Perfusion Techniques for Initiating ECMO

Molly Elisabeth Oldeen MS CCP FPP LP
Ann & Robert H Lurie Children's Hospital of Chicago

Purpose

- Avoid unwanted complications of ECMO that may be caused during the initiation period
  - Neurologic –more prevalent in pediatrics
    - ICH – 7.6% (neonates)
    - Cerebral infarction – 6.9% (neonates)
  - Acute Kidney Injury

Goals

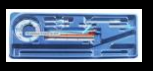
- Discuss techniques to initiate ECMO efficiently
- Discuss techniques related to each phase of ECMO initiation
  - Pre-Initiation
  - Initiation
  - Post-Initiation & Beyond

Efficiency

- eCPR: "Every minute counts."
  - Be prepared 24/7
- Simulations/Training – Multidisciplinary
  - Perfusionists, ICU & OR nursing staff, ICU physicians, etc.
- Collaboration □
  - Nursing
  - Blood bank
    - O Neg release of blood for eCPR
    - Communication re: at risk patients for expedited cross matched blood available for inpatients
    - Positive reinforcement

Efficiency

- Delegation to available staff prior to arrival
  - Blood
  - Drug Box
  - Consider RN assistance with priming and other ancillary tasks
- Location of equipment
  - Dedicated location in the ICU
  - Supplies in operating room
  - Travel cart
- Be prepared
  - Multiple sizes of cannula immediately available
  - Dilator kits

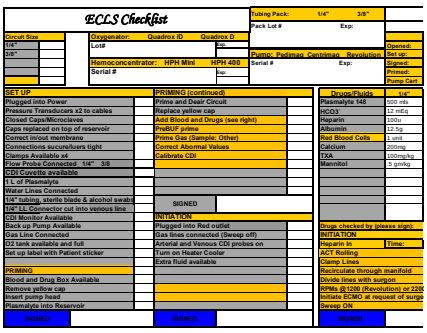


Pre-Initiation

- Established Institutional Protocols
  - Patient selection, circuitry, trouble shooting, anticoagulation
- Checklists ✓
  - Setup
    - Identical each time
    - Two person sign off
  - Priming
    - Consistency re: blood products and medications, sequencing
  - Initiation

Pre-Initiation

- Checklists ✓(continued)
  - Provide **consistency** in care
  - Documentation:
    - Equipment and lot numbers
    - Process
    - Note skipped steps during initiation process due to emergent situations
      - Bloodless initiation due to lack of blood available or eCPR



ECLS Checklist

Tubing Pack:	1/4"	3/8"
Pack Lot #	Exp:	

Circuit Size	Oxygenator: Quadrox ID	Quadrox D
1/4"	Lot#	Exp:
3/8"	Hemoconcentrator: HPH Mini	HPH 400
	Serial #	Exp:

Pump: Peplmax Centrimag Revolution
Serial # Exp:

Opened:
Set up:
Signed:
Primed:
Pump Card

SET UP		PRIMING (continued)	
Plugged into Power		Prime and Drain Circuit	
Pressure Transducers x2 to cables		Replace yellow cap	
Closed Caps/Microclaves		Add Blood and Drugs (see right)	
Caps replaced on top of reservoir		PreBUF prime	
Correct in/out membrane		Prime Gas (Sample: Other)	
Connections sucure/tuers tight		Correct Abormal Values	
Clamps Available x4		Calibrate CDI	
Flow Probe Connected 1/4" 3/8			
CDI Cuvette available			
1 L of Plasmalyte			
Water Lines Connected			
1/4" tubing, sterile blade & alcohol swabs		SIGNED	
1/4" LL Connector cut into venous line			
CDI Monitor Available		INITIATION	
Back up Pump Available		Plugged into Red outlet	
Gas Line Connected		Gas lines connected (Sweep off)	
O2 tank available and full		Arterial and Venous CDI probes on	
Set up label with Patient sticker		Turn on Heater Cooler	
		Extra fluid available	
PRIMING			
Blood and Drug Box Available			
Remove yellow cap			
Insert pump head			
Plasmalyte into Reservoir			
SIGNED		SIGNED	

Drugs/Fluids	1/4"
Plasmalyte 148	500 mls
HCO3	12 mEq
Heparin	100u
Albumin	12.5g
Red Blood Cells	1 unit
Calcium	200mg
TXA	100mg/kg
Mannitol	.5 gm/kg

