



Perioperative Management of Obstructive Sleep Apnea

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Obstructive sleep apnea (OSA) is the most common breathing disorder, with a high prevalence in both the general and surgical populations. OSA is frequently undiagnosed, and the initial recognition often occurs during medical evaluation undertaken to prepare for surgery. Adverse respiratory and cardiovascular outcomes are associated with OSA in the perioperative period; therefore, it is imperative to identify and treat patients at high risk for the disease. In this review, we discuss the epidemiology of OSA in the surgical population and examine the available data on perioperative outcomes. We also review the identification of high-risk patients using clinical screening tools and suggest intraoperative and postoperative treatment regimens. Additionally, the role of continuous positive airway pressure in perioperative management of OSA and a brief discussion of ambulatory surgery in patients with OSA is provided. Finally, an algorithm to guide perioperative management is suggested.

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Abbreviations: AHI = apnea-hypopnea index; APAP = auto-adjusting continuous positive airway pressure; ASA = American Society of Anesthesiologists; CPAP = continuous positive airway pressure; ODI = oxygen desaturation index; OSA = obstructive sleep apnea; PAH = pulmonary arterial hypertension; PAP = pulmonary artery pressure; PAR = postanesthesia recovery; P-SAP = perioperative sleep apnea prediction; PSG = polysomnography; STOP-Bang = snoring, tiredness, observed apneas, elevated BP and BMI, age, neck circumference, and male gender

Obesity has clearly emerged as a worldwide epidemic,¹ and because obesity is a well-recognized risk factor² for the development of obstructive sleep apnea (OSA), physicians will undoubtedly encounter patients with OSA undergoing surgery. Obstructive sleep apnea is characterized by partial or complete obstruction of the upper airway during sleep. This obstruction leads to oxygen desaturation, hypercapnia, and cortical microarousals in an attempt to restore upper airway patency.³ Complications such as hypoxemia, cardiac arrhythmias, myocardial injury, unanticipated admission to the ICU, and sudden unexpected death⁴ have been associated with OSA in the perioperative period. These adverse events have been attributed in part to the interaction between common

sedative and analgesic medications and OSA. Other complications result from difficulties encountered during airway management. The lack of recognition of OSA and, therefore, suboptimal perioperative preparation is also cited as a cause of increased adverse events in this population.⁵ Furthermore, coexisting illnesses, such as systemic hypertension, systolic or diastolic myocardial dysfunction, insulin resistance, pulmonary hypertension, stroke, coronary artery disease, and cardiac arrhythmias,^{5,6} make the perioperative management of these patients even more challenging. It follows that appropriate measures should be instituted to properly identify and treat patients at the highest risk for OSA⁶ to reduce perioperative risk.

The aim of this article is to discuss the available epidemiologic data about OSA in the surgical population and provide a better understanding of the impact of anesthetics on the pathophysiology of upper airway resistance. We also explore the usefulness of various

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questionnaires used to identify individuals most at risk for OSA. An algorithm is provided to simplify the management and, it is hoped, diminish the perioperative risks of these complex patients.

EPIDEMIOLOGY OF OSA IN THE SURGICAL POPULATION

Various epidemiologic studies have demonstrated that sleep-disordered breathing occurs in approximately 20% of adults, with nearly 7% exhibiting moderate to severe OSA.⁷⁻¹¹ It has been estimated that up to 80% of patients with OSA in the general population are undiagnosed and therefore untreated.⁹ Even higher rates of OSA have been identified in the surgical population, but these rates are influenced by the higher prevalence of obesity in these studies. Published data of morbidly obese patients undergoing bariatric surgery have reported OSA prevalence rates > 70%.^{12,13} A recent study¹⁴ evaluating the prevalence of OSA in general surgical patients undergoing elective non-upper airway surgery found an estimated prevalence of 22% in the adult surgical population. The authors also noted that > 70% of these patients were undiagnosed before presentation for perioperative evaluation.

PERIOPERATIVE OUTCOMES IN PATIENTS WITH OSA

Several studies have described the perioperative complications associated with OSA.¹⁴⁻¹⁷ These complications include higher reintubation rates, hypercapnia, oxygen desaturations, cardiac arrhythmias, myocardial injury, delirium, unplanned ICU transfers, and longer hospitalization stays. More recently, Liao and colleagues⁴ compared patients with OSA with matched control subjects undergoing similar non-upper airway surgeries. They found a higher prevalence of postoperative complications (44% vs 28%; $P < .01$), mostly attributed to adverse respiratory events, such as oxygen desaturations.

