Single lung ventilation in children

Shoichi Uezono, MD
Department of Anesthesiology
Jikei University, Japan
Objectives

• Understand the differences between the pediatric and adult respiratory system and the anesthetic implications for thoracic surgery
• Understand the various options for pediatric single lung ventilation including advantages and disadvantages
Indications of SLV

• To control the distribution of ventilation:
  – Bronchopleural fistula
  – Unilateral gigantic lung cysts/bullae
  – Differential lung ventilation

• To avoid spillage or contamination
  – Infection, hemorrhage, unilateral lung lavage

• To optimize a surgical field for thoracoscopy
  thoracotomy, and thoracic nonpulmonary surgery
Thoracoscopy in pediatric patients

• Pulmonary lesions
  – Biopsy, debridement, drainage, wedge resection, segmentectomy, lobectomy, excision of cyst

• Nonpulmonary lesions
  – Anterior spinal fusion, aortopexy, diaphragmatic hernia repair, esophageal atresia repair, PDA ligation, TE fistula ligation, mediastinal mass excision, thymectomy, thoracic duct ligation, hiatal hernia repair
Physiology of SLV in children

• Pediatric respiratory physiology
  – Less compliant lung, more tendency to collapse small airways, more compressible rib cage

• Oxygen consumption
  – 2-4 times higher than an adult value

• Physiology of the lateral decubitus position
  – Opposite to adult physiology (oxygenation is improved with healthy lung “up”)

• Increased risk of oxygen desaturation during thoracic surgery in the lateral position
Pediatric SLV techniques

- Selective mainstem intubation
- Double lumen endotracheal tube
- Univent endotracheal tube
- Bronchial blocker (through ETT or alongside ETT)
  - Forgarty embolectomy catheter
  - Arndt bronchial blocker
Selective endobronchial intubation

- Simplest means of providing SLV with a conventional single lumen ETT
- Easy to confirm by auscultation or FOB
- A smaller, uncuffed ETT may fail lung isolation
- May be the preferred technique in case of emergency
Double lumen tubes

- The smallest cuffed DLT available is 26 Fr
- May be used in children as young as 8 yrs old
- FOB for proper tube placement
- Risks and benefits similar to adult DLTs
- Marraro (1994) reported a bilumen tube consisting of two separate uncuffed tracheal tubes of different length attached longitudinally.
Univent tube (Fuji Sysems Corporation)

- A conventional ETT with a second lumen containing a small tube that can be advanced into a bronchus
- A balloon (low-volume, high-pressure)tipped second tube serves as a blocker
- FOB for proper placement of the blocker
- The smallest size (ID 3.5 mm) may be used in children as young as 6 yrs old
- Main lumen has an extremely high resistance to gas flow
Balloon-tipped bronchial blockers

• Currently the most preferred technique of SLV in small children and infants
• Various blockers
  – Fogarty embolectomy catheter
  – PA catheter
  – Arndt blocker (fiberoptically-directed wire-guided endobronchial blocker)
Arndt endobronchial blocker

- One-way valve
- Spherical balloon
- Guidewire
- Breathing circuit
- 15mm connector
- bronchoscope
- blocker
Placement of FOB-directed, wire-guided Arndt blocker
Sizing of Arndt blockers

<table>
<thead>
<tr>
<th>Blocker size (Fr)</th>
<th>Patient age (yr)</th>
<th>Smallest ETT (ID, mm)</th>
<th>Cuff volumes (ml)</th>
<th>FOB (mm)</th>
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<td>7</td>
<td>8-12</td>
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<tr>
<td>9</td>
<td>&gt; 12</td>
<td>8</td>
<td>4-8 (spherical)</td>
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<td></td>
<td></td>
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<td>6-12 (elliptical)</td>
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Disadvantages of Arndt blockers

• A period of decreased ventilation during placement
• Displacement
• Dislodgement
• Balloon herniation/deflation
• Cost
• Experience of pediatric bronchoscopy
Arndt blocker can be placed outside the ETT
Age-based selection of SLV technique in pediatric patients

- Under 2 yrs old
  - Endobronchial intubation with conventional ETT
  - Fogarty embolectomy catheter (3-4Fr)
  - Arndt blocker (5Fr) extraluminal placement
- 2-6 yrs old
  - Arndt blocker (5Fr)
  - Fogarty embolectomy catheter (4-5Fr)
- 6-10 yrs old
  - Arndt blocker (5Fr)
  - Endobronchial intubation with conventional ETT
  - Univent tube (3.5 or 4.5 mmID)
- Over 10 yrs old
  - Arndt blocker (7Fr)
  - Univent tube (4.5, 6mmID)
  - DLT (26 Fr or larger)