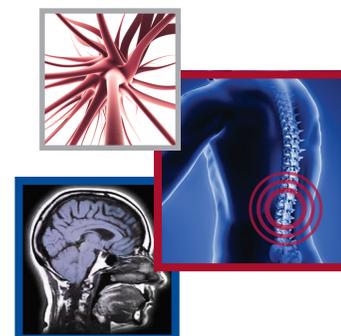


Obstructive sleep apnea in adult patients: considerations for anesthesia and acute pain management



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Practice Points

- Obstructive sleep apnea is often underdiagnosed and highly prevalent in adult surgical patients.
- Questionnaires (e.g., STOP-Bang, Berlin, Flemons) are effective screening tools for patients at high risk of obstructive sleep apnea.
- Obstructive sleep apnea negatively affects postoperative complications and outcome.
- Neuraxial or regional anesthesia may prove beneficial in patients suffering from obstructive sleep apnea.
- Perioperative CPAP therapy and the use of analgesic/anesthetic drug regimens may be beneficial but lack scientific evidence to date.

SUMMARY Obstructive sleep apnea (OSA) represents a challenge in the perioperative period for both physicians and the health care system alike. A number of studies have associated OSA with increased risk for postoperative complications. This is of particular concern in the face of this disease remaining vastly underdiagnosed. In this context, current guidelines and established concepts such as the use of continuous positive airway pressure or the level of postoperative monitoring, lack strong scientific evidence. Other interventions such as the use neuraxial/regional anesthesia may however offer added benefit. This review aims to address considerations for physicians in charge of OSA patients in the perioperative setting and to give an outlook for current and future research on this topic.

KEYWORDS:

acute pain management
 • anesthesia • obstructive sleep apnea • perioperative outcome • preoperative screening • regional anesthesia

The last years have seen increasing awareness of obstructive sleep apnea (OSA) as an important comorbidity in the perioperative setting. This often undiagnosed disorder has been reported to have reached epidemic proportions affecting up to 25% of all surgical patients, and has been attributed in part to the concomitant rise in the prevalence of obesity [1]. Complicating matters is the fact that 80% of those with OSA remain without its documentation at the time of surgery [2].

Sleep disordered breathing is a dyssomnia characterized by pauses in breathing and various subgroups have been identified. While central sleep apnea is associated with impairments in neural respiratory control [3], obstructive sleep apnea is a result of partial or complete upper airway obstruction. These obstructions result in repetitive incomplete or complete cessation of airflow during sleep along with strenuous breathing against resistance, followed by a brief period of desaturation and subsequent arousal [4].

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- **OSA & obesity**

OSA is frequently associated with obesity and obesity-related changes to the anatomy, including fat deposits around the upper airway and abdominal obesity causing difficulty in chest excursion. More than 40% of obese patients were previously reported to have significant OSA [5], and almost three quarters of OSA patients are obese [6]. A 10% increase in weight gain was reported to increase the risk for OSA by sixfold [7]. Given the strong association with obesity and metabolic syndrome-associated conditions, it is still intensely debated whether OSA should be viewed as a discrete pathophysiologic entity, actively causing further detriment, or as a symptom itself. However, numerous studies show a clear interdependency of OSA and related conditions, and these are extensively reviewed elsewhere [8]. Moreover, the impact of predisposing conditions for OSA may differ across genders. Interestingly, while the prevalence of OSA is generally reported to be higher in men, risk factors (including age, body mass index, waist-hip-ratio and metabolic syndrome) might bear different weight in females [9].

- **OSA in the non-obese**

In the nonobese subset of patients with OSA many exhibit clinical or subclinical orofacial disorders, including tonsillar hypertrophy, retropositioned mandible or tongue, macroglossia, inherited syndromal disorders (e.g., Treacher-Collins syndrome, Pierre-Robin sequence) or disorders of metabolism [10]. Particularly children are frequently affected by the second subtype, but also premenopausal women [11]. The pathogenesis of OSA in patients with neither obesity nor overt signs of craniofacial conditions is poorly understood; associations with chronic inflammation have been suggested [12].

