

# Obstructive sleep apnea and anaesthesia: perioperative issues

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## Summary

**Obstructive sleep apnea (OSA) is a common problem in public health care and yet, the perioperative management of OSA remains inadequate. Patients affected by this condition are prone to early postoperative complications, in part due to the negative effects of sedative, analgesic, and anesthetic agents on pharyngeal tone and the arousal responses to hypoxia, hypercarbia, and obstruction. The use of opioids may also contribute to late adverse events, mainly by suppressing rapid eyes movement (REM) in sleep. As a consequence, preoperative screening of patients at a high risk of OSA as well as the implementation of a perioperative strategy to reduce the risk of complications, may lead to early perioperative interventions capable of improving patient outcome.**

**KEY WORDS:** *Obstructive Sleep Apnea (OSA); preoperative evaluation; perioperative complications; postoperative care.*

## Introduction

Obstructive Sleep Apnea (OSA) is a condition which affects the general population (1, 2) and has been implicated as a comorbid factor in various clinical conditions. The signs, symptoms and consequences of OSA are a direct result of the derangements caused by the repetitive collapse of the upper airway. They include sleep fragmentation, hypoxemia, hypercapnia, marked variations in intrathoracic pressures and increased sympathetic activity. OSA has been associated with increased perioperative risk and postoperative complications (3, 4) but a significant proportion of patients remain undiag-

nosed before surgery on hospital admission (5) and yet, it is important that anaesthesiologists screen every patient scheduled for surgery, under general or loco-regional anaesthesia, for OSA risk in order to target the correct perioperative strategy.

## Prevalence of OSA

Although obesity has been considered a classical risk factor for OSA, this is not restricted to obese patients, but can occur also in non obese patients (6). Young et al. (1) reported that symptomatic OSA affects approximately 2 and 4% of middle-aged women and men, respectively, but the overall prevalence of sleep-disordered breathing was estimated as 9% for women and 24% for men between the ages of 30 and 60. This makes OSA more common than asthma among adults. Risk increases with age, as 24% of people older than 65 years have OSA and up to 50% of nursing home residents have clinically significant OSA (5). Few studies (7-10) have used polysomnography (PSG) to determine the frequency of OSA in the surgical population. In most instances, the frequency of OSA in these surgical populations is substantially higher than the incidence in the general population, and varies with the surgical intervention. In bariatric surgery of

obese patients, the prevalence was as high as 70% (11), presumably due to the high percentage of fat tissue at the neck level. Of even greater concern, despite the presence of OSA in the majority of patients presenting for bariatric surgery, most cases go undetected, unless careful screening is implemented before surgery (12). Finkel et al. (13) found, during a screening of 2.877 patients eligible for elective surgery, 661 (23.7%) of the patients to be at high risk for OSA. Out of the 661 patients, 534 of (81%) had not been diagnosed for OSA at the time of surgery and were offered a home sleep study to determine if they had OSA. The results were compared with polysomnography (PSG) when available. The portable sleep study detected OSA in 170/207 (82%) high-risk patients without diagnosed OSA. Twenty-six PSGs confirmed OSA in 19 of these patients. Postoperatively, there were no respiratory arrests, two unanticipated ICU admissions, and five documented respiratory complications. The authors concluded that implementing universal screening is feasible and can identify undiagnosed OSA in many surgical patients. Finally, Singh et al., in a study of Canadian surgical patients preopera-

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tive diagnosis was poor, even in patients with symptoms of moderate-to-severe OSA (14).

### Why is OSA a risk factor for perioperative complications?

Although the primary cause of obstructive sleep apnea is not completely known, the principal patho-physiological characteristic of the disorder is collapse of the upper airway during sleep. In simpler terms, OSA is characterized by a malfunctioning of the upper airway. Human beings have the widest pharynx among superior mammals but it is also the simplest one. In humans, the upper airway (UA) can be compared to a flexible pipe (pharynx), connected to two stiff parts (the nose and the larynx). UA patency is determined by the balance between UA muscle activity (the dilator muscles of the pharynx) and negative pressure generated in airway, wall compliance and end inspiratory UA size.

**OSA patients who are already susceptible to airway collapse during natural sleep are more sensitive to the effects of anesthetics and sedatives.**

UA wall compliance is affected by craniofacial and soft tissue structure, and sleep state (15). The higher the patient's effort and UA wall compliance, the greater the likelihood of airway obstruction. Progressive UA closure during the transition to sleep is accompanied by complete obstruction of airflow (apnea) or partial obstruction (hypopnea). In addition, during rapid eye movement (REM) sleep, pharyngeal narrowing worsens. Hypercapnia and acidosis resulting from hypoventilation stimulate arousal centers in the central nervous system, leading to increased respiratory and pharyngeal muscle activity. These changes in neurological function, further stimulated by a heightened ventilatory effort, ultimately overcome the obstruction, and ventilation resumes. The patient then returns to sleep, the pharyngeal musculature relaxes, and the cycle repeats itself. In severe cases, this scenario is repeated hundreds of times every night. These repeated cycles of apnoea will lead to several potential sequelae like systemic hypertension, ischemic heart disease, right heart failure, gastro-oesophageal reflux, intra-cranial hypertension, polycythemia and pulmonary hypertension and ultimately, heart failure (16).

