Introduction to VV ECMO

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Veno-venous ECMO

- Calendar year ending 2017, Extracorporeal Life Support Organization (ELSO) registry:
  - ~12k VV ECMO, compared to ~11k VA ECMO.
    - VV ECMO: 66% survived ECLS, 57% until DC or transfer
    - VA ECMO: 56% survived ECLS, 40% until DC or transfer
    - At UK, total ECMO 91 cases 2017 & 122 cases 2018

The national numbers have doubled compared to 2010.
Mission statement for VV ECMO

• VV ECMO is not a treatment, but creates environment to allow treatment of lung injury

• **Patient is discharged from the hospital:** Bridge until lungs heal OR bridge to lung transplant

• Therefore, we should avoid “hopeless cases” but should make sure we give salvageable patients every chance.

The first successful use of prolonged life support with a heart-lung machine was conducted by J. Donald Hill in 1971. The patient was 24 years old affected by posttraumatic ARDS, who was supported with ECMO during the acute phase of his pathology, for 3 days. The patient was eventually weaned from ECLS and survived.
Indications for VV ECMO

- Hypoxemic resp failure with P/F ratio below 100 mm Hg despite optimization of ventilator settings *. The Berlin consensus document on ARDS suggest ECMO when P/F ratio is below 70 mm Hg.

- Hypercapnic resp failure with arterial pH below 7.20. Murray score ≥ 3

- Preferably less than 7 days on ventilator (ie, minimize risk of fibrotic stage ARDS prior to initiation of VV ECMO).

- create environment to allow treatment of lung injury & subsequent patient discharge from the hospital

Murray Score

<table>
<thead>
<tr>
<th>Murray Score</th>
<th>Severity</th>
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<tr>
<td>0</td>
<td>No lung injury</td>
</tr>
<tr>
<td>01-25</td>
<td>Mild to moderate</td>
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<tr>
<td>≥25</td>
<td>Severe</td>
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<table>
<thead>
<tr>
<th>Consolidation on CTDR</th>
<th>1 quad sets</th>
<th>2 quad sets</th>
<th>3 quad sets</th>
<th>4 quad sets</th>
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</thead>
<tbody>
<tr>
<td>Pat/PAO ratio</td>
<td>&lt;100</td>
<td>100-150</td>
<td>150-250</td>
<td>&gt;250</td>
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<tr>
<td>PEEP, cm H2O</td>
<td>0</td>
<td>0-8</td>
<td>9-13</td>
<td>14-24</td>
</tr>
<tr>
<td>Compliance, ml/cm H2O</td>
<td>60-19</td>
<td>20-30</td>
<td>&gt;30</td>
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RESP Score

- Indicated if > 80% survival
- Consider if > 50% survival

Contraindications

**Absolute:**
- Preexisting condition incompatible with recovery such as severe neurologic injury; advanced stage malignancy with poor 1-2 year survival; Chronic lung disease (oxygen dependent) & not transplant candidate

**Relative:**
- Contraindication to anticoagulation
- Age, probably above 70
- Poor functional status prior to ECMO, especially prior to hospitalization
Strategies to maximize gas exchange prior to ECMO initiation

- Ventilator settings: ARDSnet criteria: survival advantage
- Nimbex drip (first 48 hrs after ARDS onset, duration 48 hrs, PaO2/FiO2 below 150 mm Hg): survival advantage
- Prone ventilation (first 24 hours, PaO2/FiO2 below 100 mm Hg): survival advantage
- Inhaled nitric oxide or inhaled flolan: NO survival advantage
- Dry lungs, appropriate/prompt antimicrobial Rx (survival advantage)

Minimize Ventilator injury to the lung

- ARDS net recommendation:
  - Keep plateau pressure 30 cm H2O or less to minimize barotrauma
  - Tidal volume ~ 6 mL/kg ideal body weight to minimize volutrauma
  - PEEP 5-12 to minimize atelectotrauma
  - Minimize respiratory rate to avoid trauma
VV ECMO indications

• When maximum ventilator strategies fail to provide adequate oxygenation or ventilation, add VV ECMO.

• Good chance for hospital discharge (honoring mission statement)

• VV ECMO will allow oxygenation and ventilation which will minimize ventilator injury to the lung

Indications for VV ECMO

• Hypoxemic respiratory failure with P/F ratio below 100 mm Hg despite optimization of ventilator settings *. The Berlin consensus document on ARDS suggest ECMO when P/F ratio is below 70 mm Hg.

• Hypercapnic respiratory failure with arterial pH below 7.20

• Ventilatory support as a bridge to lung transplantation
VV ECMO: cannulation

• Can be accomplished with 2 catheters: IJ- femoral vein, 2 femoral veins.

