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(INDian initiative on Obstructive Sleep Apnea Guidelines)
First Edition-2014

Under the auspices of
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INOSA Guidelines

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Abbreviations

AASM	American Academy of Sleep Medicine
AF	Atrial fibrillation
AGB	Adjustable gastric banding
AHI	Apneahypopnea index
APAP	Auto positive airway pressure
ASA	American Society of Anesthesiologists
AUTOPAP	Auto positive airway pressure
AVAPS	Average volume assured pressure support
BMI	Body mass index
BPAP	Bi-level positive airway pressure
BPAP-ST	Bi-level positive airway pressure spontaneous timed
BPD	Bilio-pancreatic diversion
CAD	Coronary artery disease
CHF	Congestive heart failure
CIMT	Carotid intima-media thickness
COMP –SA	Complex sleep apnea
COPD	Chronic obstructive pulmonary disease
CPAP	Continuous positive airway pressure.
CSA	ChyeneStokesrespiration
CT	Computed tomography
DISE	Drug-induced sleep endoscopy
ECG	Electrocardiography
EDS	Excessive daytime sleepiness
EEG	Electroencephalography
EMG	Electromyography
EOG	Electrooculography
EPAP	Expiratory positive airway pressure
ESS	Epworth sleepiness scale
F-CPAP	Fixed continuous positive airway pressure
FNMM	Fiberopticnasopharyngoscopywith Müller’smanouvre
GAHM	Genioglossusadvancement with hyoid myotomy
HDL	High-density lipoprotein
HfpEF	Heart failure with preserved ejection fraction
HfrEF	Heart failure with reduced ejection fraction
HST	Home sleep testing
ICSD-3	TheInternational Classification of Sleep Disorders(3 nd Ed.)
IPAP	Inspiratory positive airway pressure
LDL	Low-density lipoprotein
MAD	Mandibular advancement device

MLS	Multi-level surgery
MRA	Mandibular repositioning appliance
MRI	Magnetic resonance imaging
MSLT	Multiple sleep latency test
MWT	Maintenance of wakefulness test
NCPAP	Nasal continuous positive airway pressure
OA	Oral appliances
OHS	Obesity hypoventilation syndrome
OCST	Out of centersleep testing
OR	Odds ratio
OSA	Obstructive sleep apnea
OSAS	Obstructive sleep apneasyndrome
PAP	Positive airway pressure
PAT	Peripheral arterial tone
PM	Portable monitoring
POSA	Postionalobstructive sleep apnea
P-SAPS	Perioperative sleep apneaprediction score
PSG	Polysomnography
QOL	Quality of life
RCT	Randomized controlled trial
RDI	Respiratory disturbance index
REI	Respiratory event index
RERAS	Respiratory effort related arousals
RYGB	Roux-en-Y gastric bypass
SACS	Sleep apneaclinical score
SG	Sleeve gastrectomy
SNA	Sella-Nasion-A
SNB	Sella-Nasion-B
SOREMP	Sleep onset rapid eye movementperiod
STOP	Snoring, tiredness during daytime, observed apnea, and high blood pressure
STOP-BANG	STOP, body mass index (BMI), age, neck circumference and gender
TMJ	Temporomandibular joint
TRA	Tongue retaining appliance
UARS	Upper airways resistance syndrome
ULCT	Unattended limited channel testing
UPPP	Uvulopalatopharyngoplasty

Evidence Quality

Evidence Quality	Preponderance of Benefit or Harm	Balance of Benefit and Harm
A. Well designed RCTs or diagnostic studies on relevant population	Strong Recommendation	Option
B. RCTs or diagnostic studies with minor limitations;overwhelmingly consistent evidence from observational studies	Recommendation	
C. Observational studies (case-control and cohort design)		
D. Expert opinion, case reports, reasoning from first principles	Option	No Rec
X. Exceptional situations where validating studies cannot be performed and there is a clear preponderance of benefit or harm	Strong Recommendation Recommendation	

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1 Executive Summary

1.1 Epidemiology and risk factors of OSA

What is sleep-disordered breathing?

Sleep-disordered breathing includes abnormal respiratory pattern (apnea, hypopnea, or respiratory effort related arousals) or central sleep apnea-hypopnea syndrome including Cheyne-Stokes breathing syndrome or central hypoventilation leading to an altered gas exchange.

What are Obstructive Sleep Apnea and Obstructive Sleep Apnea Syndrome?

OSA and OSAS are subsets of sleep-disordered breathing. OSA is the occurrence of an average 5 or more episodes of obstructive respiratory events (apneas, hypopneas, or RERAs) per hour of sleep with either sleep related symptoms or comorbidities or ≥ 15 such episodes without any sleep related symptoms or comorbidities. OSAS is defined as OSA associated with daytime symptoms, most often excessive sleepiness.

What are overlap syndrome, obesity-hypoventilation and Pickwickian syndromes?

Overlap syndrome is defined as the co-occurrence of both chronic obstructive pulmonary disease and OSA in the same individual. Both are common diseases affecting the adult population, mostly over 40 years of age. Obesity-hypoventilation syndrome consists of obesity, sleep-disordered breathing, hypoxia and chronic hypercapnia during wakefulness in the absence of other known causes of hypercapnia. Historically, OHS was first described as Pickwickian syndrome in a case report in 1956. This patient resembled a character depicted by Charles Dickens in “The Posthumous Papers of the Pickwick Club as he was obese and had hyper-somnolence.

What is the epidemiology of obstructive sleep apnea in India and is it different from the rest of the world?

Community based epidemiological studies from India have shown that the prevalence of OSAS is 2.4% to 5 % in males and 1 to 2% in females. There is no considerable variation in the prevalence of OSAS compared to rest of the world where it is 4% in males and 2% in females (**Evidence Quality B**).

What are the risk factors for obstructive sleep apnea?

The demographic characteristics that predispose to development of OSA include older age (**Evidence Quality B**), male gender (**Evidence Quality B**), pregnancy (**Evidence Quality C**) and post-menopausal state (**Evidence Quality C**). Risk factors that are linked by strong published evidence include obesity (**Evidence Quality A**), central body fat distribution (**Evidence Quality B**), increased neck circumference (**Evidence Quality B**) and several anatomical abnormalities of the craniofacial region and upper airway (**Evidence Quality B**). Other potential risk factors include genetic predisposition (**Evidence Quality C**), familial aggregation (**Evidence Quality C**), tobacco smoking (**Evidence Quality C**), alcohol use (**Evidence Quality C**), night-time nasal congestion (**Evidence Quality C**), endocrine abnormalities (hypothyroidism, acromegaly) (**Evidence Quality B**), polycystic ovarian syndrome (**Evidence Quality C**), Down’s syndrome and drugs (benzodiazepines, muscle relaxants, testosterone therapy) (**Evidence Quality C**).

1.2 Consequences of OSA

Is OSA associated with increased morbidity and mortality?

Yes, it is usually associated with several co-morbidities such as insulin resistance, diabetes mellitus, hypertension, stroke and coronary artery disease. OSA increases mortality either due to apnea *per se*, increased risk of vehicular accidents or associated co-morbidities (**Evidence Quality B**).

What is the relationship of OSA with hypertension? Is hypertension reversible after treatment of OSA?

OSA is causally related to hypertension. Treatment of OSA with PAP therapy or oral appliances has been shown to modestly improve the blood pressure control (**Evidence Quality A**). However, anti-hypertensive therapy may still be required to control the blood pressure. All patients with resistant hypertension should be screened for OSA (**Evidence Quality A: Recommended**).

What is the relationship between OSA and coronary artery disease? Should all patients with CAD screened for OSA?

OSA has been found to be associated with coronary artery disease especially in men (**Evidence Quality B**). All patients with coronary artery disease should be clinically screened for OSA (**Evidence quality B, Recommended**).

What is the relationship of OSA and congestive heart failure? Should all patients with CAD screened for OSA?

OSA and congestive heart failure are associated with each other independent of confounding factors (**Evidence Quality B**). All patients with heart failure should be screened for OSA (**Evidence Quality B, Recommended**).

Is OSA associated with increased prevalence of arrhythmias? Should all patients with arrhythmia be screened for OSA?

Yes, OSA is associated with increased prevalence of arrhythmias (**Evidence Quality B**). All patients with arrhythmias, particularly those with atrial fibrillation, should be screened for OSA (**Evidence Quality B, Recommended**).

What is the relationship between OSA and stroke? Should all patients with stroke be screened for OSA?

OSA is an independent risk factor for stroke. In turn, stroke can result in OSA (**Evidence Quality B**). All patients who suffer from stroke should be screened for OSA (**Evidence Quality B, Recommended**).

Does OSA affect neuro-cognitive function and quality of life?

Yes, OSA impairs neuro-cognitive function and decreases the quality of life (**Evidence Quality B**).

What is the relationship between OSA and psychiatric disorders?

OSA is associated with various psychiatric disorders like depression, bipolar disorder, delirium, anxiety and erectile dysfunction. All patients with psychiatric disorders especially erectile dysfunction (**Evidence Quality B: Recommended**) should be screened for OSA.

Is OSA associated with an increased prevalence of metabolic syndrome? What is syndrome Z?

Yes, OSA is associated with an increased prevalence of metabolic syndrome (**Evidence Quality C**). Metabolic syndrome is a constellation of various cardiovascular risk factors. Syndrome Z refers to the co-occurrence of OSA and metabolic syndrome and these patients are at a higher risk of cardiovascular and cerebrovascular complications.

1.3 Diagnosis of OSA

Who should be evaluated for OSA?

Patients undergoing routine health check-up with snoring, daytime sleepiness, obesity, hypertension, motor vehicular accidents (**Evidence Quality A, Strong Recommendation**) and high risk cases such as congestive heart failure, diabetes mellitus, coronary artery disease, stroke, metabolic syndrome, nocturnal dysrhythmias (**Evidence Quality B, Recommended**) should undergo a comprehensive sleep evaluation. Additionally, patients with pulmonary hypertension and preoperative cases should also have a comprehensive sleep evaluation. Those suspected to have OSA on comprehensive sleep evaluation should be referred for a sleep study. High risk cases, even if asymptomatic, can be referred for a sleep study. Further, medical examiners evaluating drivers, air pilots, railway drivers and heavy machinery workers should be educated about OSA and should comprehensively evaluate applicants for OSA, if snoring, daytime sleepiness or obesity irrespective of the presence or absence of co morbidities are noted (**Evidence Quality B, Strong Recommendation**).

What is the role of ESS and pre-test screening questionnaires in the diagnosis of OSA?

ESS can be used as a tool to measure the quality of life with regard to EDS, likelihood of long-term compliance to continuous positive airway pressure (CPAP) and to evaluate the treatment response rather than to screen for OSA (**Evidence Quality C, Recommended**). Both Berlin questionnaire and modified Berlin questionnaire are moderately accurate to screen for OSA (**Evidence Quality C, Recommended**). Although, other questionnaires have not been adequately studied, they can be used to screen the patients for OSA. STOP Bang questionnaire (**Evidence Quality C, Recommended**) is the most appropriate questionnaire for screening preoperative cases. It may also be used for pre-test probability assessment before portable monitoring because of ease of administration and high sensitivity.

What are various types of sleep studies?

Type 1: Fully attended polysomnography (≥ 7 channels) in a laboratory setting

Type 2: Unattended polysomnography (≥ 7 channels)

Type 3: Limited channel study (using 4–7 channels)

Type 4: One or two channels usually using oximetry as one of the parameters

What is the “Gold standard” for diagnosis for OSA?

Type 1 study or in-hospital, in-laboratory, technician-attended, overnight polysomnography (PSG) is the “Gold standard” for evaluation of sleep-disordered breathing (**Evidence Quality A, Strong Recommendation**).

What is the role of portable monitoring (PM)/ out of center sleep testing(OCST)/ home sleep testing (HST)/ unattended limited channel testing (ULCT) in diagnosis of OSA?

Laboratory attended PSG is not necessary in all patients suspected to have OSA. Portable monitoring or OCST with type 3 or type 4 devices (which should at least include airflow, oxygen saturation and respiratory effort) is adequate for diagnosis when used in conjunction with comprehensive sleep evaluation and in patients with high pre-test probability of moderate to severe OSA without co-morbid sleep disorders or medical disorders like pulmonary disease, neuromuscular disease, or congestive heart failure (**Evidence Quality A, Strong Recommendation**).

Is sleep study necessary in preoperative evaluation or can be bypassed?

The incidence of postoperative desaturation, respiratory failure, postoperative cardiac events and intensive care unit transfers is higher in patients with OSA (**Evidence Quality A, Strong Recommendation**). Portable monitoring is preferable as it reduces the likelihood of delay in surgery, inconvenience and high cost of in-laboratory PSG. Alternatively, in a case with high likelihood of OSA, sleep study may be deferred if it is not feasible or causes delay in surgery. Instead, a standby CPAP with a close monitoring may be advised. Patients with known OSA must be advised to use CPAP in the perioperative period.

What are the diagnostic criteria for OSA?

The diagnostic criteria for OSA as recommended in International Classification of Sleep Disorders, 3rd Edition, 2014 are the presence of (A and B) or C

A. Presence of one or more of the following:

- a. Complains of sleepiness, nonrestorative sleep, fatigue, or symptoms of insomnia.
- b. Waking up with breath holding, gasping, or choking.
- c. Habitual snoring, interruptions in breathing, or both during sleep as reported by patient's bed partner or other observer.
- d. Co-existing morbidities such as hypertension, type 2 diabetes mellitus, coronary artery disease, congestive heart failure,atrial fibrillation, stroke,mood disorder, or cognitive dysfunction.

B. PSG or OCST demonstrates

- a. Five or more obstructive respiratory events (apneas, hypopneas, or RERAs) per hour of sleep during a PSG or per hour of monitoring with OCST.

OR

C. PSG or OCST demonstrates

- a. Fifteen or more obstructive respiratory events (apneas, hypopneas, or RERAs) per hour of sleep during a PSG or per hour of monitoring with OSCT, even in the absence of symptoms.

OSA severity, based on the frequency of abnormal respiratory events during sleep is graded as a) mild: ≥ 5 to <15 events/hr of sleep, b) moderate: $\geq 15-30$ events/hr of sleep and c) severe: > 30 events/hr of sleep.

What is the role of MSLT and MWT in diagnosis of OSA?

MSLT is considered to be an objective measure of reported daytime sleepiness. However, MSLT is not routinely indicated in the initial evaluation, diagnosis or treatment response for OSA (**Evidence Quality A, Strong Recommendation**). It may be indicated when EDS persists despite optimal treatment with good compliance. MWT is mainly used to assess improved alertness following therapeutic intervention (**Evidence Quality D, Optional Recommendation**).

What are the various methods to prescribe PAP therapy?

