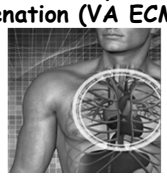
Veno-Arterial Extracorporeal Membrane Oxygenation (VA ECMO)



Kasia Hryniewicz, M.D.
Section of Advanced Heart Failure/Transplant/MCS
Director of MHI/ ANW ECMO Program

2st Advance Cardiopulmonary Support for the Critically Ill Adult Conference
April22, 2016

No disclosures

When should VA ECMO be considered?

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

Definition

- **<u>Persistent hypotension</u> (systolic blood pressure <80 to 90 mmHg or mean arterial pressure 30 mmHg lower than baseline)**
- **<u>Severe reduction in cardiac index</u> (<1.8 L/ min per m2 without support or <2.0 to 2.2 L/ min per m2 with support)**
- **<u>Adequate or elevated filling pressures</u>**

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Definition

Refractory Cardiogenic shock:

Shock persists *despite* volume administration, inotropes and vasoconstrictors, and intra-aortic balloon pump (IABP)

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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**

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Cardiogenic shock/AMI – quick facts

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

Reynolds et al. Circulation. 2008;117:686-69

Incidence of shock complicating AMI

Overall incidence 5-8%

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

LV failure	79%
Severe MR	7%
VSD	4%
Isolated RV infarct	2%
Tamponade	1.4%
Other	7%

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 (eg, 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 50%*
- Medical therapy using inotropic agents and vasopressors is often *ineffective* for adequate hemodynamic support.

What works/what doesn't

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 OCTOBER 4, 2012 VOL. 367 NO. 14

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*

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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 → 30-day all-cause mortality.

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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).

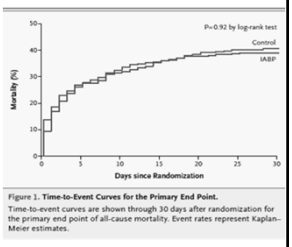

Figure 1. Time-to-Event Curves for the Primary End Point.
Time-to-event curves are shown through 30 days after randomization for the primary end point of all-cause mortality. Event rates represent Kaplan–Meier estimates.

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ECMO?

What is ECMO?

- ECMO stands for *Extracorporeal Membrane Oxygenation*.
- The ECMO circuit acts as an artificial heart and lung

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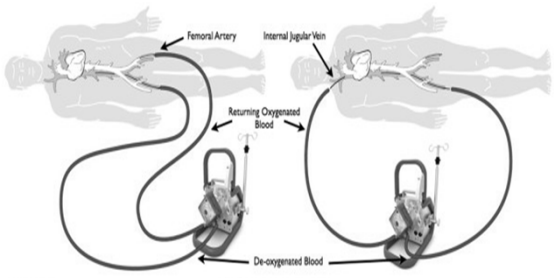
ECMO Circuits

VA-ECMO VV-ECMO



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

ECMO: Advantages:

- Immediate application
- Biventricular support
- Oxygenation
- Refractory malignant arrhythmias do *not* affect the flow
- Bridge to more durable devices (LVAD)

ELSO

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

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Contraindications to VA ECMO - relative

- Contraindication for anticoagulation ?
- Advanced age ?
- Obesity ?

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

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Outcomes

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Minneapolis Heart Institute

ECLS Registry Report
International Summary
January, 2016

Extracorporeal Life Support Organization
2800 Plymouth Road
Building 300, Room 303
Ann Arbor, MI 48109

Overall Outcomes

	Total Patients	Survived ECLS		Survived to DC or Transfer	
Neonatal					
Respiratory	28,723	24,155	84%	21,274	74%
Cardiac	6,269	3,885	62%	2,599	41%
ECPR	1,254	806	64%	514	41%
Pediatric					
Respiratory	7,210	4,787	66%	4,155	58%
Cardiac	8,021	5,341	67%	4,067	51%
ECPR	2,788	1,532	55%	1,144	41%
Adult					
Respiratory	9,102	5,989	66%	5,254	58%
Cardiac	7,850	4,394	56%	3,233	41%
ECPR	2,379	948	40%	707	30%
Total	73,596	51,837	70%	42,947	58%

