Cardiogenic shock/VA ECMO/ECPR

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3-16-2016
AHA MN
Cardiovascular Emergencies Conference
No disclosures
Cardiogenic shock (CS) is a clinical condition of inadequate tissue perfusion due to cardiac dysfunction.
Definition

• **Persistent hypotension** (systolic blood pressure <80 to 90 mmHg or mean arterial pressure 30 mmHg lower than baseline)

• **Severe reduction in the cardiac index** (<1.8 L/min per m² without support or <2.0 to 2.2 L/min per m² with support)

• **Adequate or elevated filling pressures**
Definition

Refractory Cardiogenic shock:
Shock persists *despite* volume administration, inotropes, vasoconstrictors, and intra-aortic balloon pump (IABP)
Etiology of cardiogenic shock

- Acute myocardial infarction
- Myocarditis
- Peripartum Cardiomyopathy
- Decompensated chronic heart failure
- Post cardiotomy shock
- **Septic Shock with cardiac compromise**
- Biventricular failure
- Refractory malignant arrhythmias
Cardiogenic shock/AMI – quick facts

- The median time from MI to onset of cardiogenic shock is 5.5 hours and 75% of patients developed shock within 24 hours.

Incidence of shock complicating AMI

Overall incidence 5-8%

- The majority of patients have a STEMI, but CS occurs in 2.5% (NSTE MI)
- 40-50,000 cases/year

<table>
<thead>
<tr>
<th>Condition</th>
<th>Incidence</th>
</tr>
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<tbody>
<tr>
<td>LV failure</td>
<td>79%</td>
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<tr>
<td>Severe MR</td>
<td>7%</td>
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<tr>
<td>VSD</td>
<td>4%</td>
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<tr>
<td>Isolated RV infarct</td>
<td>2%</td>
</tr>
<tr>
<td>Tamponade</td>
<td>1.4%</td>
</tr>
<tr>
<td>Other</td>
<td>7%</td>
</tr>
</tbody>
</table>

Shock Registry Data.
Risk factors

- Older age
- Anterior MI
- Hypertension
- Diabetes mellitus
- Multi-vessel coronary artery disease
- Prior MI or diagnosis of heart failure
- STEMI
- Left bundle branch block on the electrocardiogram (ECG)
Symptoms/signs

• Signs of systemic hypoperfusion (e.g., cool extremities, oliguria, and/or alteration in mental status)
• Severe systemic hypotension
• Respiratory distress due to pulmonary congestion.
RCS—quick facts

- In-hospital mortality due to refractory cardiogenic shock (RCS) remains in excess of 90%.
- Medical therapy using inotropic agents and vasopressors is often ineffective for adequate hemodynamic support.
What works/what doesn't
EARLY REVASCULARIZATION IN ACUTE MYOCARDIAL INFARCTION COMPLICATED BY CARDIOGENIC SHOCK

JUDITH S. HOCHMAN, M.D., LYNN A. SLEEPER, Sc.D., JOHN G. WEBB, M.D., TIMOTHY A. SANBORN, M.D., HARVEY D. WHITE, D.Sc., J. DAVID TALLEY, M.D., CHRISTOPHER E. BULLER, M.D., ALICE K. JACOBS, M.D., JAMES N. SLATER, M.D., JACQUES COL, M.D., SONJA M. MCKINLAY, Ph.D., AND THIERRY H. LEJEMTEL, M.D., FOR THE SHOCK INVESTIGATORS*

ABSTRACT

**Background** The leading cause of death in patients hospitalized for acute myocardial infarction is cardiogenic shock. We conducted a randomized trial to evaluate early revascularization in patients with cardiogenic shock.