OSA syndrome is therefore characterized by:

- periodic, partial, or complete obstruction of the upper airway during sleep with episodes of apnea and hypopnea and arousal to restore airway patency
- episodic sleep-associated oxygen desaturation with possible episodic hypercarbia, and cardiovascular dysfunction
- possible daytime hypersomnolence or manifestations of disrupted sleep such as aggressive or distractible behaviour.

Perioperative complications are caused both by the effect of anaesthetic agents and by anatomical features of OSA patient. Intravenous hypnotics, analgesics, narcotics, and inhalational volatile agents produce respiratory depression in a dose-dependent fashion in normal individuals (17-19). Anaesthetic agents predictably blunt or abolish the usual mechanisms available to overcome

airway obstruction in normal individuals.

However, in OSA patients (prone to UA closure), such agents may produce an airway obstruction that is not necessarily correlated to the level of sedation. In other words, OSA patient who are already susceptible to airway collapse during natural sleep are more sensitive to the effects of anesthetics and sedatives (20). OSA patients can develop respiratory complications in the early or late perioperative period. In the early phase, complications arise due to the negative effects of sedative, analgesic, and anesthetic agents on pharyngeal tone and on the arousal responses to hypoxia, hypercarbia, and obstruction. Most complications occur during the first 24 to 48 hours postoperatively. In the late phase (after one week) complications are mainly due to a "rebound" of REM phase due to the administration of high doses of opioids in postoperative care, that suppress REM phase thus causing sleep deprivation (21, 22).

### OSA and adverse perioperative outcome

OSA has been shown to increase the rate of postoperative complications, increase the need for intensive care intervention, and prolong the length of hospital stays. One of the first studies to survey the postoperative risks of OSA was conducted by Gupta et al. who retrospectively reviewed 101 OSA patients who had hip or knee replacement surgery within 3 years before or anytime after their OSAS diagnosis (23). Patients with OSAS were subcategorized as having the diagnosis either before or after the surgery and also, regardless of time of diagnosis, by whether they were using continuous positive airway pressure (CPAP) prior to hospitalization. Matched controls were patients (101) without OSAS undergoing the same operation. Only half of the patients with diagnosed OSA prior to their operation used Continuous Positive Airway Pressure (CPAP) therapy at home prior to hospitalization. Complications were significantly more frequent in patients with OSA (39%) than in control patients (18%). Serious complications requiring admission to Intensive Care Unit (ICU) for cardiac ischemia or respiratory failure were also significantly higher in OSA patients (24%) versus 9% of controls. Hospital length of stay was also significantly longer for patients with OSA compared with controls. Most complications occurred during the first day after surgery although a small number was also found on days 4 and 5 after surgery.

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Similarly, Liao et al. (24) comparing 240 OSA vs 240 matched non-OSA patients who underwent elective surgeries, reported a significantly higher complication rate in the OSA group (44% OSA vs 28% in the non-OSA group) with an oxygen desaturation < 90% higher in OSA group (17%) vs non-OSA group (8%). The OSA patients who did not use home CPAP prior to surgery but required the use of a CPAP device after surgery had

the highest rate of complications suggesting a possible beneficial role for preoperative CPAP therapy. There are few other retrospective studies on the perioperative outcomes associated with OSA (25), mainly conducted in confirmed OSA patients undergoing otolaryngologic surgeries and associated UA procedures. Respiratory complications and oxygen desaturation were the most common complications found in these studies (26-28). A retrospective review of patients undergoing cardiac surgery also found more postoperative adverse events and a longer ICU length of stay in OSA patients (29). A recent case-control study by Memtsoudis et al. analyzed perioperative pulmonary outcomes in patients undergoing orthopedic and general surgery (30). They found that patients with OSA developed pulmonary complications at a significantly higher rate than their matched controls (i.e. aspiration pneumonia: 1.18% vs 0.84% and 2.79% vs 2.05%; ARDS: 1.06% vs 0.45% and 3.79% vs 2.44%; intubation/mechanical ventilation: 3.99% vs 0.79% and 10.8% vs 5.94%, all  $p < 0.0001$ ). Pulmonary embolism was more frequent in OSA patients after orthopedic procedures than after general surgical procedures. OSA was associated with a significantly higher adjusted odds ratio (OR) of developing pulmonary complications after both orthopaedic and general surgical procedures and a higher significant adjusted OR for intubation/mechanical ventilation. They concluded that OSA was an independent risk factor for perioperative complications. OSA has been confirmed as a risk factor for postoperative pulmonary complications (31) and a recent meta-analysis concludes that patients with OSA undergoing non-cardiac surgery have a higher incidence of postoperative respiratory desaturation, respiratory failure, cardiac events, and ICU transfers than those without OSA (32).

