Practical management of one-lung anesthesia
GOALS

- Indications and options for achieving lung isolation
- Preoperative assessment and physiology
- Management and practical problem solving
- Analgesia for thoracic surgery

INDICATIONS FOR ONE-LUNG VENTILATION

Absolute
1. Isolation of each lung to prevent contamination of a healthy lung
   a. Infection (abscess, infected cyst)
   b. Massive hemorrhage
2. Control of distribution of ventilation to only one lung
   a. Bronchopleural fistula
   b. Bronchopleural cutaneous fistula
   c. Unilateral cyst or bullae
   d. Major bronchial disruption or trauma
3. Unilateral lung lavage
4. Video-assisted thoracoscopic surgery

Relative
1. Surgical exposure – high priority
   a. Thoracic aortic aneurysm
   b. Pneumonectomy
   c. Upper lobectomy
2. Surgical exposure – low priority
   a. Esophageal surgery
   b. Middle and lower lobectomy
   c. Thoracoscopy under general anesthesia

PREOPERATIVE ASSESSMENT

- Asymptomatic patient, good exercise capacity- no screening
- Respiratory mechanics
- Cardiopulmonary reserve
- Lung parenchymal function
- Respiratory mechanics: FEV₁
- Cardiopulmonary reserve: VO₂ max (2 flights stairs)
- Lung parenchymal function - DLCO capillary alveolar surface area
  (PaO₂ > 60, CO₂ < 45 mmHg)

LUNG ANATOMY

- Except for video thoracoscopy, one-lung anesthesia is usually optional
- Decision to proceed should be based on relative benefit and ability to tolerate single lung ventilation

SURGICAL INDICATIONS

- Vast majority of thoracic surgery is for lung cancer

Lobe sub-segmental anatomy helps predict the postoperative FEV₁ and DLCO
**POSTOPERATIVE FEV<sub>1</sub>**

- > 40% Few and minor respiratory complications
- < 30% Majority require postoperative mechanical support
- 30-40% Outcome dependent on secondary factors
  - Comorbid conditions and fitness
  - Airway secretions/inflammatory processes
  - Perioperative fluid balance/mechanical features
  - Thoracic analgesia

**LUNG ANATOMY**

Ventilation and perfusion

- Majority of perfusion to dependent lung zones
- Majority of ventilation to non-dependent lung zones
- Gradient of V/Q matching throughout the lung

**The four zones of the lung**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Condition</th>
<th>V-P</th>
<th>Q-P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Collapse</td>
<td>P&gt;A&gt;Pv</td>
<td>Apa&gt;Ppv</td>
<td>Apa&gt;Ppv</td>
</tr>
<tr>
<td>2. Waterfall</td>
<td>P&gt;Ap&gt;Pv</td>
<td>Apa&gt;Ppv</td>
<td>Apa&gt;Ppv</td>
</tr>
<tr>
<td>3. Distention</td>
<td>P&gt;Ap&gt;Pv</td>
<td>Apa&gt;Ppv</td>
<td>Apa&gt;Ppv</td>
</tr>
<tr>
<td>4. Interstitial pressure</td>
<td>P&gt;Ap&gt;Pv</td>
<td>Apa&gt;Ppv</td>
<td>Apa&gt;Ppv</td>
</tr>
</tbody>
</table>

**DISTRIBUTION OF VENTILATION**

- **Awake**
  - Nondependent Lung
  - Dependent Lung
- **Negative to positive pressure ventilation**
- **Anesthetized**
  - Nondependent Lung
  - Dependent Lung

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Cook DJ. *Practical management of one-lung anesthesia*
With one-lung ventilation, perfusion of non-ventilated lung results in a large shunt.

Alveolar-arterial (A-a) gradient reduced by hypoxic pulmonary vasoconstriction.

**OPTIONS FOR LUNG ISOLATION**

- Double lumen ETT
- Single lumen tube and endobronchial blocker
  - Integrated (Univent tube)
  - Stand alone blocker (Fogerty catheter)
  - Hybrid (Arndt endobronchial system)
- Endobronchial intubation
- Intermittent ventilation

**BRONCHIAL ANATOMY**

**DOUBLE-LUMEN ENDO TRACHEAL TUBES**

A. Left Robertshaw tube

B. Placement at the Carina

C. Right Robertshaw tube

D. Placement at the Carina

Guenoun T. JCTVA 2002;16:202
CONFIRMING ENDOBRONCHIAL INTUBATION

- Auscultation (left sided tube)
  
  Both sides open, listen to right, then left  
  Clamp endotracheal lumen, inflate endobronchial cuff  
  listen to left then right (use large TV of same size)

  Auscultation not completely reliable  
  Up to 48% still require adjustment  
  Auscultation may be impractical or of poor quality  
  Confusing if tube misplaced

- Fiberoptic bronchoscopy

**Trachea:**
Membranous and Cartilaginous
Carina

- Acuity of carinal angle
- Striations of membranous trachea
- Lesser acuity of right mainstem bronchus

About 2 cm from the carina, the R main bronchus divides to the R upper lobe bronchus and the bronchus intermedius.
BRONCHIAL ANATOMY

Bronchus intermedius divides into the middle lobe bronchus and the lower lobe bronchus.

