Management of the ECMO Circuit
Critical Care & Complications

Michael Varsamis, MS, CCP
New York Presbyterian Hospital
Perfusion Department
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Disclosures

- I Have No disclosures for this presentation
ECMO-Adults
ECMO-Pediatric

Pediatric ECMO YTD

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Sometimes Troubleshooting can be…

OR

OR
It can also be... 

Obvious

OR

Complex

New York Presbyterian
We may have to....

Act quickly

OR

Take our time
Recognize & Treat

- Well trained staff
- Experience
- Communication
- Think outside the box
- Available resources
- Monitoring
- Continuing education of new ICU staff
In our everyday practice, as clinicians we are called upon to address both ends of the spectrum
Identifying-Troubleshooting

- Cannulas
- Tubing
- Blood Pump
- Oxygenator
- Cannulation
- Weaning ECMO
Cannulas

- Blood, fibrin Clots - Usually where the tubing connects to the cannula (when low flows and not properly anti-coagulated)
  - Increase anti-coagulation, monitor clots - if increasing may have to replace connection
- Un-tie-banded tubing connection with cannula.
- Tubing not inserted all the way into cannula connector
  - To avoid catastrophic disconnection insert tubing well and secure.
Cannulas

- In V-V ECMO with FV-IJV cannulation, recirculation of ecmo BQ is possible if tips of cannulas are too close to each other.
- Possible recirculation also when ECMO BQ is too high.
- Indications High SvO2 (90s’), low pt SaO2
  - Decrease ECMO BQ, or pull back cannulas depending on the cause.
Cannulas

- Dual lumen cannulas (Avalon) used for V-V ECMO via the IJV needs to be placed in a way that the drainage lumen is on the bottom/infusion lumen on top. That insures ECMO flow towards the TV.
  - If not positioned correctly mixing may occur (high pre oxyg. Sat/lower SaO2)
- If cannula not inserted all the way, BQ towards Innominate vein, Left side congestion, brain death.
- If need to convert from V-V to V-A, drainage & infusion ports of dual lumen cannula CANNOT be “Y”ed. Drainage port WILL clot off.
  - Convert to V-A-V model:
    - Dual lumen V-V +
    - 1 arterial access V-A
  - DO NOT EVER only clamp post oxyg. in case of emergency. (A-V shunt)
Tubing

- Tubing on a ECMO circuit will almost never give you any problems, unless:
- Length is too short (we said, the shorter the better but Not that short!!)
- Short tubing will make every day ICU pt maintenance difficult, and there is high risk for a potential disaster (disconnection from cannula or pump).
- Really long tubing has the same risks which can be catastrophic
- Tubing get caught under bed wheels, or under x-ray machine at 5 am…etc
Blood Pump
Roller

- Roller pump is a positive displacement pump, no preload/afterload sensitivity.
- That means it needs to be connected on a console and have (+) or (-) pressure trigger in order to stop.
- In any emergency (hand crank) or non emergent situation (re initiating ECMO) clamp on the venous or arterial lines can have catastrophic effects on the patients.
  
  ✓ Always make sure you have negative/positive pressure triggers to stop the pump
  ✓ In an emergency situation (hand crank) make sure you remove both (arterial/venous) clamps before you initiate flow support.
  ✓ Over-occluded pump will rupture tubing during long runs
Blood Pump
Centrifugal

- Centrifugal pumps are widely used on ECMO circuits. They don’t come without potential risks though:
- Hypovolemia may be misdiagnosed and low ECMO flows may be treated with continuously increasing RPM. That will cause increased heat, shear forces, hemolysis.
  - Correctly diagnose hypovolemia, treat, decrease RPM. Sometimes that will increase the BQ (will release negative pressure at the tip of venous cannula)
- Kink of tubing on pump inlet/outlet (negative pressure, decrease BQ, preload/afterload sensitive)
  - Cover the pump inlet/tubing connection with a ½” tubing
- Hand crank should always be available in case of a console malfunction.
- Back up ECMO cart/console always available by bedside.
Blood Pump
Centrifugal

