The Obese Patient

Obesity and morbid obesity are BMI ≥30 and ≥40 kg/m^2, respectively. Other factors such as age and fat distribution should be taken into consideration. Waist circumference, but not BMI, reflects abdominal subcutaneous adipose tissue, as well as abdominal visceral adipose tissue, and is therefore a better index of central, or truncal, fat mass.

ANESTHETIC CONSIDERATIONS:

- Potentially difficult airway and BMV – Positioning important
- Possible difficult intravascular access
- Rapid desaturation
- Increased cardiac output and LV stress
- Increased incidence of fatty liver, insulin resistance, and sub-clinical hypothyroidism
- Hypercoagulability
- Adjustment of drug dosages based on ideal body weight vs. actual body weight

ANESTHETIC GOALS:

- Preoperative optimization of coexisting disease (especially OSA and heart failure)
- Prevent intraoperative ventricular failure (watch intravenous fluid administration or negative inotropy of anesthetic agents)
- Prevent exacerbation of pulmonary hypertension by hypoxia or hypercapnia (if pulm HTN coexists)
- Appropriate dose adjustment of anesthetic medications
- Appropriate disposition arranged for postoperative care and awareness of increased risk of postoperative complications

Physiologic Changes in Obesity:

A/W:

- Potentially difficult airway and difficult BMV
  - Limitation of movement of atlantoaxial joint and c-spine by upper thoracic and low cervical fat pads
  - Excessive tissue folds in the mouth and pharynx
  - Short, thick neck
  - Suprasternal, presternal, and posterior cervical fat; Very thick submental fat pad

Resp:

- Decreased lung/chest wall compliance and increased elastic resistance, leading to decreased FRC (mostly due to decreased ERV), decreased VC, and decreased TLC
- RV and closing capacity are unchanged
- Under anesthetic 50% reduction in FRC occurs in obese patients (compared with 20% in nonobese)
- FRC may be decreased to the point that small airway closure occurs with resulting ventilation-to-perfusion mismatching, right-to-left shunting, and arterial hypoxemia
- FEV1 and FVC are usually within normal limits
- Increased oxygen consumption and carbon dioxide production even at rest, increases alveolar ventilation and therefore work of breathing increases
- Most obese patients retain their normal response to hypoxemia and hypercapnia
- Lower PaO2 on room air in sitting and supine positions
- Chronic hypoxemia may lead to pulmonary hypertension and cor pulmonale

CVS:

- Increased total blood volume to supply adipose tissue, but on a volume-to-weight basis it is less than in nonobese individuals (50 mL/kg compared with 70 mL/kg)
- Cardiac output increases 20-30 mL per kg of excess body fat or 0.1L/min for each kg of weight gain in adipose tissue (increased stroke volume secondary to ventricular dilatation secondary to hypervolemia)
- Increased left ventricular wall stress leads to hypertrophy, reduced compliance, and impairment of left ventricular filling (diastolic dysfunction) with elevated LVEDP and pulmonary edema
  - When left ventricular wall thickening fails to keep pace with dilatation, systolic dysfunction ("obesity cardiomyopathy") and eventual biventricular failure results

GI:

- Increased aspiration risk in obese pts (questioned if this is really a concern in the textbooks):
  - Gastric volume and acidity are increased
  - Delayed gastric emptying occurs because increased abdominal mass causes antral distention, gastrin release, and a decrease in pH with parietal cell secretion
  - Abdominal obesity increases intragastric pressure, increasing the frequency of transient lower esophageal sphincter relaxation
  - Increased incidence of hiatal hernia and gastroesophageal reflux
- Abnormal liver function tests and fatty liver infiltration are frequent findings
- Gallbladder and biliary tract disease is increased threefold from abnormal cholesterol metabolism

GU:

- Increased GFR: glomerular hyperfiltration and increased renal plasma flow

Endo:

- Obesity-induced insulin resistance and glucose intolerance
- Sub-clinical hypothyroidism

Heme:

- Hypercoagulability: Increased levels of fibrinogen, factor VII, factor VIII, von Willebrand factor (fibrin formation), and plasminogen activator inhibitor-1 (inhibits the fibrinolytic system)

Other: Possible difficult iv access

Drugs:

