MHIF FEATURED STUDY:

WARRIOR - Women's Ischemia Trial

OPEN AND ENROLLING:

EPIC message: ***Research MHIF Patient Referral***

CONDITION:	**PI:**	**RESEARCH CONTACT:**	**SPONSOR:**
Non-Obstructive CAD in Women	Retu Saxena, MD	Steph Ebnet Stephanie.ebnet@allina.com | 612-863-6286	University of FL Funded by the Department of Defense

DESCRIPTION:

The purpose of WARRIOR (Women's Ischemia Trial to Reduce Events in Non-Obstructive CAD) is to evaluate if intensive medical therapy (IMT) (**potent statin plus ACE-I or ARB**) is better than usual care in women who have s/s of suspected ischemia but no obstructive CAD (defined as <50 stenosis). The hypothesis is that IMT will reduce MACE 20% vs. usual care.

CRITERIA LIST/ QUALIFICATIONS:

Inclusion

- Signs and symptoms of suspected ischemia prompting referral for further evaluation by coronary angiography or coronary CT angiogram within previous 3 years
- Non-obstructive CAD defined as 0-50% diameter reduction of a major epicardial vessel

Exclusion

- Hx NIHCM
- ACS within 30 days
- LVEF< 40% NYHA HF class III-IV
- Prior intolerance to ACE/ARB
- ESRD on dialysis
- Severe valvular disease requiring TVAR within 3 years
- Stroke within 180 days

HOPE DISCOVERED HERE™

Minneapolis Heart Institute Foundation®
Creating a world without heart and vascular disease

Are you a woman who within the last five years has had chest pain severe enough to be evaluated by either:

- **A CT scan of your heart**
- **A cardiac catheterization**

And the finding indicated no significant coronary artery blockages?

WARRIOR

WARRIOR
Women's Ischemia Trial to Reduce Events in Non-Obstructive CAD

Women who experience chest pain and other signs of ischemia who are evaluated and found to have no significant blockages in their coronary arteries are often released from cardiac care, labeled normal, but continue to have symptoms.

WARRIOR is a clinical trial designed to determine how to best treat women with chest pain and no significant coronary artery disease.

PI:
Retu Saxena, MD

RESEARCH CONTACT:
Steph Ebnet, RN
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VA-ECMO and ECPR in Adults

Michael Hart, MD
General Cardiovascular Fellow
Minneapolis Heart Institute at Abbott Northwestern Hospital
Hennepin County Medical Center
Minneapolis, MN

March 16, 2020

https://www.google.com/url?sa=i&url=http%3A%2F%2Fkramersapartment.com%2Fkramer%2Fwhich-character-appears-the-most-in-kramers-apartment%2Fattachment%2Fthe-hot-tub-1-jean-paul%2F&psig=AOvVaw2TsHhFzWmCaXg7DP_8Hg1a&ust=1584140297056000&source=images&cd=vfe&ved=0CAIQjRxqGAoTCKCcyNiElugCFQAAAAAdAAAAABCEAQ

https://mail.google.com/mail/?tab=im1

Disclosures

- I have no conflicts of interest to disclose

Objectives

- Understand the basics of VA-ECMO, including its history of use in adults
- Review the hemodynamics of cardiogenic shock and VA-ECMO
- Identify the common objectives, indications and contraindications to VA-ECMO use and ECPR
- Highlight MHI's approach to ECPR management and experience in its use

Case Presentation

50 y.o. Female, 911 called

- **HPI**:
  - Dizziness, LH, brief LOC at the end of class
  - Reported chest tightness to bystander
  - On EMS arrival, confused and diaphoretic
- **PMHx/SocHx/FHx/Meds**: Unknown

