Obesity and Anesthesia

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Objectives

- Define and describe obesity.
- Describe the effects of obesity on the cardiac, respiratory, and GI system.
- Present an overview on the effects of obesity in pediatric and obstetric populations.
- Discuss and describe pharmacological considerations for the obese patient.
- Discuss generalized anesthesia considerations for management of the obese patient.
Disclosures/Conflict of Interest

- None
Obesity

• 2nd leading cause of preventable death in the US; associated with approx. 112,000 deaths per year

• 65% of US adults are classified as overweight; 30% are classified as obese

• Obese individuals have a 10-50% greater risk of death related to all causes versus a “healthy” weight individual (BMI 18-25)
Obesity

- Increased risk of death is associated with obesity is related to cardiac causes.

- Obesity has been identified as a risk factor in the development of over 30 different medical conditions.
Diseases linked to Obesity

- Cerebrovascular disease
- Restrictive lung disease
- Obstructive sleep apnoea
- Obesity hypoventilation syndrome
- Coronary artery disease
- Sudden cardiac death
- Cardiomyopathy
- Cor pulmonale
- Hepatosteatosis
- Gallstones
- Hiatus hernia
- Colorectal cancer
- Diabetes Mellitus
- Hypertension
- Menstrual abnormalities
- Infertility
- Endometrial cancer
- Cervical cancer
- Varicose veins
- Deep venous thrombosis
- Pulmonary embolism
- Osteoarthritis of weight-bearing joints
Body Mass Index

• BMI is the accepted measure of body habitus that normalizes adiposity for height.

• 2 formulas:
  • BMI = weight in kg / height in meters squared
  • BMI = (weight in pounds/height in inches squared) x 703
### BMI Ratings Scale

<table>
<thead>
<tr>
<th>Classification</th>
<th>BMI Range</th>
<th>Description</th>
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<tr>
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<tr>
<td>Super-super obese</td>
<td>&gt; 60</td>
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BMI Ratings and Risks

• Those with a BMI >30; especially those with existing cardiovascular disease, mortality rates associated with preexisting conditions are 50-100% above the rates of those with a “normal” weight.

• Type 2 diabetes, coronary heart disease, hypertension, and hypercholesterolemia are prominent conditions in the overweight and obese pt

• **Age, male gender, and increased BMI are MARKERS for “sick pts”**
Ideal Body Weight

• Same as: normal weight; lean body weight; or desirable weight

• IBW is a measurement of height and body mass that exhibits the lowest morbidity and mortality for a population

• Certain medications are calculated based on IBW so as not to elicit unwanted side effects or drug toxicity
IBW Formulas

- For Men: height in cm - 100
- For Women: height in cm - 105
- Per literature, 3 commonly used drugs that are based on IBW are:
  1. Remifentanyl
  2. Vecuronium
  3. Rocuronium
Adipose Tissue

• Considered an ENDOCRINE organ

• Major functions are:
  • Maintain heat insulation
  • Provide a reservoir of ready to use and convert energy
The liver is essential for fat metabolism:

- It breaks down fatty acids and converts them into usable energy
- Synthesizes triglycerides from carbs and proteins
- Synthesizes cholesterol and phospholipids from other lipids
- Desaturates fatty acids from all cells
Fat as an Insulator

- Fat cells arise from modified fibroblasts

- These fibroblasts are able to hold liquid triglycerides up to 95% of the cells storage capacity
  - (basically 95% of these cells are all liquid fat, the other 5% are the actual parts of the cell-nucleus, mitochondria, etc)

- In response to the skin’s exposure to the cold (over a period of weeks) the fatty acid chains in these cells shorten becoming more unsaturated
Liquid Gold

• This allows the fat in the cell to stay liquid instead of hardening

• Why is this important?
  • *Only LIQUID fat can be hydrolyzed and transported from the cells to be used as energy*

• Bonus question: What type of reaction is hydrolysis?
Mechanisms of Obesity

- In early childhood, fat cell formation occurs rapidly.

- During adolescence, the number of fat cells stabilizes and becomes constant for the remainder of the adult life.

- Children become obese through an increase in fat cells.

- Teens and adults become obese through hypertrophy of existing fat cells.
Then and Now...
Body Fat Distribution

- Central, android, or abdominal visceral obesity AKA the “apple shape” is considered a malignant form of fat

- Apple shape people have a waist/hip ratio greater than 0.85 in men and 0.92 in women
The Waist/Hip Ratio

• Calculated by dividing the narrowest waist measurement by the broadest hip measurement while the pt is standing.

• Waist circumference is the new standard in identifying abdominal obesity.

• Normal ranges are:
  • Men-102 cm or 40 inches
  • Women-88 cm or 35 inches
Waist/Hip

- If ratio is greater than normal allowable range—there is a significant increase risk for the developing the following diseases and conditions:
  - Ischemic heart disease
  - Diabetes
  - Hypertension
  - Dyslipidemia
  - Death
• Peripheral gynecoid, or gluteal femoral obesity AKA the “Pear shape” is the least perilous form of fat accumulation.

