

# Perioperative Clinical Pathways to Manage Sleep-Disordered Breathing

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## KEYWORDS

- Obstructive sleep apnea • Perioperative clinical pathways • Screening • Perioperative management
- STOP-bang questionnaire

## KEY POINTS

- Obstructive sleep apnea (OSA) is the most common type of sleep-disordered breathing.
- OSA is an independent risk factor for increased perioperative adverse events.
- Effective screening tools are available for the detection and risk stratification of OSA.
- The perioperative care of the OSA patient is challenging, and various strategies are available for risk mitigation.
- More research is required to formulate evidence-based clinical pathways for the perioperative management of OSA patients.

## INTRODUCTION

The obstructive sleep apnea (OSA) syndrome is a disease characterized by recurrent episodic cessation of breathing lasting 10 or more seconds during sleep. In this condition, there is exaggerated depression of pharyngeal muscle tone during sleep and anesthesia, resulting in a cyclical pattern of partial or complete upper airway obstruction with impaired respiration.<sup>1</sup> Clinically this manifests as repeated nocturnal arousals and increased sympathetic output, daytime hypersomnolence, memory loss, and executive and psychomotor dysfunction.<sup>2</sup>

OSA is the most common type of sleep-disordered breathing.<sup>3</sup> There is a wide variation in the reported prevalence of this disorder because of the diversity between the different study populations, differing definitions for the disease, and the varying diagnostic methods. Its estimated prevalence is 1 in 4 males and 1 in 10 females for mild

OSA,<sup>4</sup> and 1 in 9 males and 1 in 20 females for moderate OSA.<sup>5,6</sup> The economic cost of OSA is considerable.<sup>7</sup>

A significant number of patients with OSA are undiagnosed when they present for elective surgery.<sup>8</sup> In an observational study, approximately one-fourth (24%) of elective surgical patients were found to be at high risk based on screening, of whom 4 of 5 (81%) had not been previously diagnosed with OSA.<sup>9</sup> A similar trend is seen in the setting of ambulatory surgery.<sup>10</sup> More importantly, OSA has been linked with an increased incidence of postoperative complications. The perioperative management of OSA patients is challenging, and a sound understanding of the condition is required of anesthesiologists involved in the care of such patients.

This review article endeavors to summarize the principles in the perioperative management of OSA patients, including preoperative evaluation, perioperative risk mitigation, and postoperative

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care. Functional algorithms are presented as a guide to managing such patients presenting for surgery. Where evidence in the form of published literature is lacking, certain recommendations have been made based on consensus or expert opinion. The clinical pathways suggested here serve as aids to the anesthesiologist. Clinical judgment should be exercised at all times; and exceptions made to accommodate for the various circumstantial and patient-related factors.

## DIAGNOSTIC CRITERIA

Classically the gold standard for the definitive diagnosis of OSA requires an overnight polysomnography or sleep study. The Apnea-Hypopnea Index (AHI), defined as the average number of abnormal breathing events per hour of sleep, is used to determine the presence of and the severity of OSA. An apneic event refers to cessation of airflow for at least 10 seconds, and hypopnea occurs when there is reduced airflow with desaturation of 4% or more.<sup>11</sup> The American Academy of Sleep Medicine (AASM) diagnostic criteria for OSA require either an AHI of 15 or more, or AHI greater than or equal to 5, with symptoms such as excessive daytime sleepiness, unintentional sleep during wakefulness, unrefreshing sleep, loud snoring reported by partner, or observed obstruction during sleep.<sup>12</sup> The Canadian Thoracic Society guidelines for the diagnosis of OSA specify the presence of an AHI of at least 5 on polysomnography, and either of (1) daytime sleepiness not attributable to other factors or (2) at least 2 other symptoms of OSA (eg, choking or gasping during sleep, recurrent awakenings, unrefreshing sleep, daytime fatigue, or impaired concentration).<sup>13</sup> OSA severity is mild for AHI between 5 and 15, moderate for AHI 15 to 30, and severe for AHI greater than 30.<sup>12</sup>

## COMORBIDITIES ASSOCIATED WITH OSA

OSA is associated with multiple comorbidities such as myocardial ischemia, heart failure, hypertension, arrhythmias, cerebrovascular disease, metabolic syndrome, insulin resistance, gastroesophageal reflux, and obesity. In one study, the prevalence of OSA was 41% in patients with a body mass index of greater than 28 kg/m<sup>2</sup>, and 78% in morbidly obese patients planned for bariatric surgery.<sup>14</sup> Various pathophysiologic, demographic, and lifestyle factors also predispose to OSA. These factors include anatomic abnormalities that cause a mechanical reduction in airway-lumen diameter (eg, craniofacial deformities, macroglossia, retrognathia), endocrine diseases (eg, Cushing disease, hypothyroidism), connective

tissue diseases (eg, Marfan syndrome), male gender, age older than 50 years, neck circumference greater than 40 cm, and lifestyle factors of smoking and alcohol consumption.<sup>15</sup>

## POSTOPERATIVE COMPLICATIONS IN PATIENTS WITH OSA

Chronic untreated OSA leads to multisystemic adverse consequences and is an independent risk factor for increased all-cause mortality in the general population.<sup>16,17</sup> The anatomic inherent collapsibility of the airway and the systemic effects of the disease also place the surgical patient with OSA at increased risk of serious complications perioperatively.

In a retrospective study of patients who underwent hip or knee replacements conducted by Gupta and colleagues,<sup>18</sup> 24% of patients with known OSA developed serious complications after surgery, including unplanned admission to the intensive care unit (ICU), reintubation, and cardiac events, as opposed to 9% in the control group. Subsequent studies on similar outcomes conducted by Liao and colleagues<sup>19</sup> and Chung and colleagues<sup>20</sup> reported complication rates of 44% and 27.4%, respectively following elective surgery in patients with OSA versus 28% and 12.3%, respectively in those without OSA. Gali and colleagues<sup>21</sup> reported increased rates of pneumonia and the need for noninvasive ventilation in high-risk OSA patients. Kaw and colleagues<sup>22</sup> demonstrated an increased risk of postoperative hypoxemia, transfer to ICU, and longer duration of hospitalization in OSA patients following noncardiac surgery. Memtsoudis and colleagues<sup>23</sup> found a 2-fold higher risk of pulmonary complications in OSA patients after noncardiac surgery in comparison with matched controls with no OSA. In bariatric surgical patients, the presence of OSA was found to be an independent risk factor for adverse postoperative events.<sup>24</sup> A recent prospective observational study by Flink and colleagues<sup>25</sup> reported a 53% incidence of postoperative delirium in OSA patients compared with 20% in patients without OSA (odds ratio 4.3). A summary of the relevant studies and the complications reported is presented in **Table 1**.

More recently, a meta-analysis by Kaw and colleagues<sup>26</sup> showed that the presence of OSA increased the odds of postoperative cardiac events including myocardial infarction, cardiac arrest, and arrhythmias (odds ratio 2.1), respiratory failure (odds ratio 2.4), desaturation (odds ratio 2.3), transfers to ICU (odds ratio 2.8), and reintubations (odds ratio 2.1). Given the body of evidence associating a diagnosis of OSA with adverse

perioperative outcomes, precautions should be taken perioperatively to reduce complications in this vulnerable group of patients.