**Methods** Patients with shock due to left ventricular failure complicating myocardial infarction were randomly assigned to emergency revascularization (152 patients) or initial medical stabilization (150 patients). Revascularization was accomplished by either coronary

CARDIOGENIC shock complicates 7 to 10 percent of cases of acute myocardial infarction and is associated with a 70 to 80 percent mortality rate. Cardiogenic shock remains the leading cause of death in patients hospitalized with myocardial infarction in the reperfusion era. Nonrandomized studies report markedly lower mortality rates among patients who have undergone revascularization for shock. However, selection bias is evident. In small series of patients undergoing emergency angioplasty for acute
Shock trial

- Inclusion criterion: shock due to LV failure complicating myocardial infarction
- 302 pts randomly assigned to emergency revascularization (n=152) or initial medical stabilization (n=150).
Shock trial results

- No difference in mortality at 30 days (46.7% vs 56%, p=0.11)

- Significant decrease in all cause mortality at 6 months (50.3% vs. 63.1% p=0.027)

**Figure 1.** Overall 30-Day Survival in the Study.
The 30-day survival rate was 53.3 percent for patients assigned to revascularization and 44.0 percent for those assigned to medical therapy.
Intraaortic Balloon Support for Myocardial Infarction with Cardiogenic Shock

Holger Thiele, M.D., Uwe Zeymer, M.D., Franz-Josef Neumann, M.D., Miroslaw Ferenc, M.D., Hans-Georg Olbrich, M.D., Jörg Hausleiter, M.D., Gert Richardt, M.D., Marcus Hennersdorf, M.D., Klaus Empen, M.D., Georg Fuernau, M.D., Steffen Desch, M.D., Ingo Eitel, M.D., Rainer Hambrecht, M.D., Jörg Fuhrmann, M.D., Michael Böhm, M.D., Henning Ebelt, M.D., Steffen Schneider, Ph.D., Gerhard Schuler, M.D., and Karl Werdan, M.D., for the IABP-SHOCK II Trial Investigators*
Methods

• Randomized, prospective, open-label, multicenter trial
• 600 patients with CS complicating acute myocardial infarction, randomly assigned to
  - IABP, (301 pts) or
  - no IABP (299 pts)
plus early revascularization
• The primary end point \(\rightarrow\) 30-day all-cause mortality.
Results

- **At 30 days** 119 patients in the IABP group (39.7%) and 123 patients in the control group (41.3%) had died ($P = 0.69$).
ECMO?
What is ECMO?

• ECMO stands for Extracorporeal Membrane Oxygenation.

• The ECMO circuit acts as an artificial heart and lung
Very short historic background

- 1956 - first heart-lung machine was used by Dr. Gibbon.
- 1971 - first successful ECMO placed by Dr. Hill
- 1975 - first newborn ECMO in CA by Dr. Bartlett
- 1980 - first ECMO center in the world started by Dr. Bartlett at the University of Michigan
- Currently 90+ ECMO centers in the US
When should ECMO be considered?

- Refractory cardiogenic shock (VA)
- If the process is:
  - Severe (mortality > 80-90%)
  - Acute
  - Potentially reversible
Contraindications to VA ECMO

- **absolute**

- Unrecoverable heart and *not* a candidate for transplant or VAD

- *Chronic* organ dysfunction (emphysema, cirrhosis, renal failure),

- Compliance (financial, cognitive, psychiatric, or social limitations) for further therapies if needed
Contraindications to VA ECMO
- relative

- Contraindication for anticoagulation?
- Advanced age?
- Obesity?
ECMO: Advantages:

Immediate application

Biventricular support

Oxygenation

Refractory malignant arrythmias do not affect the flow

Bridge to more durable devices (LVAD)
VA ECMO – and what next?

