Providence Brain and Spine Institute
EMS, Stroke and Heart Conference

ECMO

“A Bridge for the Cardiogenic Shock Patient”

Daniel Westerdahl MD, FACC
Advanced Heart Failure Cardiologist
Providence Heart and Vascular Institute
Helpful terms you need to know

- **MCS:** Mechanical Circulatory Support
- **OHCA:** Out-of-Hospital Cardiac Arrest
- **ECPR:** Extracorporeal Cardiopulmonary Resuscitation
- **ECMO:** Extracorporeal Membrane Oxygenation
- **ECLS:** Extracorporeal Life Support
- **ELSO:** Extracorporeal Life Support Organization
- **V-V ECMO:** Veno-Venous Extracorporeal Membrane Oxygenation
- **V-A ECMO:** Veno-Arterial Extracorporeal Membrane Oxygenation
Learning Objectives:

- What is ECMO?
- Review an ECMO patient at PSVMC
- Historical look at ECMO/ECLS
- Clinical indications and contraindications for ECMO therapy
- Important interventions and EMS implications in care of ECMO patients
Portland: City of Bridges
Portland: City of People

What is ECMO?

My 2 year old son: Merrick

"Elmo"
What is ECMO?

Many healthcare providers: “Oh No”
What is ECMO?
What is ECMO?

• **Extra Corporeal Membrane Oxygenation**
  • A life support machine
  • Capable of replacing the function of the heart and lungs

• Serves as a clinical bridge
  • To recovery
  • To decision
  • To durable device
  • To transplant
What is ECMO?

The ECMO (extracorporeal membrane oxygenation) machine is used by medical personnel to sustain life when a patient’s lungs or heart are unable to function properly.

Sources: cardiacsurgery.ucsf.edu, emedicine.medscape.com

MARK NOWLIN / THE SEATTLE TIMES
Many different ways to configure ECMO

- **VA-ECMO (Veno-Arterial ECMO)**
  - Near complete cardiac support
  - Venous and arterial cannulation
  - Bypasses pulmonary blood flow
  - ECMO circuit in parallel to heart and lungs

- **VV-ECMO (Veno-Venous ECMO)**
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  - Venous cannulation
  - Maintains pulmonary blood flow
  - ECMO circuit in series to heart and lungs
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Why spend an hour on ECMO?

• Good Question...

• How many of you can think of a patient, friend, or family member that died suddenly and unexpectedly?

• Understanding therapeutic options for those on the brink of life or death can help remind us of both the fragility and power of the human body

“Knowledge alleviates fear, and the pursuit of knowledge builds courage.”
Case Study:

- 38 y/o M named Kirk, presents to the ER sudden onset chest pain. EKG demonstrates anterior STEMI. Taken emergently to the cardiac catheterization lab. Upon arrival patient goes into refractory Ventricular Fibrillation. CPR initiated and shocked multiple times, No ROSC. Intubated. CPR provided for nearly 1 hour at which time ABG demonstrated pH <6.8, PCO2 99 and PaO2 73. Lactate >14

- What do you do?
What do you do?

A. End the code; medically futile
B. Call the CT Surgeons
C. Call the HF Team
D. Call the Shock Team
E. Call the Chaplain
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A Historical look at ECMO/ECLS
Mount Hood, OR
Historical Ascent of ECMO

1944 Dr. Willem Kolff noted blood became oxygenated as it passed through the cellophane chambers of his artificial kidney

1953 Dr. John Gibbon became 1st surgeon to use CPB successfully

1965 Rashkind and colleagues use a bubble oxygenator to support a infant dying of respiratory failure

1969 Dorson et al. reported the use of a bubble oxygenator for cardiopulmonary bypass in infants

1970 Baffes et al. reported successful use of ECMO as support in infants with congenital heart defects undergoing cardiac surgery

1972 Long-term ECMO support for severe respiratory failure in adult

1972 Kolobow developed new membrane optimized for carbon dioxide removal for pts with COPD

1989 ELSO is formed (Extracorporeal life support organization)

1990 Morris et al. failed to show to show benefit of ECMO over Mechanical ventilation in ARDS

2009 CESAR trial demonstrated survival benefit using contemporary ECMO protocols in patients with severe respiratory failure over ventilation

2014 Over 5000 cases of ECMO US Annually

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1944 Willem J. Kolff, MD

- Studied Medicine at Leiden University, Netherlands
- 1st patient was a 22 y/o m dying of renal failure
- Researched artificial renal function replacement
- 1943 built of OJ cans, used auto parts, and sausage casings he developed his first dialyzer prototype
- Over 2 years, treated 15 pt’s with his new machine... all died
- 1944 Noted that blood became oxygenated as it passed through the cellophane chambers of the artificial kidney
- 1945 he was able to save a patient’s life with experimental HD
- Became known as “Father of Artificial Organs”

