 178/age mean 50/BMI mean 34/AHI mean 50	CPAP	Examination of the factors accounting for the variability in CPAP levels required to abolish OSA, and the feasibility of predicting the lowest P_{eff} from simple PSG and anthropometric variables	Started CPAP at 2.5 or 5 cm H_2O, increased at 2.5 cm H_2O increments if AHI >10 or if 4 apneas occurred in rapid succession; once the lowest P_{eff} that reduced the AHI <10 was established and a REM sleep period was observed, the study terminated and the patient slept for the rest of the night with that pressure; arousals, periodic leg movements, and central apneas were not considered in the decision for altering the lowest P_{eff}, provided AHI <10; the study was resumed on a different night if the lowest P_{eff} could not be determined due to lack of time; the strongest factors that determine the minimum P_{eff} required to reduce the AHI <10 are obesity and apnea severity

First Author (yr), Reference (superscript), Evidence Level	Number/Male (# or %)/Age (yr)/ BMI (kg/m^2)/ Baseline AHI or RDI	PAP Type	Study Aims	Titration Protocol
Montserrat (1995)[44] II	41/M 38/age mean 52.2/BMI mean 31.5/AHI mean 52.9	CPAP	Assessment of the use of only respiratory variables to determine whether the level of CPAP required was appropriate to abolish apnea, hypopnea, snoring, and thoracoabdominal paradox	Started CPAP at 4 cm H_2O, increased at 1 cm H_2O increments until apnea, hypopnea, snoring, thoracoabdominal paradox, and arousals had disappeared; after the CPAP level required to stabilize the upper airway was achieved, it was reduced by 1 cm H_2O steps until the respiratory events or snoring resumed; the CPAP level chosen was at end-expiration, immediately before the reappearance of abnormal respiratory events
Montserrat (1995)[42] V	9/M 8/age mean 49/BMI mean 32/ AHI mean 67	CPAP	Analysis of the behavior of respiratory and neurological parameters during a stepwise, polysomnography-controlled CPAP titration to achieve P_{eff} in OSA patients	Following sleep onset at stage N2, when subjects displayed repetitive respiratory events, CPAP was progressively increased by 2 cm H_2O increments (each increment lasting 5-10 min) until apnea, hypopnea, snoring, thoracoabdominal paradox, and arousals disappeared, and the lowest negative esophageal pressure (as measured from a pressure transducer connected to a 5-cm latex balloon-tipped catheter placed transnasally into the mid-esophagus) was achieved (similar to waking baseline values)
Nilius (2006)[43] II	52/M 46/age mean 56.9/BMI mean 32.7/AHI mean 53.3	CPAP vs. PRCPAP	Comparison of PSG data and adherence in OSA patients receiving CPAP and PRCPAP as first treatment in the sleep laboratory and subsequently at home	Started CPAP at 6 cm H_2O, increased hourly at 1 cm H_2O increments up to 12 cm H_2O; the lowest P_{eff} was chosen in which the AHI was <5, and snoring and RERAs were abolished
Nino-Murcia (1989)[20] III	CPAP Group: 139/M 121/age mean 52.8/BMI mean 35.4/RDI mean 80.8; Control Group: 523/M NA/ age mean 50.5/ BMI mean 30.5/ RDI mean 37.1	CPAP	Determination of intermediate-term efficacy and side effects in a large group of OSA patients treated with CPAP	Two consecutive nights of PSG with CPAP pressure adjustments made on the 1st night and uninterrupted sleep with CPAP on the 2nd night
Oksenberg (1999)[50] V	83/M 77/age mean 53.08/BMI mean 33.01/AHI mean 62.5	CPAP	Evaluation of the impact of sleep position on P_{eff} CPAP in OSA patients and to investigate how REM and NREM sleep, BMI, RDI, and age are related to this effect	Patients initially received explanation about the way the CPAP machine works and about the pros and cons of this treatment at initial interview; before the PAP titration study, the technologist showed the patient the CPAP unit and the different mask types and explained how the mask with the headgear would be fitted; an adaptation trial of 15-20 min was carried out with the CPAP unit running while the patient was sitting awake and relaxed; the P_{eff} CPAP level was defined as the minimal pressure that overcame apneas, hypopneas, and RERAs, and stabilized O_2 levels; the P_{eff} CPAP overcame snoring in most of the cases, but in some cases, a light snoring sound was heard; the P_{eff} CPAP was titrated for the supine and lateral body positions and in the different sleep stages; the P_{eff} CPAP was defined as the minimum pressure that eliminated the respiratory abnormalities and that, by decreasing it, caused the reappearance of some of these respiratory abnormalities

