Introduction

According to the World Health Organization, in 2008 there were: 1-1.5 billion overweight adults, 300 million obese adults, and 365,000 obesity-related deaths. There are 26 million procedures each year with some form of anesthesia. There are 150,000 bariatric surgery procedures, and 15 million candidates have a BMI > 40. Obesity is becoming more commonplace.

This is a guideline for anesthetic management, perioperative care, and pain management in weight loss surgery and other surgery involving bariatric patients. These guidelines are intended for consideration only and must always be tailored to the specific anesthetic needs of the patient based on clinical judgment.

I. Types of Obesity

Android obesity is characterized by truncal fat distribution. It is associated with increased oxygen consumption (VO₂), higher glucose levels, and a higher incidence of cardiovascular disease.

Gynecoid obesity is characterized by buttock and thigh fat distribution and it is less frequently associated with cardiovascular disease.
II. Definitions: Overweight and Body Mass Index (BMI)

\[ BMI = \frac{weight(kg)}{height(m)^2} \]

<table>
<thead>
<tr>
<th>Category</th>
<th>BMI Range</th>
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<tbody>
<tr>
<td>Normal</td>
<td>22-25 kg/m²</td>
</tr>
<tr>
<td>Overweight</td>
<td>25-29.9 kg/m²</td>
</tr>
<tr>
<td>Obesity</td>
<td>30-34.9 kg/m²</td>
</tr>
<tr>
<td>Morbid Obesity</td>
<td>&gt;35-39.9 kg/m²</td>
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<tr>
<td>Superobesity</td>
<td>&gt;40-50 kg/m²</td>
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Morbid obesity is an absolute BMI more than 40 kg/m² or BMI more than 35 kg/m² in combination with life-threatening comorbidities. Obesity-related comorbidities sharply increase surgical risk. These issues should be addressed to reduce perioperative morbidity.

III. Preoperative Assessment

A. Respiratory Considerations

The bariatric patient is especially prone to pulmonary complications. They exhibit a restrictive lung pattern due to increased chest wall mass and increased pulmonary blood volume.

The most common physiologic changes are:

1. Increased chest wall and abdominal mass
2. Abnormal diaphragm position
3. Increased work of breathing
4. Decreased chest wall compliance
5. Decreased functional residual capacity (FRC), particularly in the prone position, vital capacity (VC), and total lung capacity (TLC)
6. Increased VO₂ and CO₂ production
7. Increased upper airway resistance

As a result of these changes, obesity-related atelectasis is more common. The effectiveness of preoxygenation is reduced secondary to the reduced FRC and respiratory system compliance. Rapid and profound atelectasis with subsequent intrapulmonary shunting will result in severe hypoxemia after induction of general anesthesia.

B. Obesity Hypoventilation Syndrome

Obesity hypoventilation syndrome can significantly increase morbidity associated with anesthesia. The patient should be evaluated for hypersomnolence, hypercapnia, hypoxemia, pulmonary hypertension, right ventricular enlargement and right heart failure, polycythemia, and biventricular failure.
C. Obstructive Sleep Apnea (OSA)

Undiagnosed obstructive sleep apnea (OSA) is common (up to 70%) in severely obese patients. Ideally, bariatric patients should be evaluated with overnight polysomnography prior to elective general anesthesia.

Associated symptoms and signs of OSA include: snoring, systemic and pulmonary hypertension, nocturnal angina, sleep-related cardiac dysrhythmias, gastroesophageal reflux disease, insomnia, polycythemia, and daytime somnolence. Anesthetic agents can exaggerate the upper airway obstruction in patients with sleep apnea due to reduced tone of the pharyngeal musculature that acts to maintain airway patency. The ventilatory responses to hypercapnia and hypoxia are diminished.

Moreover, an increased risk for both difficult intubation and complications with extubation require all patients with known OSA to be admitted to the intensive care unit overnight. This includes patients undergoing both laparoscopic and open procedures. Close observation, particularly at night, may reveal periods of desaturation. Patients with hypoventilation may have significant CO2 retention.

Baseline arterial blood gas measurements will help evaluate carbon dioxide retention and provide guidelines for perioperative oxygen administration.