Full-night PSG with attended manual CPAP titration is regarded as the gold standard for prescription of CPAP (**Evidence Quality A, Strong Recommendation**). However, split-night study, i.e., initial PSG followed by 3 hours of continuous positive airway pressure (CPAP) titration may be performed if AHI is >40 events/hr during first 2 hours or between 20-40 events/hr with clinical judgment regarding definitiveness of prescribing CPAP therapy (**Evidence Quality A, Strong Recommendation**). The process of BPAP titration in OSA management is initiated in two situations, i.e., after maximal CPAP has not resolved the respiratory events or less commonly as a primary PAP strategy (**Evidence Quality C, Recommended**). Certain autoPAP devices can be tried during attended titration with PSG (**Evidence Quality B, Recommended**) or in an unattended way to determine a fixed PAP level in patients with moderate to severe OSA without significant co-morbid illness such as CHF, COPD, central sleep apnea or hypoventilation syndromes (**Evidence Quality B, Recommended**).

1.4 Medical management of OSA**What is the role of behavioural therapy in OSA?**

The following measures have shown modest improvement in OSA and should be considered as adjuncts to PAP therapy:

Smoking cessation (**Evidence Quality B, Strong Recommendation**)

Avoidance of alcohol, sedatives and nicotine (**Evidence Quality D, Optional Recommendation**)

Treatment of nasal obstruction (**Evidence Quality B, Strong Recommendation**)

Weight loss (**Evidence Quality B, Strong Recommendation**)

Positional therapy during sleep (**Evidence Quality C, Recommended**)

Sleep hygiene, avoidance of sleep deprivation (**Evidence Quality D, Optional Recommendation**)

What is the role of pharmacotherapy in OSA?

There is no role of pharmacotherapy in OSA, however, modafinil and armodafinil are the only agents approved for EDS despite adequate PAP therapy (**Evidence Quality A, Strong Recommendation**). Intranasal fluticasone may result in mild improvement in AHI in OSA patients with rhinitis (**Evidence Quality C, Optional Recommendation**).

What is PAP therapy and what is its role in OSA?

PAP therapy is the mainstay of treatment of OSA, however, patient compliance is a major issue. Therefore, proper patient counselling is necessary to ensure adequate compliance. PAP creates a pneumatic splint in the upper airway which prevents collapse of the pharyngeal airway, acting at all potential levels of obstruction. PAP therapy improves quality of life in terms of significant reduction in daytime sleepiness, improvement in quality of life, driving performance, neuro-cognitive performance and cardiovascular outcomes including overall mortality (**Evidence Quality A**).

What are the indications for PAP therapy?

PAP is indicated based on PSG results showing: (**Evidence Quality A, Strong Recommendation**)

1. AHI or RDI ≥ 15 events/hour

Or

2. AHI or RDI ≥ 5 but < 15 events/hour with any one of the following symptoms:
 - Excessive daytime sleepiness
 - Neurocognitive impairment
 - Hypertension
 - Coronary artery disease
 - Cardiac arrhythmias
 - Pulmonary hypertension
 - History of stroke

Are there other versions of PAP therapy other than CPAP, and what are their roles?

PAP can also be given as Bi-level PAP (BPAP) or Auto titrating PAP (APAP). BPAP is considered better in OSA with OHS (**Evidence quality D, Optional Recommendation**). APAP adjusts PAP level based on patient's variable needs and hence, at least theoretically, enhances tolerability and compliance. Data on its added usefulness in OSA patients with co-morbid illnesses are lacking, but it is a promising modality for near future. Other modalities are still investigational.

Is there any role of oral appliances in OSA?

Yes, OAs are indicated for use in patients with mild to moderate OSA who prefer oral appliances to CPAP, or who do not respond to CPAP or who fail treatment attempts with CPAP or behavioural measures (**Evidence Quality B, Recommended**). Two types of oral appliances are available- mandibular repositioning appliance (MRA) and tongue retaining appliances (TRA). These have defined indications and contra-indications with modest efficacy.

1.5 Surgical treatment of OSA

Who should undergo surgical treatment for OSA?

Surgical treatment is recommended in patients who have failed or are intolerant to PAP therapy. Patients with BMI $\geq 35\text{kg/m}^2$ should undergo bariatric surgery rather than site directed surgery (**Evidence Quality B, Recommended**).

How is the level of obstruction evaluated preoperatively?

Of the various methods available, fibre-optic nasopharyngoscopy with Müller's manoeuvre (FNMM) is found to predict response to UPPP. Other investigations like cephalometry, acoustic analysis, somnofluoroscopy are outdated. CT and MRI do not predict level of obstruction consistently and hence are not recommended for routine use (**Evidence Quality C, Optional Recommendation**).

What is the role of nasal and nasopharyngeal surgery?

Nasal surgery (correction of anatomical defects) alone is not a useful method of treatment of moderate to severe sleep apnea (**Evidence Quality B, Not recommended**). Nasal surgery improves the compliance with PAP and also enhances its effectiveness in patients who have nasal obstruction (**Evidence Quality B, Recommended**).

When is maxillo-mandibular surgery indicated?

Maxillo-mandibular surgeries which include maxillo-mandibular advancement, genioglossus advancement, distractionosteogenesis are recommended only in the subset of patients with the specific anatomical abnormalities and intolerance to PAP therapy (**Evidence Quality C, Optional Recommendation**).

When is uvulopalatopharyngoplasty (UPPP) indicated?

It is recommended in patients with retropalatal obstruction and PAP therapy intolerance (**Evidence Quality C, Recommended**).

When is multi-level surgery done?

Multi-level surgery is done in patients who have failed PAP therapy and other conservative measures with documented multi-level obstruction (**Evidence Quality C, Optional Recommendation**).

When is bariatric surgery indicated in patients with OSA?

Bariatric surgery is indicated in patients with BMI $\geq 35\text{kg/m}^2$. Gastric bypass is the most successful procedure and gastric banding is the least effective procedure for treating OSA (**Evidence Quality B, Strongly Recommended**).

2 Epidemiology and risk factors of OSA

2.1 Introduction

Obstructive sleep apnea is a major public health problem. The International Classification of Sleep Disorders, Third Edition classifies sleep-disordered breathing into three basic categories: central sleep apnea syndrome, obstructive sleep apnea syndrome, and sleep-related hypoventilation/hypoxic syndrome.^{1,2} Community-based epidemiological studies from several parts of India have estimated that the prevalence of OSAS is 2.4% to 4.96% in men and 1% to 2% in women. This is similar to the prevalence of OSAS in the rest of the world where it has been reported to be 4% in men and 2% in women (Table 2-1). The majority of general public and primary care physicians are still unaware of OSA. In a study done in USA, nearly 93% of women and 82% of men with moderate severe OSAS are never diagnosed.¹²

In OSA, repetitive collapse of the upper airway occurs that leads to snoring, frequent episodes of sleep interruption, hypoxemia, hypercapnia, swings in intrathoracic pressure and increased sympathetic activity. Management of OSA needs a long-term multi-disciplinary approach. Once diagnosed, the patient should actively participate in treatment decisions and should be properly counselled to manage his or her illness including co-morbidities.

2.2 Definitions

2.2.1 Apnea

Apnea is defined as cessation of breathing or airflow for 10 seconds or longer in a PSG study.¹³

Apnea is of three types:

1. **Obstructive apnea:** There is no airflow at nose or mouth but there are persistent respiratory efforts.
2. **Centralapnea:** There is no airflow at nose or mouth as well as no respiratory effort.
3. **Mixedapnea:** It is a mixture of central and obstructive apneafeatures.

2.2.2 Apnea-hypopnea index (AHI)

AHI is calculated as number of apneas and hypopneas per hour of sleep.

2.2.3 Respiratory disturbance index (RDI)

RDI is the number of apneas, hypopneas and respiratory effort related arousals (RERAs) per hour of sleep, confirmed by EEG.

Apnea-hypopnea index and respiratory disturbance index are indices of sleep-disordered breathing and can be used in full PSG. In limited sleep studies (which does not include EEG), RDI or REI is defined as the number of apneasandhypopneas per hour of sleep recorded (time in bed). In a normal adult, AHI is less than 5 events/hr. OSA is diagnosed when AHI is ≥ 5 events per hour during sleep with sleep related symptoms or comorbidities and OSAS requires AHI/RDI ≥ 5 events per hour during sleep along with excessive daytime sleepiness. The severity of OSA is graded as mild (AHI ≥ 5 to <15 events per hour sleep), moderate (AHI ≥ 15 to ≤ 30 events per hour sleep) and severe OSA (AHI >30 events per hour sleep).

2.2.4 Cheyne-Stokes Breathing

Cheyne-Stokes breathing¹³ refers to the occurrence of at least three consecutive cyclical crescendo and decrescendo changes in breathing amplitude and at least one of the following:

1. Five or more central apneas or hypopneas per hour of sleep
2. Each cycle should last for at least 10 minutes

2.2.5 Complex Sleep Apnea

Complex sleep apnea¹³ is persistence or emergence of central apneas or hypopneas (with central apnea index of ≥ 5) after obstructive events have disappeared with administration of continuous positive airway pressure or spontaneous mode bi-level positive airway pressure.

2.2.6 Hypopnea

A hypopnea¹³ is defined by the presence of

1. A clear decrease in the amplitude of airflow (quantitative or semi-quantitative) of $>30\%$ from baseline during sleep

Or

A clear amplitude reduction of a valid measure of breathing during sleep that does not reach the above criterion, but is associated with either an oxygen desaturation of $>3\%$ or an arousal

And

2. The event lasts 10 seconds or longer.

2.2.7 Obesity hypoventilation syndrome (Pickwickian syndrome)

Obesity-hypoventilation syndrome (OHS) consists of obesity, sleep-disordered breathing, hypoxia and chronic hypercapnia during wakefulness in the absence of other known causes of hypercapnia. Historically, OHS was first described as “Pickwickian syndrome” in a case report in 1956. This patient resembled a character depicted by Charles Dickens in “The Posthumous Papers of the Pickwick Club” as he was obese and had hypersomnolence.¹⁴

2.2.8 Overlap syndrome

The co-occurrence of both COPD and OSA in the same individual is termed as overlap syndrome. Both are common diseases affecting adult population over 40 years of age.¹⁵

2.2.9 Polysomnography

PSG is a comprehensive in-laboratory overnight recording of different bio-physiological changes that occur during sleep.

2.2.10 Respiratory effort related arousal

A RERA is defined as an arousal from sleep that follows a 10 second or longer sequence of breaths that are characterized by increasing respiratory effort, but which does not meet criteria for an apnea or hypopnea.¹³ Snoring is usually but not always associated with this condition. Esophageal pressure monitoring is used to measure respiratory effort; the pattern is of increasing negative pressure, terminated by a sudden change to a less negative pressure and a cortical arousal. Nasal pressure signal is a useful alternative to esophageal pressure monitoring which allows RERAs to be detected non-invasively.

2.2.11 Upper airway resistance syndrome

UARS is a condition in which patients have symptoms suggestive of OSA and frequent RERAs but AHI <5 events/hr.

2.3 Risk Factors

Several risk factors (Table 2-2) are associated with the development of OSA.¹⁶⁻¹⁸

2.3.1 Genetic predisposition and familial aggregation

The genetic factors influence the anatomical factors (craniofacial structure, upper airway soft tissues, body fat distribution).¹⁹ As obesity is closely associated with OSA, these genetic factors influencing obesity have also been thought to influence the familial clustering of OSA.²⁰

2.3.2 Age

The prevalence of OSA increases with age. This increasing trend is evident till the age of 65 years and tends to plateau thereafter. Compared with middle-aged persons (30-40 years), a 2- to 3-fold higher prevalence of OSA has been observed in older persons.^{16,21} It has been suggested that with aging there is a preferential deposition of fat around the pharynx that is independent of systemic fat and deterioration of genioglossus negative pressure reflex which is largely responsible for this trend.^{16,22}

2.3.3 Gender

The prevalence of OSA has been found to be consistently higher in men compared with women (**Evidence Quality B**). While earlier epidemiological studies showed that OSA was 8 to 10 times more common in men than in women, population-based studies have found that men were only two to three times more likely to have OSA than women. In the Wisconsin Sleep Cohort study²³ 24% of men and 9% of women had an AHI more than 5; 9% of men and 4% of women had an AHI more than 15; and 4% of men and 2% of women had OSAS. Data from the Sleep Heart Health Study have shown that male gender is an independent risk factor for OSA and has been found to increase the risk for moderate-to-severe OSA by nearly 1.6 times.²⁴ At all ages, women have been found to have less severe OSA when compared with age-matched men; this trend is more evident in premenopausal women.

Pregnancy increases the risk of snoring and OSA which is reversible after delivery (**Evidence Quality C**).¹⁶⁻¹⁸ Transition to menopause has been observed to increase the risk for OSA (**Evidence Quality C**). In the Wisconsin Sleep Cohort Study, the risk of having an AHI of 15 or more was more in women (OR=3.5) after menopause, independent of multiple other known confounding factors.²⁵

2.3.4 Obesity

Obesity is an important risk factor for the development of OSA (**Evidence Quality A**). In a subset of Wisconsin Cohort, in persons initially unaffected by OSA, a 10% increase in weight was found to be associated with a 6-fold greater risk of developing OSA whereas 10 % weight loss predicted a 26 % decrease in AHI.²⁶ It has also been shown that even modest reduction in weight leads to significant improvement in OSA severity.²⁷ However, OSA has not been found to be closely associated with obesity in the elderly population. Several mechanisms have been postulated to explain how obesity increases the risk of OSA. These include deposition of fat around the pharyngeal airway resulting in its increased collapsibility; abdominal fat deposition leading to reductions in lung volume and functional residual capacity which results in decreased caudal traction thereby leading to an increase in pharyngeal collapsibility.¹⁶⁻¹⁸ Functional impairment of upper airway muscles, diminished oxygen reserve due to lower lung volumes contributing to ventilator control instability have also been postulated as likely mechanisms increasing the risk of OSA.¹⁶⁻¹⁸

2.3.5 Craniofacial abnormalities

Craniofacial abnormalities may alter the mechanical properties of the upper airway thereby increasing the risk of OSA (**Evidence Quality B**). These abnormalities have been thought to be responsible for the variations observed in the risk of development of OSA in different races and ethnic groups, especially Asians.¹⁶⁻¹⁸ These include conditions, such as Pierre-Robin, Treacher-Collins syndromes; tonsillar and adenoid hypertrophy usually in children, macroglossia, retrognathia, repositioned maxilla and inferior displacement of the hyoid bone (**Evidence Quality B**).