First Author (yr), Reference (superscript), Evidence Level	Number/Male (# or %)/Age (yr)/ BMI (kg/m^2)/ Baseline AHI or RDI	PAP Type	Study Aims	Titration Protocol
Oksenberg (2006)[59] V	353/M 86%/age mean 55.0/BMI mean 32.9/AHI mean 52.7	CPAP	Assessment of the contribution of PSG and anthropomorphic parameters in predicting the need for high optimal CPAP	Started CPAP at 4 cm H_2O; after sleep onset and with the appearance of respiratory events, pressure was increased at 1 cm H_2O increments of approximately 15 min (but not shorter than 5 min) until most apneas, hypopneas, and snoring were eliminated and stable O_2 levels were achieved; the optimal CPAP was titrated for supine and lateral body positions and in the different sleep stages; since for most of the patients the highest minimal pressure needed was observed in the supine position and during REM sleep, the patients were encouraged to begin the titration study in the supine position
Oliver (2000)[72] V	329/M 275/age mean 50/BMI mean 33/AHI mean 47	CPAP	Comparison of the pressure required to abolish apneas as predicted from an equation with true P_{eff} determined during a CPAP titration study	Started CPAP at level predicted from the equation; if AHI <10, the pressure was reduced in 1 cm H_2O increments until AHI >10; if with CPAP level equal to the CPAP predicted level, AHI >10, CPAP was increased in 1 cm H_2O increments until AHI <10; optimal CPAP defined as the lowest pressure at which AHI <10
Pieters (1996)[113] V	95/M 88/age mean 53/BMI mean 36/ AHI mean NA/AI mean 25	CPAP	Assessment of long-term adherence by a retrospective study of patients treated with CPAP for more than one year, and analysis of several parameters that may explain the adherence level in this group of patients	Subjects were instructed in the use of CPAP, and slept with the device at about 5 cm H_2O during naps and nights; they were encouraged to try different masks and to get acquainted with the apparatus; on the 3rd or 4th night, a full PSG was repeated; during the 1st part of the night, pressure was gradually increased to suppress apneas, hypopneas, snoring and sleep fragmentation. If the treatment; subjects were seen again after 1 year of treatment on routine visit, and subjects' family physicians took part in the solution of minor side effects (e.g., nasal congestion, rhinitis)
Rajagopal (1986)[67] III	11/M 11/age mean 56.27/BMI mean NA/AHI mean 58.5	CPAP	Examination of the effects of CPAP on OSA-related daytime hypersomnolence	Started CPAP at 5 cm H_2O, progressively increased at 2.5 cm H_2O up to a maximum permissible pressure of 15 cm H_2O; either reversal of apneas, a marked decrease in the number of apneas or disorder of breathing episodes (AHI <5), or a lack of tolerance of CPAP were used as endpoints in the determination of P_{eff}
Randerath (2003)[52] I	27/M 23/age mean 57.2/BMI mean 33.5/AHI 49	APAP vs. BPAP after CPAP titration	Comparison of the efficacy of APAP on the basis of the forced oscillation technique with BPAP in patients with difficult-to-treat OSA in terms of the respiratory disturbances	CPAP Titration: Patients were given a CPAP device and fitted to a nasal mask on the 1st day and were advised to use it >4 hr on the 1st and 2nd day during the daytime to adapt to the equipment; the pressure was increased from 4 to 10 cm H_2O during this daytime training period, which was also used to troubleshoot problems and optimize equipment; the treatment pressure was increased in 1 cm H_2O/hr increments until respiratory disturbances were minimized or the amount of central respiratory disturbances decreased. BPAP Titration: IPAP titration was begun at 6 cm H_2O; IPAP was increased every 30 min until no further reduction of respiratory disturbances was possible and RERAs were reduced to ≤10/hr; when this level was reached attempts were made to reduce the pressure by 1 cm H_2O/hr until respiratory disturbances reappeared; EPAP was set at 4 cm H_2O at minimum; the difference between IPAP and EPAP was at least set to 4 cm H_2O (if IPAP was >7 cm H_2O or ≥8 cm H_2O)

