Introduction

Obstructive sleep apnea (OSA) is a clinical syndrome defined by repetitive partial or complete upper airway obstruction, characterized by episodes of breathing cessation during sleep lasting 10 or more seconds. The inherent pharyngeal collapsibility due to depression of pharyngeal muscle regulation during sleep and anesthesia predisposes to impaired respiration. Recurring airway obstruction causes repeated arousals and increased sympathetic output, cumulating in daytime hypersomnolence, memory loss, executive dysfunction and other psychological disturbances. OSA is the most prevalent of sleep disordered breathing. Its reported prevalence varies widely depending on the demographics of the population studied, the definition of the disorder, and the method of diagnosis. The estimates of mild OSA are in the range of 1 in 4 males and 1 in 10 females in the general population. Moderate OSA estimates are in the range of 1 in 9 males and 1 in 20 females.

A significant proportion of OSA patients remain undiagnosed when patients present for surgery. About a quarter (24%) of elective surgical patients were found to be at high risk of OSA, of whom 4 out of 5 (81%) had not been diagnosed with OSA. Even in the context of ambulatory surgery, undiagnosed OSA may be frequently present. Furthermore, OSA may be associated with increased risk of postoperative complications. Therefore, OSA patients can be a potential management challenge for the anesthesiologist in the perioperative period and anesthesiologists need to have a thorough understanding of this disorder.

Classical Diagnosis Criteria for OSA

The classical diagnosis of OSA is established by an overnight polysomnography or sleep study. The apnea hypopnea index (AHI) is the number of abnormal respiratory events (complete cessation or apnea, and partial obstructions or hypopnea) per hour of sleep. These pauses in breathing must last for 10 seconds and are associated with decrease in oxygenation of the blood. There is a lack of conformity as to the diagnostic criteria for OSA. In 1999, the task force of the American Academy of Sleep Medicine (AASM) stipulated the minimal clinical diagnostic criteria for OSA as an AHI of 10 plus symptoms of excessive daytime sleepiness. According to the Canadian Thoracic Society guidelines, the AHI cutoffs have been used to describe the severity of OSA. The AASM defines mild OSA as AHI between 5 and 15, moderate OSA as AHI between 15 and 30, and severe OSA as AHI more than 30.

Comorbidities Associated with OSA

OSA has known associations with several comorbidities, including cardiovascular disease (acute myocardial infarction, heart failure, arrhythmias, hypertension), cerebrovascular disease, metabolic syndrome, gastro-esophageal reflux disease, and obesity. In bariatric surgery, 7 out of every 10
patients were found to have OSA. Certain patient profiles (male, above 50 years old, neck circumference greater than 40 cm), endocrine disorders (Cushing’s disease, hypothyroidism), connective tissue disorders (Marfan’s syndrome), lifestyle habits (alcohol, smoking), and anatomical abnormalities may predispose to OSA. Altered upper airway anatomy (craniofacial abnormalities, macroglossia, retrognathia) may also reduce lumen diameter, increasing the propensity for these episodic airway obstruction.

**Postoperative Complications in Patients with OSA**

In the general community, long-standing untreated OSA is an independent risk factor for increased all-cause mortality. In the perioperative setting, serious complications occurred more frequently in OSA patients because of alteration in airway anatomy and pathophysiology of the disease. This was demonstrated in several studies. Two single-center retrospective trials investigated postoperative complications in diagnosed OSA patients. Gupta et al demonstrated that serious postoperative complications in OSA patients undergoing hip or knee replacement occurred in 24% compared to 9% in the control group. These serious complications included unplanned ICU days, reintubations, and cardiac events. Similarly, Liao and Chung et al found that in 240 matched OSA and non-OSA patients who underwent elective surgery, the incidence of postoperative complications in the OSA group was 44% compared to 28% in the non-OSA group.

