

# Evidence-Based Patient Safety Advisory: Patient Assessment and Prevention of Pulmonary Side Effects in Surgery. Part 1—Obstructive Sleep Apnea and Obstructive Lung Disease

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**Summary:** Obstructive sleep apnea and obstructive lung disease may increase a patient's risk of perioperative pulmonary complications. This practice advisory provides an overview of the preoperative steps that should be performed to ensure appropriate patient selection and the safety of patients with these conditions. Also discussed are recommendations for perioperative management and strategies for minimizing complications. (*Plast. Reconstr. Surg.* 124 (Suppl.): 45S, 2009.)

**P**erioperative pulmonary complications occur in all surgical settings and may occur as frequently as cardiac complications during or after various types of surgery.<sup>1,2</sup> These complications may include pneumonia, respiratory failure with prolonged mechanical ventilation, bronchospasm, atelectasis, and exacerbation of underlying chronic lung disease.<sup>3</sup> At times, predictors of these complications may go undetected during patient assessment, leading to the onset of pulmonary problems during or after surgery. Therefore, all surgeons should become familiar with the risk factors for perioperative pulmonary complications and assess the possible presence of these factors during the preoperative evaluation of their patients.

Pulmonary comorbidities have been associated with intraoperative and postoperative morbidity and mortality.<sup>4-6</sup> In particular, obstructive sleep apnea and obstructive lung diseases, such as asthma and chronic obstructive pulmonary disease, have been associated with perioperative pulmonary complications.<sup>4,7-15</sup> Typically, patients with obstructive sleep apnea have difficulty protecting their own airway, and patients with obstructive lung diseases

are prone to bronchial hyperreactivity, both of which can be exacerbated by some types of anesthesia techniques and agents. A thorough assessment of the patient's disease status should allow the surgeon to determine the most appropriate surgical setting and operative plan for the patient, potentially reducing the risk of pulmonary complications during or after surgery.

In an effort to ensure patient safety in the ambulatory surgery setting, the American Society of Plastic Surgeons (ASPS) Patient Safety Committee sought to develop a practice advisory to assist decision-making with regard to perioperative pulmonary complications. This advisory, which is published in two parts, provides an overview of the preoperative steps that are recommended to ensure appropriate patient selection for the ambulatory surgery setting, and provides recommendations for reducing the risk of perioperative pulmonary complications. Part 1 focuses on obstructive sleep apnea and obstructive lung disease, whereas Part 2 discusses various patient and procedural factors that may predispose patients to these complications (see Haeck et al., "Evidence-Based Patient Safety Advisory: Patient Assessment and Prevention of Pulmonary Side Effects in Surgery. Part 2—Patient and Procedural Risk Factors," in this issue).

This patient safety advisory was developed through a comprehensive review of the scientific

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literature and a consensus of the Patient Safety Committee. The supporting literature was critically appraised for study quality according to criteria referenced in key publications on evidence-based medicine.<sup>16–20</sup> Depending on study design and quality, each reference was assigned a corresponding level of evidence (I through V) with the ASPS Evidence Rating Scales (Table 1),<sup>21</sup> and the evidence was synthesized into practice recommendations. The recommendations were then graded (A through D) with the ASPS Grades of Recommendation Scale (Table 2)<sup>22</sup>; grades correspond to the levels of evidence provided by the supporting literature for that recommendation. Practice recommendations are discussed throughout this document, and graded recommendations are summarized in Appendix A.

### DISCLAIMER

Practice advisories are strategies for patient management, developed to assist physicians in clinical decision-making. This practice advisory, based on a thorough evaluation of the present scientific literature and relevant clinical experi-

ence, describes a range of generally acceptable approaches to diagnosis, management, or prevention of specific diseases or conditions. This practice advisory attempts to define principles of practice that should generally meet the needs of most patients in most circumstances. However, this practice advisory should not be construed as a rule, nor should it be deemed inclusive of all proper methods of care or exclusive of other methods of care reasonably directed at obtaining the appropriate results. It is anticipated that it will be necessary to approach some patients' needs in different ways. The ultimate judgment regarding the care of a particular patient must be made by the physician in light of all the circumstances presented by the patient, the diagnostic and treatment options available, and available resources.

This practice advisory is not intended to define or serve as the standard of medical care. Standards of medical care are determined on the basis of all the facts or circumstances involved in an individual case and are subject to change as scientific knowledge and technology advance, and as practice patterns evolve. This practice advisory reflects the state of knowledge current at the time of publication. Given the inevitable changes in the state of scientific information and technology, periodic review and revision will be necessary.

