Unrecognized Sleep Apnea in the Surgical Patient*

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Unrecognized Sleep Apnea in the Surgical Patient*

Implications for the Perioperative Setting

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Anesthesia and surgery both affect the architecture of sleep. Aside from the postoperative effects of anesthesia and surgery, sleep deprivation and fragmentation have been shown to produce apneas or desaturations even in patients without presumed sleep apnea. Recent epidemiologic data have placed the prevalence of obstructive sleep apnea syndrome (OSAS) at about 5% among Western countries. The problem is further hindered by the difficulty in diagnosing OSAS, as patients with OSAS may present for surgery without a prior diagnosis. Clinical suspicion for OSAS may first be recognized intraoperatively. Adverse surgical outcomes appear to be more frequent in OSAS patients. Immediate postoperative complications may intuitively be attributed to the negative effects of sedative, analgesic, and anesthetic agents, which can worsen OSAS by decreasing pharyngeal tone, and the arousal responses to hypoxia, hypercarbia, and obstruction. Later events are, however, more likely to be related to postoperative rapid eye movement (REM) sleep rebound. In the severe OSAS patient, REM sleep rebound could conceivably act in conjunction with opioid administration and supine posture to aggravate sleep-disordered breathing. REM sleep rebound has also been suggested to contribute to mental confusion and postoperative delirium, myocardial ischemia/infarction, stroke, and wound breakdown. Although the data to guide the perioperative management of patients with moderate-to-severe OSAS is scarce, heightened awareness is recommended. The selected use of therapy with nasal continuous positive airway pressure before surgery and after extubation may be beneficial.

***Learning Objectives:* 1. Identify common sleep architectures affected by anesthesia and surgery in the perioperative period. 2. State a perioperative complication in Obstructive Sleep Apnea Syndrome patients. 3. Identify perioperative interventions and management techniques that best facilitate improved obstructive sleep apnea syndrome patient care.**

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Key words: continuous positive airway pressure; oximetry; perioperative; sleep apnea

Abbreviations: AHI = apnea-hypopnea index; CPAP = continuous positive airway pressure; MI = myocardial infarction; OSAS = obstructive sleep apnea syndrome; RDI = respiratory disturbance index; REM = rapid eye movement; SAR = significant abnormality of respiration; SWS = slow-wave sleep

Sleep apnea is a common phenomenon defined as a pause of >10 s in breathing during sleep despite continuing ventilatory effort. A more serious disorder, obstructive sleep apnea syndrome (OSAS), is defined as the occurrence of at least five apneas and/or hypopneas per hour in association with symptoms attributable to sleep-disordered breathing.[1]

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Epidemiologic data have placed the prevalence of OSAS at about 5% among persons in Western countries.[2] The prevalence in patients presenting for surgery has been estimated to be 1 to 9%, although it may be even more common in certain populations.[3] It is notable that OSAS has not been diagnosed in the majority of these individuals.[4] As such, patients with sleep apnea may present for surgery without receiving a prior diagnosis. Adverse surgical outcomes appear to be more frequent in patients with known OSAS. Therefore, the early identification of this disorder in the surgical patient is important as it may allow for specific interventions that could improve postoperative outcomes. The purpose of this discussion is to review the current state of knowledge regarding the recognition and management of sleep apnea in the surgical patient.

How Does Perioperative State Impact Sleep?

