ECMO in a Community ICU

Outline	Slide
• ECMO in a Community ICU	Slide 1:
• Disclosures	Slide 2:
▼ Objectives	Slide 3:
• What is ECMO	
• Why use ECMO	
• How to ECMO	
• Who to ECMO	
• Should you do ECMO	
▼ What is ECMO	Slide 4:
• Used in adults who are at very high risk of death with from a “reversible” cause	
• Temporary cardiopulmonary support	
▼ What ECMO can do	Slide 5:
• Oxygenate	
• Remove Carbon dioxide	
• Perfuse	
• Regulate temperature	
▼ What ECMO Can Not Do	Slide 6:
• Cure	
▼ Circuits	
▼ Venoarterial ECMO (VA)	Slide 7:
• Complete or partial cardiac and respiratory support	
▼ Peripheral configuration	
▼ Drainage cannula	
• Femoral vein	
• Advanced to right atrium	
▼ Return cannula	
• Femoral artery	
• Retrograde flow against native cardiac output	
• Competent aortic valve	
▼ Venovenous ECMO (VV)	
• Complete or partial suppport of lung function	
• Most useful for isolated respiratory failure	
▼ Femoral-Atrial Configuration	Slide 8:
▼ Drainage cannula	
• Either femoral vein or internal jugular vein	
▼ Return cannula	
• Directed into the right atrium	

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- Recirculation was an issue
- Bicaval double-lumen catheter — Slide 9:
  - Avalon catheter
  - Internal jugular vein
  - Drainage from SVC and IVC
  - Return jet directed at tricuspid valve
  - Reduces recirculation
  - Single cannula insertion
  - Facilitates ambulation/therapy
- ECMO Room — Slide 10:
  - Appears chaotic
  - Never large enough
  - Lots of equipment
    - ECMO Circuit
    - Ventilator
    - Pumps
    - CRRT Machine
    - Workstation
    - Patient!
- Circuit Components — Slide 11:
  - Blood Pump — Slide 12:
    - Easy to prime
    - Low hemolysis
    - Roller Pump — Slide 13:
      - Original Version
      - Fixed displacment
      - Same type as in dialysis machiens
      - Circuit leaks
    - Centrifugal Pump — Slide 14:
      - Sealed casing
      - Magnetically driver
      - Flow dependent on pressure
  - Membrane Oxygenator — Slide 15:
    - Easy to prime
    - Effecient gas exchange
    - Low resistance
    - Low risk for clotting
    - Cross-Flow — Slide 16:

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Blood	
Oxygen	
Silicon Membrane	Slide 17:
Microporous	
Retains proteins and cells	
Console	Slide 18:
Start/Stop	
Set RPM of pump	
Alarms	
Blender/Gas Mixer	Slide 19:
Mixes air and oxygen	
Controls flow rate (Sweep gas)	
Heat Exchanger	Slide 20:
Cardiohelp	Slide 21:
Cannulas	Slide 22:
Tubing	Slide 23:
Medications	Slide 24:
Why use ECMO	Slide 25
First Patient	
Immigrant Pregnant Mother	Slide 26:
Meconium birth	
Respiratory distress	
Cardiopulmonary bypass	
1950s	Slide 27:
Bubble Oxygenator	Slide 28:
Bob Bartlett	
Experimental Machine	
Placed on	Slide 29:
Esperanza “Hope”	
Recovered	Slide 30:
Teenager	Slied 31:
ELSO Foundation	Slide 32:
Adults ECMO Trials	
ARDS	Slide 33:
Failed Trials	Slide 34:
Zapol, 1979	
Morris, 1994	
However, it remained little used in adults, as early randomized trials showed higher rates of complications in adults who received it and no survival	Slide 35:

Outline | Slide

advantage. Proponents of using it in adult patients believe that these poor outcomes were at least partially due to limited training, intensive anticoagulation, and excessive volume and pressure during mechanical ventilation.