First Author (yr), Reference (superscript), Evidence Level	Number/Male (# or %)/Age (yr)/ BMI (kg/m^2)/ Baseline AHI or RDI	PAP Type	Study Aims	Titration Protocol
Reeves-Hoché (1995)[53] II	CPAP Group: 36/M 29/age mean 46/BMI mean 39/ AHI mean 52; BPAP Group: 26/M 16/age mean 48/BMI mean 40/ AHI mean 51	CPAP vs. BPAP	Determination of whether BPAP achieves better patient comfort and hourly use than CPAP	CPAP Group: Started CPAP at 4 cm H_2O, increased at 2.5 cm H_2O increments in a stepwise fashion until apneas, hypopneas, and snoring in both REM and NREM sleep were eliminated; no pressure >20 cm H_2O was used. BPAP Group: Started IPAP and EPAP at 2 cm H_2O and both increased together to eliminate apneas; following elimination of apneas, the IPAP alone was increased to eliminate hypopneas and snoring; final setting in all cases was that of a higher IPAP than EPAP. For both CPAP and BPAP groups, pressures were increased if ≥3 respiratory events occurred in a 30-min interval.
Resta (1998)[74] V	105/M 88/age mean 52.9/BMI mean 34.5/AHI mean 47.3	CPAP and BPAP	Verification of the frequency of prescription of BPAP in a group of OSA patients when CPAP was ineffective or not tolerated during titration	CPAP Titration: CPAP was started at 2 cm H_2O and pressure was increased by increments of 2 cm H_2O every 30 min until snoring, apneas and hypopneas were eliminated in all sleep stages, including REM and in the supine position; the P_{eff} CPAP level was titrated to eliminate snoring and all obstructive apneas and hypopneas and to preserve sleep continuity without arousals and awakenings; BPAP Titration: initially IPAP and EPAP levels were set at 2 cm H_2O and were increased by 2 cm H_2O, modifying EPAP to eliminate apneas and IPAP to eliminate desaturation events not accompanied by apneas, snoring and hypoventilation if present; for both forms of therapy the CPAP and BPAP levels were increased if ≥3 respiratory events occurred in a 30-min interval
Rowley (2005)[25] IV	416/M 182/age medians 50.5-51/ BMI medians 38.9-40.6/AHI medians 32.0-34.3	CPAP and BPAP	CPAP prediction equation[21] tested in pre- and with-equation groups	Started CPAP at 5 cm H_2O, increased at 2.5 cm H_2O increments every 20 min until apneas, hypopneas, SpO_2 desaturations, snoring eliminated; switched to BPAP if events not eliminated at a CPAP of 15 cm H_2O; EPAP started at first level of CPAP at which apneas were eliminated, and set IPAP 5 cm H_2O above the EPAP level
Sanders (1990)[71] V	13/M 9/age mean NA/BMI mean 57.41/AHI mean NA/AI mean 55.52/HI mean 39.98	CPAP and BPAP	Evaluation of whether respiratory events could be eliminated at lower levels of EPAP than IPAP, by independently adjusting EPAP and IPAP	Started CPAP at 5 cm H_2O, increased at 2.5 cm H_2O increments until apneas and SpO_2 desaturations were eliminated. For BPAP, IPAP was initially set at 5 cm H_2O and EPAP at 2.5 cm H_2O; with initial apnea, EPAP was raised to 5 cm H_2O, matching the IPAP level; persistent apneas led to alternating increments of IPAP then EPAP in 2.5 cm H_2O increments; in situations where apneas were frequently noted after the IPAP had been increased by ≥ 5 cm H_2O above EPAP in response to nonapneic desaturations, EPAP was progressively increased in 2.5 cm H_2O increments until the apneas were abolished or until EPAP = IPAP; once EPAP again = IPAP, the two pressures were alternately increased (IPAP first) in response to persistent apnea (as described above); for desaturations in the absence of apnea, IPAP was progressively raised by 2.5 cm H_2O increments