**Table 1. Evidence Rating Scale for Studies Reviewed**

Level of Evidence	Qualifying Studies
I	High-quality, multicentered or single-centered, randomized controlled trial with adequate power; or systematic review of these studies
II	Lesser quality, randomized controlled trial; prospective cohort study; or systematic review of these studies
III	Retrospective comparative study; case-control study; or systematic review of these studies
IV	Case series
V	Expert opinion; case report or clinical example; or evidence based on physiology, bench research, or "first principles"

### OBSTRUCTIVE SLEEP APNEA

Obstructive sleep apnea is characterized by obstruction of the upper airway during sleep, leading to episodes of sleep disordered breathing. The severity of sleep apnea is measured by the apnea/hypopnea index, which is the number of sleep disordered episodes per hour. In adults, the apnea/hypopnea index can range from 6 to 20 in mild cases to over 40 in severe cases. In children, mild cases range from 1 to 5; and severe cases, over 10.<sup>8</sup>

**Table 2. Scale for Grading Recommendations**

Grade	Descriptor	Qualifying Evidence	Implications for Practice
A	Strong recommendation	Level I evidence or consistent findings from multiple studies of levels II, III, or IV	Clinicians should follow a strong recommendation unless a clear and compelling rationale for an alternative approach is present.
B	Recommendation	Levels II, III, or IV evidence and findings are generally consistent	Generally, clinicians should follow a recommendation but should remain alert to new information and sensitive to patient preferences.
C	Option	Levels II, III, or IV evidence, but findings are inconsistent	Clinicians should be flexible in their decision-making regarding appropriate practice, although they may set bounds on alternatives; patient preference should have a substantial influencing role.
D	Option	Level V: Little or no systematic empirical evidence	Clinicians should consider all options in their decision-making and be alert to new published evidence that clarifies the balance of benefit versus harm; patient preference should have a substantial influencing role.

Because apneic/hypopneic events occur during sleep, obstructive sleep apnea can be difficult to diagnose without data from sleep studies and, as such, may be widely underdiagnosed. The condition can often become apparent for the first time in the perioperative setting during induction of anesthesia or at the onset of complications.

Perioperative pulmonary complications can occur in patients with obstructive sleep apnea, even when the surgical procedure is unrelated to the apnea.<sup>7</sup> Obstructive sleep apnea may increase the risk of acute hypercapnia and episodic hypoxemia requiring reintubation; difficult airway; difficult intubation; obstructed airway; respiratory depression after opioid administration; respiratory arrest; and postoperative apneic/hypopneic episodes.<sup>4,7-9</sup> Therefore, it is important for the surgeon and anesthesiologist to be aware of the predisposing factors for obstructive sleep apnea and the potential complications that can arise during surgery.

### Patient Selection

#### Determining Whether a Patient with Obstructive Sleep Apnea Is an Appropriate Candidate for Ambulatory or Office-Based Surgery

The anesthesia provider and surgeon should determine whether the patient is a good candidate for ambulatory or office-based surgery. Several factors must be considered when determining the appropriate surgical setting for these patients: sleep apnea status, anatomical and physiologic abnormalities, status of comorbidities, nature of surgery, type of anesthesia, need for postoperative opioids, patient age, adequacy of postdischarge observation, and capabilities of the outpatient facility. The American Society of Anesthesiologists recommends that only minor procedures under local or regional anesthesia should be performed in freestanding outpatient settings; patients at significantly increased risk of perioperative complications should be referred to a hospital-based facility. If a patient with obstructive sleep apnea can safely undergo ambulatory surgery, the facility should be appropriately equipped to handle potential complications and have transfer arrangements with an inpatient facility.<sup>8</sup>

#### Preoperative Evaluation

Patients presenting for surgery are often unaware that they have sleep apnea; physicians should maintain a high suspicion for the diagnosis, especially when patients have characteristic

signs and symptoms.<sup>23</sup> The preoperative evaluation should include a complete medical history, focusing on obstructive sleep apnea symptoms: history of snoring, sleep disturbances, apparent airway obstruction during sleep, and daytime hypersomnolence. If applicable, patients' sleep partners should be interviewed, as apneic events are often witnessed by others.<sup>8</sup>