Case Presentation

VS: HR 76 BP 132/68 SaO2 96% on RA

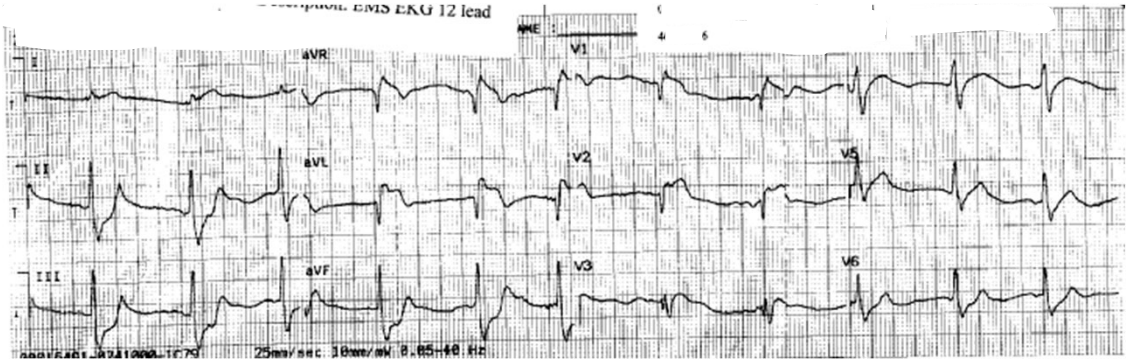
Gen: Diaphoretic, clammy

CV: Normal

Lungs: CTAB

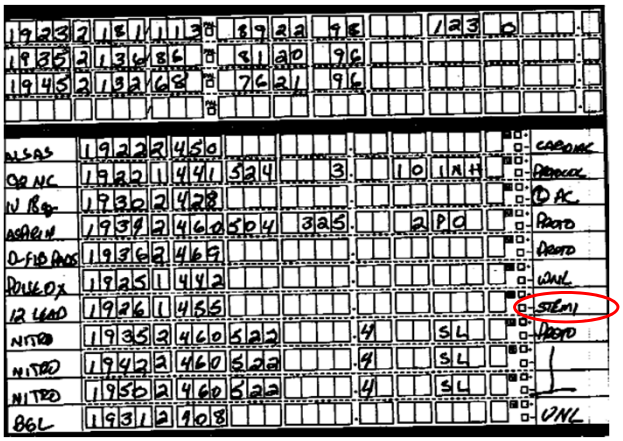
Neuro: Confused, unable to answer questions appropriately

Case Presentation

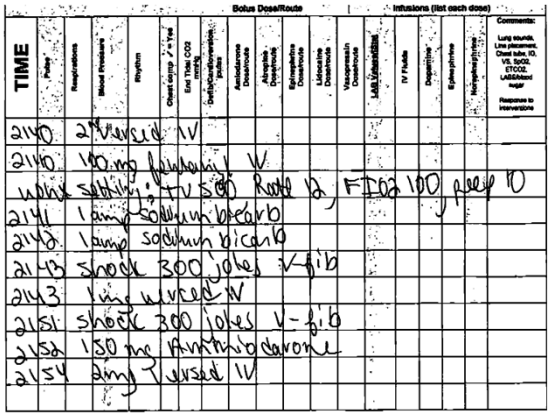


Case Presentation

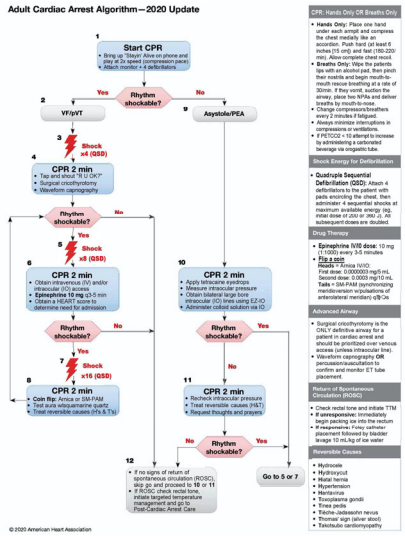
- Given ASA and nitrotab x3
- Transported to MHI
  - Bradycardia → loss of pulses
  - Manual CPR initiated