Another study¹⁶ used oxygen desaturation index (ODI) as a marker of sleep-disordered breathing to evaluate postoperative complications in patients with OSA referred for elective surgery. The ODI is the average number of oxygen desaturations $\geq 4\%$ below the baseline per hour. Patients with an ODI of five or more per hour were found to have a higher incidence of postoperative complications, including respiratory, cardiovascular, GI, and bleeding abnormalities. Overall, these studies highlight the higher prevalence and higher postoperative complication rates in patients with OSA undergoing surgery. Table 1 shows studies demonstrating adverse outcomes in patients with OSA undergoing surgery.

In general, the administration of anesthesia exacerbates the upper airway anatomic alterations that result in pharyngeal collapse during normal sleep in patients with OSA.¹⁸⁻²² Predictably, anesthetics also abolish or blunt arousal from sleep, an important defense mechanism that occurs during natural sleep to overcome airway obstruction. Anesthetic agents, such as pentothal, propofol, opioids, benzodiazepines, and inhaled halogenated agents, reduce the tone of the pharyngeal musculature and/or depress ventilation and diminish the ventilatory response to carbon dioxide.^{23,24} Patients with OSA are especially sensitive to opiates and benzodiazepines because of their synergistic respiratory depressant effects. Additionally, the tendency for airway obstruction occurs out of proportion to the level of sedation and/or analgesia achieved. In a study assessing the ventilatory response to carbon dioxide, apneic episodes were increased by up to 50% after modest doses of fentanyl (0.5 $\mu\text{g}/\text{kg}$) were administered. Although the study²⁴ was performed in children, the findings are most likely applicable to adults.

Surgical stress and pain have been shown to independently influence sleep patterns manifesting as postoperative sleep deprivation, sleep fragmentation, and reduction in rapid eye movement sleep.^{25,26} The subsequent rebound in rapid eye movement sleep is accompanied by increased vulnerability to airway obstruction and apnea that can last for several days. This sleep disturbance appears to be related to the location and invasiveness of the surgical procedure.^{27,28} In summary, anesthetic agents promote airway collapse, delay the restoration of airway patency, and their sedative and respiratory depressant effects can linger into the postoperative period for several days, depending on the type of surgery.

DIAGNOSIS OF OSA

The standard diagnostic test for OSA is an attended in-laboratory polysomnogram (PSG) that records physiologic variables, such as EEG, ECG, chin and leg electromyograms, and pulse oximetry. Nasal and oral airflow as well as chest and abdominal efforts are also measured.²⁹ Obstructive apneas are defined as complete or near-complete cessation of airflow lasting for at least 10 s. Obstructive hypopneas are characterized by at least 30% reduction in airflow for a minimum of 10 s and are associated with a 4% oxygen desaturation.³⁰ The apnea-hypopnea index (AHI) is calculated by dividing the number of apneas and hypopneas by the number of hours of sleep and is used to characterize the severity of OSA.³¹ The American Academy of Sleep Medicine (AASM) categorizes

Table 1—Adverse Outcomes in Patients With Obstructive Sleep Apnea Undergoing Surgery

Study	Type of Study	Identification of OSA	No. of Patients	Types of Surgery	Reported Complications	Outcomes
Liao et al ⁴	Retrospective matched cohort study	OSA diagnosis by <i>International Classification of Diseases 9th ed.</i> codes	240 Patients with OSA, 240 matched control subjects	Cardiothoracic, GI, genitourinary, gynecologic, orthopedic, otolaryngologic, plastic, and urologic surgeries	Oxygen desaturation, hypercapnia, respiratory failure, pulmonary edema, and bronchospasm/laryngospasm	Higher incidence of respiratory complications, including oxygen desaturation, prolonged oxygen therapy, need for additional monitoring, and more ICU admissions in the OSA group
Gupta et al ¹⁵	Retrospective case control study	Polysomnography	101 Patients with OSA, 101 matched control subjects	Orthopedic (hip or knee replacement)	Reintubation, acute hypercapnia, oxygen desaturations, arrhythmia, myocardial ischemia or infarction, and delirium	Higher rates of unplanned ICU transfers, cardiac events, and longer hospital length of stay in the OSA group
Hwang et al ¹⁶	Prospective case control study	Home nocturnal oximetry measuring 4% ODI	74 Patients with an ODI 4% > 5, 98 patients with an ODI 4% < 5	Cardiothoracic, GI, gynecologic, orthopedic, otolaryngologic, and urologic surgeries	Hospital length of stay, postoperative complications defined as adverse event affecting a major organ system that required further monitoring, additional diagnostic testing, or direct therapeutic intervention	Higher rates of respiratory, cardiovascular, gastrointestinal, bleeding complications, and longer postanesthesia recovery stay in the OSA group
Kaw et al ¹⁷	Retrospective case control study	Polysomnography	37 Patients with OSA, 185 matched control subjects	Cardiac surgery	Operating room time, frequency of reintubation, encephalopathy, postoperative infections (mediastinitis), ICU and hospital length of stay, perioperative mortality and morbidity	Higher rates of encephalopathy, postoperative infections (mediastinitis), and ICU length of stay in the OSA group

