Patients who are obese present significant anesthetic and surgical challenges, however, the weight loss expected following bariatric procedures often is lifesaving. With weight loss, these patients can experience a correction of many physiologic changes associated with obesity, including retention of CO₂, apnea events, chronic hypoxia, reduced lung volume and capacity, and polycythemia.¹

Bariatric Surgery

It is often stated that the expected mortality rate of patients undergoing bariatric surgery is 0.5%.² However, a recent study that stratified patients based on their preoperative medical evaluation reported higher mortality figures for some, compared with low-risk patients who experience a 0.2% mortality rate. These high-risk patients may experience a risk for mortality during surgery of as much as 1.44%—a 12-fold increase over the average figure.

The following 5 factors are believed to increase the risk for death in patients undergoing bariatric surgery: male sex; age greater than 45 years; body mass index (BMI) of 50 or greater; history of hypertension; or risk factors for venous thrombosis, including history of pulmonary embolism, venous thrombosis or ulcers, inferior vena cava filter, or obesity hypoventilation syndrome.²

The risks for bariatric surgery cannot be taken lightly; even patients classified as low risk must meet certain criteria to become eligible for surgery. Most bariatric surgeons require prospective patients to follow a conservative diet, as well as undergo exercise and medical therapy, under the supervision of a specialized physician. Weight loss of less than 5% to 10% of baseline, or the lack of improvement in comorbidities after 6 months, is considered a failure of treatment.³

There are 2 categories of surgical procedures for weight loss, malabsorptive and restrictive. Malabsorptive procedures, including jejunooileal bypass and biliopancreatic bypass, are rarely used. Vertical banded gastroplasty, gastric banding, and Roux-en-Y gastric bypass (RYGB) are restrictive procedures that are performed more frequently than bypass techniques, and may be conducted laparoscopically. RYGB also...
introduces an element of malabsorption and is the most commonly performed procedure of this type in the United States.\(^5\) In RYGB, a proximal gastric pouch is anastomosed to a segment of the jejunum, bypassing most of the stomach and the duodenum. In the first 1 to 2 years post-surgery, patients typically reduce their BMI by 10 kg/m\(^2\).

**Obesity: Definition and Anesthetic Concerns**

Obesity is defined as an excess of adipose tissue that contributes to the deterioration or impairment of health. Although BMI is used to give a generic definition to obesity, the World Health Organization ties the various levels of BMI to health risk (Table 1).\(^4\)

**Comorbidities**

Several respiratory and cardiovascular findings characterize the patient who is morbidly obese. The severity of these conditions increases with the duration and degree of obesity. Cardiac output and blood volume are increased; left ventricular hypertrophy and, eventually, dilatation occur. An increase in heart rate results in increased oxygen consumption, decreased diastolic filling time, ischemia, and diastolic dysfunction. Pulmonary hypertension results in right ventricular dysfunction. Common cardiac valvular lesions include tricuspid regurgitation. Insulin resistance, dyslipidemia, and a heightened inflammatory response (metabolic syndrome) exacerbate cardiovascular morbidity.\(^4\)

Changes in the respiratory system include progressive decreases in tidal volume, functional residual capacity (FRC), and vital capacity; increased airway resistance; ventilation/perfusion mismatch; and more.\(^4\) Some patients will benefit from 3 or more months of continuous positive airway pressure (CPAP) therapy before presenting for surgery.

As a result of these mechanical and physiologic changes, the obese patient is prone to oxyhemoglobin desaturation at the induction of anesthesia. The reduction in FRC diminishes the patient’s oxygen reserve during apnea. When the patient is placed in a supine position, these volumes are more profoundly reduced by the weight of the abdominal wall pushing the abdominal contents against the diaphragm. Similarly, the mass of the chest wall contributes to this reduction. In both lean and obese patients, the induction of anesthesia reduces FRC further (20% in lean patients, 50% in obese patients). These changes complicate an already increased intrapulmonary shunt in obese patients (20%) compared to a 2% to 5% shunt fraction in lean patients.\(^5\)