Case Presentation



UNABLE TO achieve ROSC



https://www.ahajournals.org/doi/pdf/10.1161/CIR.0000000000000613

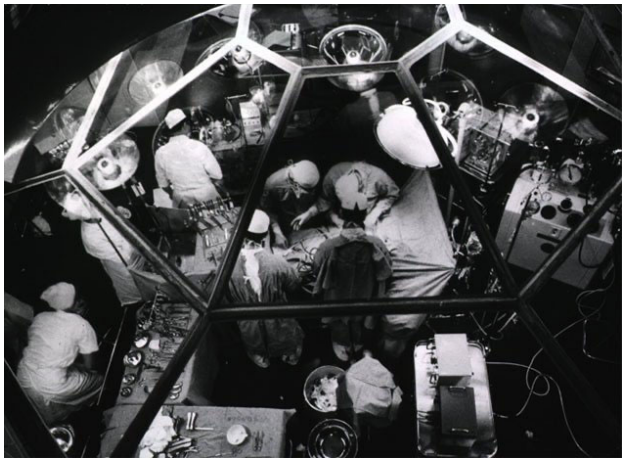
Case Presentation

https://e-watchman.com/where-do-i-go-from-here2013818where-do-i-go-from-herewhere-do-i-go-from-here/

History of VA-ECMO

Cardiac surgery

- Slow growth in the 1940s
- Heart-lung machine critical
- Poor results in the 1950s



Stoney, W. Circulation. 2009;119:2844–2853
https://www.pbs.org/wgbh/nova/article/pioneers-heart-surgery/

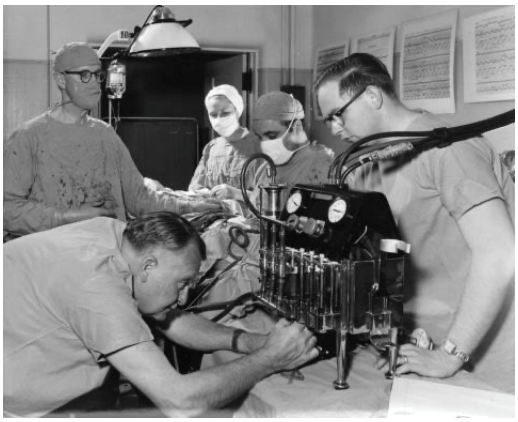
History of VA-ECMO

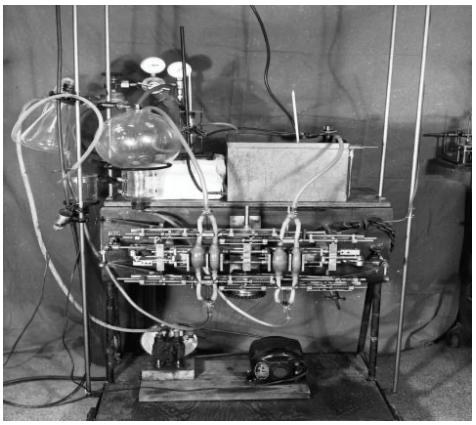
Reasons for Failure

- Multiple parties, limited collaboration
- Complex cardiac surgery still in its infancy
- No institutional review boards until ~1970s
- Sickest patients were referred
- No reliable cardiopulmonary bypass apparatus

Stoney, W. Circulation. 2009;119:2844–2853

History of VA-ECMO





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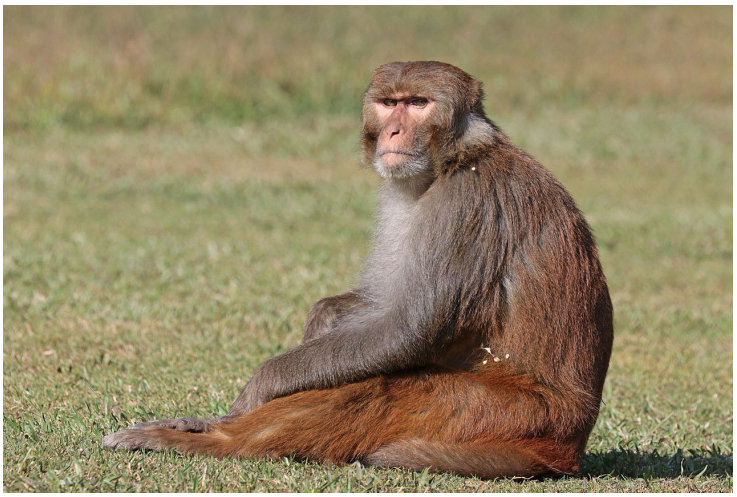
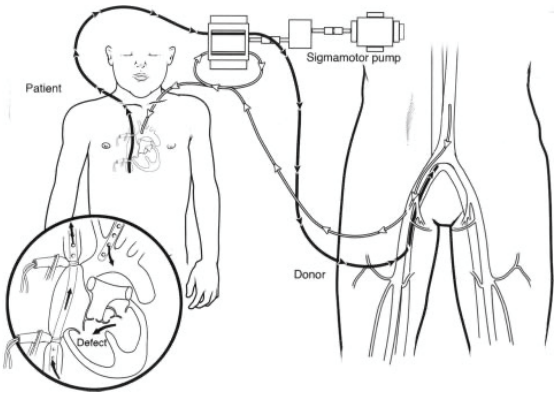
History of VA-ECMO



