Perioperative Management of Patients with Obstructive Sleep Apnea

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Submitted: 22 October 2021; Accepted: 12 December 2021; Published: 23 February 2022

DOI: https://doi.org/10.22374/cjgim.v17iSP1.601

Abstract
Obstructive sleep apnea (OSA) is the most common form of sleep-disordered breathing with up to 60% of surgical patients with moderate-to-severe OSA unrecognized at the time of preoperative assessment. OSA is a known modifier of perioperative outcomes, with an increase in difficult airway management and postoperative morbidity with early and late serious complications that may occasionally result in death. It is critical to identify at-risk patients during the preoperative period as it allows for risk stratification and mitigation, and postoperative monitoring. In this review, we will discuss the preoperative assessment, and intraoperative and postoperative management of patients with diagnosed or suspected OSA.

Keywords: Obstructive sleep apnea, perioperative outcomes

Résumé
Le syndrome d’apnées obstructives du sommeil (SAOS) est la forme la plus fréquente de troubles respiratoires du sommeil avec jusqu’à 60 % des patients chirurgicaux atteints de formes modérée à sévère de SAOS sans diagnostic formel ni traitement spécifique au moment de l’évaluation préopératoire. Le SAOS altère les résultats périopératoires, avec une augmentation de la gestion difficile des voies respiratoires et de la morbidité postopératoire associée à des complications critiques précoces et tardives pouvant parfois entrainer la mort. il est donc essentiel d’identifier les patients à risque pendant la période préopératoire enfin d’appliquer des procédures de modération de risque, ainsi que des précautions et une surveillance é quilibrées. Dans cette revue, après un aperçu de la physiopathologie du SAOS, nous discuterons de l’évaluation préopératoire, de la prise en charge intraopératoire et postopératoire des patients atteints de SAOS confirmée ou suspectée.

Keywords: Obstructive sleep apnea, perioperative outcomes
Key Points

- Obstructive sleep apnea (OSA) is common among surgical patients and most of them may not be recognized at the time of preoperative assessment.
- Preoperative identification of at-risk patients allows for risk stratification and eventual optimization before surgery.
- Intraoperative risk mitigation strategies should be utilized because OSA is associated with an increase in difficult airway management and postoperative morbidity.
- Postoperative management includes multimodal nonopioid analgesia and enhanced monitoring for early and late serious complications that may occasionally result in death.

Case Presentation

A 53-year-old male presented to the operating room for a day for surgery reconstruction of right anterior cruciate ligament (ACL). He had no known drug allergies and no family history of anesthesia-related complications. He had two uneventful minor procedures under local anesthesia. Besides the ACL injury, he had systemic hypertension controlled with amlodipine 5 mg BID. He had a STOP-Bang score of five, body mass index (BMI) 36 kg/m², and neck circumference of 42 cm with Mallampati II.

What are your perioperative considerations and how would you manage this patient?

Overview of OSA Management

The Society of Anesthesia and Sleep Medicine (SASM), and the American Society of Anesthesiologists (ASA) and the Society for Ambulatory Anesthesia (SAMBA), have provided general recommendations for optimal perioperative management of patients with Obstructive sleep apnea (OSA) (Figure 1). These recommendations include preoperative screening and identification of at-risk patients, adoption of measures to reduce the intraoperative risk, and postoperative monitoring to lessen perioperative risks. The optimal management of OSA begins preoperatively. Identifying those at high risk of OSA allows for early adoption of preventative intraoperative strategies (i.e., regional or neuraxial anesthesia when possible, and careful monitoring) and when necessary, general anesthesia with the use of short-acting agents, multimodal analgesia, and full reversal of neuromuscular blockade before cautious extubation is critical. During the postoperative period, the administration of oxygen, application of continuous positive airway pressure (CPAP) if needed, continuous monitoring, and recovery of the patient in a non-supine position can reduce negative outcomes. The SAMBA particularly emphasizes the importance of neuraxial and local anesthesia techniques for their opioid sparing effect. Upon having a reasonable suspicion of OSA, the patient in our case presentation was administered neuraxial anesthesia rather than general anesthesia. Of note, multimodal analgesia was used and standard continuous monitoring with pulse oximetry and capnometry was applied intra- and postoperatively. Adequate perioperative OSA management promotes patient recovery and reduces postoperative adverse events and healthcare costs.

Epidemiology

Due to the increasing pervasiveness of obesity in western countries and improved medical awareness, the OSA prevalence has risen in the last decades. OSA is emerging as a worldwide public health concern, with a prevalence of nearly one billion people worldwide, and almost 450 million have moderate-to-severe OSA. The majority of patients with clinical OSA are undiagnosed. The diagnosis and severity of OSA are determined by the apnea–hypopnea index (AHI) which is defined as the number of apneas and hypopneas per hour of sleep.