2.3.6 Tobacco smoking

Tobacco smoking is associated with an increased prevalence of snoring and OSA (**Evidence Quality C**).^{28,29} In Wisconsin Sleep Cohort Study, current smokers as compared to never-smokers had a greater risk of moderate or severe degree of OSA.³⁰ Tobacco smoke induced airway inflammation and damage is thought to alter the structural and functional properties of the upper airway resulting in an increased risk of collapsibility during sleep; interference with sleep stability by tobacco smoking has also been postulated as a possible cause.¹⁶⁻¹⁸

2.3.7 Alcohol consumption

Alcohol results in relaxation of upper airway dilator muscles leading to increase in the upper airway resistance and may lead to the development of OSA. It also prolongs apnea duration, suppresses arousals, increases frequency of occlusive episodes and worsens the severity of hypoxemia (**Evidence Quality C**).³¹

2.3.8 Other risk factors

Other risk factors are hypothyroidism and acromegaly, which cause an increase in soft tissue size in the upper airway and affect respiratory control; use of drugs like benzodiazepines, muscle relaxants and testosterone therapy (**Evidence Quality C**).¹⁶⁻¹⁸

2.4 Pathogenesis

Multiple factors are responsible for pathogenesis of OSA with inter-individual variation. OSA patients have repeated narrowing or obstruction of pharyngeal airway during sleep. Eckert and Malhotrasuggest that pathophysiological mechanisms, such as increased anatomic compromise, increased pharyngeal dilator muscle dysfunction, lowered arousal threshold, increased ventilatory control instability, and/or reduced lung volume tethering as the pathophysiological mechanisms linking these risk factors and OSA.³²

Table 2-1: Prevalence of Obstructive Sleep Apnea Syndrome in India and Other Countries

S.No	Author (Reference)	Year	Sample Size	Country	Study base/location	Prevalence rate %
1	Gislason et al ³	1988	3251	Sweden	Community	1.3 [#]
2	Young et al ⁴	1993	3513	USA	Community	Males 4 Females 2
3	Huang et al ⁵	2003	8081	China	Community	3.62 [*]
4	Udwadia et al ⁶	2004	658	Mumbai, India	Hospital	7.5 [#]
5	Sharma et al ⁷	2006	2150	Delhi, India	Community	Males 4.96 Females 2.03
6	Vijayan et al ⁸	2006	7975	Delhi, India	Community	Males 2.4 Females 1
7.	Suri et al ⁹	2008	200	Delhi, India	Community	Males 4.8 Females 3.8
8.	Reddy et al ¹⁰	2009	2505	Delhi, India	Community	Males 4 Females 1.5
9.	Peppard et al ¹¹	2012	1520	USA	Community	Males 14 Females 5

[#]Females not enrolled; ^{*}Gender profile not studied

Table 2-2: Risk factors for obstructive sleep apnea

Demographic characteristics
Older age
Male gender
Pregnancy
Risk factors that are linked by strong published evidence to OSA
Obesity
Central body fat distribution
Neck circumference
Anatomical abnormalities of the craniofacial region and upper airway specific syndromes (e.g., Treacher-Collins syndrome, Pierre Robbins syndrome)
Retroposed mandible/maxillae, hypertrophied tonsils, tongue
Other suspected (potential) risk factors
Genetic predisposition
Familial aggregation
Tobacco smoking
Menopause
Alcohol use
Night time nasal congestion
Endocrine abnormalities: hypothyroidism/acromegaly
Polycystic ovarian syndrome
Down's syndrome
Drugs e.g., benzodiazepines, muscle relaxants, testosterone therapy

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3 Consequences of OSA

3.1 OSA and Mortality

It has been demonstrated that OSA results in increased mortality. Severe SDB has a 3.8 fold greater risk for all-cause mortality (95% CI 1.6-9.0; p=0.004) and 5.2-fold greater risk for cardiovascular mortality (95% CI 1.4-19.2; p=0.03) than those without SDB (**Evidence Quality B**).¹ Moreover, the incidence of sudden cardiac deaths between 12:00 am to 6:00 am is significantly higher in patients with OSA than in non-OSA patients and general population (**Evidence Quality B**).² There is even worse survival for heart failure patients with untreated OSA as compared to those with mild or no sleep apnea.³

3.2 OSA and Cardiovascular Disease

3.2.1 Hypertension

OSA is an independent risk factor for systemic hypertension (**Evidence Quality A**).⁴ Several studies have shown an increased prevalence of hypertension in patients with OSA (**Evidence Quality A**).^{5,6} Multiple logistic regression analysis revealed that increase in one additional apneic event per hour of sleep enhances the odds of developing hypertension by about 1%. Similarly, the odds of developing hypertension increases by 13% with 10% decline in nocturnal oxygen saturation. With increasing severity of OSA, the chances of developing hypertension also increases even after adjusting for confounding factors.

3.2.2 Resistant Hypertension

OSA is a very important but often missed diagnosis in patients with resistant hypertension (the failure to reach goal blood pressure despite full doses of an appropriate 3-drug regimen including diuretics). Hence, all patients with resistant hypertension should be evaluated for OSA (**Evidence Quality A, Recommended**).⁷

3.2.3 Coronary Artery Disease

Epidemiological studies have shown an increased prevalence of coronary artery disease in OSA patients (**Evidence Quality B**).⁸ Factors like intermittent hypoxemia, sympathetic over-activation along with simultaneous changes in intrathoracic and cardiac pressures during sleep, implicates OSA as a potential trigger for cardiac ischemia. Studies have shown a graded increase in the risk of acute myocardial infarction with increasing AHI.⁹

3.2.4 Congestive Heart Failure

There is a high prevalence of OSA among patients with symptomatic heart failure with reduced ejection fraction (HFrEF) (**Evidence Quality B**).^{10,11} The Sleep Heart Health Study found that heart failure was more prevalent among persons with higher AHI.¹² In addition, about 15-33% of heart failure patients have central sleep apnea. OSA is also frequent among heart failure patients with a preserved ejection fraction (HFpEF).¹³

3.2.5 Arrhythmias

The Sleep Heart Health Study observed that OSA was independently associated with a high frequency of nocturnal arrhythmias such as atrial fibrillation, complex ventricular ectopy, and non-sustained ventricular tachycardia. **(Evidence Quality B)**.¹⁴ Interestingly, the prevalence of OSA was also significantly higher in patients with AF.¹⁵

3.2.6 Cerebrovascular disease

OSA is associated with increased risk of stroke.¹⁶ In fact, OSA may increase the risk of death in patients with stroke. Patients with recurrent strokes had a higher percentage of OSA (AHI > 10) than initial strokes (74% compared to 57% $p = 0.013$) **(Evidence Quality B)**.¹⁷ A meta-analysis of 17 prospective cohort studies on cardiovascular deaths concluded that moderate to severe OSA significantly increases the risk of stroke.**(Evidence Quality B)**.¹⁸

3.2.7 Diabetes Mellitus

Studies have shown that the prevalence of OSA in diabetic (78%) and pre-diabetic (67%) obese patients is higher than those with normal glucose tolerance (33%).¹⁹ Moreover, the risk of developing type 2 DM increases with the severity of OSA**(Evidence Quality B)**.²⁰ Studies have also documented that frequent snoring is associated with reduced glucose tolerance.²¹ A recent study also supports the fact that PAP therapy in combination with weight loss, reduces the insulin resistance than PAP therapy alone.²²

3.2.8 Dyslipidemia

It has been observed that OSA is independently associated with increased total cholesterol and LDL cholesterol levels, and carotid intima-media thickness irrespective of the cardiovascular co morbidity. RCTs have shown that PAP therapy may produce a clinically relevant fall in total cholesterol level, potentially reducing cardiovascular risk **(Evidence Quality A)**.^{23,24}

3.2.9 Metabolic Syndrome

The metabolic syndrome consists of a constellation of abnormalities, namely, central obesity, hypertriglyceridemia, low HDL cholesterol, hyperglycemia, and hypertension. OSAS has been shown to be strongly and independently associated with metabolic syndrome.^{25,26} The combination of OSA and metabolic syndrome is called Syndrome Z. The prevalence of metabolic syndrome varies from 74 to 85% among patients with OSA as compared to 37 to 41% among patients with no OSA. Similar prevalence has also been reported from India in an urban community based study**(Evidence Quality C)**.²⁷

3.3 OSA and Neurocognitive Function

Slow thought process, early forgetfulness, impaired concentration and decreased work related performance have been observed in OSA and have been attributed to sleep fragmentation and intermittent hypoxia during

apneic episodes (**Evidence Quality C**).²⁸⁻³⁰ Multiple meta-analyses have shown that impairment in verbal episodic memory (immediate and delayed recall, learning, and recognition), visuo-spatial episodic memory, attention span, driving ability, vigilance, executive function, have been associated with OSA (**Evidence Quality B**).^{31,32}

3.4 OSA and excessive daytime sleepiness

OSA has been found to be an important cause of insomnia due to sleep fragmentation at night and excessive daytime sleepiness.³³ Most patients with objective EDS preferred terms ‘fatigue’, ‘tiredness’ and ‘lack of energy’ much more frequently as compared to ‘sleepiness’ as the primary daytime complaint (**Evidence Quality C**).³⁴ In the landmark Wisconsin Sleep Cohort Study, patients with OSA were found to have a higher prevalence of EDS and tiredness after awakening in spite of adequate night-time sleep as compared to those without OSA.³⁵ It was also found that progressive increase in the ESS score was observed with increasing AHI (**Evidence Quality B**).³⁶ Excessive daytime sleepiness in OSA has been associated with increased risk of motor vehicle accidents.³⁷ (**Evidence Quality B**).

3.5 OSA & Psychiatric disorders

There is high prevalence of depression in patients with OSA, more in females (**Evidence Quality C**).³⁸ A population based study³⁹ on SDB found that depression scores increase with increasing severity of SDB. OSA is also associated with various other psychiatric disorders like bipolar disorder, schizophrenia, delirium, anxiety and erectile dysfunction (**Evidence Quality C**).⁴⁰⁻⁴⁴ Hence all patients with these disorders especially erectile dysfunction (**Evidence Quality B: Recommendation**)⁴⁵ should be screened for OSA.

3.5 OSA and quality of life

Studies have shown impaired quality of life in OSA with correlation of arousal index with physical function, general health and physical role which improves with PAP therapy (**Evidence Quality B**).⁴⁶⁻⁴⁸

3.6 OSA and economic impact

Potential costs attributable to OSA include the costs of diagnosis and treatment, the decrement in quality of life, the medical consequences, motor vehicle accidents, and occupational losses (**Evidence Quality B**).^{49,50} OSA may lead to increase in occupational injuries due to neuro-cognitive impairment leading to an increase in healthcare utilization and costs. However, there are no studies which estimated the costs of occupational injuries due to OSA. Moreover, OSA is associated with increased healthcare utilization even prior to diagnosis (**Evidence Quality B**).⁵¹

3.7 Cost effectiveness of OSA management

Studies have evaluated the cost-effectiveness of in-lab full-night PSG, split-night polysomnography and home-based sleep studies in the management of OSA. The home-studies were found to be economically better but not as cost-effective as split-night PSG and full-night PSG. Similarly, even though split-night study was cheaper, it

was not as cost-effective as a full-night study (**Evidence Quality B**).⁵²PAP therapy is cost-effective as compared to dental devices and other conservative measures in patients with moderate to severe OSAS (**Evidence Quality B**).⁵³The cost estimates for PAP therapy in moderate to severe OSA ranges from \$2,000-11,000 per quality-adjusted life year over 5 years.⁵⁴ In a western setting, these estimates are comparable to other interventions such as the use of anti-hypertensive medicines in hypertension. In India, besides reimbursement in the selected public sector, cost of diagnosis and treatment is out of reach for most patients.

Cost-effectiveness analysis studies have demonstrated the value of PAP therapy as a public health measure in the western populations.⁵⁵But studies regarding the same in India is lacking. This is an important area of research for future studies in this field.

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4 Diagnosis of OSA

4.1 History and Physical Examination

The diagnosis of OSA requires a high index of suspicion. OSA may be suspected during routine health check-up or while evaluating high-risk patients.¹ The chances of under-diagnosis are minimized if during routine health check-up individuals with risk factors are subjected to a comprehensive sleep evaluation. Similarly, high-risk population with congestive heart failure, extreme obesity, diabetes mellitus, coronary artery disease, stroke, nocturnal dysrhythmias including atrial fibrillation, pulmonary hypertension, preoperative patients should have comprehensive sleep evaluation (Box 4-1, 4-2, 4-3).¹ Daytime sleepiness, motor vehicular accidents, obesity and hypertension have a strong evidence (**Evidence Quality A, Strong Recommendation**) of being associated with OSA.² Whereas, congestive heart failure, diabetes, coronary artery disease, stroke, metabolic syndrome, nocturnal dysrhythmias have moderate evidence (**Evidence Quality B, Recommended**) of being associated with OSA.²⁻⁴ With increasing awareness about OSA over the last decade, self-reported snoring and EDS have increased in urban affluent population. However, there is still a need for spreading the awareness amongst the rural population and the lower strata of urban population. Nonetheless, all patients with self-reported symptoms require comprehensive sleep evaluation for nocturnal and diurnal symptoms (Box 4-1, 4-2, 4-3).¹ Additionally, medical examiners evaluating drivers, air pilots, railway drivers and heavy machinery workers should be educated about OSA and should refer them for evaluation if snoring, daytime sleepiness or obesity is noted (**Evidence Quality B, Strong Recommendation**).

In a patient suspected to have OSA, secondary causes such as hypothyroidism, facial abnormality, tonsil/adenoid hypertrophy and musculoskeletal abnormalities should be ruled out and the patient should be evaluated for consequences of OSA like metabolic syndrome, diabetes mellitus, hypertension, CAD, stroke and gastroesophageal reflux.^{1,2,5} Patient should also be investigated for associated co-morbid illnesses like allergic rhinosinusitis, nasal polyps, asthma, COPD, obesity hypoventilation syndrome and kyphoscoliosis.^{1,5} The clinical examination should include detailed anthropometry including measurement of neck circumference, BMI, modified Mallampati score (Box 4-2) and a comprehensive upper airway assessment.¹ Box 4-3 lists various clinical features of OSA.

4.2 Other Diagnostic Investigations

Anthropometric measurements, nasal and upper airway examination, orthodontic assessments and radiological measurements have low sensitivity and specificity when used alone for diagnosis of OSA.⁵ Patients suspected to have OSA should be referred for an appropriate type of sleep study after detailed history, examination and basic investigations. Various questionnaires for the prediction of OSA are available and can be used prior to sleep study, but the same is not mandatory.

Box 4-1: Nocturnal and diurnal symptoms of OSAS

Nocturnal symptoms

Snoring: Is it loud? Is it audible in the other room? Is it crescendo-decrescendo in nature? Does he/she wake up with one’s own snoring?

Witnessed apnea: Has the partner witnessed apneas or sudden interruption in the loud snoring sound?

Nocturnal choking: Does he/she wake up with a gasping or choking sensation?