## CLINICAL PATHWAYS AND PRINCIPLES OF PERIOPERATIVE MANAGEMENT

In an attempt to improve the perioperative care for OSA patients, various investigators have constructed guidelines or clinical pathways.<sup>27–32</sup> Preoperatively, the use of sensitive clinical criteria to identify and risk-stratify potential OSA patients is advocated. The Sleep Apnea Clinical Score proposed by Flemons<sup>27</sup> used a combination of clinical variables, including neck circumference of at least 43 cm, snoring, disturbed breathing during sleep, daytime somnolence, obesity, and hypertension, to determine the likelihood of OSA. The American Society of Anesthesiologists 2006 guidelines on the perioperative management of OSA patients recommended screening patients using a 16-item checklist comprising clinical criteria categorized into physical characteristics, symptoms, and complaints. The patient's perioperative risk was then predicted by a scoring system based on OSA severity, invasiveness of procedure, and expected postoperative opioid requirement.<sup>28</sup> Recent review articles have supported the use of questionnaire-based screening tools to predict the probability and severity of OSA.<sup>20,29,31</sup> Patients who exhibit high-risk features on screening should undergo formal evaluation with confirmatory sleep studies. Positive airway pressure (PAP) therapy should be commenced preoperatively if polysomnographic evidence of moderate to severe OSA is present.<sup>27–29</sup>

Intraoperative measures have focused on the anticipation and management of difficult airways, mitigating the risk of aspiration of gastric acid, and the judicious use of pharmacologic agents to avoid problems of excessive sedation and respiratory depression in the immediate postoperative period.<sup>28,29,31</sup> Issues of monitoring and intervention are pertinent in the postoperative period. Based on expert opinion by the American Sleep Association (ASA) taskforce, if discharge to an unmonitored facility is planned, the observation period for OSA patients in the postanesthesia care unit (PACU) should be prolonged by a median of 3 hours more than for non-OSA patients, or 7 hours if respiratory events occur.<sup>28</sup> Another algorithm proposed by Adesanya and colleagues<sup>29</sup> recommended that patients with known OSA or at high risk on screening be observed for a minimum of 2 hours in the PACU, and be considered for continuous PAP in the event of oxygen desaturation. Subsequent inpatient care should include continuous

monitoring of oxygen saturation in an appropriate environment. PAP therapy should be considered for patients already on PAP treatment or who have been noncompliant before surgery, as well as those at high risk of OSA.

This article provides an updated discussion on the preoperative evaluation of the diagnosed and suspected OSA patient, strategies for intraoperative risk mitigation, and postoperative patient disposition, with illustrations of published clinical algorithms.<sup>30,33</sup>

## PREOPERATIVE EVALUATION OF THE PATIENT WITH DIAGNOSED OSA

A thorough history and physical examination are essential. Focused questions regarding OSA symptoms should be asked. Polysomnography results should be reviewed to confirm the diagnosis of OSA and evaluate the severity of the disease.

Patients with long-standing OSA may manifest a myriad of signs and symptoms suggesting the development of systemic complications, such as hypoxemia, hypercarbia, polycythemia, and cor pulmonale. The patient should also be assessed for significant comorbidities including morbid obesity, uncontrolled hypertension, arrhythmias, cerebrovascular disease, heart failure, and metabolic syndrome. Pulmonary arterial hypertension is a fairly common long-term complication of OSA, occurring in 15% to 20% of patients.<sup>34</sup> Its significance lies in the fact that certain physiologic derangements may raise pulmonary artery pressures further and should be avoided intraoperatively. The American College of Chest Physicians does not recommend routine evaluation for pulmonary arterial hypertension in patients with known OSA.<sup>35</sup> However, should there be anticipated intraoperative triggers for acute elevations in pulmonary arterial pressures (eg, high-risk surgical procedures of long duration), a preoperative transthoracic echocardiography may be considered.<sup>29</sup> Simple bedside investigations may be performed in the preoperative clinic to screen for OSA-related complications. In the absence of other attributable causes for hypoxemia, a baseline oximetry reading of 94% or less on room air suggests severe long-standing OSA, and may be a red flag signaling postoperative adverse outcome.<sup>36</sup>

Frequently OSA patients may be on PAP devices for treatment, for example, continuous positive airway pressure (CPAP), bilevel positive airway pressure (BiPAP), and automatically adjusting positive airway pressure (APAP) machines. Automatically adjusting PAP devices provides respiratory assistance based on airflow measurements,

**Table 1**  
Adverse outcomes in OSA patients after surgery

	Gupta et al, <sup>18</sup> 2001	Liao et al, <sup>19</sup> 2009	Chung et al, <sup>20</sup> 2008	Kaw et al, <sup>22</sup> 2012	Gali et al, <sup>21</sup> 2009	Memtsoudis et al, <sup>23</sup> 2011	Flum et al, <sup>24</sup> 2009	Flink et al, <sup>25</sup> 2012
Study design	Retrospective case control study	Retrospective matched cohort study	Prospective cohort study	Retrospective cohort study	Prospective cohort study	Retrospective cohort study	Observational study	Prospective cohort study
Method of OSA diagnosis	Polysomnogram, nocturnal oximetry	Hospital discharge records	Polysomnogram	Polysomnogram	Sleep Apnea Clinical Score	Hospital discharge records	Patients' report of prior diagnosis	Polysomnogram
Nature of surgery	Orthopedic (hip and knee replacements)	Cardiothoracic Noncardiac <sup>a</sup> ENT <sup>b</sup>	Noncardiac <sup>a</sup> Ophthalmic Neurosurgery	Noncardiac <sup>a</sup> ENT <sup>b</sup>	Surgeries with postoperative stay $\geq$ 48 h	Noncardiac <sup>a</sup>	Bariatric surgery	Orthopedic (knee replacement), age >65 y
<b>No. of Subjects</b>								
OSA group	101	240	147	282	221	113960	2354 <sup>c</sup>	15
Non-OSA group	101 (control)	240 (control)	64 (control)	189 (control)	472	5937742 (control)	2354 <sup>d</sup>	91
<b>Complication Rate</b>								
OSA, n (%)	24 (24)	104 (43)	40 (27.4)	40 (14.2)	23 (10.4)	7828 <sup>e</sup> (6.87)	112 (5.0)	8 (53%)
Non-OSA, n (%)	9 (9)	67 (28)	8 (12.3)	5 (2.6)	19 (4.02)	221651 <sup>e</sup> (3.73)	77 (3.3)	19 (20%)
P value	0.004	<0.001	0.02	0.003	0.043	OR 1.95, 95% CI (1.91–1.98)	0.02 (unadjusted)	0.0123, OR 4.3

Complications					
Respiratory <sup>f</sup>		Yes	Yes	Yes	Yes
Cardiac <sup>g</sup>	Yes	Yes	Yes	Yes	Yes
Neurologic <sup>h</sup>		Yes	Yes		
Unplanned ICU admission	Yes	Yes	Yes	Yes	Yes
Reintubation/emergency intubation	Yes			Yes	Yes
Lengthened hospital stay			Yes	Yes	Yes
Other				NIV Pneumonia	Pneumonia ARDS PE
					Death VTE Reintervention
					Delirium

*Abbreviations:* ARDS, acute respiratory distress syndrome; CI, confidence interval; ENT, ear/nose/throat; ICU, intensive care unit; NIV, noninvasive ventilation; OR, odds ratio; PE, pulmonary embolism; VTE, venous thromboembolism.

<sup>a</sup> Noncardiac surgery: general surgery, urology, gynecology, orthopedic surgery, plastic surgery.

<sup>b</sup> ENT surgery not including upper airway surgery.

<sup>c</sup> Number of patients who reported a diagnosis of OSA preoperatively.

<sup>d</sup> Number of patients who did not report an established diagnosis of OSA preoperatively.

<sup>e</sup> Data for incidence of tracheal intubation only.

<sup>f</sup> Respiratory complications: desaturation, hypoxia, hypercapnia, respiratory failure, bronchospasm, laryngospasm, pulmonary edema.

<sup>g</sup> Cardiac complications: myocardial ischemia, myocardial infarction, arrhythmia.

<sup>h</sup> Neurologic complications: Confusion, agitation, stroke, transient ischemic attack, motor or sensory deficits.

fluctuations in pressure, or airway resistance.<sup>37</sup> The compliance of OSA patients to such treatment should be evaluated. The patient's updated PAP therapy settings should be obtained. Reassessment by a sleep medicine physician may be indicated in patients who have defaulted follow-up, have been noncompliant 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.

