Adult ECMO 2014

An old technology is given new life…

Ashok Babu

SURGERY

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

$$DO_2 = CaO_2 \cdot CO$$

$$CaO_2 = [(SaO_2 \cdot 1.39 \times Hb) + (0.0031 \cdot PaO_2)]$$

- 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?

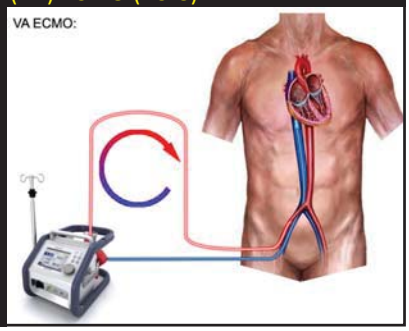
- Extracorpo on
- Extracorpo
- Step 1: Cen
- Step 2: Oxy
- Step 3: Can

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

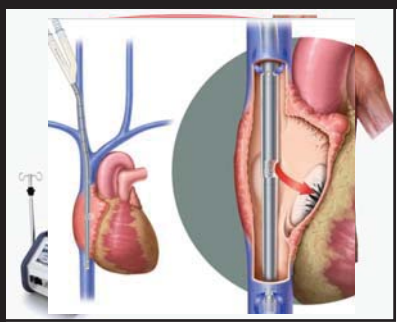
ECMO for cardiac support

- Venoarterial (VA) ECMO (ECLS)



ECMO for lung support

- Veno-venous ECMO



Adult EC rgence?

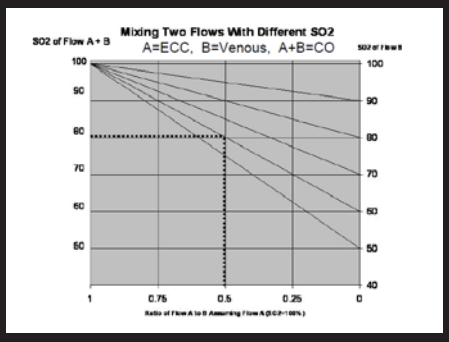
- Ve
- 2(
- Be
- Te di
  - –
  - –
  - – Total arti

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

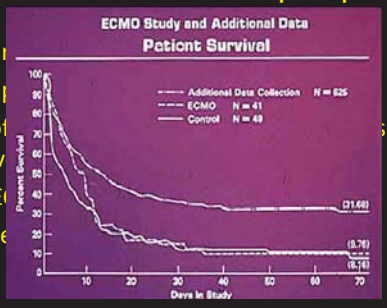
- 25 ye
- 1 wee
- Prese eath, SaO2
- Admit r
- You a P, plateau 38 on hyper 38

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
- 686
- 90 o s. conv
- VA E
- Large



Zapol et.al. JAMA. 1979.

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)

Peek et. al. Lancet. 2009.

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

Peek et. al. Lancet. 2009.

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

Peek et. al. Lancet. 2009.

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

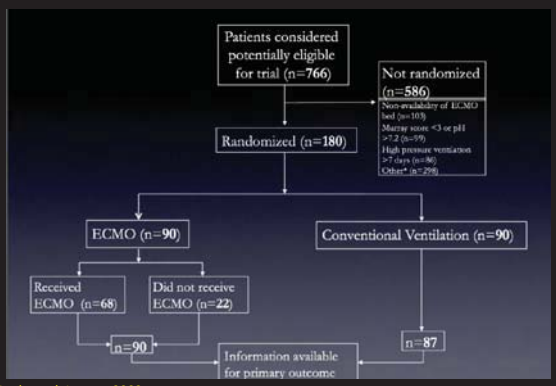
- All transported to Leicester
- Evaluated for ECMO
- All veno-venous cannulation
- Strict lung rest strategies
- ACT 160 to 220

Peek et. al. Lancet. 2009.

Conventional group

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

Peek et. al. Lancet. 2009.



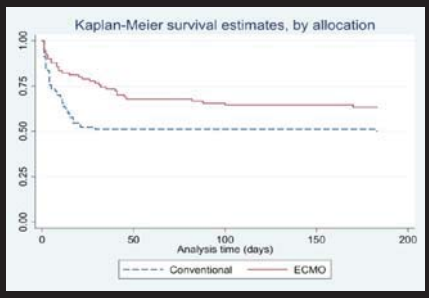
Peek et. al. Lancet. 2009.

