

Positive airway pressure therapy in sleep related breathing disorders

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Introduction

Before the innovation of positive pressure therapy by Sullivan and colleagues tracheostomy was the only treatment for sleep disordered breathing (SDB). In 1981 Sullivan and his group described a home made device with vacuum cleaner blower motor, which delivered air by tubing via nares. (fig1) This revolutionized the management of sleep disordered breathing and triggered tremendous interest in the field of sleep medicine. In the last 20 years significant advances have been made in positive airway pressure therapy. The modern day machines are smaller, quieter, lighter and lot smarter! (fig2) Wide range of interfaces is also available allowing accommodation of specialized needs. (Fig 3)



fig 1: Diagrammatic representation of delivery of air by tubing via nares



fig 2 : Prototype of a positive pressure therapy device

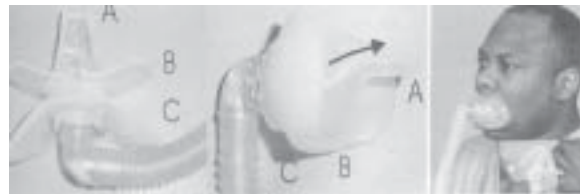


fig 3: Interfaces used with a positive pressure therapy device

Mechanism of Action

In order to know how positive airway acts, it is imperative to understand the upper airway dynamics in patients with SDB (sleep disordered breathing).

Patients with SDB have a smaller upper airway. During daytime, reflex mechanism leads to increased activity of dilator muscles. However, with sleep onset these reflexes are absent leading to collapse of the upper airways in individuals who are susceptible. (1, 2)

Positive airway pressure therapy is delivered via a system, which generates pressurized air, delivered to the patient via tubing and airtight mask. The predominant mechanism of action is believed to be mechanical splinting of the airways. Positive pressure therapy raises the intra-luminal pressure above the critical closing pressure and thus maintains airway patency. Other mechanisms have been described including: increase in FRC causing traction of neck structures increasing upper

airway patency (3) or eliciting a reflex which increases the tone of dilator muscles. These proposed mechanisms are not supported by others. (4, 5)

Indications for continuous positive airway therapy in SDB

What are the three main indications for treatment with positive airway therapy in SDB?

First, treating excessive daytime sleepiness, due to symptomatic SDB, and its resulting sequelae.

Second, to alleviate, socially unacceptable snoring and improve sleep quality in bed-partners. Resolution of snoring has been reported to improve bed-partners sleep by 13%! which is equivalent to an extra one hour of sleep per night (6). Compliance however is poor in asymptomatic patients using CPAP for snoring.

Third, CPAP should be used to improve cardiovascular consequences of SDB.

Clinical Benefits

There are many aspects to the benefits of positive pressure therapy mostly stemming from the resolution of SDB.

Improvement in symptoms.

Several randomized trials have conclusively demonstrated improvement in sleepiness; studies have also found improvement of neurocognitive functions like memory and learning. Even an average use of 3.4 hrs per night is associated with improved cognitive task performance and attention. (7)Improvement in vitality, energy and ability to stay awake (Maintenance of wakefulness test) has also been demonstrated.

Studies have also shown improved driving performance. (8, 9, 10) and decrease in the number of automobile accidents (11).However treatment of asymptomatic SDB even if severe (AHI> 30) with positive airway therapy is still not proven (12). Nocturia may also improve. (13)

Cardio-vascular consequences

There is growing body of evidence that treatment of SDB with CPAP has salutary effects on cardiovascular

and cerebro-vascular consequences. Large population based studies like Wisconsin Cohort Sleep Study (14) and Sleep Heart Health Study (15) have shown an adjusted odds ratio of 2.9 and 1.37 respectively for Hypertension in SDB. Several subsequent randomized controlled trials have found that CPAP therapy reduces diurnal and nocturnal blood pressure in hypertensive patients with SDB (16, 17). Intuitively reduction in BP should result in improving cardiovascular morbidity and mortality however convincing Data to that effect is still lacking. Joint national commission (VII) in its recommendations now recognizes SDB as a secondary cause of hypertension.