Bridge to Recovery (most common):
- Acute MI after revascularization,
- Myocarditis,
- Postcardiotomy
- Drug intoxication

Transplant/Long term VAD:
- Unrevascularizable acute MI,
- Chronic, decompensated heart failure
Outcomes
**ECLS Registry Report**

International Summary

January, 2016

### Overall Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Total Patients</th>
<th>Survived ECLS</th>
<th>Survived to DC or Transfer</th>
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<tbody>
<tr>
<td><strong>Neonatal</strong></td>
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<td>ECPR</td>
<td>1,254</td>
<td>806</td>
<td>514</td>
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<td>1,532</td>
<td>1,144</td>
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<td>707</td>
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<td><strong>Total</strong></td>
<td>73,596</td>
<td>51,837</td>
<td>42,947</td>
</tr>
</tbody>
</table>

**Cardiac** - 7850 pts
56% survived ECLS
41% survived to DC
ECPR 2379 → 30% survived to DC

**Respiratory** - 9102 pts
66% survived ECLS
58% survived to DC
Clinical outcome of mechanical circulatory support for refractory cardiogenic shock in the current era

Hiroo Takayama, MD, PhD\textsuperscript{a} \url{https://orcid.org/0000-0003-0000-0000}, Lauren Truby, BS\textsuperscript{a}, Michael Koekort, MD\textsuperscript{a}, Nir Uriel, MD\textsuperscript{b}, Paolo Colombo, MD\textsuperscript{b}, Donna M. Mancini, MD, FACC\textsuperscript{b}, Ulrich P. Jorde, MD\textsuperscript{b}, Yoshifumi Naka, MD, PhD\textsuperscript{a}

\textsuperscript{a} Departments of Surgery, Columbia University Medical Center, New York, New York.

\textsuperscript{b} Medicine, Columbia University Medical Center, New York, New York
Study design

- Retrospective review of adult patients who required MCS due to CS
- The etiology of RCS included acute MI in 49%
  acute decompensated HF in 27%
- VA ECMO was chosen in cases of unknown neurologic status, complete hemodynamic collapse or severe coagulopathy.
Study results

- 90 pts received an MCSD for refractory CS (RCS),
- 21 (23%) of whom had active CPR.
  - Mean age was 53±14 years, 71% M, 60% had IABP
  - short-term VAD in 49% and VA ECMO in 51%.
  - Median length of support was 8 days
  - Myocardial recovery in 18% and heart transplantation in 11%.
  - Survival to hospital discharge was 49%.
  - Ongoing CPR to be an independent risk factor for mortality
ECMO for cardiogenic shock

Outcomes and long-term quality-of-life of patients supported by extracorporeal membrane oxygenation for refractory cardiogenic shock*

Alain Combes, MD, PhD; Pascal Leprince, MD, PhD; Charles-Edouard Luyt, MD, PhD; Nicolas Bonnet, MD; Jean-Louis Trouillet, MD; Philippe Léger, MD; Alain Pavie, MD; Jean Chastre, MD

Objective: To assess the outcomes and long-term quality-of-life of patients supported by extracorporeal membrane oxygenation (ECMO) for refractory cardiogenic shock.

Design, Setting, and Patients: Retractive cardiogenic shock is almost always lethal without emergency circulatory support, e.g., ECMO. ECMO-associated morbidity and mortality plead for identification of early predictors of its failure, and detailed analyses of short- and long-term outcomes to refine patient selection and improve results. Outcomes of 81 patients given ECMO support for medical (n = 56), postcardiomyopathy (n = 16), or posttransplantation (n = 10) cardiogenic shock were evaluated.

Measurements and Main Results: Thirty-four (42%) patients survived to hospital discharge; 57% suffered ≥1 major ECMO-related complications. Independent predictors of intensive care unit death were: device insertion under cardiac massage (odds ratio [OR] = 20.68), 24 hr urine output < 500 mL (OR = 6.62), prothrombin activity < 60% (OR = 3.93), and female sex (OR = 3.89); myocardiolides were associated with better outcomes (OR = 0.13). Sequelae and health-related quality-of-life were evaluated for 28 long-term survivors (median follow-up, 11 months), whose mean Short-Form 36 scores were significantly lower than matched healthy controls for physical role, general health, and social functioning, but higher than those reported for patients on chronic hemodialysis, with advanced heart failure, or after recovery from acute respiratory distress syndrome.