**Upper Airway Obstruction**

Obesity is the single most frequent cause of obstructive sleep apnea (OSA) in the United States. The deposition of adipose in the soft tissues of the extrathoracic airway compromises its intrinsic regulatory and structural function that normally prevents obstruction during tidal breathing. Descent of the diaphragm and lifting of the chest wall (intercostal muscles) produces negative intrathoracic pressure that is responsible for inspiratory air flow. This negative pressure is transferred (via the tracheal-bronchial tree and larynx) to the extrathoracic, non-skeletal-supported airway. Bernoulli’s principle dictates that as air flow begins, the outward force exerted on the walls of the airway diminishes, causing the soft tissues to be pulled into the lumen. In the normal patient, phasic muscular contraction prevents airway obstruction; the tensor veli palatini tightens the soft palate, the genioglossus pulls the tongue forward, and the epiglottis is pulled upward by its attachments to the hyoid bone. In the lean normal patient, this sequence maintains the airway patency during waking hours and in sleep when pharyngeal-hypopharyngeal muscles relax. With age, the effectiveness of this system is diminished. Deposition of adipose in the pharyngeal tissues likewise compromises this system by narrowing the airway lumen. As the airway progressively narrows, Bernoulli’s principle causes a complete cessation of air flow; this, in turn, allows the side-wall force to once again increase, opening the airway and allowing air flow. The result of this cyclic pattern is snoring. Eventually, the narrowing becomes so severe that during normal sleep, the obstruction is irreversible until the patient is aroused by the ensuing hypoxia and hypercapnia.

In the operating room, sedative-hypnotics reproduce the effect of sleep with one notable difference—resolution of airway depression is dependent on the obesity-altered pharmacokinetics of the administered agents. Once iatrogenic obstruction occurs, the anesthesiologist cannot rely on patient arousal to remedy the situation, and the airway will need to be supported.

**Airway Management Issues**

Most often, both tracheal intubation and face mask ventilation are problematic in the morbidly obese patient. The patient with a BMI of 35 or greater has a risk for difficult direct laryngoscopy as much as 6-fold.
higher than that of the general population. Although the finding of a Samsoon and Young score of III or IV may be more predictive, routine airway evaluation in the obese patient has a predictive power similar to that when used in a lean population.

An additional predictor of difficult direct laryngoscopy is neck circumference. Brodsky et al found that the odds for a problematic laryngoscopy increased by 1.13 for each 1 cm of neck circumference over 40 cm. Recent studies have evaluated the physical indicators of difficult mask ventilation by direct laryngoscopy in the morbidly obese patient; both increased BMI and a history of snoring or OSA increase the likelihood of difficult ventilation with a face mask. The newer supraglottic airways (SGAs) may be used successfully in ventilating patients who fail or are expected to fail face mask ventilation. Brimacombe has employed the ProSeal laryngeal mask airway (LMA North America) as a primary ventilatory device prior to tracheal intubation in patients with BMI as high as 60 kg/m².

**Aspiration Risk**

In 1975, Vaughn et al reported that the gastric fluid of obese patients who had fasted was of significantly greater volume—and of lower pH—than that of lean patients. Since then, clinicians have perceived obese patients to be at particularly high risk for aspiration. As a result, these patients frequently undergo rapid sequence induction (RSI) of anesthesia. Although RSI itself does not lead to greater morbidity, airway failure during RSI in this population can be devastating. However, Juvin et al showed that larger patients (BMI >45) had similar pH and the same gastric volume as lean patients (26 mL). In 1999, one group found a higher volume of acidic gastric fluid in leaner patients (BMI <30), completely the reverse of previous concerns.

**Altered Drug Metabolism**

Significant obesity alters the pharmacokinetics of most lipophilic drugs; barbiturates and benzodiazepines show an increased volume of distribution in heavier patients. Agents such as remifentanil (Ultiva, Abbott Laboratories) are exceptions to this rule; their volume of distribution is based on lean body mass. The dosing of moderately lipophilic drugs, such as non-depolarizing muscle relaxants, should also be based on lean body mass, which in the obese patient may be 10% to 20% greater than the ideal body weight. Induction dosing of propofol should be based on ideal body weight, whereas succinylcholine and fentanyl should be dosed according to total body weight.