Nocturia: How many times does he/she wake up due to nocturia?

Sleep quality: Is the sleep disturbed with tossing and turning? Is there frequent sleep fragmentation and difficulty in maintaining sleep leading to insomnia? What is the total amount of sleep? Is there a feeling of un-refreshing sleep or early morning headache or dryness of throat?

Daytime symptoms

Excessive daytime sleepiness: Does the patient feel sleepy during quiet activities like reading, watching television or during activities that generally require alertness like school, work, driving.

Lethargy: Does he/she have daytime fatigue/tiredness, decreased alertness?

Cognitive deficits: History of memory loss, poor concentration and intellectual impairment

Psychiatric symptoms: Personality and mood changes, depression, anxiety, sexual dysfunction like impotence and decreased libido

Systemic complaints: Gastroesophageal reflux, hypertension, diabetes

*In patients with nocturia, UTI and BPH (in males) should be ruled out

UTI: urinary tract infection; BPH: benign prostatic hyperplasia

Box 4-2: Modified Mallampati scoring

Class 1: Tonsils, uvula and soft palate are fully visible

Class 2: Hard and soft palate and only upper portion of uvula and tonsil are visible

Class 3: Soft and hard palate and only base of uvula visible

Class 4: Only hard palate visible

Box 4-3: Clinical examination finding suggestive of OSAS

Neck circumference >16 inches (40.6 cm) in women and > 17 inches (43.2 cm) in men

Body mass index $\geq 30 \text{ kg/m}^2$

Modified Mallampati score 3 or 4

Upper airway evaluation showing retrognathia, high arched palate, macroglossia, tonsillar hypertrophy, enlarged uvula, nasal abnormality

4.3 Epworth Sleepiness Scale

Epworth Sleepiness Scale is a commonly used assessment tool for OSA. It is a simple, self-administered measurement of sleep propensity during daytime in adults that requires the subject to rate the probability of dozing off in eight different situations that are met in day-to-day life on a scale of 0-3.⁶ Thus, the sum of the score can vary from 0 to 24. ESS is a subjective test that focuses solely on excessive daytime sleepiness and does not score other signs and symptoms of OSA. Multiple studies have shown good correlation of ESS with the level of sleepiness and sleep latency as measured by objective tests such as MSLT, however, its utility to predict OSA is limited. ESS score >10 is defined as excessive daytime sleepiness and has a sensitivity of 49 % and specificity of 80% for predicting OSA.⁷ Thus, ESS can be used as a tool to measure the quality of life with regards to EDS, likelihood of long-term compliance to CPAP and to evaluate the treatment response rather than to only screen for OSA (**Evidence Quality C, Recommended**).⁵

4.4 Clinical prediction rules for OSA

Various algorithms have been devised for screening and risk stratification of patients suspected to have OSA. These tools are usually based on variables that are easily obtained through clinical interview and examination (including anthropometric measurements), items collected from questionnaires and nighttime observation. The strength of evidence for use of these prediction rules is low. Further, the utility of these tools to estimate the clinical severity of OSA and to suggest the likelihood of OSA related consequences have not been studied systematically.⁷

The various screening tools or pre-test probability questionnaires devised to detect the risk of OSA are STOP questionnaire, STOP-Bang questionnaire, Berlin questionnaire, modified Berlin questionnaire, Hawaii Sleep Questionnaire, SACS, ASA checklist and P-SAP. The comparison between these questionnaires is provided in Table 4-1.

Both STOP questionnaire which includes **S**noring, **T**iredness during daytime, **O**bservedapnea, and high blood **P**ressure and the STOP-Bang questionnaire which includes STOP with **B**ody mass index, **A**ge, **N**eck circumference and **G**ender (male) are relatively easy to administer. STOP is considered positive when two or more answers are yes and STOP-Bang is positive when three or more answers are yes.⁸

Berlin Questionnaire has three categories of questions. Category 1 questions are about snoring with 5 questions and 2 to 5 multiple choice answers. Category 2 includes excessive daytime sleepiness with 4 or more multiple choice answers. Category 3 has body mass index and blood pressure. The questionnaire is positive if two of the categories are positive.⁹ The Berlin questionnaire was modified at AIIMS, New Delhi in 2006 for application in the setting of developing countries.¹⁰ Both Berlin questionnaire and modified Berlin questionnaire are moderately accurate (sensitivity and specificity generally <90%) in screening for OSA^{7,10} (**Evidence Quality C; Recommended**). Hawaii questionnaire includes questions not only about nocturnal choking, loud snoring and history of adenotonsillectomy but also on age, gender, height, weight, and sleep history.¹⁰ ASA checklist developed for preoperative evaluation has a lower specificity than the Berlin and STOP questionnaires and contains many more variables.¹¹ P-SAP and SACS, also devised for preoperative evaluation, have better sensitivity and specificity.¹⁰

Although, these questionnaires have not been adequately studied, they can be used to screen the patients for OSA. STOP-Bang questionnaire (**Evidence Quality C, Recommended**) is the most appropriate questionnaire for the screening in preoperative cases.¹⁰ The STOP-Bang questionnaire may also be used for pre-test probability assessment before PM because of ease of administration and high sensitivity and specificity.

4.5 Types of Sleep Study

The diagnosis and severity of OSA must be ascertained before initiating the treatment of OSA. The standard diagnostic test for OSA is an attended in-laboratory PSG or PM.¹ PSG is supervised by a trained technician with at least seven channels whereas, PM is performed without a technician and has fewer channels. AASM has categorized sleep studies into type 1, 2, 3, and 4.¹² The details about various types of studies are described in Figure 4-1.¹² In-laboratory PSG with EEG-based sleep staging, the “gold standard” for the diagnosis of OSA is not necessary in all patients suspected to have OSA.⁵ Portable monitoring with type 3 and 4 (which at least include airflow, saturation and respiratory effort) in conjunction with comprehensive sleep evaluation is adequate for diagnosis of OSA in patients with high pre-test probability of moderate to severe OSA without comorbid sleep or medical disorders such as neuromuscular disease, pulmonary disease, or congestive heart failure (**Evidence Quality A, Strong Recommendation**).¹³ PSG is mainly useful for patients with symptoms of excessive daytime sleepiness but no objective evidence of obstructive sleep apnea on PM.³ The indications for PSG and PM with type 3 and 4 monitoring devices are summarized in Box 4-4. Table 4-2 provides comparison between PSG and PM.

Box 4-4: Indications of PM and PSG

Indications for PM

Patients with high pre-test probability of moderate to severe OSA

Patients for whom in-laboratory PSG is not possible by virtue of immobility, safety, or critical illness

To monitor response to non-PAP treatments for OSA including oral appliances, upper airway surgery, and weight loss

Indications for PSG

Patients with significant co-morbid medical conditions (moderate to severe pulmonary disease, neuromuscular disease, congestive heart failure)

Patients with EDS where PM is negative

Patients suspected to have other sleep disorders

Screening of asymptomatic high risk populations with heart failure, morbid obesity, diabetes, coronary artery disease, stroke, refractory hypertension, nocturnal dysrhythmias and atrial fibrillation

PM: Portable monitoring; PSG: Polysomnography; OSA: Obstructive sleep apnea; PAP: positive airway pressure; EDS= Excessive daytime sleepiness;

4.5.1 Attended In-Laboratory Polysomnography- Type I Sleep Study

Type 1 study or in-laboratory, technician-attended, overnight PSG is the present reference or “gold” standard for evaluation of sleep and sleep-disordered breathing (**Evidence Quality A, Strong Recommendation**).¹⁴ The recommended parameters to be evaluated in PSG include sleep state and stages, ventilatory parameters, cardiac function and limb movements.¹⁵ Sleep state, i.e., awake, asleep or arousal and sleep stages, i.e., rapid eye movement (REM) or non-rapid eye movement (NREM-N1, N2, N3) sleep are ascertained by EEG, EOG and chin EMG.¹⁵ The ventilatory parameters are measured by flow, effort and oxygen saturation. The cardiac function evaluation is limited to modified lead II electrode placement. The body limb movements are measured as EMG activity of the anterior muscle group of the lower legs. Thus, PSG records EEG, ECG, chin and leg EMG, nasal and oral airflow, chest and abdominal efforts and pulse oximetry.¹⁴ The study requires the constant presence of a trained individual with appropriate sleep-related training who can monitor patient compliance, technical adequacy and relevant patient behaviour (**Evidence Quality B, Recommended**).¹ It is advisable to take prior informed consent for PSG. The sleep study should be standardised as per the manual of American Academy of Sleep Medicine with regard to parameters, setting, filters, technical specifications, sleep stage scoring, event scoring and every sleep study should be reviewed and interpreted by a qualified physician.¹⁶ Full-night PSG is recommended for the diagnosis of OSA (**Evidence Quality A, Strong Recommendation**).

4.5.2 Unattended Polysomnography- Type 2 Sleep Study

Type 2 devices can record the same variables as type 1 study in absence of a technician. Thus, type 2 sleep monitoring can be practically used as portable monitors, but is not used frequently in the outpatient setting.¹² Type 2 study may identify AHI suggestive of OSA with high positive likelihood ratio and low negative likelihood ratio, though, differences in AHI have been encountered between type 2 study and PSG.^{7,17,18} The exact cause of the difference has not been well established as there are only seven studies in literature which have compared type 1 and 2 devices, but is thought to be due to differences in the devices or differences in recording conditions (home versus laboratory).^{7,17,18} Thus, the strength of evidence is moderate for the diagnosis of OSA with type 2 monitoring devices (**Evidence Quality B, Recommended**).

4.5.3 Portable Monitoring/Out Of Centre Sleep Testing (OCST) /Home Sleep Testing (HST)/Unattended Limited Channel Testing (ULCT) (Type 3 & 4 Sleep Study)

Portable monitoring or OSCT as a diagnostic test for OSA has evolved as an alternative to PSG¹ due to convenience and lower cost. The disadvantage of PM or OSCT, however, is that AHI may be falsely low.^{7,19} This is because in the absence of EEG recording in these tests, actual sleep time cannot be determined and the denominator is the total recording time instead of the total sleep time.¹ Further, RERAs and hypopneas cannot be scored by OCSTs as detection of arousal requires EEG recording, which is often not done in OCSTs. The term respiratory event index (REI), based on monitoring time rather than sleep time, can be used instead of RDI. The recording time versus sleep time difference, however, is usually not very significant as OSA patients fall off to sleep easily.⁵ But, because of the possibility of error in calculation of AHI, in patients with high pre-test probability, if PM is negative, a repeat PSG may be performed.¹ The differences between PSG and PM are given in table 4-2. Comprehensive sleep evaluation should always be done prior to PM studies.¹

To minimize the risk of error and technical failure, limited sleep studies should be performed after adequate instruction from sleep technicians or a written instruction sheet may be provided (**Evidence Quality B, Recommended**).⁵

The diagnosis and severity assessment should be performed using the same definitions as used for PSG. PM should be performed only in conjunction with comprehensive sleep evaluation and in the presence of a practitioner eligible for conducting sleep studies (**Evidence Quality B, Recommended**).¹³

4.5.3.1 Type 3 Sleep Study

Type 3 sleep study, also known as cardio-respiratory monitoring, requires measurement of at least four physiological variables, which include two respiratory variables (respiratory movement and airflow), a cardiac variable (heart rate or an electrocardiogram) and arterial oxyhemoglobin saturation using pulse oximetry.^{13,14} The airflow should be measured by both oronasal thermal sensor for apnea and nasal pressure transducer for hypopnea.¹⁴ Some devices have additional sensors for detecting snoring, body position, or movement. In general, type 3 monitoring devices accurately diagnose OSA and also predict the severity of OSA with high positive likelihood ratio and low negative likelihood ratio, however, there is a wide and variable bias in estimating the actual AHI.^{7,19} Various studies have been performed to recognize the feasibility of combination of portable monitoring with autoPAP titration for prescription of CPAP pressure.²⁰⁻²³ Studies have found no difference in the final CPAP level, CPAP adherence, degree of residual sleep apnea with CPAP therapy and subjective or objective measures of sleepiness between patients managed using PSG versus an ambulatory strategy (i.e., combination of portable monitoring with autoPAP titration for prescription of CPAP level)(**Evidence Quality B, Recommended**).²⁴ In fact, studies have found equivalent or greater satisfaction with ambulatory versus PSG-based management^{16,24}.

4.5.3.2 Type 4 Sleep study

For a PM to record an apnea or hypopnea event, it requires at least presence of flow, saturation and respiratory movement monitoring.¹ The studies using various combinations of sensors have shown wide range of sensitivities and specificities. Hence, all type 4 monitors cannot have same recommendation. Overall, type 4 monitoring performs worse than Type 3 study at AHI cut-offs of 5, 10 and 15 events/hr.¹ However, these devices have reasonable accuracy to detect moderate to severe OSA (**Evidence Quality B, Recommended**).⁷

Several newer devices with fewer channels, i.e., nasal pressure for measurement of airflow and oximetry for saturation without effort belt are commercially available and have been shown to have good diagnostic accuracy (**Evidence Quality C, Recommended**).¹⁹ Also, it has been shown recently that peripheral arterial tonometry device which utilizes PAT to monitor autonomic nervous system changes caused by respiratory disturbances during sleep is adequate for detecting arousals (**Evidence Quality B, Recommended**).¹⁹ Actigraphy by contrast is not adequate for detecting arousal.

Overall, PM (type 3 and 4) may be useful, cost-effective, convenient and speedy method of diagnosis if the patient is selected carefully.⁵ Hospital-based PSG is the investigation of choice for patients who cannot be investigated adequately at home or whose home study result does not match with the clinical suspicion of the investigating physician.⁵

4.6 Preoperative Evaluation of OSA

The incidence of postoperative desaturation, respiratory failure, postoperative cardiac events and intensive care unit transfers is higher in patients with OSA (**Evidence Quality A, Strong Recommendation**).²⁵ Both PSG and portable monitoring are helpful in diagnosing and categorizing the severity of OSA. However, portable monitoring is preferable as it reduces the likelihood of delay in the surgery, inconvenience and high cost of laboratory study. Alternatively, in a case with high risk of OSA, sleep study may be deferred if it is not feasible or causes delay in surgery. Instead, a standby positive airway pressure device with a close monitoring may be advised.²⁶ Patients who have previously been diagnosed to have OSA must be asked to use PAP preoperatively and postoperatively.

