What is ECMO?
- An alternate method of providing prolonged cardiac and pulmonary support
- Called extracorporeal membrane oxygenation (ECMO), extracorporeal life support, or extracorporeal lung assist
- Last resort

Patient selection
- Vary widely from institution to institution, usually it is started in patients as a temporary life support measure
- In patients with severe acute resp. or cardiac failure if it is potentially reversible

Indications for ECMO
- Facilitate cardiac surgery
- Cardiopulmonary bypass
- Used as a bridge for:
  - Mechanical ventricular assistance or heart transplant
  - Severe cardiogenic shock
  - Cardiac arrest or failure
  - Respiratory failure

What is ECMO?
- Involves partially removing blood from the patient
- Infusing O2 & removing CO2 (through an extracorporeal membrane)
- Return this blood back to patient
Indications for Extracorporeal Life Support (ECLS)

• Severe ARDS
  Acute onset pulmonary failure, with bilateral infiltrates on chest x-ray, and PaO2/fraction of inspired oxygen (FiO2) ratio <100 or A-aD02 >600 mm Hg despite maximal ventilator settings

Contraindications for ECMO

• Absolute
  Unlikely to be reversed in 10 – 14 days
  Multi-organ failure
  Severe reversible brain injury
  Significant pre-ECMO CPR
  Contraindication to anticoagulation
  Uncontrolled metabolic acidosis
  Terminal disease / malignancy
  Chronic lung disease (underlying)
  Chronic myocardial dysfunction
  Immunosuppression
  HIT

• Relative
  Mechanical ventilation >6 days
  Septic shock
  Severe pulmonary hypertension (MPAP >45 or >75% systolic)
  Cardiac arrest
  Acute, potentially irreversible myocardial dysfunction
  >35 years of age

ECMO

• ECMO circuits provide two types of support:
  Veno-Arterial
  Veno-Venous (V-V)

History of ECMO

• Robert Hooke (1653–1703)

• Clinical Evidence
  Historically survival rates ~35%
  Today survival rates increased to 52–66%
  Improved survival rates due to:
  The way ECMO is administered
  Improvements in supportive care of patients

(Haft & Bartlett, 2007)
Veno–Venus (V-V)

- More common
- Provides only pulmonary support
- Allows lungs to heal
- Pulmonary support and hygiene are required to improve gas exchange
- Can provide sufficient oxygenation for several weeks

Monitoring of ECMO

- Multidisciplinary team approach is used
- Patient is connected to ECMO circuit
- Blood flow is increased until respiratory and hemodynamic parameters are satisfactory

Complications of ECMO

- Cannula dislodgement
- Bleeding
- Sepsis
- Air emboli
- Risk of disseminated intravascular coagulation (DIC) & heparin induced thrombocytopenia (HIT)
- Renal failure
- Decubitis ulcers
- Neurologic damage

Prevention of Complications

- Paralyzing &/or deeply sedating the patient
- Cautious turning principles & minimal rotation settings on rotating beds
- Frequent neurological assessments

Volume management

- Maintain CVP 10–15 mmhg
  - Adjust according to flow
- CRRT is possible with access points from ECMO circuit
**Weaning / Endpoint Therapy**

- Reduce flow gradually
- Assess with TEE
- Bridge to recovery & transplant

**Case Study**

**ER- Nov. 30**

- 29 year old male
- Presented with:
  - Fever, chills, myalgia & headache
  - Nausea & vomiting
  - Severe photophobia
  - Intermittent cough, chest pain & SOB
  - Yellow sputum

**Vital Signs**

- BP = 83/40 > 109/52 with fluids
- HR = 113  Sinus Tachycardia
- RR =20/min
- Temp = 38.7

**Respiratory Assessment**

- Inspiratory wheeze throughout R lung
- ↓ breath sounds to LLL
- X-ray - RUL opacity
- 02 sat = 95% on R/A; on arrival