**Decision Making**

The Airway Approach Algorithm (AAA) describes a preoperative decision-tree approach for planning the management of the airway. The AAA starts with considering the feasibility of avoiding airway manipulation—that is, proceeding with regional or general anesthesia, which is not practicable for bariatric surgery. The clinician moves on to the evaluation of the airway (discussed previously); if the clinician believes there will be no difficulty with direct laryngoscopy, general anesthesia is then considered. The clinician who is skilled with videolaryngoscopy can apply the same concepts. However, if preoperative evaluation spells difficult laryngoscopy, the clinician should consider the feasibility of mask or SGA rescue. If this also appears potentially difficult, then aware intubation* (AI) may be the most prudent course. If the clinician judges that mask or SGA ventilation will be possible, the aspiration risk—a positive risk that again suggests AI—is assessed. Lastly, the risk of oxyhemoglobin desaturation is considered; if the comorbidities and level of obesity indicate that a period of apnea will result in uncorrectable oxyhemoglobin desaturation, AI again is suggested.

The preceding discussion can be summarized as follows: If objective and subjective evaluation casts doubt

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Table 1. Increasing BMI Is Linked to Greater Risk for Comorbid Disorders

<table>
<thead>
<tr>
<th>BMI, kg/m²</th>
<th>WHO Risk for Comorbidities</th>
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</thead>
<tbody>
<tr>
<td>18-24.9</td>
<td>Average</td>
</tr>
<tr>
<td>25-29.9</td>
<td>Increased</td>
</tr>
<tr>
<td>30-34.9</td>
<td>Moderate</td>
</tr>
<tr>
<td>35-39.9</td>
<td>Severe</td>
</tr>
<tr>
<td>≥40</td>
<td>Very severe</td>
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</tbody>
</table>

BMI, body mass index; WHO, World Health Organization

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* "Aware intubation" is the preferred terminology by the author to indicate a state where the intubation does not occur under general anesthesia.

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Figure 1.

Morbid obesity may limit airway management options. In cases such as the patient pictured, surgical access to the airway (whether it is planned or a rescue procedure) would not be an option. This should be considered during the preoperative management planning process.
on the clinician’s ability to intubate and ventilate successfully, safely and with a margin of error, then AI needs to be undertaken.

Airway Management During Bariatric Procedures

The preceding considerations come to bear on the anesthetic plan as soon as the patient is scheduled for surgery. One advantage of same day–admit surgical services is the opportunity for the anesthesiologist to examine these patients prior to admission. Cardiac, pulmonary, and other evaluations may be scheduled if deemed necessary; if so, surgery could be delayed in order to institute therapies. For example, if the patient has poor or untreated OSA, a 3-month period of CPAP can optimize the pulmonary status and reverse aspects of the metabolic syndrome. Often, patients will present suggestive symptoms without a diagnosis of OSA (Table 2).

On the day of surgery, the bariatric patient will need special planning as the anesthesiologist administers airway-related care (Figure).

Make an airway plan/evaluate for OSA

The AAA can be used to decide which pathway of the American Society of Anesthesiologists’ Difficult Airway Algorithm—induction after the onset of anesthesia or AI—will be followed. If AI is chosen, an I.V. desiccant, such as glycopyrrolate, should be administered early in the procedure. Although these drugs can be given intramuscularly, doing so may be difficult in the morbidly obese patient. If OSA is suspected, specialized equipment, such as ProSeal LMA or CPAP, should be available in the recovery room.

Sedation

Many anesthesiologists prefer to administer sedative agents in order to alleviate anxiety in patients before transporting them to the operating room. For obese patients, supplemental oxygen (nasal cannula) should be applied, and continuous monitoring of oxygen saturation should be instituted. A qualified clinician should also be in the immediate area of the patient at all times.

Positioning

Collins et al described the “ramped” position for the morbidly obese patient; the patient is positioned so that the external auditory canal is on the same horizontal plane as the sternal notch. This position facilitates both direct laryngoscopy and mask ventilation.