In another prospective cohort study, Chung et al demonstrated that the incidence of postoperative complications in 147 OSA patients compared with those without OSA was 27.4% versus 12.3%. Gali et al found an increased risk of postoperative complications in 221 high risk OSA patients. In a recent published propensity scored case-control study by Kaw et al, OSA was reported to be independently associated with increased postoperative hypoxemia, intensive care unit transfers and longer hospital stays after non-cardiac surgery. Memtsoudis et al found that sleep apnea patients, compared to matched controls, developed two-fold higher risks of pulmonary complications after both orthopedic and general surgeries versus non-OSA patients. Flum et al showed that a diagnosis of OSA in patients undergoing bariatric surgery was an independent risk factor for adverse postoperative outcomes. Convincingly, OSA patients pose an increased risk of postoperative complications; therefore perioperative precautions should be undertaken by the anesthesiologist to mitigate possible adverse outcomes in this susceptible patient group.

**Preoperative Evaluation of the Known OSA Patient (Figure 1)**

Preoperative evaluation of the known OSA patient begins with taking a detailed history and performing a physical examination. More specifically, both the diagnosis and severity of OSA should be determined in a patient with known OSA through questioning about OSA symptoms and a review of polysomnography results.

Long-standing OSA may have systemic complications, including hypoxemia, hypercarbia, polycythaemia, and cor pulmonale. The presence of significant comorbidities such as uncontrolled hypertension, arrhythmias, cerebrovascular disease, heart failure, metabolic syndrome, and morbid obesity should be determined. Of note, pulmonary arterial hypertension in patients with OSA has been reported to be in the range of 15-20%. However, the Evidenced-Based Clinical Practice Guidelines of the American College of Chest Physicians do not recommend routine evaluation for the presence of pulmonary arterial hypertension in the management of patients with OSA. Intraoperative triggers for elevation in pulmonary arterial hypertension should be avoided in the OSA patient. In the preoperative clinic, the pulse oximetry may be a simple screening tool for OSA patients.
with complications. An oxygen saturation value of < 94% on room air, in the absence of other causes such as chronic obstructive pulmonary disease, should be a red flag for severe long-standing OSA.

The OSA patient’s use of and compliance with positive airway pressure (PAP) devices (continuous positive airway pressure, bilevel positive airway pressures, auto-titrating positive airway pressure) should be assessed. Some of the patients with known OSA may have to be referred to the sleep medicine physician for reassessment preoperatively – including those who have been lost to sleep medicine follow up, have had a recent exacerbation of OSA symptoms, have undergone OSA-related airway surgery, or have been non-compliant with PAP therapy. Due consideration should be given for the re-initiation of preoperative PAP therapy in the non-compliant OSA patient, although evidence of its efficacy is lacking in this preoperative context and the duration of preoperative OSA treatment necessary to decrease perioperative risk is unknown.

Patients with moderate and severe OSA who have been on PAP therapy should continue PAP therapy in the preoperative period. The intraoperative anesthesia team should be alerted in advance so that an anesthetic plan can be formulated. Perioperative OSA risk mitigation strategies and precautions should be undertaken. It is unclear from the current literature if mild OSA would be a significant disease entity under anesthesia and in the perioperative period. Based on expert opinion, patients with mild OSA would not require preoperative PAP therapy. A published opinion-based algorithm addressing the preoperative management of the known OSA patient is shown in Figure 1.

Screening Methods for OSA in the Surgical Setting

The gold standard for diagnosing OSA is by overnight polysomnography. However, cost, expertise, equipment, and time constraints make routine polysomnography screening prohibitive. Therefore, practical screening tools for OSA are needed to filter out the patients at higher risk of OSA. Several questionnaire-based screening tools have been developed, including the Epworth Sleepiness Scale, the Berlin Questionnaire, the ASA checklist, the Sleep Apnea Clinical Score, and the P-SAP score.

A concise clinical screening tool was developed for anesthesiologists—the STOP-Bang questionnaire. The STOP-Bang questionnaire is a scoring model based on Yes / No answers to 8 easily administered questions with the acronym STOP-Bang (Table 1). Patients are considered as at risk of OSA if ≥ 3 items are scored positive on the STOP-Bang questionnaire. Patients are considered as at high risk of OSA if 5-8 items are scored positive on the STOP-Bang questionnaire.