- Increased blood volume decreases plasma concentrations of rapidly injected iv drugs; But, fat has poor blood flow and doses calculated on actual body weight could lead to excessive plasma concentrations
- Coexisting suggests that dosing of:
  - propofol, vecuronium, rocuronium, and remifentanil should be based on ideal body weight
  - thiopental, midazolam, succinylcholine, atracurium, cisatracurium, fentanyl, and sufentanil should be on the basis of total or actual body weight
  - maintenance doses of propofol should be based on TBW, and on IBW for sufentanil
- Barash suggests all drugs should be dosed based on lean body weight except for succinylcholine – for succ increase the dose based on total body weight (TBW) as pseudocholinesterase activity increases linearly with increasing weight and larger extracellular fluid compartment
- Repeated injections may accumulate in fat, leading to a prolonged response because of subsequent release from this large depot

Common Conditions in Obesity

- Obstructive sleep apnea (up to 5% have OSA)
  - Pulmonary and systemic hypertension, left and right ventricular hypertrophy, and an increased incidence of arrhythmias, MI, and stroke
- Obesity hypoventilation (Pickwickian) syndrome (5-10% of morbidly obese)
  - Diagnosis (Barash): BMI >30 kg/m^2 and awake arterial hypercapnia ($Paco_2$ >45 mm Hg) in the absence of known causes of hypoventilation
  - Diagnosis (Miller): awake chronic hypoxemia (Pao_2 <65 mm Hg) without a diagnosis of COPD or primary lung disease
  - Impaired central ventilatory drive - Increased sensitivity to the respiratory depressant effects of general anesthetics
- Hypertension (50-60% of obese patients)
  - Caused by increased cardiac output and hyperinsulinemia activating the sympathetic nervous system and causing sodium retention
  - 3- to 4-mm Hg increase in systolic and a 2-mm Hg increase in diastolic arterial pressure for every 10 kg of weight gained
  - Causes eccentric dilation of the ventricle in obese pts (vs. concentric hypertrophy in normal-weight individuals), increasing preload, stroke work, and the likelihood of heart failure
- Accelerated atherosclerosis and CAD
- Cardiac dysrhythmias
  - May be precipitated by fatty infiltration of the conduction system, hypoxia, hypercapnia, electrolyte imbalance, CAD, increased catecholamines, OSA, and myocardial hypertrophy
- Type 2 Diabetes Mellitus (>10% of obese patients)
  - Resistance of peripheral fatty tissues to insulin
  - Predisposes to wound infection and an increased risk of MI
  - Hyperinsulinemia further activates the sympathetic nervous system, causing sodium retention and contributing to the hypertension of obesity
- Nonalcoholic fatty liver disease (reflects duration of obesity), cholelithiasis, and cirrhosis
- Subclinical hypothyroidism (~25% of all morbidly obese patients)
  - Obesity possibly leads to a state of thyroid hormone resistance in peripheral tissues
  - May be associated with hypoglycemia, hyponatremia, and impaired hepatic drug metabolism
- Metabolic syndrome
  - Central obesity plus any 2 of 4 factors: raised serum triglycerides, reduced serum high density lipoprotein-cholesterol level, hypertension, or an elevated fasting plasma glucose
  - Fivefold greater risk of developing DM2 (if not already present) and are also twice as likely to die from a heart attack or stroke compared with those without the syndrome
- Thromboembolism
  - Presumably reflects the effects of polycythemia, increased abdominal pressure, and immobilization leading to venous stasis and increased abdominal pressure in deep veins
  - Double the risk of DVT in obese patients undergoing surgery
- Cancer – increased risk for endometrial, colon, breast, prostate cancer
- Sudden death

Pre-Op Assessment:

History:

- History and previous surgical records may predict anesthetic challenges including ease or difficulty in securing the airway, iv access, need for ICU admission, surgical outcomes, and the weight of the patient at that time
- Symptoms of OSA – snoring or daytime sleepiness (OSA predisposes to airway difficulties during anesthesia); or known diagnosis (sleep study, CPAP)
  - An AHI score greater than 30, implying severe sleep apnea, is a warning sign and a predictor for rapid and severe desaturation at induction
  - CPAP levels greater than 10 imply a patient with the potential for difficult mask ventilation
- Thorough cardiac and respiratory history considering common associated conditions
  - Symptoms of pulmonary hypertension - exertional dyspnea, fatigue, syncope reflect inability to increase cardiac output during activity
  - Cardiac output rises faster in response to exercise in the morbidly obese and is often associated with a rise in LVEDP and PCWP- similar changes occur during the perioperative period, which should prompt a low threshold for performing detailed cardiac investigations
- History of hiatus hernia or reflux
- Drugs or methods of weight reduction (purging, diuretics, laxatives, gastric bypass procedures)
  - May result in electrolyte abnormalities, vitamin deficiencies, malnutrition, anemia, and cardiopulmonary disorders