- **Need for perioperative screening**

OSA is known to provoke a multitude of long-term cardiovascular consequences, but also a higher incidence of complications in the immediate perioperative period. However, a timely diagnosis of the condition is often difficult to attain. While the diagnostic gold standard is polysomnography, it is hindered by its complexity and necessary expenditure, which is increasingly problematic in view of the magnitude of the problem. Therefore, other more easily applicable and predictive screening measures for OSA are currently in use and are being studied. Thus,

while the field is rapidly evolving, anesthesiologists are frequently facing patients lacking adequate preoperative diagnostic testing or initiation of a long-term therapy. Further, scientific evidence on how to treat these patients in the immediate perioperative setting and the impact on perioperative outcome is scarce and the practical implications to help preoperative decision making for both physicians and healthcare administrators are severely limited. This review aims to provide helpful considerations for both anesthesia and perioperative pain management in adult patients with OSA while taking into account the currently available evidence.

Available OSA screening methods

- **Polysomnography**

The gold standard for the definitive diagnosis of sleep-disordered breathing remains full, attended nocturnal polysomnography (PSG) [13]. In this context, a variety of parameters are usually recorded, including breathing pattern, oro- and nasopharyngeal airflow and/or pressure, arterial oxygen saturation, electrocardiogram, non-invasive blood pressure, electroencephalo- and/or electromyography. These parameters serve to evaluate the incidence of apnea, hypopnea and arousals in conjunction with other physiological parameters, including stage and depth of sleep, occurrence of desaturation as well as cardiovascular disturbances. Various metrics can be defined to quantify the frequency of apneic episodes, defining the severity of OSAS. The apnea hypopnea index (AHI) is often utilized to grade OSA severity, as it has been shown to correlate well with the incidence of many long-term complications. However, it is subject to intense debate whether other clinical measures gained through polysomnography (e.g., oxygen desaturation index) would be capable of identifying sleep disordered breathing symptoms with higher accuracy and/or better discrimination between various subtypes [14,15]. Recently, home PSG has increasingly been evaluated as an alternative to office-based, attended PSG, dramatically decreasing the cost of timely OSA detection, by elimination of facility fees [16]. However, evaluation of all patients bearing clinical signs of sleep disordered breathing is hardly feasible and would be prohibitively expensive – due to the complex and time-consuming nature of either form of PSG. This fact holds particularly true in the setting of preoperative patient evaluation, where patient contact time is typically short

and execution of time-consuming diagnostic procedures difficult to impossible.

• Screening instruments

Alternative approaches to estimate the risk of OSA are highly sought after, allowing for increased pretest probability if PSG is contemplated, or for allocation of increased postoperative monitoring in patients at risk for adverse outcomes. Over the previous decade, screening methods have been developed for the purpose of OSA risk estimation. However, while numerous methods are readily available, many have only been validated for the use in internal medicine practices and sleep clinics. Following the publishing of a practice guideline [17] for the perioperative management of patients with suspected OSA issued by the, interest in scoring instruments for the specific use in preoperative patients has been increasing. These instruments include, among others, the American Society of Anesthesiologists (ASA) sleep apnea checklist [17], the Berlin questionnaire [18], the STOP model and its more sophisticated successor, the STOP-BANG model [19], the Wisconsin questionnaire [20], Hawaii sleep questionnaire [21] and various self-reported questionnaires [22–24]. All tools estimate risk by inquiring overt signs of sleep apnea, including snoring, observed breathing pauses, and account for physical traits predisposing to the condition, including obesity and large neck circumference. While most of the available scoring tools have been evaluated thoroughly and almost consistently exhibit medium to high sensitivity in detecting patients with high risk for OSA they are burdened by low to moderate specificity to exclude those that do not have the disorder. In addition, they greatly differ in their complexity and the time and effort required for completion of question items [25]. Overview of available questionnaires is given below (Table 1).