By Charles J Sharp - Own work, from Sharp Photography, sharpphotography.co.uk, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=84763869

History of VA-ECMO



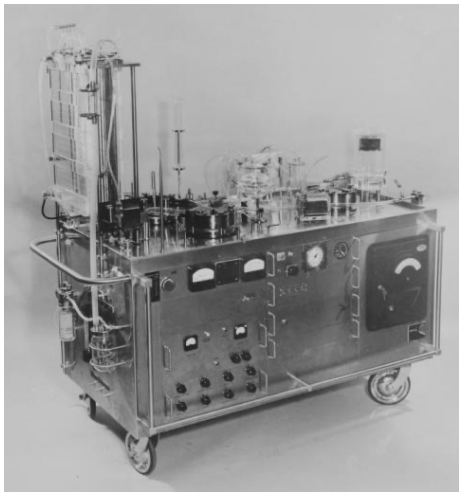
Stoney, W. Circulation. 2009;119:2844–2853

History of VA-ECMO

"I was terribly envious and yet I was terribly admiring at the same moment, and that admiration increased when a short time later a few of my colleagues and I visited Minneapolis and observed a succession of open-heart operations." – Dr. John Kirklin, Mayo Clinic

Stoney, W. Circulation. 2009;119:2844–2853

History of VA-ECMO

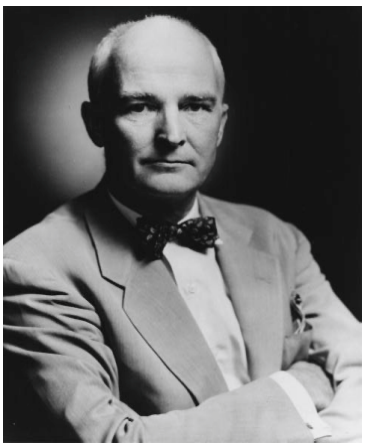


Stoney, W. Circulation. 2009;119:2844–2853

History of VA-ECMO

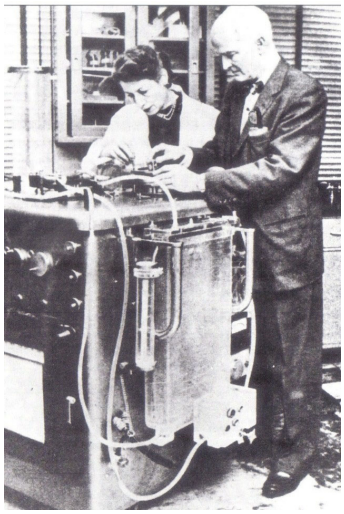
Dr. John Gibbon

- Graduated from Jefferson Medical College 1927
- Research assistant at MGH 1930
- Asked to see patient s/p CCY with suspected PE
  - Plan for pulmonary embolectomy
  - q15min vitals overnight
  - ↑ venous distension, cyanosis, ↓ BP
  - OR in AM, did not survive