Both anesthesia and surgery affect the architecture of sleep. Numerous studies[5–7] have documented that sleep is reduced in amount and is highly fragmented on the first night postoperatively. Interestingly, one study[8] of individuals with mild sleep apnea who were deprived of sleep for 36 h noted that while the minimum oxygen saturation was significantly lower following sleep deprivation, other parameters of sleep-disordered breathing did not appear to be significantly altered. Aside from the sleep deprivation and fragmentation, other postoperative effects of anesthesia and surgery have been shown to produce apneas and/or desaturations even in patients without presumed sleep apnea or preoperative snoring.[9,10] Rapid eye movement (REM) sleep is usually absent on the first postoperative night, and sometimes on the second and third postoperative nights.[6] In most patients, REM sleep subsequently reappears with increased density and duration, and REM-associated hypoxemic episodes increase about threefold on the second and third postoperative nights compared with the night before surgery.[6,11] Sleep studies[5–7,12] performed in patients undergoing major abdominal surgery and open heart surgery have shown the suppression of REM and slow-wave sleep (SWS) after surgery with a subsequent rebound in the late postoperative period. The return of REM sleep in the late postoperative period (at a time when oxygen therapy would have been discontinued) has been linked to significant respiratory abnormalities in a group of elderly patients who underwent abdominal vascular surgery.[13] No studies with EEG monitoring have been performed later than the sixth night after abdominal surgery. On the contrary, general anesthesia of 3 h in duration in nonsurgical volunteers produced only a modest reduction in SWS for 1 h and no changes in REM sleep.[14] In sum, these data suggest that a disturbed sleep pattern in postoperative state seems to be determined more by the surgical stress than by anesthesia.

Sleep disturbances also appear to be impacted by other factors such as the location and type of surgery as well as the use of medications. The magnitude of surgery is important for REM sleep, as the reduction in REM sleep and SWS, and the lack of inherent rhythmicity are more pronounced after major surgery (*ie*, gastrectomy or vagotomy) rather than after minor surgery (*ie*, hernia repair).[12] Fewer sleep disturbances occur after laparoscopic surgery. The postoperative administration of morphine has been claimed to be a contributing factor in sleep disturbance. Healthy volunteers without pain demonstrated both REM and SWS suppression at doses of morphine $\geq$ 0.2 mg/kg.[15] There are no data on the effect of systemic or extradural morphine on sleep in postoperative patients. In the patient with severe OSAS, postoperative REM sleep rebound could conceivably act in conjunction with opioid administration and supine posture to aggravate sleep-disordered breathing. Sedatives or analgesics, as well as the residual effects of anesthetic agents may worsen OSAS by decreasing pharyngeal tone and therefore may increase upper airway resistance.[16] These agents may also attenuate the ventilatory and arousal responses to hypoxia, hypercarbia, and obstruction, worsening the underlying sleep apnea.

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How Can OSAS Affect Perioperative Outcomes?

REM rebound has been suggested to contribute to hemodynamic instability, myocardial ischemia and infarction, stroke, mental confusion, and wound breakdown.[17–21] In REM sleep, the neural drive to the pharyngeal muscles is at a minimum, and the atonia of antigravity muscles predisposes the patient to airway instability causing episodic hypoxemias.[22] In a small study[23] of 25 patients undergoing minor limb surgery, the need for using positive pressures to maintain upper airway patency in patients with sleep-disordered breathing was highest during REM sleep. Episodic hypoxemias during REM sleep lead to brief arousals associated with profound sympathetic activation, which may cause hemodynamic instability and increased mean arterial pressure.[24,25]

Postoperative respiratory obstructions are associated with large fluctuations in systolic and diastolic BPs in patients with OSAS[26] (Fig 1). Surgical stress, including postoperative pain and endocrine changes, increases the sympathetic activation further. As a result of chronic adrenergic arousal, patients with sleep apnea may have down-regulated α-receptors and β-receptors, and thus have an attenuated response to vasopressors.[21] REM sleep rebound and the link to sympathetic tone may be particularly dangerous, leading to myocardial ischemia, infarction, and even unexplained postoperative death. This hypothesis is supported by the finding that the majority of unexpected and unexplained postoperative deaths occur at night within 7 days of surgery.[27] It is interesting to note that nocturnal ST-segment changes consistent with myocardial ischemia are evident in patients with OSAS who are free of clinically significant coronary artery disease.[28] The Sleep Heart Health Study Research Group found[29] apnea-hypopnea index (AHI) scores to be modest, with scores of 1 to 10 associated with manifestations of cardiovascular disease. Hung and colleagues[30] studied 101 male survivors of acute myocardial infarction (MI) and 63 age-matched control subjects. An apnea index of > 5 was found in 36% of MI patients compared with only 3.8% of the control patients. After adjustment for age, body mass index, hypertension, smoking, and serum cholesterol level, they found that an apnea index of > 5.3 was independently predictive of MI with an odds ratio of 23.3 ($p < 0.001$).