- Decoupling of the set of magnets, noise and BQ drops.
  - Usually resolves if power down and power back up the console/if not replace pump
- Noise and fractured magnets/bearing failure
- Thrombus generation and hemolysis
- Air embolism
  - Notify ICU team in case of change out
  - Fully support pt, especially on V-A (vent, pressors)
  - Get 2nd perfusionist/MD, prime the back up pump
  - Quickly/safely replace
- Flow sensor issues (continuous alarming)
  - Notify ICU team in case of ECMO discontinuation
  - Fully support pt, especially on V-A (vent, pressors)
  - Replace gel on sensor and restore BQ
Oxygenator

- Oxygenator is the component of ECMO that we see majority of circuit related problems.

- **Clot formation:**
  - Low BQ
  - Inadequate anticoagulation
  - Hours on ECMO
  - Coagulopathies
    - Increased pre Oxyg. Pressure
    - Decreased post Oxyg. Pressure
      - Assess clotting
      - Is it getting worse over time?
    - Assess Oxyg. Function (post oxyg. Gas/O2 transfer)
      - Yes – consider possible change out
      - No – keep monitoring clots/post oxyg. gases
Oxygenator

- **Both Pre/Post Oxygenator pressures decrease**
  - Cause (pump flow, kink anywhere before the oxygenator)
    - Make sure ECMO flow is not decreased, and there is no kink anywhere pre oxygenator

- **Both Pre/Post Oxygenator pressures increase**
  - Cause (elevated SVR, obstruction anywhere post oxygenator, ex. Clot formation, kink)

- **Low post Oxygenator PaO₂**
  - Oxygenator malfunction
  - Clot formation
  - Very low SvO₂
    - Check pre Oxyg. PaO₂
    - Evaluate Oxyg. Performance (O₂ transfer)
    - Decide whether to change out Oxyg. Or not
Air Embolism

- Air entrance in the ECMO circuit can be
  - Insignificant (bolus of medication via central/peripheral lines)
    ✅ Check venous line, make sure no air, then reset bubble detection
  - Significant (massive air entrance in venous/arterial lines - disconnection of venous line from cannula)
    ✅ Assess situation. If air hasn’t passed bubble detection de air venous line.
    ✅ If air went through the blood pump and oxygenator, the safest thing is to change out circuits.
- Always enable pump stop with bubble detection upon ECMO initiation then switch to alarm (secure cannula and lines)
Case Reports
Favorite words in my mind...

WHY?  
WHAT IF...?
Case #1: ECMO Bouquet

RIJV → RFV → RFV → RFV

V-V-V-V

Think outside the box
Case #2

- PO hour 3, DLTX pt became hemo-dynamically unstable
- V-A ECMO decided upon, and initiated via RFV-RFA at bedside
- Patients hemodynamics/oxygenation weren’t improving
- Unusual bleeding from both lungs
- ECMO flow was “cutting out”, requiring continues blood product transfusion.
- Bleeding from lungs continued.
- Elevated CVP, PA pressures/systemic hypotension/hypoxia
- Central cannulation was suggested (not much thought put into that btw, ex. to rule out possible issues with groin cannulas)
- “Thinking outside the box”
- Inspection of the surgical field/Venous line more red than expected

- ECMO lines were switched (venous line-arterial cannula & arterial line-venous cannula)
- Patient on A-V ECMO
- Off ECMO, lines switched, V-A ECMO, patient stable.
A-V ECMO: What went wrong?