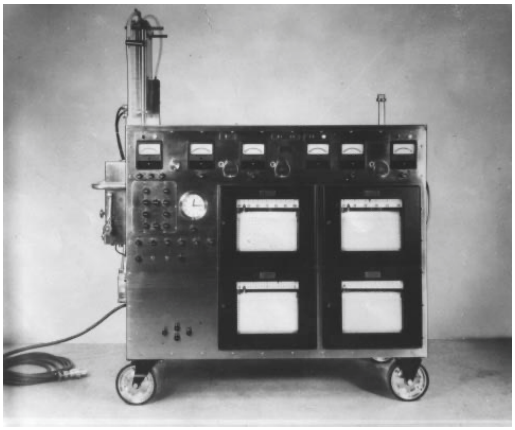


Stoney, W. Circulation. 2009;119:2844–2853

History of VA-ECMO



https://www.dotmed.com/news/story/19389/

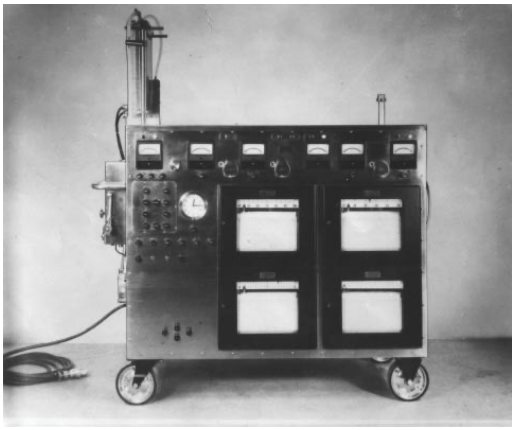


Stoney, W. Circulation. 2009;119:2844–2853

History of VA-ECMO

Gibbon-IBM Heart-Lung Machine

- Stainless steel
- Weighed >2000lbs
- Oxygenator:
  - 6 enclosed steel screens
  - Blood flow down the sides, exposed to O2
  - 100% saturation
  - Flow up to 5L/min

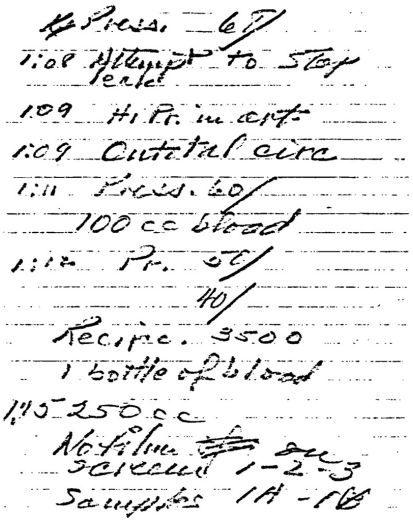


Stoney, W. Circulation. 2009;119:2844–2853

History of VA-ECMO

May 6, 1953

- 18 y.o. F w/ Rt-sided HF
- ASD closure
- Partial bypass time: 45 minutes
- Total bypass time: 26 minutes
- Complications



Kurusz, M. ASAIO Journal: 2012; 58(1) p2-5.

History of VA-ECMO

"After we finally got ready, it was ridiculously easy." – Dr. John Gibbon to Dr. Clarence Dennis

Kurusz, M. ASAIO Journal: 2012; 58(1) p2-5.
https://jdc.jefferson.edu/gibbonsocietypics/2/

History of VA-ECMO

Courtesy of Elso.org
Bonnachi, M. et al. IJS. 2016; 33(B) 213-217

History of VA-ECMO

PROLONGED EXTRACORPOREAL OXYGENATION FOR ACUTE POST-TRAUMATIC RESPIRATORY FAILURE (SHOCK-LUNG SYNDROME)

Use of the Bramson Membrane Lung

J. Donald Hill, M.D., Thomas G. O'Brien, M.D., James J. Murray, M.D., Leon Dontigny, M.D., M. L. Bramson, A.C.G.I., J. J. Osborn, M.D., and F. Gerbode, M.D.

Abstract A 24-year-old man sustained subadventitial transection of the thoracic aorta and multiple orthopedic injuries resulting from blunt trauma. The aortic injury was repaired. Because respiratory failure occurred four days later and worsened despite maximal conventional supportive therapy, partial venoarterial perfusion with peripheral cannulation, with use of the Bramson-membrane heart-lung machine, was initiated and continued for 75 hours. At a by-pass flow of 3.0 to 3.6 liters per minute, oxygen tension increased from 38 to 75 mm of mercury, inspired oxygen concentration was reduced from 100 to 60 per cent, and peak airway pressure decreased from 60 to 35 cm of water. The shock-lung syndrome was reversed, and the patient recovered.

End-stage shock lung may be reversible if the patient receives adequate gas exchange through partial extracorporeal circulation with an appropriate membrane lung.

Hill, J. et al. NEJM 1972; 286; p629-634.

