Obstructive sleep apnea (OSA) is one of the most common medical conditions identified in the last 50 years. It is caused by repetitive, partial or complete obstruction of the upper airway and is characterized by episodes of cessation of breathing during sleep. The incidence of OSA is quite varied depending on sex, age, and the criteria of diagnosis.

OSA affects 2 – 26% of the general population [1]. The perioperative management of patients with OSA begins with preoperative identification, after which plans are made to tailor specific intraoperative and postoperative care. The STOP or STOP Bang questionnaires are useful screening tests for OSA [2, 3]. Identification of patients at high risk may help to optimize the preoperative status and to define the goals for perioperative therapy.

In this review article, we present functional algorithms for the perioperative management of patients with OSA based on the present clinical evidence, and a collation of expert knowledge and practices. These recommendations may be useful for the healthcare team, i.e. primary care physicians, surgeons and anesthesiologists, in decision-making for managing patients with OSA in the perioperative period.

**OSA and postoperative complications**

In the general population, OSA is known as an independent risk factor for increased mortality and morbidity [4, 5]. The presence of OSA is known to increase the occurrence of comorbid conditions and postoperative complications [1, 6].

In a recent retrospective study of elective non-cardiac procedures, the occurrence of postoperative complications was observed in 44% of patients with OSA versus 28% in patients with no OSA[1]. The most commonly observed complication was oxygen desaturation (17% in patients with OSA versus 8% with no OSA). Conditional logistic regression revealed that OSA and preexisting stroke had a hazard ratio of 2 (1.25-3.19) for the occurrence of postoperative complications [1].

An increased risk of postoperative complications was also observed in OSA patients undergoing upper airway, joint arthroplasties and cardiac procedures [7-10]. In another study, Chung and coworkers observed that the patients who had apnea-hypopnea index (AHI) > 5 on preoperative polysomnography had a higher incidence of postoperative complications [3]. Interestingly, it was observed that OSA patients undergoing surgery had higher AHI and oxygen-desaturation index scores on the third postoperative night compared to the first postoperative night or preoperatively [11]. The significance and implications of this had not been explored.

**Diagnosis of OSA**

The clinical symptoms of OSA can be classified into diurnal and nocturnal symptoms (Table 1). There are various risk factors that predispose to the occurrence of OSA. The diagnosis of OSA is established by an overnight sleep study, polysomnography, which is considered to be the gold standard. However, polysomnography may not be ideal as it is expensive and requires trained personnel. This is further complicated by the long waiting lists at the sleep clinics. Thus it is important for the healthcare professional to have a useful screening tool that may help in the diagnosis and management of OSA. With the increasing number of morbidly obese patients, it is imperative that OSA should be evaluated and treated to minimize the occurrence of postoperative complications.

**Screening for OSA prior to surgery**

It is estimated that 82% of men and 92% of women with moderate-to-severe sleep apnea have not been diagnosed. A substantial proportion of these patients present for surgery and may have an increased risk of perioperative complications.
Although validated in primary care settings, the Berlin Questionnaire is a complicated scoring system with a large number of questions.

The American Society of Anesthesiologists taskforce on OSA developed a tool in 2006 to help assist anesthesiologists in identifying patients with OSA. It comprises a 14-item checklist categorized into physical characteristics, history of airway obstruction during sleep, and complaints of somnolence [14]. We were able to demonstrate that the sensitivity of the American Society of Anesthesiologists checklist was 79% at AHI of > 15 and 87% at AHI > 30 [3].

A significant step forward in the screening of patients for OSA was the development of a more concise and easy-to-use bedside screening tool abbreviated as the STOP Questionnaire (S: Snore loudly, T: daytime Tiredness, O: Observed to stop breathing during sleep, P: high blood Pressure) (Table 2a). The STOP Questionnaire has been validated in surgical patients at preoperative clinics. The sensitivity of the STOP questionnaire with AHI > 15 and > 30 as cut-offs were 74% and 80% respectively. The specificity at similar AHI levels was 53% and 49% respectively [2].

When combined with body mass index (BMI), age, neck circumference, and gender, the STOP Questionnaire as a preoperative screening test was described as a user-friendly and excellent method to predict severe OSA (AHI >30). The linear scale and the simple acronym make the STOP-Bang Questionnaire (B: BMI > 35kg/m2, A: Age > 50 years, N: Neck circumference > 40cm, G: male Gender) (Table 2b). The use of the STOP-Bang Questionnaire improved the sensitivity to 93%, and 100% at AHI cut-offs of >15 and >30 respectively, making it an ideal screening tool with a high sensitivity level. The specificity at similar AHI levels was 43% and 37% respectively.

In the preoperative clinic, the STOP Questionnaire was used to screen 211 patients, 27.5% of whom were classified as being at high risk of OSA [2].