OSA screening tools should have a high degree of sensitivity at the expense of lower specificity. The STOP-Bang questionnaire with a cutoff of 3 has a high level of sensitivity and negative predictive value, especially for patients with moderate and severe OSA. If the patient is scored as a low risk of OSA by the STOP-Bang questionnaire, the patient is unlikely to have moderate to severe OSA. The corollary is that the STOP-Bang score may be falsely positive. The STOP-Bang questionnaire has a sensitivity of 93% and 100% at AHI cut-off values of > 15 and > 30 respectively, with the specificity of 43% and 37% respectively.

A higher score of 5, 6, 7, or 8 is more predictive of moderate to severe OSA. By using a higher cutoff value of STOP-Bang 5, 6, and 7, the specificity for AHI > 30 (severe OSA) was increased to 74%, 88%, and 95% respectively. If the cutoff of 5 or 6 is used, the STOP-Bang score is highly specific and less sensitive, this means that there may be false negatives. Depending on the prevalence of OSA in a particular population such as the surgical patients, a higher score of 5-6 may be more practical. Patients that are identified with a high risk of OSA on STOP-Bang questionnaire have been
shown to be associated with the occurrence of higher postoperative complications.\textsuperscript{35,36} Screening questionnaires such as the STOP-Bang can be used in the preoperative clinic to categorize OSA severity, triage patients for diagnostic evaluation or exclude them from harm.\textsuperscript{37}

**Preoperative Evaluation of the Suspected OSA Surgical Patient (Figure 1)**

*Urgent or emergent surgery* should not be delayed for the detailed evaluation of suspected OSA. A patient is at risk of OSA if \( \geq 3 \) items score positive on the STOP-Bang questionnaire. A patient is at high risk of OSA if \( \geq 5-6 \) items score positive on the STOP-Bang questionnaire. A published opinion-based algorithm addressing the preoperative management of the suspected OSA patient is shown in Figure 1.\textsuperscript{28}

The anesthesiologist could consider a preoperative referral to the sleep physician and for a polysomnography if the patient screens as high risk of OSA with clinical symptoms of OSA, is scheduled for *major elective surgery* and has *significant comorbidities* suggestive of long-standing OSA. These comorbidities include uncontrolled hypertension, heart failure, arrhythmias, cerebrovascular disease, morbid obesity and metabolic syndrome. A timely and early consult would be helpful so that the sleep physician could have adequate time to prepare a perioperative management plan, which may include PAP treatment.\textsuperscript{27} Major elective surgery might have to be deferred in patients with a high clinical suspicion of severe OSA with systemic complications. Ultimately, the decision for further preoperative sleep study testing should depend on the clinical judgment and expertise of the attending physician; taking into account the patient-specific and logistical considerations in its totality.

On the other hand, there may be patients who are at high risk according to the STOP-Bang questionnaire with no clinical symptoms and significant comorbidities, and are not scheduled to undergo major surgery. Some of these patients may have had uneventful anesthetics in the past. These “at risk” patients may represent false positives on screening, or patients with mild OSA. A positive screening test would alert the anesthesiologist so that perioperative risk mitigation and precautions for possible OSA may be undertaken. If subsequent intraoperative difficult airway\textsuperscript{38} or postanesthesia care unit (PACU) recurrent respiratory events\textsuperscript{21} suggest a higher probability of OSA, a polysomnography and a sleep physician referral after the surgery may be indicated.

Because of the high sensitivity and negative predictive value of the OSA screening tools, the incidence of false negatives will be low. Therefore, patients who are at low risk of OSA (<3 on STOP-Bang) are unlikely to have OSA. These patients may be managed with routine perioperative care.

**Home Sleep Testing and Nocturnal Oximetry**

If there is a high index of suspicion for an undiagnosed OSA patient presenting for elective surgery, home sleep testing may also be a viable diagnostic alternative to the standard polysomnography.\textsuperscript{39} Level 2 portable sleep devices have been shown to be reliable alternatives to the standard polysomnography in surgical patients.\textsuperscript{40} In addition, nocturnal oximetry is a sensitive and specific tool to detect OSA in surgical patients who are STOP-Bang positive.\textsuperscript{41} There is a strong correlation between oxygen desaturation index from nocturnal oximetry and apnea hypopnea index from polysomnography.\textsuperscript{41} Nocturnal oximetry is 93% sensitive and 75% specific in diagnosing OSA.\textsuperscript{41} If polysomnography is unavailable due to resource constraints, these surrogate investigations may help to identify the patients at higher risk of OSA-related complications, so that preoperative PAP therapy may be considered and appropriate perioperative precautionary measures may be undertaken.
Perioperative Strategies to Mitigate Risks for the OSA Patient (Table 2)