D. Cardiovascular Changes

Many obese patients will show varying degrees of cardiovascular changes:

1. Circulating blood volume increases with BMI resulting in increased preload, stroke volume, cardiac output (CO), and myocardial work. Average CO = 100 cc/min/kg for adipose tissue.
2. Systemic hypertension (50-60% of patients have mild hypertension; 5-10% of patients have severe hypertension).
3. Pulmonary hypertension due to chronic hypoxemia, hypercapnia, and hypoxic pulmonary vasoconstriction.
4. Coronary artery disease. Obesity increases the risk of coronary artery disease independent from the influence of hypertension and diabetes mellitus.
5. Signs of right ventricular (RV) and left ventricular (LV) failure. The chronic hyperdynamic state eventually results in decreased LV contractility, LV hypertrophy, decreased cardiac compliance, and diastolic ventricular dysfunction. This results in poor fluid tolerance, however, obese patients with diastolic dysfunction remain dependent on adequate preload.

Functional capacity can be difficult to assess due to a sedentary lifestyle or limited mobility secondary to factors such as osteoarthritis.

For patients with severe right, left, or biventricular heart failure, intraoperative transesophageal echocardiography (TEE) evaluation should be performed before incision.

Pulmonary Hypertension:

OSA can cause mild-to-moderate pulmonary hypertension, but does not usually result in right heart failure in the absence of daytime hypoxia or coexistent pulmonary disease.
Severe pulmonary hypertension presents a significant anesthetic risk and can be exacerbated by hypoxia, hypercarbia, increased airway pressure, $\alpha$-adrenergic agonists, and metabolic acidosis. Very severe pulmonary hypertension can result in acute RV failure and systemic hypotension.

Pulmonary artery (PA) catheterization may be indicated to assess CO and PA pressures. Intraoperative TEE is valuable in assessing RV function.

**E. Thromboembolic Disease**

Obese patients are prone to venous stasis, polycythemia, decreased fibrinolytic activity, and increased fibrinogen concentration. The risk is increased in patients with pulmonary hypertension. Morbid obesity itself is a major independent risk factor for sudden death from acute postoperative pulmonary embolism.

Heparin (usually 5000 IU subcutaneously) will have been ordered for the patient to receive preoperatively. Low molecular weight heparin (LMWH) will be started by the surgical team in the postoperative period.

**F. Gastrointestinal Changes**

A number of physiologic changes occur as a result of obesity: increased intra-abdominal and intra-gastric pressure; high incidence of hiatus hernia and gastroesophageal reflux; increased liver fat deposits; and incidence of liver cirrhosis / inflammation. However, there is no definitive evidence of increased aspiration for obese patients with BMI > 35 kg/m$^2$. The stomach/lower esophageal sphincter resistance gradient as well as gastric emptying rate are similar for obese and non-obese patients. Abnormal gastric PH was only for obese patients with BMI >50.

**G. Endocrine**

Obesity is associated with a high incidence of Type II diabetes mellitus. Please refer to the Department of Anesthesiology management of the diabetic patient having surgery protocol. Start with algorithm 1 of the UWMC Insulin Infusion Protocol.

**IV. Preoperative Discussion**

In addition to discussing the usual risks of anesthesia with this patient population, preoperative discussion should include peripheral and venous access, arterial cannulation, possible PA catheterization, regional anesthesia options, and postoperative intubation and mechanical ventilation.

**V. Airway Examination**

The potential for a difficult airway should be considered. Large amounts of redundant oropharyngeal tissue, reduced oral opening, and thick neck with limited flexibility are
associated with severe obesity and OSA. It is noteworthy that neither absolute obesity nor BMI were absolute indicators associated with a difficult intubation. Large neck circumference and Mallampati grade were better predictors of potential intubation problems. Obesity and OSA are associated with loss of airway after extubation hence the need to extubate these patients when awake.

VI. Preoperative Medications

Patients should continue their usual medications until the time of surgery. Confirm that deep vein thrombosis (DVT) prophylaxis has been given if this was requested by the surgeon.

