Adult ECMO 2014

An old technology is given new life...

Overview

• ECMO basics and physiology
• ECMO for lung failure
• ECMO for heart failure
• Anesthesia considerations
• Recent UCH ECMO results

Purpose of ECMO

• Oxygen delivery is the key to life

\[ O_2 - 100 \times \frac{\text{PaO}_2}{1.39 + \frac{0.0031 \times \text{PaCO}_2}{1}} \]

• ECMO can be used to sustain the body while
  – Heart or lung heals itself
  – Heart or lung is replaced (transplant)
  – Heart is repaired (LVAD, valve, CABG)

What is ECMO/ECLS?

• Extracorporeal circulation
• Extracorporeal life support
  – Step 1: Centrifugal pump
  – Step 2: Oxygenator
  – Step 3: Cannulas and a patient

ECLS – the beginning

1975-1976, Bartlett et al. successfully apply bedside CPB to treat a newborn with meconium aspiration, marking the beginning of ECMO in critical care

ECMO for cardiac support

• Venoarterial (VA) ECMO (ECLS)
ECMO for lung support

- Veno-venous ECMO

Veno-venous ECMO

- 2009 H1N1 related ARDS
- Better circuits
- Technologies for patients with irreversible disease:
  - Lung transplant
  - Ventricular assist devices
  - Total artificial heart devices

VV ECMO Physiology

- Dark blood removed from IVC/SVC
- Bright blood returned to right atrium, mixes with the rest of venous blood and goes to RV
- Volume removed = volume returned; therefore no net effect on CVP, ventricular filling, or hemodynamics
- CO2/O2 content in arterial blood is a mixture of:
  - Returned circuit blood
  - Venous blood that bypasses circuit
  - Any gas exchange occurring in damaged lungs

VV ECMO Physiology

- CO2 is NEVER a problem
- O2 delivery is the key and can be troublesome
- Goal diversion of venous blood is 75% or greater (goal 50cc/kg/min)
  - Needs large drainage cannula
- If lungs nonfunctional sats will be in the 80s
  - This is NOT a problem!

VV ECMO Physiology

- Normal DO2 1000 mL O2/min
- Normal VO2 200 mL O2/min
- Normal DO2/VO2=5:1
- Critical DO2/VO2=2:1
- Maintaining DO2/VO2>4:1 provides plenty of physiologic reserve
- Example: CO=7LPM, Hb=13, SaO2=75%
  - DO2=930
VV ECMO Goals

1. LUNG REST!!!
2. Oxygen homeostasis (CO2 never a problem)
3. Non-paralysis
4. Awake
5. Moving
6. Eating

VV ECMO Problems

1. Bleeding
2. Circuit problems (thrombosis, hemolysis)
3. Infection

Case #1

• 25 year old male, soccer player
• 1 week history of flu like symptoms
• Presented to ED with shortness of breath, SaO2 81% on room air
• Admitted and intubated 4 hours later
• You are called at 4AM: 100%, 18 PEEP, plateau 38 on multiple pressors, TTE shows hyperdynamic heart, ABG 7.18/73/38

Case #1 result

• VV ECMO allows for low pressure ventilation and resolves shock
• After 2 weeks the lungs open up and patient is weaned from ECMO
• He goes home 2 weeks later

ARDS ECMO: historical perspective

• NIH randomized trial of adult ARDS
• 686 pts: overall survival 34%
• 90 of sickest pts randomized to ECMO vs. conventional therapy
• VA ECMO used universally
• Large tidal volumes in both groups


What is better now?

• VV Cannulation
• LUNG PROTECTION PRINCIPLES (ARDSNET)
• Better circuits
• Less anticoagulation
• Patient selection
CeSAR Trial

- PRCT from UK: ECMO vs. standard in severe ARDS. 2001 to 2006
- Enrollment halted at 180 pts
- Hospitals in UK
  - Glenfield hospital in Leicester (ECMO center)
  - 100 hospitals (conventional treatment centers)


CeSAR Trial

- Inclusion:
  - Age 18 to 65
  - Severe but reversible respiratory failure
  - Murray Score > 3
  - Severe hypercapnia with pH < 7.2
- Exclusion
  - >30cm H2O or >80% FiO2 ventilation for > 7 days
  - Contraindication to anticoagulation


CeSAR Trial

- Patient randomization
  - ECMO: all transported to Leicester
  - Conventional treatment: Stayed at conventional treatment center of transferred from referring hospital
- Intention to Treat analysis


Murray Score

- Average of all 4 of the following
  - P:F ratio
    - >300=0, 225-299=1, 175-224=2, 100-174=3, <100=4
  - PEEP
    - <5=0, 6-8=1, 9-11=2, 12-14=3, >15=4
  - Lung compliance (mL/cmH2O)
    - >80=0, 60-79=1, 40-59=2, 20-39=3, <20=4
  - CXR appearance
    - 1 point per quadrant infiltrated