OSA patients are susceptible to several perioperative risks during the conduct of anesthesia. Strategies or perioperative precautions that may be undertaken to mitigate these risks and minimize adverse outcomes in OSA patients are discussed in this section and listed in Table 2.28

Sedative premedication should be avoided.42 Alpha-2 adrenergic agonists such as clonidine and dexmedetomidine may reduce intraoperative anesthetic requirements and have an opioid-sparing effect.43

Difficulty with tracheal intubation occurs eight times as often in OSA patients compared to non-OSA patients.44 OSA is also a risk factor for difficult mask ventilation.45 A primary and back-up airway plan should be formulated in advance, identifying skills and additional equipment necessary to enact the plan.46 A variety of airway adjuncts (e.g. video laryngoscope, fibreoptic bronchoscope) and skilled anesthesiology assistance should be available prior to the induction of anesthesia. The entire anesthesia team should be familiar with center-specific difficult airway algorithms, such as the ASA difficult airway management guidelines.47 Patients should be meticulously and adequately preoxygenated. Preoxygenation with 100% oxygen with CPAP at 10 cmH20 for 3-5 min with the patient at 25 degree head-up position is advantageous in achieving higher end-tidal oxygen concentration.48 Triple airway maneuvers using two-handed mask ventilation technique may be required to achieve adequate ventilation prior to tracheal intubation. Obese OSA patients may require a ramp to be built under the patient from the scapula to the head to allow alignment of the ear and the sternal notch (head-elevated laryngoscopy position – HELP), thus facilitating laryngoscopy. This may be done by "stacking" blankets or with specially designed foam devices (Troop Elevation Pillow, Mercury Medical®).

Gastroesophageal reflux disease may be more prevalent in OSA patients due to hypotonia of the lower esophageal sphincter.49 The use of proton pump inhibitors, antacids, rapid sequence inductions, and cricoid pressure may be considered to reduce the risk of aspiration. Notably, cricoid pressure may make tracheal intubation and mask ventilation more difficult, compounding the problem of difficult airways in OSA patients.50

The use of regional blocks (neuraxial or peripheral nerve blocks) as a sole anesthetic may be beneficial to the OSA patient as it circumvents the issue of upper airway patency and decreases requirements for opioids in the perioperative period. Therefore local and regional techniques may be preferred to general anesthesia.27 Presently however, there is no evidence supporting one anesthetic technique over another. The postoperative use of wound infiltration, nerve block catheters or epidural catheters with local anesthetics reduces opioid requirements and this may be beneficial.

Patients with OSA are sensitive to the respiratory depressant effects of anesthetic agents including sedatives, opioids, and inhaled anesthetics. This is because of the propensity of airway collapse, sleep deprivation, and blunting of the physiological response to hypercarbia and hypoxia. The use of short-acting agents (propofol, remifentanil, desflurane, sevoflurane), and correspondingly the avoidance or minimization of the use of longer acting anesthetic drugs, is recommended. Intraoperative triggers for elevation in pulmonary arterial hypertension such as hypercapnia, hypoxia, hypothermia and acidosis should be avoided. In a recent novel study, intraoperative administration of intravenous doxapram (a central respiratory stimulant) may be associated with favorable post-anaesthesia recovery and outcomes in bariatric surgery patients with OSA.51
A multimodal or balanced approach for analgesia is advocated (nonsteroidal anti-inflammatory drugs, COX-2 inhibitors, acetaminophen, tramadol, pregabalin, gabapentin) for the opioid-sparing effect. Notably, postoperative oxygen desaturations were 12-14 times more likely to occur in OSA patients receiving postoperative oral or parenteral opioids versus those receiving non-opioid analgesic agents.\textsuperscript{52} Recently, there has been an increasing interest in using alternative analgesic adjuvants such as corticosteroids (e.g. dexamethasone), ketamine,\textsuperscript{53} melatonin,\textsuperscript{54} clonidine and dexmedetomidine\textsuperscript{55} to provide improved pain relief.