• Overview of available questionnaires

- The ASA checklist and Berlin questionnaire are 14- and 10-item questionnaires, respectively, capable of categorizing patients into strata regarding the risk of presence of OSA. The main criticism of both tools is the relatively complex scoring system.
- The STOP model devised by Chung *et al.* is a simplified version of the Berlin

questionnaire, consisting of only four binary questions. At AHI cutoff levels of > 5, > 15 and > 30, it yielded sensitivity of accurate OSA detection (confirmed by polysomnography) comparable to the more complex models.

- Addition of four more questions (the STOP-Bang model) led to further increased sensitivity: above 90% in patients with AHI > 15 and 100% in patients with AHI greater than 30. Specificity decreased compared with the more complex screening instruments. However, although more false-positive results and unnecessary increased monitoring measures might result, the benefits gained through avoidance of complications in correctly identified OSA patients likely outweigh this disadvantage.
- Furthermore, serum bicarbonate (HCO_3^-) might serve as an indicator of chronic metabolic compensation of a recurrent respiratory acidosis and thus provide another predictive factor for sleep disordered breathing. Chung *et al.* recently demonstrated that addition of a HCO_3^- cutoff value of ≥ 28 mmol/L to a STOP-Bang score of ≥ 3 allowed for an increase in specificity to 85.2% (all OSA), 81.7% (moderate/severe OSA) and 79.7% (severe OSA), respectively. Thus, utilizing a two-step screening process comprising (1) the STOP-Bang questionnaire and (2) measurement of serum bicarbonate level might be useful to further increase test validity [26].

• Validation of screening tools against the gold standard

A systematic review by Abrishami *et al.* analyzed 10 studies on screening instrument validation (1484 patients total), validating the OSA risk obtained through screening instruments against results from sleep studies [27]. They found that the results reported are inconsistent, likely owing to the very heterogeneous study designs. However, despite this fact, most questionnaires are suitable for broad-scale screening of patients, in whom preoperative testing is carried out, allowing for identification of patients suffering from OSA with relatively high confidence. Appropriate monitoring, caregiver attention and, possibly, advanced diagnostics and preoperative optimization in a subset of patients with high risk for OSA and adverse outcomes after surgery can then be initiated.

Table 1. Comparison of screening methods for obstructive sleep apnea in surgical patients.

Screening tool	Questions	Scoring	Ref.
ASA checklist	14 questions in three categories (predisposing physical characteristics, history of apparent airway obstruction during sleep, somnolence)	Complex (question-based category scoring)	[17]
Berlin	11 questions: five on snoring, three on daytime sleepiness, one on sleepiness while driving, one on hypertension; vital signs: age, gender, weight, weight, height, neck circumference	Complex (three to five answers, point-based scoring system)	[18]
STOP	<u>S</u> noring: do you snore loudly (louder than talking or loud enough to be heard through closed doors)? <u>T</u> ired: do you often feel tired fatigued or sleepy during daytime? <u>O</u> bserved: has anyone observed you stop breathing during your sleep? <u>B</u> lood pressure: do you have or are you being treated for high blood pressure?	Simple: two or more questions answered yes: high risk one question answered yes: low risk	[19]
STOP-Bang	STOP questions plus: <u>B</u> MI > 35 kg/m ² ? <u>A</u> ge > 50 years? <u>N</u> eck circumference > 40cm? <u>G</u> ender male?	Simple: three or more questions answered yes: high risk two or less questions answered yes: low risk	[19]