Physical:

- Thorough airway exam
  - Predictors of difficult mask ventilation and tracheal intubation: fat face and cheeks, short neck, large tongue, excessive palatal and pharyngeal soft tissue, restricted mouth opening, limited cervical and mandibular mobility, large breasts
  - BMI does not seem to have much influence on the difficulty of laryngoscopy
  - Difficulty correlates better with increased age, male sex, temporomandibular joint pathology, Mallampati classes 3 and 4, history of OSA, and abnormal upper teeth
  - Patient's neck circumference is the best predictor of problematic intubation
    - The probability of a problematic intubation is approximately 5% with a 40-cm neck circumference compared with a 35% probability at 60-cm neck circumference
  - Neck circumference >43 cm in men and >40.5 cm in women is associated with OSA
- Complete cardiorespiratory exam
  - Obese patients should be evaluated for systemic hypertension, pulmonary hypertension, signs of right and/or left ventricular failure, and ischemic heart disease
  - Signs of cardiac failure such as elevated jugular venous pressure, added heart sounds, pulmonary crackles, hepatomegaly, and peripheral edema may all be difficult to detect because of masking by excess adiposity

Labs and investigations:

- Recommended pre-op labs include: CBC, lytes (interested in HCO3 level, important if pt on diuretics), fasting blood glucose, lipid profile, renal and hepatic function, INR/PTT
- No clear correlation exists between routine liver function tests and the capacity of the liver to metabolize drugs- abnormal liver function tests are seen in up to one third of obese patients who have no evidence of liver disease (increased alanine aminotransferase is most frequently seen)
- ECG:
  - Frequent findings in morbidly obese patients include: low QRS voltage, multiple criteria for LVH and LAE, T-wave flattening in the inferior and lateral leads, leftward shift of the P-wave/QRS complex/T-wave axes, and prolonged QT interval duration
  - Pulmonary HTN: an ECG may demonstrate signs of RVH such as tall precordial R waves, right axis deviation, and right ventricular strain

- Echocardiography: Tricuspid regurgitation on echocardiography may indicate pulmonary hypertension
- Chest radiographs may show evidence of underlying lung disease and prominent pulmonary arteries
- Arterial blood gas measurements help evaluate ventilation, as well as the need for perioperative oxygen administration and postoperative ventilation

Optimization:
- Investigation and treatment for OSA and other medical conditions if suspected
- The possibility of invasive monitoring, prolonged intubation, and postoperative mechanical ventilation should be discussed with obese patients

Anesthetic Options:
- GA vs Regional
  - Many benefits of regional but may be technically difficult to perform regional techniques with inability to identify usual bony landmarks, the physical challenge of placing the catheters and the tendency of these catheters to migrate out of the epidural space
  - Epidural vascular engorgement and fatty infiltration reduce the volume of the space, making dose requirements of local anesthetics for epidural anesthesia 20 to 25% less in obese patients
  - Spinals can be unpredictable because of considerable upward spread within a short time, causing cardiovascular and respiratory compromise; can cause reduced peak expiratory flow rate and maximum mid expiratory flow
- Postoperative pain management in weight loss surgery patients can involve iv analgesia via PCA or thoracic epidural analgesia -no clear data proving the superiority of one technique over the other

Anesthetic Set-up

Drugs:
- Standard emergency drugs

Equipment:
- Obesity per se does not require invasive monitoring; standard CAS monitors plus temperature
- Indications for invasive monitoring stem from the comorbid conditions noted in these patients
  - Serious comorbid diseases such as obesity-hypoventilation syndrome with pulmonary hypertension and cor pulmonale may require a pulmonary artery catheter or intraoperative use of transesophageal echocardiography
  - May need central venous access secondary to difficulties in peripheral access
  - Difficulty in NIBP measurements because of body habitus–related difficulty in appropriate cuff placement may be an indication for placement of an arterial catheter
  - Arterial blood gas analysis may help guide intraoperative ventilation and extubation
- Require an appropriate operating table for the patient's weight +/- straps or a bean bag under the patient to keep the patient from sliding off the operating room table
- Careful positioning and padding (pressure sores and neural injuries are more common in this group)