Postoperatively, tracheal extubation should be performed only after the OSA patient is fully conscious, airway patency confirmed, and able to follow verbal commands. Importantly, coughing and reflex hand movements to the tracheal tube should not be confused with purposeful movements. In view of the fact that even a small degree of residual neuromuscular blockade can increase postoperative respiratory morbidity (e.g. aspiration, airway obstruction, inadequate ventilation, hypoxia, and the need for reintubation), muscle relaxants should be fully reversed and this verified,\textsuperscript{56} especially in the OSA patient. A non-supine position (semi-upright or lateral) is preferred for postoperative recovery.\textsuperscript{57}

Patients undergoing surgical procedures under monitored anesthetic care or regional anesthesia with sedation should have intraoperative capnography available to monitor for ventilation. Based on expert opinion, patients who use PAP therapy at home should use personal PAP therapy devices during procedures that utilize mild to moderate sedation and do not involve the face and neck.\textsuperscript{58} If deep sedation is required, a secure airway is preferable to an unprotected airway.\textsuperscript{27}

**Postoperative Disposition of the Known or Suspected OSA Patient after General Anesthesia (Figure 2)**

Patient, anesthesia, analgesia, and surgery-specific factors influence the requirements for postoperative monitoring in OSA patients. For example, the patient with severe OSA undergoing major surgery requiring postoperative opioids would likely require close and continuous postoperative monitoring. In contrast, routine postoperative care might be appropriate in the patient with suspected OSA undergoing minor elective surgery.

In reality, the final decision of whether the patient requires closer postoperative monitoring is based on the judgment, expertise and discretion of the attending anesthesiologist. Modeled on similar principles as the ASA 2006 guidelines on OSA management and on recent evidence, the algorithm described in Figure 2 was published to guide the anesthesiologist in decision-making for the postoperative disposition of the OSA patient.\textsuperscript{28}

After general anesthesia, all patients with known OSA or patients with suspected OSA should be observed in the PACU with continuous oximetry monitoring for a longer period than a patient without OSA.\textsuperscript{13} There are currently no evidenced-based recommendations as to how long OSA patients should be monitored in the PACU. ASA guidelines based on expert opinion recommended a 7 hours duration if there was apnea or airway obstruction in the PACU.\textsuperscript{27} However, monitoring in the PACU for that length of time may not be feasible in most community hospitals.\textsuperscript{58} We propose an extended PACU observation of at least 30 to 60 minutes in an unstimulated environment after the patient has met the modified Aldrete criteria for discharge.\textsuperscript{28}

The observation of recurrent PACU respiratory events can be used as a reliable second phase indicator to determine whether the known or suspected OSA patient requires continuous postoperative monitoring. A PACU respiratory event occurs when a patient has repeated episodes of
apnea for ≥ 10 s, bradypnea of < 8 breaths per minute, pain-sedation mismatch, or desaturations to < 90%.\textsuperscript{21} PACU nurses play an important role in alerting the health team regarding which patients will require additional monitoring.

Patients who are at high risk of OSA on the screening questionnaires and encounter recurrent PACU respiratory events have associated higher postoperative respiratory complications.\textsuperscript{21,35,36} It may be prudent to monitor these patients continuously with oximetry, in an area where early medical intervention can occur (Figure 2). This can be either in a step-down unit, or oximetry with telemetry. These patients may also require commencement of postoperative PAP therapy. In a similar fashion, Sundar et al published their “sleep trial” protocol – using desaturation (2 or more episodes), bradypnea (< 8 breaths/min) and obstructive apneic episodes to decide which suspected OSA patients require PAP therapy.\textsuperscript{58}

There are new monitoring technologies. Monitoring can be continuous and the trend analysis incorporated into the alarm system. Heart rate, respiratory rate, blood pressure, temperature, end-tidal carbon dioxide, oxygen saturation and other physiological channels can be monitored continuously and interpreted concurrently with smart algorithms to optimize sensitivity and minimize false alarms. This technology may have the potential to make surgical wards safer for our OSA patients and reduce the number of preventable deaths.\textsuperscript{59,60}