• **Screening tools & complication incidence**

Chung *et al.* also validated screening tools with regard to postoperative complication incidence. The authors detected a significantly increased risk for postoperative complications in those patients that were identified as high risk for OSA by the ASA and STOP questionnaires [18]. Thus far, evidence for improved perioperative and long-term outcome after implementation of screening for OSA is scarce. This might be not least due to the fact that it is challenging to assess pre- and postintervention complication incidence and mortality for ethical reasons. Once patients are identified as bearing a high risk for OSA and associated complications, increased pre- and postoperative interventions (e.g., monitoring, ICU admission, commencement of CPAP therapy) are inevitably warranted, making comparison possible only to historic cohorts, where those interventions were omitted. In a large observational study recently reported by Lockhart *et al.* [28], almost 15,000 patients in a mixed surgical cohort were assessed for OSA risk preoperatively by inquiring known history of OSA as well as results from the Berlin, Flemons, STOP and STOP-Bang questionnaires. 12.9% of patients reported a known history of OSA. All questionnaires reported a high prevalence of undiagnosed OSA cases (9.5–41.6%), however with varying agreement between the screening tools, especially towards the lower-risk end of the cohort (κ -statistic 0.225–0.611). While no mortality difference was found between patients with known OSA and the rest of the cohort, highly significant differences in one-year mortality were identified between low- and high-risk cohorts as detected by the Flemons, STOP and STOP-Bang instruments. Patients in

the high-risk groups were older, more frequently male, and suffered from a higher comorbidity burden. After adjustment for some of these risk factors, neither screening tool was able to independently predict one-year mortality after the surgical intervention. This finding, again, poses the question whether OSA should be understood as an independent risk factor for postoperative complications, or rather a composite of a number of cardiovascular and metabolic detriments that most OSA patients amass [29].

• **Summary**

Diagnostic methods for OSA detection greatly vary in ease of application, sensitivity and specificity. While PSG is the gold standard, its application is time-consuming and expensive particularly in patients with an unknown pretest probability. Available screening tools provide risk estimates utilizing questions of varying complexity, however, with validity contingent on provision of correct and concise information. In their systematic review, Abrishami *et al.* conclude that due to its ease of use the STOP-Bang questionnaire is currently the most simple and powerful method to screen patients for risk of OSA in a very short amount of time [27]. However, an appropriate questionnaire can feasibly be chosen according to individual requirements and preferences.

Perioperative outcomes

OSA has been identified to be strongly associated with acute as well as chronic detriments, including cardiovascular, metabolic, respiratory, neurologic disease [29,30] and an increased incidence of adverse perioperative outcomes [31,32].

Exact explanations for the pathogenesis of OSA-associated conditions remain to be established. Long-term changes including sympathetic surges after arousals, shifts in intrathoracic pressure during obstruction, endocrine changes as results of frequent desaturations and chronic inflammation are some of the potential culprits [30]. During the perioperative period, patients are exposed to a multitude of stresses, injuries and metabolic alterations, possibly compounding the effects of OSA. Numerous studies have shown that OSA patients are more prone to complications in the postoperative period, compared with their counterparts without the diagnosis.

- **Meta-analyses on complication rates in general surgical patients**

Gaddam *et al.* recently published a meta-analysis including 18 studies of patients undergoing nonupper airway surgery, comparing those with known OSA diagnosis to those without [33]. The former group had significantly higher odds ratios for postoperative hypoxemia (OR: 3.06; CI: 2.35–3.97), respiratory complications (OR: 2.77; CI: 1.73–4.43), cardiac complications (OR: 1.76; CI: 1.16–2.67), neurologic complications (OR: 2.65; CI: 1.43–4.92) and unplanned ICU admission (OR: 2.97; CI: 1.90–4.64). Kaw *et al.* present similar results in their meta-analysis, including 13 studies (n = 3942), with higher incidence and risk for cardiac events, respiratory failure, desaturation and ICU in OSA patients [31].

While such results have been reported across most surgical disciplines, certain subspecialties might be affected even more drastically, possibly due to an increased prevalence of OSA-predisposing conditions amongst their patients, including obesity, advanced age and history of metabolic disease. Specifically, bariatric and orthopedic surgeries fall into this category.