CHF may be associated with SDB and treatment with CPAP has been shown to improve left ventricular function (improved ejection fraction).Recent data suggests that CPAP administration to patients with CHF reduces morbidity with improved NYHA functional class (18)

Various bio-chemical markers linked to increased cardiovascular morbidity have been found to be elevated in SDB. By the same token, these markers have also been found to be reduced by positive airway therapy i.e. C-reactive proteins, BNP, serum leptin, e-selectin and soluble intracellular adhesion molecule-1.

The mechanism by which Positive airway therapy improves cardiovascular outcome is unknown although there is increased evidence that that reduction in sympathetic tone may play an important role. (19, 20)

Compliance

Despite the proven effectiveness of positive airway therapy in SDB compliance with treatment is less than optimal. To begin with, *acceptance* itself may be an issue. Considering the unique nature of treatment *acceptance* may depend on patient's pre-conceived ideas and the manner it was introduced.

Estimates of compliance by subjective means reveal a compliance rate of 65-90 %.(, 21, 22, 23)

However when compliance is measured objectively as done by Kribbs (24) et al by incorporating an hour meter into the unit compliance was substantially less. The study reported 46% compliance when adherence was defined as use for at least 4 hours on at least 70% of the nights.

One large study looked at identifying predictors of better compliance. They found that independent

predictors included snoring, higher AHI and degree of sleepiness. (25)

From clinicians perspective it is important to note that intermittent use of the machine in first few weeks is associated with long term poor long term compliance .(26)

Hence a clinician has a short window of opportunity to address potential impediments before the patient sets a non-compliant pattern. Level of education, type of work and side effects may also influence use of positive airway therapy.

Patient education, before setup and during critical first 4 weeks of use along with routine follow-up and treatment of complications can improve patient compliance. (27)

Data suggests that even one night without treatment can induce objectively measured daytime sleepiness. (28)

Data also suggests minimum of 4 hrs of use after which there is persistent beneficial effect on oxyhemoglobin saturation .It is postulated that positive airway therapy favorably influences the stability of upper airway during the latter part of the night.

Clinicians should also utilize the **newer generation machines**, which allow monitoring of duration of use each night and number of days per week. This information is helpful in feedback and education of the patient.

Side Effects and trouble shooting

Major complications of positive airway pressure therapy are extremely rare and represent isolated case reports.

Most of the adverse effects stem from 1) oro-nasal interphase 2) Excessive pressure or airflow .Some of the commonly encountered side effects and problems with potential solution are listed in table1.

Long term positive airway therapy does not appear to be detrimental to oro-nasal morphology or mucociliary functions. (29)

It is important to identify and resolve the side effects as patients who complain of adverse effects use CPAP less frequently than those who do not (30)

Various modalities can be used to overcome side-effects and improve compliance. **Ramping** been suggested to improve tolerance. This allows gradual

increase of pressure delivery over 15-45 minute time period before reaching the optimal pressure. Though a

Table1. Common side effects and problems encountered using positive airway therapy and possible solutions.

Side effects/problems	trouble shooting tips
skin breakdown local skin reaction	<ul style="list-style-type: none"> • Too tight? Refit mask • Silicon allergy? Change to polyurethane mask • Barrier therapy with duoderm / newskin • Use milder soap to clean mask • Poor fit? Select different mask • Nasal pillows • Appropriate headgear fitting • Eye patch • Chin strap (oral leak) • Full mask • Heated humidification • Saline nasal spray • Nasal steroids • Aerosolized nasal ipratropium • Use pressure ramp • Short acting benzodiazepines • Avoid high pressures in patients with bullous lung dis. • Reduce required pressure <ul style="list-style-type: none"> ○ Concomitant oral appliance ○ Elevate head side of bed (reduces AHI) • BiPAP • Counseling/education • Desensitization / acclimatization • Nasal pillows / oracle • Support group • Auto-CPAP • Use longer tubing • Keep main unit in closet
Air leaks Conjunctivitis	
Congestion Rhinorrhea Mucosal dryness Epistaxis	
High pressure Difficulty initiating sleep chest discomfort Pneumothorax Pnumomediastinum Difficulty exhaling	
Claustrophobia Poor compliance Inconvenience	
Positional apnea Too noisy	

common feature in most models, improvement in use has not been demonstrated “Ramp abuse” may in theory lead to suboptimal therapy?

