

Extracorporeal Membrane Oxygenation

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Disclosures

None

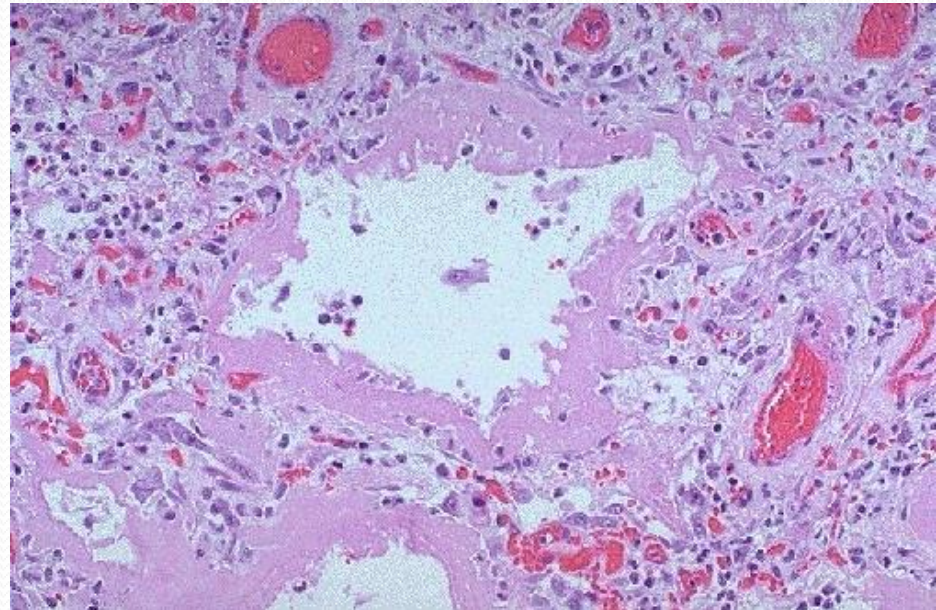
I may show a medical device or describe a commercially available pharmaceutical. I am not endorsing the use or non-use of any commercial products in this lecture.

Overview

- History
- Indications
- Types
- Benefits
- Lab Support
- Transfusion Support

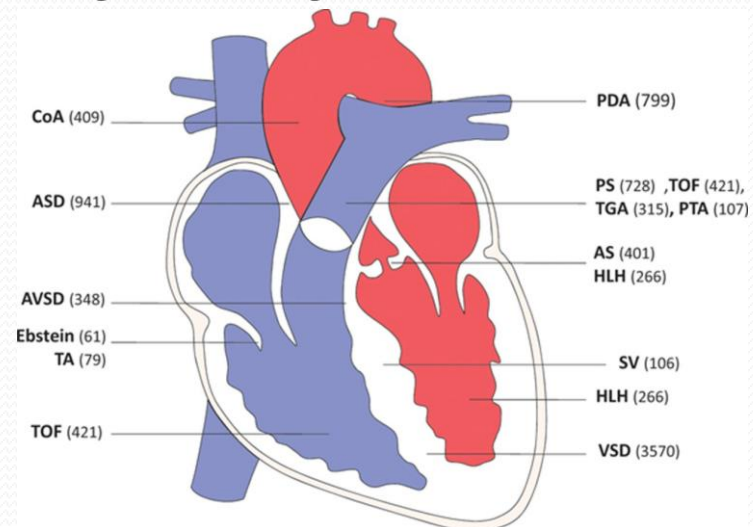
Historical Factors

- Acute Respiratory Distress Syndrome
 - Standard is intubation
 - Compromised Gaseous Exchange
 - Higher pressures leading to hyperinflation and pneumothorax



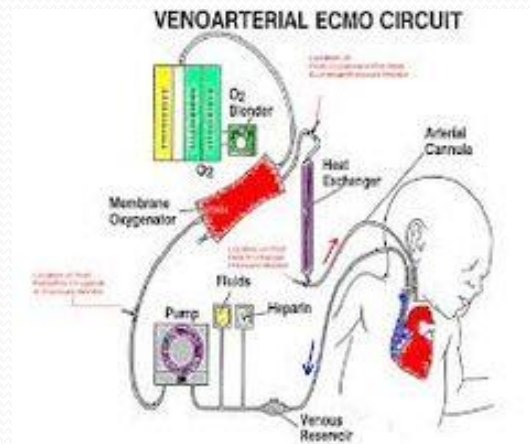
Historical Factors

- Congenital Cyanotic Heart Defects
 - “Blue babies”
 - Bypasses/Limits pulmonary flow for oxygenation
 - Try to live long enough to be large enough to survive surgical repair