Reasons for not receiving ECMO

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

Peek et. al. Lancet. 2009.

CeSAR results



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

Peek et. al. Lancet. 2009.

CeSAR limitations

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

Peek et. al. Lancet. 2009.

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

Peek et. al. Lancet. 2009.

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

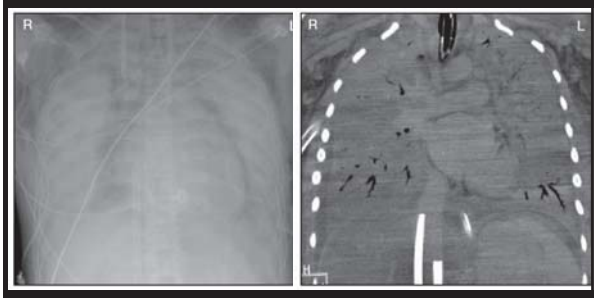
ANZ ECMO. JAMA. 2009.

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

ANZ ECMO. JAMA. 2009.

Results



ANZ ECMO. JAMA. 2009.

ARDS 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

www.elsonet.org

ARDS ECMO Contraindications

- Absolute
  - Significant pre-existing lung disease
  - Poor pre-morbid physical condition
  - Contraindication to anticoagulation
- Relative
  - Vent support > 10 days, high pressure > 7 days

www.elsonet.org

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
- Heaertmate II LVAD implanted on ECMO day 10
- Kidneys recovered at 6 weeks
- At home functioning normally with family, awaiting transplant

Extracorporeal Life Support Registry (ELSO)

27,432

9,660

3,103

		Total	Surv ECLS		Surv to DC	
Neonatal						
	Respiratory	23,191	19,665	85%	17,478	75%
	Cardiac	3,749	2,226	59%	1,454	39%
	ECPR	492	309	63%	184	37%
Pediatric						
	Respiratory	4,188	2,700	64%	2,325	56%
	Cardiac	4,564	2,842	62%	2,121	46%
	ECPR	908	473	52%	348	38%
Adult						
	Respiratory	1,663	997	60%	853	51%
	Cardiac	1,059	510	48%	360	34%
	ECPR	381	138	36%	102	27%
Total		40,195	29,860	74%	25,225	63%

July 2009

VA ECMO: Indications

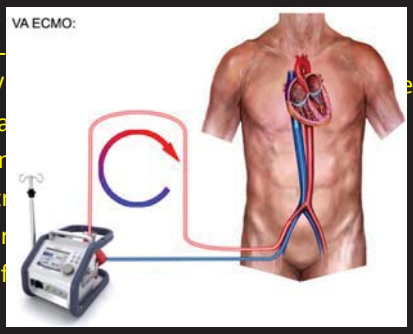
- Cardiogenic shock
  - Bridge to LVAD/transplant/cardiac operation
  - Weaning from CPB
  - Intractable arrhythmia (bridge to ablation)
  - Support for interventional procedure
  - Acute myocarditis (bridge to recovery)
  - Acute MI
  - Acute PE with hemodynamic collapse
  - In-hospital arrest >10 min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

VA ECMO: Exclusions

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

VA ECMO problems

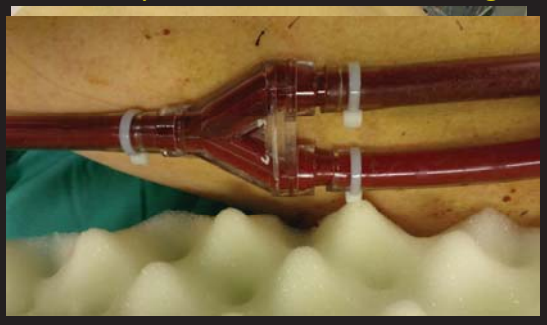
- BL
- LV ema
- Ha
- Lir
- Str
- Cir
- Inf



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)

UCH experience with LV venting



Anesthetic Considerations

- Pre-ECMO: instability
- During VV ECMO:
  - Maintain lung rest
  - Difficulty with inhaled gas diffusion
  - Drug sequestration
    - Propofol
    - benzos
- 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