• Pear shape is associated with a waist/hip ratio less than 0.76 in BOTH men and women

• Pear shape is also associated with varicose vein development, joint disease, and a DECREASED incidence of type 2 diabetes

Hip to Be Pear?
Apple V. Pear

- Pear shape people tend to be females as the location where fat is stored is meant to be utilized for lactation and pregnancy.

- Apple shape people tend to be males as it is related to continuous release of Free Fatty Acids (FFA).
FFA and the Liver

FFA's are released from the adipose tissue and are drained via the portal veins into the liver. Continued release and drainage stimulates the liver to produce very low density lipoproteins (VLDL) and low density lipoproteins (LDLs) which are then sent into systemic circulation. Continued exposure to FFA's also causes the liver to increase gluconeogenesis and thus inhibits insulin uptake-causing type 2 DM.
Causes of obesity

- Genetics (only 40% responsible)
- Socialization
- Age
- Sex
- Race
- Economic status
- Stress
• In 1994 scientists discovered the “ob” gene in mice

• They found that this gene can control the production of leptin.

• Leptin is a protein in the body that acts as an intermediary between the brain and fat storage.

• Exogenous leptin causes weight loss however the brain can become resistant to leptin’s effects which can lead to increased caloric intake and obesity
Inflammation and Obesity

- The following inflammatory mediators are all elevated as a result of obesity:
  - Angiotensinogen
  - Transforming growth factor Beta
  - Tumor Necrosis Factor alpha
  - Interlukin 6

- Research is still being conducted on how these play a role if any in fat remediation
Pathophysiology of Obesity

- Obesity has a direct affect on both the cardiac and the respiratory systems.

- There is a Direct correlation between an increased BMI and the development of many medical conditions commonly associated with obesity.

- Chief among the obese population is an increased morbidity as a result of cardiovascular disease.
Cardiovascular considerations
• Obese patients are more likely to die from: ischemic heart disease, hypertension, and cardiac failure.

• For every 13.5 kg of fat gained an estimated 25 miles of new vascularization occurs to provide blood flow to the tissue at a rate of 2-3 ml/100g of tissue per minute.

• This represents an increased CO of 0.1 ml/min for each kg of fat acquired!
A Chain Reaction

• The new vascularization of fatty tissue accelerates the renin-angiotensin pathway in order to help supply blood to the new areas.

• This coupled with the increase CO puts a huge strain on the heart causing an increase in cardiac workload and a subsequent increase in the cardiac Basal metabolic rate
• Increased cardiac BMR=increased O2 consumption which in turn=increased CO2 production resulting in a normal or slightly elevated A-a gradient.

• Chronically elevated CO causes increased LEFT sided heart pressures which then leads to LV hypertrophy.

• The heart rate usually remains the same in the obese patient as a healthy patient-so what parameter is responsible for the increased CO?
Stroke Volume

- Increased CO = HR x an increased SV
- Chronically Increased SV will cause:
  - Cardiomegaly
  - Hypertension
  - Congestive Heart Failure
Hypertension

- Defined as a systolic pressure greater than 140mmHg and/or a diastolic pressure greater than 90 mmHg

- The incidence of htn is 2x more likely to occur in the obese population when compared to the nonobese population

- BP increases 6.5mmHg for every 10% increase in body weight
Causes of hypertension in the obese patient

- Increased blood viscosity
- Catecholamine kinetics
- Increased estrogen concentrations
- Hyperinsulinemia
- Elevated mineral corticoids and abnormal Na reabsorption
CV

- Hypercholesterolemia (cholesterol levels greater than 250mg/dl) coexists with htn
- Leads to atherosclerosis and increased risk of CVA
- Coronary Artery Disease is an independent risk factor associated with obesity but not caused as a result of it.
- Ischemic heart disease is more common in the obese with a central distribution of fat
Arrhythmias

- Occurs as a result of:
  - Hypoxemia
  - Hypercapnia
  - Electrolyte disorders
  - Sleep apnea
  - LV hypertrophy
  - HTN
  - CAD
Interaction between Obesity, Systemic hypertension and Ischemic heart disease

Obstructive sleep apnoea
obesity hypoventilation

Hypoxia/hypercapnia

Pulmonary arterial hypertension

RV enlargement & hypertrophy

RT failure

Pulmonary venous hypertension

Increased circulation blood volume

Increased stroke volume

Increased cardiac output

LV enlargement

Increased LV wall stress

Eccentric LV hypertrophy

LV systolic dysfunction

LV diastolic dysfunction

LV failure

Hypertension

Ischaemic heart disease
CV Summary

Changes

• Triad of increased CO, elevated circulating blood volume, and enhanced sympathetic activity are characteristic changes in obese patient. Blood volume increases proportional to body surface area, which contributes to increased preload and CO that may lead to LV hypertrophy and failure.

• Hypertension that may be complicated by concentric LV hypertrophy.