History of VA-ECMO

Dr. Robert Bartlett

- University of Michigan Medical School 1927
- University of California at Irvine 1970
- Prolonged extracorporeal circulation
  - Membrane oxygenator
  - Cannula
  - Heparin titration protocol based on ACT
  - Servo-regulated pumps
- Returned to University of Michigan 1980
- Helped form ELSO 1989

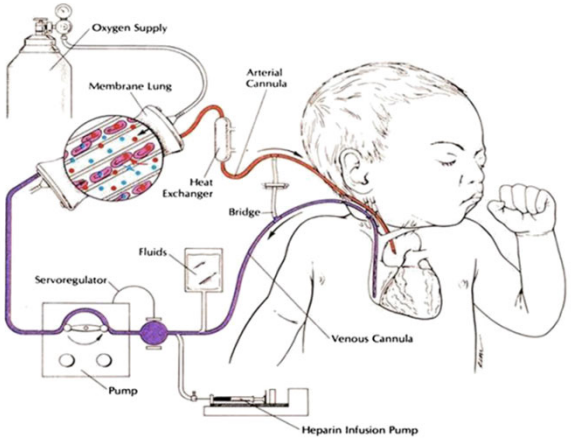
Bartlett, R. JACS. 2014; 218(3), p317-323.

https://www.uofmhealth.org/news/archive/201503/experience-saves-lives-study-advanced-life-support-reveals

History of VA-ECMO

Esperanza

- 1975
- ARDS
- Recovered after 1wk of ECMO
- First successful newborn supported



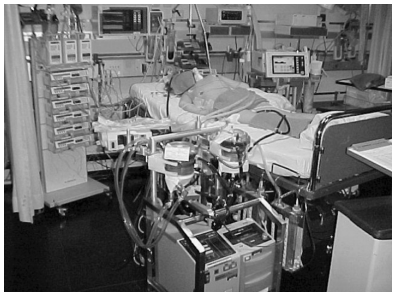
Bartlett, R. JACS. 2014; 218(3), p317-323.

History of VA-ECMO

Bartlett, R. JACS. 2014; 218(3), p317-323.

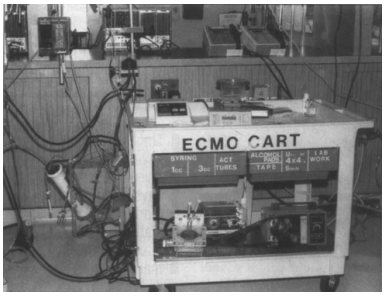
https://en.wikipedia.org/w/index.php?curid=15444658

History of VA-ECMO



https://www.google.com/url?sa=i&url=http%3A%2F%2Fwww.annalsthoracicsurgery.org%2Farticle%2FS0003-4975(03)01816-2%2Fpdf&psig=AOvVaw3IZfOpACns4pQggC78kCk8&ust=1579719363686000&source=images&cd=vfe&ved=0CA0QjhxqFwoTCOCMw6-vlecCFQAAAAAdAAAAABBU

https://www.cambridge.org/core/books/cardiopulmonary-bypass/extracorporeal-membrane-oxygenation/71FE7DBD05634E7BBE4BD797931F595F



