

ANESTHESIA FOR BARIATRIC SURGERY

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Over 65% of the US adult population is overweight or obese, defined by a Body Mass Index (BMI) ≥ 25 kg/m² or ≥ 30 kg/m², respectively [1, 2]. Bariatric surgery is usually performed in patients with a BMI ≥ 40 kg/m², or a BMI ≥ 30 kg/m² with comorbidities that are expected to respond to weight loss (i.e. hypertension, diabetes). Obese patients, undergoing bariatric or other surgical procedures, present an increased anesthetic risk because of physiologic changes, comorbidities and technical challenges [3].

Preoperative:

Obesity is often associated to multiple comorbidities. Preoperative evaluation should focus on the following aspects:

- Cardiovascular: evaluation is needed for hypertension, heart failure and coronary artery disease. Symptomatic angina or exertional dyspnea are rare because of the lack of mobility of morbidly obese patients, but it does not reflect the increased risk of cardiovascular disease.
- Respiratory: a thorough airway exam is critical, along with the problems of obstructive sleep apnea (OSA). Lung volumes such as the functional residual capacity (FRC) are reduced in obese patients, and decreased even further in the supine and Trendelenburg positions. Obesity is the greatest single risk factor for OSA. Long-term OSA may lead to obesity hypoventilation (Pickwickian) syndrome, with pulmonary hypertension and cor pulmonale. A majority of patients affected have increased oral and pharyngeal tissue, which makes ventilation, intubation, and extubation more challenging. Spirometry and arterial blood gases may be needed preoperatively. The expiratory reserve volume (ERV) is the most sensitive indicator of the effect of obesity on pulmonary function.
- Gastrointestinal: GI reflux is frequent and the risk of aspiration pneumonitis is greater than in non-obese patients. The use of anti-acid medications should be considered preoperatively.
- Metabolic, renal, hepatic, coagulation: Insulin resistance and elevated cholesterol and triglycerides are frequent. Abdominal obesity is a common feature of the "metabolic syndrome", along with other abnormalities, i.e. dyslipemia, hypertension and insulin resistance. Fluid and electrolyte abnormalities may occur from dieting or diuretic/laxative use. Serum glucose, electrolytes, liver function tests and creatinine are usually needed preoperatively. ALT is frequently elevated. Fibrinogen may be elevated and fibrinolysis impaired.

Intraoperative:

It is mandatory to arrange a surgical table with an adequate weight limit, appropriate support for body parts and cushions.

General anesthesia: Obese patients present the following challenges:

- Airway management: Prolonged preoperative oxygenation and positioning with elevation of head and shoulders above the chest level ("ramped position") are

- key to successful airway management. Availability of a video-laryngoscope is encouraged. A large neck circumference is the single best predictor of problematic intubation in morbidly obese patients. Excessive soft tissue in the upper airway usually makes mask ventilation also challenging.
- Ventilation: Preoperative pressure-support ventilation should be used adjunctively if possible. Intraoperative ventilation is assisted by complete paralysis, moderate positive end-expiratory pressure, tidal volumes based on ideal body weight, and recruitment maneuvers as needed. Positive end-expiratory pressure is the only ventilatory parameter that has shown to improve oxygenation in obese patients.
 - Pharmacokinetics: Lipophilic drugs (i.e. benzodiazepines, thiopental, sufentanyl) have a greater volume of distribution and longer elimination half-life in obese patients, although the clearance rate is similar to that in non-obese patients. The action of fat-soluble volatile anesthetics is not prolonged in obese patients. Metabolism and clearance of hydrophilic drugs is not affected by obesity. Anesthetic drugs should be tailored according to their lipid solubility and knowledge of their lingering depressive effects on respiration. Obese patients may require larger doses of succinylcholine because of greater levels of pseudocholinesterase than in non-obese patients. Table 1 shows dosing recommendations for common drugs used during general anesthesia in obese patients [4, 5]:

Regional anesthesia:

- Superficial anatomic hallmarks may be difficult to recognize because of excessive subcutaneous tissue. Ultrasound guidance may be an invaluable tool for regional anesthesia techniques.
- Dose of epidural local anesthetics is reduced in obese patients; epidural space volume is reduced secondary to increased intra-abdominal pressure, which dilates the epidural veins.

