Does Size Matter?
Anesthetic Considerations for the Obese Patient

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What does Obese Mean?

- **Obesity**: Excess Adipose Tissue or Body Weight ≥ 20% of Ideal Body Weight (IBW)
- **Morbid Obesity**: Body weight ≥ 2x Ideal Body Weight (IBW)

Ideal Body Weight / Obesity Calculation

- **Broca's Index for IBW**
  - Male: Height (cm.) - 100 = Weight/ kg
  - Female: Height (cm.) - 105 = Weight/ kg

- **Body Mass Index (BMI)**: \( \frac{Wt\ (kg)}{Ht\ (cm)^2} \)
  - BMI ≥ 25 = Overweight
  - BMI ≥ 30 = Obese
  - BMI ≥ 40 = Morbid Obese

  "Quick BMI" calculation: 703 x Lbs./in.²
Obesity Trends

  - 1991
    - 19.8% Americans classified as Obese
    - 38.8 million Americans classified as Obese (BMI ≥ 30)
    - Male: 19.6 million
    - Female: 19.2 million
  - 2000
    - Obesity prevalence from 19.8% to 20.9%
    - 2003
      - 44 million Americans are Obese
      - BMI > 30
      - 74% ↑ since 1991

2009 Obesity Rates

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Obesity Trends* Among U.S. Adults

(*BMI ≥ 30, or about 30 lbs. overweight for 5'4" person)

![Map of the United States showing state-specific prevalence of obesity among U.S. adults by race/ethnicity, 2006-2008.](Image)

"*BMI ≥ 30"

### Hispanic State-specific Prevalence of Obesity Among U.S. Adults, by Race/Ethnicity, 2006-2008

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### Prevalence of obesity, by region and race/ethnicity, 2006-2008

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## Cardiovascular

- Fatty Infiltrate of Heart Muscle
- Conduction Interference
- ↑ Predisposition to Sudden Death
- ↑ TBV
  - Plasma Volume
  - Vasculature “Highway”
  - Cardiac Output
  - ↑ Oxygen demands
Cardiovascular

- Cardiac Output (CO)
  - 1 kg body fat $\rightarrow$ ↑100 cc CO
  - Adipose tissue perfusion
    - 1 kg fat $\rightarrow$ 3,000 meters of blood vessel

- ↑ Stroke Volume
- Hypertension
  - Cardiomegaly
  - LVF
  - Pulmonary Hypertension

Cardiovascular

- Pulmonary Hypertension
  - Symptoms: Exertional Dyspnea/ Syncope
  - EKG Findings:
    - Tricuspid Regurgitation
    - Hallmark Identifier
    - RV Hypertrophy
      - Tall Precordial R waves
      - R Axis Deviation
      - RV strain
  - ↑ PA Pressures: ↑ Sensitivity of EKG

Lean Normotensive

Obese Normotensive

Lean Hypertensive

Obese Hypertensive

Dilation

Hyper trophy

Dilation and Hypertrophy

Congestive Heart Failure
Pulmonary

- Low Respiratory Compliance
  - Decrease FRC, VC, TLC
  - ↑ Weight; ↓ FRC
  - Small Airway Closure
  - Changes in TV
  - Normocarbic
  - Minute Volume
  - Normal response to CO₂

- Hypoxemia
  - Results from ↑ Metabolic Demands
  - ↑ Work of Breathing
  - Oxygen saturation
  - V/Q Mismatch
  - Intrapulmonary Shunt
  - Closure of Smaller Airways

- Pulmonary
  - Pickwickian Syndrome/ Obesity-Hypoventilation Syndrome
    - Loss of Hypercarbic Drive
    - Hypersomnolent
    - Difficult Airway
      - Neck Circumference
      - Mallampatti Score

- Pulmonary
  - Obstructive Sleep Apnea
    - Hypoxemia
      - Polycythemia
      - Hypercarbia
      - Hypersomnolence
      - Pulmonary Hypertension
      - Biventricular Failure
Pulmonary Changes

- Increasing Obesity
- Tidal Volume
- Expiratory Reserve Volume
- Residual Volume

Metabolic

**Hepatic**
- Elevated Enzymes
- Fatty Infiltrations of Hepatocytes
- Inflammation
- Focal Necrosis
- Cirrhosis

**Renal**
- ↑ GFR
- Focal Glomerular Sclerosis
- Proteinuria
- Declining Renal Function

**Gastrointestinal**
- ↑ GFR
- Focal Glomerular Sclerosis
- Proteinuria
- Declining Renal Function

**Endocrine/ Metabolic**
- Diabetes
  - Impaired Glucose Tolerance
- Pancreatic Islet Hypertrophy & Hyperinsulinemia
- Abnormal Lipid Profiles
- Due to ↑ Tissue Mass
  - ↑ Total O2 consumption
  - ↑ CO2 production
Pre-Op Considerations