Conclusions: ECMO support can rescue 40% of otherwise fatal cardiogenic shock patients but its initiation under cardiac massage or after renal or hepatic failure carried higher risks of intensive care unit death, while fulminant myocarditis had a better prognosis. Despite satisfactory mental health and vitality, long-term survivors' persistent physical and social problems might benefit from tailored medical or psychosocial interventions. (Crit Care Med 2008; 36:1404–1411)

Key Words: extracorporeal membrane oxygenation; salvage therapy; shock; cardiogenic; cardiac arrest; treatment outcome; quality-of-life assessment

81 pts
42% survival to discharge
34% survived 11 months

Risk of ICU death
- Female gender
- CPR during insertion
- 24h urine output < 500
- Hepatic failure
I. Patient Condition:

A. Indications

AHA guidelines for CPR recommends consideration of ECMO to aid cardiopulmonary resuscitation in patients who have an easily reversible event, have had excellent CPR.

Contraindications: All contraindications to ECMO use (such as Gestational age < 34 weeks) should apply to ECPR patients.

DNR orders

Futility: Unsuccessful CPR (no return of spontaneous circulation) for 5-30 minutes.

ECPR may be indicated on prolonged CPR if good perfusion and metabolic support is documented.

II. Vascular Access

A. Cannulation Site

Thoracic (for cardiac patients with recent sternotomy) or Peripheral vessel should be at discretion of the surgical team. Percutaneous cannulation of vessels for ECPR is only recommended if access to the vessels exists prior to CPR, and should only be performed by providers who are skilled with vascular access. Percutaneous cannulation can be performed in patients >15 kgs. Placement in specialized areas such as the cardiac catheterization (or interventional radiology) laboratory where the placement of these catheters can be directly observed is ideal but non-mandatory.
III: Management during ECLS

A. Initiation of ECMO Flow: Once cannulation is achieved ECMO circuit management should continue as for all other ECMO uses. Because ECPR required rapid cannulation and ECMO access, correct connection of the arterial and venous cannulae to the corresponding limbs should be checked using a “Time-Out’ system prior to ECMO flow.

B. Patient Management on ECMO: CNS protection during and after CPR is critical. Therapies known to improve survival and CNS outcomes after CPR such as:

1. Total body hypothermia should be included. Cooling should be achieved by applying ice to the head during CPR and for 48 – 72 hours after ECMO cannulation.
2. Neurological exams should be performed following discontinuation of neuromuscular blocking agents after hemodynamic stability is achieved in collaboration with the neurologist.

C. Management of Left Atrial Hypertension: Evaluation for LA hypertension should be undertaken soon after the patient is placed on ECMO and LA decompression should be considered if left atrial pressure is thought to be elevated.
# ECLS Registry Report

## International Summary

January, 2016

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<td>70%</td>
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Cardiac → 7850 pts
ECPR 2379 → 30% survived to DC
- 26 pts with out of hospital arrest
- Average age 40 (+/- 15)
- 54% male
- Time from cardiac arrest to initiation of ECMO 77 min (+/- 51)
- 4 patients survived to Discharge (15%)
Emergency physician-initiated extracorporeal cardiopulmonary resuscitation.

Bellezzo JM et al. Resuscitation 2012 Aug;83(8):966-70
3 stage approach to eCPR

- A three-stage algorithm was developed for ED ECPR in patients meeting inclusion/exclusion criteria.

- 42 patients who presented to the ED with cardiopulmonary collapse

- 18 patients (43%) met inclusion/exclusion criteria for the algorithm.

- 8 patients (44%) were admitted to the hospital after successful ED ECPR and 5 (28%) of those patients survived to hospital discharge neurologically intact.