To date there is insufficient evidence to prove conclusively the benefit of PAP therapy in the preoperative setting, and the duration of therapy required to effectively reduce perioperative risks has not been delineated. A retrospective matched cohort study by Liao and colleagues<sup>19</sup> suggested that preoperative PAP therapy may possibly be beneficial based on the observation that OSA patients who did not use home PAP devices before surgery but required PAP therapy after surgery had increased complication rates.

Current guidelines recommend that patients with moderate or severe OSA who are already on PAP therapy should continue to use PAP before surgery.<sup>28</sup> The anesthesia team should be informed early to allow for advanced planning of intraoperative management and risk mitigation. Mild OSA may not be a significant disease entity for patients undergoing surgery and anesthesia. According to the published results of the Busselton Health Cohort Study, mild OSA was not an independent risk factor for higher mortality in the general population.<sup>17</sup> Based on expert opinion and symptomatology of OSA patients, preoperative PAP use may not be indicated in patients with mild OSA. **Fig. 1** suggests an algorithm for the preoperative evaluation and management of the patient already diagnosed with OSA.<sup>30,33</sup>

## METHODS FOR PERIOPERATIVE SCREENING FOR OSA

An overnight polysomnography is the gold-standard diagnostic test for OSA. However, routine screening with polysomnography is costly and resource intensive, because of equipment constraints and the requirement for special technical expertise. As a result, several tools have been developed to meet this need for simple, economical, and sensitive screening tests for the detection of patients with suspected OSA. These tools include questionnaire-based methods such as the Epworth Sleepiness Scale,<sup>38</sup> the Berlin Questionnaire,<sup>39</sup> the ASA checklist,<sup>28</sup> the Sleep Apnea Clinical Score,<sup>27</sup> the P-SAP score,<sup>40</sup> and the STOP-Bang questionnaire.<sup>41</sup> The STOP-Bang

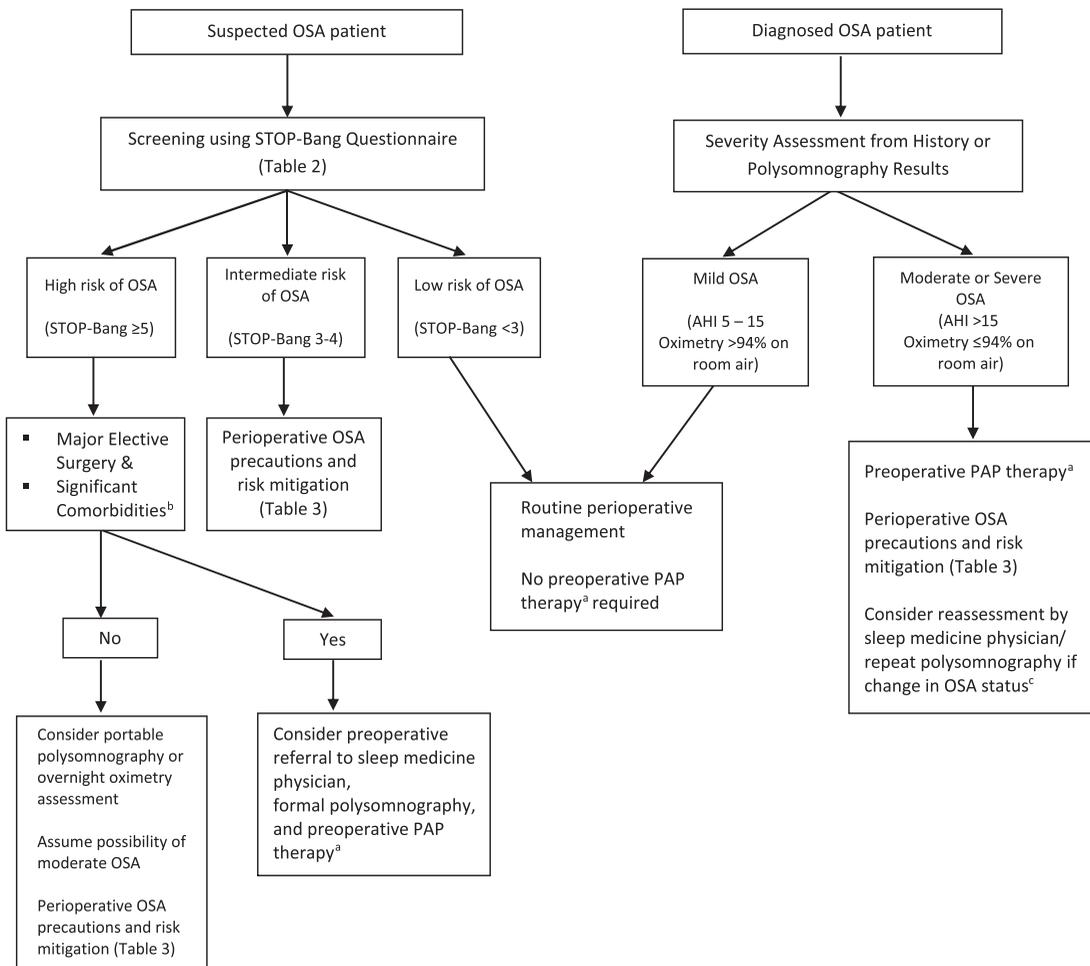
questionnaire was originally developed in the surgical population but has been validated in various patient populations.<sup>41,42</sup> This concise scoring system consists of 8 easily administered questions framed with the acronym STOP-Bang (**Table 2**). Each question is scored based on the answer "Yes" or "No." Patients are deemed to be at risk of OSA if they have a STOP-Bang score of at least 3 and at high risk of OSA if the STOP-Bang score is 5 or more.<sup>41,43</sup>

The purpose of a screening test is to detect as many subjects with disease as possible with a low false-negative rate, that is, high sensitivity at the expense of lower specificity. The STOP-Bang questionnaire has high sensitivity and a high negative predictive value, especially for patients with moderate to severe OSA.<sup>41</sup> A STOP-Bang score of less than 3 is reassuring, as the patient is unlikely to have moderate to severe OSA. On the other hand, the false-positive rate may be high. For moderate OSA (AHI >15) and severe OSA (AHI >30), the sensitivity of STOP-Bang score is 93% and 100%, respectively, whereas the specificity is 43% and 37%, respectively.<sup>41</sup>

STOP-Bang scores of 5 and greater are even more predictive for moderate to severe OSA. For higher cutoff values of 5, 6, and 7, the specificity of STOP-Bang questionnaire for severe OSA (AHI >30) was 74%, 88%, and 95% respectively.<sup>43</sup> Based on these test characteristics, patients with STOP-Bang scores of 0 to 2 may be considered to be at low risk, 3 to 4 at intermediate risk, and 5 to 8 at high risk of having OSA. 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 cutoff between 5 and 8. In addition, patients identified as high risk on STOP-Bang have been shown to have increased rates of postoperative complications.<sup>20,44</sup> The STOP-Bang questionnaire is useful in the preoperative setting to predict OSA severity, triage patients for further confirmatory testing, and exclude those without disease.<sup>42</sup>

## PREOPERATIVE EVALUATION OF THE PATIENT WITH SUSPECTED OSA

In patients suspected of OSA, a thorough clinical examination should be performed with emphasis on pertinent symptoms and signs of OSA (see **Fig. 1**). The bed partner's presence at the interview would be useful in the assessment of snoring and observed apnea. The subsequent management is determined by the urgency of surgery. In emergency situations, the patient should proceed for surgery. Extensive testing for OSA will result in



