Perioperative Management of Obstructive Sleep Apnea

Hairil R. Abdullah · Frances Chung

Published online: 7 November 2013
© Springer Science + Business Media New York 2013

Abstract Obstructive sleep apnea (OSA) has been linked to a myriad of chronic diseases with physically serious and economically draining consequences. There has been a substantial increase in its prevalence over the last two decades and up to one-quarter of the elective surgical patients have been found to be at high risk for OSA. These patients are at an increased risk for perioperative adverse events such as cardiac and pulmonary complications as well as postoperative delirium. This review addresses the screening methods such as the STOP-Bang questionnaire for the undiagnosed and the preoperative management of the known and at-risk patients. Recommendations for the evaluation of the systemic complications and its management are included. Recent suggestions for the intraoperative management and risk mitigation methods are reviewed, such as the role of regional anesthesia and non-opioid analgesics. Special focuses on postoperative issues such as pain control, oxygenation, positioning, and patient disposition are also included.

Keywords Perioperative · Obstructive sleep apnea · Sleep disordered breathing · Anesthesia · Surgery

Introduction

Obstructive sleep apnea (OSA) is characterized by closure of the pharyngeal airspace during sleep resulting in cessation of airflow into the lungs and bouts of hypoxia and hypercapnia, with these events most often terminated by arousal from sleep [1]. Definitive diagnosis of OSA requires polysomnography or sleep study, which derives the average number of abnormal breathing events per hour of sleep—the Apnea-Hypopnea Index (AHI). An apneic event refers to cessation of airflow for at least 10 s, and hypopnea occurs when there is reduced airflow with desaturation of 4 % or more [2]. The American Academy of Sleep Medicine (AASM) diagnostic criteria for OSA require either an $AHI \geq 15$, or $AHI \geq 5$, with symptoms such as excessive daytime sleepiness, unintentional sleep during wakefulness, unrefreshing sleep, loud snoring reported by partner, or observed obstruction during sleep [3]. The OSA severity is mild for AHI between 5 and 15, moderate for AHI between 15 and 30, and severe for AHI greater than 30 [3].

OSA has been gaining a lot of attention from health professionals especially in the last decade, as current evidence links it to a myriad of chronic diseases with physically serious and economically draining consequences [4]. Myocardial ischemia, heart failure, hypertension, arrhythmias, cerebrovascular disease, metabolic syndrome, insulin resistance, gastroesophageal reflux, and obesity are just some of the diseases associated with OSA [5•, 6]. Quality of life is adversely affected by the symptoms of OSA and productivity is also impaired [6, 7•]. It has even been estimated that the average life span of a patient with untreated OSA is 58 years, much shorter than the average life span of 78 years for men and 83 years for women [8].

The prevalence of OSA in the population is very large. A recent study estimates the prevalence of moderate to

H. R. Abdullah · F. Chung (✉)
Department of Anesthesiology, Toronto Western Hospital,
University Health Network, University of Toronto, Toronto, ON,
Canada
e-mail: frances.chung@uhn.ca

H. R. Abdullah
Department of Anesthesiology, Singapore General Hospital,
Singapore, Singapore
e-mail: hairil.rizal.abdullah@sgh.com.sg

severe OSA at 10 % among 30- to 49-year-old men, 17 % among 50- to 70-year-old men, 3 % among 30- to 49-year-old women, and 9 % among 50- to 70-year-old women [9]. These estimated prevalence rates represent substantial increases over the last 2 decades (relative increases of between 14 and 55 % depending on the subgroup) [9]. Of interest to anesthesiologists, the prevalence of OSA in the population presenting for surgery is higher than in the general population. One-quarter (24 %) of elective surgical patients were found by Finkel et al. [10] to be at high risk based on screening using the ARES questionnaire in an academic center in the Midwest in 2009, in agreement with a Toronto study by Chung et al. [11], who in 2007 used the Berlin Questionnaire preoperatively and found that 24 % of surgical patients were at high risk. A recent study showed that, out of 708 surgical patients not known to have OSA, 38 % of patients were diagnosed by polysomnography to have moderate-to-severe OSA and the majority of them were not diagnosed by the surgeons or the anesthesiologists [12]. This just shows how the effort and technique of screening for OSA could be improved in surgical patients.

Perioperative Complications

Evidence suggesting that OSA may be an independent risk factor for perioperative complications is increasing. Patients with diagnosed OSA have an increased risk for perioperative cardiac events such as ischemia and hemodynamic instability. Gupta et al. [13] demonstrated this in 2001 and Kaw et al. [14•] showed in their meta-analysis more than a decade later that the presence of OSA increased the odds (OR 2.1) of postoperative cardiac events.

As for pulmonary complications, Memtsoudis et al. [15] reported a higher risk for developing pulmonary complications, after both orthopedic and general surgical procedures, which includes aspiration pneumonia, acute respiratory distress syndrome and postoperative intubation/mechanical ventilation in their large cross-sectional study using the National Inpatient Sample database. Kaw et al. [16] again in 2012 demonstrated an increased risk of postoperative hypoxemia, transfer to ICU, and longer duration of hospitalization in OSA patients following noncardiac surgery. Other findings of the meta-analysis by Kaw and colleagues included increased risk of respiratory failure (OR 2.4), desaturation (OR 2.3), transfers to ICU (OR 2.8), and reintubations (OR 2.1) in the presence of OSA.

