INDEPENDENT LUNG VENTILATION COMBINED WITH HIGH FREQUENCY JET VENTILATION IN A 2 MONTH OLD WITH CONGENITAL PULMONARY AIRWAY MALFORMATION

Introduction: Independent lung ventilation (ILV) is a ventilation strategy used for patients with non-homogenous lung disease. This is a two month old female with Congenital Pulmonary Airway Malformation (CPAM). This patient, ventilated with ILV and High Frequency Jet Ventilation (HFJV), was being considered for lung transplant.

Case Summary: A term infant presented with tachypnea, hypoxia, and persistent left lower lobe atelectasis. She was intubated for respiratory distress. By day two of life her left lower lobe infiltrate had not changed and it was thought that she could have a congenital pulmonary abnormality. On day 5 of life, CT scan was obtained which showed Left Lower Lobe Pulmonary Sequestration and CPAM Type II. As the patient became more difficult to manage on the ventilator, due to respiratory acidosis and unequal tidal volume distribution, the decision was made to excise the defect. Post operatively, she required high frequency oscillatory ventilation due to need for high ventilator pressures and severe respiratory acidosis. Due to continued mechanical ventilation, a tracheostomy tube was placed at four weeks of age. Throughout her ICU course, she continued to have: persistent left sided atelectasis, persistent extreme hyperinflation of the right lung, and severe respiratory acidosis. Her baseline PaCO2 was in the 60s, but ranged from 45-130 mmHg throughout the next month. The decision was made to trial ILV and ventilate her right lung with HFJV. To initiate ILV, the following interventions were made: fiberoptically intubated her left bronchus through her tracheostomy stoma with a 3.5 cuffed ETT, orally intubated her trachea with a 3.0 ETT to ventilate her right lung. The left lung was ventilated via her trach stoma with conventional ventilation (PC/AC Rate: 40 PIP: 40 PEEP 3 Ti: 0.35, iNO 20ppm) to achieve 4 ml/kg Vte. The right lung was ventilated via the oral tube with HFJV. Her initial HFJV settings were: PIP 25, Rate 420, Ti .02s; the conventional ventilator was set at Rate 2, PIP 18, PEEP 5, Ti 0.35. FiO2 100%, iNO of 20 ppm. Arterial blood gas prior to initiation of this strategy was pH 7.32/PaCO2 102/ PaO2 171/HCO3 53/SaO2 99%. Arterial blood gas 2 hours after initiation showed: pH 7.47/PaCO2 72/PaO2 62/HCO3 48/SaO2 91%. Chest radiograph three hours after initiation showed markedly improved aeration of left lung and markedly reduced hyperinflation of the right lung. This strategy was continued for three days uneventfully with PaCO2 67-80 and pH 7.30-7.45. On day three, transient respiratory acidosis developed due to left lung ETT leak. On day four of ILV the left endobronchial tube inadvertently slipped into the bronchial stump of the resected left lower lobe. This resulted in transient respiratory acidosis that resolved when the tube was returned to proper position. On day 5, ILV was aborted and conventional ventilation was initiated through her tracheostomy tube to facilitate better secretion clearance and prepare for transport to the transplant center.

Discussion: There currently are no commercially available neonatal double lumen endotracheal tubes in the United States. Initiating ILV in an infant can be logistically difficult, but the presence of a tracheostomy can be beneficial. Maintaining ILV in an infant is a very labor intensive strategy due to the precarious nature of managing two endotracheal tubes. Our greatest challenge during this process was maintaining the endotracheal and endobronchial tubes in the correct position and assuring patency of each.
Independent Lung Ventilation Utilizing High Frequency Jet Ventilation in a Two Month Old With Congenital Pulmonary Airway Malformation

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Disclosures

- I have no disclosures or affiliations
Objectives

- Discuss initial patient presentation to the NICU
- Discuss the changes in ventilator management throughout the ICU course
- Discuss how independent lung ventilation was initiated
- Share our experience with independent lung ventilation paired with HFJV
Patient History

- Term female infant
- Uncomplicated pregnancy with normal fetal ultrasounds
- Outborn
- Shortly after birth developed:
  - Tachypnea
  - Hypoxia
  - Respiratory distress
Admission

• Patient was intubated at referral center by the transport team for severe respiratory distress
  – Grunting
  – Tachypnea (RR 120)
  – Severe subcostal retractions

• Transferred to MPLS NICU for ongoing critical care management

• Admission chest radiograph showed left lower lobe infiltrate and hyperinflated right lung
Admission

- **Initial working diagnoses were**
  - Pneumonia (no other infectious concerns)
  - MAS (meconium not noted at delivery)
  - Amniotic fluid aspiration
  - R/O Sepsis

- **Ventilator settings at this time**
  - PC/AC, Rate 40, PIP 21, PEEP5
Early ICU Course

• **Day of life 2**
  - Left lower lobe infiltrate unchanged
  - Continued right sided hyperinflation
  - Cultures negative
  - Possibility of congenital pulmonary abnormality discussed

• **Day of life 5**
  - Chest CT
    - Left lower lobe pulmonary sequestration (CPAM Type II)
    - Grossly abnormal right lung development
Early ICU Course