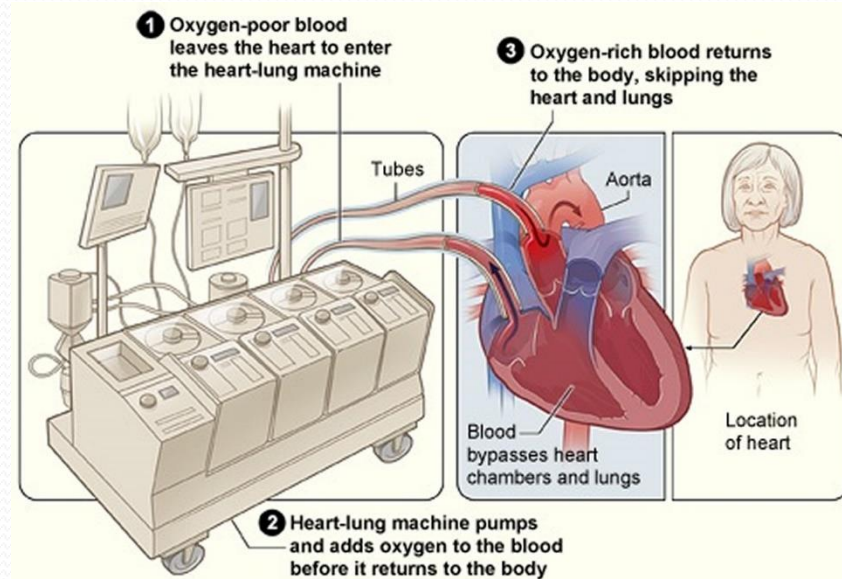
Function

- Hyperbaric nitrogen with variable oxygen concentration
- Micropore “bubbler” into blood supply
- Nitrogen and oxygen dissolve into blood stream
- Oxygen is bound through normal physiologic patterns to hemoglobin in RBCs



Heart – Lung Machines

- Date back to 1930s with Gibbon and his colleagues
- Time limited
 - Earliest could give 15 minutes
 - By 1950's up to 90-120 minutes
- Directed interventions
 - Coronary surgeries
- Roller pumps
 - Turbulence
 - Concern for air emboli

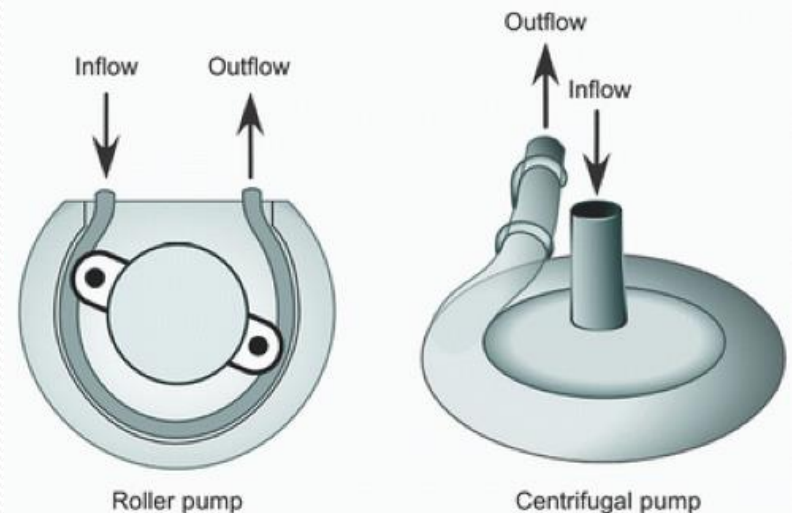


Advances

- 1971 – Hill at UCSF - Heart-Lung machine used to support adult trauma patient with heart injury for 75 days – pt survived
- 1975 – New ECMO machine developed by Dr. Robert Bartlett at U Michigan supports a neonate with severe meconium aspiration for three days