In obese patients undergoing bariatric surgery, Mokhlesi et al. [17] recently reported from a large sample database of 91,028 patients that OSA is independently associated with

increased risk of emergent endotracheal intubation (OR 4.35), CPAP/NIV use (OR 14.12), and atrial fibrillation (OR 1.25). They did, however, also report that there is a significantly decreased mortality (OR 0.34), total hospital charges, and length of stay (−0.25 days). A similar pattern was also reported in a review by the same authors of more than 1 million patients who underwent elective orthopedic, abdominal, and cardiovascular surgery [18•].

The possible complications are beyond cardiorespiratory, with Flink et al. [19] reporting a 53 % incidence of postoperative delirium in OSA patients versus 20 % in non-OSA patients, and more studies are emerging linking OSA with renal impairment [20, 21], although more research looking at these issues in the perioperative context are needed.

Preoperative Screening

While polysomnography is the gold standard for the diagnosis of OSA, it is often impractical to be used as a routine preoperative assessment tool due to the costs, time, and manpower requirements. As such, a number of screening tools had been developed to assess patients for OSA. The American Society of Anesthesiologists published guidelines in 2006 recommending screening of patients using a 16-item checklist comprising clinical criteria, categorized into physical characteristics, symptoms, and complaints, in order to identify probable OSA patients and its severity [22]. Munish et al. [23] recently found the tool to be useful with 95.1 % sensitivity and 52.2 % specificity and, at a prevalence of 10 %, the negative predictive value was 98.5 %.

Other tools and questionnaire-based methods include the Epworth Sleepiness Scale [24], the Berlin Questionnaire [25], the Sleep Apnea Clinical Score [26], the P-SAP score [27], and the STOP-Bang questionnaire [28]. Abrishami et al. [29] conducted a systematic review to evaluate the utility of eight patient-based questionnaires, and the Wisconsin and Berlin questionnaires were found to have the highest sensitivity and specificity, respectively, in predicting the existence of mild OSA, while the STOP-Bang and the Berlin questionnaires were found to have the highest sensitivity and specificity, respectively, in predicting moderate or severe OSA. The STOP-Bang questionnaires were found to have the highest methodological validity, reasonable accuracy, and easy-to-use features [29, 30].

The STOP-Bang questionnaire was initially developed for the surgical population in North America, but has since been validated and used in various patient populations internationally [5•, 28–36]. It has been reported to have a high sensitivity up to 92.8 % for moderate OSA and 95.6 % for severe OSA, with negative predictive values of

84.5 and 93.4 %, respectively in an Asian population [36]. This concise scoring system consists of eight easily administered questions framed with the acronym STOP-Bang, assessing snoring, tiredness, observed apnea, high blood pressure, body mass index more than 35, age more than 50, neck circumference more than 40 cm and male gender. A “yes” answer will be scored as 1, and patients are deemed to be at risk of OSA if they have a STOP-Bang score of 3 or greater, and at high risk of OSA if the STOP-Bang score is 5 or more [5•, 28]. The presence of a bed partner during questioning may be helpful to elucidate the symptoms of OSA, such as habitual snoring, nocturnal choking or gasping, or observed apneas. Patients are unlikely to have moderate to severe OSA with a score of 0–2. However, the false-positive rate can be a concern. For moderate OSA (AHI > 15) and severe OSA (AHI > 30), the sensitivity of the STOP-Bang score is 93 and 100 %, respectively, whereas the specificity is 43 and 37 %, respectively [26]. STOP-Bang scores ≥ 5 are more predictive for moderate to severe OSA and, for higher cut-off values of 5, 6, and 7, the specificity of the STOP-Bang questionnaire for severe OSA (AHI > 30) was 74, 88, and 95 %, respectively [5•, 32]. To avoid overzealous testing and unnecessary postoperative monitoring resulting from the high false-positive rates associated with lower cutoff values, it may be more cost-effective to use a STOP-Bang cut off of 5–8 [5•, 32].

Preoperative Evaluation and Management

The Known OSA Patient

Preoperative interviews with the diagnosed OSA patients are essential as they should be counseled regarding increased perioperative risks and the possible need for postoperative monitoring. Polysomnography results should be reviewed to confirm the diagnosis of OSA and to evaluate the severity of the disease. Systemic complications of long-standing OSA such as hypoxemia, hypercarbia, polycythemia, and cor pulmonale should be looked for [5•]. The presence of significant comorbidities, including morbid obesity, uncontrolled hypertension, arrhythmias, cerebrovascular disease, heart failure, and metabolic syndrome, are important. Their medication and state of control should be assessed and optimized.