Drugs checked by (please sign):
INITIATION
Heparin In Time:
ACT Rolling
Clamp Lines
Recirculate through manifold
Divide lines with surgon
IVMs @1200 (Revolution) or 2250
Initiate ECMO at request of surge
Sweep ON
SIGNED

ECMO Cart Contents/ Hardware

Sorin/ Thoratec Console	Gas blender with Gas lines	
Sorin/Thoratec Drive motor	Oxygenator & reservoir bracket	
Flow probe ¼" 3/8"	Manifold holder	
Heater cooler	Main power strip plugged In	
CDI (plugged in to power strip)	Oxygen/Co2 tank(size 1000psi) with holder	
Pressure transducer cables (Sorin)	Clamps x 4	

Dry Circuit set up Checklist

All connections secure	Backup Pump / Hand crank available	
Sealed caps replaced on top of reservoir	O2 tank min 1000 psi	
All vented caps replaced with non-vented white caps	Pyxis Supplies: 1 liter Plasmalyte , CDI Cuvette (Both circuits)	
Microclave connectors on manifold and transducers (5 in total)	Extra ¼" Carmeda Connector, ¼" tubing , sterile blade, alcohol wipes (1/4" Circuit)	
Green Oxygen line connected to Gas blender and Oxygenator	Fill out set up label with Previous Patient sticker- date and time	
Revolution Pump head connected	Attach Lot number to reservoir	
Safety bracket attached to oxygenator	Clamps x 4	
Pressure transducers connected to cables (Sorin)	Circuit is covered with plastic drape	
Proper size flow Probe available	Plugged into power	
Water lines connected ,Valves off		

Expiration date (60-7 days from set up)	**Perfusionist Signature :-**
Dry __/__/___ **Wet** __/__/___	2nd Check by:-
Oxygenator Lot :-	
Hemoconcentrator Lot :-	
Tubing Pack Lot :-	
Pump Lot :-	

Initiation

- Priming Techniques
  - Physiologic Prime
- Blood Gas Management
  - Monitoring
  - pCO_2
  - pO_2
- Temperature Considerations

Priming Techniques

- Similar to CPB
- Physiologic Prime
  - Sodium
    - Avoid hypernatremia. → Neurologic/kidney injury and increased mortality
      - Wash blood with Plasmalyte/0.45% NS
      - Sterile water??
  - Calcium**
  - Potassium**
    - Utilize preBUF or cell washing to avoid hyperkalemic arrest from older/irradiated banked blood on initiation
  - Glucose
  - Oncotic/Osmotic pressure
- Obtain Prime Samples and correct abnormalities
  - Documentation!

** Especially important in VV ECMO

Blood Gas Management

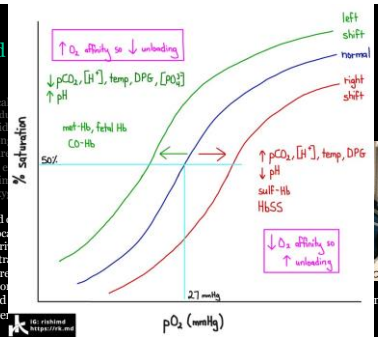
- **Monitoring**
- Incorporate continuous blood gas monitoring to monitor prime values and immediate post initiation values
  - CDI
  - Spectrum M4
- Cerebral/Somatic NIRS monitoring

Blood Gas Management - pCO_2

- Critical to correct hypercapnia s l o w l y
  - Reduce venoarterial CO2 gradient (Grist 2009)
- Consider matching pre-ECLS values –slowly brought into target range
  - Congenital Diaphragmatic Hernia → CO_2 >100mmHg
- Be sure sweep is OFF in closed system
- Have exogenous CO_2 available
  - Priming
  - Oxygenator efficiency

Blood

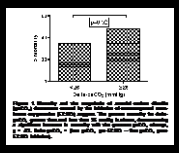
- Critica
  - Red
- Consi
  - Con
- Be sur
- Have e
  - Pri
  - Oxy
- Rapid
- Hypoc
  - Peri
  - Intr
  - Cer
  - Poo
- Rapid deliver



Zhou et al 2008

Blood Gas Management – pCO_2

- Consequences associated with drastic CO2/pH shifts
  - Bambea et al, 2013.
    - Retrospective observational study ECMO patients
    - Magnitude of CO2 decrease was sig. associated with mortality (p = 0.036)
  - Muellenbach et al, 2014
    - Adult study, retrospective review, n=15
    - Decrease in $PaCO_2$ was associated with decrease in cerebral rSO_2 in nonhypoxemic patients
  - Short, 2005
    - Animal studies that showed dramatic increase in CO2 after hyperventilation showed 100% increase in CBF and neurologic injury
    - Author suggests change in practice to increase CO2 over 24 hours