Ramachandran and coworkers analyzed the accuracy of clinical screening methods in the diagnosis of OSA in a meta-analysis [15]. The authors identified 26 different clinical prediction tests with 8 in the form of questionnaires, and 18 algorithms, regression models or neural networks. The STOP-Bang Questionnaire as a preoperative screening test was described as a user-friendly and excellent method to predict severe OSA (AHI >30). The linear scale and the simple acronym make the STOP-Bang Questionnaire an ideal screening tool for OSA.

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**Diurnal Symptoms**

- Daytime sleepiness
- Memory and concentration dysfunction
- Sexual dysfunction
- Gastroesophageal reflux
- Behavioral irritability (irritability, depression, chronic fatigue, delirium)
- Road traffic accident

**Nocturnal symptoms**

- Heavy persistent snoring, worse in supine position or after alcohol or sedatives
- Apnea with limb movement, witnessed by bed partner
- Sudden awakening with noisy breathing
- Accidents related to sleepiness
- Nocturnal sweating
- Wake up with dry mouth
- Nocturnal epilepsy
- Nocturia

**Signs**

- Edematous soft palate and uvula
- Long soft palate and uvula
- Decreased oropharyngeal dimensions
- Nasal obstruction
- Maxillary hypoplasia
- Retrognathia
- Central adiposity and increased neck circumference
- Hypertension and other cardiovascular consequences

Table 1. Symptoms and signs of OSA. Adapted from Chung F, et al. [12].
STOP-Bang Questionnaire practical and easy-to-use in the preoperative setting. STOP-Bang is now widely adopted as a screening tool for OSA in primary care settings, preoperative clinics and sleep clinics.

Various other screening modalities including the modified Mallampati score of 3 or 4, or a waist circumference of more than 40 inches, have been correlated well with an increased AHI [16, 17]. Nocturnal oximetry may be a sensitive and specific tool to detect OSA in surgical patients. Our recent investigation showed that there was a strong correlation between nocturnal oximetry and the AHI from polysomnography [11]. The ODI measured by nocturnal oximetry had a sensitivity of 75-95% and a specificity of 67-97% as compared to AHI. The availability of various screening modalities and an increasing awareness of the occurrence of OSA may lead to more patients being diagnosed with this challenging condition.

Preoperative optimization of patients with known or suspected OSA

It is imperative to recognize that the postoperative complications are mitigated with adequate preoperative preparation and optimization. There are a substantial percentage of patients diagnosed with OSA who are often prescribed continuous positive pressure (CPAP) or bilevel positive airway pressure (BiPAP) devices. The current use of CPAP or BiPAP should be noted with special care on compliance to therapy. Patients should be advised to bring their CPAP devices to the hospital on the day of surgery for postoperative use. A subset of patients may need reassessment preoperatively, especially patients with a known diagnosis of OSA but lost on follow-up, recent exacerbation of OSA symptoms, those who have undergone OSA-related airway surgery, or have been non-compliant with CPAP. Despite limited evidence, experience suggests that restarting preoperative CPAP may be beneficial on non-compliant patients.

The American Society of Anesthesiologists task force on the management of OSA recommends that patients with moderate and severe OSA who have been on CPAP therapy should continue with CPAP in the postoperative period [14]. Precautions should be taken in anticipating the possibility of having a difficult airway. Most patients may be obese and appropriate care should be taken to prevent desaturation. It is useful to employ short-acting anesthetic drugs, less soluble inhalational agents, titrate opioids, and minimize sedation. In patients with anticipated difficult airways, awake extubation may have to be performed preferably in a 30° to 45° head-up position (Table 3).

The routine perioperative care may be adequate for patients with mild OSA. If patients have any co-morbidities, they should be optimized. It is important that anesthesiologists discuss the implications of OSA along with the anesthetic options. Patients may benefit by the modifications of anesthetic technique such as avoidance of general anesthesia in favor of a central neuraxial or a peripheral nerve block.

Management of OSA after surgery

This can be discussed broadly based on whether patients are planned to be managed as an ambulatory surgical patient or as an inpatient.

### Table 2. Obstructive sleep apnea screening tools. Adapted from Chung F, et al. [2].

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Snoring: Do you snore loudly (loud enough to be heard through closed doors)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Tired: Do you often feel tired, fatigued, or sleepy during daytime?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Observed: Has anyone observed you stop breathing during your sleep?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Blood Pressure: Do you have or are you being treated for high blood pressure?</td>
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</table>

**High risk of OSA:** answering yes to 2 or more questions.

**Low risk of OSA:** answering yes to less than 2 questions.

### Table 2a. The STOP questionnaire.

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<td>4. Blood Pressure: Do you have or are you being treated for high blood pressure?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. BMI: BMI more than 35 kg/m2?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Age: Age over 50 years old?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Neck circumference: Neck circumference greater than 40 cm?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Gender: Male?</td>
<td></td>
<td></td>
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</tbody>
</table>

**High risk of OSA:** answering yes to 3 or more items

**Low risk of OSA:** answering yes to less than 3 items

### Table 2b. The STOP-Bang scoring model.
Management of patients scheduled for ambulatory surgery
It is presently unclear as to the degree of severity of OSA which is appropriate for patients to be managed as ambulatory surgical patients. Although some centers do perform surgeries on OSA patients as ambulatory surgical patients, evidence is still lacking. Controversy exists as to whether OSA patients should be treated on an ambulatory basis.