H₂-receptor antagonists (e.g. ranitidine), non-particulate antacids (e.g. sodium bicarbonate) or proton pump inhibitors should be given preoperatively to reduce the risk of aspiration. Deeply sedating premedication should be avoided. If intravenous anxiolytic drugs are used, the patient should be appropriately monitored and receive supplemental oxygen.

VII. Access

Peripheral and central venous access and arterial cannulation may be technically difficult. Ultrasound guidance is strongly recommended for placement of internal jugular central venous catheters.

Femoral cannulation is associated with a risk of infection particularly in presence of intertrigo and should be avoided, if possible.

VIII. Special Intraoperative Monitoring

A. Noninvasive Blood Pressure (NIBP)

Use of a proper-sized cuff is essential, with length of the bladder 75 to 80% of the upper arm circumference, and width of the bladder more than 50% of the length and ± 40% of the circumference of the upper arm. Consider using a blood pressure cuff on the forearm if the upper arm is unsuitable.

B. Invasive Monitoring

The presence of comorbidities and type of surgery planned should be used to guide the need for invasive monitoring. Selected obese patients may benefit from pulmonary artery catheter or TEE.
C. Arterial Cannulation
An arterial line may be needed to assess blood gases or to obtain reliable blood pressure readings because the patient’s body habitus may interfere with the performance of NIBP cuffs. Avoid femoral artery cannulation if possible.

IX. Intra-operative Management

A. Position on the Table
Regular operating room tables will accommodate patients weighing up to 350 pounds. For patients weighing between 350-450 pounds, bariatric beds are required. Bariatric surgical patients are prone to slipping off the operating table during table position changes; therefore, they should be well strapped to the operating table.

Place patient in the semi-sitting position with head and upper body elevated, i.e. “ramped” for the induction. Proper positioning will maximize the chances for successful direct laryngoscopy on the first attempt. This may require significant elevation of the upper body and head. The “ramp” should be removed after induction to avoid brachial plexus traction injury due to excessive shoulder extension.

Particular care should be paid to protecting pressure areas, because pressure sores and neural injuries are more common in this group, and particularly in patients with diabetes.

1. Prone position:
The prone position can be difficult. Obese patients’ bodies may not fit well into frames designed for normal weight individuals. Gel rolls may be excessively compressed from the added weight. Pressure points, breasts, and genitalia should be carefully inspected. Pay particular attention to eyes.

2. Lateral position:
The non-dependent arm should be well padded. Consider an axillary roll although it may not be necessary. The dependent hip is subject to a substantial amount of pressure.

3. Lithotomy position:
Stirrups must be able to support the weight of the patient’s legs. Minimize the amount of time the patient spends in this position.

4. Pressure-induced rhabdomyolysis:
This is a rare, but well-described, postoperative complication from prolonged, unrelieved pressure to muscle during surgery which may affect the lower limbs, gluteal, or lumbar regions. Risk factors include prolonged surgery, obesity, and diabetes mellitus. Prevention of rhabdomyolysis includes attention to padding and positioning on the operating table, however, minimization of operative time is most important.
**B. Preoxygenation**

Preoxygenate with 100% oxygen in the sitting position at **10 l/min** for up to **10 minutes**. Alternately, preoxygenation with 100% inspired oxygen and 10 cm H₂O continuous positive airway pressure (CPAP) for 5 minutes before the induction of general anesthesia followed by 10 cm H₂O positive end-expiratory pressure (PEEP) during mask ventilation prevents atelectasis formation, improves arterial oxygenation, and increases the non-hypoxic safe apnea period.

**C. Induction**

It is crucial to have a well-established airway management plan prior to attempting endotracheal intubation. Apply cricoid pressure with 10-20 Newtons (1kg = 9.8N). Preparation should be made for alternative techniques if the initial attempt is unsuccessful. If the preoperative examination indicates the potential for difficult airway, an awake intubation technique should be considered. Laryngeal mask airways (LMA) are effective for establishing ventilation and should be immediately available in the event of a failed intubation or bag mask ventilation.

Options to consider for airway management on induction include: awake fiberoptic intubation, rapid sequence induction, inhalation induction, intubating LMA, and Pro Seal LMA. An intubating LMA helps to avoid difficult mask ventilation, avoid airway collapse after induction, and avoid desaturation due to induction and apneic period. Note that a surgical airway may be technically more difficult with excessive adipose tissue around the neck.

