CENTRAL ECMO
WHEN AND HOW?

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CENTRAL ECMO

- Background
- How to do
- Case reports
- When to do
- Managing complications
- Post operative management strategies
46 year old male presented to outside hospital ER with severe shortness of breath and hypotension. Intubated, rapidly requiring pressors. Cardiac arrest, requiring 15 minutes CPR. Pupils reportedly dilated, fixed. On arrival, SBP 60-70s, HR 140s. Extremities cold, cyanotic, mottled. WBC 18, Creatinine 3.4, INR 6, AST/ALT 5000s, Lactate 18. Drips – Dopamine, Epinephrine, Neosynephrine. Bedside Echo – Severe biventricular dysfunction, EF <10%.
Treatment Options

1. IABP, Continue aggressive medical management

2. Take patient immediately to OR:
   - Revascularization (CABG)
   - or
   - Temporary mechanical support (temporary LVAD/RVAD – Centrimag vs ECMO)
   - or
   - Continuous flow ventricular device +/- RVAD

3. Take patient to Cath lab – percutaneous VAD support
   (Impella, Tandem heart, ECMO), treat underlying CAD

4. Do nothing, allow patient to die
Mechanical circulatory support has evolved markedly over recent years.

ECMO (extra corporeal membrane oxygenation) in particular has become more reliable with improving equipment, and increased experience, which is reflected in improving results.
Ongoing Questions

- What is the ideal device?
- Uni- or biventricular support?
- When to institute temporary support?
- Where to institute it? – ER/OR/Cath lab
- For how long?
Types of Short Term Devices

- **Percutaneous LVAD**
  - Impella, Tandem Heart
- **Percutaneous ECMO**
  - CentriMag, Cardiohelp
- **Surgical**
  - Centrimag, Cardiohelp
  - “Temporary LVAD/RVAD/Bivad”
GENERAL GOALS of Short Term Support

- Immediate circulatory support
- Maximum drainage without complications of venous obstruction
- Unobstructed inflow without distal Ischemia
- Lowest risk of infection
- Mobilization of the patient when possible
Decision to Institute ECMO

Several considerations must be weighed:

- Likelihood of organ recovery.: only appropriate if disease process is reversible with therapy and rest on ECMO
- Cardiac recovery: to either wait for further cardiac recovery to allow implant of device (LVAD) or to list for transplantation.
- Disseminated malignancy
- Advanced age
- Known severe brain injury
- Unwitnessed cardiac arrest or cardiac arrest of prolonged duration.
- Technical contraindications to consider: aortic dissection or aortic incompetence
Indications – Cardiac Failure

- Post-cardiotomy
  - when unable to get pt off cardiopulmonary bypass following cardiac surgery
- Post-heart transplant
  - usually due to primary graft failure
- Severe cardiac failure due to almost any other cause
  - Decompensated cardiomyopathy
  - Myocarditis
  - Acute coronary syndrome with cardiogenic shock
  - Profound cardiac depression due to drug overdose or sepsis
ARTERIAL OPTIONS

- Femoral artery
  - Perc / Retrograde, Leg ischemia, Infection
- Axillary artery
  - Good flow, less CVA / Graft, Arm overcirculation
- Aorta
  - Great flow / Sternotomy, infection
Advantages

- Flow from Central ECMO is directly from the outflow cannula into the aorta provides antegrade flow to the arch vessels, coronaries and the rest of the body.

- In contrast, the retrograde aortic flow provided by peripheral leads to mixing in the arch.
Central vs. Peripheral Cannulation

- Disadvantages

  - Previously insertion of central ECMO required leaving chest open to allow the cannulae to exit.
    - Increased the risk of bleeding and infection
    - Newer cannulae are designed to be tunneled through the subcostal abdominal wall allowing the chest to be completely closed.