Depending on the definition of hypopnea and the diagnostic criteria, the prevalence of OSA fluctuates.

With hypopnea defined as a decrease of 4% in blood oxygen saturation, the Wisconsin Sleep Cohort Study estimated that 17.4% of women and 33.9% of men in the US aged 30–70 years had mild OSA, (AHI 5–14.9), while 5.6% of women and 13.0% of men had moderate (AHI of 15–29.9) or severe (AHI ≥ 30 events per hour) OSA. When using a more rigid criterion (AHI ≥ 5 events per hour plus symptoms or AHI ≥ 15 events per hour), the estimated prevalence of mild OSA declines to approximately 15% in males and 5% in females. The prevalence of OSA increases with age and BMI. Race can also be a determinant of the prevalence of OSA; one such example is young African Americans (<35 years) who have a higher OSA rate compared to Caucasians, independent of body weight. Notably, the prevalence of OSA in Asia is similar to that in the United States, despite lower rates of obesity. This concept is known, and the World Health Organization (WHO) defines overweight and
Figure 1. Summary of recommendations on the perioperative management of OSA from the Society of Anesthesia and Sleep Medicine (1), the American Society of Anesthesiologists Task Force on Perioperative Management of Patients with OSA (2), and the Society for Ambulatory Anesthesia (3). OSA, Obstructive Sleep Apnea; PAP, Positive Airway Pressure.
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obesity among Asians with BMI cut-offs of 23 and 25 kg/m² versus 25 and 30 kg/m² in Caucasians.13

OSA is underestimated in the surgical population with up to 60% of surgical patients having moderate-to-severe OSA without a formal diagnosis or specific treatment by the time of the preoperative assessment.14 Even higher prevalence of OSA is seen in bariatric surgical patients ranging between 77% and 88%.15,16 Various studies have shown that the presence of OSA is a modifier of perioperative outcome, with an increase in difficult airway management and postoperative risk for pulmonary and cardiovascular complications with early and late critical complications that may occasionally result in intensive care unit (ICU) admission or even death.17–20 OSA severity, less intense monitoring, absence of supplemental oxygen, and higher cumulative opioid and sedative doses are factors that can lead to severe outcomes such as brain damage and death.21

Pathophysiology of OSA

OSA is characterized by repetitive partial or complete pharyngeal collapse during sleep for at least 10 s, which leads to two sets of consequences: arousal from sleep to resume airflow, and gas exchange disturbances from hypopneas (reductions in breathing) or apneas (cessations of breathing). The repeated arousals in OSA lead to neurocognitive consequences including diminished memory consolidation, daytime sleepiness, and reduced quality of life.22 The episodes of hypoxemia and hypercapnia lead to endothelial dysfunction, oxidative stress, low-grade inflammation, and catecholamine surges; and in turn increases risk for cardiovascular and metabolic complications,3 arrhythmias, stroke,23 and sudden cardiac death.24

The contraction of upper airway dilator muscles is necessary to counterbalance the negative airway pressure generated by inspiratory muscle activity to maintain airway patency. The obstruction is prevented by a reflex-mediated increase in upper airway dilation while awake.25 The phasic activity of genioglossus (the most important upper airway dilator muscle) prevents posterior collapse of the tongue, assisted by the levator and tensor palatini muscles (advancing and elevating the soft palate) and the geniohyoid and stylohyoid muscles (opposing medial collapse of the lateral pharyngeal walls).26 As a result, in a healthy subject, the collapsing force generated by the respiratory pump may reach a critical level of ~5 cm H₂O. Most individuals with OSA have a restricted upper airway and suffer from a less negative critical level of airway collapse.

Besides this mechanism, other factors contributing to airway obstruction include extra luminal pressures caused by external pharyngeal soft tissue accumulation,27 body position (with a higher risk of obstruction in the supine position, compared to lateral or sitting positions),28 craniofacial abnormalities,29 fluid redistribution during the supine position or fluid overload,30 and lung volume which exerts a mechanical traction on the upper airway with a sleep-induced reduction in lung volume associated with a reduction of upper airway airflow.