Anesthesia Implications

• Anesthesia induction and intubation cause greater reduction in cardiac index in obese patient than in nonobese, which can decrease 17%-33% in obese patients versus 4%-11% in nonobese. This decrease can persist into the postoperative period in obese patients.

• Increased risk for intraoperative BP lability. Cerebral autoregulation may be altered.
CV Summary

Changes

- Atrial Fib- as patient obesity increases, left atrium becomes dilated.

- Obesity-related cardiomyopathy

Anesthesia Implications

- Additional perioperative cardiac and hemodynamic monitoring needed as patients have a higher risk for perioperative myocardial infarction.

- Increased with the duration of obesity (>10 y) and the severity of obesity. Mostly manifests as diastolic cardiac failure. Diastolic dysfunction increases the risk for postoperative CHF, prolonged hospital stay, and complications in major surgery.
CV Summary

Changes

• Pulmonary artery hypertension, as a consequence of prolonged hypoxia and hypercapnia of OSA and OHS. It can be complicated by RV enlargement and hypertrophy that can cause RV failure (cor pulmonale).

• Cardiac failure (can be due to LV wall stress and elevated filling pressure secondary to the longstanding increased stroke volume and decreased SVR to compensate for increased CO demands, or as a consequence of leptin related hypertrophic changes, or hypertensive changes).

Anesthesia Implications

• Avoid elevated PVR (by preventing hypoxemia, acidosis, hypercarbia, and pain) and avoid myocardial depressants. Maintain SVR, preload, and sinus rhythm.

• Hemodynamic goals: **AVOID** tachycardia, hypertension, hypotension, hypoxia, and hypercarbia.
Respiratory considerations
Compromise of the respiratory system results from compression of fat on abdominal, diaphragmatic, and thoracic structures. Thoracic kyphosis and lumbar lordosis develop over time impairing rib movement causing fixation of the thorax in an inspiratory position. As a result, chest wall, lung, parenchyma, and pulmonary compliance is reduced by 35% of predicted values.
The “fixed” position causes premature airway closure which then causes CO2 retention, VQ mismatches, shunting, and hypoxemia. Increased metabolic needs lead to increased O2 demand causing an increase in CO2 production and retention.

Add to it a decrease in ventilation r/t adipose compression and a fixed inspiratory position and the has a major decrease in FRC and CC.
Resting lung volumes (FRC) in nonobese lungs with good lung compliance.

Reduced resting lung volumes (FRC) in obese lungs due to restriction from surrounding adipose tissue and reduction in lung compliance.

Graphs showing volume (liters) versus pressure (cmH₂O) for normal and obese conditions.
Morbid obesity is associated with reductions in FRC, ERV, and TLC

FRC declines exponentially with increasing BMI whereas forced vital capacity varies inversely with BMI

Decreased VC, TLC, ERV, and inspiratory capacity are demonstrated by rapid shallow breathing causing a restrictive lung disease.

(You assess this preoperatively by observation and inquiring into exercise tolerance, pulm function test results if available, etc)
• Hypoventilation leads to hypercarbia which causes acidosis which in turn depresses the CNS’ response to chronic hypoxia

• This usually leads to the development of OSA

• New research has shown that the likelihood for developing OSA is directly proportional to increasing BMI
• The prototypical OSA patient is classified as the following:
  • BMI greater than 30
  • Abdominal fat distribution
  • Large neck girth (>17 in men; >16 in women)

• The obese patient undergoing any type of bariatric surgery has a 71-77% chance of having OSA
OSA

- Characterized by intermittent closure or narrowing of the upper airway during sleep leading to episodes of apnea-hypopnea, arousal, and o2 desaturation

- Estimated that 85-90% of patients with OSA are undiagnosed
Apnea

Defined as the cessation of airflow at the nose and mouth for greater than 10 seconds.

Considered obstructive if there is continued respiratory effort despite airflow cessation.

Hypopnea is defined as a 50% reduction in airflow for more than 10 seconds for 15 or more times per hour of sleep associated with snoring and a decrease in O2 sat by 4%.
AHI

- OSA is diagnosed via sleep study using an AHI

- To have OSA you must have:
  - Presence of at least 5 obstructive apneas, hypopneas or both per hour while the patient is asleep

- Graded into 3 levels of severity:
  - Mild (AHI >5 but <15 events per hour)
  - Moderate (AHI 15-30 events per hour)
  - Severe (>30 events per hour)
Airway obstruction

The site of upper airway obstruction is the pharynx.

Awake pts, patency of the airway is maintained by CNS mediated contraction of the tensor muscles.

When asleep, the tensor muscle tone is decreased and the adipose tissue that surrounds these muscles and airway structures “weigh” them down causing obstruction.
The Cycle of Airway Obstruction

- In response to the upper airway collapse and subsequent increased levels of CO2, the CNS will activate the pharyngeal dilator muscles which then opens the airway.

- After the airway is open, a period of hyperventilation occurs to reduce the effects of hypercarbia.

