One Lung Ventilation

Paul Alfille
Disclaimers and Commercial Sponsorships

- None

Andrea Pisano 1437 “The Creation of Eve”
Goals and Objectives

• What are the indications for one lung ventilation
• What is best practice for managing one-lung ventilation
• What are the techniques for one-lung ventilation
Indications for Lung Isolation

- Surgical exposure
- Lung resection
- Airway protection
  - Hemoptysis
  - Infection
- Differential ventilation
  - Post transplant
  - Giant bleb
  - Bronchopleural fistula
  - bronchial disruption
- Lung lavage
How to choose

<table>
<thead>
<tr>
<th></th>
<th>Surgical exposure</th>
<th>Differential ventilation</th>
<th>Lavage</th>
<th>Difficult airway</th>
<th>Small patient</th>
<th>Bronchial lesion</th>
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</thead>
<tbody>
<tr>
<td>DLT</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Blocker</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
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<tr>
<td>Bronchial tube</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Spontaneous ptx</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tbody>
</table>
• Left sided with carinal hook
• Right sided version called the White tube
Robertshaw

• Both left and right sided version
• No carinal hook
• RUL window for right version
• Multiple modern designs
Right sided tubes

- Asymmetric cuff
- RUL orifice
- Often avoided by the inexperienced

Bronchial lengths

- FOB, casts, cadavers
- Female slightly smaller

- Design of tube important

Tips for positioning

- Start of medial cuff (carina location)
- Start of blue plastic
- RUL window
- Cuff holds tube away from wall
<table>
<thead>
<tr>
<th></th>
<th>Right DLT</th>
<th>Left DLT</th>
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<tbody>
<tr>
<td>Initial placement</td>
<td>min</td>
<td>3.37</td>
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<tr>
<td></td>
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<td>2.08</td>
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<tr>
<td>Left lung collapse</td>
<td>min</td>
<td>13</td>
</tr>
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<td></td>
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<td>10</td>
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<tr>
<td>FOB exams</td>
<td>number</td>
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<tr>
<td>Surgical exposure</td>
<td>Excellent</td>
<td>19/19</td>
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<tr>
<td></td>
<td>Fair</td>
<td>0/19</td>
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<td>19/20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/20</td>
</tr>
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<td>RUL expansion</td>
<td>Post-op Xray</td>
<td>Full 17/17</td>
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<tr>
<td></td>
<td></td>
<td>Full 18/18</td>
</tr>
</tbody>
</table>

Porcine bronchus

- Incidence < 1%
- Some or all segments of RUL start above carina
- Very occasionally on L side, too.
- Contraindication for ipsilateral DLT (or blocker)
Mallinckrodt

- Left DLT
  - 28 32 35 37 39 41
- Right DLT
  - 35 37 39 41
- Left with Hook
  - 35 37 39 41
- Left Robershaw
  - 26 28 35 37 39 41
- Right Robershaw
  - 26 28 35 37 39 41
- Carlens
  - 35 37 39 41
- Dr. White
  - 35 37 39 41
Portex

• Nicest design for the top of the tube
Phycon (Fuji Systems)

- “Silbroncho”
- Left and Right DLT
- Flexible silicone wire-reinforced bronchial lumen
- 33, 35, 37, 39 Fr
- Less kinking
Endobronchial tube

- Long tube
- Flexible wire-reinforced
- Small cuff
- Short distance cuff to tip
- 5.5 6.5 7.5 mm I.D.
VivaSight

- 37Fr L DLT
- Embedded (disposable) fiberoptic camera and light
- View of carina
- Continuous monitoring
EZ-Blocker

- Two cuffs
- Sits at carina
- Not for selective work
- Individual lumens small


Efficiency, efficacy, and safety of EZ-blocker compared with left-sided double-lumen tube for one-lung ventilation.

Arndt Blocker

- Loop to capture bronchoscope
- Sizes 5, 7, and 9
- Good for selective blockade
- Can “catch” on carina
Endobronchial tube

- Fuji systems endobronchial tubes
- Long tube
- Flexible wire-reinforced
- Small cuff
- Short distance cuff to tip
- 5.5 6.5 7.5 mm I.D.
Fogarty Embolectomy Catheter

- No suction/CPAP lumen
- Various sizes
- Connections difficult
Univent Tube

- Integral blocker
Monitor isolation

- Modern ventilators can measure inspiratory and expiratory volumes
- Assess needed bronchial cuff volume
- Early warning of tube movement.
Tube variability – bronchial lumen

W. J. RUSSELL, T. S. STRONG Dimensions of Double-Lumen Tracheobronchial Tubes
Anaesthesia and Intensive Care, Vol. 31, No. 1, February 2003
Paul with calipers: SLTs vs Left Mallinckrodt outer diameter at cords.
Resistance

• Overall resistance ~ 7.0 to 8.0 ETT
  – (both lumen)
• Better than Univent tube
• Unclear comparison with blockers
  – (resistance to both lumen low and comparable)
• Use in ICU discouraged because of unfamiliarity rather than resistance.