### Preoperative evaluation

Given the high prevalence of this condition and the high number of undiagnosed OSA patients, all surgical patients should be screened for OSA. Although comprehensive, the use of PSG or Portable Monitors (PMs) for preoperative screening is limited by factors such as the inconvenience of being studied in a sleep laboratory, the

high cost of testing and the possible surgery delay due to waiting lists stretching from weeks to more than a year (33). Moreover, PSG is not practical for rapid screening in a fast-paced preoperative clinic. Screening tools can assist in identifying relevant sleep-related issues. So far, three screening tools for OSA have been validated for use in a surgical population: the Berlin Questionnaire, the American Society of Anesthesiologists (ASA) Checklist, and the STOP Questionnaire (34). Although all of these screening tools appear to improve the likelihood of identifying OSA preoperatively, the quickest and the simplest to use seems to be the STOP Questionnaire. This questionnaire has also been modified to include questions about additional risk factors for OSA such as Body Mass Index (B), age (A), neck circumference (N), and gender (G); the modified tool is called the STOP-BANG Questionnaire (Figure 1). In a validation study, the addition of "BANG" increased the score's specificity for moderate to severe OSA (35). In a study comparing the STOP-BANG to PSG, the odds ratio for diagnosing moderate to severe OSA increased significantly, based on the number of points a patient scored (36). It should be noted that none of these questionnaires are particularly useful in excluding mild OSA, as defined by an apnoea hypnoea index (AHI) of more than 5 but less than 15 (negative predictive values of 38-44%). Vasu et al. (37) showed that STOP-BANG scores indicative of a high risk of OSAS confer a heightened risk of postoperative complications in patients undergoing elective surgery. Chung et al. found that ODI from a high-resolution nocturnal oximeter is a sensitive and specific tool to detect undiagnosed sleep disordered breathing in surgical patients. Compared to CT90, ODI had a stronger correlation and was a better predictor for AHI. The ODI >10 demonstrated a sensitivity of 93% and a specificity of 75% in the detection of moderate and severe SDB (38).

### Management strategies

The approach to patients already diagnosed for OSA or at high risk of having OSA (HRO) and presenting for surgery can be divided into a preoperative, intraoperative, and postoperative strategy (39) (Figures 2 and 3).

<b>S. Snoring</b> (observed during sleep)		
Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?	Yes	No
<b>T. Tiredness</b> (in the daytime)		
Do you often feel tired, fatigued or sleepy during daytime?	Yes	No
<b>O. Observed apnea</b>		
Has anyone observed you stop breathing during your sleep?	Yes	No
<b>P. Blood Pressure</b>		
Do you have or are you being treated for high blood pressure?	Yes	No
<b>B. Body Mass Index</b>		
BMI more than 35 kg/m <sup>2</sup> ?	Yes	No
<b>A. Age</b>		
Age over 50 yr old?	Yes	No
<b>N. Neck circumference</b>		
Neck circumference greater than 40 cm?	Yes	No
<b>G. Gender</b>		
Gender male?	Yes	No

Figure 1 - The STOP-BANG Questionnaire. A high risk of sleep apnea is defined as a score of 3 or more; low risk of sleep apnea, a score of less than 3.