\textbf{Known OSA} patients who have been non-compliant with PAP therapy or have severe OSA may have to be fitted with postoperative PAP therapy and cared for in a monitored environment with continuous oximetry, particularly if there has been a recurrent PACU respiratory event (Figure 2). Known OSA patients requiring postoperative parenteral opioids may require continuous oximetry monitoring to detect drug-induced postoperative respiratory depression.\textsuperscript{61} Moderate OSA patient requiring oral opioids, and without recurrent PACU respiratory events may be managed postoperatively on the surgical ward with oximetry monitoring (Figure 2).

OSA patients may have upregulation of central opioid receptors due to recurrent hypoxemia, therefore they are more sensitive to the respiratory depressive effect of narcotic agents. Opioid delivery via patient controlled analgesia with no basal infusion rate and restricted per hour dosing may limit narcotic drug. It may also be expedient to place patients requiring postoperative parenteral opioids on supplemental oxygen.\textsuperscript{62} In a recent multi-disciplinary consensus meeting organized by the Anesthesia Patient Safety Foundation, it was suggested that if supplemental oxygen was used, monitors of ventilation (e.g. capnography) may be required to detect hypoventilation.\textsuperscript{61}

Multimodal analgesic techniques should be utilized to minimize the postoperative administration of opioids. These would include local anesthetic wound infiltration, peripheral nerve block catheters or neuraxial catheters running local anesthetic agents (without opioids), and use of opioid-sparing analgesic agents – such as non-steroidal anti-inflammatory drugs, COX-2 inhibitors, ketamine, acetaminophen, pregabalin, gabapentin, tramadol, dexmedetomidine, and dexamethasone.

Known OSA patients previously on PAP therapy should be encouraged to be compliant with PAP therapy postoperatively. PAP therapy should be ordered in the postoperative period; although high level evidence studies addressing specifically PAP therapy and postoperative outcomes in OSA patients are lacking. Notably, a recent retrospective review of 797 patients scheduled for bariatric surgery suggested the possibility that recognition and appropriate management of OSA (with 93% of the patients receiving perioperative CPAP) may mitigate the risk of postoperative complications.\textsuperscript{63}
Interestingly, a significant increase in AHI occurred on postoperative night 3, particularly in male patients with moderate and severe OSA. Normalization of sleep architecture and AHI occurs only on the 5th to 7th postoperative nights. This may help to explain the late postoperative complications seen in OSA patients. The necessary level of monitoring for each individual OSA patient continues to pose a difficult triage decision. To avoid postoperative complications, it may be best to have the OSA patient received perioperative PAP. Unfortunately, the current paucity of high level evidence in the literature does not contribute knowledge to assist the practicing anesthesiologist with the decision-making process. Further good quality research on the postoperative management of OSA patients is essential.

**OSA Patient and Ambulatory Surgery**

Disagreement exists as to whether OSA patients should be discharged for home after surgery. The 2006 ASA guidelines on OSA highlighted that superficial surgeries or minor orthopedic surgery using local or regional techniques and lithotripsy may be done on an ambulatory basis. In our opinion, patients suspected of OSA or with mild OSA who have undergone ambulatory surgery, without recurrent PACU respiratory events, and not requiring higher dose of oral opioids for analgesia, may be discharged home at the discretion of the attending physicians (Figure 2). However, severe OSA patients without optimized comorbid conditions are not ideal candidates for ambulatory surgery. The threshold for unanticipated hospital admission should be lowered. OSA patients should not be allowed to return home without an escort. Escorts and/or care-givers for the patients should be provided with information regarding possible postoperative complications in the OSA patient. As a safety net, ambulatory surgical centers managing OSA patients should have transfer agreements to inpatient facilities and be equipped to manage contingencies associated with OSA.

