The Role of ECMO in Thoracic Surgery

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Disclosure Slide

• Consultant for Mallincrodt and Quark Pharmaceuticals
Case #1

• 28 y.o. female with tracheal mass
  – No previous medical or surgical history
  – Non-smoker
  – Worsening stridor for a year, recently in and out of ED with SOB, feeling “smothered”
  – Eventually CT scan done demonstrating a mid-distal tracheal mass.
Case #1
Case #1
Case #1
Operative Events

- Single lumen ETT
- VV ECMO 4-4.5 L
  - Venous drainage
    - 19 fr arterial cannula RIJ to SVC/RA junction
    - 21 fr multistage venous cannula LFV to IVC
  - ”Arterial” return
    - 21 fr single stage venous cannula RFV to RA
- Right posterolateral thoracotomy
Operative Events

- Tracheal dissection anterior and posterior with hilar release
- Resection of about 3cm of trachea with negative frozen margins
- Tracheal anastomosis with running 3-0 PDS
- Weaned from ECMO and decannulated in OR
Operative Events
Case #1

- Final path with myofibroblastic tumor

- 6 month f/u bronch and CT without evidence of recurrence
It's much easier to stay out of trouble now than to get out of trouble later.

--- Warren Buffett ---
Case

- 54 y.o. male with COPD and tracheomalacia
  - In and out of hospital with recurrent pneumonias
  - On 2-4 liters of oxygen
  - s/p bronchial dilation 2 years prior
  - History of DVT and PE s/p IVC filter but no PH
  - Y-stent trial with good symptomatic relief and FEV1 increased from 21% to 46%
Case

- 54 y.o. male with COPD and tracheomalacia
  - Dynamic CT demonstrates airway collapse with exhalation (B)
Case

• 54 y.o. male with COPD and tracheomalacia
  – Bronchoscopy shows nearly complete collapse of the distal trachea and proximal main bronchi bilaterally
Operative Events

- Left sided double lumen ETT
- Right posterolateral thoracotomy
- Exposure of membranous trachea and bilateral bronchi
- Recurrent/Persistent hypoxemia during single lung ventilation—despite confirmation of adequate tube position
Operative Events

• VV ECMO initiated
  – Right atrial appendage for IVC cannula 24 Fr
  – Body of right atrium for red return 16 Fr
  – Heparin for ACT of 150
  – Quadrox oxygenator

• Remainder of tracheal dissection performed and mesh placement begun
Operative Events

- Endotracheal tube dislodges back into the trachea
- Right lung hyper-inflated
- Atrial cannula dislodged and was replaced
- Vfib arrest
- CPR initiated
- Defibrillation attempts unsuccessful
Operative Events

• Conversion to VA ECMO
  – Red return cannula repositioned into ascending aorta
  – Defibrillation successful
  – Cooling protocol initiated

• Hemodynamically stable over a period of 30 minutes

• Downsizing tracheobronchoplasty performed with marlex mesh

• Physiologically and hemodynamically stable
  – Normalization of acidosis and return of BIS
Case

• Weaned from ECMO and decannulated
• Routine closure and to ICU on cooling protocol
• Fully neuro intact
• Transferred to step down day 7 and discharged to home on day 10

• Follow up
  – Good result from tracheobronchoplasty
  – Numbness of the tongue and loss of taste
ECMO, Then

• The original ECMO circuit

J. Donald Hill, MD and Maury Bramson, BME, Santa Barbara, CA 1971
ECMO, Now

- Today’s ECMO circuit

What is ECMO?