4.7 Multiple Sleep Latency Test

MSLT is a measure of time taken for a subject to fall asleep on four or five occasions in lying down position in a quiet, darkened room after full night of sleep and 1.5-3 hours of rising with a gap of 2 hours between the two nap episodes. MSLT must be performed following polysomnography recorded during the individual's major sleep period. Smoking, coffee, tea and other stimulants are prohibited prior to the study. The sleep and rapid eye movement sleep onset is measured by EEG, EOG and EMG. The test is continued for 15 minutes after the first epoch of sleep.²⁷ If sleep does not occur for 20 minutes after lights out, the nap is considered terminated and the sleep latency is scored as 20 minutes. MSLT reports should include average or mean latency to sleep and the number of sleep onset rapid-eye-movement sleep periods. Based on several studies of normal volunteers, a plausible reference range is 3.2 to 20 minutes. Patients with mild OSA usually show normal sleep latencies, whereas moderate to severe OSA usually show severely reduced sleep latencies on the MSLT.²⁸ Apart from sleep onset, sleep onset REM period (SOREMP), i.e., the first epoch of REM sleep at any time during the nap trial is also important. Two or more SOREMPs are very common in individuals with narcolepsy and has sensitivity of 78% and a specificity of 93%. However, SOREMPs do not occur exclusively in patients with narcolepsy, it may be seen in OSA and idiopathic hypersomnolence.²⁸

Thus, MSLT is considered to be an objective measure of reported daytime sleepiness (**Evidence Quality A, Strong Recommendation**). However, MSLT is not routinely indicated in the initial evaluation, diagnosis or treatment response for OSA (**Evidence Quality A, Strong Recommendation**).²⁷ It may be indicated in patients when EDS persists despite optimal treatment with good compliance. The presence of moderate to severe sleepiness may aid in the clinician's recommendations regarding the need for any behavioural or occupational changes, therapeutic intervention and follow-up assessment.²⁸

4.8 Maintenance of Wakefulness Test

A variation of the MSLT, the MWT, is performed under identical conditions (quiet, dimly lit room) as the MSLT but with the patient in semi-reclining position and an instruction to remain awake. Use of the MWT-40 minutes protocol is recommended, i.e., the trial should be terminated after a period of 40 minutes (if no sleep occurs) or after onset of unequivocal sleep.

The MWT is used less commonly than the MSLT. It is mainly used to assess improved alertness following therapeutic intervention (**Evidence Quality D, Optional Recommendation**). The MWT may be used to

measure the ability to stay awake in individuals with jobs that require high levels of alertness, especially when public safety is at stake like pilots, truck, bus and railway engine drivers.²⁷

Overall, neither MSLT nor MWT correlate well with subjective measures of sleep such as the ESS. Also, the ESS, MSLT and MWT are not well correlated with one another. For both the MSLT and the MWT, there have been no large, multicenter, prospectively collected data to establish normative values, so available data from smaller, more limited studies have been used to describe cut-off values.²⁷

4.9 Diagnostic Criteria for OSA (Box 4-5)

The diagnostic criteria for OSA²⁹ as recommended in International Classification of Sleep Disorders, 3rd Edition, 2014 are the presence of (A and B) or C

- A. Presence of one or more of the following:
 - a. Complains of sleepiness, nonrestorative sleep, fatigue, or symptoms of insomnia.
 - b. Waking up with breath holding, gasping, or choking.
 - c. Habitual snoring, interruptions in breathing, or both during sleep as reported by patient's bed partner or other observer.
 - d. Co-existing morbidities such as hypertension, type 2 diabetes mellitus, coronary artery disease, congestive heart failure, atrial fibrillation, stroke, mood disorder, or cognitive dysfunction.
- B. PSG or OCST demonstrates
 - a. Five or more obstructive respiratory events (apneas, hypopneas, or RERAs) per hour of sleep during a PSG or per hour of monitoring with OCST.

OR

- C. PSG or OCST demonstrates
 - a. Fifteen or more obstructive respiratory events (apneas, hypopneas, or RERAs) per hour of sleep during a PSG or per hour of monitoring with OSCT, even in the absence of symptoms.

OSA severity, based on the frequency of abnormal respiratory events during sleep is graded as a) mild: ≥ 5 to < 15 events/hr of sleep, b) moderate: ≥ 15 – 30 events/hr of sleep and c) severe: > 30 events/hr of sleep.¹⁶

4.10 Optimal CPAP Titration

Optimal PAP to treat OSA is the effective pressure that eliminates sleep-disordered breathing events in all sleep positions and stages, particularly REM sleep, without creating any untoward pressure-related side effects for the patient and improves sleep quality. Mask fitting is an important component of the process, both to enhance the tolerance and to minimize the leak. The concept of 'fitting the interface to the patient' is advised which is vital to enhance long-term adherence to PAP.

Titration effectiveness has been described by a grading system, detailed below.³⁰

- A. Optimal titration: AHI < 5 per hour and includes supine REM sleep.
- B. Good titration: AHI < 10 per hour or by 50% if the baseline < 15 per hour and includes supine REM.
- C. Adequate titration: AHI cannot be reduced to < 10 per hour, but is reduced by 75% from baseline or criteria for optimal or good titration is attained, but without supine REM sleep.
- D. Unacceptable titration: Any one of the above grades is not met, which requires a repeat titration.

Box 4-5: Criteria for Diagnosis of OSA²⁹

The diagnostic criteria for OSA as recommended in International Classification of Sleep Disorders, 3rd Edition, 2014 are the presence of (A and B) or C

A. Presence of one or more of the following:

- a. Complains of sleepiness, nonrestorative sleep, fatigue, or symptoms of insomnia.
- b. Waking up with breath holding, gasping, or choking.
- c. Habitual snoring, interruptions in breathing, or both during sleep as reported by patient's bed partner or other observer.
- d. Co-existing morbidities such as hypertension, type 2 diabetes mellitus, coronary artery disease, congestive heart failure, atrial fibrillation, stroke, mood disorder, or cognitive dysfunction.

B. PSG or OCST demonstrates

- a. Five or more obstructive respiratory events (apneas, hypopneas, or RERAs) per hour of sleep during a PSG or per hour of monitoring with OCST.

OR

C. PSG or OCST demonstrates

- a. Fifteen or more obstructive respiratory events (apneas, hypopneas, or RERAs) per hour of sleep during a PSG or per hour of monitoring with OSCT, even in the absence of symptoms.

4.11 Process of PAP Titration

CPAP titration is done by starting at a minimum pressure of 4 cm H₂O which is then increased by 1 cm H₂O every five minutes or more, with the target of eliminating all the events (**Evidence Quality A, Strong Recommendation**).³¹⁻³⁵ The interface is a nasal mask for most patients, with mouth breathers requiring an add-on chin-strap or conversion to a full-face mask. The events requiring up-titration include at least two obstructive apneas, three hypopneas, five RERAs or three minutes of significant snoring.³⁶ The maximum pressure of PAP suggested is 20 cm H₂O. If this pressure does not allow adequate titration, BPAP titration is recommended (**Evidence Quality C, Recommended**).^{37,38} Ideally, fifteen minutes of supine REM must be a part of the titration.

Several studies looking at the effectiveness of CPAP and BPAP have shown no difference between CPAP and BPAP in terms of improvement in AHI, daytime sleepiness, quality of sleep or comfort level. However, BPAP offers advantage in patients with concomitant central apnea or co-morbidities such as COPD, neuromuscular diseases and diseases with restrictive ventilatory defects.

The process of BPAP titration in OSA management is initiated in two situations, i.e. after maximal CPAP has not resolved the respiratory events or less commonly as a primary PAP strategy. If a patient is switched from CPAP to BPAP the EPAP is started at the maximal CPAP level. When BPAP is used primarily, the EPAP is started at 4 cm H₂O and IPAP is usually started 4 cm H₂O higher than the EPAP. The minimum IPAP-EPAP difference is kept at 4 cm H₂O while the maximum difference is 10 cm H₂O. Increase in both EPAP and IPAP is made by 1 cm H₂O with an interval no less than 5 min when ≥ 2 apnea events are recorded. Once all the apnea events are resolved, increase IPAP by 1 cm H₂O when either three or more hypopneas, five RERAs or at least 3

minutes of significant snoring is noted.³⁷⁻⁴⁰ The maximum IPAP allowed is 30 cm H₂O in adults because of reports of increased risk for barotrauma though, such pressures are uncommon in practice.^{41,42}

4.12 Split Night vs. Single Night Titration

Full-night PSG with attended manual PAP titration is regarded as the gold standard for prescription of PAP pressure (**Evidence Quality A, Strong Recommendation**). However, split-night study, i.e., initial PSG followed by 3 hrs of PAP titration may be performed if AHI is >40 events/hr during first 2 hrs or between 20-40 events/hr with clinical judgment regarding definitiveness of prescribing PAP therapy (**Evidence Quality A, Strong Recommendation**). It is recommended that the arousals should be abolished with PAP; otherwise, a repeat study with PSG is indicated for PAP titration (**Evidence Quality A, Strong Recommendation**).⁴³ AutoPAP titration is an alternative method for prescribing a fixed pressure. However, only certain autoPAP devices that monitor snoring, apnea or hypopnoea by airflow, flow contour, and/or impedance by forced oscillation technique can be tried during attended titration with PSG (**Evidence Quality B, Recommended**) or in an unattended way to determine a fixed PAP level in patients with moderate to severe OSA without significant co-morbid illness such as CHF, COPD, central sleep apnea or hypoventilation syndromes (**Evidence Quality B, Recommended**).⁴⁴ Portable monitoring with unattended autoPAP is considered to a good option in moderate to severe OSA without co-morbid illnesses.

Table 4-1: Comparison of various Questionnaires for Prediction of OSA^{7, 8, 9, 10}

	STOP Bang questionnaire	Hawaii questionnaire	Berlin questionnaire^{***}	Modified Berlin questionnaire	American Society of Anesthesiologist (ASA) Checklist	Perioperative sleep apnoea prediction score (P-SAP)
Development of screening tool	Primarily developed for preoperative evaluation as STOP, Bang being added subsequently	Developed as a sleep clinic questionnaire	Developed as screening tool for primary health care, subsequently validated for preoperative evaluation	Modified at AIIMS, New Delhi (2006) from Berlin questionnaire for the application in the setting of developing countries	Compiled list of predisposing factors and symptoms by ASA	Recently developed tool specifically for preoperative cases
Questionnaire	The following questions are given to the patients, the answers of which are in yes and no S- Snoring T- Tiredness O- Observed apnoea P- Blood pressure B- BMI > 35 kg/m ² A- >50 years N- > 40 cm	Frequency of snoring, frequency of nocturnal choking and tonsillectomy	10 questions in 3 categories. Category 1 and 2 questions are answered in 2-5 options. Category 1-Snoring and its detail Category 2- Excessive day time sleepiness Category 3-BP & BMI.	10 questions in 3 categories. Similar to Berlin questionnaire except Category 2. Question on tendency to fall asleep while driving replaced by three other relevant questions i.e., tendency to fall asleep while waiting in a line to meet doctor or watching television or waiting in a queue to pay	3 categories of questions and there are multiple questions in each category Category 1- Predisposing physical features such as BMI, neck circumference Category 2- History suggestive of airway obstruction during sleep like snoring, observed apnoea	3 demographic variables: age > 43 years, male gender, and obesity; 3 history variables: history of snoring, type 2 diabetes mellitus and hypertension; 3 airway measures: thick neck, modified Mallampati class 3 or 4, and reduced thyromental distance

G- gender, male				electricity/telephone bill	Category 3- History suggestive of excessive day time somnolence	
Score indicating high probability	≥ 3 yes	≥ 2 if history of tonsillectomy is not available, else ≥ 3	Two of the categories should be positive for classification into high-risk category	Two of the categories should be positive for classification into high-risk category	Two of the categories should be positive	The exact score not yet decided
Feasibility	Easy to remember and execute	Easy	Many variables included with complexity of permutation combination	More feasible than Berlin questionnaire as driving is not a necessity. Does not classify patients into moderate and severe OSA	Not many variables included but complex in its execution because of permutation combination	Easy to remember and execute
Sensitivity AHI cut-offs						
5	84%	59%	69- 93 %		72%	Score ≥2 95%, ≥6 22%
15	93%	78%**	54- 79 %	86%	79%	Score ≥2 97%, ≥6 26%
30	100%		17- 87 %		87%	Score ≥2 98%, ≥6 32%
Specificity AHI cut-offs						
5	56%	69%	56 -95 %	95%	38%	Score ≥2 26 %, ≥6 91%
15	43%	67%**	51-97 %		37%	Score ≥2 17%, ≥6 87%
30	37%		46-97 %		36%	Score ≥2 13%, ≥6 85%

*AHI- apnea-hypopnea index, ** The cut off available in the study was 10

*** Modified Berlin questionnaire- Simplified form of Berlin questionnaire where instead of 3 categories of questions only 7 questions with multiple choice answers are given.

Table 4-2: Comparison between Polysomnography and Unattended Limited Channel Sleep Testing

	Polysomnography	Limited sleep study
Number of channels	At least 7	At least 4
Presence of technician	Yes	No
Arousals determination	Yes	No
AHI	RERAs included in AHI and the denominator is sleep time	RERAs cannot be included and the denominator is the test time, so AHI lower than the actual test
Cost	High	About one third of PSG*
Time taken by technician	At least 8 hrs	Less than half an hour
Feasibility	Not easily available	Easily available

AHI= Apnea-hypopnea Index; RERAs = Respiratory Event Related Arousals

*Calculated cost of home study by subtracting the cost of the accommodation in the sleep centre, the attendant staff costs and equipment cost

Figure 4-1: Types of Sleep Studies

	Channel		
Neurological	EEG		
	EOG		
	EMG		
Cardio-respiratory	ECG/Heart Rate		
	Thoraco-abdominal movements		
	Airflow	TYPE-IV STUDY	TYPE-III STUDY
	Oximetry		
		TYPE-I & TYPE-II STUDIES	