Sanders (1993)[46] III	50/M 45/age mean 48.86/BMI mean 36.91/AHI mean 76.67	CPAP or BPAP	Evaluation of whether a prescription for PAP therapy for OSA can be developed on the same night as the PSG diagnosis is established	Started CPAP at 5 cm H_2O, increased at 2.5 cm H_2O increments to eliminate apneas, hypopneas, SpO_2 desaturations below 85%, and arousals associated with respiratory events including snoring; if intolerance to CPAP was encountered or the requisite CPAP level was unacceptably high, BPAP was applied

First Author (yr), Reference (superscript), Evidence Level	Number/Male (# or %)/Age (yr)/ BMI (kg/m^2)/ Baseline AHI or RDI	PAP Type	Study Aims	Titration Protocol
Sanders (2000)[69] IV	48/M NA/age means 48.2-50.5/ BMI means 40.9-41.3/AHI means 65.1-66.1	Split-night CPAP or BPAP	Split-night CPAP study vs. standard 2-night strategy (diagnostic PSG and then PAP study) to assess PAP acceptance and adherence	Split-night titration initiated >30 apneas + hypopneas; pressure titrated in 2.5 cm H_2O increments to eliminate apneas, and 1 cm H_2O increments to eliminate hypopneas, SpO_2 desaturations, and RERAs; CPAP switched to BPAP in the event that the patient was intolerant of CPAP (e.g., discomfort related to the level of pressure)
Schäfer (1998)[68] III	CPAP Failure Group: 13/M 9/ age mean 57/BMI mean 44.4/AHI mean 44.4; Control Group: 13/M 9/ age mean 56/BMI mean 30.8/AHI mean 38.0	CPAP	Analysis of the factors which are associated with a primary failure in the initial CPAP therapy in order to identify these patients before starting CPAP therapy	Started CPAP at 5 cm H_2O, increased at 1 cm H_2O increments until apnea, hypopnea, and snoring were abolished
Sériès (1994)[113] V	40/M 34/age range 35-63/BMI mean 36.3/AHI mean 48.4	CPAP	Prospective determination of the changes in the required CPAP level in OSA over time of use, and the evaluation of changes in persisting SRBD with the use of suboptimal CPAP therapy	Started CPAP at 3 cm H_2O, progressively increased at 1 cm H_2O increments until apneic and hypopneic events, as measured by the AHI, and snoring were abolished in all sleep stages and all sleep positions, or at the maximal pressure level that was tolerated by the subjects
Sforza (1995)[18] V	22/M 22/age mean 50.2/BMI mean 34.7/AHI mean 97.8	CPAP	Determination of whether cephalometric measurements, nocturnal indices of negative intrathoracic pressure, or SRBD frequency are related to the effective CPAP level in OSA patients	Started CPAP at 2 cm H_2O, increased at 1 cm H_2O increments until P_{eff} reached, which was defined as the PAP level that abolished apneas and snoring and reduced P_{es} swings below a maximum of twice their value during quiet respiration in the awake state
Silva (2007)[35] IV	CPAP Oriented Group: 782/M 75%/age mean 52/ BMI mean 31/ AHI mean 11; PAP Control Group: 699/M 76%/age mean 53/BMI mean 31/AHI mean 12	CPAP	Determination of whether an orientation session led by a PSG technologist at the start of a CPAP titration night can improve objective sleep quality and CPAP acceptance in patients referred to a sleep laboratory	Started CPAP at 4 cm H_2O, increased at 1 cm H_2O increments until the disappearance of respiratory events, SpO_2 desaturation, snoring, and arousals; mask leak was continuously monitored and corrected in case it reached values above 25 L/min; humidifiers were not used during the titration; in case of the lack of acceptance of the CPAP equipment, the technologist was instructed to try a new model of nasal or oral mask and to reassure the patient, reminding him/her of the importance and value of the exam

First Author (yr), Reference (superscript), Evidence Level	Number/Male (# or %)/Age (yr)/ BMI (kg/m^2)/ Baseline AHI or RDI	PAP Type	Study Aims	Titration Protocol