OR

• Single catheter via IJ vein (Avalon catheter)

2 catheter VV ECMO

Ventetuolo, C: Extracorporeal Life Support in Critically Ill Adults. AJRCCM, 190 (5): 497-508
Dual Lumen Single catheter VV ECMO

VV ECMO settings

• Maximize Flow (higher flow, higher oxygenation)

• Set sweep via ECMO circuit to normalize pH

• Ventilator is NOT used to correct pH (ie, no tidal volume goal) and plateau pressure settings are lowered
**Ventilator setting when on VV ECMO**

- Many advise Plateau pressure below 20 to allow “lungs to rest” and to maximize venous return/Cardiac output
- Wean FiO2 to 0.4, then decannulate ECMO

**Ventilator setting when on VV ECMO**

- My approach: goal is maximize ECMO flow and sweep and vent settings to allow us to adequately oxygenate patient (ie, PaO2 above 55 mm Hg).
  - Start at plateau pressure 20-24: If unable to adequately oxygenate patient, then increase plateau pressure to 28-29 by increasing PEEP, or Inspiratory time. Decannulate when vent FiO2 is 50%.
  - Ok to minimize ventilator minute ventilation as sweep on VV ECMO will normalize pH (do NOT correct PCO2, rather keep pH 7.35-7.45)
Medical Management while on ECMO

Cardiovascular

VV ECMO allows reduction of ventilator settings:

- Decrease in intrathoracic pressures
- Improved venous return
- Decreased vasopressor support
  Improved myocardial oxygen delivery
Neurologic

- Neuromuscular Paralysis: often on ECMO initiation
- Sedation: RASS. Try to ambulate with ECMO
- Delirium: often
- Intracerebral Hemorrhage: potential

Renal

Patients often receive 3-5 liters/24 hours

Diuretics  CRRT  Negative Fluid Balance

Negative fluid balance decreases vent days and improve survival
Hematologic complications

• Acute Anemia: from inflammation; hemolysis from ECMO circuit; blood draws
• Thrombocytopenia: from ECMO circuit
• Acquired Fibrinogen deficiency: from ECMO circuit
• IV anticoagulation for ECMO circuit (creates bleeding risk)

Mechanical Ventilation
Lung Protective Ventilation

Evidence for VV ECMO

- Efficacy and economic assessment of Conventional ventilatory support versus Extracorporeal membrane oxygenation for Severe Adult Respiratory failure (CESAR): a multicentre randomised controlled trial

**CESAR trial**

- 180 patients that met criteria, 1:1 randomization:
  - Murray score 3 or above, OR pH below 7.20
  - less than 7 days on ventilator
  - age 18-65

Exclusion: intracranial bleeding, on high vent settings >7 days, or “any contraindication to continuation of active treatment”

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**CESAR trial**

- 180 patients were randomized VV ECMO vs conventional Rx.
- ~70/90 in each arm had 1-2 organ failure, the rest 3 or more
- 68 patients (75%) actually received VV ECMO
- 50% had 48 hours or less ventilator support, the rest less than 7 days
6 months survival, p=0.03

Pitfalls of CESAR trial

- Much more ECMO patients received steroids than conventional rx.

- 22 patients assigned to ECMO did not receive it (some died, some got better before transfer to ECMO center)

- Much more ECMO patients got protective ventilation than conventional rx (not required, prior to ARDSnet recs)
Complications of VV ECMO

• Complications:
  – ICU complications PLUS: thrombocytopenia, catheter infection, bleeding, thromboembolism from catheter/oxygenator site, oxygenator thrombosis

ECMO for severe ARDS randomized clinical trail (EOLIA)
Combes, A et al: NEJM, 378(21): 1965-75, 2018

• Primary end point was 60 day mortality

• Complications: similar except more bleeding requiring transfusion (46% vs 28%) & more thrombocytopenia (27% vs 16%) in ECMO group

• No significant difference in 60 day mortality between the two groups.
Inclusion criteria

- On vent less than 7 days. Randomized according to 72 hours
- Randomly assigned patients with very severe ARDS (P/F ratio below 50 mm Hg for > 3 hrs; P/F ratio below 80 mm Hg for more than 6 hrs; or pH below 7.25 with PCO2 above 60 mm hg for more than 6 hrs

Exclusion criteria

- BMI above 45
- Chronic lung disease especially on oxygen at home
- Coantraindication to anticoagulation
- Age below 18
- Irreversible neurologic injury
- Cancer with life expectancy less than 5 years
- SAPS II score above 90
ECMO for severe ARDS

This trial was stopped early because of efficacy between the 2 arms of the study, although the actual survival difference of 11% was not significant.

VV ECMO resulted in improved oxygenation, more days free of renal failure, lower rate of ischemic stroke and mortality benefit was almost reached significance.

This study does not definitively support the routine use of ECMO of all patients with ARDS, it does support the early use of ECMO in those for whom conventional therapy does NOT improve oxygenation.
Assessment of Therapeutic Interventions and Lung Protective Ventilation in Patients With Moderate to Severe Acute Respiratory Distress Syndrome: A Systematic Review and Network Meta-analysis

JAMA 2019, Aoyama H, et al

- Randomized clinical trials of interventions for adults with moderate to severe ARDS that used lung protective ventilation.

- The primary outcome was 28-day mortality
Assessment of Therapeutic Interventions and Lung Protective Ventilation in Patients With Moderate to Severe Acute Respiratory Distress Syndrome: A Systematic Review and Network Meta-analysis

JAMA 2019, Aoyama H, et al

Figure 8. Ranking Probabilities for the Effect of Interventions on the Outcomes

(a) Ranking Probabilities for the Effect of Interventions on 28-day mortality
Meta-analysis, JAMA---
Results

• Compared with lung protective ventilation alone, prone positioning and VVECMO were associated with significantly lower 28-day mortality

• (prone positioning: risk ratio, 0.69; 95% credible interval, 0.48-0.99; low quality of evidence; VVECMO: risk ratio, 0.60; 95%credible interval, 0.38-0.93; moderate quality of evidence).

VV ECMO

• When all else fails (including dry lungs)
• Less than 7 days on vent
• No CNS injury, no contraindication to anticoagulation
• Reasonable chance at returning to pre ECMO functional status
• Can be as treatment option OR as a bridge to lung transplant
THE END