1953 John Gibbon, MD

- American Surgeon who invented the heart-lung machine

- Served in Burma China India Theater during WWII

- Medical School at Jefferson Medical College of Philadelphia in 1927

- 1953 he became the 1st surgeon to use CPB successfully

- Died in 1973, ironically from a heart attack while playing tennis

Lawrence H. Cohn Circulation. 2003;107:2168-2170
Contemporary Use of ECMO

• Since 1989 the ELSO (Extracorporeal Life Support Organization) has collected data on nearly 100,000 ECLS patients

• Adult Pulmonary Cases 59% Survival

• Adult Cardiac Cases 41% Survival
Portland: City of People

ECMO is implemented in moribund patients

ECMO is intended to be a bridge
All-comer adult ECMO survival 57%
57% survival is great...but we can do better!
ECMO: “Knowledge alleviates fear”

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V-V ECMO: Access and Equipment

- Access Sites
  - RIJ Venous*
V-V ECMO: Access and Equipment

• Access Sites
  • RIJ Venous*
V-V ECMO: Access and Equipment

- Access Sites
  - RIJ Venous*
  - Femoral Venous

Figure 2: Veno-venous ECMO: two cannulation approach (A) femoral vein (for drainage) and right internal jugular for infusion, (B) both femoral veins are used for drainage and perfusion. ECMO, Extra Corporeal Membrane Oxygenation.
V-A ECMO: Access and Equipment

- Access Sites
  - RIJ Venous*
  - Femoral Venous and Arterial
  - Carotid Artery*
  - Subclavian Arterial*

Figure 3 Peripheral veno-arterial ECMO cannulation approach: femoral vein (for drainage), (A) femoral, (B) axillary, (C) carotid, artery are used for perfusion. ECMO, Extra Corporeal Membrane Oxygenation.
ECMO: Access and Equipment

• Access Sites
  • RIJ Venous*
  • Femoral Venous and Arterial
  • Carotid Artery*
  • Subclavian Arterial*

Dual Circulations and Blood Mixing During Veno-Arterial ECMO: Femoral Cannulation
ECMO: Access and Equipment

• Access Sites
  • RIJ Venous*
  • Femoral Venous and Arterial
  • Carotid Artery*
  • Subclavian Arterial*
  • Central RA, PA, and Aortic*
ECMO: Access and Equipment

- Cannula Size determines flow rate: Goal CI 2.2-2.5
- Requires 60-80ml/kg/min
  - 80 kg pt requires 4.8L/min
- Typical Arterial Cannula’s
  - 15-25 Fr
- Typical Venous Cannula’s
  - 19-25 Fr
ECMO: Arterial Access

**Radial artery**
(Lumen 1.8 - 2.5 mm)

**Femoral artery**
(Lumen 8.5 - 12 mm)

- Catheter / Sheath
- Vessel wall

- 5F: 1.65 mm
- 6F: 1.98 mm
- 7F: 2.31 mm

24 F
ECMO: Recap Slide

- Two Main Types of ECMO
  - (VA) Veno-arterial
  - (VV) Veno-venous

- PUMP TYPE: Centrifugal Flow
  - Venous cannula for device inflow
  - Arterial cannula for device outflow

- ACCESS SITE: Central Venous and Arterial Access with 15-24F
  - OUTPUT SUPPORT: 4-6L/min
ECMO: Connection and Start up
ECMO: External Pump and Oxygenator
22 year old soldier with thoracic gunshot injury goes into critical respiratory failure
ECMO: CARDIOHELP SYSTEM

CARDIOHELP SYSTEM
The world’s smallest portable heart-lung support system.
ECMO: CARDIOHELP SYSTEM

- 2011 FDA gave 510k clearance to CardioHelp
- Lightweight ~10kg
- Power supply ~2 hours
- First time a single exchangeable device contained:
  - Membrane oxygenator
  - A centrifugal pump
  - Arterial and venous pressure sensors
  - Temperature monitoring
  - Devices for measuring mixed venous sat and hemoglobin
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Cardiogenic Shock

• Most severe form of Acute Heart Failure
  • Many different etiologies
• Inability of LV to maintain adequate cardiac output (CI <2.2) despite normal or elevated pre-load
• PCWP > 18mmHg
• Clinical signs of peripheral hypo-perfusion
  • Decreased urine output
  • Altered mental status
  • Cold extremities
• Mortality typically exceeds 42-48%

Clinical Indications for VA-ECMO

• Low Cardiac Index <2L/min/m2 and hypotension despite inotropic support and an IABP
• Cardiogenic Shock or Severe cardiac failure
  • ACS
  • VT Storm or refractory arrhythmia’s
  • Sepsis with profound myocardial dysfunction
  • Drug overdose/toxicity with profound myocardial dysfunction
  • Myocarditis
  • Pulmonary Embolism
  • Cardiac Trauma
  • Acute Anaphylaxis