Advances

- Centrifugal pump
 - Less mechanical stresses on the blood flow
- Silicon membrane oxygenator
 - Forces microscopic oxygen bubbles into the blood
 - Polymethylpentane used to “eliminate” plasma leak



Problems

- Turbulent flow
 - Platelet activation
 - Latest silicon coatings designed to minimize platelet inactivation
 - Slight RBC damage
 - Early clearance rather than destruction in the filter
 - Non-specific coagulation activation
 - Fibrin microstrands develop
 - Increase until circuit failure

Venovenous ECMO

- Draw from vein, return to same vein
- Can run at max pump pressures/flows to obtain optimal oxygenation
 - If disrupted, can spray blood everywhere!!
- Most common use of ECMO
- “Lung” ECMO

Venoarterial ECMO

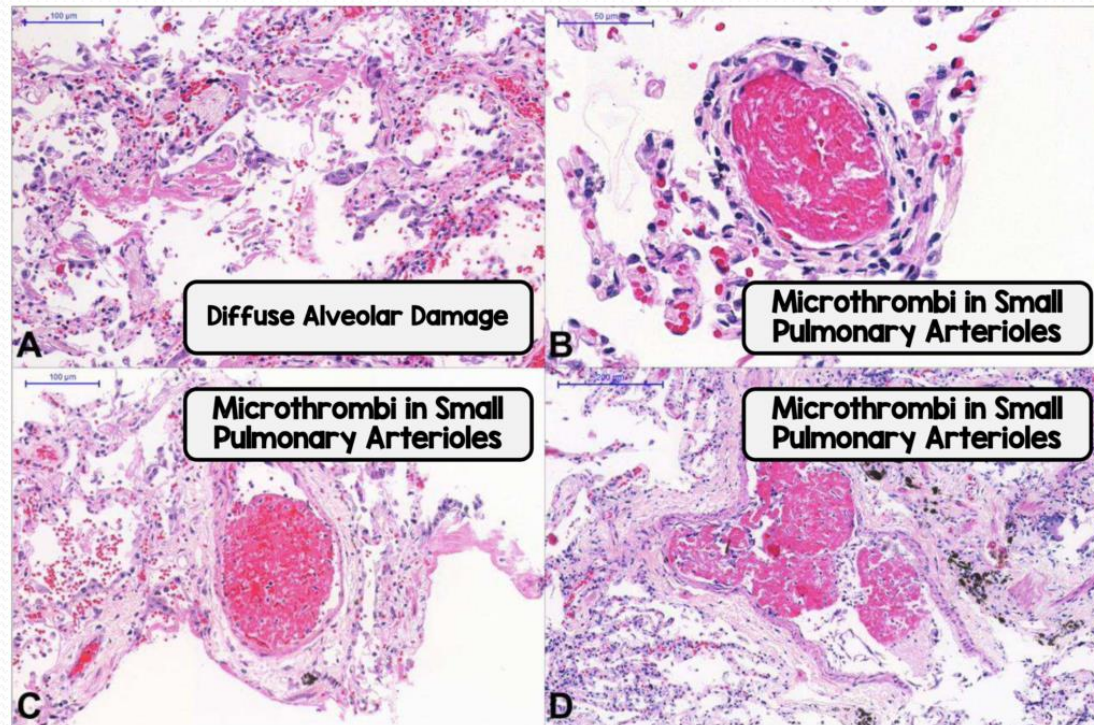
- Draw from venous system and return to arterial system
- Allows for pressure support in cardiac failure
- Cannot run at maximum pressures/flows as too not overload a limited cardiac function
- “Heart/Lung” ECMO

Acute Respiratory Distress Syndrome

- Traumatic
- Infectious (Influenza!!)
- Inhalation Injury (Burn Center)
- Toxic (Meconium Aspiration)
- Autoimmune (Goodpasture/ANCA vasculitis)
-

Indications

- COVID – 19
 - Microvascular thrombotic vasculopathy
 - Inability for gaseous exchange to occur