Stradling (1997)[114] II	CPAP Titration Group: 61/M NA/ age mean NA/ BMI mean 33.7/ AHI mean NA (desaturation index [# of >4% SpO_2 dips/hr of sleep] mean 20.0); APAP Titration Group: 52/M NA/ age mean NA/ BMI mean 32.5/ AHI mean NA (desaturation index mean 16.6)	CPAP Titration vs. APAP Titration	Determination of whether the substitution of automatic (APAP) for manual CPAP titration on a patient's first night improved or reduced CPAP acceptance at 5 weeks	Patients were allowed to fall asleep wearing their nasal mask, with the pressure set to about 3 cm H_2O; once the patient was asleep and was experiencing upper airway obstruction the pressure was raised until all evidence of obstruction and its consequences disappeared (absence of snoring, movement arousals, pulse rate rises, and dips in SpO_2); the pressure was then reduced until obstructive events returned and then increased again; this cycle was repeated until the P_{eff} was confidently assessed; this process usually took about 2 hr and thereafter no further titration was performed; the following morning the tracings were reviewed for any return of events; if there had been a return of events, with the mask satisfactorily in place, then the pressure at which the patient was sent home was increased 1-2 cm H_2O; this usually occurred if there had been no supine sleep during the supervised first 2 hr; the pressure was then kept at the same level until the follow up visit 6 wk later
Teschler (1996)[115] II	20/M 20/age mean 52/BMI mean 33.8/AHI mean 60.3	CPAP vs. APAP	Comparison of the effectiveness of APAP in treating OSA and the selection of a suitable pressure for subsequent fixed-pressure CPAP therapy	P_{eff} was selected to eliminate apneas and hypopneas in all sleep stages and body positions, but there was no attempt to eliminate snoring or airflow limitation.
Wiest (2001)[16] III	50/M 45/age mean 49.9/BMI mean 30.5/AHI mean 39.3	CPAP	Determination of the reproducibility of the effective pressure (P_{eff}) determined by manual CPAP titrations with in-laboratory PSG	P_{eff} established at which most apneas, hypopneas, snoring, and arousals disappeared in all body positions and sleep stages; starting from an initial 4 mbar (cm H_2O), pressure increased in steps of 1 mbar at intervals ≥5 min whenever events occurred; if no further events occurred over 30 min, down titration performed once during the titration in which pressure was reduced again every 10 min in 1 mbar steps until events recurred, then the pressure was once more increased in same manner until no events occurred (P_{eff}); titration repeated the following night if initial titration failed to obtain P_{eff}
Yamashiro (1995)[73] V	107/M 90/age mean 52.3/BMI mean 34.4/AHI mean 23.6	CPAP	Comparison of full-night and split-night CPAP titrations in patients with OSA and UARS	Started CPAP at 3 cm H_2O, increased at 1-2 cm H_2O increments until apneas, hypopneas, and disordered breathing-related arousals were abolished

AHI = apnea-hypopnea index, AI = apnea index, APAP = auto-titrating positive airway pressure, BMI = body mass index, BPAP = bilevel positive airway pressure, CPAP = continuous positive airway pressure, EEG = electroencephalographic, EPAP = expiratory positive airway pressure, HI = hypopnea index, IPAP = inspiratory positive airway pressure, NA = not available, NREM = non-rapid eye movement; OSA = obstructive sleep apnea, PAP = positive airway pressure, P_{eff} = effective (optimal) positive airway pressure, P_{es} = esophageal pressure, PRB-PAP = pressure-relief bilevel positive airway pressure; PRCPAP = pressure-relief continuous positive airway pressure; PSG = polysomnography, RDI = respiratory disturbance index, REM = rapid eye movement; RERAs = respiratory effort-related arousals, SRBD = sleep-related breathing disorders, UARS = upper airway resistance syndrome

Evidence Table 3b—PAP Titration Protocols in Infants and Children

First Author (yr), Reference (superscript), Evidence Level	Number/Male (# or %)/Age (yr)/ BMI (kg/m^2)/ Baseline AHI or RDI	PAP Type	Study Aims	Titration Protocol