Clinical Indications for VA-ECMO

• Post Cardiotomy: Inability to wean from CPB after CT Surgery
• Post Heart Transplant: Primary graft dysfunction
• Chronic Cardiomyopathy:
  • Bridge to durable LVAD support
  • Bridge to decision
  • Bridge to transplant
• Periprocedural support for high-risk PCI

Clinical Indications for VV-ECMO

• Acute respiratory distress syndrome:
  • Severe bacterial or viral pneumonia
  • Aspiration syndromes
  • Alveolar proteinosis

• Extracorporeal assistance to provide lung rest
  • Airway obstruction
  • Pulmonary contusion
  • Smoke inhalation
Clinical Indications for VV-ECMO

- Lung transplant
  - Primary graft failure s/p transplant
  - Bridge to transplant
  - Intraoperative ECMO
- Lung hyperinflation
  - Status asthmaticus
- Pulmonary hemorrhage or hemoptysis
- Congenital diaphragmatic hernia

Absolute Contraindications for ECMO

• Any of the below situations without an exit strategy
  • Unrecoverable heart and not a candidate for Tx or durable VAD support
  • Disseminated malignancy
  • Known severe brain injury
  • Unwitnessed cardiac arrest
  • Prolonged CPR without adequate tissue perfusion
  • Unrepaired aortic dissection
  • Severe aortic regurgitation
  • End-Stage organ dysfunction: COPD, Cirrhosis, ESRD
  • Compliance: (Financial, cognitive, psychiatric, or social limitations without social support)
  • Peripheral vascular disease in VA ECMO
  • Severe Pulmonary hypertension (mean PAP >50)
Relative Contraindications for ECMO

• Coagulopathic or intolerant of anticoagulation
• Advanced age
• Obesity
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EMS Implications

• More than 350,000 patients experience OHCA in the US annually
• Only 12% survive with favorable neurologic outcomes
• Case series and Observational studies have demonstrated the successful application of intra-arrest ECPR can lead to nearly 53% of patients surviving with favorable neurologic outcomes
Development and Implementation of a Comprehensive, Multidisciplinary Emergency Department Extracorporeal Membrane Oxygenation Program

Joseph E. Tonna, MD, Craig H. Selzman, MD, FACS, Michael P. Mallin, MD, Brigham R. Smith, MD, Scott T. Youngquist, MD, MSc, Antigoni Koliopoulos, MD, Frederick Welt, MD, Kathleen Diane Stoddard, RN, BSN, CCRN, Ram Nirula, MD, MPH, FACS, Richard Barton, MD, James Franklin Fair III, MD, James C. Fang, MD, FACC, FAHA, Stephen McKellar, MD, MSc
# University of Utah ECLS Criteria

## Table 2: University of Utah ECLS criteria

### Inclusion criteria
- Age 18–60
- Out-of-hospital cardiac arrest due to presumed cardiac cause
- Witnessed arrest
- Bystander CPR performed
- Initial rhythm is "shockable" (VFib or pulseless VTach)
- Remains in cardiac arrest at the scene after 15 minutes of standard paramedic ACLS (i.e., intubation, IV epinephrine)
- Within 10-minute transport time
- ECMO commences within 90 minutes of initial collapse

### Exclusion criteria
- Presumed non-cardiac cause of cardiac arrest (e.g., trauma, hanging, drowning, intracranial bleeding or respiratory arrest)
- Any pre-existing significant neurological disability
- Confirmed or presumed significant non-cardiac co-morbidities that cause limitations in daily living such as:
  - COPD, pulmonary fibrosis (i.e., no patients on oxygen)
  - Cirrhosis/liver failure (look for ascites, jaundice, or stigmata or liver disease)
  - Kidney failure or dialysis (look for fistulas or catheters)
  - Cancer (look for a port catheter in the chest)
  - Morbid obesity (difficult with emergent cannulation just like difficult IV access)
  - Ventricular assist device (VAD) or other mechanical circulatory support
  - Active infection in the groin region
Putting a patient on ECMO: ABC’s

- **A** is for **A**ssessment
  - A patient with appropriate indication for ECMO and no exclusion criteria

- **B** is for **B**egin the notification process early
  - It can take anywhere from 30-90 minutes to place a patient on ECMO

- **C** is for **C**all the ED/Heart Failure Cardiologist/CT Surgeon or Shock Team
Where can ECMO be done?

Operating Room
Where can ECMO be done?

Cardiac Catheterization Lab
Where can ECMO be done?

ED or Bedside
Where can ECMO be done?

In the Field
Where can ECMO be done?