- Decreased CO2 causes the resp drive to be reduced/relaxed which in turn can start the cycle all over again.
Obese Hypoventilation Syndrome

- AKA Pickwickian Syndrome
- Complication of extreme obesity characterized by:
  - OSA
  - Hypercapnia
  - Daytime hyper somnolence
  - Arterial cyanosis induced polycythemia
  - Resp acidosis
  - Pulmonary hypertension
  - Right sided Heart Failure
OHS

- Diagnosed when the patient exhibits inappropriate or sudden somnolence, sleep apnea, hypoxia, and hypercapnia

- Alveolar ventilation is reduced d/t shallow and inefficient ventilation r/t decreased TV, inadequate inspiratory strength, and inadequate elevation of the diaphragm
Respiratory Summary

Changes

- Morbid obesity results in a typical restrictive pattern; decreasing FVC (25%-50% of predicted), FRC, and TLC, as well as causing a decrease in tidal volume and ERV (30%-60% of predicted). FRC decreases exponentially as BMI increases. Tidal volume may or may not be reduced.

Anesthesia Implications

- Rapid desaturation during apnea period of intubation; requires effective preoxygenation. Lower abdominal operations-FRC decreases by 10%-15%; upper abdominal procedures FRC decreased by 30%, and thoracotomy by 35%.

- With anesthesia, pneumoperitoneum, and supine or Trendelenburg position, further reduction in FRC will occur. Once FRC falls below the closing capacity of the lung, premature airway closure and atelectasis can occur, which subsequently will lead to ventilation/perfusion mismatch and impaired oxygenation.
Changes

• Decreased chest wall and lung compliance (especially with truncal obesity). Lung compliance can be reduced ≤40% in MO. Abdominal and peritoneal fat mass cause a cranial shift of the diaphragm (~4 cm in supine position), impairing lung expansion.

Anesthesia Implications

• Results in rapid, shallow breathing and increased work of breathing, with subsequent increase in O2 consumption and increase in CO2 production. Trendelenburg position exaggerates these effects.
Respiratory Summary

Changes

• Increased airway resistance due to small airway collapse, reduced volumes, and potential airway remodeling secondary to low adiponectin levels.

• Mild increase of the alveolar-arterial O2 gradient, hypoxemia on room air and K O2 consumption on exercise.

Anesthesia Implications

• Increased resistance is exaggerated in the supine and Trendelenburg positions.

• Ventilation/perfusion mismatch leads to hypoxemia
Respiratory Summary

Changes
• Decreased Tissue oxygenation

Anesthesia Implications
• Increased risk for wound infection; can be prevented by optimization of perioperative ventilation and oxygenation, proper antibiotic selection with appropriate dosing to reach adequate tissue concentrations, tight glycemic control, proper fluid and pain management, avoidance of hypothermia
Respiratory summary

Changes

• OSA

Anesthesia Implications

• Leads to hypoxemia and hypercapnia, increased susceptibility to the respiratory depressant effects of sedatives, opioids, and anesthetics.
• Increased risk for difficult intubation, and postoperative complications; hypoxia, apnea, respiratory arrest, hypertension, arrhythmias, and cardiac arrest.
• Increased risk for liver disease, liver fibrosis, and nonalcoholic fatty liver disease.
• Increased risk for right heart side HF.
Respiratory summary

Changes

• OHS

Anesthesia Implications

• High risk for postoperative respiratory complications; more likely to develop opioid-related side effects.
• Patients have compromised central respiratory drive. Main treatment is positive airway pressure therapy, and appropriate sleep referral may be mandated before major surgery
Gastrointestinal considerations
GI

- Incidence of GERD, gallstones and pancreatitis increases with obesity

- Obesity is associated with nonalcoholic fatty liver disease, which includes steatosis, steatohepatitis, fibrosis, cirrhosis, hepatomegaly, and abnormal liver chemistry.
Liver Impairment

- Usually caused by triglycerides invading hepatocytes

- Triglycerides block bile canaliculi causing elevated serum alkaline phosphatase causing the hepatic cells to degenerate and become necrotic dumping their collagen stores.

- Portal inflammation or fibrosis ensues in 29% of pts; 3% of these pts progress to cirrhosis.
Gallstones

- Gallstones are 30% more prevalent in obese women than nonobese women.

- Gallstones result from increased concentrations of cholesterol in the bile and an increased ratio of bile salts to lecithin.
Endocrine

- Obese men tend to experience decreased libido or impotence indicative of hypogonadism
- Risk of type 2 diabetes increases linearly with obesity
- Metabolic Syndrome AKA Syndrome X-characterized by insulin resistance, impaired glucose tolerance, type 2 diabetes, dyslipidemia, and hypertension.
- Osteoarthritis develops from continued stress on weight bearing joints.
Metabolic syndrome dx criteria

• Three or more of the following must be present:
  • Waist circumference > 102 cm men; > 88 cm women.
  • Serum triglycerides > 150 mg/dl
  • HDL cholesterol < 40 mg/dl men; < 50 mg/dl women
  • SBP > 130/DBP > 85 mmHg or on Rx for hypertension.
  • Fasting BG > 110 mg/dl or Rx for diabetes
Changes

• Syndrome X

Anesthesia Implications

• Impaired glucose tolerance even without diabetes mellitus can lead to disturbances of the autonomic nervous system with abnormal adrenergic reflexes in ~25% of patients.