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

The Journal of Heart and Lung Transplantation
Volume 32, Issue 1, January 2013, Pages 106–111
ELSEVIER

Original clinical science

Clinical outcome of mechanical circulatory support for refractory cardiogenic shock in the current era

Hiroo Takayama, MD, PhD[a], Lauren Truby, BS[a], Michael Koekort, MD[a], Nir Uriel, MD[b], Paolo Colombo, MD[b], Donna M. Mancini, MD, FACC[b], Ulrich P. Jorde, MD[b], Yoshifumi Naka, MD, PhD[a]

[a] Departments of Surgery, Columbia University Medical Center, New York, New York.
[b] Medicine, Columbia University Medical Center, New York, New York

Study design

- **Retrospective review of adult patients who required an 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: Refractory cardiogenic shock is almost always lethal without emergency circulatory support, e.g., ECMO. ECMO-associated mortality and morbidity 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), postcardiotomy (n = 16), or posttransplantation (n = 10) cardiogenic shock were evaluated.

Measurements and Main Results: Thirty-two (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], = 20.69), 24 hr urine output <500 mL (OR = 6.52), prothrombin activity <50% (OR = 3.83), and female sex (OR = 3.80); myocarditides were associated with better outcomes (OR = .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)

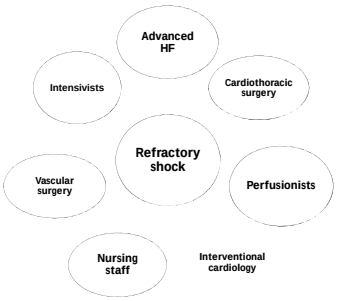
Key Words: extracorporeal membrane oxygenation; salvage therapy; shock; cardiogenic; cardiac arrest; treatment outcome; quality-of-life assessment

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**

ECMO Program at Minneapolis Heart Institute/ Abbott Northwestern Hospital

Evolution of ECMO Program at ANW

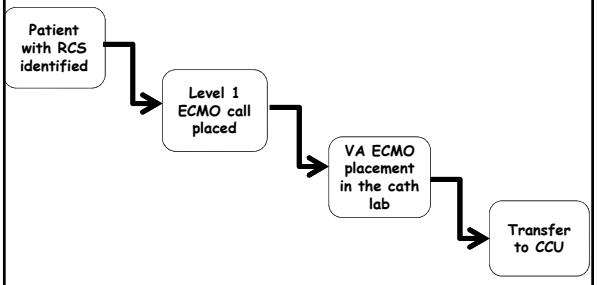
ANW Shock-ECMO Team



Evolution of ECMO Program at ANW

- Daily multidisciplinary rounding
- Monthly multidisciplinary ECMO conference
- M&M
- Monthly operational meeting
- Level 1 ECMO call system
- Unified approach to access/cannula sizes
- ECMO database, research projects, presentations, publications
- ECMO sym lab
- Training for RNs/paramedics
- Credentialing

How does it work at ANW…



Management of an ECMO patient

Management

ECMO circuit

Patient

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

ANW ECMO Experience 2012-2015

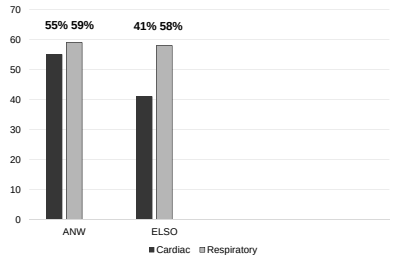
ECLS Registry Report
Center Specific Summary
January, 2016
Abbott Northwestern Hospital (313)

Extracorporeal Life Support Organization
2800 Plymouth Road
Building 300, Room 303
Ann Arbor, MI 48109