The American College of Chest Physicians does not recommend routine evaluation for pulmonary arterial hypertension in patients with known OSA, thus a preoperative transthoracic echo cardiogram is usually not needed, even though the pulmonary arterial hypertension is recognized as a common long-term complication of OSA, occurring in 15–20 % of patients [37, 38]. However, it may

be considered if there are anticipated intraoperative triggers for acute elevations in pulmonary arterial pressures, for example, high-risk surgical procedures of long duration [39]. Simple bedside investigations may be performed in the preoperative clinic to screen for OSA: a baseline oximetry reading of ≤ 94 % on room air without any other underlying condition may suggest severe OSA, and may be a red flag signaling postoperative adverse outcome.

Patients on positive airway pressure therapy (PAP) at home, either continuous PAP (CPAP) or bilevel PAP, should be encouraged to bring their PAP devices with them to the medical facility, as this may well facilitate compliance in the postoperative period [40]. Reassessment by a sleep medicine physician may be indicated in patients who have defaulted follow-up, been non-compliant to treatment, have had recent exacerbation of symptoms, or have undergone upper airway surgery to relieve OSA symptoms. Patients who default PAP use should be advised to resume therapy [5•]. Recognizing that the adherence to prescribed CPAP therapy during the perioperative period can be extremely low [41], a regular reminder on how patients identified preoperatively to have OSA and treated with CPAP have long-term health benefits in terms of improved snoring, sleep quality, daytime sleepiness, and reduction of medications for comorbidities may be needed [42].

To date, evidence is still inconclusive regarding the benefit of PAP therapy in the preoperative setting and the duration of therapy needed for reducing the perioperative risks. A retrospective matched cohort study by Liao et al. [43] suggested that preoperative PAP therapy may possibly be beneficial, based on the observation that OSA patients who did not use home PAP devices prior to surgery but required PAP therapy after surgery had increased complication rates. Perioperative auto-titrated continuous positive airway pressure treatment was also shown to significantly reduce the postoperative apnea hypopnea index and to improve oxygen saturation in surgical patients with moderate and severe obstructive sleep apnea in one recent trial [44].

The Suspected OSA Patient

The preoperative management of the suspected OSA patient will depend on the urgency of the surgery. In the emergency setting, the patient should proceed with the surgery and perioperative precautions be taken based on clinical judgment, as extensive preoperative testing will not be appropriate. Seet et al. has published a suggested clinical pathway (Fig. 1) for the perioperative management of the suspected OSA patient in the elective surgery setting, using the STOP-Bang questionnaire [5•, 45]. The invasiveness of the surgery and the presence of significant chronic OSA-related comorbidities (such as uncontrolled

Fig. 1 Preoperative evaluation of diagnosed or suspected obstructive sleep apnea patients.

a Positive airway pressure (PAP) therapy—includes continuous PAP, bilevel PAP, and automatically adjusting PAP. **b** Significant comorbidities—heart failure, arrhythmias, uncontrolled hypertension, pulmonary hypertension, cerebrovascular disease, metabolic syndrome, and obesity BMI >35 kg/m². **c** PSG (Polysomnography)—includes level 1 to level 4 in-laboratory and portable polysomnography devices

hypertension, heart failure, arrhythmias, pulmonary hypertension, cerebrovascular disease, morbid obesity, and metabolic syndrome) are the two most important determinants of the need for further evaluation. The authors suggested that, for high-risk patients (STOP-Bang scores ≥ 5), who are scheduled for major elective surgery and have the said comorbidities, a preoperative assessment by the sleep physician and a polysomnography should be considered for diagnosis and treatment. For the high-risk patients without the comorbidities, further evaluation by a portable monitoring device if available could be considered, or the surgery could proceed, with a presumed diagnosis of moderate OSA and perioperative risk mitigation steps (Table 1) [45]. These patients can be referred to the family or sleep physicians after the surgery. Seet et al. [45] further suggested that patients with an intermediate risk of OSA based on the STOP-Bang questionnaire may proceed for surgery with perioperative OSA precautions. Nonetheless, increased vigilance is recommended in managing these at-risk patients and, if the subsequent intraoperative and postoperative course suggests a higher likelihood of OSA, for example, difficult airway or recurrent postoperative respiratory events such as desaturation, hypoventilation, or apnea, a postoperative referral to the family or sleep physician and polysomnography may be indicated [5•, 45, 46].

A recent retrospective review by Chong et al. [47] has also shown that there was no significant increase in the postoperative complications, as long as these at-risk patients are managed on an OSA risk mitigation protocol.

The Portable Monitoring Task Force of the AASM suggests that portable devices may be considered when there is high pretest likelihood for moderate to severe OSA

without other substantial comorbidities [48]. Among the available options for testing are included the overnight oximetry and portable polysomnography (or Home Sleep Testing—HST). Overnight oximetry with recording, which can report an oxygen desaturation index (ODI), is a sensitive and specific tool for detecting sleep-disordered breathing that is characterized by respiratory events associated with desaturations [49, 50]. The combination of the STOP-Bang questionnaire and the nocturnal oximeter may provide the higher sensitivity and specificity required in the diagnosis of OSA.