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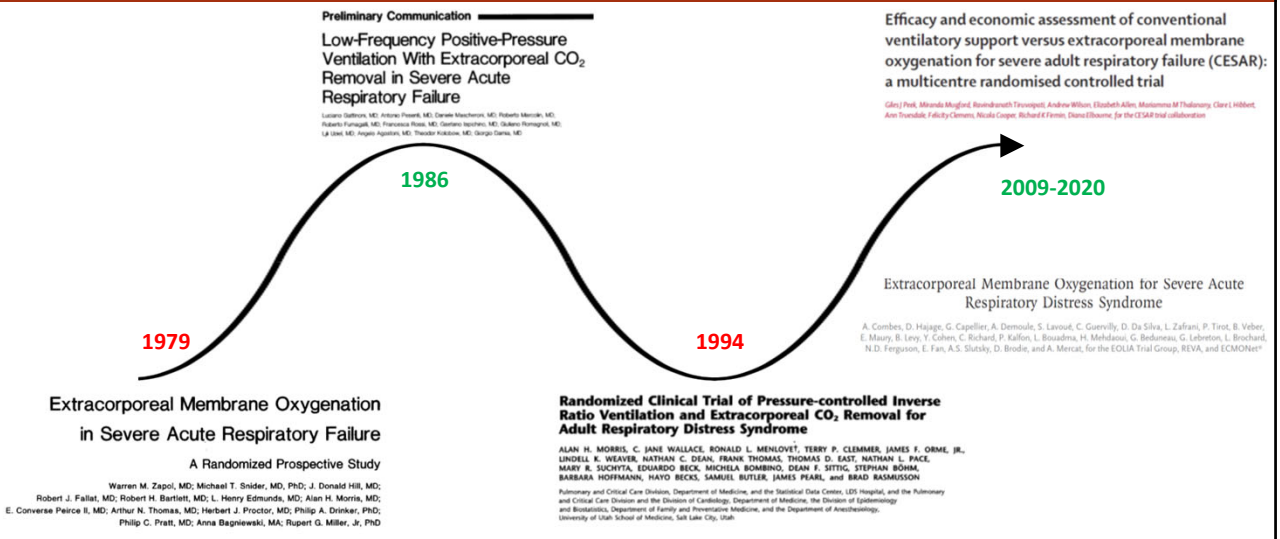
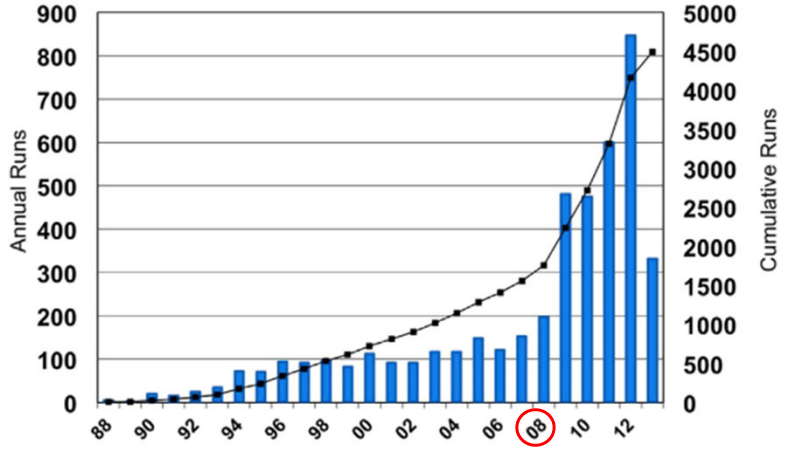
History of VA-ECMO



History of VA-ECMO

Adult ECMO cases for Respiratory Failure, ELSO Registry July 2013

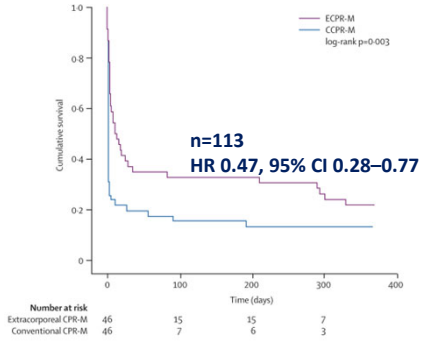


Bartlett, R. JACS. 2014; 218(3), p317-323.

History of VA-ECMO

Cardiopulmonary resuscitation with assisted extracorporeal life-support versus conventional cardiopulmonary resuscitation in adults with in-hospital cardiac arrest: an observational study and propensity analysis

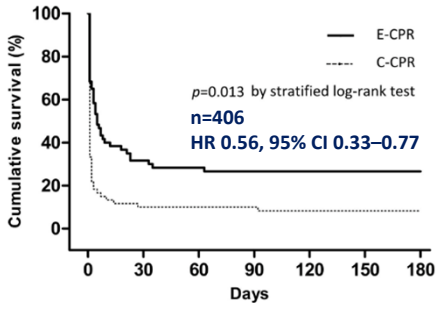
Yih-Sharng Chen*, Jou-Wei Lin*, Hsi-Yu Yu, Wen-Je Ko, Jih-Shuin Jerng, Wei-Tien Chang, Wen-Jone Chen, Shu-Chien Huang, Nai-Hsin Chi, Chih-Hsien Wang, Li-Chin Chen, Pi-Ru Tsai, Sheoi-Shen Wang, Juey-Jen Hwang, Fang-Yue Lin



Chen, Y. et al. Lancet 2008; 372: 554-61.