Even at the Louvre
Preferred Location for ECMO at PSVMC/PPMC

• Operating Room
• Cardiac Catheterization Lab
Pre-hospital extra-corporeal cardiopulmonary resuscitation

Ben Singer¹,²,³,⁴*, Joshua C. Reynolds², David J. Lockey³ and Ben O’Brien¹,⁴,⁵

Abstract

Survival from out-of-hospital cardiac arrest (OHCA) has remained low despite advances in resuscitation science. Hospital-based extra-corporeal cardiopulmonary resuscitation (ECPR) is a novel use of an established technology that provides greater blood flow and oxygen delivery during cardiac arrest than closed chest compressions. Hospital-based ECPR is currently offered to selected OHCA patients in specialized centres. The interval between collapse and restoration of circulation is inversely associated with good clinical outcomes after ECPR. Pre-hospital delivery of ECPR concurrent with conventional resuscitation is one approach to shortening this interval and improving outcomes after OHCA. This article examines the background and rationale for pre-hospital ECPR; summarises the findings of a literature search for published evidence; and considers candidate selection, logistics, and complications for this complex intervention.

Keywords: Pre-hospital, Extracorporeal cardiopulmonary resuscitation, Extracorporeal membrane oxygenation, Extracorporeal life support
<table>
<thead>
<tr>
<th>Inclusion Criteria for Consideration of Pre-hospital ECPR:</th>
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<tbody>
<tr>
<td>1. Age 18–65 years</td>
</tr>
<tr>
<td>2. Witnessed arrest with bystander CPR</td>
</tr>
<tr>
<td>3. VF/VT Rhythm or signs of life during resuscitation*</td>
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<tr>
<td>4. No-flow time &lt; 5 min</td>
</tr>
<tr>
<td>5. Ability to initiate ECPR within 60 min of collapse</td>
</tr>
</tbody>
</table>

*signs of life include attempted respiratory effort, gasps, movement, or pupil reactivity. ECPR extracorporeal cardiopulmonary resuscitation, CPR cardiopulmonary resuscitation, VF ventricular fibrillation, VT ventricular tachycardia
Table 3
Common complications of prehospital ECPR

<table>
<thead>
<tr>
<th>Complication</th>
<th>Specific Pre-hospital Concerns</th>
</tr>
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<tbody>
<tr>
<td>Vascular injury and Bleeding</td>
<td>Availability of pre-hospital blood products, difficulty recognising complications such as retroperitoneal bleeding. No access to interventional radiology or operating theatres.</td>
</tr>
<tr>
<td>Failure to cannulate</td>
<td>Hospital-based percutaneous VA-ECMO cannulation has a reported failure rate between 7% and 10% [52, 53] and is anticipated to be higher in the pre-hospital environment. Surgical cut down may reduce the expected failure rate in the pre-hospital setting.</td>
</tr>
<tr>
<td>Limb Ischaemia</td>
<td>In-hospital limb ischaemia after insertion of VA-ECMO cannulae is reported in the range of 12–15% [31, 52] and would be similar in the pre-hospital environment. The usual practice of inserting a retrograde distal limb perfusion cannula would be deferred until arrival at hospital. One alternative could be using smaller calibre arterial cannulae accepting either lower flows or higher pressures.</td>
</tr>
<tr>
<td>Infection</td>
<td>Although the true infection rate related to ECMO cannulae insertion is unknown, ECMO is an independent risk factor of blood stream infection. [54] Pre-hospital ECMO insertion will not be as clean as an operating theatre and the infection risk may be increased.</td>
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ECPR extracorporeal cardiopulmonary resuscitation, VA-ECMO veno-arterial extracorporeal membranous oxygenation, ECMO extracorporeal membranous oxygenation
ECMO: Complications
ECMO: Complications
ECMO: Complications
ECMO: EMS Implications

What is the best system for OHCA (Out-of-hospital Cardiac Arrest) for Oregon?

ECPR in the field vs ECPR in the ED

ECMO Recovery Team (Examples: San Diego, U of Utah, France)

What does the ideal ECMO Transport team look like?

Physician, ECMO Trained RN, EMS team

How can we as a team of pre-hospital and post-hospital clinicians improve survival for the patients we care for?
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Case Study:

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• What do you do?
What do you do?

A. End the code; medically futile
B. Call the CT Surgeons
C. Call the HF Team
D. Call the Shock Team
E. Call the Chaplain
ECMO: Team Members

• CT Surgical Team
• Perfusionist
• Interventional Cardiologist
• Advanced HF Cardiologist
• Surgical/Cath lab Technicians
• RN Staff
• Anesthesiologist
• Transport team
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Thank you
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Advanced Heart Failure Cardiologist
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Email: Daniel.Westerdahl@Providence.org