• Syndrome X is an independent predictor of postoperative complications, and increases the risk for pulmonary atelectasis, pneumonia, ARDS, and respiratory failure and cardiac issues.
Changes
• GERD, chronic gastritis, and gastroparesis.

Anesthesia Implications
• Sufficient NPO time (although there is a lack of specific recommendations for obese patients).
• Premedications and precautions; consider these patients to have a full stomach.
GI/endocrine Summary

Changes

- Type 2 diabetes, as a result of hepatic steatosis and dysregulation of glucose metabolism.
- Stiff Joint Syndrome-caused by glycosylation of collagen and its deposition in the joints.

Anesthesia Implications

- Optimize glycemic control.
- Pt may have an increased risk for difficult intubation. A good indicator of this syndrome is to ask the patient to put hands in a prayer position and look for stiff fingers or joint deformities.
Changes

• Hepatic steatosis
• Hypothyroidism
• Renal: glomerular hyperfiltration and increased creatinine clearance

Anesthesia Implications

• May affect drugs that are metabolized in the liver
• Drug metabolism maybe slower. Patients may have increased sensitivity to respiratory depression
• May affect drugs that are cleared by the kidneys
Gi/endocrine summary

Changes
- Thiamine deficiency
- Iron and vitamin B12 deficiency

Anesthesia Implications
- May present with neurologic symptoms that may be misinterpreted as regional or neuraxial anesthesia side effects
- Concomitant anemia of different underlying causes
Pediatric obesity
Pediatric obesity

- More common than diabetes, HIV, cystic fibrosis, and all childhood cancers COMBINED.

- Obese kids are at a 3 fold higher risk for hypertension than non obese children

- Obesity is clinically diagnosed as a weight for height greater than the 90\textsuperscript{th} percentile or a BMI $\geq 95\textsuperscript{th}$ percentile per the CDC

- Adolescents tend to be more overweight than preschool children
Pediatric obesity associated conditions

- Childhood obesity is associated with the following:
  - Primary hypertension
  - Type 2 diabetes
  - OSA and sleep disordered breathing
  - Psychosocial disorders
  - Coronary artery disease
  - Insulin resistance
  - Metabolic syndrome

- In other words: everything also associated with obesity in adults!
Syndrome x in peds

- AKA Metabolic syndrome AKA Insulin Resistance Syndrome

- Underlying risk factors include:
  - Abdominal obesity (apple shape)
  - Insulin resistance
  - Hypertriglyceridemia
  - Hypertension
  - Proinflammatory and prothrombotic states
Complications of obesity in children

- Usually affect cardiac, respiratory, gi, endocrine systems as well as joints and bones.

- **Cardiac effects:** dyslipidemia and hypertension
- **Respiratory:** Sleep apnea, snoring, asthma
- **GI:** gallbladder disease/stones; steatohepatitis
- **Endocrine:** insulin resistance, hyperinsulinism, impaired glucose tolerance, type 2 diabetes
- **Ortho:** Blount’s disease, slipped capital femoral epiphysis
Maternal obesity
Maternal obesity

- Most important link to nation’s increase in mean birth weight
- First and 2\textsuperscript{nd} stages of labor are longer in obese women
- Obese women who are pregnant are more likely to have gestational diabetes, preeclampsia, preterm labor, c-section, postpartum hemorrhage, infection, pregnancy induced hypertension, and macrosomic infants.
Maternal obesity

- During pregnancy, weight gain should be limited following the IOM suggestions:
  - 25-35lb increase in nonobese women
  - 15-25lbs in overweight
  - 15lbs in obese women

- Newborns considered large for gestational age (LGA) are considered macrosomic.

- Fetal macrosomia is defined as a birth weight > 4000 grams
Children born to Moms who had a BMI > 30 in the 1st trimester are approx. 20% more likely to be obese.

FYI:
- Metabolic Syndrome in pregnancy manifests as preeclampsia, gestational hypertension, insulin resistance, and diabetes
pharmacology
Volume of distribution

- Alterations in VOD are related to:
  - size of the fat organ
  - increased blood volume
  - increased cardiac output
  - decreased total body water
  - alterations in protein binding
  - lipophilicity of the drug
• Increased VOD requires higher doses of lipophilic drugs to produce desired pharmacological effects

• These increased doses can prolong elimination of certain drugs such as benzos

• Protein binding and end organ clearance also affect VOD

• Doses of drugs with moderate to high lipophilic tendencies should be based on Ideal Body Weight
Fentanyl

• Highly lipophilic synthetic opioid

• Clearance not correlated with TBW >70 kg

• “Dosing weight” is based on pharmacokinetic mass (the body mass to which the drug is redistributed) and not actual body weight.
<table>
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<th>Pt’s weight</th>
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<td>107 kg</td>
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<td>200 kg</td>
<td>109 kg</td>
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Corrected body weight drugs