Summary of critical bronchoscopic anatomy

DOUBLE-LUMEN TUBE MISPLACEMENT

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Breath Sounds Heard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Cuff Blocks Right Lumen</td>
<td>In Too Far (On L side)</td>
</tr>
<tr>
<td>Left Cuff Blocks Right Lumen</td>
<td>Out Too Far (In trachea)</td>
</tr>
<tr>
<td>Left Cuff Blocks Right Lumen</td>
<td>In Too Far (On R side)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clamp Right Lumen Both Cuffs Inflated</th>
<th>Left</th>
<th>Left and Right</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clamp Left Lumen Both Cuffs Inflated</td>
<td>None or Very</td>
<td>None or Very</td>
<td>None or Very</td>
</tr>
<tr>
<td>Clamp Left Lumen Deflate Left Cuff</td>
<td>Left</td>
<td>Left and Right</td>
<td>Right</td>
</tr>
</tbody>
</table>
RIGHT DOUBLE-LUMEN ENDOTRACHEAL TUBE

UNIVENT OR “FUJI” TUBES

- Integrated blocker
- Lesser curvature
- Blocker is vented and angulated
- Blocker position can be “fixed” sizes??

A. View Down Left (Tracheal) Lumen

B. View Down Right (Bronchial) Lumen

C. Insert FOB through self-seating diaphragm and decide R from L mainstem
   - Ventilate 12 ml/kg

D. Self-sealing diaphragm in elbow connector

E. After FOB orientation, deflate cutt slightly and rotate Univent tube toward the side to be blocked and identify BB
   - Ventilate 10 ml/kg

F. Inflate BB (6-7 ml) Soo cutt just below carina
   - Ventilate 10 ml/kg

- Advance BB into mainstem bronchus to be blocked

- Withdraw FOB
**ONE-LUNG ANESTHESIA: GOALS IN RESPIRATORY MECHANICS**

- Limit inspiratory driving pressure < 20
  \[(\text{PIP} - \text{PEEP}) = \text{IDP}\]
- Limit PIP < 35-40 cm H\(_2\)O
- Frequent manual lung recruitment maneuvers
  \((\text{CPAP at 30-40 cm H}_2\text{O for 30 seconds})\)
- RR < 25 breaths/minute

**ONE-LUNG ANESTHESIA: PRACTICAL CONSIDERATIONS**

- May be benefit to pressure controlled ventilation
- Adjust I:E ratios as indicated
- Watch for breath stacking: inadequate expiratory time
- If hypotension occurs go to manual ventilation to assess possible contribution of ventilatory mechanics
- If anesthetic is volatile based, give i.v. agents if interrupting ventilation
- Hypercarbia better tolerated than hypoxia

**INCREASED RISK FOR ONE-LUNG HYPOXEMIA**

- High A-a gradient with two lung ventilation when in lateral position
- V/Q scan showing high proportion of ventilation or perfusion to operative lung
- Right sided lung surgery
- Good preoperative spirometry (FEV\(_1\) or FVC) (pts with airflow limitation develop auto-PEEP)

For DLTs endobronchial portion should not be occlusive without the cuff up
- Dbl lumen tubes tend to migrate outward on lateral positioning
- Assess adequacy of isolation and oxygenation before it is critical
IMPRESSING ONE-LUNG OXYGENATION

- 5-10 cm of CPAP to non-ventilated lung
- 5 cm PEEP to ventilated lung
- Recruitment maneuvers
- Intermittent ventilation
- Lobe isolation

IMPROVING OXYGENATION: CPAP

Prior to major vascular surgery, coronary-

RIGHT VS LEFT-LUNG SURGERY?

- More lung to use if surgery is left-sided
- More options for right-sided ventilation
  - Left endobronchial dbl lumen ETT
  - Single lumen tube with left bronchial blocker
  - Single lumen right endobronchial intubation
- Better respiratory mechanics, easier secretion control if surgery is left-sided

THE RIGHT UPPER LOBE

- Limits ability to achieve adequate ventilation and oxygenation with right endobronchial intubation
  42-26 (20 left and 6 right upper) = 14 (33%)
- If right sided surgery and a blocker is placed it is frequently dislodged

POSTOPERATIVE MANAGEMENT

- Determine predicted postoperative FEV1
- Extubation and postoperative status must be considered in choosing an isolation strategy
- Goal: extubate directly from double lumen ETT
- If anticipate postoperative mechanical ventilation, single lumen tube with bronchial blocker usually better than tube change

POSTOPERATIVE ANALGESIA

- Analgesia is fundamental to extubation and postoperative ventilatory mechanics
  - Narcotic-based analgesia
  - Intercostal/paravertebral blocks
  - Interpleural local anesthetics
  - Lumbar epidurals
  - Thoracic epidural analgesia with PCA supplementation

LUNG ISOLATION IN THE DIFFICULT AIRWAY

- Assess requirement for lung isolation (intraoperative and postoperative considerations)
- If dbl ETT impractical:
  - secure single lumen ETT
  - bronchial blocker?  Change to dbl?  Mainstem?

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POSTOPERATIVE PAIN AND RESPIRATORY MECHANICS

Lung volumes and capacities

Pre-op

Post-op day one

TV VC

ERV RV FRC CC

IRV IC

TV FRC CC

ERV RV FRC CC

EPIDURAL INFUSIONS FOR THORACOTOMY

<table>
<thead>
<tr>
<th></th>
<th>Thoracic catheter</th>
<th>Lumbar catheter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fentanyl</td>
<td>30-50 µg/h</td>
<td>Not recommended</td>
</tr>
<tr>
<td></td>
<td>5 µg/ml 10 µg/ml</td>
<td></td>
</tr>
<tr>
<td>Hydromorphone</td>
<td>30-50 µg/h</td>
<td>40-80 µg/h</td>
</tr>
<tr>
<td></td>
<td>5 µg/ml 10 µg/ml</td>
<td></td>
</tr>
<tr>
<td>Morphine</td>
<td>300-500 µg/h</td>
<td>400-800 µg/h</td>
</tr>
<tr>
<td></td>
<td>100 µg/ml</td>
<td></td>
</tr>
<tr>
<td>Bupivacaine</td>
<td>All</td>
<td>Not recommended</td>
</tr>
<tr>
<td>0.075%</td>
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