- 10 patients were not started on ECMO support because either their clinical conditions improved or resuscitative efforts were terminated.
# 3 stage approach to eCPR

<table>
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<th>Table 1</th>
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</table>

**Inclusion criteria:**
- Persistent cardiopulmonary arrest despite traditional resuscitative efforts
- Shock (SBP < 70 mmHg) refractory to standard therapies

**Exclusion criteria:**
- Initial rhythm asystole
- Chest compressions not initiated within 10 min of arrest (either bystanders or EMS personnel)
- Estimated EMS transport time > 10 min
- Total arrest time > 60 min
- Suspicion of shock due to sepsis or hemorrhage
- Pre-existing severe neurological disease prior to arrest (including traumatic brain injury, stroke, or severe dementia)

SBP, systolic blood pressure; EMS, emergency medical services.
3 stage approach to eCPR

• typically 2 physicians.
• first physician supervising ACLS (AKA the “code doc”),
• second doctor is responsible for percutaneous femoral venous and arterial access (AKA the “line doc”).
• On average, it takes 20 to 30 minutes to complete all 3 stages, which provides enough time to allow the patient to achieve ROSC via traditional means.
• Concomitantly, the critical care ECLS nursing team is called, and the portable ECLS unit is brought from the intensive care unit to the ED.
3 stage approach to eCPR

Cardiopulmonary Arrest or Refractory Shock (42)

Meets ED ECPR inclusion/exclusion criteria?  
Yes (18)

STAGE 1
Place femoral and venous angiocatheters?  
Yes (18)

ROSC or RORS?  
Yes (2)

STAGE 2
Replace femoral lines with ECLS cannulas?  
Yes (12)

ROSC or RORS?  
Yes (1)

STAGE 3
Total Percutaneous Cardiopulmonary Bypass  
Yes (8)

Circulation Established (ROSC, RORS, or ECLS)  
Manage Medical and/or Surgical Issues
Management of an ECMO patient
IT TAKES A VILLAGE!
Management

ECMO circuit

Patient
ANW Shock Team

- Advanced HF
- Cardiothoracic surgery
- Vascular surgery
- Intensivist
- Refractory CS
- Perfusionists
- Nursing staff
- Interventional cardiology
Management of ECMO circuit

- Management of circuit ABG
- Adequate volume
  - Low flows/chatter of the lines
    - hypovolemia
    - cannula obstruction
    - VC obstruction
- Anticoagulation
Management of the patient

• Hemodynamic management
• Fluid and electrolyte
• Hematology
• Anticoagulation
• **Respiratory**
• Renal
• Neurologic
• **Nutrition**
Hemodynamic monitoring

- ECG/HR
- A-line/saturation
- S-G catheter
- Cerebral perfusion
- EEG
Knowing about complications...

- Bleeding
- Ischemia → limb, cerebral
- Infection
- Pulmonary complications
COMMUNICATIONS and TEAM WORK is KEY!
MHI/ANW Experience
How does it work at ANW...

- Level 1 ECMO call (ext 31290)
- Discussion between HF cardiologist/interventionalist/intensivist/CT surgeon
- Placement in the cath lab with perfusionist present
- ECMO management on H 4100
### Overall Outcomes

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<tr>
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<td>1</td>
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<td>22</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Cardiac</td>
<td>81</td>
<td>55</td>
<td>44</td>
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<tr>
<td>ECPR</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td><strong>Total</strong></td>
<td>108</td>
<td>75</td>
<td>62</td>
</tr>
</tbody>
</table>

Survived ECLS: 69%
Survived to DC or Transfer: 57%
Survival to Discharge

ANW
55% 59%

ELSO
41% 58%

Cardiac
Respiratory
ECPR - survival

ELSO  ANW  
n= 2379  n= 13
Pilot In-House eCPR

- Monday-Friday, 0800-1700
- Target Start Date - Sept 1, 2015 (modified 11-23-15)

**Criteria:**
- Age 18-75 (was 65)
- Arrest of cardiac origin - VF/VT
- ETCO2>20
- Patient on H4000/5000/5200 or in CVICU