Type 1: Fully attended polysomnography (≥ 7 channels) in a laboratory setting

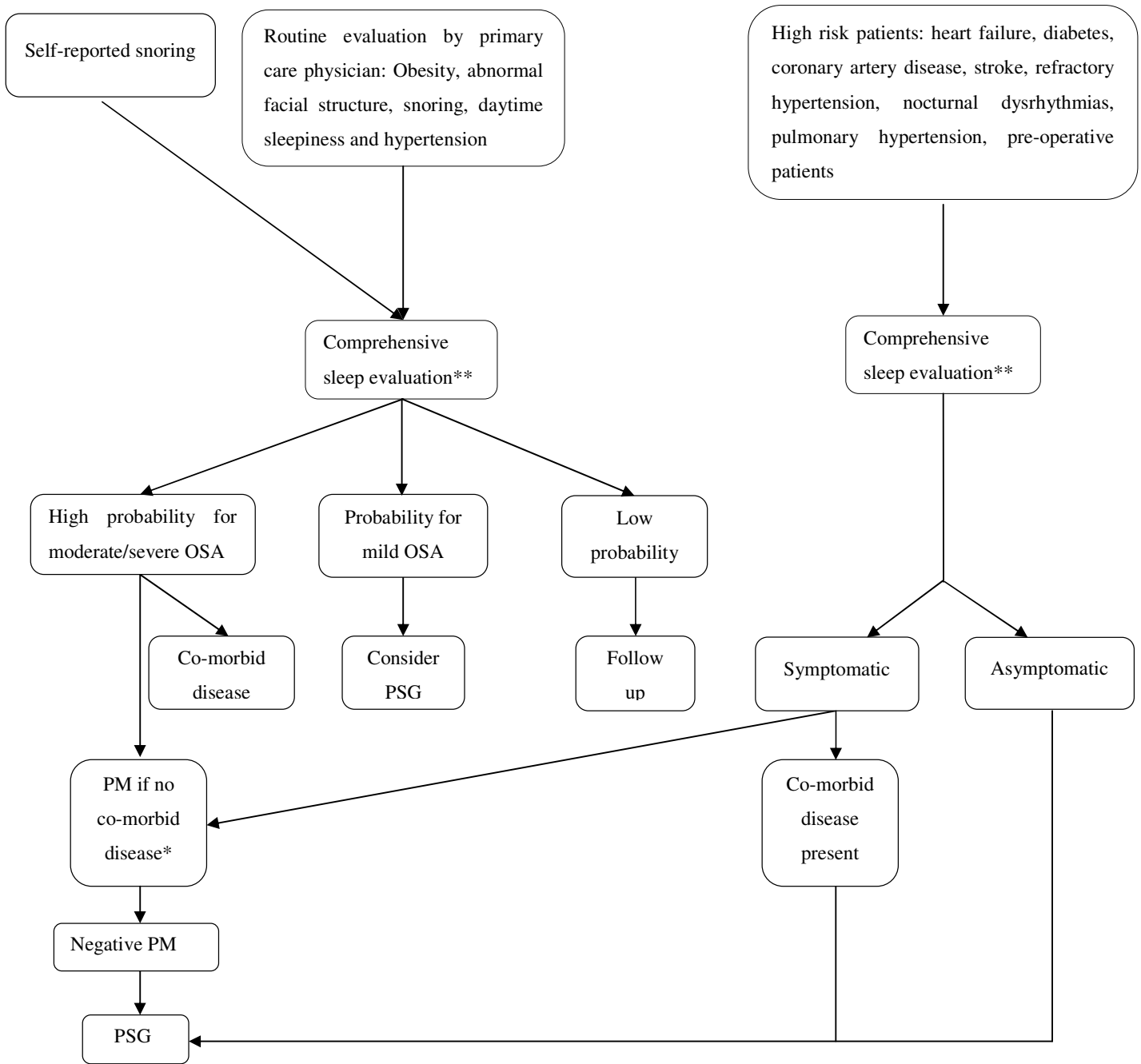
Type 2: Fully unattended polysomnography (≥ 7 channels)

Type 3: Limited channel study (usually using 4–7 channels)

Type 4: 1 or 2 channels usually using oximetry as one of the parameters

Note: A technician constantly supervises type 1 study; types 2, 3 and 4 are unattended

Figure 4-2: Algorithm for diagnosis of OSA



*Pulmonary disease, neuromuscular disease, or congestive heart failure

** Box 4-1, 4-2, 4-3

4.13 References

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5 Medical management of OSA

The medical management of OSA can be divided into the following categories:

- General measures, including pharmacotherapy
- Positive airway pressure (PAP) therapy
- Oral appliance therapy
- Recent advances

5.1 General measures, including pharmacotherapy

The treatment options, with advantages and disadvantages, should be properly discussed with patient and bed-partner. They should be fully involved in the decision-making process. As the treatment of OSA is usually long-term, patients and their bed-partners should be properly explained the implications of therapy, which can help in improving compliance. This can be done using a multidisciplinary approach, using audio-visual material as needed. Patients having mild sleep apnea generally respond best to conservative measures mentioned below. These general measures include predominantly behavioural interventions, which improve OSA and maintain overall quality of sleep (Box 5-1).

Box 5-1: General measures for treating OSA

- Counselling regarding smoking cessation
- Avoidance of alcohol, sedatives and nicotine
- Treatment of nasal obstruction in consultation with otolaryngologist
- Weight loss
- Positional therapy
- Counselling about sleep hygiene and avoidance of sleep deprivation

5.1.1 Smoking cessation

Cigarette smoke can cause upper airway inflammation. Nicotine has a stimulant effect on the upper airway muscles, and similar to alcohol, can have a rebound effect after the nicotine level falls. Smoking cessation using counselling and periodic reinforcement is recommended as a part of treatment of OSA.¹ (**Evidence Quality B, Strong Recommendation**)

5.1.2 Avoidance of alcohol and sedatives

Alcohol has muscle relaxant properties and avoidance of alcohol intake is recommended in all patients with OSA. Patients with OSA also tend to sleep poorly and are more likely to use sedatives to promote sleep which should be avoided as these are known to worsen the severity of OSA. (**Evidence Quality D, Optional Recommendation**)

5.1.3 Treatment of nasal obstruction

Nasal disorders that include nasal polyps, chronic rhinitis, turbinate hypertrophy or septal deviation increase the propensity to snore and decrease nasal airflow, impairing effective PAP therapy. Therefore, these should be detected and appropriately treated. Nasal obstruction leads to mouth breathing and will require an oro-nasal or full-face mask for PAP therapy. Topical corticosteroids like fluticasone may have an adjunctive role in OSA with concurrent rhinitis,²(**Evidence Quality C**) but topical nasal decongestants are better avoided due to lack of adequate evidence for prescription and the concerns for their short-lived action and rhinitis medicamentosa¹(**Evidence Quality D**).²

5.1.4 Weight loss

Cervical obesity favours upper airway collapsibility and is associated with general obesity. Achieving weight loss by dietary program may improve OSA(**Evidence Quality B**).³ An RCT showed decrease in AHI by an average of 23 events/hr for average 20 kg weight loss by dietary methods but with benefit largely skewed towards patients with high AHI (>30 events/hr) at baseline.⁴ Pharmacological therapy for weight loss should be discouraged. PSG may be repeated after successful weight reduction to assess if CPAP is still required, or warrants a change of CPAP (**Evidence Quality B, Strong Recommendation**). For OSA patients with BMI>35 kg/m², Bariatric surgery is indicated.

5.1.5 Positional Therapy

Sleeping position has been shown to affect the amount of snoring and OSA parameters (**Evidence Quality C**).⁶ POSA (Position-dependent OSA) is defined as a difference of 50% or more in AHI between supine and non-supine positions. Positional therapy to reduce POSA can be done by sewing tennis balls to the back of pajama tops, using a specialized thoracic anti-supine band, sleeping with a Styrofoam filled back-pack, raising the upper body to an angle of 30-60 degrees, using a posture alarm, specially designed pillowset,etc. POSA should be documented by PSG before advising positional therapy (**Evidence Quality C, Optional Recommendation**).

5.1.6 Sleep Hygiene

Box 5-2: Practices in sleep hygiene

- Spend adequate time in bed
- Reduce physical activity shortly before bedtime
- Avoid stimulants such as caffeine,theophylline in the evening
- Minimize annoying noise, light, or extremes of temperature
- Exercise regularly for at least 20 minutes, preferably 4 to 5 hours before bedtime
- Do not try harder and harder to fall asleep. If you are unable to sleep, do something

5.2 Pharmacotherapy in OSA

Several drugs have been tried in OSA in small trials and the data at present are insufficient to recommend primary drug treatment in OSA. Tricyclic antidepressant protriptyline, selective serotonin reuptake inhibitor fluoxetine and paroxetine have shown mild improvement in subjective sense of well-being in OSA patients. **(Evidence Quality C, Optional Recommendation)** Wake promoting agents -Modafinil and armodafinil are the only agents approved for EDS (Excessive Daytime Sleepiness) despite adequate PAP therapy in OSA patients⁷.
⁸**(Evidence Quality A, Strong Recommendation)**

5.3 Positive airway pressure therapy

5.3.1 Introduction

The principle of positive airway pressure in OSA is based on providing air under positive pressure through an interface (nasal or face mask), thus creating a pneumatic splint in the upper airway which prevents collapse of the pharyngeal airway, acting at all potential levels of obstruction.⁹

PAP is the most effective and widely used treatment for OSA and is the first-line therapy for moderate to severe OSA. PAP improves quality of life, in terms of clear-cut reductions in daytime sleepiness and quality of life measures. Effective PAP therapy reduces snoring and nocturnal respiratory disturbances and improves nocturnal oxygenation and sleep architecture. Benefits of PAP therapy include reduced daytime sleepiness, improved driving performance, health status and improvement in neuro-cognitive performance. Positive effects on cardiovascular outcomes, such as hypertension, cardiac arrhythmias, nocturnal ischemia, left ventricular function, and even overall mortality have been reported.

5.3.2 Indications for CPAP and BPAP

CPAP is currently the 'gold standard' for treatment of moderate to severe OSA (AHI >15), and an option for less severe OSA. Treatment of OSA is indicated with the following criteria on polysomnography: **(Evidence Quality A, Strong Recommendation)**¹⁰⁻¹⁵

1. AHI or RDI ≥ 15 events/hr
2. AHI (or RDI) ≥ 5 but < 15 events/hr with any of the following symptoms:
 - Excessive daytime sleepiness (confirmed by either a score of greater than 10 on ESS or inappropriate daytime napping (e.g. during driving, conversation, or eating) or sleepiness that interferes with daily activities on a regular basis.
 - Impaired cognition or mood disorders
 - Hypertension
 - Ischemic heart disease
 - History of stroke
 - Cardiac arrhythmias
 - Pulmonary hypertension

All these factors have to be taken into account while planning treatment of OSA.

Currently, three types of PAP devices are available for treatment of OSA: continuous PAP (CPAP), Bi-level PAP (BPAP), and automatic self-adjusting PAP (APAP). CPAP devices generate a fixed continuous pressure during inspiration and expiration. In BPAP, the pressure alternates between a fixed inspiratory and lower expiratory level during the respiratory cycle, which allows differential titration of the inspiratory (IPAP) and expiratory positive airway pressures (EPAP). In APAP, the pressure changes throughout the night in response to changes in airflow, respiratory events, and snoring.

5.3.3 Role of supplemental oxygen

The role of supplemental O₂ is after adequate CPAP/BPAP titration, for residual sleep-related hypoxemia. Specifically, O₂ supplementation is done during the PAP titration study, if the SpO₂ is <88% for ≥5 minutes in the absence of sleep-disordered breathing events, and oxygen flow rate is increased at a rate of 1 L/min every 15 minutes to target SpO₂ ≥88%. Patients on O₂ prior to PAP titration usually need a higher amount of O₂ with the PAP device due to flow related dilution of the supplied O₂. Supplemental O₂ is to be connected to the PAP device outlet and not to the mask. The possibility of a rise in CO₂ due to the supplemental O₂ is to be kept in mind, and should be monitored with an arterial blood gas next day after disconnecting the PAP device.

5.3.4 Auto-PAP¹⁶⁻¹⁹

Auto titrating PAP (APAP) is a concept based on continuously adjusting positive airway pressure to meet the patient's variable needs to maintain a patent airway, thereby reducing the overall mean airway pressure. This could be done in an unattended setting such as the patient's home, and potentially enhances tolerability and compliance.

The purpose of APAP devices included the following:

- a. Replacement of in-laboratory manual titration
- b. Reducing mean pressures for achieving better compliance with PAP
- c. Adapting PAP levels to changes in severity of OSA in response to changes in sleep state, weight and body position

APAP when used after home study (level 3 and 4) to diagnose OSA, has been shown to achieve benefits comparable to CPAP levels derived from in-lab attended polysomnography. However, it should be kept in mind that APAP is recommended only in patients without comorbid conditions, as most studies using APAP have excluded patients with significant co-morbid conditions that could cause hypoventilation, such as morbid obesity, COPD and CHF.

5.3.5 Recommendations for APAP :

1. Certain APAP devices may be useful for attended titration with PSG to identify a single pressure for use with standard CPAP (also called fixed CPAP, or f-CPAP) for management of moderate to severe OSA.
(Evidence Quality B, Optional Recommendation)
2. Patients who are being treated with APAP itself, or f-CPAP calculated on the basis of APAP titration must have close clinical follow-up to monitor treatment effectiveness. In the event of an inadequate symptomatic or objective response with APAP therapy, a standard attended CPAP titration should be done.

3. APAP devices are not recommended for split-night titration. (**Evidence Quality A, Strong Recommendation**)
4. Patients with CHF, COPD, CSA are not currently considered candidates for APAP titration or treatment. (**Evidence Quality A, Not Recommended**)

5.3.6 PAP compliance²⁰

The treatment of sleep apnea with PAP has inherent problems with initial acceptance and long-term adherence, together called compliance due to discomfort from the mask interface, positive pressure itself, need for daily night use and long-term therapy. Acceptance is defined as a patient's readiness after the diagnosis of OSA to have a PAP titration study followed by using a PAP device at home. Following acceptance of the device comes the stage of adherence to PAP therapy. This is the phase of long-term usage of the device. Compliance with PAP is a significant problem, and nasal congestion and mask intolerance are the most common complaints that reduce PAP compliance.

Assessment of PAP usage varies considerably when assessed subjectively and objectively. Objective usage and pressure data should be assessed from the PAP machine using a computer program which provides sufficient data. Objective monitoring is a standard requirement for follow-up while OSA patients are on PAP therapy.

Some patients cannot tolerate PAP because of initial discomfort of sudden application of pressure, or discomfort perceived in exhaling against high pressure. Most PAP devices have a pressure "ramp," where the pressure rise can be slow till it attains the target pressure, over as much as 45 minutes. An option for reducing expiratory pressure is BPAP, which allows independent adjustment of inspiratory and expiratory pressures, though the comfort benefits of BPAP have not been categorically demonstrated. Paradoxically, the CPAP level has not been found to be a determinant of long-term use, with no difference between higher and lower pressures.

Pressure-relief CPAP reduces the discomfort of breathing against high pressure during expiration by lowering the pressure at the onset of expiration. Recent Cochrane database review has concluded that pressure-relief CPAP did not improve compliance.²¹ Similarly, APAP, with a lower mean pressure through the night has a minimal impact on improving compliance.

5.3.7 Newer Modes of PAP¹⁹

AVAPS (Average volume assured pressure support) is a hybrid mode, which combines the advantages of pressure-limited (BPAP) and volume-limited modes of ventilation into one ventilation mode. In AVAPS, the pressure support can be varied to target a fixed tidal volume, using proprietary algorithms. In terms of efficacy, it is comparable to nocturnal non-invasive pressure support with improved oxygenation, sleep quality and quality of life, with greater improvement in ventilation. It can be used in the therapy of OHS.