- CBW = IBW + (0.4 x excess weight)

- The following drug dosages should be based on CBW prior to administration:
  - Propofol
    - 1.5-2.5 mg/kg for induction (CBW)
  - Neostigmine
    - (usual max dose is no more than 5mg)
  - Lidocaine
    - 1.5 mg/kg bolus, and 2 mg/kg/h infusion
The following drug dosages should be based on IBW prior to administration:

- Vecuronium
  - 0.1-0.12 mg/kg (IBW)

- Rocuronium
  - 0.6-1.2 mg/kg (IBW)

- Remifentanyl
  - 1 mcg/kg for endotracheal intubation, and 0.2-2 mcg/kg/min for infusion (IBW)

- Etomidate
  - 0.2 mg/kg (IBW)
Sux

- Gold standard for RSI

- Dosage based on TBW, however recommended max dose is 150 mg

- Obese patients that have received greater than 150 mg have reported phase 2 block, bradycardia, and gross fasciculations
• Sometimes preferred over inhalational agents because IA’s diffuse into the fatty tissue and can delay recovery

• Advantages of TIVA include:
  • Better intraop hemodynamic stability
  • Early recovery from GA
  • Better post op analgesia

• Short acting agents such as Remi, propofol, and precede are preferred
Key points

- Lipophilic drugs have > volume distribution and > elimination half-life.
- Hydrophilic drugs have similar volume of distribution if adjusted for BSA
- > dose of succinylcholine required due to > pseudocholinesterase.
- > metabolism of volatile agents and > fluoride ion release.
Other considerations

- Faster emergence associated with Des>Sevo>Iso

- Elimination of drugs in obese patients is normal or slightly increased in phase 1 reactions; Increased in phase 2 reactions.

- Longer needle may be needed for IM injections
Anesthetic considerations
Central nervous system
- Decreased central respiratory drive

Respiratory
- Restrictive chest physiology
- Pulmonary hypertension
- Hypoxemia/hypercapnia

Airway
- Potential difficult airway
- Obstructive sleep apnea

Cardiovascular
- Coronary artery disease
- Congestive heart failure

Others
- Difficult vascular access
- Difficult positioning
• Goal of preop assessment is treatment and optimization of comorbidities such as htn, CAD, diabetes, OSA, and venous thromboembolism.

• Thorough H&P, vital signs, baseline labs and ekg should be obtained as well as informed consent
• CV assessment should contain a review of pt’s history of dyspnea, orthopnea, exercise limitations and palpations.

• Review history for prior MI, htn, angina

• Signs of cardiac failure include:
  • Raised JVP
  • S3, S4
  • Pulmonary crackles
  • Hepatomegaly
  • Peripheral edema
CV Assessment

- Measure non invasive BP with proper sized cuff
- Cuff size should be greater than 20% of upper diameter
- In the morbidly obese, invasive BP monitoring is recommended
- In presence of pulmonary htn, avoid hypoxemia, and N2o.
- In severe pulm htn pts consider monitoring pulmonary artery pressures via catherization
Thromboprophylaxis

- DVT is the most common post op complication of bariatric surgery.
- (DVT > NERVE INJURY)
- Consider use of pneumatic compressive devices during procedure.
- Pts at high risk of DVT may have IVC filters placed prior to bariatric surgery
The best way to predict difficult intubation in obese patients is still being debated.

The following is a summary of the most useful predictors:

- Mallampati score (≥3) and large neck circumference (NC; >40 cm) may increase the chances for difficult laryngoscopy (intubation with the traditional laryngoscope).

- NC should be measured at the level of the thyroid cartilage.
  - A neck diameter of 50 cm carries a risk for difficult intubation of about 20%.

- Thyromental distance (TMD; <6 cm) is another predictor. TMD is the distance from the thyroid notch to the mentum in centimeters.
Preop ABG should be considered

As pt’s O2 reserve is reduced, they desat rapidly. Therefore preoxygenation is essential prior to intubation.

Higher inflation pressure is needed d/t decreased chest wall compliance

Application of PEEP

Avoid sedative premed
Difficult airway predictors

- High BMI
- Decreased incisor gap
- Sternal pad of fat
- Limited mobility at TM or AO joint
- Short thick neck
- Large breasts
Preoxygenation

- Very important in these patients to compensate for their high lability with rapid desaturation during intubation.

- As these patients are also likely to be difficult to ventilate by mask, proper face mask selection is critical.

- Preoxygenation for 3 minutes in the 25-degree head-up (“ramped”) position achieves a 23% increase in oxygen tension and a clinically significant increase in the desaturation safety period, in comparison to preoxygenation in the supine position.