Blood Gas Management – pO_2

- FiO2 considerations
  - 21% post resuscitation
    - Avoid reperfusion injury
  - 50-70% VA
  - 100% VV
    - Maximize dissolved oxygen going through the lungs

Temperature Considerations

- Hypothermia post arrest/eCPR??
  - Confirm with physician
  - Set heater cooler temperature appropriately
  - Prevent reperfusion injury
  - Ability to remove CO2 more effectively (more soluble)
- Avoid unwanted hypothermia
  - Post Cardiac??
- Avoid hyperthermia
  - Note equipment default settings

Temperature Management Literature Review

- NEST Trial
  - Randomized neonates, no improved outcomes at 2 years of age
- THAPCA Trial
  - No differences in seizures between TH and control patients
- Guaman 2018, Bleeding Complications and Mortality in Neonates Receiving TH and ECMO
  - No difference in mortality between those who did and did not receive TH, TH not contraindicated
- Cashen 2018
  - Therapeutic hypothermia independently associated with hemorrhage in neonates
  - Secondary analysis of BATE study, Prospective data collection, n=20
  - 40% v 15.8% ICH. Temperature <34deg C
- * Cheng 2018, Post Arrest Therapeutic Hypothermia in patients with CHD
  - CHD post arrest can be treated effectively and safely with TH, decrease incidence of seizures, n=30
- * Lou 2015, Safety of TH in children on VA ECMO after cardiac surgery.
  - Retrospective review, n=96.
  - TH can be safely provided with no increase in complication rates

Post-Initiation – Reevaluate Plan of Care

- Blood pressure considerations
  - Reduce dopamine/inotropic support
  - Limit increase in flows until blood pressure normalizes
- Ventilator Considerations
  - Reduce support – trends in ventilator settings (avoid complete rest)
- Optimal Flows
  - 20 to 50 ml/kg increased slowly to avoid excessive cardiac afterload/reperfusion injury
- Avoid aggressive treatment of acidosis
  - Limit treatment with NaHCO3 to avoid post arrest alkalosis
- Volume resuscitation
  - Circuit has distensible volume
  - Cytokine response may vasodilation and increased capillary permeability
  - Options: Blood products, albumin, crystalloid

In conclusion…

- As Perfusionists, ***optimize*** what is within our control during this phase of ECMO
  - Efficiency in preparedness
  - Circuit Prime
  - Initial prime and patient blood gases
  - Temperature
- Not every initiation is the same
  - Variable physiology
  - Same circuit

References

- Bembea MM, Lee R, Masten D, et al. Magnitude of arterial carbon dioxide change at initiation of extracorporeal membrane oxygenation support is associated with survival. *The journal of extra-corporeal technology*. 2013;45(1):26.
- Cashen K, Reeder RW, Shanti C, Dalton HJ, Dean JM, Meert KL. Is therapeutic hypothermia during neonatal extracorporeal membrane oxygenation associated with intracranial hemorrhage? *Perfusion*. 2018;33(5):354-362.
- Cheng HH, Rajagopal SK, Sonesvere AJ, et al. Post-arrest therapeutic hypothermia in pediatric patients with congenital heart disease. *Resuscitation*. 2018;126:83-89.
- Kredel M, Lubnow M, Westermaier T, et al. Cerebral tissue oxygenation during the initiation of venovenous ECMO. *ASAIO Journal*. 2014;60(6):694-700.
- Lou S, MacLaren G, Paul E, Best D, et al. Safety of therapeutic hypothermia in children on veno-arterial extracorporeal membrane oxygenation after cardiac surgery. *Cardiology in the Young*. 2015;25:1367-1373.
- Short BL. The effect of extracorporeal life support on the brain: A focus on ECMO. *Seminars in Perinatology*. 2005;29(1):45-50.
- Werho DK, Pasquali SK, Yu S, et al. Hemorrhagic complications in pediatric cardiac patients on extracorporeal membrane oxygenation: An analysis of the extracorporeal life support organization registry. *Pediatric critical care medicine : a journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies*. 2015;16(3):276-288.
- Zhou W, Lin W. Hypercapnia and hypocapnia in neonates. *World J Pediatr*. 2008;4(3):192-196.