Downey (2000)[80] V	18/M NA/age mean NA (<2 yr)/BMI mean NA/AHI mean NA/AI mean 12.8	CPAP	Demonstration that CPAP is efficacious in children with OSA who are <2 yr of age	The goal of the initial CPAP trial night was to abolish both apnea and snoring while maintaining patient comfort so that the patient and parent would use CPAP at home; started CPAP at 5 cm H_2O in all patients, and then was titrated by 2 cm H_2O increments until both OSA and snoring were abolished; technologists used their respective judgments and assessments of sleep-EEG arousals, leaks from the masks, and respiratory patterns (apnea) to adjust the CPAP in 1 cm H_2O increments to provide the best possible patient comfort; 4 patients required more than 1 CPAP trial night to obtain optimal effectiveness; many of the early patients in this study used custom-made masks, commercially available pediatric-sized masks (Respironics; Murrysville, PA), or nasal pillows; full-face masks were not needed for the patients in this study
McNamara (1999)[81] V	24/M 15/age range 1-51 wks/BMI mean NA/AHI mean NA/NREM AI mean 44.4/REM AI mean 68.6	CPAP	Determination of: whether OSA could be effectively treated with CPAP in infants who possibly have different upper airway obstructive mechanisms; whether CPAP could be used as a long-term therapy; whether it could be an alternative to more common therapy; the effects of increasing age and development on OSA severity and CPAP requirements in infants	The P_{eff} level of CPAP for each infant was determined during a full-night CPAP titration study; the CPAP equipment included a commercially available CPAP machine, to which was attached a small infant CPAP mask (Sullivan APDII, ResMed, Sydney, Australia); the mask was fitted over the infant's nose and secured with a head strap (RemCap; ResMed); the CPAP was started at 3.7 cm H_2O and was gradually increased by 0.3 cm H_2O increments until the obstructive events were prevented; as the pressure was increased, the breathing patterns and CO_2 measurements were carefully monitored; the P_{eff} was the level that minimized obstruction and did not increase the CO_2 level or the length of central apneas; the infants who continued to use CPAP at home were treated with the pressure level that was determined during the study, and the parents were asked to administer CPAP to their infants during all sleep periods, including daytime naps.
Marcus (2006)[66] II	29/M 21/AHI mean 27; CPAP Group: 13/M 8/age mean 11/BMI mean 33.8; BPAP Group: 16/M 13/BMI mean 31.2	CPAP and BPAP	Determination of adherence and effectiveness of PAP (both CPAP and BPAP) in children with obstructive apnea	Children were given a mask and headgear without the PAP unit to practice wearing for 2 wk while awake to help them habituate to the system; each family also received a standardized behavioral instruction sheet; after 2 wk, the patient underwent an overnight laboratory titration study to determine the P_{eff} required; the goal of the titration PSG was to eliminate all obstructive apneas, desaturation, and hypercapnia at a P_{eff} tolerated by the patient without excessive awakenings; CPAP was started at 3 cm H_2O and was increased to 4 cm H_2O and then increased further in 2 cm H_2O increments as needed; for patients assigned to BPAP, the aim was to keep a 6 cm H_2O difference between IPAP and EPAP; the patient was started on 4/3 (minimum) cm H_2O; pressure then was increased by 2 cm H_2O increments to 6/3, 8/3, 10/4, 12/6, 14/8, 16/10 cm H2O, etc.; supplemental oxygen was added when the patient desaturated persistently to <92% in the absence of apnea, paradoxical breathing, or snoring; patients received a follow-up telephone call after 48 hr and again after 1 wk of PAP use; they then were seen in clinic every other month to be assessed clinically and received a telephone call on alternate months when they were not being seen; side effects were assessed and treated at the discretion of the sleep specialist as per standard clinical practice; after 6 mo, a repeat PSG was performed on current PAP settings; and height, weight, blood pressure, and subjective complaints were reevaluated