- **Bariatric surgery**

Bariatric surgery (specifically, Roux-Y gastric bypass, sleeve gastrectomy or biliopancreatic diversion) has been identified as a frequently successful means to achieve weight loss [34] and reduce the prevalence of associated major morbidity. However, in absence of large-scale evidence, its role with regard to the treatment of OSA remains controversial [35]. Moreover, the influence of OSA on short-term perioperative outcomes in bariatric surgery candidates remains elusive. Interestingly, in a database

study by Mokhlesi *et al.* analyzing close to 100,000 patients undergoing elective bariatric surgery, presence of sleep-disordered breathing was associated with lower mortality (OR: 0.34; CI: 0.23–0.50, $p < 0.001$), lower hospital charges (-869 USD, $p < 0.001$) and shorter length of stay (-0.25 days, $p < 0.001$) [36]. However, OSA patients had higher risk for emergent intubation (OR: 4.35; CI: 3.97–4.77, $p < 0.001$), noninvasive ventilation (OR: 14.12; CI: 12.09–16.51, $p < 0.001$) and atrial fibrillation (OR: 1.25; CI: 1.11–1.41, $p < 0.001$). While speculative, the negative association between OSA diagnosis and mortality might be related to more attentive postoperative care for patients with a history of sleep-disordered breathing on the one hand, or may result from the fact that only patients with a pre-existing diagnosis code for the disease have been included in the study group, possibly biasing the overall result.

- **Orthopedic surgery**

For orthopedic surgical patients, the body of evidence has been increasing in recent years. Gupta *et al.* performed a case-control study including 101 patients undergoing hip or knee replacement with OSA diagnosis which was matched to 101 controls. Approximately two-thirds of the study group already had an OSA diagnosis at the time of surgery, and one-third was diagnosed at a later time. The authors found increased rates of perioperative complications and longer hospital stay amongst OSA patients. Interestingly, complication rates were similar whether sleep apnea was already known at the time of surgery, or only diagnosed later [37].

- **Population-based studies**

Population-based studies are a particularly powerful tool in the comparison of complication incidence in a real-life rather than tightly controlled settings. In a study by Memtsoudis *et al.*, more than half a million patients undergoing total lower extremity joint arthroplasty were analyzed for perioperative outcomes, according to presence of OSA diagnosis. 8.4% of patients had a pre-existing diagnosis of OSA [38]. Utilizing multivariate analysis, OSA was identified as a significant risk factor for major perioperative complications (OR: 1.47; CI: 1.39–1.55), including pulmonary complications (OR: 1.86; CI: 1.65–2.09), and cardiac complications (OR: 1.59; CI: 1.48–1.71). Moreover, OSA patients required ventilatory support, ICU

admission, stepdown and telemetry services more frequently and posed a higher economic burden.

Similar results were obtained for spine surgery. Stundner *et al.* analyzed differences in perioperative outcome of patients undergoing posterior lumbar fusion surgery with or without a diagnosis of OSA by means of a large, national inpatient database [39]. Of 84,655 patients, 7.28% had a diagnosis for sleep apnea. The latter group of patients exhibited a higher complication rate, required prolonged postoperative ventilation and ICU admission more frequently, had higher rates of blood product transfusion, longer hospital stay and incurred higher hospital cost. In the multivariate regression analysis adjusting for demographic, health-care-related and surgical parameters as well as comorbidities, OSA emerged as an independent risk factor for perioperative complications (OR: 1.50; CI: 1.38; 1.62), blood product transfusion (OR: 1.12; CI: 1.38; 1.62), mechanical ventilation (OR: 6.97; CI: 5.90; 8.23), ICU admission (OR: 1.86; CI: 1.71; 2.03), prolonged hospital stay (OR: 1.28; CI: 1.19; 1.37) and increased hospital cost (OR: 1.10; CI: 1.03; 1.18).

While these population-based studies serve to demonstrate the high impact of OSA on perioperative outcomes, unlike studies testing all subjects in a sleep lab, they cannot take into account the large number of undiagnosed patients, in other words, those that do not have a definitive diagnosis code of OSA as of the day of their surgery. With an estimated OSA prevalence of as high as one in four patients in certain populations, [2] such studies might still underestimate the magnitude of the impact OSA exerts on perioperative outcomes. A very recent study by Mutter *et al.* gave evidence that the preoperative diagnosis of OSA and therefore possible changes in perioperative care might positively impact cardiovascular complications [40].