**ER - Investigations**

Lab results/tests:
- LP - normal
- Cultures, aspirates & serology pending
- WBC normal, febrile

Diagnosis:
- ? Community acquired pneumonia VS influenza
Nov 30 – Dec 3 / medical ward

Condition deteriorates

- Temp – 36.5-39.3
- Headache & photophobia persists
- Epistaxis
- Chest: ↓ A/E noted with crackles
- RUL consolidation
- 02 sat 4 l/min = 89% to 97%; RA 83%
- Yellow sputum with hemoptysis
- Diarrhea
- ↑ CK (619) & myoglobin (76)

Case Study

- Darrin was deteriorating rapidly
- What saved him?
  - Was it the nurses quick action
  - The vigorous care of the ICU team who opted to try ECMO

Let’s put all the pieces together as we investigate Darrin’s story...

Dec 4 - 0830h / medical ward

- BP = 50/30
- RR = 20-30/min
- 02 sat ↓ to 85%
- Crackles to R lung
- Wheezing & ↓ A/E throughout
- ↑ density RUL & RML
- ICU consult

ABG – Dec 4 / medical ward

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<tr>
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<tr>
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<td>53</td>
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<tr>
<td>O2</td>
<td>74</td>
<td>67</td>
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<td>27</td>
</tr>
<tr>
<td>BE</td>
<td>2</td>
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<td>92%</td>
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<tr>
<td>O2</td>
<td>10L NRB</td>
<td>15L NRB</td>
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Dec 4 / ICU

- Admitted to ICU
- Intubated secondary to hypoxia
- Sedated & paralyzed
  - Rocuronium, midazolam & fentanyl
- HR 100-120/min ST
- Levophed for MAP >70 mmHg
- PAWP = 28
Dec 4 - 1900 / ICU

- Ventilator settings
  - 650 x 16
  - PEEP 10
  - FiO2 1.0
  - Peak pressure = <33

- ABG
  - pH 7.36
  - CO2 51
  - O2 67
  - HCO3 26
  - BE 2
  - Sat 92%

Dec 5 – Cooling Strategies

- Temperature rose to 40 º
- Tylenol 650 mg q4h Temp >38.5
- Naproxen 500 mg x 2 for Temp
- Active external cooling
- Refrigerated N/S 1000ml wide open

Dec 5 – Respiratory Tests

- Chest US
- Bronchoscopy
- Cultures
- Inhaled Nitric Oxide (NO) added
- PEEP studies
- Recruitment technique
- Modified Lung Protective Strategies

Dec 5 - Ventilation

- PS Trial – ↓ sat to 84% put back on AC
- ↓ sat when Right side down
- PEEP ↑ to 12; maintain O2 sat >90
- Peep studies done to optimize compliance
  - PEEP ↓ to 8cm H2O; sat 81%
  - PEEP maintained at 12cm H2O
  - Inhaled Nitric Oxide (NO) added

Recruitment Technique

- CPAP
  - 40 cm H2O – 40 sec then
  - 45 cm H2O – 40 sec then
  - 50 cm H2o – 40 sec

Modified Lung Protective Strategies

- VT = 7ml/h
- PEEP = 15
- FiO2 = 1.0
- PEAK 35
**Respiratory - ABG**

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<th>Dec 6/1820</th>
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<td>23</td>
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<td>BE</td>
<td>3</td>
<td>-2</td>
<td>-0</td>
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<td>Sat</td>
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<td>AC 500x20</td>
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<td>AC 340x35</td>
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<td></td>
<td>FiO2 1.0</td>
<td>FiO2 1.0</td>
<td>FiO2 1.0</td>
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<tr>
<td></td>
<td>PEEP 15</td>
<td>PEEP15</td>
<td>PEEP 15</td>
</tr>
<tr>
<td></td>
<td>NO 20ppm</td>
<td>NO 20ppm</td>
<td>NO↑40ppm</td>
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**Acute Respiratory Distress Syndrome (ARDS)**