Conversely, retrospective observational studies of OSA patients undergoing bariatric surgery in free-standing ambulatory surgical centers have demonstrated that postoperative complication rate can be low (<0.5%), and that these surgeries may be performed on an ambulatory basis or as short-stay surgeries. Judicious patient selection, preoperative optimization of medical conditions (including PAP therapy for OSA), skilled medical personnel, and experienced high volume facilities with strict home-care criteria may be the ingredients for successful outcomes in this high risk population. However, such an approach is still controversial.

**Conclusions**

In the perioperative period, OSA is often unrecognized and under-diagnosed. It is known to be associated with increased postoperative complications and morbidity. Screening tools for OSA, such as the STOP-Bang questionnaire, allows risk stratification of the suspected OSA patients. Individualized and tailored patient care is required to mitigate the perioperative risks of the known and suspected OSA patient. Practical algorithms based on the current best evidence and expert opinion may guide anesthesiologists in the perioperative management of these vulnerable OSA patients. Looking to the horizon, an interdisciplinary collaboration and cross-fertilization of ideas between anesthesiology and sleep medicine will provide the substrate for further research, with the hope of answering important questions in OSA management.

**Acknowledgement**

The work is written together with Edwin Seet, MBBS MMed, Department of Anesthesia, Alexandra Health Private Limited, Khoo Teck Puat Hospital, Singapore.
References:


57. Dixon BJ, Dixon JB, Carden JR, Burn AJ, Schachter LM, Playfair JM, Laurie CP, O’Brien PE: Preoxygenation is more effective in the 25 degrees head-up position than in the supine


Table 1: Obstructive Sleep Apnea Screening Tools

**STOP-Bang Questionnaire**

<table>
<thead>
<tr>
<th></th>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Snoring: Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>Tired: Do you often feel tired, fatigued, or sleepy during daytime?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>O</td>
<td>Observed: Has anyone observed you stop breathing during your sleep?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>P</td>
<td>Blood Pressure: Do you have or are you being treated for high blood pressure?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>B</td>
<td>BMI: BMI more than 35 kg/m²?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>A</td>
<td>Age: Age over 50 years old?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>N</td>
<td>Neck circumference: Neck circumference greater than 40 cm?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>G</td>
<td>Gender: Male?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

*At risk of OSA:* Yes to 3 or more questions for STOP-Bang.

High risk of OSA: Yes to 5 or more questions for STOP-Bang


<table>
<thead>
<tr>
<th>Anesthetic Concern</th>
<th>Principles of Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premedication</td>
<td>Avoid sedating premedication.(^\text{42}) Alpha-2 adrenergic agonist (clonidine, dexmedetomidine)(^\text{43}) may reduce intraoperative anesthetic requirements and have an opioid-sparing effect.</td>
</tr>
<tr>
<td>Possible difficult airway – mask ventilation and tracheal intubation(^\text{44,45})</td>
<td>Ramp from scapula to head if patient is obese. Adequate preoxygenation. Consider CPAP preoxygenation.(^\text{48}) Two-handed triple airway maneuvers American Society of Anesthesiologists Difficult Airway Algorithm.(^\text{47})</td>
</tr>
<tr>
<td>Gastroesophageal reflux disease(^\text{49})</td>
<td>Consider proton pump inhibitors, antacids, rapid sequence induction with cricoid pressure.</td>
</tr>
<tr>
<td>Opioid-related respiratory depression(^\text{42})</td>
<td>Minimize use of opioids for analgesia. Use of short-acting agents (remifentanil). Regional and multimodal analgesia (NSAIDs, acetaminophen, tramadol, ketamine, gabapentin, pregabalin, dexmedetomidine, clonidine, dexamethasone.)</td>
</tr>
<tr>
<td>Carry-over sedation effects from longer-acting intravenous sedatives and inhaled anesthetic agents</td>
<td>Use of propofol / remifentanil for maintenance of anesthesia. Use of insoluble potent anesthetic agents (desflurane). Use of regional blocks as a sole anesthetic technique.</td>
</tr>
<tr>
<td>Excessive sedation in monitored anesthetic care</td>
<td>Use of intraoperative capnography for monitoring of respiration.(^\text{27})</td>
</tr>
<tr>
<td>Post-extubation airway obstruction</td>
<td>Verification of full reversal of neuromuscular blockade.(^\text{27}) Ensure patient fully conscious and cooperative prior to extubation.(^\text{27}) Non-supine posture for extubation and recovery.(^\text{27}) Resume use of positive airway pressure device.(^\text{27})</td>
</tr>
</tbody>
</table>