- This preoxygenation technique can be further enhanced by augmenting the FRC using 5 to 10 cm H2O CPAP.
Induction

- Use oropharyngeal airway during mask ventilation

- If airway management and intubation prove difficult consider emergency airway adjuncts (LMA, bougie, glidescope, etc)

- Trach kit should be available if needed

- ETCO2 monitor should be used to confirm placement of ETT as breath sounds are inherently distant in the obese patient
• One of the major airway issues that occurs after anesthesia induction is collapse of the soft tissue of the pharynx as a consequence of loss of muscle tone, which is more pronounced in morbidly obese patients, especially when they lie supine and when they have associated OSA.

• This is why OSA is a good predictor for difficult intubation.

• This fact has caused some experts to believe that intubation should be done awake. We recommend that when awake FOI is required, the patient should be in the semi-sitting position and it might be better if airway is approached from the front.
• A ramped position has been proposed to facilitate ventilation and visualization of the glottis for intubation. The external auditory meatus and sternal notch should align horizontally at the same level.

• Current research has shown that video assisted tracheal intubation had a 100% success rate, shorter duration to tracheal intubation, and better arterial oxygenation quality compared with the Macintosh laryngoscope.

• If awake FOI is mandatory, adequate airway topicalization (anesthetizing) and/or remifentanil (0.05–0.1 mg/kg/min IBW) can be successfully used.
FIGURE 1. Operating table with a ramp made with blankets (A); MRI scan of the upper airways in the supine position (B); Patient placed in the ramped position with external auditory meatus and the sternal notch horizontally aligned (C); MRI scan of the upper airways in the ramped position, showing a better alignment of the axis compared to the supine position, similar to what happens in the sniffing position in lean patients.

MA: mouth axis; PA: pharyngeal axis; LA: laryngeal axis; LV: line of vision, $\alpha$, $\beta$, and $\delta$: angles between the axis
H.E.L.P.

- **Head Elevated Laryngoscopy Position**

- Importance of proper positioning of obese patients prior to induction/intubation is essential for successful intubation

- Can also use “ramping” wherein blankets/pillows are placed under the patient
Position for intubation

- Supine sniffing position with 30° back-up position provides optimal conditions for successful intubation.
- Aligning the external auditory meatus with the sternum horizontally has been shown to improve the laryngoscopic view.
• Common practice in obese patients and is used to avoid the risk for aspiration.

• Rather than giving a hypnotic (such as propofol) followed by a muscle relaxant (such as rocuronium) after loss of consciousness and the ability to mask-ventilate has been confirmed, both drugs are administered almost simultaneously, to shorten the time span between spontaneous breathing and intubation.

• Additionally, cricoid pressure may be maintained to prevent regurgitation of stomach contents.
• Placement of central venous catheters should be avoided as much as possible, as these patients may have concomitant CF and may decompensate if placed in the supine or head-down position to facilitate line insertion.

• Even in the absence of major cardiac issues, prolonged periods in those positions can cause respiratory decompensation, mainly in the awake patient.

• Central line placement in the sitting position carries a high risk for air embolism.

• Ultrasound-guided vascular access can be of great benefit for inserting central lines, if absolutely indicated, peripherally inserted central catheters and peripheral lines.
Maintenance Fluids—should always be administered based on patient IBW

- To avoid overload consequences and maintain good hydration and oxygenation, careful perioperative fluid management is crucial in obese patients.

- Calculation of Estimated Blood Volume should be based on 45-55 ml/kg

- Volume expanders such as Hespan should not be administered at greater than 20 ml/kg of IBW

- For blood loss-3:1 for crystalloids based on TBW; 1:1 for blood products based on TBW
Intra OP Ventilation

Tidal volume of 6-10 mL/kg (IBW) with respiratory rate that maintains normocapnia (aim: pH 7.3-7.45).

Use of recruitment maneuvers (plateau pressure ~40-55 cm H2O) for 7-8 sec, as long as the patient is hemodynamically stable, after induction and before extubation, and whenever indicated.

Avoid losing PEEP effect by suctioning the tube or by accidental disconnection of the circuit.
PEEP

• Application of PEEP 10 cm H2O until extubation.

• Severely obese patients may require ≤15 cm H2O.

• PEEP: Only ventilatory parameter shown to improve respiratory function in obese.
  • Improves ventilation-perfusion matching and arterial oxygenation.
Intra op ventilation

Use of reverse Trendelenburg position whenever possible, from the time of preoxygenation to extubation.