Obstructive apneas and hypopneas result in inherently less stable ventilatory control, intermittent hypoxemia, and hypercarbia. The hypercapnic respiratory drive and diaphragmatically generated negative intrapharyngeal pressure during airway obstruction episodes cause frequent sleep arousal. The sleep fragmentation is the primary cause of excessive sleepiness in individuals with OSA. Intermittent hypoxemia, particularly with concomitant hypercapnia, activates the sympathetic nervous system and is the major contributor of the elevation of blood pressure,31 decreased insulin sensitivity, inflammation, increased reactive oxygen species, and metabolic abnormalities,32 hence contributing to the development and progression of vascular disease.26 Cardiovascular events are a major perioperative complication among OSA patients which may contribute to short- and long-term outcomes.17,20

Phenotypes in OSA

The mechanisms contributing to OSA are complex and are the result of the interaction of the underlying pathophysiologic mechanisms causing different clinical manifestations (phenotype). Depending on different underlying processes, the OSA pathophysiology can be classified as anatomic (structural restriction of the upper airway) and nonanatomic (ineffective upper airway dilator muscles, fluid retention or overnight rostral fluid shift, low and high arousal threshold, unstable ventilatory control, high and low respiratory arousal threshold).35

Based on the interaction between the genotype and the environment, four key phenotypes of OSA have been identified34:

1. **Impaired upper airway anatomy**: It is the most important determinant of OSA and there is a degree of upper airway anatomical impairment in all OSA patients.

2. **Low respiratory arousal threshold**: These patients wake up easily because of minor pharyngeal narrowing.

3. **High loop gain**: These patients have an unstable control of breathing due to high sensitivity to small changes in carbon dioxide (CO₂).
4. **Poor upper airway muscle responsiveness.**

The majority of patients with OSA have an impairment in one or more of the nonanatomical phenotypic traits (low respiratory arousal threshold, high loop gain, and poor upper airway muscle responsiveness).\(^3\)\(^5\) Each OSA phenotype is susceptible to specific perioperative risk factors. For example, a low respiratory arousal threshold has shown to be a key contributor to OSA.\(^3\)\(^4\)\(^6\) A premature arousal in patients with a low respiratory arousal threshold phenotype results in inadequate build-up of respiratory stimuli, precluding recruitment of upper airway dilator muscles.\(^3\)\(^7\)

The administration of sedatives such as benzodiazepines was significantly associated with induced mild respiratory depression in chronic pain patients taking opioids, but paradoxically this reduced severity of sleep apnea in these patients by increasing the respiratory arousal threshold.\(^3\)\(^8\) If sleep can be maintained in these patients using a sedative or a hypnotic without impairing pharyngeal muscle activity, the accumulation of stimuli (CO\(_2\) and negative pharyngeal pressure) may allow for recruitment of upper airway pharyngeal dilator muscles to enable stable breathing in many cases.\(^3\)\(^9\)

OSA is a heterogeneous disease with multiple underlying mechanisms, an understanding of these phenotypes and their interactions with perioperative risk factors is critical to providing safer personalized care for patients with OSA.\(^4\)\(^0\) At present, the characterization of OSA phenotypes is an emerging topic and remains challenging.\(^4\)\(^1\),\(^4\)\(^2\) Should this become feasible in future, the recognition of different phenotypes can potentially guide individualized clinical management and improve the perioperative risk stratification and outcomes.

**Preoperative Screening for OSA**

Due to the high prevalence of OSA in the surgical population, it is important to identify at-risk patients during the preoperative period as it allows time for the application of risk stratification and mitigation, appropriate postoperative disposition, and monitoring. The ASA, SASM, and SAMBA recommend that all patients with risk factors or suspicion of OSA undergo a comprehensive preoperative assessment. This assessment includes medical record review, patient and family interviews, physical exam, and screening protocols.

Several screening tools have been validated and are available for preanesthetic risk stratification of OSA patients including the STOP-Bang questionnaire, the Perioperative Sleep Apnea Prediction Score, the Berlin Questionnaire, and the ASA checklist.\(^4\)\(^3\)

The STOP-Bang questionnaire is the commonly used and validated screening tool for OSA; it consists of four dichotomous self-reportable variables, (STOP: Snoring, Tiredness, observed apnea, and high blood Pressure) and four dichotomous demographic items (Bang: BMI, age, neck circumference, gender) with one point attributed to each positive answer, leading to a score range of 0–8. It is straightforward, self-reportable, and can be completed within 1–2 min. In the surgical setting, the sensitivity of a STOP-Bang score \(\geq 3\) is 84%, 93%, and 100% to predict all OSA (\(\text{AHI} \geq 5\)), moderate-to-severe OSA (\(\text{AHI} \geq 15\)), and severe OSA (\(\text{AHI} \geq 30\)), respectively.\(^4\)\(^4\),\(^4\)\(^5\)

In case of a positive screening test for OSA in the absence of preoperative polysomnography (PSG), the patient should be treated as having OSA and considered at increased risk for perioperative complications. However, the surgery does not need to be delayed if the patient’s comorbid conditions are optimized and if the postoperative pain can be managed predominantly with nonopioid analgesics.\(^3\)\(^6\)–\(^4\)\(^8\)

There are no specific physical examination findings to OSA, although it is approximately twice as common in individuals who are overweight and four times as common in individuals with obesity than without obesity.\(^5\) Examination of the upper airway may identify anatomic abnormalities, such as tonsillar hypertrophy, macroglossia, or retrognathia, but normal airway findings do not exclude OSA. If the clinical evaluation suggests OSA, diagnostic confirmation requires sleep studies.