ODI = oxygen desaturation index; OSA = obstructive sleep apnea.

the severity of OSA in terms of an AHI of 5 to 15 indicating mild OSA, AHI of 15 to 30 for moderate OSA, and an AHI > 30 indicating severe OSA.³² For treatment purposes, the United States Centers for Medicare and Medicaid Services provides coverage for treatment of adult patients with OSA when the AHI > 15, or when the AHI > 5 and is accompanied by comorbidities such as excessive daytime sleepiness, impaired cognition, mood disorders, insomnia, hypertension, ischemic heart disease, or history of stroke.³³

Although comprehensive, the use of PSG for preoperative screening of surgical patients is limited by factors such as a delay of the surgery, the inconvenience of being studied in a sleep laboratory, and the

high cost of testing.^{34,35} The waiting period for PSG has been reported to be a few weeks to more than a year in the United States.³⁶ Given these limitations, home-based unattended portable screening devices have been suggested as a less costly and less disruptive alternative to attended PSG. Portable home-based polysomnographs record at least four channels of physiologic data, which are analyzed after the study is complete. The AASM has published guidelines for the use of portable monitoring as an alternative to attended PSG in selected patients.³⁷ Portable monitoring has been effectively used in evaluating prevalence of OSA in a large academic medical center and may be a useful alternative in the perioperative setting.¹⁴

CLINICAL SCREENING TOOLS

Screening tools assist with the identification of patients at highest risk for OSA using established risk factors. Obesity and old age are the strongest risk factors for OSA.³⁵ Other risk factors include male sex, excessive alcohol intake, and female menopause.³⁹ Craniofacial abnormalities, such as retrognathia and macroglossia, and wide neck circumference (17 inches for men and 16 inches for women),⁴⁰ are also considered as risk factors for OSA. Common signs and symptoms include loud snoring, observed apnea, daytime hypersomnolence, and morning headaches.

By incorporating risk factors, clinical symptoms, and physical examination features, several preoperative screening questionnaires have been developed to facilitate the diagnosis of OSA. The Berlin questionnaire,³⁵ the American Society of Anesthesiologists (ASA) checklist,⁴¹ the STOP-Bang (snoring, tiredness, observed apneas, elevated BP and BMI, age, neck circumference, and male gender) questionnaire,⁴² and the sleep apnea clinical score⁴³ have all been studied for perioperative screening.

The Berlin questionnaire was initially used and validated for outpatient screening of OSA in primary care clinics⁴⁴ but has also been validated as a screening tool in the surgical population.³⁵ The ASA OSA scoring checklist combines the severity of OSA, invasiveness of surgery and anesthesia, and postoperative opioid requirements to estimate overall perioperative risk.⁴¹ When compared with diagnostic PSG testing for preoperative screening, both the Berlin and the ASA checklist had sensitivities > 85% for an AHI > 30 and > 78% for an AHI > 15.⁴⁵ The specificities were 46% and 36%, respectively for the Berlin and ASA checklist, respectively for Berlin and ASA checklists when AHI > 30 and 50% and 37% for AHI > 15. The STOP-Bang questionnaire was developed and validated by Chung et al⁴² as a screening tool for surgical patients undergoing elective surgery. It is self-administered and uses yes/no questions for the mnemonic STOP

(snoring, tiredness, observed apneas, and elevated BP) and Bang (BMI > 35, age > 50 years, neck circumference > 40 cm, and male gender). The advantage of the STOP-Bang model is that it is brief, simple to administer, and requires only a fifth-grade reading level.⁴² Most importantly, the STOP questionnaire predicted the occurrence of postoperative complications, particularly respiratory complications.⁴² The STOP-Bang scoring system is shown in Table 2. A recent study of surgical patients⁴⁶ identified nine common elements from the standard perioperative evaluation and used it to create the perioperative sleep apnea prediction (P-SAP) score. The P-SAP score was then validated against a group of patients who underwent standard PSG. The P-SAP score showed high sensitivity but poor specificity for OSA and requires further refinement.