The effect of sleep deprivation on upper airway muscle function is of equal concern. A lower threshold for upper airway collapse,[31] presumably due to reduced genioglossus muscle activity,[32] has been reported following complete sleep deprivation for 1 night. In addition, in a canine model of OSAS,[33] sleep fragmentation by itself was found to prolong the time to arousal and to worsen the oxygen desaturation accompanying apneas. Partial sleep deprivation can have many effects on the respiratory system, including reduced responsiveness to hypercapnia and hypoxia.[34] The deprivation of REM sleep in volunteers produced irritability, impaired learning, and impaired memory processing, thus making REM sleep suppression a possible contributing factor in postoperative delirium.[35,36] Despite these more recent findings, it remains possible, although yet unproven, that patients with OSAS are at increased risk for sleep-related apneas postoperatively simply due to sleep deprivation.

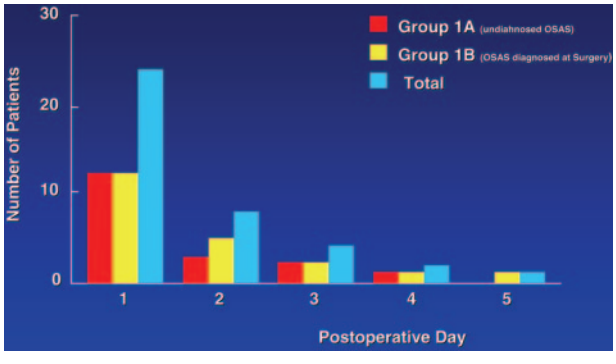

FIGURE 1. Time course of postoperative complications in patients undergoing hip or knee replacement. Based on data from Gupta et al.[44]

Cardiac arrhythmias such as ventricular tachycardia and severe bradycardia are common with sleep apnea and can exacerbate underlying heart disease, especially if massive blood loss or large fluid electrolyte shifts have occurred during surgery. The most frequent dysrhythmia observed in patients with OSAS is a sinus bradytachyarrhythmia. The extent of slowing correlates with apnea duration and the severity of desaturation. The sudden increase in heart rate that occurs after apnea termination is considered to be the combined effect of decreased vagal parasympathetic tone and increased sympathetic neural activity related to hypoxemia and arousal. With oxyhemoglobin desaturations of $< 60\%$, Shepard et al[37] have observed a significant threefold increase in premature ventricular contraction frequency in a study of 31 patients with severe OSAS. It appears that severe hypoxemia is required to induce ventricular tachycardia.[37] Sinus pauses of 2 to 13 s duration have been reported in 9 to 11% of patients with OSAS, and second-degree AV block has been reported in 4 to 8% of those patients.[37–39] Finally, data from the Sleep Heart Health Study[40] revealed that patients with OSAS have an odds ratio of 4.5 for the development of atrial fibrillation compared to matched control subjects.

The problem in addressing the relative impact of OSAS on perioperative outcomes is further hindered by the difficulty in diagnosing OSAS. The diagnosis can be elusive as the symptomatology of sleep apnea may be difficult to distinguish from normal variations in sleep behavior. Clinical examination carries a diagnostic sensitivity and specificity of only 50 to 60% for sleep apnea, even when performed by experienced sleep physicians.[41] A majority of patients without a previous diagnosis of sleep apnea was found to have obstructive sleep apnea when an outpatient diagnostic procedure involving conscious sedation was used. About 74% of patients met the minimum criteria for the diagnosis of OSAS, and 48% had respiratory disturbance indexes (RDIs) of ≥ 15, suggesting significant sleep apnea.[42]

Is OSAS an Independent Risk Factor for Perioperative Complications?