- Physical and Metabolic Work-Up
  - Increased incidence Obesity related maladies
    - Cardiac
    - Pulmonary Disease
- Risk Stratified Classification
  - Based on History and Physical findings
  - Low: 1 Risk Factor
  - Intermediate: 2-3 Risk Factors
  - High: > 3 Risk Factors

Pre-Op Considerations

- Anticipated Events
  - Central Line Placement
  - Arterial Cannulation
  - Awake Intubation
- Medication usage
  - Continue Regular Regimen
    - Exception: Insulin, Oral Hypoglycemics
  - Weight reduction agents

Pre-Op Considerations

- DVT Prophylaxis
  - Heparin 5000u SQ
    - Before Surgery & 12 hours until mobilized
  - LMW Heparin
    - ↑ Bioavailability with SQ injection
- Anxiolysis
  - Benzodiazepines
    - Minimal Respiratory Depression
Pre-Op Considerations

- Airway examination
  - Neck Circumference
  - Mallampati
  - OSA
- Aspiration Prophylaxis
  - H$_2$ Receptor Antagonists
  - Nonparticulate Antacids
  - Protein Pump Inhibitors

Airway Considerations

- Anatomy
  - Low Cervical/High Thoracic Fat Pads
  - Numerous "chins"
  - Limited ROM of Neck
    - Restricted Neck Flexion/Extension
    - Restriction of Atlantoaxial Joints
  - Increase Tissue Mass
    - Oral and Pharyngeal Structures
    - Airway narrowed

Intubation Preparation

Airway Examination

- Mallampati Exam
- Neck Circumference
  - 16" for women
  - 17" for women
- SAS

Risk Factors

- Morbidly Obese
- "Superobese": BMI >50
- OSA
- Documented GERD
- Neck Circumference
  - Mallampati Score
Mallampatti AW Classification

- Technique
- Determined by Severity of Obesity
- RSI
- Morbid Obesity
- Awake or w/o Relaxation
  - BMI > 50
  - OSA
  - Neck circumference

Intubation Preparation

- Position
  - Stacking Position
    - Goal: Tip of Chin higher than Chest level
  - Troop Elevation Pillow
  - Reverse Trendelenburg
    - Increases respiratory excursion
    - Enhances oxygenation
Logistical Considerations

- Equipment
  - OR Table
    - Decades ago: OR table weight limit: 250# / 91 kg
    - Necessitated putting 2 OR tables together for Obese Patient
  - Present table: 450#/ 205 kg
  - Special OR table: #1007/ 455 kg
- BP Cuff
  - Bladder should encircle ≥ 75% of arm.
  - Vasotrac: noninvasive measures at radial artery
    - Accuracy/ Dependability

Positioning Considerations

- Nerve Injury and Pressure Sores
  - More prevalent in the Obese
  - Stretch Injuries
    - Extreme Abduction
    - Extremity Weight
  - Traction Injury
    - Sciatic
    - Lateral Femoral Cutaneous
    - Ulner
  - Bean Bag for Positioning
Medication Dosing Properties

- Majority of Dosing
  - Ideal Body Weight (IBW)
  - Lean Body Mass (LBM)
  - Corrected Body Weight (CBW)
    - \[ IBW + (0.4 \times \text{excess weight}) \]

Anesthetic Agents Properties

- **Lipid Soluble Drugs**
  - Longer Elimination 1/2 life
  - Redosing at longer intervals
  - Require larger loading dose
    - Barbiturates
    - Benzodiazepines

- **Volatile Agents**
  - Not weight dependent
  - Age-dependent dosing

- **Water-soluble (Hydrophilic)**
  - Dosed by Lean Body Mass (LBM)
  - Ideal Body Weight (IBW) + 20%

- **Non-Depolarizing Neuromuscular Agents**

Which Anesthetic Agents to Use?

- **Induction**
  - Etomidate
    - Large Volume of distribution
    - Titrated to effect
    - Goal Cardiac Stability
  - Propofol
    - Clearance exceeds normal Hepatic Blood Flow
    - Dosage calculated by CBW
Which Anesthetic Agents to Use?