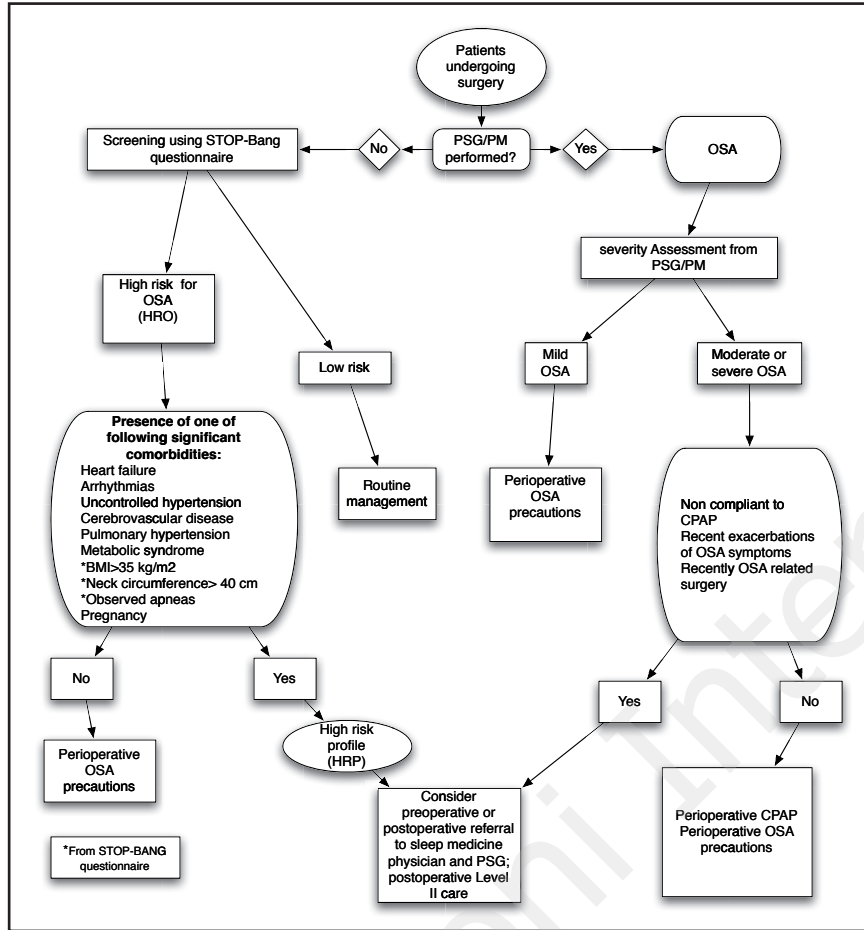


Figure 2 - Flow diagram for the preoperative evaluation.

**Preoperative management**

Patients identified as HRO and with one of the risk factors cited in the Table 1, should be identified under a “highest risk” patient profile (HRP) and would benefit from a high level of care or referral to a sleep medicine specialist for further evaluation and treatment. The perioperative management of such high risk patients should be identical to the management of patients with known OSA. In the case of patients with an established diagnosis of OSA, the severity of apnoea, patient’s compliance with the treatment (i.e. CPAP) and the presence of co-morbidities such as pulmonary hypertension should be taken into account. Patients in CPAP treatment should be instructed to bring with them their CPAP machine and mask during hospital admission and use CPAP in the perioperative period.

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**Premedication**

The use of anxiolytic premedication is not recommended. Preoperative sedation with benzodiazepines for anxiolysis may decrease the tone of UA muscles, thus in-

Table 1 - Risk Factors.

- Heart failure
- Arrhythmias
- Uncontrolled hypertension
- Cerebrovascular disease
- Pulmonary hypertension
- Metabolic syndrome
- BMI>35 kg/m2
- Neck circumference> 40 cm
- Observed apneas
- Pregnancy

creasing the risk of UA closure. It has been found that benzodiazepines can cause an appreciable reduction of the pharyngeal space, which may lead to a higher risk of hypopnoea/apnoea events, causing in turn a higher risk of hypoxia and hypercapnia (40). In a case report of a morbidly obese woman with tracheal stenosis, dexmedetomidine (an alpha-2 adrenergic agonist) has been used

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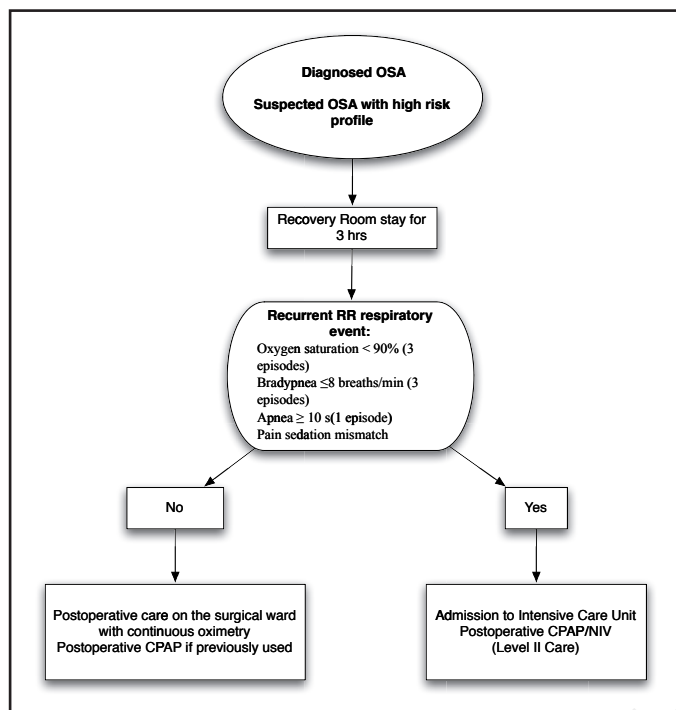


Figure 3 - Flow diagram for the postoperative strategy.

as a premedication agent due to its anxiolytic and sedative properties. The benefit of dexmedetomidine is the lack of significant respiratory depression within the clinical dose range (41). Pawlik, in a randomized, double-blind, placebo-controlled study in OSA patients, showed that oral clonidine premedication may reduce the amount of intraoperative anaesthetics and postoperative opioids without a deterioration of spontaneous breathing (42).

#### Intraoperative management

Hypertension and cardiovascular diseases are more common than in other patients. The anaesthetic care of patients with OSA is a challenging issue because anaesthetic agents, beyond the fact that they deeply influence the patency of an already unstable airway, are being used in the presence of significant co-morbidities. No evidence exists regarding the type of used anaesthetic techniques and perioperative risk. It is generally believed that regional anaesthesia (RA) is preferable over general anaesthesia (GA) whenever possible. Regional anaesthesia minimally affects respiratory drive. Because it avoids the side effect of anaesthetic agents on sleep patterns, it maintains arousal responses during apnoeic episodes. Regional anaesthesia may also avoid or reduce the need for sedative drugs and opioids during all the perioperative period. As mentioned in the next paragraph, some regional techniques may unintentionally result in unconsciousness or respiratory paralysis;

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therefore, patients should always be evaluated for potential airway difficulties and management.