Chronic Pulmonary Disease

- Cystic Fibrosis

- Bridge to transplant

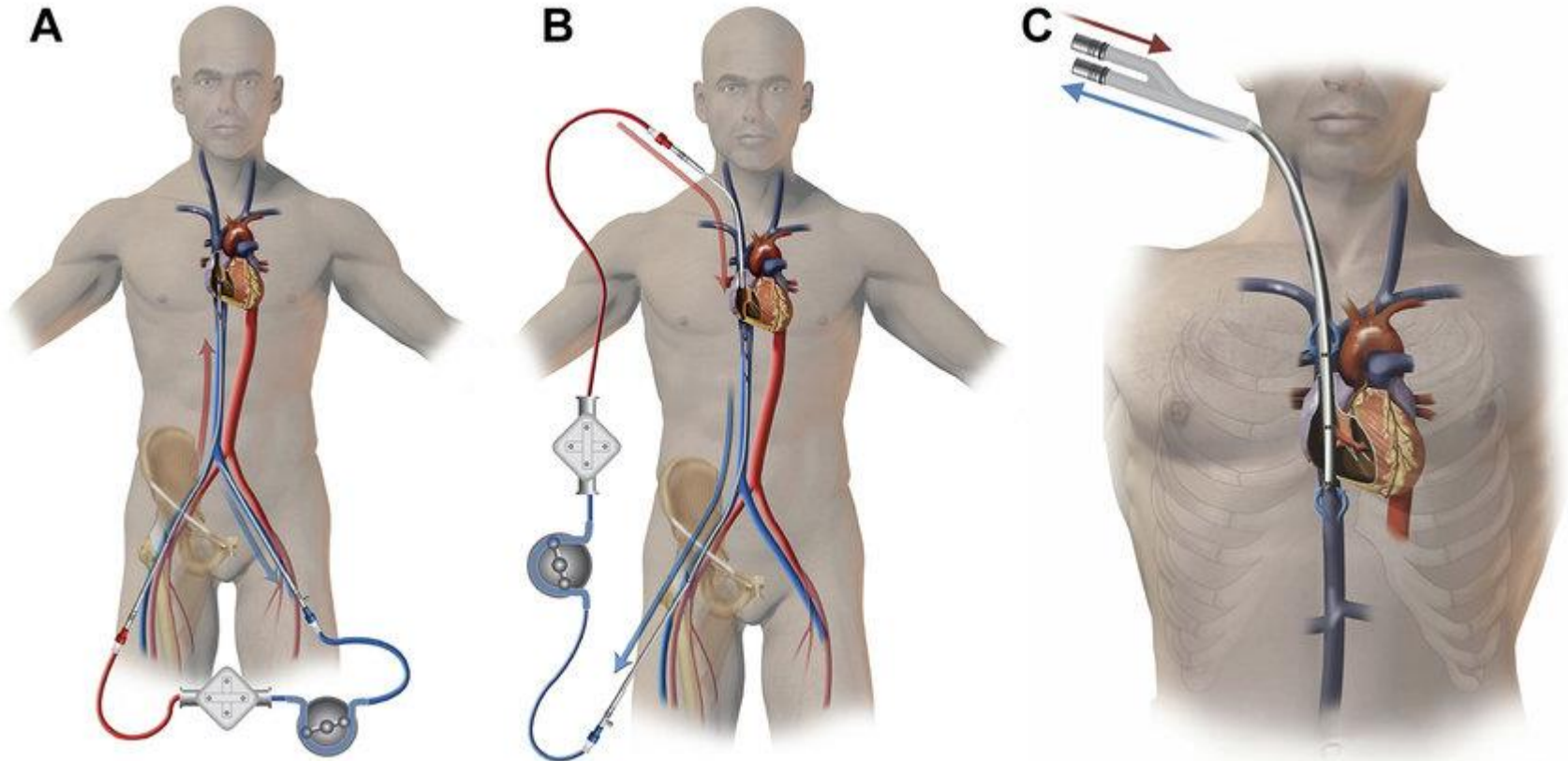
Never seen this work out!