The limited channel Home Sleep Testing is becoming more popular due to its advantages, such as accessibility, ease of use, ability to study patients in their home, and potential cost savings. The use of HST, however, is limited to patients without significant cardiac, pulmonary, or neurologic disease, and a rigorous quality oversight, including review of the raw data by a knowledgeable practitioner, is necessary to ensure good patient care. The data suggest that HST can identify OSA preoperatively in a substantial portion of the adult surgical population at risk for OSA [10]. HST provides a valid diagnosis of OSA for most insurance carriers, which is necessary for patients to obtain their own personal CPAP equipment.

Intraoperative Management

The intraoperative management and risk mitigation strategies for the OSA patient rely on the understanding of the pharmacology of sedatives and anesthetics as well as the physiological changes of OSA and its relationship with one

Table 1 Perioperative precautions and risk mitigation for OSA patients

Anesthetic concern	Principles of management
Premedication	Avoid sedating premedication [56] Consider Alpha-2 adrenergic agonists (clonidine, dexmedetomidine) [57]
Potential difficult airway (difficult mask ventilation and tracheal intubation) [58, 59]	Optimal positioning (Head Elevated Laryngoscopy Position) if patient obese Adequate preoxygenation Consider CPAP preoxygenation [62] Two-handed triple airway maneuvers Anticipate difficult airway. Personnel familiar with a specific difficult airway algorithm [61]
Gastroesophageal reflux disease [64]	Consider proton pump inhibitors, antacids, rapid sequence induction with cricoid pressure
Opioid-related respiratory depression [56]	Minimize opioid use Use of short-acting agents (remifentanyl) Multimodal approach to analgesia (NSAIDs, acetaminophen, tramadol, ketamine, gabapentin, pregabalin, dexmedetomidine, clonidine, dexamethasone, melatonin) Consider local and regional anesthesia where appropriate
Carry-over sedation effects from longer-acting intravenous and volatile anesthetic agents	Use of propofol/remifentanyl for maintenance of anesthesia Use of insoluble potent anesthetic agents (desflurane) Use of regional blocks as the sole anesthetic technique
Excessive sedation in monitored anesthetic care	Use of intraoperative capnography for monitoring of ventilation [26]
Post-extubation airway obstruction	Verify full reversal of neuromuscular blockade [26] Extubate only when fully conscious and cooperative [26] Non-supine posture for extubation and recovery [26] Resume use of positive airway pressure device after surgery [26]

Adapted from Ref. [45, Table 2] with kind permission of Springer Science+Business Media

CPAP continuous positive airway pressure, NSAID nonsteroidal anti-inflammatory drug

another. Various protocols have been described by various institutions [5•, 22, 51], but most of the concerns and the suggested mitigating techniques are summarized in Table 1. In essence, any sedatives administered should be titrated slowly to the desired effect or avoided, if possible. Regional anesthesia may be preferred over general anesthesia, as suggested by a recent data analysis of more than 30,000 sleep apnea patients undergoing total joint arthroplasty [52•]. Pain adjuvants such as the α_2 -agonists (dexmedetomidine) have an opioid-sparing effect and also reduce the anesthetic requirement [53]. The ideal general anesthetic technique should use agents that allow rapid restoration of consciousness and return to baseline respiratory function, thus short-acting agents such as propofol and desflurane are preferred. The use of perioperative opioids has been reported as the main factor associated with adverse perioperative outcome in a systematic review by Chung et al. [54]. As such, intraoperative and postoperative analgesia should be provided, preferably with nonopioid analgesics, and, when opioid use is unavoidable, ultra-short acting opioids such as remifentanyl should be considered [51]. Furthermore, alternative techniques of pain relief, including regional blocks, acetaminophen, NSAIDs, Cox-2 inhibitors, etc., should be used when possible.

As OSA is associated with difficult mask ventilation, and a difficult tracheal intubation occurs eight times more often in OSA patients than in those without OSA, the induction of anesthesia should never be rushed and the airway manipulation planned well ahead with appropriate adjuncts if necessary [55, 56]. Preoxygenation with 100 % oxygen until the end-tidal oxygen is at least 90 % can be accomplished by using CPAP at 10 cm H₂O for 3–5 min with the patient in a 25° head-up position [57, 58]. Since pulmonary hypertension is a known complication of chronic OSA, intraoperative triggers for elevation of pulmonary artery pressures, namely hypercarbia, hypoxemia, hypothermia, and acidosis, should also be avoided [5•].

Post-operative tracheal extubation should be done carefully after adequate assessment for the recovery of muscle strength following appropriate reversal of neuromuscular blocking agents, and when the patient is fully awake and able to follow simple commands. It is also reasonable for patients receiving sedation under monitored anesthetic care to be monitored for adequacy of ventilation by capnography.