- **Muscle Relaxants**
  - **Depolarizers**
    - Pseudocholinesterase in Obesity
    - **Dose to 1.2-1.5 mg/kg**
  - **Nondepolarizers**
    - Prolonged 1/2 life with Hepatic elimination drugs
      - Pancuronium
      - Vecuronium
      - Rocuronium
    - **Hoffman Elimination**
      - Cisatricurium
      - Atracurium

- **Opioids**
  - Lipophilic
    - Suggests higher Volume of Distribution
  - **Sensitivity to respiratory depressants in Obese**
  - **Dosage Recommendations**
    - Corrected Body Weight
      - Fentanyl
      - Alfentanil
    - Ideal Body weight
      - Remifentanil

Anesthetic Solubility:
Effects on Recovery in the Obese

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**Blood:gas solubility** has been shown to correlate with speed of recovery in morbidly obese patients.
- Slower recovery with the more soluble isoflurane vs. Enflurane
- No evidence that **fat: blood solubility** of anesthetic agents affects recovery time in obese patients

References:
- Roizen In: Anesthesia. 5th ed. 2000:903
- Cork et al.; Anesthesiology. 1981;54:310
Does Fat Solubility Affect Recovery?

Supine Position
- Respiratory
  - ↓ FRC
  - ↓ Compliance
  - ↑ V/Q Mismatch
  - ↑ Intra-abdominal Pressure
  - ↑ Splintering effect of abdominal contents on diaphragm
- Cardiovascular
  - Vena Cava Compression
  - ↓ TBV
- Oxygenation
  - PEEP
  - ↓ Intrathoracic Pressure
  - Lifting of Pulmonary
  - ↑ Pulmonary Compliance
  - ↑ BV
- Obesity Supine Death Syndrome
  - ↑ Intra-abdominal Pressure
  - ↓ Oxygenation
  - ↓ Compliance
  - ↑ V/Q mismatch
  - Volume shift to hyperactive/hypoxic heart
  - Fatal outcome

Trendelenburg Position
- Less tolerance than Supine
- Pulmonary
  - Weight of Abdominal Contents and Chest
  - Further ↓ in FRC/compliance
  - Results in Atelectasis/Hypoxemia
- Cardiovascular
  - Auto-transfusion: Lower Extremities → Central and Pulmonary System
  - ↓ PaO2 when going from Supine to Trendelenburg
Other Positions

- **Head-Up**
  - Increases in
    - FRC, Pulmonary Compliance
    - Oxygenation
  - Change from Head Up to Supine (Post-Op)
    - Decreases Effect
      - Venous Compression
      - Decrease CO

- **Prone**
  - Abdomen hangs freely
    - Reduces in Cephalad displacement of Diaphragm
    - Re-opening of atelectatic lung segments
  - Abdomen Compressed
    - Improves diaphragm
    - Restricts chest wall movement
    - Extends V/Q mismatch
    - Compression of Veins/Cava

Other Positions

- **Lateral Decubitus**
  - Panniculus displaced off the abdomen
  - Decrease in abdominal pressure
  - Greater Diaphragmatic excursion
  - Preferred position for prone position procedures

- **Lithotomy**
  - Decrease in VC
  - Restricts Diaphragmatic movement
  - Cardiac output
    - ↑ Venous return
    - ↑ Pulmonary blood flow
  - Positive Pressure Ventilation required in obese patient

Ventilation Considerations

- **Mechanical Ventilation**
  - Body Mass affects:
    - Lung Volume
    - Respiratory Mechanics
    - Gas Exchange
  - Traditional Thinking
    - Increase Tidal Volume
    - Increase Rate
    - Does NOT enhance ventilation
  - **PEEP**
    - Positive; Improves Oxygenation and Respiratory function
    - Negative; ↑ V/Q Mismatch
  - Monitor PAWP
Laparoscopy and Anesthesia

- Systemic Changes
  - Intra-abdominal Pressure (IAP)
  - Effects on venous return
  - Myocardial performance
- Biphasic Cardiovascular response
  - IAP < 10 mm Hg: Venous return
  - IAP > 20 mm Hg: Compression of inferior vena cava
- Trendelenburg Position
  - Cephalad displacement of diaphragm
- V/Q mismatch
- Pneumoperitoneum
  - CO₂ absorption
  - Acidosis
  - Changes in GFR
  - Gas Embolism
  - Pneumothorax
  - Mediastinal Emphysema

Which Type of Anesthesia

- General
- Regional
- General/Regional Combination

Thank you...
for your Attention

Questions?
Trends in Obesity

Classifications of Obesity

- National Institute of Health
  - Grade I: BMI 25 - 29.9 kg/m²
  - Grade II: BMI 30 - 39.9 kg/m²
  - Grade III: BMI 40 kg/m²

- BMI / Percentage Overweight
  - Normal: BMI < 24.0
  - Mild: BMI 27-29 < 10% overweight
  - Moderate: BMI 30-35 10%-40% overweight
  - Severe: BMI > 35 > 100% overweight
  - Morbid Obesity: 2x IBW or BMI > 35

Obesity Loves Inequity

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<td>8%</td>
<td>8%</td>
</tr>
</tbody>
</table>