MANAGEMENT STRATEGIES

The approach to the management of patients diagnosed with OSA presenting for surgery can be divided into preoperative, intraoperative, and postoperative strategies. Figure 1 shows suggested steps in the management of adult patients with OSA and adult patients at high risk of OSA undergoing elective non-upper airway surgery.

Preoperative Management

Preoperative management should begin with a directed history and physical examination with emphasis on airway examination and identifying comorbidities. Patients with illnesses that commonly coexist with OSA, such as hypertension, diabetes mellitus, and congestive heart failure, should be identified and assessed for adequacy of control. Patients with uncontrolled hypertension, hyperglycemia, or decompensated heart failure should be referred to a primary care physician for medical optimization.

In obtaining the history, the presence of a bed partner at the evaluation may be helpful in eliciting the typical clinical symptoms of OSA, such as habitual snoring, tiredness, or observed apneas, along with a history of elevated BP (STOP). Patients suspected of OSA based on the history and physical examination should have a screening questionnaire, such as the STOP-Bang, Berlin, or ASA questionnaire, administered and then be classified as low or high risk for OSA as indicated in Figure 1. In a study designed to screen surgical patients for OSA using STOP questions, more than one-fourth of patients were classified as high risk based on a positive response to two or more questions.⁴² The presence of other predisposing characteristics and comorbidities, such as those outlined in Table 3,⁴⁷ should also be noted. Physical examination

Table 2—STOP-Bang Scoring System

S = Snoring. Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?
T = Tiredness. Do you often feel tired, fatigued, or sleepy during daytime?
O = Observed apnea. Has anyone observed you stop breathing during your sleep?
P = Pressure. Do you have or are you being treated for high BP?
B = BMI > 35 kg/m ²
A = Age > 50 y
N = Neck circumference > 40 cm
G = Male gender
High risk of OSA: ≥ 3 or more questions answered yes
Low risk of OSA: < 3 questions answered yes

See Table 1 for expansion of abbreviation. (Adapted with permission from Chung et al.⁴²)

should include a thorough examination of the airway, because mask ventilation and tracheal intubation are likely to be more difficult in patients with OSA.⁴⁸

Patients identified as high risk for OSA should either proceed to surgery as “high risk” for OSA or get referred to a sleep medicine specialist for further evaluation and treatment. The decision to proceed directly to surgery or to refer a patient for further evaluation will depend on the relative urgency of the surgery and should be made in consultation with the surgeon. It is imperative that the anesthesiologist be consulted about all high-risk patients well in advance of surgery so that an appropriate anesthetic plan can be developed prior

to the time of presentation for surgery. When this is not practical or possible, an exhaustive discussion of the risk and benefit of the procedure given the history of OSA should be undertaken with individual patients. The perioperative management of such high risk patients should be identical to the management of patients with known OSA. It should be noted that patients who have had corrective airway surgery, such as uvulopalatopharyngoplasty, are assumed to remain at risk for complications of OSA unless they are asymptomatic and repeat PSG has normalized.

Patients who are diagnosed with OSA after PSG testing are usually treated with preoperative CPAP,