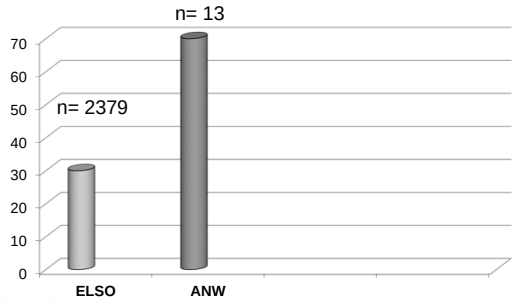
Overall Outcomes

	Total Patients	Survived ECLS		Survived to DC or Transfer	
Pediatric					
Cardiac	1	1	100%	1	100%
Adult					
Respiratory	22	15	68%	13	59%
Cardiac	81	55	68%	44	54%
ECPR	4	4	100%	4	100%
Total	108	75	69%	62	57%

Survival to Discharge



ECPR - survival



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

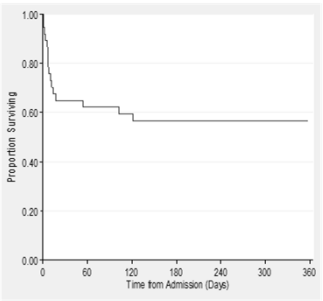
- Process:
- AHF & Intensivist go to all codes at the above locations and time, within LESS than 10 minutes
- ECMO candidacy to be determined by AHF & Intensivist
- Level 1 ECMO call placed by AHF MD or the intensivist (ext #31290 or #33535)
- Patient to be transported to the cath lab with LUCAS device 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

Hryniewicz K et al, ASAIO J. 2016 Apr 4

Outcomes: Survival



- Majority of deaths occur within the first 15 days (~33%).
- Another 10-11% between 15 days and 4 months.

Hryniewicz K et al, ASAIO J. 2016 Apr 4

Long term survival (n=37)

Among those who were discharged from initial hospitalization, survival rate 87.5% with a median follow-up time of 450 days

Hryniewicz K et al, ASAIO J. 2016 Apr 4

Outcomes

Mean duration of ECMO support for RCS (days)	5.6
Mean length of stay – median (days)	13 (8, 28)
Renal replacement therapy during index admission (%)	30
Long term HD	0

Hryniewicz K et al, ASAIO J. 2016 Apr 4

Outcomes: ECMO → LVAD

Bridge to LVAD	Yes (n=9)	No (n=53)	P-Value
Age (Years), mean	50.4 ± 17.3	59.6 ± 12.3	0.057
Male, (%)	7 (77.8)	36 (67.9)	0.55
Hypertension, (%)	3 (60.0)*	16 (47.1)†	0.59
Diabetes, (%)	1 (11.1)	12 (22.6)	0.43
History of CAD, (%)	1 (11.1)	17 (32.1)	0.20
History of CHF, (%)	5 (55.5)	13 (24.5)	0.058
Cardiac arrest, (%)	3 (33.3)	24 (45.3)	0.50
CPR, (%)	2 (22.2)	20 (40.0)	0.31
ECMO duration (Days)	7 (6, 12)	5 (3, 7)	0.034
Median admit EF (%)	10 (10, 10)	25 (10, 60)	0.008
Initial creatinine,	1.74 (1.23, 2.38)	1.11 (0.92, 1.50)	0.040
In-hospital death, (%)	2 (22.2)	24 (46.2)	0.18

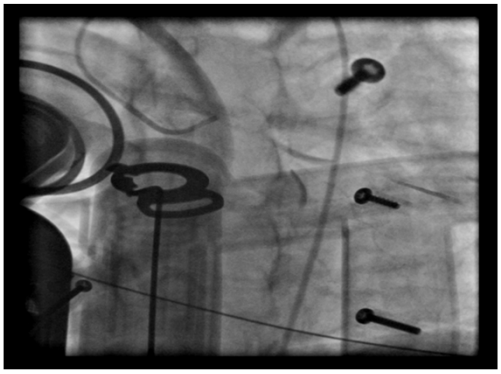
- Prior hx of CHF
- Longer ECMO support
- Lower initial EF
- Worse renal function