Anesthetic Management

Induction:
- Acid aspiration prophylaxis, including H_2 receptor agonists or proton pump inhibitors, must be considered in patients with identifiable risk for aspiration
  - Awake fiberoptic intubation may also be considered in such patients
- Arterial oxygen desaturation following induction during apneic period despite preoxygenation secondary to decreased FRC and an increase in oxygen consumption

Maintenance:
- Ventilation:
  - Controlled ventilation using large tidal volumes is often applied to offset the decreased FRC
  - Application of PEEP improves FRC, ventilation-to-perfusion matching, and arterial oxygenation, but at the expense of cardiac output and oxygen delivery in obese patients
  - Using pressure control ventilation and changing the inspiration-to-exhalation ratio could help limit the airway pressure
  - Prone and head-down positions can further decrease chest wall compliance and PaO2 in obese patients
  - Acute assumption of the supine position by spontaneously breathing obese patients can decrease the PaO2 and lead to cardiac arrest
- Drugs
  - A combination of intraoperative nonopioid analgesics and anesthetic adjuvants (ketorolac, clonidine, ketamine, lidocaine, magnesium sulfate, and methylprednisolone) that produce analgesia by mechanisms different from opioids decreases sedation during recovery from anesthesia and reduces postoperative morphine requirements
  - Use short-acting drugs and nondepressors of ventilation such as dexmedetomidine (if we had it!!!) to speed up the return to baseline respiratory function
  - Complete neuromuscular blockade in the morbidly obese is necessary not just for surgeons' convenience but also to facilitate mechanical ventilation
  - Despite evidence that volatile anesthetics are defluorinated to a greater extent in obese patients, there is no evidence of exaggerated anesthetic-induced hepatic dysfunction
  - Some evidence suggests that desflurane may be the anesthetic of choice because of a more consistent and rapid recovery profile than is seen with sevoflurane and propofol; However, a more recent study has suggested that the difference in immediate recovery between sevoflurane and desflurane is not clinically significant
  - Even though nitrous oxide provides some analgesic effect and is eliminated rapidly, avoid it because of the high oxygen demand in the obese

Emergence:
- Comparable recovery times in obese and lean individuals undergoing anesthesia less than 4 hours
- Tracheal extubation:
  - Consider when obese patients are fully recovered from the depressant effects of anesthetics
  - Recover in a head-up to sitting position
  - A history of OSA or OHS mandates intense postoperative monitoring to ensure maintenance of a patient's upper airway and acceptable oxygenation and ventilation

Disposition and Monitoring:
- Delayed respiratory depression with centrally administered neuraxial opioids, when coupled with a potentially difficult airway in the obese patient, may require close postop monitoring

- The hazards and risk of OSA and OHS may extend several days into the postoperative period
    - Arterial oxygenation should be closely monitored (pulse oximetry or arterial blood gases) and supplemental oxygen provided as indicated
    - The maximum decrease in PaO2 typically occurs 2 to 3 days postoperatively
- The semisitting position is often used during the postoperative period in attempts to decrease the likelihood of arterial hypoxemia

Postoperative Complications:
- Postoperative morbidity and mortality rates are higher in obese patients than in nonobese patients mostly due to the preexisting comorbidities and the risk of aspiration during intubation
- Wound infection is twice as common in obese patients compared with their nonobese counterparts
- Postoperative ventilation is more likely to be required in obese patients who have co-existing carbon dioxide retention and have undergone prolonged surgery, especially abdominal operations
- The likelihood of DVT and PE is also increased, emphasizing the importance of early postoperative ambulation and the potential need for prophylactic anticoagulation

Obesity and Pregnancy:
- Increased incidence of:
    - Airway difficulties
    - Hypertensive disorders including chronic hypertension and preeclampsia
    - Gestational diabetes
    - Thromboembolic disease
    - Abnormal labor
    - Failed induction
    - Cesarean delivery and emergency cesarean delivery
- Obesity has been found to increase the risk of maternal death, related to the increased incidence of preeclampsia, diabetes, pulmonary embolism, and infection
- Perinatal outcome is adversely affected by obesity secondary to increased incidence of:
    - Macrosomia which leads to a greater risk of birth trauma and shoulder dystocia
    - Meconium aspiration
    - Fetal neural tube defects and other congenital abnormalities

<u>References:</u>
Barash Chapter 47 Anesthesia and Obesity
Miller Chapter 64 Anesthesia for Bariatric Surgery
Coexisting Pg. 297-310 and Chapter 23 Pregnancy-associated Diseases