Postoperative:

- Postoperative morbidity is increased in obese patients but increased mortality is controversial [6-8]. Outpatient surgery in this population is also controversial [9].
- Common postoperative complications are respiratory (i.e. atelectasis, pneumonia), vascular (thrombophlebitis, deep venous thrombosis) and wound (infection, dehiscence) complications.
- Beach chair position, aggressive physiotherapy and noninvasive respiratory support if needed improve respiratory function in the early postoperative period [10]. Adequate pain control and fluid management are especially important in obese patients to minimize respiratory complications.
- Narcotic-based analgesia may be challenging because of the increased risk of hypoventilation and hypoxemia in obese patients. Local anesthetic wound infiltration and non-steroidal anti-inflammatory drugs should be part of multimodal opioid-sparing postoperative analgesia.
- Rhabdomyolysis may occur in morbidly obese patients after prolonged surgeries. It should be suspected if unexplained increases of serum creatinine and creatine phosphokinase and patients complain of buttock, hip or shoulder pain.

Table 1. Dosing recommendations of common anesthetic drugs in obese patients.

Drug	Dosing	Comments
Propofol *	Induction: 1-2.5mg/kg (LBW) Maintenance: 50-200mcg/kg/min (TBW)	Preferable induction agent. Titrate dosing to effect.
Etomidate	Induction: 0.2-0.5mg/kg (LBW)	Alternative induction agent for hemodynamically unstable patients.
Desflurane , Sevoflurane, Isoflurane	MAC: 6.0%, 2.0%, 1,2% respectively	Similar to non-obese patients.
Thiopental	Induction: 3-5mg/kg (LBW)	Risk of prolonged duration.
Fentanyl	0.5-1.5 mcg/kg (LBW) boluses	Slowly titrate dosing to effect.
Sufentanil	0.5-8mcg/kg boluses, max 1mcg/kg/h (LBW)	Risk of prolonged respiratory depression.
Remifentanyl	0.05-1mcg/kg/min (LBW)	Similar to non-obese patients. Titrate dosing to effect.
Midazolam	0.01-0.1mg/kg (LBW), usually 1-2mg pre-induction	Risk of prolonged sedation
Dexmedetomidine	0.2-0.7mcg/kg/h (TBW)	Analgesic adjuvant during general anesthesia. Ideal for sedation because of minimum respiratory depression. Titrate dosing to effect.
Succinylcholine	Intubation: 1mg/kg (TBW)	Ideal for endotracheal intubation. Myalgias are rare in obese patients.
Rocuronium	Intubation: 0.6-0.8mg/kg (LBW) Maintenance: 10-12mcg/kg/min (LBW)	Good alternative for intubation.
Vecuronium	Maintenance: 1-2 mcg/kg/min or 10mcg/kg boluses (LBW)	
Cis-atracurium	Intubation: 0.2mg/kg (LBW) Maintenance: 1-2mcg/kg/min or 20mcg/kg boluses (LBW)	Good option for muscle relaxation maintenance because of metabolism independent of renal and liver function.
Neostigmine	40-80mcg/kg (LBW)	Reversal of muscle relaxants may be slower than in non-obese patients.

(**LBW**=Lean Body Weight, which can be calculated adding 20% to the estimated Predicted Body Weight for patient's gender and height; **MAC**=Minimum Alveolar Concentration; **PBW**=Predicted Body Weight, calculated with the following formulas: Males: $PBW (kg) = 50 + 0.91 \times (\text{height (cm)} - 152.4)$; Females: $PBW (kg) = 45.5 + 0.91 \times (\text{height (cm)} - 152.4)$ [11]; **TBW**=Total Body Weight)
(*=Preferred drugs for routine use in bariatric patients)

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