Figure 1: Preoperative Evaluation of Known or Suspected Obstructive Sleep Apnea Patient in the Anesthesia Clinic

Suspected OSA patient

Screening using STOP-Bang questionnaire

Severity Assessment from History or Polysomnography

Known OSA patient

- Major Elective Surgery & Significant Comorbidities
  - Arrhythmias
  - Uncontrolled hypertension
  - Cerebrovascular disease
  - Metabolic syndrome
  - Obesity with BMI > 35 kg/m²

- Changes in OSA Status
  - Recent exacerbation of OSA symptoms
  - Non-compliant to PAP therapy
  - Recently undergone OSA-related surgery
  - Lost to sleep medicine follow-up

Routine perioperative management. No preoperative PAP therapy required.

- Assume possibility of moderate OSA. Perioperative OSA precautions and risk mitigation (Table 2).

- Yes
  - Consider preoperative referral to sleep medicine physician, polysomnography, and preoperative PAP therapy.

- No
  - Preoperative PAP therapy.
  - Perioperative OSA precautions and risk mitigation (Table 2).

Low risk of OSA ($<3$ on STOP-Bang)

At risk of OSA ($\geq 3$ STOP-Bang)

Mild OSA

AHI $5 – 15$

Oximetry $\geq 94\%$ on room air

Moderate or Severe OSA

AHI $> 15$

Oximetry $< 94\%$ on room air

No

Yes
Figure 2 - Postoperative Management of the Known or Suspected Obstructive Sleep Apnea Patient after General Anesthesia

- Patient monitored in postanesthesia care unit for longer duration (> 30-60 min after modified Aldrete criteria met)

**Known OSA**

- Non-compliant with PAP therapy†,
- Severe OSA (AHI > 30),
- Postoperative parenteral opioids, or
- Recurrent PACU Respiratory Event of oxygen desaturation <90%, bradypnea <8 breaths/min, apnea ≥ 10 s and pain sedation mismatch (concurrent high pain and sedation scores) #

  **Yes**
  - Recurrent PACU Respiratory Event of oxygen desaturation <90%, bradypnea <8 breaths/min, apnea ≥ 10 s and pain sedation mismatch (concurrent high pain and sedation scores) #

  **No**
  - Consider discharge to home if minor surgery.

**Suspected OSA** (≥3 STOP-Bang)

  **Yes**
  - Consider care in a monitored bed† with continuous oximetry and/or postoperative PAP therapy‡

  **No**
  - Consider discharge to home if minor surgery or postoperative care on the surgical ward.

**Moderate OSA** (AHI > 16-30),

- Require postoperative oral opioids (> codeine 60 mg q4h, or equivalent)

  **No**
  - Consider postoperative monitored care on the surgical unit.

  **Yes**
  - Consider discharge to home if minor surgery.
Legend for Figures:

Figure 1: Preoperative Evaluation of Known or Suspected Obstructive Sleep Apnea Patient in the Preoperative Clinic
‡ Positive Airway Pressure (PAP) therapy – including continuous PAP, bilevel PAP, or auto-titrating PAP. Adapted from Seet E, Chung F. Management of sleep apnea in adults – functional algorithms for the perioperative period Can J Anesth 2010; 57: 849-64.

Figure 2: Postoperative Management of the Known or Suspected Obstructive Sleep Apnea Patient after General Anesthesia
# Recurrent Postanesthesia Care Unit (PACU) Respiratory Event.‡
‡ Positive Airway Pressure (PAP) therapy – including continuous PAP, bilevel PAP, or auto-titrating PAP.
† Monitored bed - environment with continuous oximetry and the possibility of early nursing intervention (e.g. intensive care unit, step-down unit, or remote pulse oximetry with telemetry in surgical ward).

# Recurrent PACU Respiratory Event - any event occurring more than once in each 30-min evaluation period (not necessary to be the same event) [82].