#### Airway issues

It has been well established that the presence of OSA may lead to difficulties in airway management both in term of difficult mask ventilation and tracheal intubation (43-46). Although these findings do not imply that awake intubation is necessary in patients with OSA, prudence dictates that clinicians should have immediate access to alternative techniques to secure the airway and ventilate the patient, including a second generation supraglottic airway device. Risk assessment for aspiration and difficult airway management is always recommended.

It should be emphasized that in obese patients, complications with ventilation rather than intubation are to be expected. Finally, in very obese patients with OSA, special attention should be paid to patient positioning; a "ramped" position rather than the usual "sniffing" position can be very helpful. A ramped position is achieved by stacking blankets underneath the patient's shoulders and head until the ear canal and the sternal notch align horizontally (47). In addition, 2-handed mask ventilation is generally recommended to achieve an optimal mandibular advancement (48). The equipment for the management of a difficult airway should be in place before the induction of general anaesthesia.

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It has also been shown that patients showing difficult tracheal intubation are at greater risk of having OSA (49). Some people suggest that anesthesiologists should refer patients with difficult intubation to a sleep

lab for a PSG sleep investigation (50). Interestingly, in a prospective study, Plunkett et al. (46) found that nine out of ten patients exhibiting difficult ventilation at the time of anaesthetic were proven to be affected by OSA.

### **The effect of anaesthetic drugs**

There is evidence that many anaesthetic agents cause exaggerated responses in patients with sleep apnea. Drugs such as thiopentone, propofol, opioids, benzodiazepines, and nitrous oxide may blunt the tone of the pharyngeal musculature that acts to maintain airway patency. The choice of induction and maintenance agents is probably not important although it would seem reasonable to avoid large doses of long acting drugs. This is true with both neuromuscular blocking agents and benzodiazepines. As a matter of fact, anaesthesia techniques using short half-life agents should be advised to avoid any residual drugs in the respiratory system (51, 52).

### **Extubation**

Whenever the patient is extubated, early in the operating room or later in the recovery room or in the ICU, the patient should be fully awake (53). Full recovery from neuromuscular blockade should be proven by a neuromuscular blockade monitor. Extubation in the reverse Trendelenburg or semi-upright position should be advised because it minimizes the compression generated by abdominal contents on the diaphragm (54). In the case of difficult airways, guidelines for safe extubation should be followed (55). In case of continuous regional block associated with general anaesthesia, analgesia should be operative at the time of extubation.

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### **Postoperative care**

#### **Patient positioning**

Loadsmann suggested the adoption, whenever possible, of a lateral position during postoperative care due to a high rate of prevalence of upper airway obstruction in a supine position (56). The head should be elevated to 30° while the patient remains in the recovery room and whenever possible throughout the patient's hospital stay because it decreases UA collapsibility (57).

**The lateral position during postoperative care may be preferred in high risk patients because of the high rate of prevalence of upper airway obstruction in supine position.**

#### **Role of CPAP**

CPAP remains the most effective therapy for OSA, acting as a pneumatic splint to maintain upper airway patency. Nasal or facial CPAP should be applied if airway obstruction is persistent even after the correct positioning of the patient. Rennotte et al. (58) found that CPAP started before surgery and resumed immediately after extubation enabled the safe management of a variety of surgical pro-

cedures in patients with OSA, as well as the use of sedative, analgesic, and anaesthetic drugs without major complications. Those who conducted the study recommended that every effort should be made to identify patients with OSA and to perform CPAP therapy before surgery. Gupta et al. (23)

**It appears that the consistent use of CPAP therapy prior to surgery and immediately after surgery holds the best potential for decreasing postoperative complications.**

found that patients with OSA who were using CPAP preoperatively had a lower incidence of postoperative complications and shorter hospital length of stay when compared with those who were not on CPAP therapy. It appears that the consistent use of CPAP therapy prior to surgery and immediately after surgery holds the best potential for decreasing postoperative complications. However, CPAP does not provide adequate protection for the patient in the face of central apnoea, associated with the deterioration of airway condition caused by opioids. Although there are no studies addressing this topic, the use of Non-Invasive Positive Pressure Ventilation (NIPPV) with a back-up respiratory rate (i.e. Spontaneous Timed/ST mode or Assisted Pressure Controlled Ventilation/APCV) may be advisable (59). However, well-designed studies on the postoperative effect of CPAP and NIPPV in surgical patients with OSA are required to determine its role in the postoperative management of these patients.