• Cognitive outcomes

Another factor worth taking into consideration is the impact of anesthesia and surgery on cognitive condition, especially in elderly patients and those with pre-existing cognitive deficits. In a small study by Flink *et al.*, patients aged 65 years or older undergoing elective total knee arthroplasty were twice as likely to suffer from postoperative delirium when they had a diagnosis of OSA (53 vs 20%, $p = 0.0123$, OR: 4.3),

with OSA being the only independent predictor of postoperative delirium in the multivariate analysis [41].

Anesthesia & acute pain management

The recent guideline on the management of OSA patients by the ASA recommends utilization of regional anesthesia whenever possible [42]. Regional anesthesia (i.e., neuraxial anesthesia and peripheral nerve blocks) was shown to reduce need for systemic analgesics while simultaneously providing superior analgesia, as has been extensively outlined in the literature [43,44]. Moreover, the advent of regional anesthesia allowed numerous procedures previously requiring general anesthesia, intubation and mechanical ventilation to be managed in awake or only mildly sedated patients. Beyond this, addition of continuous regional anesthesia (e.g., by insertion of an epidural or peripheral nerve catheter) facilitates postoperative analgesia even in procedures mandating general anesthesia, including major abdominal or thoracic surgery. Advantages of regional anesthesia thus include avoidance of airway instrumentation and fewer interventions interfering with respiratory control, consciousness and airway reflexes. Intuitively, a combination of these factors might be capable of preventing obstructive episodes in OSA patients, particularly in the postoperative period. Additionally, a higher rate of difficult airway is known to coincide with obesity and/or OSA, rendering regional techniques safer by circumventing need for tracheal intubation [45]. However, evidence on improved outcome on a broad scale, based on these recommendations, was long missing. In a large-population based study [46] neuraxial anesthesia alone for total hip or knee arthroplasty was indeed associated with lower rates and adjusted odds for perioperative complications, compared with a combination of neuraxial-general or general anesthesia alone (complication incidence: 16.0, 17.2 and 18.1%, $p = 0.0177$; OR: 0.83; CI: 0.74–0.93; $p = 0.0012$), 0.90 (CI: 0.82–0.99; $p = 0.03$). While mechanisms for these benefits might include avoidance of general anesthesia, loss of upper airway reflexes and airway instrumentation as well as better postoperative pain control with less opioid utilization, the authors acknowledge that further research is necessary into the benefits that regional anesthesia confers for OSA patients.

Even though expert opinion supported by case series [47] favors the implementation of perioperative continuous positive airway pressure (CPAP) to affect postoperative pulmonary complications, little data exists on its efficacy. While a randomized controlled trial by Liao *et al.* showed a decrease in the postoperative apnea-hypopnea index and better oxygenation utilizing auto-titrated continuous positive airway pressure based on PSG with an AHI > 15 [48], another randomized controlled trial by O’Gorman *et al.* could not show a benefit in length of stay or other complications for autotitrating positive airway pressure in CPAP-naïve patients at high risk for OSA (according to Flemons’ score) after orthopedic surgeries [49]. Also, retrospective data could not show a difference in complication rates between patients using and not using CPAP prior to hospitalization for major surgeries [32,50] or is providing conflicting evidence on the topic [37,51–52]. Still, evidence exists that initiation of CPAP therapy in the perioperative setting may have beneficial effects on long term effects and comorbidity burden [53]. Almost all previously mentioned studies report on the issue of low compliance (about 40–50% of patients) with perioperative CPAP therapy, further limiting its possible impact.

Opioids have been shown to not so much lead to respiratory obstruction, but an increase in central apneas [54,55] with overall analgesic opioid requirements being lower in OSA patients [56]. While proinflammatory markers and nocturnal hypoxemia in high risk OSA patients have been identified as factors for increased opioid analgesic potency [57], only limited data exists on the effect of opioids on perioperative outcome. Orlov *et al.* conducted a systematic review on the utilization of neuraxial opioids in OSA patients but could only identify an aggregate of 127 surgical patients from mostly low quality studies reporting a total of 5 patients with cardiorespiratory complications [58]. Ankichetty *et al.* also reported few adverse events after the use of sedatives and anesthetics in their systematic review covering an aggregate of 149 OSA patients, but again could not draw strong conclusions from the studies at hand [59]. Adaptive servo-ventilation was suggested in patients suffering from opioid-related central sleep apnea, particularly those in whom CPAP therapy was found to be noneffective, showing promising results [60].