- Initiation time was 7 am. Attending surgeon & fellow were in OR with cases + the DLTx for over 24hrs.
- Fatigue/Lack of clear thinking
- ICU room over-crowded. Hard to communicate
- Emergency ECMO initiation
- Lack of proper attention from surgeons and Perfusionists during cannulation/ECMO line connection.
- Lets treat the numbers and not “think outside the box”
- When ECMO BQ is low, lets give volume, instead of trying to figure out the reason for that.
Case #3: “Fem-Fem” V-A ECMO (no cardiac function present)

- Post cardiac arrest ECMO
- Bridge to recovery or bridge to OHTX
- NO cardiac function
- NO wave form on the Art line
- ECMO BQ @ 2.4 CI or higher
- V-A ECMO fully supports the pt
- Femoral arterial line NOT a good indicator of adequate perfusion (head)
- Preferably R radial
- Post Oxygenator ABG values should be = or similar to radial artery ABG values
- It is **safe** to treat patient’s radial
- ABG with ECMO( FiO2/GQ)
“Fem-Fem” V-A ECMO (cardiac function improves)

- few days post V-A ECMO initiation
- heart function improves
- Arterial line waveform present
- ECMO partially supports the pt
- **Two separate circulations**
- upper body been perfused by patient’s cardiopulmonary system
- lower body been perfused by ECMO
- IF for any reason lung function isn't good, a V-A-V should be considered
“Fem-Fem” V-A ECMO (cardiac function improves)
“Fem-Fem” V-A ECMO (cardiac function improves) … continued

- R radial ABG: 7.58/25/98/-2/21/96%

(Resp. Alkalosis)

CTICU staff (without notifying perfusionist on call) **Decreases** ECMO GQ to increase PCO2 (NO change on the vent was made)

Repeat R radial ABG: 7.55/27/98

CTICU staff further Decreases ECMO GQ to increase PCO2

CTICU staff: “I don’t think the oxygenator works, I keep decreasing the sweep, and nothing is happening, the pCO2 isn’t going up…”

Perfusionist does Post Oxy. ABG: 7.15/65/500/8/34/100%

(Resp. Acidosis-Metabolic compensation)

Post ox. Gas is been shown to CTICU staff

CTICU staff: “I don’t understand what happened…??”
Case# 4: Weaning V-A ECMO

- CTICU fellow decides to wean V-A ECMO by weaning FiO2 on ecmo.
- Perfusion Team wasn’t notified for changes
- Patient is desaturating
- Fellows reports to ECMO rounds that patients isn’t ready to come off ecmo
- What really happened was a R-L Deoxygenated shunt
- Off course no pt is able to wean off ECMO when R-L shunt occurs
Case # 5: Oxygenator inlet de-attach

- V-V ECMO, post LTX pt
- Nursing stuff while repositioning the bed, hits the inlet of the oxygenator.
- Inlet de-attached from oxygenator.
- Likely the nurse was recently in serviced so she clamped arterial and venous lines
- Perfusion was called
- Broken oxygenator was replaced
- Metal clamp from manufacture is placed on every oxygenator to prevent future disasters
Case # 6: Accidental V-V, conversion to V-A

16 y/o fem, s/p Fontan, cardiogenic shock, cardiac arrest, CPR ~1 hr
v-a ecmo (LFV-RFA, percutaneous)
It was V-V ECMO
Indications:
- High SvO2,
- low RRABG PaO2,
- same pressure in both ECMO lines.
It was decided that it was V-V ECMO
immediate R groin cut down
direct RFA cannulation
ON V-A ECMO (LFV/RFV-RFA)
Managing ECMOs

- 11 Ecmo patients at once
- 4 Perfusionists covering them
- 5 different locations
- 2 in PICU
- 1 in NICU
- 4 in MICU
- 3 in CTICU
- 1 in CCU
- + one more patient was going ON ECMO in the OR (12th ECMO)
- + another patient was coming OFF ECMO

- Perfusion team notified for a ECMO transport late in the afternoon
- 3 patients in MICU need PT and walk
- 2 patients in CTICU are weaning (BQ/GQ adjustments, vent adjustments, followed by ABGs
- BUSY…BUSY…BUSY….
Identify