Postoperative Issues and Follow-Up

Pain

Multiple studies have demonstrated the respiratory effects of various postoperative analgesic regimens on ventilatory

function and apnea episodes. Ramachandran et al. [59] concluded that the first 24 h after commencing opioid-based analgesic therapy for acute pain represents a high-risk period for an OSA patient. Blake et al. [60] noted in their study on postoperative patient-controlled analgesia that the frequency of central apneas and the rate of respiratory events $>15/h$ were related to the postoperative morphine dose, reinforcing the recommendation that a multimodal approach to analgesia should be used to minimize the use of opioids postoperatively. The ASA guidelines states that regional analgesic techniques rather than systemic opioids reduce the likelihood of adverse outcomes in patients at increased perioperative risk from OSA, and if neuraxial blocks is performed, exclusion of opioids from neuraxial postoperative analgesia reduces the risks [22]. And if patient-controlled analgesia is warranted, careful consideration should be applied to reduce the total amount of opioid used, such as no basal infusion and a strict hourly dose limit.

Oxygenation and Positioning

Supplemental oxygen should be administered as needed to maintain acceptable arterial oxygen saturation, and may be discontinued when patients are able to maintain their baseline oxygen saturation while breathing room air. OSA patients may also have an up-regulation of the central opioid receptors secondary to recurrent hypoxemia, and are therefore more susceptible to the respiratory depressant effects of opioids; thus, they may benefit from supplemental oxygen while on parenteral opioids [61]. However, it should also be kept in mind that oxygen therapy may prolong apneas in some individuals, and the use of supplemental oxygen therapy may also mask the development of hypercapnia, which may be seen in patients with known OSA who require supplemental oxygen added to home PAP therapy, as well as in patients with suspected OSA who require upward titration of oxygen supplementation [62].

While there is insufficient evidence to recommend a specific patient position postoperatively, the ASA guidelines states that the supine position should be avoided when possible during the recovery of patients who are at increased perioperative risk from OSA. Improvement in AHI scores when adult patients with OSA sleep in the lateral, prone, or sitting positions has been described in non-perioperative settings [22]. CPAP or NIPPV should also be administered as soon as feasible after surgery to patients with OSA who were receiving it preoperatively [22].

Disposition

All patients with known or suspected OSA who have received general anesthesia should have extended

monitoring in the PACU with continuous oximetry (Table 2). While data are lacking on the optimal duration, the ASA recommend prolonged observation for 7 h in the PACU if respiratory events such as apnea or airway obstruction occur, which is difficult to adhere to, especially in the context of community hospitals [63]. Seet and Chung [45] developed a postoperative management pathway for patients with known or suspected OSA which takes into account the OSA status, postoperative opioid requirement, and respiratory events in the post-anesthesia care unit. It incorporates a two-phase assessment concept which includes preoperative and postoperative assessments to arrive at an algorithm for triage to appropriate postoperative care [64]. An extended PACU observation for an additional 60 min after the modified Aldrete criteria for discharge have been met was recommended. Here, the patients should be observed for respiratory events such as episodes of apnea for >10 s, bradypnea <8 breaths per minute, repeated oxygen desaturation $<90\%$, or pain-sedation mismatch. Any of these recurrent events should prompt the anesthesiologist to consider continuing care in an environment with continuous oximetry and the possibility of early medical intervention (e.g., intensive care unit, step-down unit, or remote pulse oximetry with telemetry in the surgical ward). These patients may also require postoperative PAP therapy [63]. Seet and Chung also recommended in their pathway for patients with known moderate–severe OSA (AHI >15) or those non-compliant to PAP therapy, to be discharged to a monitored environment. Furthermore, monitoring with continuous oximetry is recommended if parenteral opioids are administered, in view of possible drug-induced respiratory depression. Patients with moderate OSA who require high-dose oral opioids should also be managed in a surgical ward with continuous oximetry, regardless of the number of PACU respiratory events [5•].

Ambulatory Surgery

Managing OSA patients in the ambulatory setting can be challenging. The Society for Ambulatory Anesthesia (SAMBA) consensus statement has provided guidelines addressing the selection of suitable OSA patients for ambulatory surgery [65]. A systematic review of studies involving ambulatory surgery in OSA patients found that, despite a higher incidence of desaturation and the need for supplemental oxygen among OSA patients, there was no significant difference in rates of serious adverse outcomes such as re-intubation, mechanical ventilation, surgical airway, or death.

Among their recommendations are that OSA patients with non-optimized comorbid medical conditions may not be good candidates for ambulatory surgery. Painful

Table 2 Points for continuous postoperative management of obstructive sleep apnea

Recurrent PACU respiratory events or Moderate/severe OSA (AHI > 15) or Non-compliance with PAP therapy or Significant comorbidities(heart failure, arrhythmias, uncontrolled hypertension, cerebrovascular disease, metabolic syndrome, obesity BMI >35 kg/m ²) or Postoperative parenteral opioids	STOP-Bang ≥ 5 with Postoperative parenteral opioids or Recurrent PACU respiratory events
Both groups should have extra PACU monitoring, 60 min after modified Aldrete criteria met	
If yes to any points, suggests continuous oximetry monitoring &/or PAP therapy (including continuous PAP, bilevel PAP, or automatically adjusting PAP). Consider monitoring in patients with parenteral opioids	
If none, discharge for minor surgery not requiring high dose oral opioids	

Adapted from Ref. [45, Fig. 2] with kind permission of Springer Science+Business Media

ambulatory surgery may not be suitable if postoperative pain relief cannot be predominantly provided with non-opioid analgesic techniques. As such, the use of multi-modal pain control methods such as local/regional anesthesia, NSAIDs, acetaminophen, and dexamethasone should be considered. Patients with known OSA who are unable or unwilling to use CPAP after discharge may not be appropriate for ambulatory surgery, and for those who are, they should be advised to use their devices when sleeping even in daytime for several days postoperatively [65].