The diagnostic test is lab PSG, during which both sleep and respiratory parameters are monitored.\(^4\)\(^9\) However, PSG requires overnight admission and is a time-consuming, labor-intensive, and costly procedure that is not readily available.\(^5\)\(^0\) Home sleep apnea testing (HSAT) with portable devices may be used in some countries to diagnose OSA as alternatives to PSG. This approach to OSA diagnosis has been shown to be accurate and cost-effective.\(^5\)\(^1\) Although practice guidelines recommend HSAT in the setting of a high probability of OSA and absence of significant cardiorespiratory disease or insomnia, high diagnostic accuracy has been demonstrated in stroke patients with moderate suspicion of OSA.\(^5\)\(^2\) Currently, there is a lack of evidence to support delaying surgery to perform a PSG or HSAT. It is unclear whether establishing CPAP before surgery reduces perioperative complications. As well, the minimum duration of CPAP use to reduce postoperative complications in unknown.
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Decisions Regarding Surgical Setting: Inpatient or Outpatient
Although OSA patients are at an increased perioperative risk, patient selection for inpatient versus outpatient setting remains controversial. Despite the significance of postoperative monitoring in patients with OSA, the current literature is insufficient to guide the appropriate timing of discharge to unmonitored settings. Szeto et al., have shown that patients with moderate, high-risk, or diagnosed OSA can safely undergo outpatient and advanced ambulatory oncology surgery without increased healthcare burden of extended stay or hospital admission and avoid adverse postoperative outcomes. These findings have been confirmed by a recent study by Rosero et al., which demonstrated that the complications and 30-day readmission rates after airway surgery for OSA are low with no significant differences in the composite outcome of 30-day readmissions, reoperations, or complications between inpatient and outpatient settings. A multidisciplinary consensus addressing the perioperative care of OSA patients undergoing upper airway surgery has been published. The consensus reaffirmed that the determination of whether a surgical patient with suspected or diagnosed OSA is most appropriately performed on an inpatient or outpatient basis depends on multiple factors: (1) Patient factors: OSA severity and patient adherence to therapy, optimized coexisting diseases, and age; (2) Procedure factors: type of surgery, surgical urgency, type of anesthesia, and need for postoperative opioids; (3) Structural factors: adequacy of post-discharge observation and capabilities of the outpatient facility.

Patients with suspected or diagnosed OSA with optimized comorbid medical conditions can safely undergo ambulatory surgery if the postoperative pain can be managed principally with nonopioid analgesics. The continuous perioperative use of positive airway pressure (PAP) devices is recommended in case of known OSA diagnosis. Patients should resume CPAP after discharge. Education of the patient and family regarding the use of nonopioid drugs and the minimization of opioids after discharge should be implemented. OSA patients with nonoptimized comorbid medical conditions may not be good candidates for ambulatory surgery. The aforementioned measures are recommended based on a consensus reached by the Society for Ambulatory Anesthesia.

Preoperative Preparation

Adherent patient
Weight loss, PAP therapy, and the implementation of mandibular and oral appliances are the principal medical treatments for OSA. Patients with an OSA diagnosis and prescription of CPAP up to 5 years before surgery have significantly decreased risk for postoperative cardiovascular events, compared to patients with undiagnosed OSA. Both myocardial infarctions and unplanned reintubations are higher in untreated OSA patients. In case of severe OSA, the perioperative application of CPAP decreases postoperative AHI and is associated with a reduced length of hospital stay. Furthermore, perioperative use of alternative treatments such as oral appliance, positional therapy pillows, or hypoglossal nerve stimulators should be continued. If questions or concerns emerge about effectiveness of therapy, a referral prior to surgery to their sleep specialist is recommended.

PAP nonadherent patient
Due to discomfort, the compliance with PAP is generally low. It is recommended not to delay surgery in patients with diagnosed OSA but CPAP nonadherent prior to surgery. In patients with certain comorbid conditions such as controlled systemic disease including pulmonary hypertension, hypoventilation, or resting hypoxemia, the risk of postoperative complications is elevated, and further referral for optimization is recommended.