**Fig. 1.** Preoperative evaluation of a patient with known or suspected obstructive sleep apnea in the anesthesia clinic. <sup>a</sup> Positive airway pressure (PAP) therapy: includes continuous PAP, bilevel PAP, and automatically adjusting PAP. <sup>b</sup> Significant comorbidities: heart failure, arrhythmias, uncontrolled hypertension, pulmonary hypertension, cerebrovascular disease, metabolic syndrome, obesity (body mass index >35 kg/m<sup>2</sup>). <sup>c</sup> Change in OSA status: recent exacerbation of OSA symptoms, noncompliant to PAP therapy, recently underwent OSA-related surgery, lost to sleep medicine follow-up. AHI, Apnea-Hypopnea Index. (Adapted from Seet E, Chung F. Obstructive sleep apnea: preoperative assessment. *Anesthesiol Clin* 2010;28:199–215, with permission; and Seet E, Chung F. Management of sleep apnea in adults-functional algorithms for the perioperative period: continuing professional development. *Can J Anaesth* 2010;57:849–64. Copyright 2010 by Canadian Anesthesiologists’ Society; with kind permission from Springer Science and Business Media.)

a delay of vital surgery. Perioperative precautions should be taken based on the clinical suspicion of OSA. A clinical algorithm is suggested regarding the elective setting (see Fig. 1).<sup>30</sup>

When nonurgent elective surgery is planned, the decision for further evaluation rests on (1) the risk of surgery and (2) the presence of other significant comorbidities suggestive of chronic OSA, such as uncontrolled hypertension, heart failure, arrhythmias, pulmonary hypertension, cerebrovascular disease, morbid obesity, and metabolic syndrome. For patients who are scored as high risk on STOP-Bang (score ≥5) who are planned for major elective surgery and have comorbid disease(s)

associated with long-standing OSA, a preoperative assessment by the sleep physician and a polysomnogram should be considered to confirm the diagnosis and establish the severity of disease. An early review by the sleep physician is recommended to allow for optimal PAP treatment and sufficient time for planning of the intraoperative and postoperative management.<sup>28</sup> Sometimes, major elective surgery may have to be deferred to allow adequate evaluation and optimization of suspected severe OSA. The eventual decision to evaluate a patient preoperatively should ultimately be made based on the clinical judgment of the attending physician, after taking into account

**Table 2**  
**Obstructive sleep apnea screening questionnaire: STOP-Bang**

STOP Questionnaire			
S	Snoring: Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?	Yes	No
T	Tired: Do you often feel tired, fatigued, or sleepy during daytime?	Yes	No
O	Observed: Has anyone observed you stop breathing during your sleep?	Yes	No
P	Blood Pressure: Do you have or are you being treated for high blood pressure?	Yes	No
B	Body mass index: greater than 35 kg/m <sup>2</sup> ?	Yes	No
A	Age: Age over 50 y old?	Yes	No
N	Neck circumference: Neck circumference greater than 40 cm?	Yes	No
G	Gender: Male?	Yes	No

Low risk of OSA: Yes to fewer than 3 questions.

At risk of OSA: Yes to 3 or more questions.

High risk of OSA: Yes to 5 or more questions.

*Modified from* Chung F, Yegneswaran B, Liao P, et al. STOP questionnaire: a tool to screen patients for obstructive sleep apnea. *Anesthesiology* 2008;108:812–21; and 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.

patient-related and logistic factors. The authors suggest that patients scored as high risk but without significant comorbidities be considered for further evaluation with portable monitoring devices, or to proceed with surgery with a presumed diagnosis of moderate OSA and undertaking perioperative OSA precautions.

Patients with an intermediate risk of OSA based on STOP-Bang may proceed for surgery without further testing with perioperative OSA precautions. This subset of patients may have previously undergone anesthesia uneventfully, and represent false positives on screening, or may have less severe OSA. Nonetheless, increased vigilance is prudent in managing these at-risk patients. If the subsequent intraoperative and postoperative course suggests a higher likelihood of OSA, for example, difficult airway,<sup>45</sup> or recurrent postoperative respiratory events such as desaturation, hypoventilation, or apnea,<sup>21</sup> a subsequent referral to the sleep physician and polysomnography may be indicated. OSA screening tests have a low false-negative rate. Patients deemed to be at low risk on screening with a score of less than 3 on STOP-Bang are unlikely to have OSA. These patients may proceed for surgery with routine perioperative care.

#### PORTABLE POLYSOMNOGRAPHY AND OVERNIGHT OXIMETRY

Home sleep testing may be a viable alternative to standard polysomnography for the diagnosis of OSA in certain subsets of patients.<sup>46</sup> Such monitoring equipment is classified into level 2 (full unattended polysomnography with  $\geq 7$  channels),

level 3 (devices limited to 4–7 channels), and level 4 (1–2 channels including nocturnal oximetry) devices. In particular, the level 2 portable polysomnograph has been shown to have a diagnostic accuracy similar to that of standard polysomnography,<sup>47</sup> while nocturnal oximetry is both sensitive and specific for detecting OSA in STOP-Bang-positive surgical patients.<sup>48</sup> The oxygen desaturation index derived from nocturnal oximetry correlates well with the AHI obtained from polysomnography.<sup>48</sup> Furthermore, a mean nocturnal oxygen saturation of 94.6% or less or mean oxygen desaturation index of greater than 9.2 are predictive of increased postoperative adverse events.<sup>36</sup>

The Portable Monitoring Task Force of the American Academy of Sleep Medicine (AASM) suggests that portable devices may be considered when there is high pretest likelihood for moderate to severe OSA without other substantial comorbidities.<sup>49</sup> Following the AASM 2007 guidelines, the Canadian Thoracic Society 2011 update on the diagnosis and treatment of sleep-disordered breathing recommended that portable monitoring devices of levels 2, 3, and 4, including nocturnal oximetry, may be used as confirmatory tests for the diagnosis of OSA, provided that proper standards for conducting the test and interpretation of results are met.<sup>50</sup> These portable devices are useful surrogates for the detection of OSA, especially if standard polysomnography is not available. The devices may also help with risk stratification of patients with suspected OSA, allowing preoperative PAP therapy and ample perioperative measures to be instituted for those identified to be at increased risk of complications.

**INTRAOPERATIVE RISK-MITIGATION STRATEGIES FOR OSA PATIENTS**

Various strategies may be used to mitigate the risks and avert adverse outcomes in OSA patients in the immediate perioperative and intraoperative periods, and these are listed in **Table 3**. Preoperatively, sedative premedication should be avoided.<sup>51</sup> Pain adjuvants such as the  $\alpha$ 2-agonists (dexmedetomidine) have an opioid-sparing effect and also reduce anesthetic requirement.<sup>52</sup>

Intraoperatively, the anesthesiologist may often be presented with a difficult airway. A history of

OSA may be associated with difficult mask ventilation<sup>53</sup> as well as difficult intubation, with a difficult tracheal intubation occurring 8 times as often in OSA patients than in those without OSA.<sup>54</sup> Advanced planning of airway management is required. In addition, a backup action plan should be in place in anticipation of the possibility that the intended technique turns out to be unsuitable. Adequately skilled personnel and appropriate equipment, including a range of airway adjuncts, should be available before induction of anesthesia.<sup>55</sup> The entire anesthesia team should be familiar with a specific difficult airway algorithm,

<b>Table 3 Perioperative precautions and risk mitigation for OSA patients</b>	
<b>Anesthetic Concern</b>	<b>Principles of Management</b>
Premedication	Avoid sedating premedication <sup>51</sup> Consider $\alpha$ 2-adrenergic agonists (clonidine, dexmedetomidine) <sup>52</sup>
Potential difficult airway (difficult mask ventilation and tracheal intubation) <sup>53,54</sup>	Optimal positioning (Head Elevated Laryngoscopy Position) if patient obese Adequate preoxygenation Consider CPAP preoxygenation <sup>57</sup> Two-handed triple-airway maneuvers Anticipate difficult airway. Personnel familiar with a specific difficult-airway algorithm <sup>56</sup>
Gastroesophageal reflux disease <sup>59</sup>	Consider proton-pump inhibitors, antacids, rapid sequence induction with cricoid pressure
Opioid-related respiratory depression <sup>51</sup>	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 a sole anesthetic technique
Excessive sedation in monitored anesthetic care	Use of intraoperative capnography for monitoring of ventilation <sup>28</sup>
Postextubation airway obstruction	Verify full reversal of neuromuscular blockade <sup>28</sup> Extubate only when fully conscious and cooperative <sup>28</sup> Nonsupine posture for extubation and recovery <sup>28</sup> Resume use of positive airway pressure device after surgery <sup>28</sup>

*Abbreviations:* CPAP, continuous positive airway pressure; NSAID, nonsteroidal anti-inflammatory drug.