Hypoxia and OLV

- Unique is pure anatomic shunt
- Definitions vary
  - 10% had Sat < 90
- Pre-op conditions
- Position
- Ventilation
- FiO2
- Drugs

- Oxygenation vs Lung protection
Factors Effecting Shunt

• Ventilated side:
  – Improve gas exchange
  – Keep low PVR
• Non-ventilated:
  – Keep PVR high
  – Add O2
• Improve mixed venous O2
Shunt and oxygenation

- Dependent on HPV
- FiO2 has little effect at high shunt fraction
- Cardiac output and mixed venous content important
Mixed venous concentration

- More important at high shunt
- Metabolic rate
- Anemia
- Cardiac output
Position

• Gravity has strong effect on 1LV
• Supine < Lateral

Cardiac Output

- Higher cardiac output improves oxygenation
- Confounds some studies

Assymetry

• Sicker non-ventilated lung helps
• Higher Δ between lung
• Better oxygenation
• Prior lobectomy

Inhalation vs TIVA

- Multiple studies
- Confounding variables
- Weak effect on oxygenation
- Titrated to BIS
- Inflammatory attenuation

Inflammation and Anesthetic

- BAL samples from ventilated lung
- No difference in oxygenation
- Decrease in markers
- Clinical import unclear

Vasopressors

- α-block ↓ HPV
- β-block ↑ HPV
- Epidural effect from α and β block
- β-agonists ↓ HPV
- Nitrates ↓ HPV
- Vasopressin no effect
- α-agonists ↑ HPV?

Epidural

- Equivocal studies
- Propofol GA
- Similar pO2
- Similar Qs/Qt
- Similar output

Almitrine

- Respiratory stimulant
- Agonist at peripheral chemoreceptors
- Not FDA approved
• Improves oxygenation

• Little effect on cardiac output

Nitric Oxide

• Dilates pulmonary vessels
• Matched to ventilation
• No effect in OLV in normals
• Perhaps in PAH

Tidal volume

- High TV improves oxygenation
- Higher PEEP may balance (based on plateau pressure)
- Lung injury

Tidal volume

- Low TV protects lung
- PEEP prevents collapse
- Moderate FiO2
- 3-6 ml/kg for OLV
• Conventional
  – 10 ml/kg
  – FiO2 1.0
  – ZEEP

• Protective
  – 6 ml/kg
  – FiO2 0.5
  – 5 PEEP
  – 58% required ↑ FiO2

PEEP

• Variable effect on PVR
• Dependent lung at low volume
• Optimal PVR and oxygenation at FRC

• Variable effect on PVR
• Dependent lung at low volume
• Optimal PVR and oxygenation at FRC

PEEP

- Variable results
- 6 ml/kg TV
- Recruitment
- 12/41 improved
- No Δ CO, MAP

Recruitment

- Applied prior to OLV
- Improved pO2
- Improved Vd/VT

Hypercapnea

- Unpublished
- Therapeutic hypercapnea (exogenous CO2)
- Reduced inflammatory markers
Limb ischemia

- Limb Remote Ischemic Preconditioning Attenuates Lung Injury after Pulmonary Resection under Propofol–Remifentanil Anesthesia: A Randomized Controlled Study
- Li, Cai M.D.; Xu, Miao M.D.; Wu, Yan M.D.; Li, Yun-Sheng M.D.; Huang, Wen-Qi M.D.; Liu, Ke-Xuan M.D., Ph.D.
- Anesthesiology
- Issue: Volume 121(2), August 2014, p 249–259
CPAP

- Very effective
- Intact airway
- Start inflated
- Surgical conditions
- Inject O2

Selective ventilation

- Selective lobar blockade
- Optionally CPAP only that lobe

Campos JH. Effects on Oxygenation During Selective Lobar Versus Total Lung Collapse With of Without Continuous Positive Airway Pressure. Anesth Analg 1997; 85:583-6
850-2

- “rescue” blocker with DLT

Selective ventilation

- Bronchoscope in lobe
- O2 carefully

High Frequency Jet Ventilation

- Open airway
- HFJV vs CPAP
- ? COPD
- Hemodynamics

- Sander’s injector
- Hand control
- Vary driving pressure, rate, I:E ratio
- Requires blender to alter $F_iO_2$
- No pressure monitoring

- Risk of barotrauma
- Risk of hypoventilation
Monsoon Automated Jet

Safety cut off
Humidification and heating
FiO2 Consistent
Extreme measures

- Pulmonary artery occlusion
- ECMO
- CPB
ECMO

- Endobronchial intubation
- Marginal oxygenation
- VV
- Improve oxygenation
- Less need for anticoagulation

Anesthetic Management of a Delayed Carinal Resection Following Traumatic Disruption
Algorithm

- Severe desaturation
  - 2 lung ventilation

- Gradual
  - Check tube position, suction, vent settings
  - Increase FiO2
  - Try Recruitment and PEEP
  - CPAP or selective ventilation
  - Intermittent inflation
  - Adjust hemodynamics
  - Surgical occlusion of blood flow