Extracorporeal CO₂ Removal to Treat Respiratory Failure: Where are we?

Nicholas S Hill MD
Tufts Medical Center
Boston, MA
USA
Disclosures

• Research
  – Alung Chief Investigator, US clinical trial of Hemolung

• Consultant, Advisory Board
  – Alung
Outline

- Technical aspects of ECCO$_2$R
- Recent History
- Potential Clinical Applications
- Brief overview of Current Evidence
- Where does it currently fit in?
ECCO$_2$R – Basic Concept

• Efficient gas exchanger removes CO$_2$ from blood accounting for up to 1/3 of CO$_2$ production

• Functions at approximately 1/10 blood flow c/w extracorporeal membrane oxygenation (ECMO) but much less efficient at oxygenating

• “Continuous veno-venous hemofiltration (CVVH) for the lungs”
Physiologic Factors Determining PaCO2

\[ \text{PaCO2} = 0.763 \times \frac{V\text{co}_2}{V\text{A}} \]

\[ V\text{E} = V\text{D} + V\text{A} \]
ECCO$_2$R Reduces need for $V_A = 0.763 \times V_{co2}$

$V_A + ECCO_2R$

$\downarrow V_E = V_D + \downarrow V_A$
**Effect of ECCO$_2$R on diaphragmatic work of breathing**

- 4 COPD pts failed 2 spont breathing trials – successfully extubated using **ECCO$_2$R**

<table>
<thead>
<tr>
<th>SBT without</th>
<th>SBT with <strong>ECCO$_2$R</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta P_{di}$ (cm H20)</td>
<td>10.9</td>
</tr>
<tr>
<td>$\Delta P_{TP_{di}}$ (cmH20xs/min)</td>
<td>270</td>
</tr>
</tbody>
</table>

Pisani L et al, AJRCCM 2015
Available ECCO2R Devices

- **Novalung iLA** – Uses gas exchange membrane made of polymethylpentene
- woven into hollow fibers through which blood is perfused
- Usually used without a pump in arterio-venous setup, can also be used as veno-venous device with pump
- Flow 1-2 L/min, can remove almost full CO2 production – used as bridge to txplant
Novalung ECCO2R Device
Available ECCO2R Devices

- ProLUNG (Estor) –
- Uses membrane in cartridge perfused with roller pump
- Venovenous system
- Used for bridge, ARDS
Available ECCO2R Devices

• **Hemolung Alung** – Uses microporous polypropylene membrane with hollow fibers through which blood perfused
  - Has single double lumen catheter designed for veno-venous use driven roller pump
  - Flow 0.4 to 0.6 L/min, remove 1/3 CO2 production
Hemolung ECCO2R Devices
Potential Clinical Applications of ECCO$_2$R Devices

- COPD exacerbations in patients at high risk of failing NIV
- Hypercapnic resp failure in patients having difficulty weaning
- Hypoxemic respiratory failure to facilitate lung protective strategies
What do we know about clinical applications of ECCO$_2$R?

• First studies feasibility studies showing removal of 1/3 CO2 production and reduced VT and case report of severe emphysema with bilat air leaks – able to be extubated with ECCO$_2$R, eventually returned home.

• Gatinoni L et al, JAMA 1986

• Pesenti A et al, Anesth 1990
What do we know about clinical applications of ECCO$_2$R?

- RCTs – in ARDS pts showing facilitation of lung protective strategy – UK REST trial in progress
- Bein et al, ICM 2013, Finelli et al, Crit Care 2016
- Retrospective on mainly COPD showing avoidance of intubation in 9-%, no mortal diff c/w historical controls
- Kluge et al, ICM 2012
What do we know about clinical applications of ECCO$_2$R?

- Prospective study on COPD pts showing avoidance of intubation in COPD pts and facilitated extubation
  - Burki et al, Chest 2013
- Prospective matched study on COPD pts showing 73% reduced risk of intubation.
  - Del Sorbo et al, CCM 2015
Summary: ECCO₂R - Where are we?

- Effectively removes CO₂ and appears to avoid intubation, facilitate extubation in COPD
- Facilitates Lung Protective Strategies in ARDS
- Bleeding complications have been concern
- We need to know whether this translates into better outcomes - vent free days, mortality in suitably powered RCT