Caution should be exercised if diagnosed or suspected OSA patients develop repeated respiratory events in the early postoperative period, and there should be a lower threshold for unanticipated hospitalization and, ideally, ambulatory surgical centers that manage OSA patients should have transfer agreements with better equipped inpatient facilities, and should also have the capacity to handle the postoperative problems associated with OSA [5••].

Conclusion

Obstructive sleep apnea in patients undergoing surgery presents a special challenge to the anesthesiologist with implications extending from the preoperative throughout the postoperative period. A high degree of vigilance should be practised, with help from screening questionnaires to identify the undiagnosed patients. A greater awareness

among medical practitioners involved in the surgical and perioperative care, coupled with the use of OSA perioperative algorithms, may help to guard the safety and improve the outcome of these patients.

Compliance with Ethics Guidelines

Conflict of Interest Hairil R. Abdullah and Frances Chung declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:

- Of importance
- Of major importance

1. Horner RL. Pathophysiology of obstructive sleep apnea. *J Cardiopulm Rehabil Prev.* 2008;28(5):289–98.
2. Iber C, Ancoli-Israel S, Cheeson A, et al. The AASM manual for the scoring of sleep and associated events, rules, terminology and technical specifications. Westchester: American Academy of Sleep Medicine; 2007.
3. Epstein LJ, Kristo D, Strollo PJ, et al. Clinical guideline for the evaluation, management and long-term care of obstructive sleep apnea in adults. *J Clin Sleep Med.* 2009;5:263–76.
4. Hillman DR, Murphy AS, Antic R, et al. The economic cost of sleep disorders. *Sleep.* 2006;29:299–305.
5. •• Seet E, Tee LH, Chung F. Perioperative clinical pathways to manage sleep-disordered breathing. *Sleep Med Clin* 2013; 8:105–120. *Good update on clinical pathways and algorithms for the perioperative care of OSA patients.*
6. Bennett LS, Barbour C, Langford B, et al. Health status in obstructive sleep apnea: relationship with sleep fragmentation and daytime sleepiness, and effects of continuous positive airway pressure treatment. *Am J Resp Crit Care Med.* 1999; 159:1884–90.
7. • Leger D, Bayon V, Laaban JP, et al. Impact of sleep apnea on economics. *Sleep Med Rev* 2012; 16:455–62. *A good review on the possible links between sleep apnea and its consequences on accidents, work, economics, and health-related quality of life.*
8. Young T, Finn L. Epidemiological insights into the public health burden of sleep disordered breathing: sex differences in survival among sleep clinic patients. *Thorax.* 1998;53:S16–9.
9. Peppard PE, Young T, Barnet JH, et al. Increased prevalence of sleep disordered breathing in adults. *Am J Epidemiol.* 2013; 177(9):1006–14.
10. 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;10:753–8.
11. Chung F, Ward B, Ho J, Yuan H, et al. Preoperative identification of sleep apnea risk in elective surgical patients using the Berlin questionnaire. *J Clin Anesth.* 2007;19:130–4.
12. Singh M, Liao P, Kobah S, et al. Proportion of surgical patients with undiagnosed obstructive sleep apnea. *Br J Anaesth.* 2013;110:629–36.