Intraoperative Management
During the intraoperative phase, adequate airway management, choice of anesthesia technique, monitoring, pain management, and class and dosage of medications are of utmost importance. The ASA, the SASM, and the American Academy of Sleep Medicine, have provided recommendations for the perioperative management of patients with OSA.

Airway management
OSA is often associated with obesity and multiple variations in upper airway and craniofacial anatomy abnormalities. A significant association between OSA and difficult ventilation and intubation has been established. Sixty-six percent of patients with unexpected difficult intubation who underwent a sleep study were diagnosed with OSA by PSG. Therefore, patients with difficult intubation are at high risk for OSA and should be screened for signs and symptoms of sleep apnea. Patients with OSA should be considered at risk for airway complications, and it is recommended to manage these patients according to the practice guidelines for the management of the difficult airway. Prudent intraoperative airway management should be implemented, including the use of regional anesthesia where possible. If general anesthesia is required, suggested precautions include ramped position
for induction and intubation, application of PAP or non-invasive positive pressure ventilation during induction, use of videolaryngoscopy and rapid sequence induction weighed against the risk of rapid oxygen desaturation following induction of general anesthesia and eventual difficult airway management. Supplemental high-flow nasal oxygen during induction may improve safe apnea time. Emergency airway devices should be readily available.

In the presence of significant predictors of difficult airway, that is, anatomical abnormalities, restriction of neck movements, it is important to consider having a fiberoptic bronchoscope available. With the widespread availability of videolaryngoscopy, it is rare to perform awake intubation; however, if this method is chosen, 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 postextubation airway obstruction. Importantly, it may be preferable to use general anesthesia with endotracheal intubation versus deep sedation without a secure airway.

**Choice of anesthesia techniques**

**Sedation**

Sedative premedication should not be routinely prescribed to patients with OSA; if needed, it should be administered with caution. The same caution should be applied during procedural sedation and in postoperative recovery, given the absence of a secured airway. Sleep, sedation, and anesthesia cause a depression of upper airway function at various degrees, while there is a sustained arousal response during sleep. The arousal response is depressed during sedation and completely suppressed during anesthesia. This effect results from the depression of central respiratory output to upper airway dilator muscles and suppression of upper airway reflexes. When sedation is used, the standard of care requires respiration monitoring with capnography and pulse oximetry. Capnography results in earlier detection of respiratory depression compared to pulse oximetry and may be more appropriate for use in high-risk patients with OSA. Moreover, the use of capnography has demonstrated improved patient safety by reducing the frequency of hypoxia, severe hypoxemia, and apnea during sedation. Consider administering CPAP or using an oral appliance during sedation for patients previously treated with these modalities.

**Regional anesthesia**

A wide range of literature indicates that the implementation of regional over general anesthesia may improve postoperative outcome. OSA patients postoperatively experience a worsening of sleep-disordered breathing and changes in sleep architecture, expressed as an increased AHI and exacerbation of nocturnal hypoxemia and hypercapnia.

In OSA patients undergoing lower extremity surgery, neuraxial anesthesia may decrease respiratory complications, ICU admissions, and length of stay. Similarly, upper extremity surgery can be performed under upper extremity block. Regional anesthesia avoids the need for administration of systemic anesthetics, avoids airway manipulation, and neuromuscular blockade, resulting in reduction of residual paralysis and consequent pulmonary complications. In addition to the opioid-sparing effect resulting in minor hypoxia and sleep fragmentation in OSA patients, the regional anesthesia technique provides better pain management.

**General anesthesia**

For some types of surgery, there may not be an alternative to general anesthesia. The optimal general anesthetic technique for patients with OSA should consider the use of short-acting agents that allow for a more rapid restoration of consciousness and a return to baseline respiratory function. A multimodal analgesia approach aiming for opioid-sparing effect is recommended in the perioperative setting. Neuromuscular monitoring and full reversal of neuromuscular blockade before cautious extubation is critical. After administration of reversal agents, residual effects that cause pharyngeal dysfunction, airway obstruction, and aspiration should be excluded. Airway collapse resulting from premature extubation can lead to severe negative pressure pulmonary edema. Patients with OSA should be extubated while they are awake and able to respond to commands. Importantly, OSA patients should be placed in nonsupine positions throughout the recovery process if possible. Excessive intravenous fluid administration should be minimized to avoid rostral fluid shifts that can worsen airway edema.