# Obesity and Age

![Bar chart showing age-adjusted prevalence of overweight and obesity among U.S. adults, age 20-74 years.](chart)

*Note: Data adjusted for race/ethnicity and age.*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Overweight or obese (BMI &gt; 25.0)</td>
<td>47%</td>
<td>58%</td>
</tr>
<tr>
<td>Obese (BMI &gt; 30.0)</td>
<td>15%</td>
<td>23%</td>
</tr>
</tbody>
</table>

# Obesity and Youth

![Bar chart showing prevalence of overweight among children and adolescents ages 6-19 years.](chart)

*Note: Data collected from 1983-94 and 1999-2000. Survey participants are age 6-19 years. Data adjusted for age/sex and race/ethnicity.*

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6-11</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>12-19</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>11</td>
<td>18</td>
</tr>
</tbody>
</table>

# Obesity in US Cities

<table>
<thead>
<tr>
<th>City, State</th>
<th>Highest Rate</th>
<th>Lowest Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Antonio, TX</td>
<td>31.1%</td>
<td>14.2%</td>
</tr>
<tr>
<td>Gary, IN</td>
<td>28.8%</td>
<td>15.0%</td>
</tr>
<tr>
<td>Jackson, MS</td>
<td>27.6%</td>
<td>15.1%</td>
</tr>
<tr>
<td>Fort Wayne, IN</td>
<td>27.3%</td>
<td>15.8%</td>
</tr>
<tr>
<td>Shreveport-Bossier City, LA</td>
<td>28.7%</td>
<td>16.1%</td>
</tr>
</tbody>
</table>
## Overweight in US Cities

<table>
<thead>
<tr>
<th>Cities</th>
<th>Rate</th>
<th>Cities</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charleston, WV</td>
<td>67.8</td>
<td>Portland, ME</td>
<td>49.3</td>
</tr>
<tr>
<td>San Antonio, TX</td>
<td>68</td>
<td>Burlington, VT</td>
<td>49.3</td>
</tr>
<tr>
<td>San Diego, CA</td>
<td>64.8</td>
<td>Rapid City, SD</td>
<td>51</td>
</tr>
<tr>
<td>Tulsa, OK</td>
<td>64.4</td>
<td>Honolulu, HI</td>
<td>51.2</td>
</tr>
<tr>
<td>Jackson, MS</td>
<td>63.1</td>
<td>Provo-Orem, UT</td>
<td>51.8</td>
</tr>
</tbody>
</table>

## Impact of Obesity

- **CV Implications**
  - Ischemic Heart Disease
  - Hypertension
  - Essential
  - Pulmonary
  - Left Ventricular Hypertrophy
  - Congestive Heart Failure
- **Metabolic**
  - Type 2 Diabetes
  - Cholelithiasis
  - Dyslipidemias
- **Pulmonary**
  - Obstructive Sleep Apnea
  - Rapid Desaturation
- **Skeletal**
  - Degenerative Joint Disease
- **Psychological**
  - Depression
  - Emotional Distress
- **Socioeconomic**
  - Discrimination
  - Social Stigmatization

## Obesity by Region

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>New England: CT, MASS, ME, NH, RI, VT</td>
<td>9.9</td>
<td>11.4</td>
<td>16.9</td>
</tr>
<tr>
<td>Mid-Atlantic: NJ, NY, PA</td>
<td>12.7</td>
<td>16.7</td>
<td>18.4</td>
</tr>
<tr>
<td>East North Central: IL, MI, OH, WI</td>
<td>14.1</td>
<td>19.1</td>
<td>21.0</td>
</tr>
<tr>
<td>West North Central: IA, KS, MN, MO, ND NE, SD</td>
<td>12.2</td>
<td>18.0</td>
<td>19.9</td>
</tr>
<tr>
<td>South Atlantic: DC, DE, FL, GA, MD, NC, SC, VA, WV</td>
<td>11.1</td>
<td>18.6</td>
<td>19.3</td>
</tr>
<tr>
<td>East South Central: AL, KY, MS, TN</td>
<td>13.1</td>
<td>20.0</td>
<td>23.1</td>
</tr>
<tr>
<td>West South Central: AR, LA, OK, TX</td>
<td>13.1</td>
<td>20.0</td>
<td>22.2</td>
</tr>
<tr>
<td>Mountain: AZ, CO, ID, MT, NM, UT, WY</td>
<td>9.6</td>
<td>14.1</td>
<td>17.1</td>
</tr>
<tr>
<td>Pacific: AK, CA, HI, NV, OR, WA</td>
<td>10.2</td>
<td>17.0</td>
<td>19.1</td>
</tr>
</tbody>
</table>
Hours of Anesthesia

Minutes of Elimination