Keeping in mind that the diagnosis of OSAS may in certain cases be clinically subtle and likely has been overlooked in some studies on perioperative outcomes, there is a limited amount of data that has focused specifically on OSAS and its impact on postoperative outcomes. Ashton et al[43] studied 1,487 men > 40 years of age for risk of perioperative MI before undergoing noncardiac surgery and surprisingly did not report a single case of obstructive sleep apnea. Assuming the lowest reported prevalence of 1%, at least 15 patients in this large series of patients should have had OSAS prior to undergoing the surgical intervention. This leaves open the possibility that some of these patients who had perioperative MIs had unrecognized OSAS.

In a retrospective study[44] in orthopedic patients, more adverse outcomes were noted in patients with OSAS compared to matched control subjects. Up to one third of those patients with OSAS developed substantial respiratory or cardiac complications, including arrhythmias, myocardial ischemia, unplanned ICU transfers, and/or reintubation. The length of hospital stay was significantly higher for patients with OSAS compared with control subjects. The majority of the cardiorespiratory or neuropsychiatric postoperative complications occurred within the first 72 h after the joint replacement (Fig 2). The authors theorize that this may have been due to the combined effect of anesthetic agents, sedatives, and narcotics in conjunction with supine positioning during sleep postoperatively.

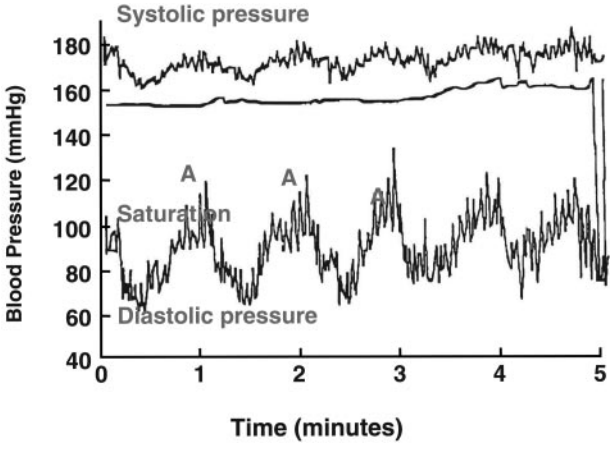

Figure 2. Postoperative BP fluctuations observed during obstructed breathing. Tracings show systolic and diastolic BP during obstructed breathing. Large pulsus paradoxus in the troughs marked by "A" are the result of negative intrapleural pressure swings occurring as a consequence of obstruction. The peaks of BP with small pulsus paradoxus coincide with arousal, the release of obstruction, and hyperpnea.

In contrasting literature, Ghamande and colleagues[45] performed a retrospective study of patients undergoing cardiopulmonary bypass grafting and did not show any correlation between polysomnography variables such as the AHI, the lowest absolute oxygen saturation and the percentage sleep time spent at < 90% oxygen saturation, and the rate of perioperative complications, including MI, stroke, arrhythmias, and respiratory failure. There was a trend, however, toward increased length of ICU stay in patients with OSAS. One possible explanation could be that perioperative complications may be less of a concern in a revascularized heart that is less susceptible to hypoxemia, sympathetic activation, and hemodynamic changes. Moreover, routine monitoring of this group in the ICU in the early postoperative period would be expected to decrease the consequences of hypoxemia, heart rate, and BP fluctuations.

In a small prospective study[46] evaluating the incidence of arrhythmia in patients with OSAS who had undergone coronary artery bypass surgery, those with an oxygen desaturation index (defined as the number of desaturations of ≥ 4% per hour) of ≥ 5 had a relative risk of 2.8 for the development of atrial fibrillation postoperatively. However, while there was a trend toward an increased incidence of atrial fibrillation in those with an AHI of ≥ 5 (32% vs 18%, respectively), this finding did not achieve statistical significance.[46]

What Is the Most Reliable Tool To Assess OSAS in the Perioperative Setting?