No difference in in-hospital survival

Outcomes – ECMO & QOL

Case 1

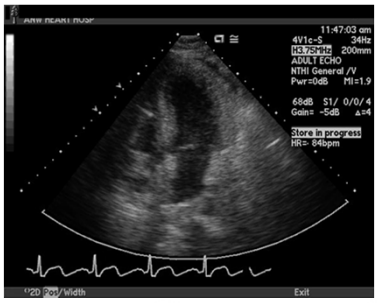
- 50 years old female, no PMH, started to feel dizzy, while teaching karate class
- 911 called, anterior and lateral ST elevation, in ambulance progressive hypotension, clammy, cardiac arrest while pulling into ambulance bay of ANW
- Manual CPR started, then LUCAS initiated
- Cath lab → coronary angiogram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



Case 1

- Dissection of LCx into LM and LAD
- Unsuccessful PCI
- Not a surgical candidate
- Decision about ECMO placement with on-going CPR with LUCAS and adequate MAPs

Case 1 – initial 2 D ECHO



Case 1 – hospital course

- Shock liver, acute renal failure requiring CVVH-D
- ARDS
- Rhabdo – bilateral fasciotomies
- Day 2 – CT head demonstrated bilateral cerebellar infarcts
- Multiple family and multi-disciplinary meetings…

Case 1 – hospital course

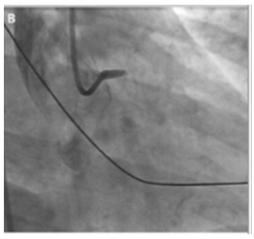
- Sedation weaned to off and patient starts following simple and…complex commands
- EF still less than 10%
- Decision to move with permanent LVAD
- Resolution of pulmonary edema
- Return of renal function to normal
- Transmetatarsal amputation R foot
- Rehab, back to work, driving!

A year later…status post heart transplantation – doing well!

Case 2

- 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 2 – coronary angiogram



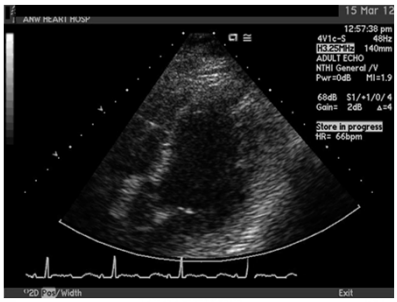
Case 2

- Despite successful PCI with DES to LM persistent cardiogenic shock requiring multiple pressors and inotropes
- Rising lactate levels
- 2D echo…

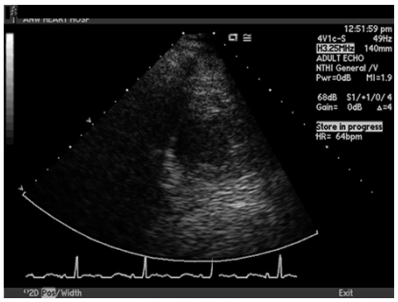
Slide 57

1 Kasia, 1/18/2015

Case 2 – initial ECHO

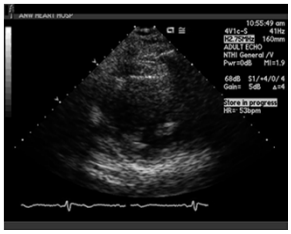


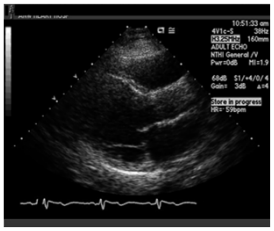
Case 2 – initial ECHO



ECMO

Case 2 – ECHO 5 days later





Case 2 – f/u

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

Conclusions

When in doubt… call us! We are available 24/7

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ADVANCED HEART FAILURE
CARDIAC TRANSPLANTATION
MECHANICAL CIRCULATORY SUPPORT
PULMONARY HYPERTENSION

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