*Adapted from* Seet E, Chung F. Management of sleep apnea in adults—functional algorithms for the perioperative period: continuing professional development. *Can J Anaesth* 2010;57:849–64. Copyright © 2010 by Canadian Anesthesiologists' Society; with kind permission from Springer Science and Business Media.

such as the ASA guidelines for the management of a difficult airway.<sup>56</sup> Preoxygenation using 100% oxygen with continuous PAP of 10 cm H<sub>2</sub>O for 3 to 5 minutes with a 25° head-up tilt has been reported to achieve higher end-tidal concentrations of oxygen.<sup>57,58</sup> Triple-airway maneuvers and two-handed mask ventilation may be needed to attain adequate ventilation. Obese patients may have to be positioned on an incline to achieve optimal alignment to facilitate laryngoscopy—the Head Elevated Laryngoscopy Position or HELP. This action may be taken by simply stacking up multiple towels or blankets, or by using specially designed devices such as the Troop Elevation Pillow (Mercury Medical, Clearwater, FL, USA). Gastroesophageal reflux disease secondary to hypotonia of the lower esophageal sphincter is common among patients with OSA.<sup>59</sup> Measures to decrease the risk of aspiration of gastric acid should be considered, and include preoperative proton-pump inhibitors, antacids, and rapid sequence induction and cricoid pressure. Of note, use of cricoid pressure may further impede mask ventilation and tracheal intubation.<sup>60</sup>

Many of the anesthetic agents, for example, volatile agents, anxiolytics, and opioids, cause respiratory depression. OSA patients have a heightened sensitivity to the respiratory depressant effects of these drugs because of their increased susceptibility for airway collapse, chronic sleep deprivation, and blunted response to hypercarbia and hypoxia. Short-acting agents such as propofol, remifentanyl, and desflurane are preferred, whereas long-acting agents should be avoided or their use minimized. Pulmonary hypertension is a known complication of chronic OSA. Intraoperative triggers for elevation of pulmonary artery pressures, namely hypercarbia, hypoxemia, hypothermia, and acidosis, should be avoided.

Intraoperative use of opioid-sparing agents such as nonsteroidal anti-inflammatories, cyclooxygenase-2 inhibitors, paracetamol, tramadol, and adjuvants such as the anticonvulsants pregabalin and gabapentin are helpful in reducing postoperative opioid requirements. Previous studies showed that desaturation was 12 to 14 times more common in patients with OSA who received opioids postoperatively than in those who were given nonopioid analgesic agents.<sup>61</sup> Other novel opioid-sparing adjuvants being investigated include corticosteroids such as dexamethasone, the *N*-methyl-D-aspartate receptor antagonist ketamine,<sup>62</sup> the  $\alpha$ 2-agonists clonidine and dexmedetomidine,<sup>63</sup> and melatonin.<sup>64</sup> A recent study investigating the beneficial effects of intraoperative intravenous doxapram found that postanesthetic recovery and outcomes of OSA patients

undergoing bariatric surgery were improved with the use of central respiratory stimulants.<sup>65</sup>

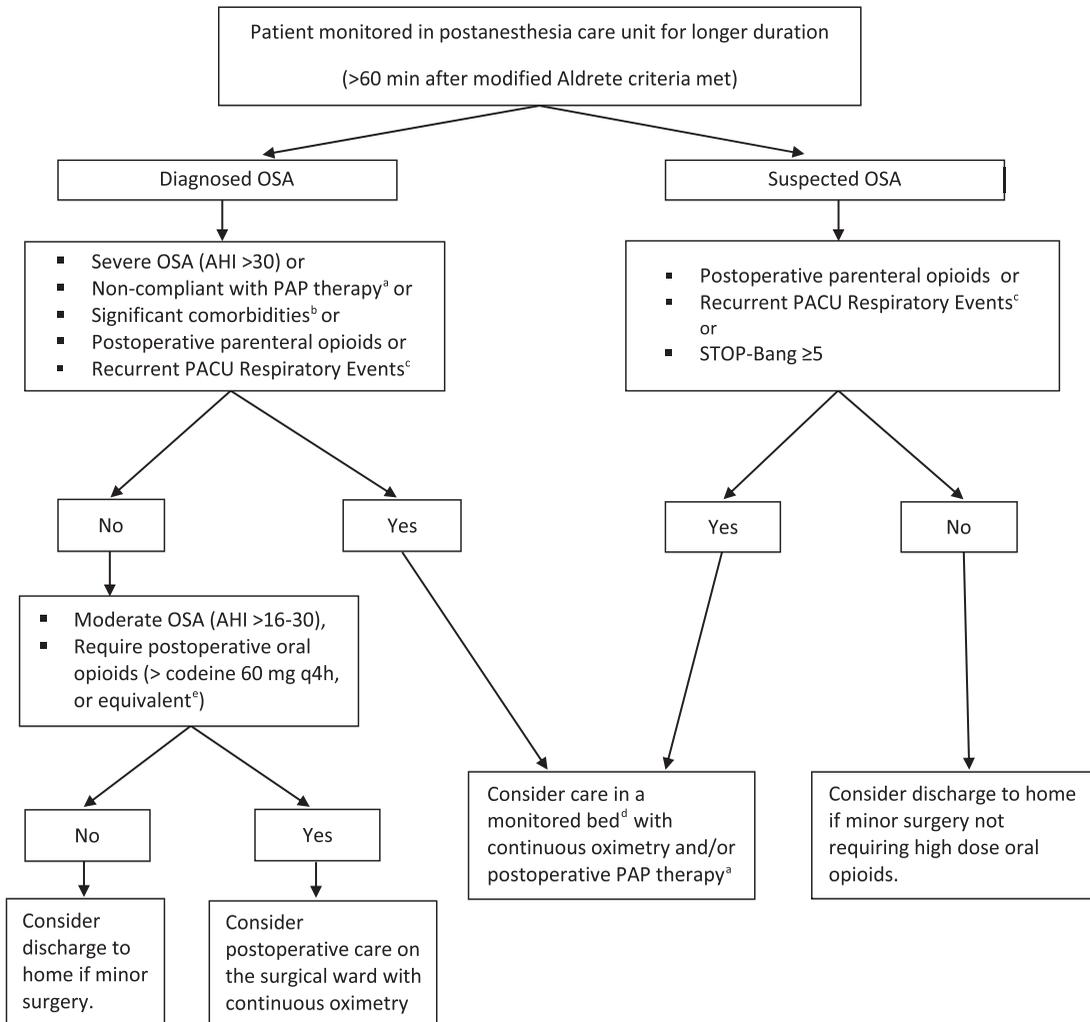
At the end of surgery, neuromuscular blockade should be fully reversed. An objective assessment of the neuromuscular junction using train-of-4 or other methods is ideal. It has been reported that even minute amounts of residual neuromuscular blockade can result in greater postoperative morbidity with increased risks of aspiration, airway obstruction, hypoventilation, hypoxia, and reintubation.<sup>66</sup> Patients should be extubated only when awake: fully conscious, obeying commands, and with airway patency confirmed. Purposeful movements must be distinguished from involuntary actions such as coughing and reflex reaching for the endotracheal tube. After extubation, patients should be nursed in a semi-upright or lateral position.<sup>28</sup>