Currently the American Society of Anesthesiologists Advisory Guidelines on the perioperative management of patients with obstructive sleep apnea suggests that superficial surgeries or minor orthopedic surgery using local or regional techniques, and lithotripsy, may be done on an ambulatory basis. Due consideration must be given to the type of surgery, associated comorbidities, patient’s age, severity of OSA and the treatment status, anticipated use of postoperative opioids, the type of anesthesia (local vs general vs nerve blocks with or without sedation) and home care [14]. However, preliminary research from our group show that patients with regional anesthesia also have elevated apnea hyponea index and oxygen desaturation. This may imply that OSA patients need to be treated with CPAP [18].

Patients may be discharged to home provided that there is no moderate or severe OSA, no recurrent adverse events in postanesthesia care unit (PACU) such as apnea or desaturation, and no requirement of postoperative opioid. However, it is important to realize that ambulatory surgical facilities managing OSA patients should have transfer arrangements to an inpatient facility, and be equipped to handle the potential problems that may arise while dealing with OSA patients.

Management of patients scheduled for hospital stay
The 2006 American Society of Anesthesiologists guidelines were essentially directed by expert consensus in the absence of good scientific evidence. The guidelines recommend that the postoperative destination should be based on risk factors and a weighted scoring system [14]. The patient’s risk is determined based on the severity and treatment of OSA, the type of surgery and anesthesia, and the need for postoperative opioids. The final total risk score will be the guide for the anticipated requirement for postoperative monitoring of patients [14].

We recommend that the occurrence of recurrent respiratory events in PACU can be used as a reliable indicator to determine whether the known or suspected OSA patient requires continuous postoperative monitoring. The PACU respiratory event is defined as either an apnea for $\geq 10$ s (1 episode needed for yes), bradypnea of $< 8$ breaths per minute (3 episodes needed for yes), pain-sedation mismatch, or desaturations to $< 90\%$ (3 episodes needed for yes) in one 30-minute time block. The event is considered significant when any of one of them occurs in two separate 30-minute time blocks [19]. This will make it possible to identify the majority of OSA patients that require further monitoring. It is highly likely that these patients may require CPAP therapy.

We detected a novel finding that patients with OSA have a more profound increase in AHI on postoperative night 3 and return to preoperative levels on night 7 [20]. Further research on this concept may provide a better insight into the monitoring and management of patients with OSA.

Special considerations for postoperative management

Postoperative analgesia
OSA is one of the major risk factors contributing to the occurrence of respiratory depression [21]. The use of opioids can be a special concern in patients with OSA, as most opiates including morphine, meperidine, hydromorphone, and fentanyl cause a dose-dependent reduction of respiratory drive, respiratory rate, and tidal volume that in turn can lead to hypventilation, hypoxemia, and hypercarbia [22]. Sedatives, anesthetics and analgesics may selectively compromise respiratory function in OSA patients. The general recommendation is that opioids and other drugs with central respiratory and sedating effects should be avoided, if possible. It is imperative to minimize the use of opioids in diagnosed or suspected OSA patients.

The use of morphine in OSA has been deleterious with reports of respiratory depression and even death. Also, there may be genetic factors that may play a role in having differing effects on opioid induced respiratory effects. Postoperative oxygen desaturations were 12 to 14 times more likely to occur in OSA patients receiving oral or parenteral opioids as opposed to those receiving non-opioid analgesic agents [23].

Alternative to opioid therapy
There is an accumulating evidence to suggest that the use of multimodal analgesia may be more beneficial in patients with OSA in minimizing the opioid-related side effects and providing effective analgesia as well. There are a plethora of medications that can be used, such as nonsteroidal anti-inflammatory drugs,
acetaminophen, tramadol, ketamine, gabapentin, pregabalin, clonidine, and dexamethasone. Caution should be advocated while using some of these drugs like gabapentin with the side effect of sedation. Dexmedetomidine has been particularly beneficial because of the opioid-sparing effect and the lack of respiratory depression [24].