The overall goal of preoperative evaluation is to ensure the best surgical outcome possible. To that end, the preoperative visit is designed to suspect unrecognized disease, to describe the severity of underlying chronic illness, and to assess for any consequent physiologic limitations. Inquiry about heavy snoring, sudden awakenings with a choking sensation, and witnessed apneas by a bed partner should be a routine component of the preoperative visit. The severity of these historical items correlates with the severity of sleep study-proven OSAS.[47,48] It should be recognized that patients with a known diagnosis of OSAS who have undergone uvulopalatopharyngoplasty surgery and no longer snore may still have residual OSAS and may warrant further evaluation. The use of a simple screening questionnaire for OSAS would seem reasonable, though none have so far been validated for use in the preoperative setting. A physical examination may reveal the characteristic stigmata of OSAS including a short thick neck, nasal obstruction, tonsillar hypertrophy, nar-

row oropharynx, retrognathia, and obesity. Although these clinical features are typical, they are not reliable predictors of the presence of severity of the disease.[49] Physical examination and laboratory studies may also reveal the presence of unexplained right heart dysfunction or erythrocythemia, suggesting the severity of OSAS.

Clinical suspicion for sleep apnea may also first be recognized intraoperatively if the patient has problems with the maintenance of the airway, proves difficult to intubate, or is observed postoperatively to be snoring and/or having obstructions. An airway obstruction that is out of proportion to the apparent degree of sedation can suggest undiagnosed sleep apnea as well.[49] Eastwood et al[23] suggest that sleep-disordered breathing be considered in all patients with a pronounced tendency for upper airway obstruction during anesthesia or recovery from it. The degree of difficulty in visualizing the faucial pillars, the soft palate, and the base of the uvula predicts difficulty with intubation and should increase the suspicion of OSAS.[50]

The main issue with intervention centers around deciding what is the most efficient, inexpensive, and reliable tool available for assessing the severity of OSAS. Polysomnography remains the "gold standard" for diagnosing and treating OSAS. However, restricted access and practical application may limit its utility in the preoperative setting. As such, some authors have explored alternative screening tools to assess for the severity of sleep-disordered breathing preoperatively. In their study utilizing preoperative overnight oximetry in 24 patients, Reeder et al[13] demonstrated "significant abnormalities of respiration" (SARs) postoperatively in all patients with preoperative SARs. SARs were defined as dips in oxygen saturation of $\geq$ 4% at least five or more times in 1 h. However, the preoperative nocturnal oximetry identified only a third of those who experienced postoperative SARs. Outcomes resulting from the hypoxemia were not reported. In contrast, a more recent multicenter Japanese study[51] conducted with elective surgery patients established that the presence of preoperative sleep-disordered breathing (as evidenced by an elevated preoperative oxygen desaturation index and witnessed apneas) was positively associated with the severity of postoperative nocturnal desaturations. In the series by Gupta et al[44] of orthopedic patients, while the presence or absence of OSAS correlated with postoperative outcomes, the severity of sleep apnea (as determined by the polysomnographic measure RDI) did not correlate with the incidence of postoperative complications. Of interest, RDI determined with the patient in the supine position was found to be high in patients with OSAS who were undergoing joint replacement even though they had a low preoperative RDI. This study suggests that the supine RDI could be proposed as a measure of OSAS severity when considering the perioperative assessment of these patients. Further study of this measure should be considered. At present, the optimal preoperative screening tool to assess for the presence and severity of OSAS is not known. Until further data are available to answer this question, a formal polysomnogram should be performed in high-risk patients, assuming it is feasible in the given clinical situation.

What Is the Best Perioperative Intervention for Suspected Cases of OSAS?