**Process:**
- AHF & Intensivist go to all codes at the above locations and time, within LESS than 10 minutes
- ECMO candidacy to be determined by AHF & Intensivist
- Level 1 ECMO call placed by AHF MD or the intensivist (ext #31290 or #33535)
- Patient to be transported to the cath lab with LUCAS device and ongoing CPR
- ECMO to be initiated in CV Lab - target time from arrest to initiation of ECMO 60 minutes or less
Cardiogenic shock outcomes: Survival

- Total of 37 patients:
- Age – mean 61, 28 males (75%)
- Mean time on support 5 days
- Median LOS – 13 days
  - 13 pts (35%) died during in-hospital course.
  - 24 pts (65%) survived the index admission
  - 9/24 pts (24%) – discharged home
ANW experience: Survival

- Majority of deaths occur within the first 15 days (~33%).

- Another 10-11% between 15 days and 4 months.

Among those who were discharged from initial hospitalization, survival rate (by 2/2014): 87.5% (21/24) with a median follow-up time of 450 days.
Bridge to LVAD
<table>
<thead>
<tr>
<th></th>
<th>Bridge to LVAD (n=9)</th>
<th>Not Bridge to LVAD (n=53)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years), mean (SD)</td>
<td>50.4 ± 17.3</td>
<td>59.6 ± 12.3</td>
<td>0.057</td>
</tr>
<tr>
<td>Male, (%)</td>
<td>7 (77.8)</td>
<td>36 (67.9)</td>
<td>0.55</td>
</tr>
<tr>
<td>Hypertension, (%)</td>
<td>3 (60.0)*</td>
<td>16 (47.1)†</td>
<td>0.59</td>
</tr>
<tr>
<td>Diabetes, (%)</td>
<td>1 (11.1)</td>
<td>12 (22.6)</td>
<td>0.43</td>
</tr>
<tr>
<td>History of tobacco, (%)</td>
<td>4 (44.4)</td>
<td>27 (60.9)</td>
<td>0.72</td>
</tr>
<tr>
<td>History of CAD, (%)</td>
<td>1 (11.1)</td>
<td>17 (32.1)</td>
<td>0.20</td>
</tr>
<tr>
<td>History of CHF, (%)</td>
<td>5 (55.5)</td>
<td>13 (24.5)</td>
<td><strong>0.058</strong></td>
</tr>
<tr>
<td>Chest pain, (%)</td>
<td>5 (55.5)</td>
<td>26 (49.1)</td>
<td>0.72</td>
</tr>
<tr>
<td>Shortness of breath, (%)</td>
<td>4 (44.4)</td>
<td>31 (58.5)</td>
<td>0.43</td>
</tr>
<tr>
<td>Cardiac arrest, (%)</td>
<td>3 (33.3)</td>
<td>24 (45.3)</td>
<td>0.50</td>
</tr>
<tr>
<td>CPR, (%)</td>
<td>2 (22.2)</td>
<td>20 (40.0)</td>
<td>0.31</td>
</tr>
<tr>
<td>ECMO duration (Days), median (25th, 75th percentile)</td>
<td>7 (6, 12)</td>
<td>5 (3, 7)</td>
<td><strong>0.034</strong></td>
</tr>
<tr>
<td>Admit EF, median (25th, 75th percentile)</td>
<td>10 (10, 10)</td>
<td>25 (10, 60)</td>
<td><strong>0.008</strong></td>
</tr>
<tr>
<td>Initial creatinine, median (25th, 75th percentile)</td>
<td>1.74 (1.23, 2.38)</td>
<td>1.11 (0.92, 1.50)</td>
<td><strong>0.040</strong></td>
</tr>
<tr>
<td>In-hospital death, (%)</td>
<td>2 (22.2)</td>
<td>24 (46.2)</td>
<td>0.18</td>
</tr>
</tbody>
</table>
Case 1