- **Day 5-10**
  - Ventilator management became difficult
    - Unequal tidal volume distribution
      - Right sided hyperinflation
      - Left sided atelectasis
    - Persistent respiratory acidosis
    - Pulmonary hypertension
      - Nitric Oxide started
  - DOL 10
    - Left lower lobectomy and pulmonary sequestration surgically removed
Post-Op

- Developed severe respiratory acidosis and hypoxemia
  - PC/AC, Rate 60, PIP 30, PEEP5, Ti 0.3s 65% oxygen
    - 4.5 ml/kg Vte
    - Sedated and Paralyzed
  - pH 6.9/PaCO2 126
  - Left upper lobe atelectasis
- HFOV started
ICU Course

• Throughout her ICU course she continued to have:
  – Persistent left sided atelectasis
  – Persistent extreme hyperinflation of right lung
  – Occasional severe respiratory acidosis

• Baseline PaCO2 was 65mm Hg
  – Ranged of 45-130mm Hg throughout the next month

• Failed extubation

• Due to continued mechanical ventilation a tracheostomy was placed at one month of age

• Multiple ventilation strategies attempted
**DOL 55**

- **Elective left mainstem intubation attempted**
  - Inflate atelectatic left lung
  - Allow hyperinflated right lung to deflate
  - Abandoned after four hours due to severe respiratory acidosis (PaCO₂ > 130)

- **At this time the referral process for lung transplant was initiated**
  - Continued inability to properly ventilate
  - Pulmonary
    - Dysplastic lungs with grossly abnormal physiology
  - Poor prognosis
ICU Course

- Due to continued difficulty with ventilation the decision was made to trial independent lung ventilation
- In addition, high frequency jet ventilation would be utilized to ventilate her emphysematous right lung
ILV Initiation

• To initiate ILV the following interventions were made
  − Fiberoptically intubated the left bronchus through her tracheostomy stoma with a 3.5 ETT
  − Orally intubated her trachea with a 3.0 ETT
  − Left lung was placed on conventional ventilation
  − Right lung was placed on high frequency jet ventilation
  − Inhaled nitric oxide was delivered to both lungs
Response

• Prior to initiation of ILV:
  − pH 7.32/PaCO₂ 102/PaO₂ 171/HCO₃ 53.

• ABG 2 hours after initiation of ILV:
  − pH 7.47/PaCO₂ 72/PaO₂ 62/HCO₃ 48.
## Initial Settings

<table>
<thead>
<tr>
<th>Right Lung</th>
<th>Left Lung</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HFJV</strong></td>
<td><strong>CMV</strong></td>
</tr>
<tr>
<td>PIP 25 cmH2O</td>
<td>PIP 39 cmH2O</td>
</tr>
<tr>
<td>Rate 420</td>
<td>Rate 40</td>
</tr>
<tr>
<td>Ti 0.02s</td>
<td>PEEP 6 cmH2O</td>
</tr>
<tr>
<td>20ppm iNO</td>
<td>Ti 0.35s</td>
</tr>
<tr>
<td><strong>CMV</strong></td>
<td>PC/AC</td>
</tr>
<tr>
<td>Rate 2</td>
<td>Rate 40</td>
</tr>
<tr>
<td>PIP 18 cmH2O</td>
<td>PIP 39 cmH2O</td>
</tr>
<tr>
<td>PEEP 6 cmH2O</td>
<td>PEEP 6 cmH2O</td>
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<tr>
<td>Ti 0.35s</td>
<td>Ti 0.35s</td>
</tr>
</tbody>
</table>

*To achieve 3 ml/kg Vte*

<table>
<thead>
<tr>
<th>Airway</th>
<th>Airway</th>
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</thead>
<tbody>
<tr>
<td>3.0 oral uncuffed endotracheal tube</td>
<td>3.5 cuffed endobronchial tube via tracheostomy</td>
</tr>
</tbody>
</table>
Pre-ILV Chest X-RAY
Post-ILV Chest X-RAY
Ventilator management

- **HFJV**
  - PIP ranged from 25-40 throughout ILV duration
  - Rate remained 420
  - CMV settings remained same throughout

- **CMV**
  - Rate 40-45
  - PIP 35-40
  - PEEP 6
  - Ti 0.3s
  - Vte 1.8-4 ml/kg
PaCO2 during ILV

- ILV Initiated
- Left ETT Leak
- Left ETT Malpositioned
ILV Day 5

- Patient de-compensated due to mucus plugging
  - Required therapeutic bronchoscopy
- Transport to lung transplant center being arranged
- Decision was made to switch to conventional ventilation via tracheostomy tube to facilitate better secretion clearance and prepare for transport
Discussion

- Independent lung ventilation in adults is accomplished via a double lumen endotracheal tube (Carlen’s tube)

- There are currently no commercially available neonatal double lumen ET tubes in the United States
  - Limited case reports from Europe

- Initiating ILV in an infant can be logistically difficult
  - Tracheostomy was beneficial
Discussion/Challenges

• Labor intensive strategy
  – Extremely vigorous monitoring
  – Increased staffing
    ▪ Dedicated RT for first day
  – Charting?

• Maintaining endotracheal and endobronchial tubes in correct position and assuring patency
  – Secretions had a dramatic affect on ventilation due to need for smaller than normal ETTs for this patient
References

Questions?

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