Management of the ECMO Circuit
Critical Care & Complications

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Disclosures

- I Have No disclosures for this presentation
ECMO-Adults
Sometimes Troubleshooting can be...
It can also be...

Obvious

OR

Complex
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 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
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
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/O_2 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

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 ~1hr
- 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
Thank you...

NYPH-Columbia Campus Perfusion Team 2014