A thorough physical examination can identify physical characteristics consistent with sleep apnea. Obesity (body mass index,  $>35 \text{ kg/m}^2$ ) and increased neck circumference (men,  $>17$  inches; women,  $>16$  inches) are often indicative of obstructive sleep apnea.<sup>24</sup> In patients with obesity, obstructive sleep apnea is usually caused by adipose deposition in the pharyngeal tissue, resulting in decreased pharyngeal area; increased pharyngeal resistance; and, potentially, difficult intubation, postextubation complications, and postoperative pharyngeal collapse induced by sedatives and opioids.<sup>25-27</sup> Often, patients with obesity have decreased lung volume and reduced oxygen reserves, which may predispose them to hypoxemia during general anesthesia.<sup>4</sup> Patients with normal body mass index also can have sleep apnea. Craniofacial abnormalities, hypertrophic tonsils, retrusive mandibles, or extraordinarily long uvulas may cause obstructive sleep apnea in these patients.<sup>8,28</sup> If the medical history and physical examination suggest apnea, additional tests may be ordered to identify other indicators of sleep apnea—cardiac arrhythmias, desaturation with hypercapnia, polycythemia, right and left ventricular hypertrophy, and cor pulmonale secondary to pulmonary or systemic hypertension—although polysomnography is the standard for determining a definitive diagnosis.<sup>28</sup>

#### Severity of Obstructive Sleep Apnea

The severity of obstructive sleep apnea may possibly increase the perioperative risks for the patient. However, few reports suggest a strong correlation with severity. In one study, severity was not associated with additional risk of difficult intubation<sup>25</sup> or adverse outcomes,<sup>7</sup> although patients with severe apnea were highly compliant with prescribed medications, and this may have prevented complications.<sup>7</sup> In another study, high oximetry scores, which corresponded to severe apnea, were associated with increased risk of respiratory compromise.<sup>29</sup> However, oximetry by itself can be inconclusive in some patients, and additional diagnostic measures may be necessary.<sup>29</sup>

**Invasiveness and Location of Surgery**

Invasive procedures requiring general anesthesia and postoperative opioids can disrupt sleep patterns and worsen obstructive sleep apnea symptoms. Surgery of the upper airway can exacerbate airway obstruction, and procedures near the diaphragm, upper abdomen, and thorax may compromise ventilatory function. Use of nasal packing or a nasogastric tube may affect pharyngeal pressures, potentially leading to airway collapse.<sup>4,9,30</sup>

Nasal surgery is particularly challenging in patients with obstructive sleep apnea, especially if postoperative nasal packing is required. In patients who use continuous positive airway pressure, nasal packing inhibits the pressure applied through a nasal mask, thereby requiring use of a full face mask.<sup>30</sup> In addition, nasal packing can increase sleep disordered breathing and oxygen desaturation, even in patients without obstructive sleep apnea. Overnight oxygen administration has been shown to prevent oxygen desaturation in patients with apnea who required nasal packing.<sup>31</sup>

**Management**

**Continuous Positive Airway Pressure**

Continuous positive airway pressure is an effective treatment for patients with obstructive sleep apnea.<sup>32-34</sup> It involves the use of a close-fitting nasal or face mask to apply positive airway pressure to the oropharyngeal cavity, thereby preventing collapse of the airway during inspiration. Preoperative and postoperative use of continuous positive airway pressure may minimize or prevent perioperative complications.<sup>7,35</sup> In patients requiring a nasogastric tube, this treatment may be chal-

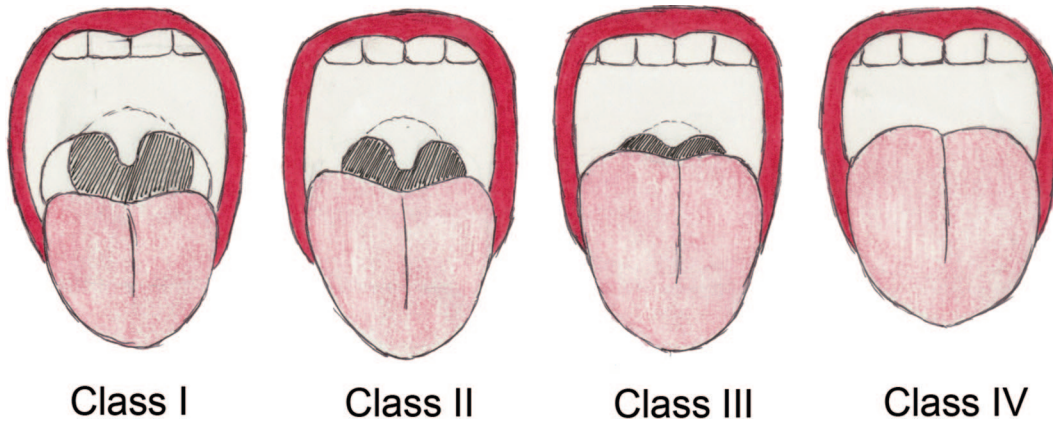
lenging because of potential leakage around the mask and patient discomfort.<sup>30</sup>