Humidification has been shown to prevent increase in nasal resistance due to upper airway dryness (31). Heated humidification has been found to be superior to cold humidification. (32) And almost essential when pressure requirements exceed 10 cm H₂O.

For patients with air leak due to open mouth, a chin strap or Oro-nasal (full face) mask should be instituted. And for patients with nasal pathology or claustrophobia oral device (oracle™) may solve the problem.

Persistent or residual sleepiness despite appropriate positive airway pressure therapy should prompt the clinician to look for alternative reasons. (Table 2). If no other explanation is present, residual hypersomnia is likely.

Alternative modalities of Positive airway pressure therapy

Bilevel positive airway Pressure

Upper airway hysteresis is such that more pressure is required to open the upper airways on inspiration and less pressure to maintain the patency on expiration. (33)

Bilevel PAP device is designed to deliver different pressure during inspiration and expiration. Since most patients feel suffocated on high pressures on expiration the device can be set at lower pressure during expiration (EPAP) and higher pressure during inspiration (IPAP) subsequently preventing upper airway closure and hypopneas. The difference between these pressures becomes the pressure support patient receives. If EPAP is equal to IPAP the device works as a continuous PAP device! It is useful in patients with overlap syndrome (OSA + COPD) where it appears to improve compliance and reduces arterial PCO₂ during sleep and awake. (34)

Devices are available in spontaneous mode where the patient triggers all breathing patterns or “back –up mode” where a certain numbers of breath cycles are guaranteed. This second mode is often used in patients with both hypoventilation and central apnea.

Some models offer additional features for those with neuromuscular disease such as adjustable inspiratory threshold and expiratory triggers.

Auto –CPAP

The fact that airway resistance varies from throughout the night and is dependent on several factors i.e. position of sleep, alcohol consumption, sedatives sinus infection etc. it appeared fairly intuitive that a fixed pressure throughout the night may not be appropriate for all patients. Auto- CPAP is just such a machine designed to respond dynamically to changes in patient's upper airway resistance by increasing or decreasing the pressures.

There are two areas of potential usefulness of auto-CPAP. Treatment with auto-CPAP has been found to be equivalent to fixed positive airway pressure therapy in terms of AHI, Epworth sleepiness score and arousal index. Overall the mean overnight pressures are lower with auto-titrating device. (35) Comparative data regarding improved compliance and adherence are mixed. (36) Though many of them recorded increase in the number of hours of use. Considering the cost of the device the precise role of auto-CPAP in treating patients with SDB remains unclear. Additionally, some patients may not tolerate Auto-CPAP due to significant fluctuations in pressures .Other problem is that different devices operate on unique algorithms. Bench studies reveal that some of the devices did not respond appropriately when subjected to different sleep breathing patterns. (37)

A proposed use of auto –titrating units may be in subset of patients with position and sleep stage dependent SDB. (38)

Another common use of auto –titrating units is helping titrate the optimal pressure. Problems with in house titration include inadequate time as in split –night studies. Some patients may not be able to sleep in alien environment. We recently published data that there may be more than 2 cm difference in final optimal pressure when comparing titration by auto-titrating device at home versus fixed CPAP titration during a split night study.(39) A practical approach is to conduct a full night diagnostic polysomnography followed by 2 week titration by auto-CPAP .This needs confirmation by larger trials.

When should use of Auto- CPAP be avoided?

It may also be prudent to avoid auto –titrating devices in patients who have undergone UPPP as they may not

snore. Its efficacy and utility is not known in patients with central sleep apnea, central hypoventilation syndromes and patients with underlying cardio-pulmonary disorders. The AASM practice guidelines recommend that an Auto-CPAP device not be used if the minimal oxygen saturation by pulse-oximetry dips below 80%, as these devices do not currently record oxygen saturation.

Conclusion

Successful institution of Positive airway pressure therapy is a combination of art and science.. Rapid strides in technology have introduced devices which can deliver complex functions. It is the duty of clinicians to familiarize themselves with these devices in order to properly serve their patients. Recognizing, the subset of patients which may benefit from bilevel PAP or auto-titrating devices requires the physician to be informed and actively involved in the care of the patient during the first few weeks of treatment.

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