The American Society of Anesthesiologists guidelines recommend regional anesthesia to reduce the possibility of negative adverse events associated with systemic opioids. The use of nonsteroidal anti-inflammatory analgesics is strongly recommended [14]. The use of nerve blocks with or without catheters with local anesthetics obviates the need for systemic opioid analgesics. However, caution should be exercised in using neuraxial opioids in patients with OSA as there are reports of postoperative respiratory arrest in a case series of three patients [25]. Patients with OSA may be at an increased risk of perioperative complications with the use of strong opioids even after a regional anesthetic [26].

**Evidence for using perioperative CPAP**

CPAP exerts its beneficial effects by acting as a pneumatic splint and prevents the obstruction to airflow during sleep. Nasal CPAP is commonly used and reduces the occurrence of apnea or hypopnea. The use of CPAP alleviates the symptoms of daytime sleepiness, restores the quality of life, improves vigilance, concentration and memory, lessens fatigue, decreases healthcare usage and reduces road traffic accidents [21].

Evidence surrounding the perioperative use of CPAP is not available. However, considering the low level of invasiveness of the CPAP, a short-time preoperative trial in patients with severe OSA may be worthwhile. The American Society of Anesthesiologists task force recommends that patients continue with their routine CPAP through the perioperative period.

Well-controlled studies demonstrating the beneficial effects of CPAP in the postoperative period are lacking. Limited evidence of a retrospective trial, however, does suggest that postoperative CPAP reduces airway obstruction, reduces major postoperative complications and shortens the hospital stay [21].

There are various questions concerning the use of CPAP that presently remain unanswered, especially regarding the optimum duration or specific surgical procedures. However, logic dictates that clinicians should have a low threshold to use CPAP on patients in the postoperative period. The patients are better advised to get their own CPAP device to the hospital on the day of surgery.

**Conclusion**

The combination of anesthesia and undiagnosed OSA can be potentially dangerous and places the patients at an increased risk of perioperative complications and postoperative morbidity. Screening of patients with the STOP-Bang Questionnaire will identify patients at risk of OSA. Combining preoperative screening of OSA and identifying recurrent PACU respiratory events will allow risk stratification of diagnosed or suspected OSA patients for more focused postoperative care. Practical guidelines based on the current best evidence and expert opinion may guide anesthesiologists in the perioperative management of these OSA patients.

<table>
<thead>
<tr>
<th>Table 3. Perioperative anesthetic management of the patient with obstructive sleep apnea. ASA = American Society of Anesthesiologists, CPAP = Continuous Positive Airway Pressure OSA = Obstructive Sleep Apnea</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preoperative period</strong></td>
</tr>
<tr>
<td>OSA risk stratification, evaluation and optimization.</td>
</tr>
<tr>
<td>Optimization of associated comorbidities.</td>
</tr>
<tr>
<td>Anesthetic management tailored to individual needs.</td>
</tr>
<tr>
<td>Preoperative CPAP or BiPAP continued perioperatively or start if patient previously noncompliant.</td>
</tr>
<tr>
<td><strong>Intraoperative period</strong></td>
</tr>
<tr>
<td>Adequate positioning for intubation, fiberoptic and/or videolaryngoscopes.</td>
</tr>
<tr>
<td>ASA Difficult Airway Algorithm.</td>
</tr>
<tr>
<td>Titration of opioids.</td>
</tr>
<tr>
<td>Regional anesthesia and/or multimodal analgesia.</td>
</tr>
<tr>
<td>Anesthetic agents with low blood fat solubility – desflurane may be beneficial.</td>
</tr>
<tr>
<td><strong>Extubation of airway</strong></td>
</tr>
<tr>
<td>Complete reversal of neuromuscular blockade – checked with a nerve stimulator.</td>
</tr>
<tr>
<td>Awake extubation.</td>
</tr>
<tr>
<td>Semi-upright posture for recovery.</td>
</tr>
<tr>
<td><strong>Postoperative period</strong></td>
</tr>
<tr>
<td>Minor or superficial procedures with minimal or no requirements of postoperative opioids can be performed as day surgery.</td>
</tr>
<tr>
<td>Plan should be flexible as day surgery patients may end up with an unanticipated admission.</td>
</tr>
<tr>
<td>Longer monitoring for patients with high risk OSA.</td>
</tr>
<tr>
<td>Patients may need CPAP if recurrent episodes of desaturation, apnea, or pain sedation mismatch.</td>
</tr>
</tbody>
</table>

The combination of anesthesia and undiagnosed OSA can be potentially dangerous and places the patients at an increased risk of perioperative complications and postoperative morbidity. Screening of patients with the STOP-Bang Questionnaire will identify patients at risk of OSA. Combining preoperative screening of OSA and identifying recurrent PACU respiratory events will allow risk stratification of diagnosed or suspected OSA patients for more focused postoperative care. Practical guidelines based on the current best evidence and expert opinion may guide anesthesiologists in the perioperative management of these OSA patients.
References