Patients who use continuous positive airway pressure preoperatively should bring the equipment with them on the day of surgery. It is important to note that the pressure must be titrated for each patient, and if a patient has not used the equipment before, only experienced physicians and nurses should attempt to administer continuous positive airway pressure postoperatively to ensure proper titration. If a patient has used the equipment before surgery, it is still important that surgical and nursing staff be familiar with the equipment should the patient need assistance.<sup>23</sup>

**Intubation/Extubation**

If a patient with obstructive sleep apnea requires general anesthesia, a hospital-based facility is recommended, as obstructive sleep apnea may increase the patient's risk of airway collapse and difficult intubation.<sup>25,36</sup> Recognizing the potential for difficult airway management preoperatively may avert airway collapse during surgery. Characteristics that can cause difficult intubation, even in patients without apnea, include obesity, facial and airway abnormalities (retrognathia, short and thick neck, large tongue), submandibular (lateral) jowls, often indicative of enlarged pharyngeal fat pads, and dental malocclusion or chin retrusion, potentially masked by chin implants.<sup>25,26,37</sup>

The Mallampati score (Fig. 1)<sup>38</sup> has been used to predict difficult intubation, and a high score has been associated with obstructive sleep apnea.<sup>39</sup> However, as results can be unreliable,<sup>25,27</sup> difficult intubation should be considered a risk for all patients with obstructive sleep apnea, and preventive measures should be used accordingly.



**Fig. 1.** Mallampati classification. *Class I*, soft palate, fauces, uvula, and pillars. *Class II*, soft palate, fauces, and a portion of the uvula. *Class III*, soft palate and base of the uvula. *Class IV*, hard palate only. (Reprinted with permission from T. Euliano, University of Florida.)

The sniffing position (i.e., neck flexion with upper cervical extension) has been shown to improve pharyngeal airway patency during mask ventilation and tracheal intubation.<sup>40</sup> A fiberoptic scope may also help visualize the airway. Local or topical anesthetics may be helpful, although it is unclear whether these drugs can be safely administered to the airway, as topical anesthesia (lidocaine) has been shown to reduce genioglossal activity and increase pharyngeal airflow resistance in patients with obstructive sleep apnea.<sup>41</sup> Paralytic agents used to facilitate intubation should be used cautiously, as desaturation may worsen if muscle paralysis persists. Short-acting, titrated drugs are recommended for these patients.<sup>42</sup> Equipment for managing difficult intubation should be readily available and personnel should be familiar with its use.

Before extubation, full reversal of neuromuscular blocks should be verified and patients should be fully awake with adequate airway muscle tone.<sup>42</sup> Then, extubation should be performed with the patient in a semiupright, lateral, or prone position.<sup>8,42</sup> It is important to note that difficult extubation can occur in patients with even mild obstructive sleep apnea or morbid obesity, and airway obstruction resulting from difficult extubation can subsequently lead to difficult reintubation.

**Sedation, Anesthesia, and Analgesia**

Sedatives, anesthetics, and analgesics should be used with extreme caution in patients with obstructive sleep apnea, as they may cause respiratory depression, inhibit airway muscle activity, and depress pharyngeal muscle tone, further increasing the possibility of airway obstruction or collapse in an already fragile airway (Table 3). Moreover, many of these agents can interfere with the natural arousal response to airway obstruction, which can worsen hypoxia and hypercapnia, leading to respiratory and cardiac arrest and, potentially, death.<sup>42-44</sup> The pa-

tient with obstructive sleep apnea must be monitored continually during the postoperative period and observed in an area equipped to monitor oxygen saturation and administer reversal agents, if needed. Continuous positive airway pressure should be available at all times as well.<sup>30,42,44</sup>

Sedatives are usually not recommended for patients with obstructive sleep apnea because they may cause respiratory depression and reduce the patient’s ability to protect his or her own airway. Although benzodiazepines have been well tolerated in some patients, they can increase apneic events and desaturation.<sup>45-47</sup> Anecdotally, chloral hydrate has been associated with pulmonary adverse events in pediatric patients with obstructive sleep apnea.<sup>48,49</sup>

The option to use local and regional anesthesia is often recommended for patients with obstructive sleep apnea because this precludes the potential adverse effects of sedatives and intubation.<sup>5</sup> However, regional methods are not without risk, as neuroaxial blockade can paralyze respiratory muscles, compounding respiratory problems in patients with obstructive sleep apnea.