The BPAP-ST (Spontaneous-Timed) mode guarantees a certain number of pressure cycles (or breaths) /minute, if the patient does not initiate a breath within a specified period. This is useful in patients who hypoventilate on PAP due to abnormal respiratory control, and can also be used for treatment of complex sleep apnea, non-invasive ventilation in OHS and neuromuscular or chest restrictive disorders(**Evidence Quality A, Recommended**).

Auto bi-level PAP is another new-generation device, which can increase not only the CPAP level similar to auto-PAP, but also the inspiratory PAP (IPAP) separately to treat obstructive events.

Various imported devices commonly available in India include CPAP, BPAP and auto-PAP machines, none being manufactured indigenously. The other devices include BPAP with ST-mode, ASV devices (with different proprietary names and algorithms), AVAPS devices, and optional pressure-relief features in some of the new devices.

The interfaces available in India include the nasal mask, full-face mask, nasal pillows, with latex-free silicone material and gel to enhance comfort and reduce leaks. Mask fitting is an important part of the PAP prescription. Heated humidification should be considered in the appropriate climatic conditions.

Selection of devices and interfaces follows the same scientific principles as outlined in these guidelines. CPAP is the device of choice, based on robust scientific data and supported by economic considerations. Compliance problems merit consideration for auto-PAP and BPAP. Individual patient preference should be considered while selecting auto-PAP. In OSA patients with OHS the use of BPAP/BPAP-ST/AVAPS is recommended. Pressure relief may be used as a comfort mode to enhance compliance if there is a tolerability issue due to perceived high pressure.

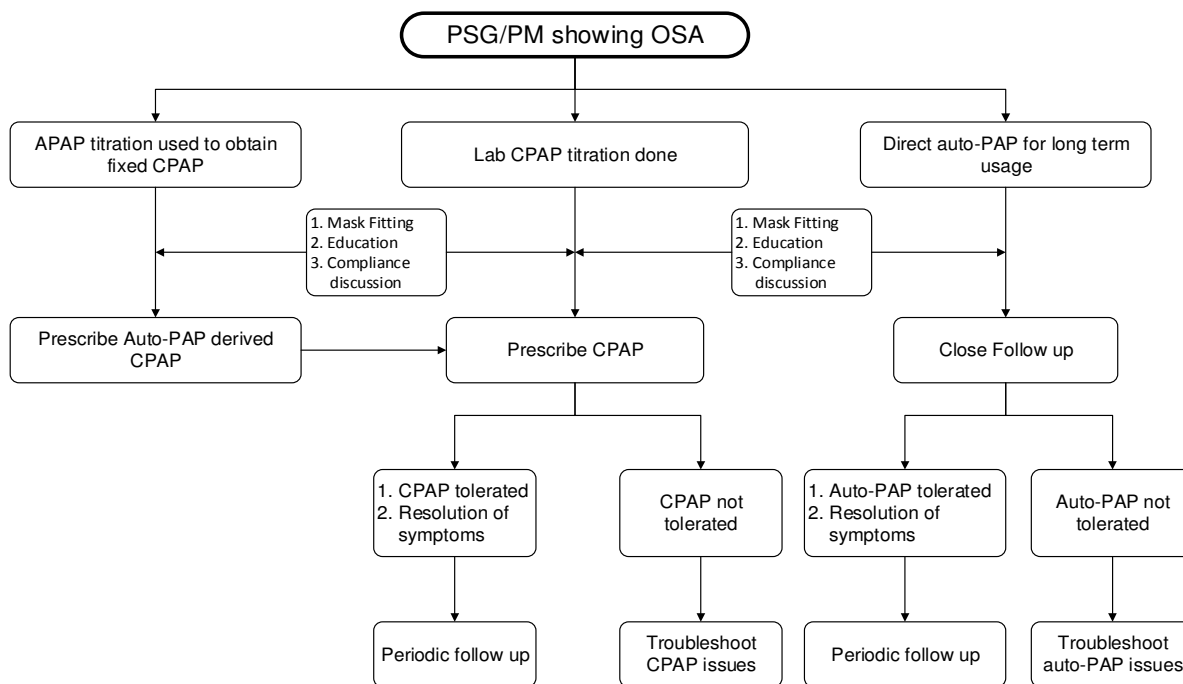


Figure 5-1: Comprehensive Approach to PAP Prescription

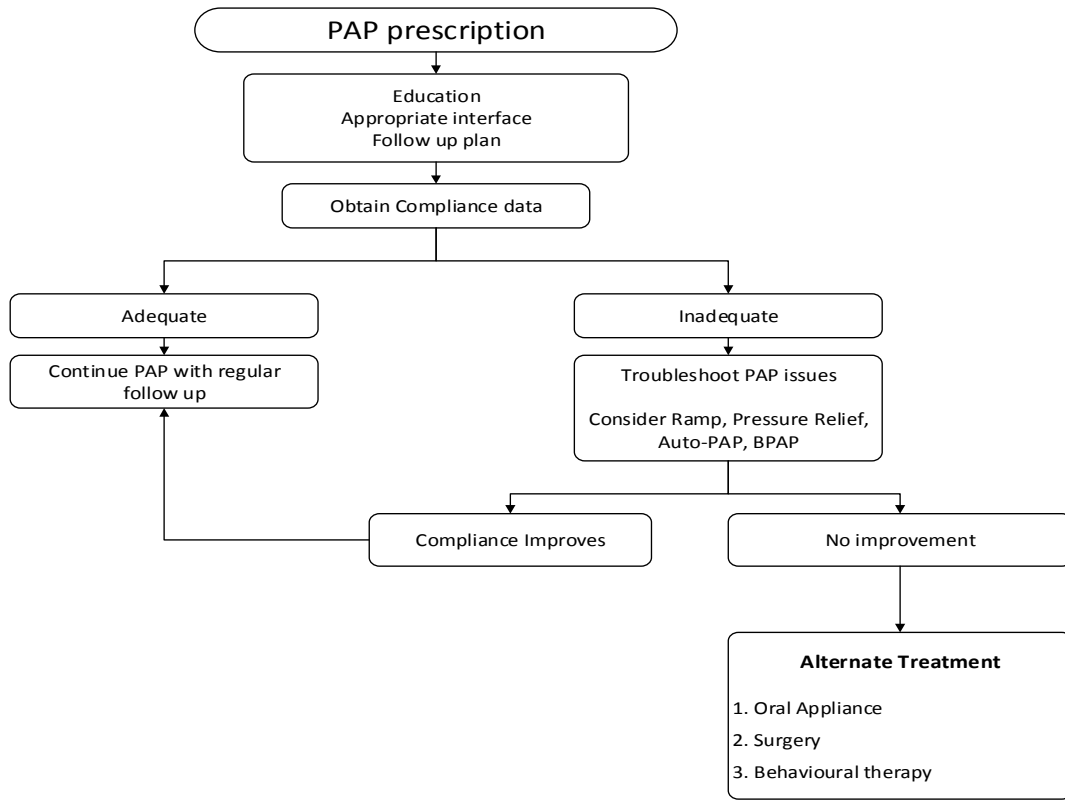


Figure 5-2: Suggested follow-up after PAP prescription.

5.4 Oral Appliances:

5.4.1 Background and rationale

Multiple anatomical and neuromuscular etiological factors are involved in the patho-physiology of OSA. Oral appliances are an established treatment option for snoring and mild to moderate OSA in selected cases. Oral devices like mandibular repositioning appliance (MRA) and tongue retaining appliances (TRA) are mechanical devices designed to prevent retro-glossal collapse during sleep. Advancement of the mandible also increases the volume of upper airway²²⁻²³ The stimulation of genioglossus muscle activity with oral appliances also contributes to upper airway stabilization.²⁴ Oral appliances are less cumbersome than PAP therapy and should be considered for patients who have failed or refused PAP treatment, for those with snoring or mild to moderate OSA.^{25,26,27} Dental Professionals trained in sleep medicine should prescribe and prepare appropriately fitting OA for the treatment of OSA.²⁸

5.4.2 Types of oral appliances

5.4.2.1 Mandibular repositioning appliance (MRA)

MRA works by bringing the mandible forward, thereby increasing the airway volume. It can be either fixed (pre-determined advancement), titratable (adjustable) or either a one-piece or a two-piece appliance.^{27,29} The titratable MRA has an adjustable mechanism that allows progressive advancement of the mandible after initial construction until the optimal mandibular position is achieved.^{27,29} Single-piece or non-adjustable appliances often have to be made again if the initial jaw advancement is insufficient.^{27,29}

5.4.2.2 Tongue retaining appliances (TRA)

These are indicated for patients with large tongue and when use of MRA is limited due to edentulous ridges. Once the patient is using the appliance routinely, overnight PSG is required to assess the clinical response objectively.^{27,29}

5.4.3 Contraindications to OA therapy^{27,28,30,31}

Box 5-3: Contraindications to OA therapy

- Inadequate number of healthy teeth in upper and lower dental arch (At least 6-10 teeth in each arch desirable)
- Periodontal diseases
- Patients with full dentures
- Limitation in forward protrusion of mandible and jaw opening
- Temporomandibular joint diseases

5.4.4 Effects of OA therapy

5.4.4.1 Effects on snoring

Numerous investigators have concluded that OAs are beneficial in decreasing snoring in the majority of OSA patients and all of the randomized, placebo-appliance-controlled studies found a significant decrease in snoring, in both subjective and objective assessment.^{25,29, 32,33} **(Evidence Quality A)**

5.4.4.2 Effects on OSA

OAs are effective in the treatment of mild to moderate OSA.^{25,26} Though the patterns and magnitude of changes in upper airway structure and AHI differed between appliances, the majority of the studies reported improvement in the AHI and oxygen saturation following OA therapy.^{25,26,33-37}

(Evidence Quality B)

5.4.4.3 Effects on daytime functions

Improvement in daytime sleepiness assessed by Epworth Sleepiness Scale is seen with usage of oral appliances.^{33,35,38} The assessment of neuropsychological function showed significant improvement in measures of self-reported sleepiness, fatigue and energy levels.^{37,38} One study has shown improvement in simulated driving performance with oral appliances.³⁹

(Evidence Quality B)

5.4.4.4 Effects on vascular diseases

There is a modest favourable effect of OAs on systolic and diastolic blood pressure and on mean arterial pressure.⁴⁰⁻⁴³ **(Evidence Quality A)**

5.4.5 Predictors of response to oral appliances⁴⁴⁻⁴⁶

Box 5-4: Predictors of response to oral appliances

Better prognosis is seen with:(Evidence Quality C)

- Female sex
- Younger age
- Lower BMI
- Smaller Neck circumference
- Cephalometric parameters:
 - Short palate
 - Large retro-palatal airway space
 - Narrow anterior posterior position of mandible (small SNB angle)
 - Higher anterior posterior position of the maxilla (large SNA angle)

5.4.6 Adverse effects of OAs⁴⁷⁻⁵⁰

Box 5-5: Adverse effects of OAs

Adverse effects of OAs (Evidence Quality C)

- Excessive salivation
- Temporary discomfort after awakening
- Mucosal dryness
- Transient discomfort in teeth, gum and TMJ
- Head ache
- Mesial migration of lower dentition
- Distal migration of upper dentition

5.4.7 Compliance with OAs

The compliance depends on benefits and discomfort. Various studies reported different level of compliance for different types of OAs in OSA; it ranges from 51% to 88%. Among the various types of oral appliances, MAD has more compliance than any other appliance.^{46,49, 51}

(Evidence Quality C)

5.4.8 Conclusion:

- Appropriate for use in patients having primary snoring.**(Evidence Quality A, Recommended)**
- Indicated for use in patients with mild to moderate OSA who prefer oral appliances to CPAP, or who do not respond to CPAP.**(Evidence Quality B, Recommended)**
- In severe OSA, initial trial with PAP should be given before treating with OAs. **(Evidence Quality C, Recommended)**

5.5 Recent Advances and Other Therapies

5.5.1 Complex sleep apnea

In a certain subgroup of patients (about 5% to 14%) initially diagnosed with OSA, the AHI remains high despite therapeutic levels of CPAP. The persistently high AHI despite the elimination of obstructive apneas is attributable to central apnea episodes that were either present at baseline or appear after CPAP initiation. This condition is called ‘complex sleep apnea’ or ‘Comp-SA’. The US Centres for Medicare and Medicaid Services defines Comp-SA as “a form of central apnea specifically identified by the persistence or emergence of central apneas or hypopneas upon exposure to CPAP or an E0470 device (i.e., bi-level device without a back-up rate) when obstructive events have disappeared.”⁵² These patients have predominantly obstructive or mixed apneas during the diagnostic sleep study occurring at ≥ 5 events/hour. With use of a CPAP or E0470, they show a pattern of apneas and hypopneas that meet the definition of central sleep apnea. The pathogenesis of Comp-SA is attributed to the intrinsic instability of ventilation in patients with OSA that results in loop gain following CPAP treatment. However, recent studies indicate that the Comp-SA resolves with continued CPAP treatment in more than 50% of these patients.

5.5.2 Treatment of complex sleep apnea

The options available for treating persistent Comp-SA include BPAP devices with spontaneous/timed (S/T) mode (i.e., with a back-up rate) and adaptive servo ventilation devices⁵³ (ASV; *not to be mistaken for adaptive support ventilation algorithm used in mechanical ventilators*). While BPAP devices with S/T mode provide back-up ventilation with fixed pressures during episodes of central apnea, ASV devices deliver a variable level of inspiratory pressure (adjusted breath-to-breath by proprietary algorithms) with a back-up rate in addition to the expiratory pressure (user set or auto-titrated) so as to maintain a target minute ventilation.

What is the role of ASV and BPAP (with S/T mode) devices compared to CPAP for treating complex sleep apnea?

Observational studies indicate that ASV improves AHI and sleep architecture in patients with Comp-SA.⁵³ In a recent study, ASV improved the AHI to < 10 events/hour in about 80% of patients with Comp-SA. Otherwise, most of the studies evaluating ASV were done in patients with congestive heart failure (CHF), and concrete outcomes such as survival were often not studied.⁵⁴⁻⁵⁷ Improvement in AHI was significantly better with ASV than CPAP in CHF patients with OSA and Cheyne-Stokes respiration (CSR). In terms of other devices, in two small RCTs comparing ASV with a BPAP device with S/T mode, both devices were similarly effective in improving AHI in a mixed population of patients with CHF/CSR and Comp-SA.

Post-hoc analyses of two RCTs suggest a dramatic reduction in the risk of death with CPAP use in CHF/CSR (Cheyne-Stokes respiration).⁵⁸ In an observational study, adherence to ASV was associated with a better survival in CHF regardless of severity of SBD.⁵⁹

Oxygen supplementation and rebreathing have been also mentioned as modalities to improve Comp-SA. Supplemental oxygen improves the ventilatory instability in patients with OSA and might be beneficial in patients with Comp-SA, especially in patients who otherwise require domiciliary oxygen treatment. However, in patients with Comp-SA alone, the incremental value of supplemental oxygen is unclear.