FiO2 between 0.4 and 0.8, even during the preextubation period, as higher levels may lead to formation of resorption atelectasis.
Recommendations for intraoperative ventilation of obese patients

Ventilatory mode
VCV = PCV
PCV-VG may be helpful

Airway pressure
PIP/Ppl ≤ 30 cmH₂O as suggested reasonable target

Tidal volume
6-8 mL/kgPBW as suggested reasonable target

Respiratory rate
Titrated for normocapnia

FiO₂
Minimize to assure SpO₂ ≥ 90%

Perioperative adjuvant maneuvers
Position: head-up or reverse Trendelenburg
Encourage deep breathing: incentive spirometry, early mobilization
Consider perioperative CPAP/BiPAP (pre-induction, postoperative)
Minimize respiratory depressants, consider regional technique
Prepare for possible difficult airway management

PEEP
Optimal fixed PEEP unknown
PEEP titrated to maximum Cdyn, PaO₂, or SpO₂ seems reasonable
Combined with recruitment maneuvers, more efficient in reducing atelectasis and improving oxygenation. Prepare for possible hypotension

(Cdyn=Dynamic compliance; BiPAP=Bilevel positive airway pressure; CPAP=Continuous positive airway pressure; FiO₂=Inspiratory fraction of oxygen; PaO₂=Arterial oxygen partial pressure; PBW=Predicted body weight; PCV=Pressure controlled ventilation; PCV-VG=Pressure controlled ventilation volume guaranteed; PEEP=Positive end-expiratory pressure; PIP=Peak inspiratory pressure; Ppl=Plateau airway pressure; SpO₂=Peripheral saturation of oxygen by pulse oximetry; VCV=Volume controlled ventilation)
Intra op ventilation

- Use a ratio of the duration of inspiration to expiration of 1:1-1:3.

- Monitor peak airway pressure and airway plateau pressure ($\leq 30$ cm H2O).

- Extubation should be after ensuring adequate reversal of NMB, with the patient positioned almost upright or in reverse Trendelenburg, and fully awake.
Supine position

- Stretch injury to the brachial plexus and ulnar neuropathy among the most commonly reported.

- Prolonged hyperextension, external rotation or abduction greater than 90 degrees can cause post op muscle pain, nerve palsies or paralysis.
Supine positioning causes:
- Ventilatory impairment
- Inferior vena cava and aortic compression
- FRC and oxygenation further decreased by supine positioning.

- Avoid Trendelenberg position if possible in obese.
- Reverse Trendelenberg position provides longest safe period of apnea at induction.
- Lateral position provides better diaphragmatic excursion than prone positioning.
Lithotomy position/laparoscopic insufflation

- Compression damage to the lateral femoral cutaneous nerve (meralgia paresthetica); patients usually develop pain, paresthesia, or hypersensitivity in the anterolateral aspect of the thigh.

- Bilateral sciatic nerve palsy after bariatric surgery was reported in a patient with BMI 78 kg/m² after prolonged laparoscopic surgery, despite adequate precautions.
Vagus nerve injuries

- Vagal nerve injury is common especially in gastric banding surgery.
  - Usually presents with nausea and vomiting secondary to decreased gastric motility.
- Excessive vagal nerve stimulation that may be associated with an intragastric balloon overstretching the gastric wall may lead to bradyarrhythmia and cardiac arrest.
Other nerve injuries

- Lower back pain can be aggravated by both GA and spinal anesthesia because of ligamentous relaxation that results in loss of spinal curvature.

- Genital and pudendal nerve injury usually results from adipose tissue surrounding the thighs that isn’t properly padded.
Positioning key points

- Regular OR tables have weigh limit of 205Kg.
- Brachial plexus, ulnar lower extremity nerve injuries frequent.
- Carpel tunnel syndrome most common mononeuropathy after bariatric surgery.
Pain management

- Continuous peripheral nerve blocks, local anesthetic wound infiltration, or TAP block also are useful.

- If opioids are required, use a minimally effective dose.

- Ultrasound-guided TAP block after laparoscopic bariatric surgery has been found to be feasible and reduces opioid requirements, improves pain score, decreases sedation, promotes early ambulation, and results in greater patient satisfaction.

- The use of opioid-free total IV anesthesia (with propofol, ketamine, and dexmedetomidine) was associated with a large reduction in relative risk for PONV compared with balanced anesthesia (volatile anesthetics and opioids).
Regional anesthesia

- Can be used as primary or complimentary anesthetic

- Inherent challenges in the obese population
  - Unable to palpate landmarks
  - Risk of ventilatory and circulatory collapse
  - May require longer needles and use of ultrasound device
  - Positioning for spinals/epidurals may be a challenge
  - Loss of resistance may be hard to appreciate
Regional anesthesia

- Local anesthetic requirements for spinal and epidural are < 20% when compared to nonobese
- Height of subarachnoid block unpredictable
- Extubate when fully recovered from depressant effects of anesthetics.
- Recover in head up, sitting position.
• Combined epidural and general anesthesia can be given to decrease doses used for GA drugs

• Epidurals have been shown to decrease post op complications

• Fatty infiltration of the epidural space as well as increased blood volume caused by increased intra-abdominal pressure may reduce the volume of the epidural space resulting in an unpredictable spread of anesthetic and block height.
Regional anesthesia

- Abdominal wall muscles play the major role in forced expiration.

- These may become less effective in the presence of a good epidural block.

- Moreover, there are significant practical difficulties in siting epidural catheters in the morbidly obese.

- These include the lack of palpable bony landmarks, the depth of the space (extra long needles may be required), and ‘false’ loss-of-resistance in fatty tissues. A multimodal analgesic approach is often required.
Questions?