13. 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.
14. • Kaw R, Chung F, Pasupuleti J, et al. Meta-analysis of the association between obstructive sleep apnoea and postoperative outcome. *Br J Anaesth* 2012; 109:897–906. *A good meta-analysis of 13 studies demonstrating the higher incidence of complications in patients with OSA.*
15. Memtsoudis S, Liu SS, Ma Y, et al. Perioperative pulmonary outcomes in patients with sleep apnea after noncardiac surgery. *Anesth Analg.* 2011;112:113–21.
16. Kaw R, Pasupuleti V, Walker E, et al. Postoperative complications in patients with obstructive sleep apnea. *Chest.* 2012;141(2): 436–41.
17. Mokhlesi B, Hovda MD, Vekhter B, et al. Sleep disordered breathing and postoperative outcomes after bariatric surgery: analysis of the nationwide inpatient sample. *Obes Surg.* 2013;23(11):1842–51.
18. • Mokhlesi B, Hovda MD, Vekhter B, et al. Sleep disordered breathing and postoperative outcomes after elective surgery: analysis of the nationwide inpatient sample. *Chest.* 2013; 144(3):903–914. *An interesting recent study of a large sample size concluding that patients with Sleep Disordered Breathing undergoing surgery do not have increased odds of in-hospital death despite the higher postoperative cardiopulmonary complications.*
19. Flink BJ, Rivelli SK, Cox EA, et al. Obstructive sleep apnea and incidence of postoperative delirium after elective knee replacement in the nondemented elderly. *Anesthesiology.* 2012;116: 788–96.
20. Ahmed SB, Ronksley PE, Hemmelgarn BR, et al. Nocturnal hypoxia and loss of kidney function. *PLoS ONE.* 2011;6(4): e19029.
21. Chou YT, Lee PH, Yang CT, et al. Obstructive sleep apnea: a stand-alone risk factor for chronic kidney disease. *Nephrol Dial Transplant.* 2011;26:2244–50.
22. Gross JB, Bachenberg KL, Benumof JL, et al. Practice guidelines for the perioperative management of patients with obstructive sleep apnea: a report by the American Society of Anesthesiologists Task Force on perioperative management of patients with obstructive sleep apnea. *Anesthesiology.* 2006;104:1081–93.
23. Munish M, Sharma V, Yarussi KM, et al. The use of practice guidelines by the American Society of Anesthesiologists for the identification of surgical patients at high risk of sleep apnea. *Chron Respir Dis.* 2012;9:221–30.
24. Johns MW. A new method of measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep.* 1991;14:540–5.
25. Netzer NC, Hoegel JJ, Loubé D, et al. Prevalence of symptoms and risk of sleep apnea in primary care. *Chest.* 2003;124: 1406–14.
26. Flemons WW, Whitelaw WA, Brant R, et al. Likelihood ratios for a sleep apnea clinical prediction rule. *Am J Respir Crit Care Med.* 1994;150:1279–85.
27. Ramachandran SK, Kheterpal S, Consens F, et al. Derivation and validation of a simple perioperative sleep apnea prediction score. *Anesth Analg.* 2010;110:1007–15.
28. Chung F, Yegneswaran B, Liao P, et al. STOP questionnaire: a tool to screen patients for obstructive sleep apnea. *Anesthesiology.* 2008;108:812–21.
29. Abrishami A, Khajehdehi A, Chung F. A systematic review of screening questionnaires for obstructive sleep apnea. *Can J Anesth.* 2010;57:423–38.
30. Ankichetty S, Chung F. Considerations for patients with obstructive sleep apnea undergoing ambulatory surgery. *Curr Opin Anesthesiol.* 2011;24:605–11.
31. Farney RJ, Walker BS, Farney RM, et al. The STOPBang equivalent model and prediction of severity of obstructive sleep apnea: relation to polysomnographic measurements of the apnea/hypopnea index. *J Clin Sleep Med.* 2011;7:459–65.
32. Chung F, Subramanyam R, Liao P, et al. High STOP-Bang score indicates a high probability of obstructive sleep apnoea. *Br J Anaesth.* 2012;108:768–75.
33. Yu Y, Mei W, Cui Y. Primary evaluation of the simplified Chinese version of STOP-Bang scoring model in predicting obstructive sleep apnea hypopnea syndrome. *Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi.* 2012;26:256–9.
34. Coelho FM, Pradella-Hallinan M, Palombini L, et al. The STOP-Bang questionnaire was an useful tool to identify OSA during epidemiological study in Sao Paulo (Brazil). *Sleep Med.* 2012; 13(4):450–1.
35. Silva GE, Vana KD, Goodwin JL, et al. Identification of patients with sleep disordered breathing: comparing the four-variable screening tool, STOP, STOP-Bang, and Epworth Sleepiness Scales. *J Clin Sleep Med.* 2011;7:467–72.
36. Ong TH, Raudha S, Fook-Chong S, et al. Simplifying STOP-Bang: use of a simple questionnaire to screen for OSA in an Asian population. *Sleep Breath.* 2010;14:371–6.
37. Bady E, Achkar A, Pascal S, et al. Pulmonary hypertension in patients with sleep apnoea syndrome. *Thorax.* 2000;55:934–9.
38. Atwood CW, McCrory D, Garcia JG, et al. Pulmonary artery hypertension and sleep-disordered breathing: ACCP evidence-based clinical practice guidelines. *Chest.* 2004;126:72S–7S.
39. Adesanya AO, Lee W, Greilich NB, et al. Perioperative management of obstructive sleep apnea. *Chest.* 2010;138:1489–98.
40. Auckley D, Bolden N. Preoperative screening and perioperative care of the patient with sleep-disordered breathing. *Curr Opin Pulm Med.* 2012;18:588–95.
41. Guralnick AS, Pant M, Minhaj M, et al. PAP adherence in patients with newly diagnosed obstructive sleep apnea prior to elective surgery. *J Clin Sleep Med.* 2012;8:501–6.
42. Mehta V, Subramanyam R, Shapiro CM, et al. Health effects of identifying patients with undiagnosed obstructive sleep apnea in the preoperative clinic: a follow-up study. *Can J Anesth.* 2012; 59:544–55.
43. 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.
44. Liao P, Luo Q, Elsaid H, et al. Perioperative auto-titrated continuous positive airway pressure treatment in surgical patients with obstructive sleep apnea: a RCT. *Anesthesiology.* 2013;119:837–47.
45. Seet E, Chung F. Management of sleep apnea in adults—functional algorithms for the perioperative period: continuing Professional Development. *Can J Anesth.* 2010;57:849–64.
46. Chung F, Yegneswaran B, Herrera F, Shenderoy A, Shapiro CM. Patients with difficult intubation may need referral to sleep clinics. *Anesth Analg.* 2008;107:915–20.
47. Chong CT, Tey J, Leow SL, et al. Management plan to reduce risks in perioperative care of patients with obstructive sleep apnoea averts the need for presurgical polysomnography. *Ann Acad Med Singap.* 2013;42:110–9.
48. Collop NA, Anderson WM, Boehlecke B, et al. Clinical guidelines for the use of unattended portable monitors in the diagnosis of obstructive sleep apnea in adult patients: portable Monitoring Task Force of the American Academy of Sleep Medicine. *J Clin Sleep Med.* 2007;3:737–47.
49. Malbois M, Giusti V, Suter M, et al. Oximetry alone versus portable polygraphy for sleep apnea screening before bariatric surgery. *Obes Surg.* 2010;20:326–31.
50. Chung F, Liao P, Elsad H, et al. Oxygen desaturation index from nocturnal oximetry a sensitive and specific tool to detect sleep