The current treatment of OSAS in the nonsurgical setting consists of continuous positive airway pressure (CPAP) administered during sleep at night. In individuals with a known diagnosis of OSAS who are receiving CPAP therapy, it is thought that the perioperative use of CPAP will reduce the risk of postoperative complications.[31,52] This was also suggested by the case-control study of Gupta et al,[44] in which patients with known OSAS who are receiving CPAP at home experienced significantly fewer postoperative complications regardless of whether they used CPAP postoperatively or not. This finding also implies that there may be a beneficial "carryover" effect of CPAP therapy on the airway, although the small number of subjects in this subanalysis limits the strength of these conclusions. Thus, while there is no definitive evidence that the timing of surgery should be delayed for the initiation of CPAP therapy, this issue has not been adequately studied to guide management decisions.

One possible approach in surgical patients who are suspected of having OSAS, but are unable to undergo polysomnographic evaluation, would be to empirically start administering CPAP therapy to the patient in the perioperative setting utilizing self-adjusting or autoadjusting CPAP devices. This approach has not been studied and may have significant limitations to implementation. If the patient is not familiar with CPAP therapy, technical difficulties in initiating CPAP therapy postoperatively may limit its effectiveness. In addition, titrating CPAP for the first time in the postoperative period is less likely to be successful.[53]

In general, surgery need not be delayed to allow for improvements in cognition and hemodynamics that accompany the long-term use of CPAP. This late effect may, however, be beneficial in certain settings, such as before major elective intraabdominal, in-

trathoracic, or vascular surgery is planned. Other interventions, such as the use of oral appliances, body positioning, and oxygen, have not been studied in this setting.

How Beneficial Is Perioperative CPAP?

No studies have conclusively shown CPAP therapy to be beneficial in the postoperative setting, although adequate trials to assess its efficacy have not been performed. Case series[52] and the limited data noted previously suggest that the use of CPAP therapy in the perioperative setting for known cases of OSAS may help to reduce postoperative complications.

There are numerous effects of CPAP therapy that may be beneficial in the postoperative setting. Nasal CPAP therapy is highly effective at preserving airway patency during sleep, and over several weeks can improve the diminished reflex responses to hypoxia and hypercapnia.[54] As mentioned earlier, Gupta et al[44] found that use of home CPAP therapy in patients with an established diagnosis of OSAS had a possible carryover protection resulting in a significantly lower rate of complications, even though most of them did not receive CPAP therapy in the hospital. This may in part be related to upper airway stabilization, which is a residual effect of CPAP therapy following as little as 4 h of use.[55] Hemodynamic fluctuations accompanying early episodes of respiratory obstruction in a patient with undiagnosed sleep apnea after aortic reconstructive surgery were abolished with nasal CPAP therapy (Fig 3). Reductions in mean systolic, diastolic, and mean BP after CPAP therapy were 27.7%, 16%, 25%, respectively.[25] Treatment with CPAP significantly reduces the total duration of ST-segment depression in persons with sleep apnea.[56] In patients cardioverted for atrial fibrillation, the presence of untreated sleep apnea doubles the likelihood of recurrence of the atrial fibrillation within 12 months when compared with patients with OSA receiving CPAP therapy.[57]

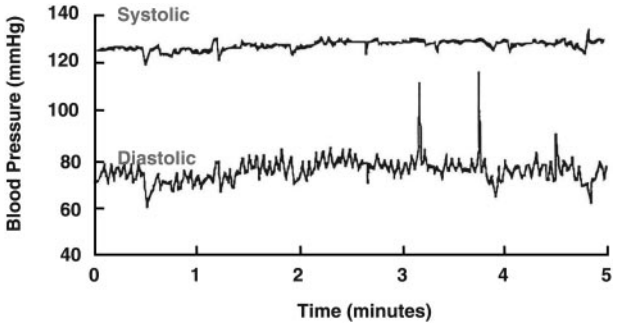

Figure 3. Postoperative BP fluctuations following nasal CPAP therapy. Large peaks in BP were abolished following relief of respiratory obstructions using nasal CPAP therapy.