### **Postoperative analgesia**

The management of postoperative analgesia in the patient with OSA is extremely challenging for the clinician. The use of major opioids (i.e. morphine, buprenorphine, oxycodone), whatever the route of administration, (including neuraxial administration) should be avoided or minimized (60). When morphine is necessary it should be used with additive /synergic drugs (i.e. ketamine, ketorolac) to reduce the dosage (multimodal analgesia). The use of morphine in patient-controlled analgesia (PCA) mode, without continuous infusion is also advised. However, in a retrospective study of 1600 patients (where not all were affected by OSA) using PCA, Etches et al. (61) found 8 cases of serious respiratory depression. Contributing factors were the concurrent use of a continuous infusion of opioids, advanced age, concomitant administration of sedative or hypnotic medications and a pre-existing history of sleep apnea. As mentioned above, late respiratory complications are reported in case of high dose of opioids within one week after surgery (rebound of the suppressed REM sleep phase). The return to a supine position after few day after surgery may aggravate sleep-disordered breathing. Whenever possible, clinicians should be advised to use:

1. Less powerful opioids such as tramadol.
2. Multimodal analgesia: Nonsteroidal anti-inflammatory drugs (NSAIDs) and acetaminophen (prescribed as "around the clock" rather than "as needed").
3. Regional analgesic techniques both intraoperatively and postoperatively (e.g. continuous wound infiltration with local anesthetic via an indwelling catheter) or continuous peripheral nerve analgesia.

## Conclusion

The perioperative management of OSA is characterized by a variety of problems requiring the joint effort of anaesthesiologists, surgeons and sleep experts. Anaesthesiologists have the opportunity to closely observe their patients in the postanesthesia care unit and can provide important information on where “the patient is going.” Appropriate perioperative protocols are the best way to avoid perioperative complications associated with this common syndrome. Last but not least, in daily practice, anaesthesiologists need “simple things” in order to avoid “choking” the postanesthesia unit and overcrowding the critical care environments (62).

**Appropriate perioperative protocols are the best way to avoid perioperative complications associated with OSAS.**

## References

1. Young T, Peppard PE, Gottlieb DJ. Epidemiology of obstructive sleep apnea: a population health perspective. *Am J Respir Crit Care Med* 2002;165:1217-1239.
2. Young T, Palta M, Dempsey J, et al. The occurrence of sleep-disordered breathing among middle-aged adults. *New Engl J Med* 1993;328:1230-1235.
3. Liao P, Yegneswaran B, Vairavanathan S, et al. Postoperative complications in patients with obstructive sleep apnea: a retrospective matched cohort study. *Can J Anesth* 2009;56:819-28.
4. Kaw R, Pasupuleti V, Walker E, Ramaswamy A, Foldvary-Schafer N. Postoperative complications in patients with obstructive sleep apnea. *Chest* 2012 Feb;141(2):436-41.
5. Chung F, Ward B, Ho J, et al. Preoperative identification of sleep apnea risk in elective surgical patients using the Berlin questionnaire. *J Clin Anesth* 2007;19: 130-4.
6. Garg R, Singh A, Prasad R, Saheer S, Jabeed P, Verma R. A comparative study on the clinical and polysomnographic pattern of obstructive sleep apnea among obese and non-obese subjects. *Ann Thorac Med* 2012 Jan;7(1):26-30.
7. Frey WC, Pilcher J. Obstructive sleep-related breathing disorders in patients evaluated for bariatric surgery. *Obes Surg* 2003;13:676-83.