• 54 years old male, no PMH, significant family hx of CAD
• Presents with sudden onset CP while at work
• 911 called, cardiac arrest in ED, CPR initiated
• cath lab → coronary angiogram
Case 1 – coronary angiogram
Case 1

- Despite successful PCI with DES to LM persistent cardiogenic shock requiring multiple pressors and inotropes
- Rising lactate levels
- 2D echo...
Case 1 - initial ECHO
Case 1 - initial ECHO
ECMO
Case 1 – ECHO 5 days later
Case 1 - f/u

- Successful explantation of ECMO circuit
- Final EF 30% with moderate MR
- NYHA class 1
- On HF therapies and ICD
Case 2

• 50 years old female, no PMH, started to feel dizzy, while teaching karate class
• 911 called, anterior and lateral ST elevation, in ambulance progressive hypotension, clammy, cardiac arrest while pulling into ambulance bay of ANW
• Manual CPR started, then LUCAS initiated
• Cath lab → coronary angiogram →...
Case 2

- Dissection of LCx into LM and LAD
- Unsuccessful PCI
- Not a surgical candidate
- Decision about ECMO placement despite on-going CPR with LUCAS, with adequate MAPs
Case 2 - initial 2D ECHO
Case 2 – hospital course

- Shock liver, acute renal failure requiring CVVH-D
- ARDS
- Rhabdo – bilateral fasciotomies
- Day 2 – CT head demonstrated bilateral cerebellar infarcts
- Multiple multi-disciplinary/family meetings...
Case 2 - hospital course

- Sedation weaned to off and patient starts following simple and...complex commands
- EF still less than 10%
- Decision to move with permanent LVAD
- Resolution of pulmonary edema
- Return of renal function to normal
- Transmetatarsal amputation R foot
- Rehab, back to work, driving!

A year later...status post heart transplantation - doing well!
Save the date for April 22nd conference...

Advanced Cardiopulmonary Support for the Critically Ill Adult

Friday, April 22, 2016
The Depot at the Renaissance Minneapolis Hotel
Call us if in doubt

Phone: 612-863-8800
Ask for CCU Heart Failure Doc

ADVANCED HEART FAILURE
CARDIAC TRANSPLANTATION
MECHANICAL CIRCULATORY SUPPORT
PULMONARY HYPERTENSION
Acknowledgement

- HF team
- Intensivists – Dr. Seatter
- Interventionalists – Dr. Chavez, Dr. Mooney
- CT Surgery – Dr. Sun
- Vascular surgery – Dr. Alexander, Dr. Titus
- Perfusionists
- Anesthesia
- 4100 RNs and RTs
- Echo techs – Jon Fink
- David Hildebrand/Mark Ebeling
- And … special thanks to Sharom Wahl – CVICU Clinical Nurse Specialist and ECMO coordinator
Questions?
Thank You!
Circuit malfunction