These data all suggest that there may be some benefit to the use of CPAP in the perioperative setting for patients with suspected OSAS, although this remains to be proven. In patients with known OSAS, nasal CPAP therapy has been recommended by some authors prior to surgery, and is to be resumed soon after extubation to allow for the safe use of analgesic and anesthetic medications in patients with OSAS.[58]

Does the Diagnosis of OSA Influence the Decision Regarding the Appropriate Setting of Surgery?

Guidelines to address this issue have been proposed by some authors, though they are based more on expert opinion than evidence.[59,60] Factors to consider when evaluating how patients with suspected OSAS should be monitored postoperatively include the preclinical suspicion of the severity of OSAS, the type of surgery being performed, the need for narcotics postoperatively, and the clinical course in the recovery room. Outpatient surgery is likely appropriate for patients with mild OSAS who do not need CPAP and are to undergo minimally invasive or orthopedic limb surgery. Surgery requiring only regional anesthesia and/or a limited need for postoperative narcotic analgesia could also be considered for the outpatient setting. These patients could be sent home when fully conscious if they are not snoring or have an obstruction in the recovery room. Patients with OSAS undergoing abdominal or invasive surgery, who have significant expected pain or require opioid therapy, have severe OSAS at baseline that requires CPAP therapy at home, or have an observed obstruction or experience episodic desaturations that are evident in the recovery room should be considered for continued inpatient monitoring.[28] Routine postoperative ICU admission may not be necessary except in patients with coexisting cardiopulmonary disease, a difficult airway, or significant postoperative pain.

Given the lack of good data in this area, there have been calls to establish guidelines to help determine how best to care for these patients in the postoperative setting.[61,62] It should be recognized that an unsupervised holding area is inappropriate for a premedicated sleep apnea patient. In practice, some anesthesiologists will not premedicate patients with OSAS due to concerns of airway compromise. It is probably prudent to minimize or avoid the use of sedatives in this patient population and to minimize the use of narcotics. The use of benzodiazepines

should be avoided altogether in the postoperative setting for these patients due to their effects on the CNS and upper airway musculature. Likewise, the use of narcotics should be limited, and the use of alternative forms of analgesia, such as nonsteroidal antiinflammatory medications, nerve blocks, or local analgesics should be considered. If narcotics are required for pain control, then patient-controlled analgesia with no basal rate and restricted dosing may help to limit dosing. Whether the use of epidural agents in this setting is helpful has not been studied, and users should be aware that respiratory depression can still occur with this type of analgesia. Respiratory arrest has been reported in those patients with OSAS who are receiving epidural opioids 2 to 3 days postoperatively.[58] Patients with suspected OSAS requiring IV narcotics should be kept in a monitored setting with frequent assessments, and naloxone should be kept at the bedside. With this approach, if compromise is detected, naloxone can be administered if needed and CPAP can be applied, with supplemental oxygen added as needed.[52]

Conclusion

Sleep apnea is often undiagnosed in patients presenting for surgery. An increased risk for perioperative complications has been found in patients with OSAS, as has been reported in several case reports and one retrospective case-control study.[9,11,13,18,25,44,58] There is biological plausibility to support these findings. Prospective studies are needed to determine whether prior awareness of OSAS and earlier intervention for these patients is associated with improved outcomes. Until additional information is available to guide decision making, screening for OSAS should be incorporated as part of the preoperative assessment of patients who are subjected to surgery.

While immediate postoperative complications can intuitively be attributed to the negative effects of narcotics or sedatives, or to the residual effects of anesthesia on upper airway muscles, later events are more likely related to marked REM sleep rebound. Few definitive data exist to guide the perioperative management of patients with known sleep apnea or those suspected of having this condition. Heightened awareness for the close monitoring of high-risk patients is recommended. Anesthetic, sedative, and analgesic drugs should be used with extreme caution in patients with OSAS or in those suspected of having OSAS who are to undergo surgery. Nasal CPAP therapy before surgery and after extubation may improve outcomes in these patients, although further study is needed.

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