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Massa (2002)[60] V	66/M 39/age range <1-19/BMI mean NA/AHI mean NA	CPAP	Review of children with OSA for whom a trial of CPAP was proposed	The CPAP trial was a split-night study, starting at 4 cm H_2O and increased at 2 cm H_2O increments until OSA and SaO_2 desaturation were overcome; a CPAP trial was considered successful if the child was cooperative in wearing the mask for the time necessary to define CPAP efficacy; a failed trial was defined when the child did not tolerate the mask for the necessary time to define therapeutic efficacy; CPAP could only be classed as successful if it was shown to be effective in both quiet sleep (i.e., deep sleep stages) and active sleep (including REM sleep); the time taken to achieve a decision on CPAP efficacy was 2-4 hr with CPAP in place and depended on the CPAP level required and the sleep state patterns; children were sent home with the equipment, and parents received a detailed explanation about OSA, the need for treatment, and how CPAP works; telephone support, for any problems arising or for equipment replacement parts, was also given to the families; follow-up sleep studies and clinical assessments were performed at 1-mo, 6-mo, and 1-yr intervals to evaluate the continued effectiveness of CPAP, to readjust the mask size, and to change the pressure level where necessary; on each occasion, information regarding problems, side effects, and adherence were obtained from parents
Migliori (2005)[116] V	20/M 10/age mean 26.3 wks/BMI NA/AHI NA - but severe apnea episodes, acidosis (pH ≤7.25), or hypercapnia ($PaCO_2$ ≥55 mm Hg)	CPAP or BPAP	Comparison of the effects of BPAP and CPAP on gas exchange in preterm babies	For BPAP, IPAP set at 4 cm H_2O more than EPAP level
Uong (2007)[62] V	46/M 26/age mean 13.6/BMI mean 39.8/AHI mean 28.4	CPAP and BPAP	Description of PAP effectiveness and adherence among school-aged children and adolescents who had been followed in a clinic through a comprehensive program dedicated to PAP education and follow-up	Started CPAP at 5 cm H_2O, increased at 2 cm H_2O increments when needed; patients who seemed uncomfortable or who required single level pressures >15 cm H_2O were switched to BPAP, beginning at 10/5 with ≥5 cm H_2O difference between IPAP and EPAP; once optimal pressures were determined, the family received a follow-up telephone call from a dedicated sleep nurse to review study results, PAP pressures, and instructions regarding home health PAP set-up and clinic follow-up; humidifiers were used for all of the patients; a representative of the home health care company who visited the patients in their home offered various masks for the best fit; patients had clinic follow-up visits 2-4 wk into PAP therapy and every 6 mo thereafter; problem areas, if any, were determined at each follow-up visit
Waters (1995)[117] V	80/M 57/age mean 5.7/BMI mean NA/ RDI mean 27.3	CPAP	Evaluation of the characteristics of 80 children who underwent overnight PSG studies between 1980 and 1993, were diagnosed with OSA, and who used CPAP	Daytime practice sessions and games were encouraged until the child was able to wear the CPAP mask without fear or distress and then was encouraged to sleep wearing the mask; when the child was able to wear the mask overnight, CPAP was commenced at 3.5-4.5 cm H_2O in the home environment; a CPAP titration study was conducted in the sleep unit when the infant or child was comfortable sleeping with low pressure CPAP; close supervision during this introductory phase allowed correction of any practical problems with mask fitting or attachment

AHI = apnea-hypopnea index, AI = apnea index, APAP = auto-titrating positive airway pressure, BMI = body mass index, BPAP = bilevel positive airway pressure, CPAP = continuous positive airway pressure, EEG = electroencephalographic, EPAP = expiratory positive airway pressure, HI = hypopnea index, IPAP = inspiratory positive airway pressure, NA = not available, NREM = non-rapid eye movement; OSA = obstructive sleep apnea, PAP = positive airway pressure, P_{eff} = effective (optimal) positive airway pressure, P_{es} = esophageal pressure, PRBPAP = pressure-relief bilevel positive airway pressure; PRCPAP = pressure-relief continuous positive airway pressure; PSG = polysomnography, RDI = respiratory disturbance index, REM = rapid eye movement; RERAs = respiratory effort-related arousals, SRBD = sleep related breathing disorders, UARS = upper airway resistance syndrome