- disordered breathing in surgical patients. *Anesth Analg.* 2012; 114:993–1000.
51. Adesanya AO, Lee W, Greilich NB, et al. Perioperative management of obstructive sleep apnea. *Chest.* 2010;138:1489–98.
 52. • Memtsoudis SG, Stundner O, Rasul R, et al. Sleep apnea and total joint arthroplasty under various types of anesthesia : A population-based study of perioperative outcomes. *Reg Anesth Pain Med* 2013;38:274–281. *One of the first analyses of a large database that shows the benefit of choosing regional anesthesia over general anesthesia in sleep apnea patients.*
 53. Bamgbade OA, Alfa JA. Dexmedetomidine anaesthesia for patients with obstructive sleep apnoea undergoing bariatric surgery. *Eur J Anaesthesiol.* 2009;26:176–7.
 54. Chung SA, Yuan H, Chung F. A systemic review of obstructive sleep apnea and its implications for anesthesiologists. *Anesth Analg.* 2008;107:1543–63.
 55. Kheterpal S, Martin L, Shanks AM, et al. Prediction and outcomes of impossible mask ventilation: a review of 50,000 anesthetics. *Anesthesiology.* 2009;110:891–7.
 56. Siyam MA, Benhamou D. Difficult endotracheal intubation in patients with sleep apnea syndrome. *Anesth Analg.* 2002;95: 1098–102.
 57. Delay JM, Sebbane M, Jung B, et al. The effectiveness of non-invasive positive pressure ventilation to enhance preoxygenation in morbidly obese patients: a randomized controlled study. *Anesth Analg.* 2008;107:1707–13.
 58. Dixon BJ, Dixon JB, Carden JR, et al. Preoxygenation is more effective in the 25 degrees head-up position than in the supine position in severely obese patients: a randomized controlled study. *Anesthesiology.* 2005;102:1110–5.
 59. Ramachandran SK, Haider N, Saran KA, et al. Life-threatening critical respiratory events: a retrospective study of postoperative patients found unresponsive during analgesic therapy. *J Clin Anesth.* 2011;23:207–13.
 60. Blake DW, Yew CY, Donnan GB, et al. Postoperative analgesia and respiratory events in patients with symptoms of obstructive sleep apnoea. *Anaesth Int Care.* 2009;37:720–5.
 61. Blake DW, Chia PH, Donnan G, et al. Preoperative assessment for obstructive sleep apnoea and the prediction of postoperative respiratory obstruction and hypoxaemia. *Anaesth Int Care.* 2008;36:379–84.
 62. Mehta V, Vasu TS, Phillips B, et al. Obstructive sleep apnea and oxygen therapy: a systematic review of the literature and meta-analysis. *J Clin Sleep Med.* 2013;9:271–9.
 63. Sundar E, Chang J, Smetana GW. Perioperative screening for and management of patients with obstructive sleep apnea. *J Clin Outcome Manag.* 2011;18:399–411.
 64. Gali B, Whalen FX, Schroeder DR, et al. Identification of patients at risk for postoperative respiratory complications using a pre-operative obstructive sleep apnea screening tool and postanesthesia care assessment. *Anesthesiology.* 2009;110:869–77.
 65. Joshi GP, Ankichetty SP, Gan TJ, et al. Society for Ambulatory Anesthesia Consensus statement on preoperative selection of adult patients with obstructive sleep apnea scheduled for ambulatory surgery. *Anesth Analg.* 2012;115:1060–8.