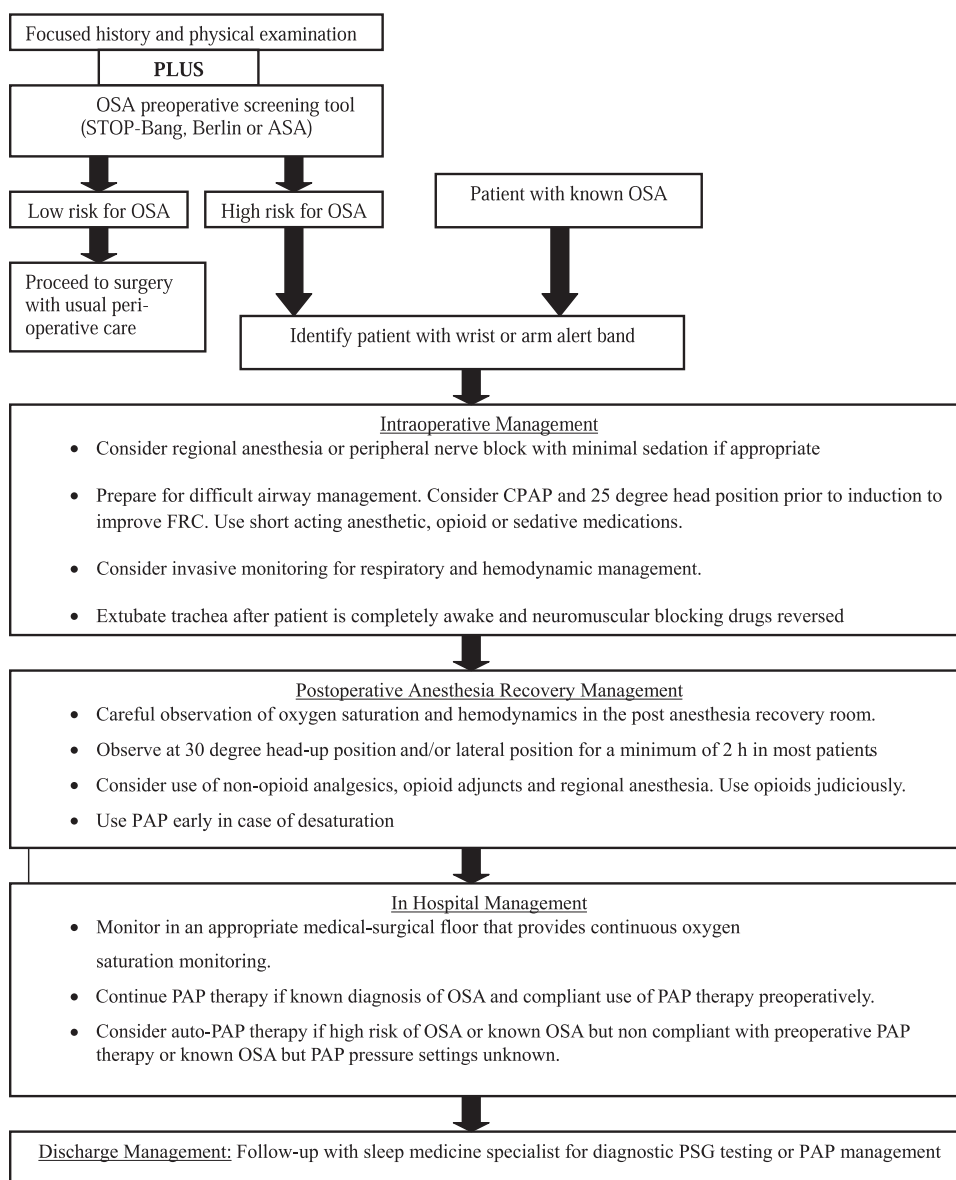


FIGURE 1. Perioperative management of adult patients with OSA or at high risk for OSA undergoing elective, non-upper airway surgery. ASA = American Society of Anesthesiologists; CPAP = continuous positive airway pressure; FRC = functional residual capacity; OSA = obstructive sleep apnea; PAP = pulmonary artery pressure; PSG = polysomnography; STOP-Bang = snoring, tiredness, observed apneas, elevated BP and BMI, age, neck circumference, and male gender.

especially if the OSA is severe.^{41,49} Although limited data^{41,42} support the routine preoperative use of CPAP, preoperative familiarization and adjustment to CPAP may be beneficial by increasing the likelihood of successful postoperative use. Other patients with established diagnosis of OSA should be asked about compliance with treatment and instructed to bring their CPAP machine and mask for use in the postoperative period. The anesthesiologist and/or surgeon should inquire about and obtain the patient's updated CPAP settings in the event that the patient's home machine is not available for use in the postoperative period.