If general anesthesia is necessary, the airway should be secured, especially for procedures that may compromise the airway. Although guidance is limited as to which agents are most appropriate for general anesthesia in patients with obstructive sleep apnea, it is recommended that short-acting agents be used and large doses of long-acting adjuvant drugs, such as neuromuscular blocking agents, be avoided.<sup>44</sup>

Opioids can increase the risk of complications for patients with obstructive sleep apnea,<sup>43,50</sup> and have been reported to increase respiratory depression and lead to apneic events.<sup>50</sup> Delayed effects of epidural opioids have also been known to result in later respiratory arrest.<sup>43</sup> It may be advisable to avoid patient-controlled analgesia and epidural

**Table 3. Continuum of Depth of Sedation: Definition of General Anesthesia and Levels of Sedation/Analgesia\***

	Minimal Sedation (anxiolysis)	Moderate Sedation/Analgesia (conscious sedation)	Deep Sedation/Analgesia	General Anesthesia
Responsiveness†	Normal response to verbal stimulation	Purposeful response to verbal or tactile stimulation	Purposeful response following repeated or painful stimulation	Unarousable even with painful stimulus
Airway	Unaffected	No intervention required	Intervention may be required	Intervention often required
Spontaneous ventilation	Unaffected	Adequate	May be inadequate	Frequently inadequate
Cardiovascular function	Unaffected	Usually maintained	Usually maintained	May be impaired

\*Source: <http://www.asahq.org>.

†Reflex withdrawal from a painful stimulus is not considered a purposeful response.

opioids unless other options (e.g., nonsteroidal antiinflammatory drugs or regional anesthesia with local anesthetics) are unavailable or inappropriate for the particular procedure. If narcotic-based pain control is unavoidable, the agents should be titrated carefully to allow for adequate pain control without compromising the airway or respiratory function. Alternative nonnarcotic medications, such as Toradol (Roche Pharmaceuticals, Nutley, N.J.) and gabapentin, can be considered after weighing their potential side effects.

### Postoperative Monitoring

The postoperative period is a critical time for patients with obstructive sleep apnea, especially when sedatives, anesthetics, and analgesics have been administered. Because these agents depress respiration and can block the arousal response for several hours after surgery, oxygenation and ventilation should be monitored closely; pulse oximetry and capnography are strongly recommended during the postoperative period. The American Society of Anesthesiologists recommends monitoring these patients longer than their nonobstructive sleep apnea counterparts. If an episode of airway obstruction or hypoxemia occurs, additional monitoring of these patients should be performed after the last episode while breathing room air in an unstimulated environment.<sup>8</sup> If satisfactory levels of oxygenation cannot be achieved, transfer arrangements should be made for further monitoring in an inpatient setting.

## OBSTRUCTIVE LUNG DISEASE

Asthma and chronic obstructive pulmonary disease are often considered to be risk factors for perioperative pulmonary complications.<sup>10–15</sup> Asthma is characterized by reversible airway obstruction resulting from smooth muscle spasm, mucosal edema, and excessive mucus production. Chronic obstructive pulmonary disease, which is often associated with chronic bronchitis and emphysema, is characterized by temporary or permanent narrowing of the airways. Asthma and chronic obstructive pulmonary disease are considered separate diseases, yet both are associated with airway obstruction and bronchial hyperreactivity and often require similar perioperative management. The actual incidence of perioperative pulmonary complications in these patient populations varies, which some authors suggest may be a result of inconsistent definitions of asthma, chronic obstructive pulmonary disease, and what qualifies as a pulmonary complication.<sup>3,15</sup> Despite the variability, the most commonly reported peri-

operative pulmonary complication for patients with obstructive lung diseases is perioperative bronchoconstriction, which can lead to life-threatening bronchospasm.

### Patient Selection

#### Preoperative Evaluation

Although patients with well-controlled disease can safely undergo surgery, patients who are symptomatic may be at greater risk of perioperative pulmonary complications. Patients should be asked about recent symptoms, including whether the symptoms required use of rescue medications and/or treatment in a medical facility.<sup>51,52</sup> The physical examination should include chest auscultation to assess lung function. Patients should also be asked about their smoking history.