  - Central cannula are costly (no longer??)
VENOUS OPTIONS

- Femoral vein (Intrahepatic IVC)
  - Perc / Leg edema, Infection, Immobilization
- Subclavian Vein
  - Perc / Size, Arm edema
- Internal Jugular Vein
  - Perc, RA flow, DL option/ (SVC syndrome?)
- Right Atrium
  - Great flow / Sternotomy, open chest, infection
PERIPHERAL CANNULATION
Peripheral ECMO - Standard of care
Central ECMO Cannulation
56 year old female with history of dilated cardiomyopathy admitted with recurrent VT/VF

Hemodynamically unstable, refractory to medical therapy

Placement of peripheral ECMO via fem fem cannulation with distal perfusion cannula

Despite this, ischemic leg in 12 hours

Ultrasound of contralateral LE vessels - PVD
- Central ECMO placed with median sternotomy and aortic and right atrial cannulation
- Concomitant removal of peripheral cannula, repair and embolectomy of right femoral artery
- Eventually bridged to permanent LVAD.
CASE REPORT # 2

- 32 year old male transferred with cardiogenic shock with hemodynamic collapse
- Peripheral ECMO placed via femoral vessels
- 8 hours later, ECHO shows LV severely distended, pulmonary edema
- Plan for Impella 2.5; echo at time of Impella placement shows clot in aortic root
- Options?
Right mini thoracotomy and placement of LV vent through right superior pulmonary vein
- Echo showed moderate LV decompression and stable ECMO flows
- 24 hours later, severe hemolysis likely from LV vent
- Median sternotomy, with Centrimag LVAD and RVAD placement, with oxygenator in RVAD circuit – supported for 2 weeks
- Subsequently bridged to permanent LVAD
- LV recovery in 6 months, with LVAD explant
- Currently doing well, normal EF
CASE REPORT # 3

- 58 year old male transferred with cardiogenic shock on multiple pressors
- Hypotensive, intubated
- Severe aortic regurgitation secondary to aortic valve endocarditis with enterococcus
- Options?
- ECMO?? With LV venting
- Emergent aortic valve replacement
- Temporary LVAD support
- Plan was to take patient directly to OR

- Patient coded during transfer and was dead on arrival to hospital with ongoing CPR for more than 45 minutes
58 year old male transferred with cardiogenic shock on multiple pressors post emergent CABG

- Hypotensive, intubated, open chest
- Acute renal and hepatic failure
- Echo – severe biventricular function
- Options?
• Central ECMO via aortic and right atrial cannulation
• Wash out chest
• Inspect grafts; Inspect all surgical sites
• Chest closed in 3 days
• Prolonged recovery and discharged to TCU
CASE REPORT # 5

- Uneventful heart transplantation with primary graft failure immediately post tx
- Usual maneuvers – nitric oxide, optimizing drips, AV pacing, IABP – still significant graft dysfunction with significant RV failure
- Temporary RVAD, now LV failure
- Central ECMO
- Recovery in 5 days with subsequent discharge
When to do CENTRAL ECMO

- Post- cardiotomy shock – biventricular failure and/or hypoxia with respiratory failure
- Post-heart transplant primary graft failure
- Cardio-respiratory failure in patients with severe peripheral vascular disease
- Ongoing peripheral ECMO with
  - Limb ischemia
  - Refractory groin bleeding/hematoma
  - Rising lactate? – inadequate flows/ cannula size
  - Retroperitoneal hematoma
  - Need for LV venting?
CENTRAL ECMO VIA MEDIAN STERNOTOMY
CENTRAL ECMO VIA Right MINI THORACOTOMY
Surgical Cannulation Strategy for LVAD/RVAD/BVAD and ECMO
Surgical Cannulation Strategy for LVAD/RVAD/BVAD and ECMO

- ECMO (CENTRAL)
  - Outflow – ascending aorta
    - ? LV apical cannula placed into aorta distal to aortic valve
  - Inflow – right atrium
    - Right atrial appendage
    - Body of right atrium
Surgical Cannulation Strategy for LVAD/RVAD/BVAD and ECMO

- LVAD
  - Outflow – ascending aorta
  - Inflow – left atrium
    - Right superior pulmonary vein
    - Left atrial appendage
    - Dome of left atrium (between aorta and SVC)
  - Inflow – left ventricle
    - Left ventricular apex (increased risk of bleeding?)
Surgical Cannulation Strategy for LVAD/RVAD/BVAD and ECMO

- **RVAD**
  - **Outflow** – pulmonary artery
    - can also use RVOT through pulmonary valve
  - **Inflow** – Right atrium
    - Right atrial appendage
    - Body of right atrium
  - **Inflow** – Right ventricle
    - Free/anterior wall of RV (if RA friable or already use during open heart surgery)
Surgical Cannulation Strategy for LVAD/RVAD/BVAD And ECMO

CANNULAS

Arterial – 20 F EOPA cannula
- Length makes it favorable for subcostal tunnel
- Stylet facilitates rapid entry