ARDs
- Refers to patients with an acute or progressive respiratory disease of a non-cardiac nature, in association with diffuse bilateral pulmonary infiltrates demonstrated on chest radiograph, and hypoxemia

**Dec 6 – ICU**
- Still sedated & paralyzed
- Inotropes for BP support
- ID following regarding antibiotic regime
- Unable to give APC r/t heparin
- High dose steroids for ARDS

**Dec 7 - Respiratory**
- Worsening respiratory failure with rapid progression to ARDS
- Inability to respond to any ventilatory strategies: APVR, Recruitment techniques, proning, NO
- CXR – severe bilateral infiltrates
- Cardiac surgery consulted for ECMO

**Dec 7 - The PLAN**
Cardiac surgery
- Placed on veno-venous ECMO
- ACT 180-200 with IV Heparin
- CXR for cannula positioning
- U/S R groin to R/O bleeding from femoral artery / retroperitoneal hematoma
- Insert PA cath to measure PA sat/O2/C02

**Dec 7 – ABG pre-ECMO**

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<th>HCO3</th>
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<td>AC 340 x 35</td>
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<td>69</td>
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Dec 7 – ABG post-ECMO
FiO2 1.0 Flow 5 L/min

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<th>Patient</th>
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<td>40</td>
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<td>374</td>
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<td>BE</td>
<td>2.6</td>
<td>2.6</td>
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<td>Sat</td>
<td>87%</td>
<td>84%</td>
<td>86%</td>
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Respiratory - ABG

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<td>O2</td>
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<td>HCO3</td>
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<td>29 / 29</td>
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<tr>
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<td>4</td>
<td>6 / 5</td>
<td>1</td>
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<tr>
<td>Sat %</td>
<td>87</td>
<td>89 / 91</td>
<td>93</td>
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Dec 10 – ICU progress

• Ventilator AC = 500 x 14 x 12 cm x 0.5
• X-ray improvement
• A/E slight decrease to bases, bilateral wheezes
• CRRT continued
• Inotrope requirements decreasing
• U/S of heart = improved function

Dec 10 – FiO2 0.3 Flows 2 L/min

<table>
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<th>Patient</th>
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<tbody>
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<td>31</td>
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<td>BE</td>
<td>2.3</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Sat</td>
<td>57%</td>
<td>97%</td>
<td>97%</td>
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Dec 11 – ECMO

• Substantial improvements in respiratory function over past 24 – 36 hrs
• Decreased flow to 1 L/min & FiO2 to 21%
  • No change in paO2 noted
  • Heparin 40,000 units IV given
  • Cannula clamped
  • Pt stable, Protamine 400 mg IV given
  • Cannulas removed

ICU progress

• CI ↑↑ without vasopressors
• ↑ PAW/D/AD
• CRRT continued until Dec 15
• Agitation / c/o pain
• Extubated Dec 17
• Adenovirus isolated on blood sample
• New working Dx:
  • Pneumonia 2° Adenovirus
Additional Issues

• Myopathy
• GI Bleed
• Renal failure
• ? Sepsis
• MRSA

Dec 18 – Transferred to Ward

• To ward on 10L NRBM
• Sat ≥ 92 %
  • pH 7.29
  • CO2 45
  • O2 91
  • HCO3 20
  • BE -5
  • Sat 96
• Hemodialysis for continued Rhabdomyolysis & poor circulatory function

Patient Progress

Dec 23
• Agitation & delirium, requiring Haldol
• ↑ WOB/agitation
• Re-admitted to ICU x 48 hrs

Jan 18
• DISCHARGED HOME

Patient Follow Up

April 10
• Still having some unexplained CP

June 27
• Chest medicine consulted re: Pulmonary Function Studies & further investigations
• PFT :
  • moderate restrictive ventilation pattern
  • Residual pulmonary fibrosis, as a complication of ARDS

July 18
• CT: some scarring in Left mid lung field
• ID following in clinic for Right heel dressing changes

Questions ? ? ?