**D. Pharmacology / Weight-Based Dosing**

Obesity leads to alterations in the drug distribution, binding, and elimination. Factors affecting this alteration include body composition, regional blood flow, and affinity to plasma proteins or fat tissues. The net pharmacologic effect is variable due to hepatic/renal clearance.

Drug should be dosed using either ideal body weight (IBW), total body weight (TBW), or dosing weight (DW = IBW + 0.4 x [TBW - IBW]).

The ratio of adipose to lean body mass is increased, thereby altering the volume of distribution of lipophilic drugs. Distribution of lipophilic drugs to adipose tissue increases the dose necessary to achieve a therapeutic level and also prolongs the elimination half-life. Dosing of lipophilic drugs (propofol, heparin, and sufentanil) in obese patients should be based on TBW rather than IBW.

Most drugs with weak or moderate lipophilicity can be dosed on the basis of ideal body weight (IBW) or more accurately, lean body mass. These drugs include remifentanil, beta-blockers, digoxin, penicillins, cephalosporins, and H2-blockers. Drugs dosed upon DW include aminoglycosides, fluoroquinolones, and vancomycin.

1. **Fentanyl**:
   Fentanyl infusion based on TBW led to an overestimation of fentanyl dose requirements in obese patients. A parameter called “pharmacokinetic mass” can be
used to guide fentanyl infusions. For patients weighing 140 to 200 kg, the pharmacokinetic mass was 100 to 108 kg.

2. Neuromuscular blockers:
Nondepolarizing neuromuscular blockers should be administered based on IBW to avoid prolonged duration of action.

Succinylcholine: Pseudocholinesterase increases activity linearly with weight. Obese patients have larger extracellular fluid compartment. The initial dose is based on TBW: 1.2 - 1.5 mg/kg.

3. Volatile anesthetic gases:
Sevoflurane and desflurane offer lower blood solubility, which should speed anesthetic uptake, distribution, and also recovery after drug delivery is terminated.

4. Sedative hypnotics:
Midazolam has longer elimination T½. Barbiturates have a lower plasma concentration.

E. Induction of General Anesthesia

Induction: propofol or etomidate

Opioids: fentanyl or sufentanil or remifentanil (lack of accumulation, but more likely to cause hypotension than fentanyl)

Neuromuscular blockade: succinylcholine or rocuronium or cisatracurium (the dose of rocuronium and cisatracurium should be calculated on an ideal body weight basis).

Consider awake fiberoptic ETT intubation with back-up intubating LMA. Alternatively, consider a rapid sequence induction with propofol and succinylcholine or rocuronium with the GlideScope or conventional laryngoscopy. Maintain anesthesia with desflurane, sevoflurane, and remifentanil. Monitoring should consist of standard monitors plus BIS monitor and an arterial line, decided upon a case by case basis.

F. Maintenance of Anesthesia

1. Anesthetic Agents
Desflurane or sevoflurane are the preferred inhaled anesthetic agents due to low solubility, rapid emergence, and less depression of cardiac output.

2. Ventilation
Static pulmonary compliance is due to a heavy, noncompliant chest wall. Delivered tidal volume (TV) should be calculated based on IBW rather than TBW. Initial TV should be 8 ml/kg of IBW. This is altered based on peak airway pressures and results of arterial blood gas measurements. End-tidal CO₂ level may poorly reflect arterial PCO₂. High airway pressures with positive pressure ventilation widen the alveolar-arterial gradient by increasing physiological dead space.

Plateau airway pressures should be maintained below 35 cm H₂O to avoid barotrauma. Up to 10 cm H₂O of PEEP may help improve lung compliance by reversing atelectasis.
and increasing FRC. Tidal volumes of 10-12 ml/kg IBW and respiratory rates of up to 12-14 breaths/minute may be required to maintain normocapnia during laparoscopic procedures with the concomitant use of carbon dioxide insufflation.

Obesity increases mean increased oxygen consumption as much as 25%. Therefore, it is not uncommon to use 100% oxygen during the maintenance of anesthesia.