**Pain management**

Preoperative education, accurate pain assessment, and multimodal analgesia promote effective pain management, enhance patient recovery and rehabilitation, and may be associated with a reduction of postoperative adverse events and healthcare costs. The goal of multimodal analgesia is to improve pain relief while reducing opioid requirements and opioid-related adverse effects. Multimodal nonopioid analgesics including local anesthetic infiltration, peripheral nerve blocks and neuraxial blocks, acetaminophen,
nonsteroidal anti-inflammatory drugs (NSAIDS), and cyclo-
ocytogenase-2-specific inhibitors (COX-2) as well as analgesic
adjuncts such as steroids, ketamine, and α-2 agonists are cur-
rently the main modalities of pain management. Individuals
with OSA are at increased risk for opioid-induced respira-
tory depression. Chronic recurrent nocturnal hypoxia and
sleep disruption present in OSA patients may enhance the
sensitivity to pain.
However, the perpetual hypoxia may
potentiate opioid analgesic effects resulting in alterations in
pain perception with a significant reduction in postoperative
opioid consumption. Intra- and postoperative parenteral
opioid use have been associated with significantly higher
odds for respiratory failure in patients with OSA. There
is therefore a concern regarding the perioperative pain man-
gagement in these high-risk patients.

Acetaminophen, a weak analgesic with rare adverse
effects is an essential component of multimodal perioper-
ative analgesia used for the treatment of mild-to-moderate
pain. Its efficacy can be significantly enhanced by using
appropriate doses (i.e., 1 g every 6 h, maximum 4 g/day) and
by combination with NSAID or COX-2 inhibitors.
Nonselective NSAID and COX-2-specific inhibitors play
an important role in prevention of peripheral and central
sensitization. Despite the proven analgesic benefits, its use
is limited by a few adverse effects such as bleeding, gastric irri-
tation or ulceration, impairment of wound and bone healing,
and bronchospasm in patients with reactive airway disease.
To avoid the side effects of NSAIDS, the COX-2-specific
inhibitors are preferred. Limiting the length of therapy to the
acute phase after surgery can also reduce the eventual side
effects.

Local anesthetic techniques include neuraxial anesthe-
sia or analgesia such as epidural and paravertebral block and
peripheral nerve blocks as well as wound infiltration. These
approaches provide adequate pain relief and reduce opioid
requirements. Thus, local anesthetic techniques should be
used whenever possible in the OSA patient.

The analgesic effect of intravenous (iv) glucocorticoids
is attributed to their effects on reducing the inflammatory
response to surgical stress by blocking the COX and lipoxy-
genase enzymes. A single dose of iv dexamethasone admin-
istered perioperatively significantly reduced postoperative
pain as well as opioid consumption and postoperative nausea
and vomiting. It should be used when there are no contra-
indications. However, iv dexamethasone has been associated
with mild increases in blood glucose on the first postopera-
tive day and can be a concern in OSA patients with glucose
intolerance or diabetes.

In case of regional anesthesia, perineural dexametha-
sone prolongs the analgesic duration of a single-shot periph-
eral nerve block by decreasing nociceptive C fiber activity via
direct modulation of glucocorticoid receptors without any
reported serious adverse effects and can be used if there is a
contraindication to systemic use.

Opioids are effective for treatment of moderate-to-severe
pain but is associated to some dose-related adverse effects,
such as nausea, vomiting, itching, prolonged ileus, urinary
retention, dizziness, drowsiness, and most importantly, respi-
atory depression which can be significant in OSA patients
(the initial 24 h after opioid administration appear to be the
most critical). Opioid use should be reserved for rescue, and
the preferred route of administration should be oral.

There is a potentially greater risk for neuraxial opioid-in-
duced respiratory depression in patients with OSA; thus, spe-
cial attention should be given to signs of adverse effects after
opioid administration. Preventive measures after neuraxial
opioid administration include accurate decisions regarding
opioid dose, type, and administration modality, such as sin-
gle injection neuraxial or continuous epidural opioids versus
parenteral opioids. OSA patients receiving neuraxial opioids
should be continuously monitored for adequacy of ventila-
tion, oxygenation, and level of consciousness.

Gabapentinoids inhibit central sensitization through
presynaptic or postsynaptic inhibition of calcium influx,
which inhibits the release of neurotransmitters from the pri-
mary afferent nerve fibers in the spinal cord. The use of gab-
epentinoids in multimodal analgesic regimens is associated
with increased rates of perioperative respiratory depression
and should therefore be avoided in patients affected with
OSA.

Intraoperative monitoring
There is no specific type of monitoring for OSA population
standard monitor recommend by ASA guidelines. With
attention of capnometry and pulse oximetry during sedation,
in case of general anesthesia, an attention to residual neuro-
muscular blockade is required. The intensity of intraopera-
tive monitoring should be determined by the type of surgery
and accompanying comorbidities in any given patient.