In some patients, pulmonary arterial hypertension (PAH) may coexist with OSA, further increasing perioperative risk. The prevalence of PAH in patients with OSA has been reported to be 17% to 52% in various studies,⁵⁰⁻⁵² depending on the method used for diagnosis. Studies that exclude patients with significant cardiac and pulmonary diseases report a lower estimated prevalence of 15% to 20%.^{50,53,54} The average pulmonary artery pressure (PAP) in most studies was 30 mm Hg, and PAH was classified as mild. However, the majority of these studies were confounded by the heterogeneity of the methods (Doppler echocardiography vs right-sided heart catheterization) and PAP thresholds used for diagnosis. The existence of shared risk factors, such as aging and obesity, between patients with OSA and PAH further confound the results of these studies. The American College of Chest Physicians Evidence-Based Clinical Practice Guidelines on Pulmonary Artery Hypertension and Sleep-Disordered Breathing⁵⁵ does not recommend routine evaluation for the presence of PAH in the management of patients with OSA. However, because the likelihood of exposure to known triggers for acute elevations in PAP, such as hypercapnia, hypoxia, extremes of temperature, and decreased pH, is increased in the perioperative period, transthoracic echocardiography should be considered in newly diagnosed patients scheduled to undergo high-risk procedures projected to require high-dose postoperative opioids. Intraoperative triggers for PAP elevation should be avoided in all patients with OSA, especially in newly diagnosed patients suspected of PAH after echocardiographic evaluation.

Table 3—Predisposing Characteristics of OSA

Patient characteristics	Male; > 50 y old
Obesity	BMI > 30 kg/m ²
Neck circumference	> 40 cm
ENT conditions	Septal deviation, tonsillar and adenoidal hypertrophy, laryngomalacia, tracheomalacia
Craniofacial abnormalities	Down syndrome, micrognathia, achondroplasia, acromegaly, macroglossia

ENT = ear, nose, and throat. See Table 1 for expansion of other abbreviation. (Adapted with permission from Seet et al.⁴⁷)

Intraoperative Management

Few studies have addressed the anesthetic management of patients with OSA. Regional anesthesia may be preferred over general anesthesia, if feasible. The ideal general anesthetic technique should use shorter-acting agents that allow for a more rapid restoration of consciousness and a more rapid return to baseline respiratory function. Presently, there is no definitive evidence supporting one anesthetic technique over another. In a recent review of the implications of OSA for anesthesiologists, Chung et al⁵⁶ reported that adverse perioperative outcomes were almost uniformly associated with the use of perioperative opioids. They also noted the difficulty in distinguishing OSA-related adverse events from those because of its many associated comorbidities.

During preparation for the induction of anesthesia, sedatives administered for anxiolysis should be titrated slowly to desired effect or avoided entirely. Preoxygenation with 100% oxygen until the exhaled or end-tidal oxygen is at least 90% can be accomplished by using CPAP at 10 cm H₂O for 3 to 5 min with the patient in a 25° head-up position.^{57,58} Because patients with severe OSA can have significant airway compromise, treating physicians should be skilled in the use of ancillary intubation techniques and possibly awake fiberoptic intubation. Emergency airway devices should be readily available. If awake intubation is undertaken, it should be noted that the topical anesthetics applied to the oropharyngeal and upper airway to facilitate awake tracheal intubation may further impair upper airway protective reflexes and increase the frequency of OSA and postextubation airway obstruction.^{59,60}

The intensity of intraoperative monitoring should be determined by the type of surgery and accompanying comorbidities in any given patient. Invasive arterial BP monitoring may be necessary if noninvasive BP monitoring is inaccurate or impossible because of associated morbid obesity. Arterial blood gases can be checked frequently to maintain metabolic control as needed. Intraoperative and postoperative analgesia should be provided preferably with nonopioid analgesics. When opioid use is unavoidable, ultrashort-acting opioids such as remifentanyl should be considered. Ultimately, alternative techniques of pain relief, including regional blocks, should be used when possible, although anatomic limitations can make placement challenging if the patient is morbidly obese. Occasionally, infiltrating the surgical incision site with local anesthetics is an acceptable option to decrease the need for postoperative opioid analgesia use.

Tracheal extubation at the end of surgery should be preceded by careful assessment for the return of protective airway reflexes and recovery of muscle strength

after reversal of neuromuscular blocking agents and should only proceed when the patient is fully awake and is able to follow simple commands.

Postoperative Management

Hypoxemia and hypercapnia are major concerns in the postoperative period. Patients admitted to the postanesthesia recovery (PAR) unit or the ICU should be maintained in a semi-upright (30° head-up) position to minimize airway obstruction, because the supine position typically exacerbates OSA.⁶¹ CPAP acts as a pneumatic splint to maintain upper airway patency; therefore, prompt application of a CPAP device if available is advisable. Patients on treatment with CPAP preoperatively should be instructed to bring their device and have it applied shortly after arrival in the PAR unit or ICU.