#### Pulmonary Function

Preoperative pulmonary function tests and chest radiographs may be helpful for assessing and optimizing the patient's lung function<sup>53–56</sup> or identifying problems when there is uncertainty about the patient's lung status.<sup>12</sup> However, these are not recommended for all patients with obstructive lung disease, as results may not be predictive of perioperative pulmonary complications.<sup>10,12,13,53,54,57,58</sup> Ultimately, the decision to order pulmonary function tests should be based on findings from the medical history and physical examination, which are the most important components of the preoperative evaluation.<sup>13</sup>

### Management

#### Intubation/Extubation

Patients with obstructive lung disease often have bronchial hyperreactivity and increased sensitivity to airway irritation associated with endotracheal intubation. As such, patients may be at increased risk of intraoperative bronchospasm.<sup>59–62</sup> The incidence of intraoperative bronchospasm may be related to the degree of bronchial reactivity, as patients with impaired lung function but no bronchial reactivity have been shown to safely tolerate endotracheal intubation.<sup>63</sup>

When endotracheal intubation is required, preoperative prophylaxis may reduce the risk of intubation-induced airway response. Inhaled  $\beta_2$ -adrenergic agonists may protect against reflex bronchoconstriction, either during awake intubation or under general anesthesia.<sup>60,64,65</sup> Preoperative administration of corticosteroids, alone or in combination with  $\beta_2$  agonists, may be beneficial, although it is unclear whether corticosteroid therapy is necessary for all patients with asthma or

chronic obstructive pulmonary disease.<sup>65,66</sup> The decision to administer corticosteroids should depend on the patient's pulmonary function and the type of surgery.<sup>57</sup> Patients already receiving steroid therapy should continue therapy perioperatively. Asthma patients who have used corticosteroids in the previous 6 months may need intraoperative steroids up to every 8 hours postoperatively, depending on the severity of their condition and the extensiveness of the procedure. The dose should be reduced rapidly within 24 hours after surgery.<sup>55</sup>

Lidocaine has been studied as a prophylactic agent in patients with bronchial hyperreactivity; however, results are inconclusive and appear to vary depending on the route of administration. Inhaled lidocaine can cause some airway irritation, but may be effective at reducing intubation-induced bronchoconstriction, especially when administered in combination with a  $\beta_2$  agonist, such as salbutamol.<sup>59,64</sup> By contrast, intravenous lidocaine administered during general anesthesia may be less effective at preventing intubation-induced bronchoconstriction.<sup>60</sup> When feasible, extubation should be performed under deep anesthesia to prevent bronchospasm.<sup>67</sup>

#### Anesthesia and Analgesia

Volatile anesthetics have bronchodilatory properties and are often recommended for patients with asthma or chronic obstructive pulmonary disease (Table 3). Halothane and sevoflurane, the preferred volatile anesthetics, can prevent bronchoconstriction and effectively treat bronchospasm<sup>54</sup>; however, desflurane and sodium thiopental have been found to be ineffective bronchodilators,<sup>68</sup> and some investigators suggest that they should be contraindicated in patients with obstructive lung diseases.<sup>54,57</sup> Propofol (without metabisulfate preservative<sup>69</sup>), the preferred intravenous induction agent, generally does not cause bronchospasm.<sup>54,70</sup>

Regional anesthesia is often recommended over general anesthesia to avoid the need for oral airway management; however, there is little evidence indicating that regional anesthesia contributes to fewer perioperative pulmonary complications.<sup>53</sup> It is important to note that certain forms of regional anesthesia (e.g., epidural) may be problematic in patients with severe chronic obstructive pulmonary disease or asthma. Respiratory motor blockade that paralyzes accessory breathing muscles (e.g., abdominal) can inhibit spontaneous breathing, and pulmonary sympathetic blockade increases bronchial tone and reactivity.<sup>53,62</sup> Despite these risks, some evidence suggests that regional anesthesia by these

methods is safe for patients with obstructive lung disease. In one study, high thoracic segmental epidural anesthesia with ropivacaine or bupivacaine was well-tolerated by women with severe chronic obstructive pulmonary disease who had elective breast surgery.<sup>62</sup>

Anesthetics, analgesics, and muscle relaxants with histamine-releasing properties (e.g., thiopental, meperidine, morphine, atracurium, mivacurium, and succinylcholine) are also problematic in patients with reactive airways, as are agents used for reversal of muscle relaxation, which can cause bradycardia, increased secretion, and increased bronchial tone and reactivity.<sup>54,67</sup>

Opioids, when injected slowly, are usually well tolerated by patients with asthma.<sup>54</sup> In patients with aspirin-induced asthma, fentanyl may be the most appropriate analgesic.<sup>67</sup>

#### Other Procedure-Related Concerns

If the type of surgery will require ischemic preconditioning of flap tissue, it is important to note that adenosine-induced bronchospasm has been reported in patients with obstructive lung disease.<sup>71</sup>

## CONCLUSIONS

Pulmonary complications can occur in all surgical settings. As the demand for surgery increases, so does the need for guidelines regarding patient selection and perioperative management. Although most studies report on pulmonary complications in hospital-based settings, the evidence has shed light on risk factors for perioperative pulmonary complications and strategies that can reduce these risks, even in ambulatory settings. Among these risk factors are comorbidities including obstructive sleep apnea and obstructive lung disease. A complete preoperative evaluation is an important component of patient selection and allows for a full assessment of the patient's health status. Understanding the patient's risk level with regard to these conditions and the risks associated with the procedure will help determine the most appropriate surgical setting. A successful operative plan is one that incorporates risk assessment, risk reduction strategies, and appropriate treatment methods, should complications occur.