Postoperative Management

Patient positioning
The soft palate of the upper airway is predisposed to col-
lapse in OSA patients. This obstruction of the upper airway
is dependent on different factors including the administra-
tion of anesthetics, sedatives, opioids, and more importantly
to the adoption of the supine position. In some phenotypes of OSA, such as those with impaired upper airway anatomy, rostral fluid shifts during the supine position may cause edema and further worsen airway obstruction. The lateral position can promote the maintenance of the passive upper airway aperture in OSA. Moreover, upper body elevation may improve upper airway stability during sleep and may minimize the abdominal compression against the diaphragm, reducing the level of PAP leading to better compliance of the patients. Whenever possible, patients should be in lateral, semi-upright, or other nonsupine positions during recovery.

Oxygenation
Postoperative supplemental oxygen has been shown to improve oxygenation and decrease the AHI without increasing the duration of apnea–hypopnea events or level of transcutaneous CO₂. However, 11% of the patients had significant CO₂ retention that exceeded 55 mm Hg while receiving supplemental oxygen, indicating a degree of respiratory depression in the postoperative nights, mostly first postoperative night. Supplemental oxygen increases ventilatory stability in patients with ventilatory instability (high loop gain) phenotype. It has been shown to decrease AHI in patients with high loop gain but not in patients with low loop gain. When supplemental oxygen is given, it may mask the ability of oximetry to detect hypoventilation. Additional methods for detecting hypoventilation such as continuous measurement of respiratory rate or end-tidal carbon dioxide (EtCO₂) monitoring may be needed.

Supplemental oxygen should be administered continuously to all patients who are at increased perioperative risk from OSA until they are able to maintain their baseline oxygen saturation while breathing room air. Supplemental oxygen therapy should be discontinued as soon as baseline oxygen saturation can be maintained with room air.

Use of CPAP
PAP is the fundamental treatment for patients with moderate-to-severe OSA. Chronic use of PAP improves the ventilation, enhances vigilance, and cognitive function, and improves quality of life of OSA patients. The adherence to PAP therapy is reduced due to discomfort. In the perioperative setting, there is limited literature on the effectiveness of PAP in surgical patients with newly diagnosed OSA. In a study by Liao et al., the perioperative randomization of patients with newly diagnosed moderate and severe OSA who underwent auto-titrated PAP treatment resulted in significantly decreased postoperative AHI and improved oxygen saturation. Suen et al., found that among patients with a preoperative CPAP prescription, approximately 50% were consistently adherent pre- and postoperatively. CPAP adherence was associated with improved preoperative oxygen desaturation index, and the benefit was maintained on Night 1 after surgery. Due to the small sample size, two studies showed no significant difference in the postoperative adverse events between CPAP and no-CPAP treatment. The heterogeneity of OSA severity in different studies, the difficulty of randomization of PAP therapy, and the assessment of perioperative efficacy of PAP therapy remain challenging. Further research is needed in perioperative use of CPAP. Given the absence of possible adverse effects and the hypothetically beneficial effect of PAP treatment, the ASA, SASM, and SAMBA recommend the perioperative application of PAP with or without supplemental oxygen to patients already using these modalities preoperatively, particularly if OSA is severe, unless contraindicated by the surgical procedure.

Postoperative monitoring
Intermittent hypoxia, hypercapnia, sympathetic activation, and associated arousals which characterize OSA have been found to increase the risk for arterial hypertension, heart failure, arrhythmias, cerebrovascular disease, metabolic diseases, and sudden cardiac death. Because of the residual effect of sedatives and opioids with respiratory depression, the emergence and recovery from anesthesia are of high concern. A postoperative alteration of sleep architecture with increased AHI occurred in both OSA and non-OSA patients, but OSA patients had a greater degree of postoperative change in AHI. A recent study has demonstrated that among at-risk patients undergoing major noncardiac surgery, unrecognized severe OSA was significantly associated with 30-day cardiovascular complications such as myocardial injury, cardiac death, congestive heart failure, thromboembolism, atrial fibrillation, and stroke. However, further research would be needed to assess whether interventions can modify this risk.