Complete muscular relaxation is crucial during laparoscopic bariatric procedures to facilitate ventilation and to maintain an adequate working space for visualization and safe manipulation of laparoscopic instruments. Collapse of pneumoperitoneum may be an early indication that muscle relaxation is inadequate.

Other considerations include maintaining euvoolemia, monitoring body temperature, and maintaining normothermia.

**G. Extubation of Obese Patients**

Postoperative ventilation in ICU or postanesthesia care unit (PACU) should be considered to allow full recovery from the effects of anesthetic agents. Although these criteria are similar to other patients, the obese patient needs to be fully awake and alert prior to extubation. CPAP and bilevel (biphasic) positive airway pressure (BiPAP) should often be used in the PACU and ICU to prevent postoperative hypoxemia, and should be arranged in advance of patient arrival.

**Criteria:**

1. Patient is alert and awake
2. Relaxants are reversed train-of-four / head lift > 5s
3. Circulatory status is stable
4. Respiratory function is stable
5. Patient has no pain
6. VC ~ 8-10 ml/kg
7. RR ~ 10-15 x min
8. TV ~ 5-8 cm/kg
9. Negative inspiratory force (NIF) > 25-30 cm H2O
10. Temperature > 35.5 degrees C

Consider extubating in the semi-sitting position. As usual, ensure an adequate airway (nasopharyngeal airway may be of use) and breathing prior to transfer to PACU.

**X. PACU**

Patients using CPAP or BiPAP at home will have been instructed to bring this with them the day of surgery. Prior to these patients going to the recovery room postoperatively, PACU should be notified. PACU will then notify respiratory therapy to check the status and set-up the patient’s machine to be used in the post-operative period. Atelectasis has been reported in 45% of obese patients after upper abdominal surgery. Initiation of
CPAP or BiPAP treatment will accelerate the reestablishment of preoperative pulmonary function.

If patients are not discharged to ICU, ensure that patients have overnight O₂ therapy and SpO₂ monitoring with CPAP / BiPAP as required.

**XI. Regional Anesthesia**

In open gastric bypass procedures, combined use of thoracic epidural and general balanced anesthesia can be extremely helpful if it is technically feasible. Epidural analgesia has been shown to reduce postoperative pulmonary depression, improve pain relief, improve oxygenation and reduce atelectasis. Laparoscopic bariatric surgery induces less postoperative pain and is less likely to interfere with pulmonary mechanics. Therefore, regional techniques, other than local infiltration of the wound by the surgeon, are not indicated for laparoscopic procedures.

Obesity is associated with higher block failure and complication rates in regional anesthesia. Overweight patients should, however, not be excluded from regional anesthesia procedures. The rate of successful blocks (94%) and overall satisfaction remains high in patients with a high BMI. Caution is needed if LMWH will be ordered by the surgeon postoperatively. See UWMC protocol regarding anticoagulation and neuraxial blockade for details.

**XII. Laparoscopy in Obese Patients**

The cardiovascular consequences depend on intra-abdominal pressure (IAP). Low levels of IAP of ≤ 10 mmHg increase venous return and systemic vascular resistance, resulting in an increased arterial blood pressure and CO. Higher levels of IAP compress the inferior vena cava with decreased venous return and decreased CO.

Increased IAP can reduce urine output. In the absence of hypovolemia and with IAP ≤ 12 – 15 mmHg, it should not be necessary to administer additional fluids to ensure preservation of renal function.

Respiratory mechanics are further compromised by the creation of pneumoperitoneum. Atelectasis can be a significant clinical problem in the perioperative period.

The Trendelenburg position and abdominal insufflation can cause displacement of the endotracheal tube into the right mainstem bronchus. Despite all these physiologic changes, laparoscopy is usually well tolerated if the IAP is maintained at less than 15 mmHg.
XIII. Obesity Bias and Care With Dignity

Operating room staff should take care to completely avoid any inappropriate or unprofessional comments regarding the patient.

Suggested Reading

4) Passannante AN, Rock P. Anesthetic Management of Patients with Obesity and Sleep Apnea. Anesthesiology Clin N Am 2005;23:479–91
5) Brenn BR. Anesthesia for Pediatric Obesity. Anesthesiology Clin N Am 2005;23:745-64