- 1990-2014
  - 14,000 pts
  - Survival to discharge of 57%
  - Rates increased 433% from 2006-2011
- CESAR Trial — Slide 36:
  - 2009
  - No benefit due to ECMO — Slide 37:
- H1N1 — Slide 38:
  - Something else happened in 2009
  - Massive number of cases
  - Wide-spread use of ECMO
- 2009-2011 — Slide 39:
  - 1000 papers published
- AZ ECMO Trial

- How to ECMO — Slide 40:
  - Getting the right type — Slide 41:
    - Circuit
      - Seems that should Self-evident that VA VV
      - ARDS with acidemia, which type. — Slide 42:
        - Not self-evident.
    - VA or VV — harder
  - Getting the Right size
    - Ultrasound
    - Flurosocopy
    - Angiography Suite
  - Cannulation
    - What could possibly go wrong.
    - Not the same as arterial or femoral line
    - Size can expose or deficiencies
    - Landmark based approach
    - Never underestimate the damage you can do with a needle and cannula
    - TEE
  - Understand Oxygen Delivery — Slide 43:
    - Components of Oxygen Delivery
      - Blood flow

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- Hemoglobin concentration
- Inlet hemoglobin saturation
- Oxygenator Properties
- Carbon dioxide removal always exceeds oxygen delivery
- Metabolic rate drives oxygen consumtption — Slide 44:
- FDO2
- O2 Delivery = CO x CaO2
- Oxygen content (CaO2) = (SaO2 x Hgb x 1.34) + 0.003 x PaO2
- Oxygen consumption (VO2) = CO x (CaO2 - CvO2)
- EBF/CO, Recirculation blood flow, native lung function
- SaO2 usually 80-90%, paO2 40-50

▼ Controls — Slide 45:

▼ Blood Flow

- Pump RPM, Preload, Afterload
- Resistance—Cannula size

▼ Sweep Gas

▼ FDO2

- Increases oxygen partial pressure

▼ Flow rate

- Controls carbon dioxide removal

- Temperature

▼ Ventilator

- LTV vs Lung rest vs Extubate

- Anticoagulation

▼ Monitoring — Slide 46:

- Pulmonary artery catheter
- BIS monitoring
- Pulse-oximetry multiple limbs

▼ Labs

- ABG
- Pre- / Post-ABGs

▼ Lactic acid

- Marker of tissue hypoxia

▼ Plasma free hemoglobin

- Marker of hemolysis

- Fibrinogen
- HIT Labs

▼ Problems — Slide 47:

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- Bleeding, bleeding, bleeding
  - 43% of patients
  - Cannulation / Surgical sites
  - Intracranial hemorrhage
  - Gastrointestinal hemorrhage
- Clotting including HIT — Slide 48:
- Renal Failure
- Pump Thrombosis
- Murphy's law of mechanical devices
- Limb ischemia
- Infection

- Best Practices — Slide 49:
  - Consider ECMO Early
  - Don't Use the Lungs
  - Minimize Sedation
- Team Approach — Slide 50:
  - It takes a VIllage
- Organized Program — Slide 51:
  - Daily Multidisciplinary Rounding
  - Monthly multidisciplinary ECMO Conference
  - M&M
  - Monthly Operational Meeting
  - Level 1 ECMO Call System
  - Unified Approach to Access
  - ECMO Database, research projects, presentations, publications
  - Credentialling
  - Operational Committee
- Culture of Safety — Slide 52:
  - Checklists
  - Order Sets
  - Continuous team training
  - Simulation
  - Review Your Work
  - Celebrate Success
  - Partner with ELSO
  - Spare equipment
    - Spare circuit
    - Clamps

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- Who to ECMO — Slide 53:
  - Getting the patient right
    - Choosing the right patient — Slide 54:
      - Toughest Part
      - Somebondy who needs it
        - Consider when risk of death >50%
        - Indicated if predicted risk of death >80%
        - Will benefit from ECMO
          - Does ECMO fix the problem
      - Not too sick to benefit
        - Duration of organ failure
          - Organ failure becomes irreversible
        - Severity of organ failure
        - Comorbidities
      - Has an “out” clause
    - Generally Favored
      - Respiratory Failure — Slide 55:
        - ARDS (PaO2/FiO2 100-150)
        - Status asthmaticus
        - Exacerbation of COPD (PaCO2 >80, pH <7.15)
        - Primary graft dysfunction following lung transplantation (within 7 days)
        - Pulmonary vasculitis (Goodpasture’s, ANCA-associated, Autoimmune)
      - Cardiac Failure — Slide 56:
        - Myocardial infarction-associated cardiogenic shock
        - Pulmonary embolism with cardiogenic shock
        - Drug overdose with profound cardiac depression or arrhythmia
        - Extracorporeal cardiopulmonary resuscitation
        - Acute fulminant myocarditis
        - Postcardiotomy or post-heart transplant cardiogenic shock
        - Primary graft failure after transplant
        - Bridge to VAD or transplant
    - Absolute contraindications — Slide 57:
      - Uncontrolled active hemorrhage
      - Terminal illness
      - Irreversible or end-stage heart or lung failure in patients who are not candidates for transplant
    - Relative contraindications — Slide 58:

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- More than 7 adys of mechanical ventilation
- Multiorgan failure (especially renal failure)
- Irreversible neurologic injury
- Malignancy, solid-organ transplant, or immunosuppresion
- Contraindications for anticoagulation
- Advanced age — Slide 59:
- Weight
- ?Pregnancy/Postpartum
- ?Trauma

▼ Making the decision — Slide 60:
- Clinical Triggers for evaluation
- ▼ Decision support
  - Indications and exclusions
  - Most are relative factors
  - Experience matters
  - Guide, but breakable
- Often very limited time
- Often limited information
- Review all decisions
- Shares cases / Review Registry
- Be willing to be wrong

▼ Should you ECMO — Slide 61:

▼ Getting the Ethics right — Slide 62:

▼ 3 Senses of Dignitity
- Intrinsic Dignity = your value for just being human
- Attributed Dignity = your “market value” to society
- Inflorescent Dignity = your “flourishing”; or your quality of life

▼ The Dilemmas:

▼ How old is too old…or better yet…how young is too young?
- Aside from routine resuscitation: drugs, chest compressions, shocks, is there an age that is too old for ECMO? We currently use a soft cutoff of 75 yoa. Lets take all of the variables out of the equation and just assume a person has ZERO medical problems and is on ZERO medications. They ambulate on their own, live independently, and they believe they have a good quality of life. In this scenario, is there any age that is too old for ECMO? This should be our starting point and then move down (in age) from there. The 95 year old is easy. The 40 year old is easy. All the rest

are tough and that's where we will get criticism for “doing too much.”

- Concrete resuscitation cutoff vs. a graded response?
  - Whatever we decide is the cutoff (age, quality of life, comorbidities), should we use the exact same set of criteria for even initiating CPR as we do for ECMO? Should they be the same? In other words, should we have the same set of criteria for both or should there be a graded response to the dying patient (over 75 I do CPR and intubate but don't do ECMO but under 75 I go full-court-press and possible ECMO)?
- Only Reverse the Reversible.
  - Somehow we need to identify inevitable death and allow that to happen. Greg Henry always says, “Despite all the advances of modern medicine, the death remains the same: one per person.” But when we can't be sure that death is inevitable, does everyone deserve a shot? In other words, should we be making that decision on the front end (ED) when little information is known to us, or should that be sorted out on the back end…in the ICU? Is there a way to tell a resuscitationist that its ok to err on the side of over-resuscitation, so long as your intent to is to reverse the reversable? Peter Safar's quote, “Death is not the enemy, but occasionally need help with timing.” exemplifies this.
- Define “Quality of Life”. How do we determine “Quality of Life”? Who decides this in the heat of the moment? The doctor or the family?
- What is the real goal of resuscitation? Should we only resuscitate people who were previously healthy and have a chance of 100% recovery?
  - It seems we've come to a place where the knee-jerk reaction by ED doctors is to do full CPR on everyone and then see what happens. So how do we determine when and where to stop?
- MD paternalism vs. patient automony = “The Tyranny of Choice.”

- Is ECMO the answer Slide 63:
  - Refractory Cardiogenic Shock (RCS)
  - ECMO
    - Quick placement for acute resuscitation
    - Reestablish perfusion
    - No left ventricular unloading
      - Generates high afterload
    - Impaired coronary perfusion
    - Regional hypoxia

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- IABP — Slide 64:
- Impella — Slide 65:
  - Miniature rotary pump — Slide 66:
  - Fully unloads left ventricle
    - Reduces EDV/EDP
    - Reduces myocardial oxygen demand

Key Points — Slide 67:

- Two basic configurations of ECMO are used in adults: venoarterial, which can provide cardiac or cardiopulmo- nary support; and venovenous, which provides respiratory support only.
- ECMO is used in adults who are at very high risk of death without it.
- Because ECMO patients must receive anticoagulation, bleeding is a common complication. Others are infection, renal failure, and thrombosis.
- ECMO may provide “lung rest,” allowing lower tidal volumes and pressures and lower fractions of inspired oxygen to be used in mechanical ventilation, strategies associated with lower mortality rates.