Venous – 28 to 34 F angled venous cannula
- Malleability to angle tip of cannula away from septum or free wall towards tricuspid valve
- Malleability makes it favorable for subcostal tunnel
Surgical Cannulation Strategy for LVAD/RVAD/BVAD And ECMO

- Plegetted rosette of sutures at cannula insertion sites (2 sets of sutures if possible)
- Snares to maintain position of cannulas
- Adequate securing of cannulas to skin
- Tunnel all cannulas in a subcostal fashion
- Keep in mind need for chest tubes and additional cardiac surgery – such as LVAD driveline, temporary RVAD cannulas
- Attempt to close chest if possible
Retrograde arterial flow

- Increased LVEDP
  - Increased capillary leak
  - Acute lung injury

- Not favorable for myocardial recovery
Pulmonary Edema on ECMO

- Central cannulation does not prevent it
- LA/LV venting – minithoracotomy LV vent
- Do Echo 6-24 hours after initiation of ECMO to look for LV DISTENTION
- Pulmonary edema on CXR is an early clue
- Attempt inotropes to facilitate LV ejection
SPECIAL CIRCUMSTANCES

- LV Venting (VA ECMO)
  - PV, LA appendage (open sternotomy)
  - LV apex (mini L Thoracotomy)
  - PA
  - Atrial septostomy
LV Venting through apex
LV Venting through apex

- LAD
- Heart apex
- Rummel with button
- Cannula tunneled under pectoralis m.
LV Venting through apex
Central ECMO Complications

1) Bleeding
2) Infection
3) Neurologic sequelae
BLEEDING

- **Bleeding/Hemolysis**
  - Out of proportion to the degree of coagulopathy and patient platelet count

- **Coagulopathy**
  - Continuous activation of contact and fibrinolytic systems by the circuit
  - Consumption and dilution of factors within minutes of initiation of ECMO
BLEEDING – Central ECMO

- Chest re-exploration
- Packing
- Inspection of cannulation sites with reinforcement
- Common culprit after 24-72 hours is right atrial cannula site – use of an additional suture tie around cannula including right atrial cuff
- Aggressive replacement of FFP, platelets
Troubleshooting - Tamponade

- Make diagnosis in OR room
- Low flow in post cardiotomy patient or ECMO
- Echo does not rule out tamponade
- Tamponade can occur in patients with open chest
Post-Operative Management

Decision making once ECMO initiated:

1. Bridge to recovery

2. Bridge to permanent LVAD once end-organ dysfunction reversed, neurological recovery and bridge to transplant (or destination therapy) candidacy ascertained.

OR

3. Bridge to discontinuation
ECMO or biventricular support 
(centrimag)
Post-Operative Management

- Wean off pressors and inotropes as tolerated
- Maintain flows to keep MAPs 65-90mmHg, UOP >30cc/hr, lactate down trending, Sats > 90%
- Transfusion Hgb > 8gm/dL, Platelets > 80
- CI >2.2 -2.4; decompress but maintain or encourage contractility
Post-Operative Management

• Heparin to maintain ACT 160 to 200 sec only when no bleeding issues exist (can hold up to 48 hours)

• Liberal use of diuretics or CVVHD

• Prophylactic antibiotics

• Early and aggressive nutritional support
Weaning From ECMO/Temporary MCS

• Easy to assess recovery at bedside
  Turn down RPM, adequate ionotropic loading, volume
  Adequate heparinization
  Parameters to follow: MAP, CVP, SVO₂, CI
  ECHO added benefit to look at ventricular function, valve regurgitation
  Oxygenation - ABG
• Sometimes slow wean over 24 hours is beneficial to allow for gradual ventricular loading
• If reversible insult (myocarditis, post-cardiotomy, MI), longer support may be needed
Central ECMO - Decannulation

• Usually OR, one final TEE assessment
• Heparinize, remove cannulas and clamp vessels
• Allow for back bleeding from aortic and atrial cannulation sites, as clots can form around cannulas
• Pursestring or more commonly, direct repair
• Thorough irrigation of chest with antibiotic solutions
• Consider IABP support, ionotropes and volume
Central ECMO - CONCLUSIONS

• Well defined indications for Central ECMO in current era
• Can be done safely with easily reproducible surgical techniques
• Should be done expeditiously in the post-cardiotomy situation
• Critically ill patients can be transferred safely with central ECMO
• Central ECMO is not recommended for all patients doing poorly on peripheral ECMO