8. Malow BA, Levy K, Maturen K, et al. Obstructive sleep apnea is common in medically refractory epilepsy patients. *Neurology* 2000;55:1002-7.
9. Pollak L, Shpirer I, Rabey JM, et al. Polysomnography in patients with intracranial tumors before and after operation. *Acta Neurol Scand* 2004;109:56-60.
10. Fidan H, Fidan F, Unlu M, Ela Y, Ibis A, Tetik L. Prevalence of sleep apnoea in patients undergoing operation. *Sleep Breath* 2006;10:161-5.
11. Lopez PP, Stefan B, Schulman CI, et al. Prevalence of sleep apnea in morbidly obese patients who presented for weight loss surgery evaluation: more evidence for routine screening for obstructive sleep apnea before weight loss surgery. *Am Surg* 2008;74:834-838.
12. O’Keeffe T, Patterson EJ. Evidence supporting routine polysomnography before bariatric surgery. *Obes Surg* 2004;14:23-6.
13. Finkel KJ, Searleman AC, Tymkew H, et al. Prevalence of undiagnosed obstructive sleep apnea among adult surgical patients in an academic medical center. *Sleep Med* 2009;10(7):753-758.
14. Singh M, Liao P, Kobah S, Wijeyesundera DN, Shapiro C, Chung F. Proportion of surgical patients with undiagnosed obstructive sleep apnoea. *Br J Anaesth* 2013 Jan 7. [Epub ahead of print].
15. Ayappa I, Rapoport DM. The upper airway in sleep: physiology of the pharynx. *Sleep Med Rev* 2003 Feb;7(1):9-33.
16. Owens RL, Eckert DJ, Yim Yeh S, et al. Upper airway function in the pathogenesis of obstructive sleep apnea: a review of the current literature. *Curr Opin Pulm Med* 2008;14:519-524.
17. Dahan A, van den Elsen MJ, Berkenbosch A, DeGoede J, Olievier IC, van Kleef JW, Bovill JG. Effects of subanesthetic halothane on the ventilatory responses to hypercapnia and acute hypoxia in healthy volunteers. *Anesthesiology* 1994;80:727-38.
18. Drummond GB. Effects of extradural sufentanil and morphine on ventilation. *Br J Anaesth* 1995;74:492-3.
19. Eastwood PR, Platt PR, Shepherd K, Maddison K, Hillman DR. Collapsibility of the upper airway at different concentrations of propofol anesthesia. *Anesthesiology* 2005;103:470-7.
20. Kaw R, Michota F, Jaffer A, Ghamande S, Auckley D, Golish J. Unrecognized sleep apnea in the surgical patient: Implications for the perioperative setting. *Chest* 2006;129:198-205.
21. Rosenberg J, Wildschjødtz G, Pedersen MH, von Jessen F, Kehlet H. Late postoperative nocturnal episodic hypoxaemia and associated sleep pattern. *Br J Anaesth* 1994 Feb;72(2):145-50.
22. Ramachandran SK, Haider N, Saran KA, Mathis M, Kim J, Morris M, O’Reilly M. Life-threatening critical respiratory events: a retrospective study of postoperative patients found unresponsive during analgesic therapy. *J Clin Anesth* 2011 May;23(3):207-13.
23. Gupta RM, Parvizi J, Hanssen AD, et al. Postoperative complications in patients with obstructive sleep apnea syndrome undergoing hip or knee replacement: a case-control study. *Mayo Clin Proc* 2001; 76:897-905.
24. Liao P, Yegneswaran B, Vairavanathan S, et al. Postoperative complications in patients with obstructive sleep apnea: a retrospective matched cohort study. *Can J Anesth* 2009;56:819-828.
25. Chung SA, Yuan H, Chung F. A systemic review of obstructive sleep apnea and its implications for anaesthesiologists. *Anesth Analg* 2008;107:1543-1563.
26. Gessler EM, Bondy PC. Respiratory complications following tonsillectomy/UPPP: is step-down monitoring necessary? *Ear Nose Throat J* 2003;82:628-632.
27. Kim JA, Lee JJ, Jung HH. Predictive factors of immediate postoperative complications after uvulopalatopharyngoplasty. *Laryngoscope* 2005;115: 1837-1840.
28. Esclamado RM, Glenn MG, McCulloch TM, et al. Perioperative complications and risk factors in the sur-