• **3 Essential Component**
  – Vascular access cannulas
  – Membrane “oxygenator”
  – Pump

• **VV ECMO**
  – VV preferred for isolated lung failure
  – Can be performed via single cannula

• **VA ECMO**
  – VA required if cardiac function also compromised
  – Arterial access increases complications
Recent Advances in ECMO

- Bicaval dual-lumen cannula
  - Single access site
  - Less recirculation
  - Ambulation/rehab potential

- PMP oxygenator
  - PMP hollow fibers can last for weeks

- Improved tubing
  - Thicker PVC decreases rupture or breach
  - Heparin-bonding

- Centrifugal pumps
  - No more tube-crimping roller pumps

- Portability
  - less than 30 kg

Cannulation

- **Venous Drainage**
  - Peripheral
    - Femoral vein
    - Right internal jugular
    - Left subclavian
  - Central
    - Right atrium (into IVC for VV)
    - Pulmonary artery

- **Venous Return (VV)**
  - Peripheral
    - IJ (if femoral venous or dual lumen cannula)
  - Central
    - Right atrium
    - PA

- **Arterial Return (VA)**
  - Peripheral
    - Femoral artery
    - Axillary artery
  - Central
    - Ascending aorta
    - Descending aorta
Cannulation Strategies

• Elective
  – Peripheral –
    • VV – RIJ Avalon cannula
    • VV- VA Avalon with either femoral cannulation or right axillary
    • VA – femoral or IJ for venous femoral or axillary artery (assess for embolic risk and access)
  – Emergent
    • VV
      – Right thoracotomy right atrial appendage for IVC cannula, body of right atrium for red return
      – Left thoracotomy- femoral venous to left PA
    • VA
      – Right thoracotomy atrial drainage, ascending aorta for return
      – Left thoracotomy femoral venous or left PA for drainage, descending aorta return
Technical Considerations

• Match your cannula location and size to the physiologic need
  – Total support—unlikely but need larger cannulas and more central location--
  – **Partial support**—smaller cannulas needed, can get by with less than perfect placement

• CO2 removal—increase the sweep gas flow
• O2 -higher flows necessary- minimize mixing—
  – placement will matter
  – size will matter
  – venous inflow usually the limiting factor
Technical Considerations

- Anticoagulation is not mandatory but probably advisable, particularly for VA ECMO
  - Hypocarbia, nitric oxide and inotropic support may preclude the need for VA ECMO
  - VA hedge, Y the red return and can cannulate for systemic arterial return if necessary
    - Can balance the V versus A return
  - Large scale bleeding—more likely to have coagulopathy
    - Presumptive therapy
  - Operative manipulation will frequently impact ECMO flows
Technical Considerations

Right internal jugular vein

Right axillary artery
Technical Considerations
National review of use of extracorporeal membrane oxygenation as respiratory support in thoracic surgery excluding lung transplantation†

Philippe Rinieri*, Christophe Peillon†, Jean-Paul Bessou‡, Benoît Veber*, Pierre-Emmanuel Falcoz*, Jean Melki* and Jean-Marc Baste*

Table 1: Number and types of ECMO/centre

<table>
<thead>
<tr>
<th>Centres</th>
<th>VV</th>
<th>VA (peripheral)</th>
<th>VA (central)</th>
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<tr>
<td>Total</td>
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ECMO: extracorporeal membrane oxygenation; VV: veno-venous; VA: veno-arterial.
### Table 2: Types of ECMO by operating indication

<table>
<thead>
<tr>
<th>Types of ECMO (cannulation)</th>
<th>VW</th>
<th>VA (peripheral)</th>
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<td>Pulmonary resection</td>
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<tr>
<td>Total</td>
<td>20</td>
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<td>6</td>
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#### Circulatory support potentially necessary
(risk of cardiac failure or vascular wound)

- Veno-arterial ECMO
- Tracheo-bronchial or Single lung surgery

#### sternotomy
- Central cannulation
  - Anterograde perfusion
  - Femoro-axillary
  - Femoro-femoral
  - Emergency

#### Veno-venous ECMO
- Isolated respiratory support
  - (sufficient and less invasive)
  - Femoro-jugular
  - Jugular (dual-lumen cannula)
Complex Airway Repairs

Figure 3: Preoperative CT scan. Left broncho-oesophageal fistula after concomitant radio-chemotherapy for oesophageal carcinoma. Veno-arterial ECMO for total respiratory support during bronchus repair.
Summary

- ECMO can be an effective tool to augment surgical therapies
  - Clearly not necessary for most of thoracic surgery
- Better to initiate in more elective than emergency circumstances
- When needed
  - Plan for cannulation
  - Match the ECMO run to the needs