Local and regional anesthesia techniques may be preferable to general anesthesia, as they avoid manipulation of the airway and reduce the postoperative requirement for sedating analgesic medication.<sup>28</sup> Wound infiltrations, peripheral nerve-block infusions, and epidural infusions of local anesthetic reduce opioid requirements postoperatively and may be of benefit. However, owing to the paucity of published literature in this field, there is currently no good-level evidence supporting one technique over the other. Patients receiving sedation for surgical procedures under monitored anesthetic care should be monitored for adequacy of ventilation by capnography. Patients previously on PAP therapy at home should continue the use of their PAP devices during procedures under mild to moderate sedation.<sup>67</sup> A secured airway is preferred to an unprotected one for procedures requiring deep sedation.<sup>28</sup>

## POSTOPERATIVE DISPOSITION OF KNOWN AND SUSPECTED OSA PATIENTS AFTER GENERAL ANESTHESIA

The postoperative disposition of the OSA patient depends on 3 main components: the invasiveness of the surgery, the severity of OSA, and the requirement for postoperative opioids (**Fig. 2**). To illustrate, a patient with severe OSA who just had major surgery and is receiving high-dose opioids would be more likely to require continuous monitoring than another patient with suspected OSA undergoing minor surgery. The final decision regarding the level of monitoring is determined by the attending anesthesiologist, taking into account all patient-related, logistic, and circumstantial factors.

A practical algorithm (see **Fig. 2**) has been formulated based on the ASA 2006 guidelines on



**Fig. 2.** Postoperative management of the patient with known or suspected obstructive sleep apnea after general anesthesia. <sup>a</sup> Positive airway pressure (PAP) therapy: includes continuous PAP, bilevel PAP, or automatically adjusting PAP. <sup>b</sup> Significant comorbidities: heart failure, arrhythmias, uncontrolled hypertension, cerebrovascular disease, metabolic syndrome, obesity (body mass index >35 kg/m<sup>2</sup>). <sup>c</sup> Recurrent postanesthesia care unit (PACU) respiratory event: repeated occurrence of oxygen saturation less than 90%, or bradypnea less than 8 breaths/min, or apnea 10 seconds and longer, or pain-sedation mismatch (high pain and sedation scores concurrently).<sup>21</sup> <sup>d</sup> Monitored bed: environment with continuous oximetry and the possibility of early medical intervention (eg, intensive care unit, step-down unit, or remote pulse oximetry with telemetry in surgical ward). <sup>e</sup> Equianalgesic doses of oral opioids: codeine 60 mg every 4 hours (q4h), Oxycodone 5 mg q4h, Hydromorphone 2 mg q4h. (Adapted from Seet E, Chung F. Obstructive sleep apnea: preoperative assessment. *Anesthesiol Clin* 2010;28:199–215, with permission; and Seet E, Chung F. Management of sleep apnea in adults-functional algorithms for the perioperative period: continuing professional development. *Can J Anaesth* 2010;57:849–64. Copyright 2010 by Canadian Anesthesiologists’ Society; with kind permission from Springer Science and Business Media.)

the perioperative management of patients with OSA, and on evidence from recent research.<sup>30,33</sup> All patients with known or suspected OSA who have received general anesthesia should have extended monitoring in the PACU with continuous oximetry. There are currently no evidence-based guidelines addressing the optimal length of monitoring required in the PACU. The ASA guidelines, which were based on expert opinion, recommended

prolonged observation for 7 hours in the PACU if respiratory events such as apnea or airway obstruction occur. Such recommendations are difficult to adhere to, especially in the context of community hospitals.<sup>67</sup> The algorithm recommended in this article proposes extended PACU observation for an additional 60 minutes in a quiet environment after the modified Aldrete criteria for discharge has been met.<sup>30,33</sup>

The occurrence of recurrent respiratory events in the PACU is another indication for continuous postoperative monitoring.<sup>21</sup> PACU respiratory events are: (1) episodes of apnea for 10 seconds or more, (2) bradypnea fewer than 8 breaths per minute, (3) pain-sedation mismatch, or (4) repeated oxygen desaturation to less than 90%. Any of these events occurring repeatedly in separate 30-minute intervals may be considered recurrent PACU respiratory events. Patients with suspected OSA (ie, scored as high risk on screening questionnaires) and who develop recurrent PACU respiratory events postoperatively are at increased risk of postoperative respiratory complications.<sup>20,21,44</sup> Continuous monitoring with oximetry in a unit with ready access to medical intervention is advocated. These locations would include ICUs, step-down units, or surgical ward equipped with remote telemetry and oximetry monitoring. These patients may also require postoperative PAP therapy.<sup>67</sup>

Advances incorporating smart technologies have been made in monitoring equipment. Multiple parameters including heart rate, blood pressure, temperature, capnography, and oxygen saturation can be tracked continuously, and the trends analyzed and interpreted according to preprogrammed algorithms. Such monitoring will potentially improve the sensitivity in detecting at-risk patients during their recovery while reducing false alarms, making the postoperative care of OSA patients safer than before.<sup>68,69</sup>

One should consider discharging a patient with known OSA to a monitored environment if the patient has severe OSA, has been noncompliant to PAP therapy, or has experienced recurrent PACU respiratory events (see **Fig. 2**). Furthermore, monitoring with continuous oximetry is recommended if parenteral opioids are administered, in view of possible drug-induced respiratory depression.<sup>70</sup> Patients with moderate OSA who require high-dose oral opioids should be managed in a surgical ward with continuous oximetry (see **Fig. 2**) regardless of the number of PACU respiratory events.

Known OSA patients already on PAP devices should continue PAP therapy postoperatively. Although there is insufficient high-level evidence demonstrating an improvement of outcomes with postoperative PAP therapy in OSA patients, a recent retrospective review of 797 patients scheduled for bariatric surgery suggested that timely recognition and management of OSA with perioperative continuous PAP may mitigate the risk of postoperative complications.<sup>71</sup>

When possible, a multimodal approach to analgesia should be used to minimize the use of opioids postoperatively. Apart from oral or systemic administration of opioid-sparing agents,

other effective techniques include local anesthetic wound infiltration, peripheral nerve block catheters, and neuraxial infusions of local anesthetic agents. If postoperative parenteral opioids are necessary, consideration should be made for the use of patient-controlled analgesia with no basal infusion and a strict hourly dose limit, as this may help reduce the total amount of opioid used. OSA patients may have an upregulation of the central opioid receptors secondary to recurrent hypoxemia, and are therefore more susceptible to the respiratory depressant effects of opioids. As such, they may benefit from supplemental oxygen while on parenteral opioids.<sup>72</sup> The Anesthesia Patient Safety Foundation advises that ventilation should be monitored (eg, capnography) for the detection of hypoventilation when supplemental oxygen is delivered.<sup>70</sup>

An interesting phenomenon has been described in recent studies: the AHI increased significantly on postoperative day 3, particularly in male patients with moderate to severe OSA.<sup>73</sup> The occurrence of late complications in OSA patients may be attributed to delayed normalization of sleep architecture and AHI after the fifth postoperative night.<sup>74</sup> At present, deciding on the optimal level and duration of monitoring for OSA patients remains a daunting challenge. The vulnerable OSA patient is at risk of serious postoperative complications and even death. Granted, the incidence of postoperative OSA-related mortality is low; however, it only takes one unnecessary death or one case of hypoxic encephalopathy to be the impetus for closer postoperative monitoring.<sup>75,76</sup>