Use of an enhanced expiratory rebreathing space has been found to improve the AHI by minimizing hypocapnia during sleep in Comp-SA. This is a promising low-cost alternative for the treatment of complex sleep apnea.⁶⁰

5.5.3 Other recent advances in the treatment of OSA

Nasal EPAP device is a single-use device applied over the nostrils that functions like an inspiratory valve allowing unimpeded inspiration but offers resistance to expiration, creating an EPAP. This resultant EPAP cannot be titrated. In a large RCT, the nasal EPAP device significantly improved AHI (43% vs. 10%) and Epworth sleepiness score at 3 months as compared to a sham device. However, some patients do not show any improvement in AHI with nasal EPAP, and among the responders not all would achieve an AHI < 10/hour. The clear-cut indication for nasal EPAP devices is still not well defined.⁶¹

One potential population would be patients unwilling to use CPAP and showing a good response to a trial of the nasal EPAP device. However, due to cumulative cost considerations of using a new device daily, CPAP would still remain the first-line treatment for OSA.

Meta-analysis of 10 RCTs has using atrial overdrive pacing found that though the magnitude of improvement in AHI was statistically significant, it was small as compared to CPAP, and hence is not recommended for routine use.⁶²

Fluid shift towards head is one of the factors responsible for SDB in CHF. A similar mechanism might operate in the absence of CHF as well. In two small studies, use of compression stockings resulted in a modest decrease in AHI in non-obese patients with OSA who were sedentary or had chronic venous insufficiency.^{63,64}

In general, drug treatment is ineffective for the treatment of OSA. Notwithstanding, two small RCTs suggest that short-term use of acetazolamide (500-750 mg/day) is beneficial in patients on CPAP during travel to high altitude.^{65,66}

Electrical stimulation of the hypoglossal nerve/genioglossus muscle is a potential approach to prevent upper airway obstruction in OSA. In a preliminary study, an implantable hypoglossal nerve stimulation system synchronized with inspiration has been found to be effective in improving AHI and functional outcome measures and needs further studies to confirm the efficacy.⁶⁷

Table 5-1: Adverse effects of PAP therapy

Problem	Solution
Nasal congestion, rhinorrhoea, nasal dryness, sinus pain	Nasal steroids, heated humidification
Mask discomfort, leakage	Using suitable mask interface, good mask fitting
Skin breakdown, abrasions	Gel and air-cushion interface masks
Mask claustrophobia	Other types of masks, nasal prongs
Pressure intolerance, difficulty in exhalation	Use “ramp”, pressure_relief, BPAP, auto-PAP
Mouth breathing	Chin strap, full face or oro-nasal mask
Bed partner intolerance	Teaching adaptation skills to the patient and bed partner

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6 Surgical treatment of OSA

PAP therapy has been considered to be the first-line of management for patients with OSAS.¹ However, some patients may prefer alternative treatment options because they are unable to tolerate, are non-compliant² or do not benefit from PAP therapy. The lack of randomized controlled trials comparing PAP therapy and surgical treatment make it very difficult to attain a consensus in selecting the appropriate management option.³ The decision for surgical management should be strictly individualized after careful assessment of patient with due importance given to the sites of obstruction. Following description provides an insight into the procedures that are currently available and their potential role in routine management.

6.1 Evaluation of level of obstruction

The most significant concern in the assessment of airway is that it can only be performed in an awake patient and the scenario hardly simulates the exact status during sleep. The methods available are summarised in Table 6-1.

6.2 Surgeries in OSA

Surgical options in OSA are site directed surgeries and bariatric surgery. The various site specific surgeries in the upper airway are summarized in Table 6-2.

6.2.1 Nasal and Nasopharyngeal Surgery

Patients with OSAS frequently have nasal obstruction which results in snoring and mild sleep apnea, but nasal blockage *per se* does not lead to severe OSA.

1. Nasal surgery (correction of anatomical defects) alone is not a useful method of treatment of moderate to severe sleep apnea (**Evidence Quality B, Not recommended**).^{16,17}
2. It also improves the compliance with PAP and also improves its effectiveness. (**Evidence Quality B, Recommended**).^{16,18,19}

6.2.2 Maxillo-Mandibular Surgeries

Malpositioning of maxilla and mandible contribute to OSAS by reducing the posterior hypopharyngeal space. Role of surgery in the correction of such anatomical abnormalities is described below.

6.2.3 Genioglossus advancement

Genioglossus advancement is found to be helpful in patients with hypopharyngeal soft tissue and tongue base abnormalities. The short and long-term effects of genioglossus advancement are improvement of Epworth scale, AHI score and oxygen saturation (**Evidence Quality C, Optional Recommendation**).²⁰

6.2.4 Maxillo-mandibular advancement surgery

Maxillo-mandibular advancement surgery is an option for severe OSA patients with maxillary and mandibular retrusion, unable to tolerate PAP therapy and in whom oral appliances have failed.²¹ It can also be considered in patients who have failed to improve after other surgical procedures (**Evidence Quality C, Optional Recommendation**).

6.2.5 Distraction osteogenesis

Distraction osteogenesis can be employed in patients with severe OSA due to maxillofacial skeletal disharmony, particularly mandibular and maxillary retrusion where more than 10-12mm advancement is required (**Evidence Quality C, Optional Recommendation**).²²

6.2.6 Uvulopalatopharyngoplasty (UPPP)

UPPP is the standard mode of management in patients with retropalatal obstruction. UPPP showed promising short-term results in several studies in terms of reduction in snoring and EDS but long-term results are conflicting. Therefore, its efficacy as an isolated treatment modality in the long-term is debatable with the strict requirement of regular postoperative evaluation (**Evidence Quality C, Recommended in patients with retropalatal obstruction**).^{23,24}

6.2.7 Other surgeries

1. Base of tongue reduction with radio frequency as an isolated or combined procedure cannot be recommended as a treatment for OSA owing to lack of sufficient evidence in the literature (**Evidence Quality C, Recommended**).²⁵
2. Laryngeal surgery is limited to a definite subset of patients with laryngeal obstruction requiring surgical excision for its management. PAP therapy is the primary mode of management in patients with laryngeal pathology. Surgery is usually preferred for intractable cases or patients with poor compliance to PAP (**Evidence Quality C, Recommended only for patients with laryngeal pathology**).²⁶
3. Tonsillar hypertrophy is rare in adults and studies regarding effectiveness of tonsillectomy in OSA are lacking. Tonsillectomy is indicated in adults with tonsillar hypertrophy which is non-responsive to medical management (**Evidence Quality C, Recommended in the subset of adults with tonsillar hypertrophy**).²⁷

6.2.8 Multilevel Surgery in OSAS

Multilevel surgery refers to surgical procedures performed at two or more sites in the upper airway. These surgical procedures can be either staged or can be done in a single stage. The three main levels of obstruction identified are nasal, retropalatal and retroglossal/hypopharyngeal. There is no randomized controlled trial comparing multilevel surgeries (either one stage or multiple stages) with PAP therapy for OSAS. MLS is a viable option for patients who failed PAP or other conservative methods.²⁸ The suitable candidates include those with mild-moderate OSA, BMI <30kg/m², age <60years, retroglossal obstruction and without any comorbidity (**Evidence Quality C, Recommended for cases with documented multiple level obstruction**).²⁹

6.2.9 Tracheostomy for OSAS

Tracheostomy is poorly accepted in the present scenario. Patients with significant OSA who have failed all medical and surgical procedures might require permanent tracheostomy. It significantly decreases apnea index, desaturation index, sleepiness and mortality in OSA subjects³⁰ but does not correct central apnea. Temporary tracheostomy can be used following oropharyngeal surgeries in the post-operative period (**Evidence Quality C, Optional Recommendation**).

6.2.10 Role of Bariatric surgery for treatment of OSAS:

Bariatric surgery (BS) is a surgery done in order to create caloric restriction and/or malabsorption for weight loss. The commonly performed bariatric procedures are adjustable gastric banding (AGB), Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG) and bilio-pancreatic diversion (BPD).

6.2.10.1 Mechanism of OSA improvement following BS

Improvement in OSA following bariatric surgery is due to body weight dependent factors and weight independent metabolic factors. Reduction of subcutaneous adiposity reduces the physical pressure on the neck, upper airway and the breathing apparatus. The reduction in visceral adiposity reduces the intra-abdominal pressure and thereby increases the diaphragmatic excursion and further improves gas exchange. These positive pulmonary changes in turn affect the neurological pathways and higher centres responsible for respiration.^{31,32}

6.2.10.2 Impact of BS on OSA

Following BS, there is improvement of post-operative sleep quality, reduction in day time sleepiness, improvement in quality of life, decrease in use of PAP and decrease in use of high PAP pressure requirement. These subjective improvements are seen regardless of the type of bariatric procedures.³¹ There is objective improvement in severity of OSA as measured by AHI or RDI score. In a meta-analysis of BS, OSA resolved or improved in 83.6% of the total population post-surgery. Gastric bypass was the most successful procedure in improving or resolving OSA followed by gastroplasty, BPD and gastric banding being the least effective procedure.³² In another meta-analysis, there was a decrease in the pooled mean AHI from 38.2 events/hour to 15.8 events/hour. The combined reduction in AHI was 71%. However, in the majority of the patients (62%), the mean residual AHI after surgery was more than 15 events per hour. This indicates that there is a persistent residual disease, even though there has been considerable improvement. As such, all patients should undergo repeat PSG after surgical weight loss and those patients who have residual disease consistent with moderately severe OSA need continued treatment with PAP. This meta-analysis also found that the patients cured of OSA were less obese and younger than those who had residual OSA after bariatric surgery. OSA cure rate was independent of gender and baseline AHI.³³

In a recent meta-analysis of 13,900 patients who underwent bariatric surgery, 79% of patients experienced either resolution or improvement of their sleep apnea. The percentage of patients showing either resolution or improvement in their OSA was 86% following SG, 79% following RYGB and 77% following AGB. Bariatric surgery is strongly recommended for obese OSA patients with BMI $\geq 35\text{kg/m}^2$ (**Evidence Quality B**).³⁴

Table 6-1: Methods for evaluation of site of obstruction

Method	Purpose	Disadvantage	Evidence quality	Recommendation
Cephalometry ⁴	For maxillo-mandibular advancement procedures	2D image obtained, does not reveal physiological obstruction.	C	No Recommendation for routine use
Pressure catheter ^{5, 6}	For recurrence following UPPP	Few studies proving its usefulness in OSA	C	Optional in those with recurrence following UPPP
Acoustic analysis	Based on different acoustic patterns produced in different parts of obstruction	Poor sensitivity and specificity	D	No recommendation
Fiberoptic nasopharyngoscopy with Mueller manoeuvre (FNMM) ⁷	UPPP found to be useful in patients with collapse on FNMM	Low evidence of usefulness	C	Recommended
Somnofluoroscopy ⁸	Demonstrates level of obstruction in two dimensions	Radiation exposure	C	No Recommendation for routine use
Drug-induced sleep nasoendoscopy (DISE) ⁹⁻¹¹	Dynamic, physiological, can assess multilevel obstruction	Operator dependent	C	Optional in those planned for surgery
Computed Tomography ¹²⁻¹⁴	Identifies retropalatal obstruction	<ul style="list-style-type: none"> • Costly • Radiation exposure • Not physiological • Does not identify retroglottal obstruction 	C	No recommendation for routine use
Magnetic resonance Imaging during sleep (Sleep MRI) ¹⁵	Dynamic evaluation of airway obstruction and respiratory events	Noise disturbs sleep	C	No recommendation for routine use.

Table 6-2: Level of obstruction in upper airway and proposed surgical methods

Site of Obstruction	Surgery
Nasal Cavity	Inferior turbinate reduction Septoplasty Endoscopic sinus surgery
Nasopharynx	Adenoidectomy
Oropharynx	Tonsillectomy Uvulopalatopharyngoplasty
Retroglossal	Tongue base reduction Lingual tonsillectomy GAHM and suspension
Multilevel	Nasal corrective surgeries, UPPP, GAHM Maxillomandibular osteotomy and advancement

UPPP: uvulopalatopharyngoplasty

GAHM: Genioglossus advancement with hyoid myotomy

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7 Future directions

These guidelines represent a major step in establishing standards for diagnosing and managing sleep-disordered breathing and shall provide a platform for building further capacity in the field of sleep medicine. However, much still needs to be done to increase awareness amongst both health care professionals and general population and facilitate better management of patients diagnosed with these disorders.

- Sensitization of children should start in school and information regarding importance of sleep hygiene, good sleep habits and consequences of sleep loss on health should be included in the primary school curriculum.
- Practical sessions with knowledge about basic terms such as snoring, sleep apnea and consequences of sleep-disordered breathing and other sleep disorders should be included in the higher secondary education curriculum.
- Sleep disorders are an independent risk factor for vehicular accidents and, therefore, it is imperative that awareness campaigns and screening programmes be organised amongst various transport bodies and associations, such as those for drivers, rail engine operators and pilots. This shall require inter-sectoral co-ordination between central health agencies, vehicular transport authorities and the civil aviation ministry.
- Truckers, pilots and drivers should be comprehensively evaluated for OSA at the time of issuing licence or renewal of licence.
- Curriculum on sleep disorders should be included in medical schools along with attendance of minimum five overnight sleep studies. All recognised medical schools should have centrally accredited sleep laboratories.
- The relation between OSA in pregnancy and pregnancy outcomes must be further investigated along with sensitisation of Obstetricians.
- Registered medical practitioners should be imparted training through recognised CMEs, government sponsored training programmes and centrally sponsored fellowships in higher institutes.
- Recognition of sleep medicine as a super-speciality in the field of medicine will ensure higher standards of patient care and provide a tier of specialists for handling complicated cases, thereby, establishing the framework for a referral system.
- Recognizing regional and central institutes of excellence is necessary to establish an Indian OSA map.
- A national policy on rational practices for diagnosis of OSA, prescription of PAP therapy/oral appliances and reimbursement for PAP/oral appliances should be established.
- Task forces for research on sleep disorders should be established under the purview of central bodies such as CSIR, DBT, DST and ICMR to fund and supervise good quality research relevant to Indian settings. Research on cost-effectiveness of PAP therapy in Indian setting is necessary for planning future practice guidelines.
- A national registry of sleep disorders should be established, which will help to provide data on the burden of various sleep disorders.
- Collaboration between IITs, biomedical engineers and medical practitioners should be encouraged for innovations in indigenous and affordable diagnostic and therapeutic equipments necessary.

These guidelines will be updated at regular intervals with evidence-based recommendations based on systematic reviews and meta-analysis done in the Indian setting.