Brown et al^{62,63} found that the total analgesic opiate dose in patients with OSA and recurrent hypoxemia was half that required in patients without such a history and attributed this finding to upregulation of central opioid receptors due to recurrent hypoxemia. Postoperative opioid therapy should therefore be individualized and titrated with extreme caution in all patients with OSA. Patients who undergo surgery under regional anesthesia should have the regional anesthetic continued into the PAR and beyond if possible. Other patients should be evaluated for placement of regional analgesia for postoperative pain control. Nonopioid analgesics, such as nonsteroidal anti-inflammatory drugs and acetaminophen, should be considered as they may reduce the need for opioid analgesics. Analgesic adjuncts such as ketamine and dexmedetomidine, a highly selective α_2 adrenergic agonist with sedative, amnestic, and analgesic properties, should also be considered. Both medications can reduce postoperative opioid requirements without affecting the respiratory drive.⁶⁴ IV opioid-based patient controlled analgesia can lead to respiratory depression and should be used on a case-by-case basis with monitoring in place to detect hypoxia and/or inadequate ventilation.

In general, discharge from the PAR should occur only after the patient's oxygen saturation on room air returns to baseline and hypoxemia or airway obstruction does not occur when the patient is left undisturbed. Patients who experience respiratory events, such as apnea, bradypnea, desaturations, and pain-sedation mismatch, during cardiopulmonary monitoring in the PAR should be admitted to a monitored bed with continuous oxygen saturation monitoring. In a study of patients without a previous diagnosis of OSA, Gali et al⁶⁵ combined the preoperative sleep apnea clinical score and the number of respiratory events in the PAR to identify patients who were most at risk for postoperative oxygen desaturation following discharge from the PAR. Patients with high sleep apnea clinical scores combined with the greatest number of respiratory events in the PAR developed a significantly higher number of oxygen desaturation events over the following 24 to 48 h.

THE ROLE OF CPAP IN THE PERIOPERATIVE PERIOD

CPAP remains the most effective therapy for OSA, acting as a pneumatic splint to maintain upper airway patency.⁶⁶ A study⁶⁷ of patients with severe OSA showed that patients who were compliant with CPAP therapy had significantly decreased rates of both fatal and nonfatal cardiovascular events over a 10-year period. However, the impact of CPAP therapy on short-term reduction in cardiovascular events is controversial.

Gupta et al¹⁵ found that patients with OSA who were using CPAP preoperatively had a lower incidence of postoperative complications and shorter hospital length of stay when compared with those who were not on CPAP therapy. The explanation for this "carryover protection" is unclear, but may include decreased inflammation or edema of the upper airway, decrease tongue size, as well as increased upper airway volume and stability.⁶⁸

The data describing the impact of postoperative CPAP therapy on adverse outcomes are limited, although current guidelines recommend CPAP therapy. One small study⁶⁹ showed a reduction in postoperative

Table 4—American Society of Anesthesiologists Scoring System to Estimate Perioperative Complications

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- A: Severity of sleep apnea based on sleep study (ie, AHI) or clinical indicators if sleep study not available: None = 0; Mild OSA = 1; Moderate OSA = 2; Severe OSA = 3. Subtract 1 point in patients using CPAP or bilevel pressure ventilation preoperatively and postoperatively, and add 1 point in a patient with $\text{PaCO}_2 > 50$ mm Hg.
- B: Invasiveness of surgery and anesthesia: Superficial surgery under local or peripheral nerve block anesthesia without sedation = 0; Superficial surgery with moderate sedation or general anesthesia or peripheral surgery under spinal or epidural anesthesia (with no more than moderate sedation) = 1; Peripheral surgery with general anesthesia or airway surgery with moderate sedation = 2; Major surgery or airway surgery under general anesthesia = 3.
- C: Requirement for postoperative opioid: None = 0; Low-dose oral opioids = 1; High-dose oral opioids or parenteral or neuraxial opioids = 3.
- D: Estimation of perioperative risk: Overall score = score of A + greater score of either B or C. Patients with overall score ≥ 4 may be at increased perioperative risk from OSA. Patients with a score ≥ 5 may be at significantly increased perioperative risk from OSA.
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AHI = apnea-hypopnea index; CPAP = continuous positive airway pressure. See Table 1 for expansion of other abbreviation. (Adapted with permission from Gross et al.⁴¹)

complications in patients who used CPAP therapy preoperatively, on extubation, and nearly continuously for 24 to 48 h after surgery. Another study showed that the rate of postoperative CPAP use was relatively low (58%-63%) even in patients with OSA on established home CPAP,^{15,16} reflecting a lack of hospital policy guiding the routine use of CPAP when such patients are hospitalized.