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**Appendix A. Summary of Recommendations for Preventing Perioperative Pulmonary Complications in Plastic Surgery**

Recommendations	Supporting Evidence	Grade
<b>OBSTRUCTIVE SLEEP APNEA</b>		
Patient selection		
<ul style="list-style-type: none"> <li>For patients without previous diagnosis of OSA, inquire about the following symptoms: airway obstruction during sleep; loud and frequent snoring; frequent arousal from sleep, especially with choking sensation; daytime somnolence or fatigue; falling asleep in nonstimulating environments (e.g., watching television, reading, driving); it may also be helpful to interview family members, as they may have witnessed some of the symptoms (e.g., apneic events, restless sleep, vocalizations).</li> </ul>	Expert opinion	D
<ul style="list-style-type: none"> <li>For patients with suspected OSA, the surgeon and anesthesia provider may decide to refer the patient for additional tests (e.g., sleep studies, more extensive airway assessment) and OSA treatment before surgery.</li> </ul>		
<ul style="list-style-type: none"> <li>The physical examination should include an evaluation of the airway, nasopharyngeal characteristics, tonsil and tongue size, neck circumference, and BMI.</li> </ul>	39, 72	B
Surgical setting		
<ul style="list-style-type: none"> <li>Only minor procedures under local or regional anesthesia should be performed in a freestanding ambulatory or office-based settings.</li> <li>Much consideration should be given to factors such as sleep apnea status, anatomical and physiologic abnormalities, status of comorbidities, nature of surgery, type of anesthesia, need for postoperative opioids, patient age, adequacy of postdischarge observation, and capabilities of the outpatient facility.</li> <li>The ASA believes that patients at significantly increased risk of perioperative complications generally are not appropriate candidates for procedures in freestanding outpatient settings.</li> <li>If it is determined that a patient with OSA can safely undergo ambulatory surgery, the facility should be appropriately equipped to handle potential complications and have transfer arrangements with an inpatient facility.</li> </ul>	Expert opinion	D
Preoperative		
<ul style="list-style-type: none"> <li>CPAP has been shown to be effective at treating OSA; preoperative CPAP may be beneficial, especially in patients who are already using home CPAP.</li> </ul>	7, 35, 32, 33, 73	A, B
<ul style="list-style-type: none"> <li>If premedication, such as benzodiazepines, will be administered, patients must be monitored continuously for any signs of respiratory compromise; CPAP should be available for use if the patient becomes sleepy and cannot control his or her own airway.</li> </ul>	7, 35, 45, 47	B

(Continued)