Cardiac

- #1 Failure to wean from cardiopulmonary bypass circuit
 - Valve repair
 - Intracardiac interventions
 - Less CABG
- Infectious Myocarditis
- Handful of patients with both VA ECMO and ventricular assist device

Limiting Factors

- Two large bore cannulas placed for long term use
 - Vascular surgeon or other critical care provider trained



Limiting Factors

- Nurses or perfusionists trained to manage the circuit
 - Venous Pressure
 - Arterial Pressure
 - Internal Pressure
 - Venous O₂
 - Hgb
 - Blood Temp
 - Sweep



Limiting Factors

- ICU
 - Seen providers cross cover, but nurses remain separate to maintain good order
- Respiratory Therapy
 - Often both ECMO and ventilator
- Dietician
- Physical Therapy
- Case Manager
- Other consult services (nephrology/cardiology/etc.)

Benefits

- Air Transportation
 - Limited impact from pressure changes
- Prolonged Therapy



Lab Tests

- Activated Clotting Time (ACT)
 - Unfractionated heparin (UFH) is typical anticoagulant for ECMO
 - ACT is a whole blood point of care test with significant historical use in use of UFH
 - Whole blood correlate of aPTT – factor XII activators such as kaolin or glass beads
 - Poorer correlation device to device and lot to lot than other tests

Lab Tests

- aFX assay
 - Measurement of heparin effect, not concentration
 - Preferable to test without exogenous added anti-thrombin
 - Unmasks AT deficiency
 - Focused only on fibrin formation
 - Factor deficiency will be missed
 - ?? Daily ACT based on aFX results

Lab Tests

- Plasma Free Hemoglobin
 - Not a test of anti-coagulation
 - Assessment for impending circuit failure due to thrombosis
 - Sub-clinical RBC destruction due to turbulent flow
 - No FDA approved methodology
 - Hemocue POC instrument from donor center use
 - Modification of chemistry hemolysis detection
 - Mass spectrometry

Lab Tests

- aPTT
 - Plasma based test of coagulation through intrinsic pathway
 - Reference ranges established for patients on UFH
 - Best in mild-moderate UFH doses
- CBC
 - Assess for anemia or thrombocytopenia
- TEG/ROTEM
 - With/without heparinase
 - AA/ADP platelet inhibition assay

Argatroban

- Heparin induced thrombocytopenia
 - Heparin forms a novel antigen with platelet factor 4 (PF₄)
 - Significant thrombocytopenia with “white clots” in moderate-large vessels
- ACT and aPTT instead of aFX

Transfusion Support

- Circuit Failure
 - RBC/Plasma in 1:1 distribution
 - Non-emergent circuit failure with saline and post-swap transfusion per labs
- Circuit Prime with 1:1 in pediatric patients
 - Similar to apheresis
 - Transport team left with 4:4 in a cooler

Transfusion Support

- Ongoing Needs
 - RBC
 - Reject the restrictive transfusion thresholds
 - Maintain a Hct 35-40%
 - FFP
 - Keep INR >2 or if AT deficiency suspected without available concentrate
 - **PLATELET**
 - Anticipated platelet dysfunction
 - Counts $>100K$ or for any significant bleeding

Transfusion Support

- COVID convalescent plasma is treatment for infection, not for coagulation
 - Should be separate from prime units
 - Counsel that it is infusion of ATIII and fibrinogen that may change anticoagulation needs

Availability

- 330 medical centers in the United States per the ELSO registry (pulled 4 Dec 2020)
- 2623 COVID-19 cases treated with ECMO with 46% in-hospital mortality (pulled 4 Jan 2021)

Review

- History
- Indications
- Types
- Benefits
- Lab Support
- Transfusion Support



Any Questions?

References

- Barlett RH, Ogino MT, Brodie D, *et al.* Initial ELSO Guidance Document: ECMO for COVID-19 Patients with Severe Cardiopulmonary Failure. *ASAIO Journal* Vol 66(5) 2020: 474-4
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- <https://www.mdnxs.com/topics-2/procedures/venoarterial-extracorporeal-membrane-oxygenation/> and [venovenous-extracorporeal-membrane-oxygenation/](https://www.mdnxs.com/topics-2/procedures/venovenous-extracorporeal-membrane-oxygenation/)