<table>
<thead>
<tr>
<th>Cardiac Complications (0-30 days)</th>
<th>No. Reported</th>
<th>% Reported</th>
<th>No. Survived</th>
<th>% Survived</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical: Oxygenator failure</td>
<td>416</td>
<td>6.7%</td>
<td>103</td>
<td>25%</td>
</tr>
<tr>
<td>Mechanical: Raceway rupture</td>
<td>18</td>
<td>0.3%</td>
<td>6</td>
<td>33%</td>
</tr>
<tr>
<td>Mechanical: Other tubing rupture</td>
<td>30</td>
<td>0.5%</td>
<td>10</td>
<td>33%</td>
</tr>
<tr>
<td>Mechanical: Pump malfunction</td>
<td>99</td>
<td>1.6%</td>
<td>28</td>
<td>28%</td>
</tr>
<tr>
<td>Mechanical: Heat exchanger malfunction</td>
<td>32</td>
<td>0.5%</td>
<td>18</td>
<td>56%</td>
</tr>
<tr>
<td>Mechanical: Clots: oxygenator</td>
<td>724</td>
<td>11.6%</td>
<td>215</td>
<td>30%</td>
</tr>
<tr>
<td>Mechanical: Clots: bridge</td>
<td>242</td>
<td>3.9%</td>
<td>74</td>
<td>31%</td>
</tr>
<tr>
<td>Mechanical: Clots: bladder</td>
<td>370</td>
<td>5.9%</td>
<td>98</td>
<td>26%</td>
</tr>
<tr>
<td>Mechanical: Clots: hemofilter</td>
<td>267</td>
<td>4.3%</td>
<td>67</td>
<td>25%</td>
</tr>
<tr>
<td>Mechanical: Clots: other</td>
<td>846</td>
<td>13.6%</td>
<td>290</td>
<td>34%</td>
</tr>
<tr>
<td>Mechanical: Air in circuit</td>
<td>197</td>
<td>3.2%</td>
<td>57</td>
<td>29%</td>
</tr>
<tr>
<td>Mechanical: Cracks in pigtail connectors</td>
<td>36</td>
<td>0.6%</td>
<td>18</td>
<td>50%</td>
</tr>
<tr>
<td>Mechanical: Cannula problems</td>
<td>373</td>
<td>6.0%</td>
<td>127</td>
<td>34%</td>
</tr>
<tr>
<td>Hemorrhagic: GI hemorrhage</td>
<td>66</td>
<td>1.1%</td>
<td>9</td>
<td>14%</td>
</tr>
<tr>
<td>Hemorrhagic: Cannulation site bleeding</td>
<td>663</td>
<td>10.9%</td>
<td>209</td>
<td>32%</td>
</tr>
<tr>
<td>Hemorrhagic: Surgical site bleeding</td>
<td>1,872</td>
<td>30.0%</td>
<td>577</td>
<td>31%</td>
</tr>
<tr>
<td>Hemorrhagic: Hemolysis (hgb &gt; 50 mg/dl)</td>
<td>683</td>
<td>10.9%</td>
<td>194</td>
<td>28%</td>
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<tr>
<td>Hemorrhagic: Disseminated intravascular coagulation (DIC)</td>
<td>246</td>
<td>3.9%</td>
<td>45</td>
<td>18%</td>
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<tr>
<td>Neurologic: Brain death clinically determined</td>
<td>66</td>
<td>1.1%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Neurologic: Seizures: clinically determined</td>
<td>423</td>
<td>6.8%</td>
<td>135</td>
<td>32%</td>
</tr>
<tr>
<td>Neurologic: Seizures: EEG determined</td>
<td>183</td>
<td>2.9%</td>
<td>55</td>
<td>30%</td>
</tr>
<tr>
<td>Neurologic: CNS infarction by US/CT</td>
<td>220</td>
<td>3.5%</td>
<td>59</td>
<td>27%</td>
</tr>
<tr>
<td>Neurologic: CNS hemorrhage by US/CT</td>
<td>707</td>
<td>11.3%</td>
<td>171</td>
<td>24%</td>
</tr>
<tr>
<td>Renal: Creatinine 1.5 - 3.0</td>
<td>693</td>
<td>11.1%</td>
<td>163</td>
<td>24%</td>
</tr>
<tr>
<td>Renal: Creatinine &gt; 3.0</td>
<td>121</td>
<td>1.9%</td>
<td>38</td>
<td>31%</td>
</tr>
<tr>
<td>Renal: Dialysis required</td>
<td>516</td>
<td>8.3%</td>
<td>100</td>
<td>19%</td>
</tr>
<tr>
<td>Renal: Hemofiltration required</td>
<td>1,618</td>
<td>25.9%</td>
<td>460</td>
<td>28%</td>
</tr>
<tr>
<td>Renal: CAVHD required</td>
<td>401</td>
<td>6.4%</td>
<td>66</td>
<td>16%</td>
</tr>
</tbody>
</table>