The adequate level and duration for postoperative monitoring has seen a long history of

dispute, with guidelines now agreeing to monitor patients while they are at risk for postoperative respiratory depression but remaining unclear on the appropriate setting (e.g., step-down unit, intensive care ward or postoperative care unit) and length of observation [42]. The added value of pulse oxymetry monitoring has so far only been studied in a general patient population and data on the OSA population is missing [61]. More recently, the monitoring or end tidal carbon dioxide has been suggested as a potentially superior monitoring option [62].

Future perspective

Administrative data shows that, even though OSA has been identified as an important influence on postoperative complications, perioperative interventions such as postoperative monitoring, neuraxial or regional anesthesia and CPAP therapy remain widely underutilized in surgical patients [38]. With the number of OSA steadily increasing, a major future challenge will be to identify which OSA patients might benefit most from specific perioperative interventions and further strengthen our available guidelines with scientific evidence, eventually leading to a more standardized care for this demanding patient population. As an immediate action, adherence to published guidelines (e.g., by the American Society of Anesthesiologists [42]) should be critically assessed in the individual institutions. Available data shows that despite the availability of such recommendations, only a fraction of patients with a known diagnosis of sleep apnea were placed in advanced settings (e.g., stepdown units or telemetry) for postoperative observation [63]. While it may seem clinically unnecessary and economically unfeasible to provide advanced monitoring for every patient suffering from OSA at this point, concern for litigation prevails among clinicians in the event of an adverse outcome and gives rise to much uncertainty. Before more diverse information on the individual complication risk is available, it is difficult to assess which patients need monitoring and which do not. In the long term, providing this data might prove critical in order to be able to create more definitive evidence-based guidelines. These guidelines should, ideally, address the appropriate allocation of resources, allowing for safe and economically sound decision-making on the one hand and increasing patient comfort on the other. In light of the vastly increasing surgical volume

predicted for the next decades, likely involving older patients and those with higher comorbidity burdens, this aspect becomes of even higher importance.

Moreover, future research should focus on individual differences in pathogenesis of OSA. Most of the data available today pertains to OSA associated with obesity and/or does not strictly distinguish between obese and nonobese subjects. It must be kept in mind that important differences might exist between obese and non-obese patients suffering from OSA, particularly with regard to long-term treatment and outcome. However, patients across both groups are likely to benefit from targeted care and alternative anesthetic approaches in the perioperative period in a similar way, although there is limited data available at the moment to support this notion.

Finally, much uncertainty prevails with regard to the optimal treatment of OSA and prevention of complications, in the long term as well as in the immediate perioperative period. Discovery of novel therapeutics as well as evaluation of established forms of therapy (CPAP, assisted spontaneous ventilation) in the perioperative setting could both contribute to further improve safety in OSA patients in need for surgery.

Conclusion

OSA has been shown to negatively affect perioperative outcomes, even though its impact on overall mortality has been questioned. A handful of possible screening tools (e.g., STOP-Bang) and interventions have been proposed in recent

guidelines, including prolonged postoperative monitoring, use of regional anesthesia, upright patient positioning and CPAP therapy. Still, it remains largely unclear how screening for OSA in the preoperative setting and resulting perioperative interventions affect outcome. Even after successful identification of patients at risk, the question remains whether these patients might benefit from perioperative interventions such as improved patient selection, anesthesia techniques and increased physician and staff attentiveness, which are difficult to take into account. At the present time no definitive answer can be given on whether to delay specific surgeries and initiate treatment, leaving such decisions up to individual judgment of the perioperative clinician. Despite the lack of evidence on contributing mechanisms, increased utilization of neuraxial or regional anesthesia might improve postoperative complications. Further study in this developing field is needed to strengthen or reshape available guidelines and give solid evidence on perioperative care for OSA patients.

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