- gical treatment of obstructive sleep apnea syndrome. *Laryngoscope* 1989;99:1125-1129.
29. Kaw R, Golish J, Ghamande S, et al. Incremental risk of obstructive sleep apnea on cardiac surgical outcomes. *J Cardiovasc Surg* 2006;47(6):683-689.
  30. Memtsoudis S, Liu SS, Ma Y, et al. Perioperative pulmonary outcomes in patients with sleep apnea after noncardiac surgery. *Anesth Analg* 2011;112(1):113-121.
  31. Smetana GW. Postoperative pulmonary complications: an update on risk assessment and reduction. *Cleve Clin J Med* 2009 Nov;76 Suppl 4:S60-5.
  32. Kaw R, Chung F, Pasupuleti V, Mehta J, Gay PC, Hernandez AV. Meta-analysis of the association between obstructive sleep apnoea and postoperative outcome. *Br J Anaesth* 2012 Dec;109(6):897-906.
  33. Flemons WW, Douglas NJ, Kuna ST, et al. Access to diagnosis and treatment of patients with suspected sleep apnea. *Am J Respir Crit Care Med* 2004;169(6):668-672.
  34. Chung F, Yegneswaran B, Liao P, et al. Validation of the Berlin questionnaire and American Society of Anesthesiologists checklist as screening tools for obstructive sleep apnea in surgical patients. *Anesthesiology* 2008;108:822-30.
  35. Chung F, Yegneswaran B, Liao P, et al. STOP Questionnaire: a tool to screen patients for obstructive sleep apnea. *Anesthesiology* 2008;108:812-21.
  36. Chung F, Subramanyam R, Liao P, Sasaki E, Shapiro C, Sun Y. High STOP-Bang score indicates a high probability of obstructive sleep apnoea. *Br J Anaesth* 2012 May;108(5):768-75.
  37. Vasu TS, Doghramji K, Cavallazzi R, et al. Obstructive Sleep Apnea Syndrome and Postoperative Complications: Clinical Use of the STOP-BANG Questionnaire. *Arch Otolaryngol Head Neck Surg* 2010;136(10):1020-1024.
  38. Chung F, Liao P, Elsaid H, Islam S, Shapiro CM, Sun Y. Oxygen desaturation index from nocturnal oximetry: a sensitive and specific tool to detect sleep-disordered breathing in surgical patients. *Anesth Analg* 2012 May;114(5):993-1000.
  39. Petrini F, Vicini C, Gregoretti C, Corso RM. Raccomandazioni SIAARTI - AIMS per la gestione perioperatoria del paziente affetto da Sindrome delle Apnee Ostruttive del Sonno. [www.siaarti.it/lineeguida/pdf\\_img/file\\_37.pdf](http://www.siaarti.it/lineeguida/pdf_img/file_37.pdf).
  40. Dhonneur G, Combes X, Leroux B, et al. Postoperative obstructive apnea. *Anesth Analg* 1999;89:762-7.
  41. Ramsay MA, Saha D, Hebler RF. Tracheal resection in the morbidly obese patient: the role of dexmedetomidine. *J Clin Anesth* 2006 Sep;18(6):452-4.
  42. Pawlik MT, Hansen E, Waldhauser D, et al. Clonidine premedication in patients with sleep apnea syndrome: a randomized, double-blind, placebo-controlled study. *Anesth Analg* 2005 Nov;101(5):1374-80.
  43. Siyam MA, Benhamou D. Difficult endotracheal intubation in patients with sleep apnea syndrome. *Anesth Analg* 2002;95:1098-102.
  44. Kim JA, Lee JJ. Preoperative predictors of difficult intubation in patients with obstructive sleep apnea syndrome. *Can J Anaesth* 2006;53:393-7.
  45. Corso RM, Piraccini E, Calli M, et al. Obstructive sleep apnea is a risk factor for difficult endotracheal intubation. *Minerva Anestesiol* 2011 Jan;77(1):99-100.
  46. Plunkett AR, McLean BC, Brooks D, et al. Does difficult mask ventilation predict obstructive sleep apnea? A prospective pilot study to identify the prevalence of osa in patients with difficult mask ventilation under general anesthesia. *J Clin Sleep Med* 2011 Oct 15;7(5):473-7.
  47. El-Orbany M, Woehlick H, Salem MR. Head and neck position for direct laryngoscopy. *Anesth Analg* 2011 Jul;113(1):103-9.
  48. Kheterpal S, Han R, Tremper KK, et al. Incidence and predictors of difficult and impossible mask ventilation. *Anesthesiology* 2006 Nov;105(5):885-91.
  49. Hiremath AS, Hillman DR, James AL, Noffsinger WJ, Platt PR, Singer SL. Relationship between difficult tracheal intubation and obstructive sleep apnoea. *Br J Anaesth* 1998 May;80(5):606-11.
  50. Chung F, Yegneswaran B, Herrera F, Shenderoy A, Shapiro CM. Patients with difficult intubation may need referral to sleep clinics. *Anesth Analg* 2008 Sep;107(3):915-20.
  51. Payen JF, Jaber S, Levy P, et al. Obstructive sleep-apnoea syndrome in adult and its perioperative management. *Ann Fr Anesth Reanim* 2010 Nov;29(11):787-92.
  52. Ankichetty S, Wong J, Chung F. A systematic review of the effects of sedatives and anesthetics in patients with obstructive sleep apnea. *J Anaesthesiol Clin Pharmacol* 2011 Oct;27(4):447-58.
  53. Passannante AN, Rock P. Anesthetic management of patients with obesity and sleep apnea. *Anesthesiology Clin N Am* 2005;23:479-91.
  54. Murphy GS, Brull SJ. Residual neuromuscular block: lessons unlearned. Part I: definitions, incidence, and adverse physiologic effects of residual neuromuscular block. *Anesth Analg* 2010 Jul;111(1):120-8.
  55. Cooper RM, O'Sullivan E, Popat M, Behringer E, Hagberg CA. Difficult Airway Society guidelines for the management of tracheal extubation. *Anaesthesia* 2013 Feb;68(2):217.
  56. Loadman JA, Hillman DR. Anaesthesia and sleep apnea. *Brit J Anaesth* 2001;86(2):254-66.
  57. Neill AM, Angus SM, Sajkov D, et al. Effects of sleep posture on upper airway stability in patients with obstructive sleep apnea. *Am J Respir Crit Care Med* 1997;155:199-204.
  58. Rennotte MT, Baele P, Aubert G, et al. Nasal continuous positive airway pressure in the perioperative management of patients with obstructive sleep apnea submitted to Surgery. *Chest* 1995;107:367-74.
  59. Pelosi P, Gregoretti C. Perioperative management of obese patients. *Best Pract Res Clin Anaesthesiol* 2010 Jun;24(2):211-25.
  60. Cullen DJ. Obstructive sleep apnea and postoperative analgesia: a potentially dangerous combination. *J Clin Anesth* 2001;13:83-85.
  61. Etches RC. Respiratory depression associated with patient controlled analgesia: a review of eight cases. *Can J Anaesth* 1994;41:125-32.
  62. Gregoretti C, Corso RM, Insalaco G, Fanfulla F, Braghiroli A. Anesthesiologists and Obstructive Sleep Apnea: Simple Things May Still Work. *Chest* 2011;140:1097-1098.