## AMBULATORY SURGERY FOR OSA PATIENTS

The 2006 ASA guidelines on the perioperative management of OSA patients advised that superficial surgery, minor orthopedic surgery under local anesthesia or regional anesthesia, and lithotripsy may be performed as day cases.<sup>28</sup> Since the publication of the ASA guidelines in 2006, there has been increasing interest in ambulatory surgery for OSA patients. The newly published Society for Ambulatory Anesthesia (SAMBA) consensus statement has provided guidelines addressing the selection of suitable OSA patients for ambulatory surgery. The committee found, on systematic review of studies involving ambulatory surgery in OSA patients, 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 reintubation, mechanical ventilation, surgical airway, or death. The investigators recommend that known OSA patients with

well-controlled comorbid diseases and who will comply with postoperative PAP therapy may be considered for ambulatory surgery. Patients are advised to use their PAP devices when sleeping even in daytime for several days postoperatively. Patients presumed to have OSA based on screening, who have optimized comorbid conditions and who will not require oral opioids postoperatively, may also be safely discharged after ambulatory surgery.<sup>77</sup> Emphasis was placed on advanced planning of the intraoperative and postoperative anesthetic and analgesic options, and timely education of patients and caregivers regarding their postdischarge care. The authors similarly recommend that diagnosed or suspected OSA patients without significant comorbidities, recurrent PACU respiratory events, or the need for high-dose oral opioids be considered for discharge home after minor surgery at the discretion of the attending physician (see **Fig. 2**).<sup>30,78</sup> Patients with severe OSA and uncontrolled comorbid diseases are not suitable for ambulatory surgery.<sup>77,78</sup> With regard to the type of procedures suitable for day surgery, the SAMBA guidelines recommend that painful operations for which postoperative nonopioid analgesia would be inadequate should not be performed on an outpatient basis. Based on current evidence, the committee suggests that laparoscopic upper abdominal procedures may be performed as day cases, in contrast to the ASA 2006 recommendations.<sup>77</sup>

All OSA patients should be escorted home by a reliable adult upon discharge. 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. 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.

From recent publications, it appears that the safe conduct of ambulatory surgery for OSA patients may be possible. Retrospective observational studies have reported low (<0.5%) postoperative complication rates with ambulatory or short-stay surgery for OSA patients undergoing bariatric surgery.<sup>79–81</sup> Such approaches are still deemed unconventional.<sup>82</sup> Discriminating criteria for patient selection, meticulous preoperative risk stratification, and optimization of OSA and related comorbidities, together with well-trained medical personnel, experienced high-volume facilities, and strict discharge criteria are all essential for the delivery of safe ambulatory surgery for this subset of patients.

## SUMMARY

It is well known that OSA patients can suffer serious postoperative consequences, and this has led to the formulation of various screening methods for the detection and risk stratification of OSA patients. Although every patient deserves individualized care, practical algorithms to guide the perioperative management of such high-risk patients would be advantageous. The authors have formulated clinical algorithms to guide the care of diagnosed and suspected OSA patients in the preoperative, intraoperative, and postoperative periods. To date, many care pathways and recommendations are based on consensus or expert opinion rather than on high-level evidence. Future research in these areas and collaboration between the fields of anesthesiology and sleep medicine will be instrumental in shedding light on these lingering OSA-related perioperative care issues.<sup>83</sup>

## REFERENCES

1. Isono S. Obstructive sleep apnea of obese adults: pathophysiology and perioperative airway management. *Anesthesiology* 2009;110:908–21.
2. Beebe DW, Gozal D. Obstructive sleep apnea and the prefrontal cortex: towards a comprehensive model linking nocturnal upper airway obstruction to daytime cognitive and behavioral deficits. *J Sleep Res* 2002;11:1–16.
3. Kryger MH. Diagnosis and management of sleep apnea syndrome. *Clin Cornerstone* 2000;2:39–47.
4. Young T, Palta M, Dempsey J, et al. The occurrence of sleep-disordered breathing among middle-aged adults. *N Engl J Med* 1993;328:1230–5.
5. Bixler EO, Vgontzas AN, Ten HT, et al. Effect of age on sleep apnea in men: I. Prevalence and severity. *Am J Respir Crit Care Med* 1998;157:144–8.
6. Bixler EO, Vgontzas AN, Lin HM, et al. Prevalence of sleep-disordered breathing in women. *Am J Respir Crit Care Med* 2001;163:608–13.
7. Hillman DR, Murphy AS, Antic R, et al. The economic cost of sleep disorders. *Sleep* 2006;29:299–305.
8. Chung F, Ward B, Ho J, et al. Preoperative identification of sleep apnea risk in elective surgical patients using the Berlin Questionnaire. *J Clin Anesth* 2007;19:130–4.
9. 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.
10. Stierer TL, Wright C, George A, et al. Risk assessment of obstructive sleep apnea in a population of patients undergoing ambulatory surgery. *J Clin Sleep Med* 2010;6:467–72.

11. 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 (IL): American Academy of Sleep Medicine; 2007.
12. 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.
13. Fleetham J, Ayas N, Bradley D, et al. CTS Sleep Disordered Breathing Committee. Canadian Thoracic Society guidelines: diagnosis and treatment of sleep disordered breathing in adults. *Can Respir J* 2006;13:387–92.
14. Lopez PP, Stefan B, Schulman CI, et al. Prevalence of sleep apnea in morbidly obese patients who presented for weight loss surgery evaluation: more evidence for routine screening for obstructive sleep apnea before weight loss surgery. *Am Surg* 2008;74:834–8.
15. Chung F, Elsaid H. Screening for obstructive sleep apnea before surgery: why is it important? *Curr Opin Anaesthesiol* 2009;22:405–11.
16. Young T, Finn L, Peppard PE, et al. Sleep disordered breathing and mortality: eighteen-year follow-up of the Wisconsin sleep cohort. *Sleep* 2008;31:1071–8.
17. Marshall NS, Wong KK, Liu PY, et al. Sleep apnea as an independent risk factor for all-cause mortality: the Busselton Health Study. *Sleep* 2008;31:1079–85.
18. 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.
19. Liao P, Yegneswaran B, Vairavanathan S, et al. Postoperative complications in patients with obstructive sleep apnea: a retrospective matched cohort study. *Can J Anaesth* 2009;56:819–28.
20. Chung F, Yegneswaran B, Liao P, et al. Validation of the Berlin questionnaire and American Society of Anesthesiologists checklist as screening tools for obstructive sleep apnea in surgical patients. *Anesthesiology* 2008;108:822–30.
21. Gali B, Whalen FX, Schroeder D, et al. Identification of patients at risk for postoperative respiratory complications using a preoperative obstructive sleep apnea screening tool and postanesthesia care assessment. *Anesthesiology* 2009;110:869–77.
22. Kaw R, Pasupuleti V, Walker E. Postoperative complications in patients with obstructive sleep apnea. *Chest* 2012;141:436–41.
23. 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.
24. Longitudinal Assessment of Bariatric Surgery (LABS) Consortium, Flum DR, Bella SH, et al. Perioperative safety in the longitudinal assessment of bariatric surgery. *N Engl J Med* 2009;361:445–54.
25. 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.
26. Kaw R, Chung F, Pasupuleti J, et al. Meta-analysis of the association between obstructive sleep apnea and postoperative outcome. *Br J Anaesth* 2012;109(6):897–906.
27. Flemons WW. Obstructive sleep apnea. *N Engl J Med* 2002;347:498–504.
28. 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.
29. Adesanya AO, Lee W, Greilich NB, et al. Perioperative management of obstructive sleep apnea. *Chest* 2010;138:1489–98.
30. Seet E, Chung F. Management of sleep apnea in adults—functional algorithms for the perioperative period: continuing professional development. *Can J Anaesth* 2010;57:849–64.
31. Porhomayon J, El-Solh A, Chhangani S, et al. The management of surgical patients with obstructive sleep apnea. *Lung* 2011;189:359–67.
32. Meoli AL, Rosen CL, Kristo D, et al. Upper airway management of the adult patient with obstructive sleep apnea in the perioperative period—avoiding complications. *Sleep* 2003;26:1060–5.
33. Seet E, Chung F. Obstructive sleep apnea: preoperative assessment. *Anesthesiol Clin* 2010;28:199–215.
34. Bady E, Achkar A, Pascal S, et al. Pulmonary hypertension in patients with sleep apnoea syndrome. *Thorax* 2000;55:934–9.
35. 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.
36. Chung F, Zhou L, Liao P. Association of preoperative oximetry parameters with postoperative adverse events [abstract: 12-A-2312-ASAHQ]. *Anesthesiology* 2012.
37. Berry RB, Parish JM, Hartse KM. The use of auto-titrating continuous positive airway pressure for treatment of adult obstructive sleep apnea. *An American Academy of Sleep Medicine review. Sleep* 2002;25:148–73.
38. Johns MW. A new method of measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep* 1991;14:540–5.
39. Netzer NC, Hoegel JJ, Loubé D, et al. Prevalence of symptoms and risk of sleep apnea in primary care. *Chest* 2003;124:1406–14.