Many questions remain regarding the best perioperative use of CPAP therapy. The optimal duration of CPAP therapy in newly diagnosed patients awaiting surgery is unknown. Furthermore, how established patients with OSA who are noncompliant with CPAP therapy should be treated is unclear. It appears that the consistent use of CPAP therapy prior to surgery and immediately after surgery holds the best potential for decreasing postoperative complications. The role of alternative therapies, such as oral appliances, in the acute setting is also not well defined.

Auto-adjusting continuous positive airway pressure (APAP) devices present an attractive alternative in the perioperative setting when optimal CPAP settings may not be available or are difficult to determine. The APAP devices provide respiratory assistance based on airflow measurements, pressure fluctuations, or airways resistance.⁷⁰ The pressure adjustments take into consideration changes in upper airway resistance as the patient metabolizes anesthetic medications and neuromuscular blocking medications. Because postoperative patients are at risk for opioid-induced central apnea, they should be closely monitored for the occurrence of central apnea while on treatment with CPAP and APAP. The perioperative use of APAP has not been prospectively evaluated. However, a study of patients with OSA receiving treatment of decompensated heart failure using auto bilevel PAP therapy in an inpatient setting found it to be a promising and feasible approach to treatment.⁷¹

AMBULATORY SURGERY IN PATIENTS WITH OSA

The literature regarding the safety of ambulatory surgery in patients with OSA is sparse and of limited quality,⁵⁶ and whether ambulatory surgery is suitable in patients with OSA remains controversial.^{41,56} In determining eligibility for ambulatory surgery, an overall assessment of perioperative risk should be performed using guidelines suggested by the ASA⁴¹ as shown in Table 4. This risk estimation takes into account the severity of sleep apnea, the invasiveness of the surgery, and the projected need for postoperative opioids. The adequacy of postdischarge observation facilities and the ability of the ambulatory facility to manage patients with OSA should also be taken into consideration. Procedures for patient transfer to an inpatient facility in the event of adverse events should

be well established. OSA patients who are deemed eligible for ambulatory surgery should be scheduled for surgery early in the day or have their surgery performed as the first case of the day to enable longer monitoring times in the postanesthesia period.

The ASA practice guidelines⁴¹ recommend that patients with OSA should be observed for an additional 3 h before discharge home after ambulatory surgery. If a significant episode of airway obstruction or apnea occurs during the observation period, postoperative monitoring should continue for additional 7 h. Patients who undergo surgery under a regional anesthetic block are also required to be monitored for additional 3 h in the PAR even when supplemental sedatives have not been used. These recommendations⁴¹ are based on expert reviews and are not supported by clinical evidence.

SUMMARY

Patients with OSA are at high risk for perioperative complications and pose multiple challenges, including difficult airway management and increased incidence of postoperative complications. Because undiagnosed OSA is common, a focused history and physical examination followed by the administration of clinical screening tools should be used to identify patients at high risk for OSA. Patients at high risk for OSA should be managed similarly to patients with known OSA in the perioperative period. Such patients should also be referred for further diagnostic testing and treatment after surgery. Consultation with the operating surgeon will identify which operations can safely be delayed while preoperative diagnostic testing is done and prior consultation with the anesthesiologist will allow for the development and delivery of a safe anesthetic plan. Although PSG will help to identify new patients requiring CPAP therapy, the full effect of preoperative CPAP therapy on perioperative outcome in this group is unclear. In addition, the optimal duration of preoperative CPAP therapy in patients awaiting elective surgical procedures is not known. All patients (compliant and noncompliant) who use CPAP preoperatively should be advised to bring the device to the hospital for use in the postoperative period. Hospital policies should encourage the routine use of CPAP in patients with established OSA already on CPAP therapy when such patients are hospitalized for surgery or other illnesses.

Prudent perioperative management should be guided by the awareness of the potential complications of OSA based on the severity of OSA, invasiveness of diagnostic or therapeutic procedure, and requirement for postoperative opioids. An algorithm for perioperative management of these patients is provided in Figure 1.

Further studies are needed to assess the clinical questions raised in this review. In addition, the impact

of currently available guidelines, such as the ASA practice guidelines, on perioperative outcome remain to be evaluated.

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