The risk factors for postoperative respiratory depression may include the underlying severity of the sleep apnea, systemic administration of opioids, use of sedatives, site and invasiveness of surgical procedure, and sleep patterns. A combination of a preoperative OSA screening tool and identification of recurrent postanesthesia care unit (PACU)
respiratory events such as apnea, bradypnea, desaturations, and pain–sedation mismatch was associated with a higher oxygen desaturation index and postoperative respiratory complications. A two-step process consisting of identifying patients at higher risk for perioperative respiratory desaturations with preoperative screening tool and an early recognition of PACU complications have been proposed to stratify and manage surgical patients postoperatively.\(^\text{105}\)

The ASA Guidelines recommend to consider monitoring in high-risk patients after discharge from PACU with severe OSA, STOP-Bang score \(\geq 5\), postoperative parenteral opioids, or significant comorbid conditions.\(^\text{5}\) A risk prediction model derived from continuous oximetry and capnography for 48 h has been shown to accurately predict respiratory depression episodes in patients receiving opioids on the general care ward.\(^\text{106}\)

Patient monitoring is essential for the early identification of clinical deterioration of patients requiring extended care. However, the current literature is insufficient to guide the appropriate timing of discharge to unmonitored settings. This presents a significant clinical challenge, given the emergence of an increasing number of studies that have identified preventable lapses in monitoring as the predominant drivers of life-threatening adverse outcomes in OSA.\(^\text{78,107,108}\) In surgical patients after general anesthesia, monitoring with capnography and utilization of Integrated Pulmonary Index algorithm (IPI) in PACU have detected respiratory adverse events earlier than standard monitoring in 75 and 88% of cases, respectively, with an average early warning time of 8 ± 11 min. The addition of capnography and IPI to current standard monitoring may provide potential clinically relevant information on respiratory status, including early warning of some respiratory adverse events.\(^\text{109}\) Due to the growing surgical OSA population, the resources required for monitoring are an expanding concern for healthcare systems.

Studies on postoperative death and near-death events in OSA have confirmed the critical role of postoperative opioids, sedatives, and insufficient patient monitoring in this setting, with the highest risk for opioid-induced respiratory compromise happening within 24 h of opioid utilization.\(^\text{107}\) Moreover, a multiple opioid administration modality has been associated in half of the postoperative opioid-induced respiratory depression cases.\(^\text{108}\) Continuous postoperative monitoring in the first 24 h, and improved compliance with CPAP, may mitigate the risk for death or near-death events in patients with suspected or untreated OSA who require opioids after surgery.

**Case Presentation Management**

With a STOP-Bang score of five, this patient is at high risk for OSA. Because his hypertension is controlled, and his postoperative pain can be managed predominantly with nonopioid analgesics, we will presume he has OSA and proceed with his planned surgery on an outpatient basis with risk mitigation strategies.

In the preoperative care area, an anesthesia assistant established peripheral intravenous access. Considering the possibility of undiagnosed OSA, regional anesthesia with multimodal analgesia and sedation was planned. Acetaminophen 1000 mg was administered orally for preventive analgesia. The patient was transferred to the block room and connected to the anesthesia monitors (electrocardiogram, noninvasive blood pressure, and pulse oximeter). Midazolam 2 mg was administered, and right adductor canal block was performed for postprocedural pain management, followed by a spinal anesthetic with mepivacaine 60 mg at L2–L3. During surgery, EtCO\(_2\) was measured in addition to the standard monitors, and the patient was sedated with a propofol infusion at 45 µg/kg/min.

After 2 h and 15 min of surgery, the patient was transferred to the PACU in a semi-upright position. He was spontaneously breathing with no obstruction with numerical rating scale pain score of 2/10. He had no nausea or vomiting and was hemodynamically stable. The postoperative course was uneventful, and patient was discharged home after 3 h of postoperative monitoring with acetaminophen 1 g q6h, celecoxib 200 mg q12h, and oxycodone 5–10 mg as needed, maximum 10 mg every 4–6 h. Patient education regarding risks of opioids and use of nonopioid analgesics was provided. At 72 h postoperation follow-up, the pain was well managed with minimal use of opioid. He was advised to follow-up with his primary healthcare provider for referral for a sleep study and sleep medicine specialist.

Screening patients for the risk of OSA allows us for to avoid airway manipulation by using local anesthetic techniques (neuraxial anesthesia and peripheral nerve blocks). Multimodal analgesia provided adequate pain management with limited opioid consumption and with no major perioperative complications.

**Conclusion**

OSA is a common condition in the surgical population and is characterized by increased postoperative morbidity and
Preoperative identification allows risk stratification of patients and the adoption of perioperative measures to reduce cardiopulmonary complications.

Acknowledgments

We would like to thank Ewan Scallion for the contribution in the visual sketches of the figure.

Author Contribution Statement

ARMH wrote the first draft of the manuscript. All authors contributed to critical revision of the manuscript and have agreed to the final version of the manuscript.

Competing Interests

JW received grants from the Ontario Ministry of Health and Long-Term Care, and Merck Inc. outside of the submitted work. She is supported by a Merit Research award from the University of Toronto, Department of Anesthesiology and Pain Medicine.

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