40. 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.
41. Chung F, Yegneswaran B, Liao P, et al. STOP questionnaire: a tool to screen patients for obstructive sleep apnea. *Anesthesiology* 2008;108:812–21.
42. Farney RJ, Walker BS, Farney RM, et al. The STOP-Bang 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.
43. 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.
44. Vasu TS, Doghramji K, Cavallazzi R, et al. Obstructive sleep apnea syndrome and postoperative complications: clinical use of the STOP-Bang questionnaire. *Arch Otolaryngol Head Neck Surg* 2010; 136:1020–4.
45. Chung F, Yegneswaran B, Herrera F, et al. Patients with difficult intubation may need referral to sleep clinics. *Anesth Analg* 2008;107:915–20.
46. Collop NA. Home sleep testing: it is not about the test. *Chest* 2010;138:245–6.
47. Chung F, Liao P, Sun Y, et al. Perioperative practical experiences in using a level 2 portable polysomnography. *Sleep Breath* 2011;15:367–75.
48. Chung F, Liao P, Elsaid 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.
49. 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.
50. Fleetham J, Ayas N, Bradley D, et al. Canadian Thoracic Society 2011 guideline update: diagnosis and treatment of sleep disordered breathing. *Can Respir J* 2011;18:25–47.
51. Chung S, Yuan H, Chung F. A systematic review of obstructive sleep apnea and its implications for anesthesiologists. *Anesth Analg* 2008;107:1543–63.
52. Bamgbade OA, Alfa JA. Dexmedetomidine anaesthesia for patients with obstructive sleep apnoea undergoing bariatric surgery. *Eur J Anaesthesiol* 2009;26:176–7.
53. 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.
54. Siyam MA, Benhamou D. Difficult endotracheal intubation in patients with sleep apnea syndrome. *Anesth Analg* 2002;95:1098–102.
55. Cook TM, Woodall N, Harper J, et al. Fourth National Audit Project. Major complications of airway management in the UK: results of the fourth national audit project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 2: intensive care and emergency departments. *Br J Anaesth* 2011;106:632–42.
56. American Society of Anesthesiologists Task Force on Management of Difficult Airway. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists task force on management of the difficult airway. *Anesthesiology* 2003;98:1269–77.
57. Delay JM, Sebbane M, Jung B, et al. The effectiveness of noninvasive 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. Sabate JM, Jouet P, Merrouche M, et al. Gastroesophageal reflux in patients with morbid obesity: a role of obstructive sleep apnea syndrome? *Obes Surg* 2008;18:1479–84.
60. Ovassapian A, Salem MR. Sellick's maneuver: to do or not do. *Anesth Analg* 2009;109:1360–2.
61. Bolden N, Smith CE, Auckley D, et al. Perioperative complications during use of an obstructive sleep apnea protocol following surgery and anesthesia. *Anesth Analg* 2008;105:1869–70.
62. Eikermann M, Gross-Sundrup M, Zarembo S, et al. Ketamine activates breathing and abolishes the coupling between loss of consciousness and upper airway dilator muscle dysfunction. *Anesthesiology* 2012;116:35–46.
63. Ankichetty S, Wong J, Chung F. A systematic review of the effects of sedative and anesthetics in patients with obstructive sleep apnea. *J Anaesthesiol Clin Pharmacol* 2011;27:447–58.
64. Yousaf F, Seet E, Venkatraghavan L, et al. Efficacy and safety of melatonin as an anxiolytic and analgesic in the perioperative period: a qualitative systematic review of randomized trials. *Anesthesiology* 2010;113:968–76.
65. Bamgbade OA. Advantages of doxapram for post-anaesthesia recovery and outcomes in bariatric surgery patients with obstructive sleep apnoea. *Eur J Anaesthesiol* 2011;28:387–91.
66. Murphy GS, Brull SJ. Residual neuromuscular block: lessons unlearned part 1: definitions, incidence, and adverse physiologic effects of residual neuromuscular block. *Anesth Analg* 2010;111:120–8.
67. 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.
68. Overdyk FJ, Carter R, Maddox RR, et al. Continuous oximetry/capnography monitoring reveals frequent desaturation and bradypnea during patient-controlled analgesia. *Anesth Analg* 2007;105:412–8.
  69. Lynn LA, Curry JP. Patterns of unexpected in-hospital deaths: a root cause analysis. *Patient Saf Surg* 2011;5:3.
  70. Weinger MB, Lee LA. "No patient shall be harmed by opioid-induced respiratory depression". In: proceedings of "Essential monitoring strategies to detect clinically significant drug-induced respiratory depression in the postoperative period" conference. *APSF Newsletter* 2011;26(2):21, 26–8.
  71. Weingarten TN, Flores AS, McKenzie JA, et al. Obstructive sleep apnoea and perioperative complications in bariatric patients. *Br J Anaesth* 2011;106:131–9.
  72. Blake DW, Chia PH, Donnan G, et al. Preoperative assessment for obstructive sleep apnoea and the prediction of postoperative respiratory obstruction and hypoxaemia. *Anaesth Intensive Care* 2008;36:379–84.
  73. Chung F, Liao P, Fazel H, et al. What are the factors predicting the postoperative apnea-hypopnea index? *Chest* 2010;138:703A.
  74. Chung F, Liao P, Fazel H, et al. Evolution of sleep pattern and sleep breathing disorders during first seven nights after surgery—a pilot study [abstract]. *Sleep* 2009;32:0667.
  75. Gay PC. The value of assessing risk of obstructive sleep apnea in surgical patients: it only takes one. *J Clin Sleep Med* 2010;6:467–72.
  76. Chung F, Liao P. Preoperative screening for obstructive sleep apnoea—one death is too many. *Anaesth Intensive Care* 2010;38:949–50.
  77. Joshi GP, Ankichetty SP, Gan TJ, et al. Society for Ambulatory Anesthesia Consensus statement on perioperative selection of adult patients with obstructive sleep apnea scheduled for ambulatory surgery. *Anesth Analg* 2012;115(5):1060–8.
  78. Ankichetty S, Chung F. Consideration for patients with obstructive sleep apnea undergoing ambulatory surgery. *Curr Opin Anaesthesiol* 2011;24:605–11.
  79. Kurrek MM, Cobourn C, Wojtasik Z, et al. Morbidity in patients with or at high risk for obstructive sleep apnea after ambulatory laparoscopic gastric banding. *Obes Surg* 2011;21:1494–8.
  80. Bergland A, Gaslason H, Raeder J. Fast-track surgery for bariatric laparoscopic gastric bypass with focus on anaesthesia and peri-operative care. Experience with 500 cases. *Acta Anaesthesiol Scand* 2008;52:1394–9.
  81. Raeder J. Bariatric procedure as day/short stay surgery: is it possible and reasonable? *Curr Opin Anaesthesiol* 2007;20:508–12.
  82. Schumann R. Anaesthesia for bariatric surgery. *Best Pract Res Clin Anaesthesiol* 2011;25:83–93.
  83. Chung F, Hillman D, Lydic R. Sleep medicine and anesthesia—a new horizon for anesthesiologists. *Anesthesiology* 2011;114:1261–2.