**Appendix A. (Continued)**

Recommendations	Supporting Evidence	Grade
<b>Intraoperative</b>		
<ul style="list-style-type: none"> <li>● If possible, consider local or regional anesthesia.</li> </ul>	Expert opinion	D
<ul style="list-style-type: none"> <li>● If sedatives will be used, ventilation should be monitored by capnography.</li> </ul>	7, 35	B
<ul style="list-style-type: none"> <li>● Patients who have been using CPAP preoperatively may benefit from its continued use during sedation.</li> </ul>		
<ul style="list-style-type: none"> <li>● If general anesthesia is necessary, it is important to secure the airway, especially for procedures that may compromise the airway; consider short-acting drugs; avoid large doses of long-acting drugs, such as neuromuscular blockers.</li> </ul>	Expert opinion	D
<ul style="list-style-type: none"> <li>● If endotracheal intubation is necessary, consider intubating in the sniffing position under fiberoptic scope.</li> </ul>	40	D*
<ul style="list-style-type: none"> <li>● Time to extubate should be based on severity of OSA, surgical site, cardiopulmonary comorbidities, difficult intubation, and intraoperative course; if possible, extubate in semiupright, lateral, or prone position when patient is fully awake with adequate airway muscle tone.</li> </ul>	Expert opinion	D
<b>Postoperative</b>		
<ul style="list-style-type: none"> <li>● If possible, systemic opioids should be avoided; other options, such as local or regional anesthetics and analgesics, a pain pump, nonsteroidal antiinflammatory drugs, or ice, should be considered to avoid use of opioids.</li> </ul>	50	D*
<ul style="list-style-type: none"> <li>● For patients at increased perioperative risk from OSA, consider administering continuous supplemental oxygen.</li> </ul>	Expert opinion	D
<ul style="list-style-type: none"> <li>● If patient experiences recurrent hypoxemia, consider treatment with CPAP and supplemental oxygen.</li> </ul>	7, 35	B
<ul style="list-style-type: none"> <li>● If patient used CPAP preoperatively, resume CPAP when patient is awake and alert.</li> </ul>		
<ul style="list-style-type: none"> <li>● Monitor patients longer than non-OSA counterparts; if an episode of airway obstruction or hypoxemia occurs, patients should be continually monitored after the last episode while breathing room air in unstimulated environment; if the patient is in an ambulatory setting, transfer arrangements to an inpatient facility should be made for further monitoring.</li> </ul>	Expert opinion	D
<b>OBSTRUCTIVE LUNG DISEASE</b>		
<b>Patient selection</b>		
<ul style="list-style-type: none"> <li>● The medical history should include questions about current symptoms (e.g., cough, dyspnea, wheezing) and frequency of symptoms; intensity of treatment (did patient require therapy at a medical facility?); current medications; recent use of rescue medications; tolerance to aspirin, cold air, dust, or smoke; smoking history; and previous exposures to general anesthesia and endotracheal intubation.</li> </ul>	53	D†
<ul style="list-style-type: none"> <li>● A complete physical examination should be performed, including chest auscultation, assessment of skin coloration, and chest radiography when indicated.</li> </ul>		
<ul style="list-style-type: none"> <li>● Patients should be free of symptoms and have optimal lung function. If a patient presents with symptoms, elective surgery should be postponed, if possible, pending resolution of symptoms.</li> </ul>		
<ul style="list-style-type: none"> <li>● Patients with severe or uncontrolled disease, or those in which pulmonary status is uncertain, should be referred to a pulmonologist for assessment of pulmonary function.</li> </ul>		
<ul style="list-style-type: none"> <li>● If patients have been on steroid therapy during the past 6 mo before surgery, additional steroid support may be necessary.</li> </ul>		
<b>Preoperative</b>		
<ul style="list-style-type: none"> <li>● If endotracheal intubation is required, consider preoperative prophylaxis (corticosteroids, topical lidocaine, <math>\beta_2</math>-adrenergic agonists).</li> </ul>	59, 60, 64, 65	A
<ul style="list-style-type: none"> <li>● Consider preoperative sedation with benzodiazepines.</li> </ul>	Expert opinion	D
<b>Intraoperative</b>		
<ul style="list-style-type: none"> <li>● If possible, consider regional anesthesia over general anesthesia.</li> </ul>	62	D†
<ul style="list-style-type: none"> <li>● If general anesthesia is required, consider the volatile anesthetics, halothane and sevoflurane, or intravenous propofol.</li> </ul>	68–70	A
<ul style="list-style-type: none"> <li>● Avoid anesthetics and muscle relaxants with histamine-releasing properties (e.g., thiopental, atracurium, mivacurium, succinylcholine).</li> </ul>	67	D†
<ul style="list-style-type: none"> <li>● If endotracheal intubation is necessary, consider extubating under deep anesthesia.</li> </ul>	67	D†

(Continued)

**Appendix A. (Continued)**

Recommendations	Supporting Evidence	Grade
Treatment of intraoperative bronchospasm <ul style="list-style-type: none"> <li>● If intraoperative bronchospasm is suspected, it is important to first rule out alternative diagnoses (e.g., mechanical obstructions, pneumothorax, pulmonary edema).</li> <li>● If the diagnosis of intraoperative bronchospasm is confirmed, initial treatment includes deepening of anesthesia.</li> <li>● For persistent bronchospasm, additional options for treatment include administration of <math>\beta_2</math>-adrenergic agonists, parasympatholytics, systemic corticosteroids, magnesium, and lidocaine.</li> </ul>	Expert opinion	D
Postoperative <ul style="list-style-type: none"> <li>● Avoid analgesics with histamine-releasing properties (e.g., meperidine, morphine).</li> <li>● Consider the use of lung expansion maneuvers.</li> </ul>	67 Expert opinion	D† D

OSA, obstructive sleep apnea; BMI, body mass index; ASA, American Society of Anesthesiologists; CPAP, continuous positive airway pressure.

\*Evidence composed of only one level III or IV study; more than one study would be needed to assign a higher grade of recommendation.

†Evidence composed of only one level II, III, or IV study; more than one study would be needed to assign a higher grade of recommendation.