Induction

As discussed previously, the anesthesiologist must be aware of the altered pharmacokinetics of obese patients to avoid both underdosing and overdosing. Underdosing during induction may result in nonoptimized conditions for airway management. Overdosing may result in prolonged apnea should the airway prove difficult to secure. In the author’s practice, thiopental (Pentothal, Hospira/Abbott Laboratories) is the preferred induction agent in patients for whom airway management is a concern. Thiopental, when given as a stand-alone induction agent, allows for faster immediate emergence if difficulties in securing the airway arise.

Table 2. Symptoms Suggestive of Obstructive Sleep Apnea

<table>
<thead>
<tr>
<th>Physical attributes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI &gt;35 kg/m²</td>
<td></td>
</tr>
<tr>
<td>Neck circumference 17-in male; 16-in female</td>
<td></td>
</tr>
<tr>
<td>Craniofacial abnormalities/nasal obstruction</td>
<td></td>
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<tr>
<td>Tonsils near touching</td>
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<table>
<thead>
<tr>
<th>Sleep-related findings</th>
<th></th>
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<tbody>
<tr>
<td>Snoring or hypoapnea</td>
<td></td>
</tr>
<tr>
<td>Sleep arousal/vocalizations</td>
<td></td>
</tr>
<tr>
<td>Restlessness/choking</td>
<td></td>
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<table>
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<tr>
<th>Daytime findings</th>
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<tbody>
<tr>
<td>Somnolence</td>
<td></td>
</tr>
<tr>
<td>Napping (unintentional)</td>
<td></td>
</tr>
</tbody>
</table>

BMI, body mass index

OSA, obstructive sleep apnea

Figure 2. Special planning is needed for bariatric surgery.
Inhalation induction often is a poor alternative for the patient with OSA. As the pharyngeal-hypopharyngeal tissues relax, obstruction is more likely to occur. Although inhalation induction often is chosen for the patient with a potentially difficult airway, the mechanics of OSA make it relatively contraindicated for this approach.

**Airway control.** Because of increased incidences of difficult tracheal intubation (by direct laryngoscopy) and mask ventilation in the obese patient, alternative devices should be readied. Ensuring the immediate availability of a video laryngoscope and an SGA is a wise preemptive action. More importantly, the devices available should be familiar to the anesthesiologist, as applying a new technique on a lost airway with a little reserve is ill advised. The clinician who cares for an at-risk population should first acquire resuscitation skills in nonurgent settings.

**Emergence and extubation.** During the induction of anesthesia, control of ventilation is managed by the anesthesiologist in a prescribed fashion. At emergence and extubation, that control is relinquished to the patient; the clinician should make sure the patient is prepared for this eventuality. Residual inhaled anesthetics or injected agents, including narcotic analgesics, may exacerbate baseline airway obstruction. Likewise, residual neuromuscular blockade may not be fully appreciated. Murphy et al determined that complete reversal of blockade rarely occurred at the time of tracheal extubation, despite clinical assessment to the contrary. Use of reversal agents and ensuring adequate patient wakefulness should be practiced. If any difficulties with the airway were found at induction, the anesthesiologist should consider the use of a hollow tracheal tube exchange catheter, which can be used for oxygen insufflation or Seldinger-like reintubation should the patient fail an extubation trial.

**Postoperative period.** The risk of airway obstruction continues in the postoperative period. As the postanesthesia care unit staff administers analgesics agents, the obese and OSA patient may require special attention to maintain safety. Opioid analgesics are administered judiciously. Non-narcotic agents, including tramadol and nonsteroidal anti-inflammatory drugs, may be a better first-line choice. Lateral, prone, and head-up positions reduce hypopnea events. Continuous pulse-oximetry must be maintained, even after patients leave the recovery room and as long as they are receiving opioids. For patients with moderate to severe OSA, monitoring should be continued until they are free of desaturation events for at least 7 hours.

**Conclusion**

Airway-related care of the bariatric patient is not specialized. Therefore, the principles and procedures above are applicable to any number of patient groups. The bariatric patient has few unique pathologies; basic principles apply, but often with a narrowed margin for error. An expectant approach to the possibilities of airway failure at induction or emergence, poor apnea reserve, and altered drug metabolism is needed.

**References**