ECMO group

- All transported to Leicester
- Evaluated for ECMO
- All veno-venous cannulation
- Strict lung rest strategies
- ACT 160 to 220


Conventional group

- Could use any treatment though to be appropriate
  - iNO, HFOV, prone positioning
- Low tidal volumes suggested
- No crossover to ECMO group

Reasons for not receiving ECMO

- 5 died before arrival
- 16 did not meet inclusion criteria
- 1 required amputation

CeSAR results

- Survival without severe morbidity 63% ECMO vs. 47% conventional (p=0.03)

CeSAR limitations

- Small size—halted due to survival benefit
- Variations in quality of care in conventional arm
- Many “ECMO” patients did not receive ECMO

CeSAR Conclusions

- Should not conclude that ECMO itself improves survival
- Transfer of patients with severe ARDS early in their course to a center that has ECMO capability improves survival by an absolute 16%
- Number needed to treat=6

H1N1 2009 in Australia / NZ

- NONRANDOMIZED retrospective cohort
- June, July, August 2009
- 201 pts req. mech. vent. for H1N1 ARDS
- Those with most severe disease received ECMO
- Decision made by clinician to place on ECMO
  - VV ECMO with centrifugal pump
  - Heparin bonded cannulas
- 68 ECMO, 133 deemed to not need it
Characteristics of ECMO pts.

- pH 7.2, pCO2 69, P:F 55, PEEP 18, FiO2 100%
- Murray score 3.8
- 81% had attempted one or more of following:
  - Prone, prostacyclin, iNO, HFOV

ARS ECMO indications

- Patients with mortality risk >80%
  - P:F < 80
  - Murray score 3 to 4
  - Inability to maintain plateau less than 30 or refractory hypercarbia (pH < 7.2)
- Example:
  - Patient with ARDS, PaO2 50 on 100% / 10 PEEP, plateau > 30

Case #2

- 54F diagnostic left heart cath for chest pain
  - Left main dissection
  - VF arrest
- Emergent CABG
- Unable to wean from bypass
- Temporary external LVAD placed (LV apex to aorta)
- In ICU for 3 days with 2 LPM LVAD flow on multiple vasopressors, bleeding
  - Arrives to us with black fingers and toes, anuric, shock liver, unresponsive with no sedation x 24 hours
- TEE: still RV and LV

Case #2 Result

- R IJ venous cannula added
- LV apex cannula used as LV vent into circuit
- 6LPM immediately established
- All vasopressors stopped
- Extremities turned pink over 1 to 2 days
- Woke up 7 days later, RV recovered
- Heartmate II LVAD implanted on ECMO day 10
- Kidneys recovered at 6 weeks
- At home functioning normally with family, awaiting transplant
VA ECMO: Indications

- Cardiogenic shock
- Bridge to LVAD/transplant/cardiac operation
- Weaning from CPB
- Intractable arrhythmia (bridge to ablation)
- Support for interventional procedure
- Acute myocarditis (bridge to recovery)
- Acute MI
- Acute PE with hemodynamic collapse
- In-hospital arrest >10 min CPR (eCPR)

VA ECMO: Exclusions

- Age > 70
- Irreversible etiology without VAD/transplant option
- Known neurologic injury
- Contraindication to anticoagulation

VA ECMO problems

- BLEEDING
- LV distention/refractory pulmonary edema
- Harlequin syndrome
- Limb ischemia
- Stroke
- Circuit dysfunction
- Infection

UCH Program

- Since July 1, 2012—38 TOTAL CASES
  - Cardiogenic shock (18 cases)
    - Overall survival 61%
    - 9 bridged to Heartmate II LVAD (100% survival)
  - Bridge to Lung transplant (5 cases) (100% survival)
  - Bridge to lung recovery (12 cases) (60% survival)
  - 3 peri-procedural support (100% survival)
Anesthetic Considerations

- Pre-ECMO: instability
- During VV ECMO:
  - Maintain lung rest
  - Difficulty with inhaled gas diffusion
  - Drug sequestration
    - Propofol
    - Benzodiazepines
- During VA ECMO:
  - Issues with minimal pulmonary blood flow and gas scavenging
  - Use of TIVA
- TEE for cannula guidance

Summary

- Proper patient selection is critical
- Center experience is critical
- ARDS patients with high expected mortality should be offered ECMO support
  - Expected survival of 60%
- Patients in cardiogenic shock with potential for cardiac recovery or LVAD can be salvaged at a rate of 40 to 60%
- ECMO use at specialized centers will continue to rise