Extracorporeal cardiopulmonary resuscitation in patients with inhospital cardiac arrest: A comparison with conventional cardiopulmonary resuscitation*

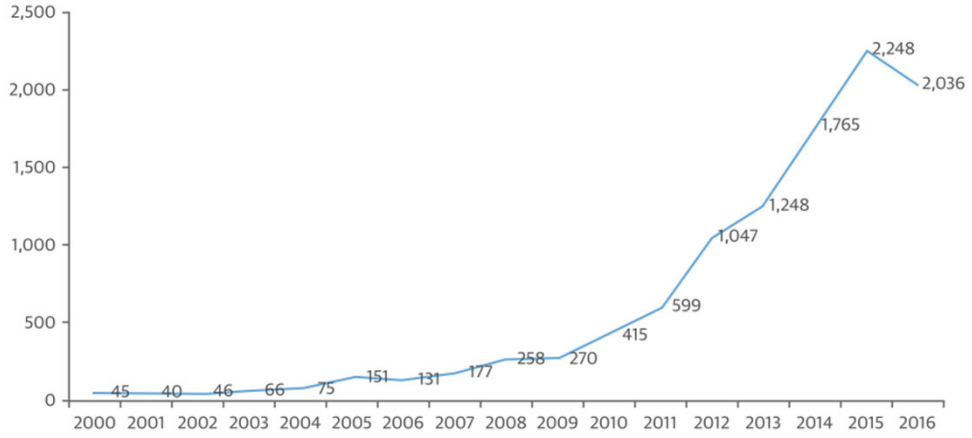
Tae Gun Shin, MD; Jin-Ho Choi, MD, PhD; Ik Joon Jo, MD, PhD; Min Seob Sim, MD; Hyoung Gon Song, MD, PhD; Yeon Kwon Jeong, MD, PhD; Yong-Bien Song, MD, PhD; Joo-Yong Hahn, MD, PhD; Seung Hyuk Choi, MD, PhD; Hyeon-Cheol Gwon, MD, PhD; Eun-Seok Jeon, MD, PhD; Kiick Sung, MD, PhD; Wook Sung Kim, MD, PhD; Young Tak Lee, MD, PhD



Shin, T. et al. Crit Care Med. 2011; 39(1), 1-7.

History of VA-ECMO

Growth of Adult Cardiac Extracorporeal Membrane Oxygenation Runs



Adapted from: Guglin, M. et al. J Am Coll Cardiol. 2019;73(6):698–716.

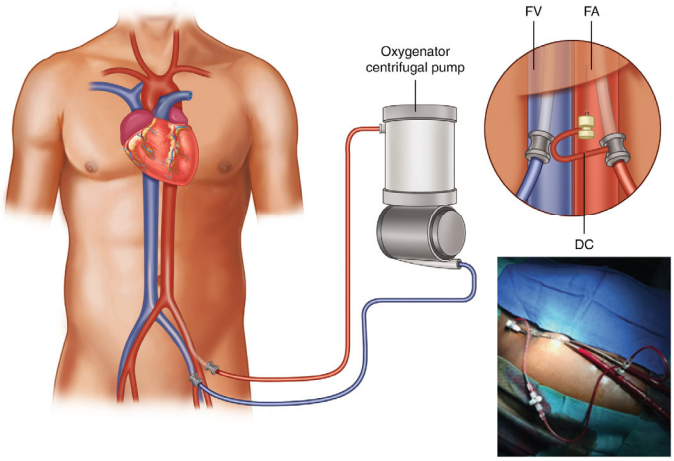
The Basics of VA-ECMO

- Availability of durable membranes and portable circuits
- Ease of implantation
- Increasing familiarity with the technology and its utility
- Provides full circulatory and oxygenation support
- Bridge to transplant or mechanical support

The Basics of VA-ECMO

https://www.jems.com/2017/12/01/how-physicians-perform-prehospital-ecmo-on-the-streets-of-paris/

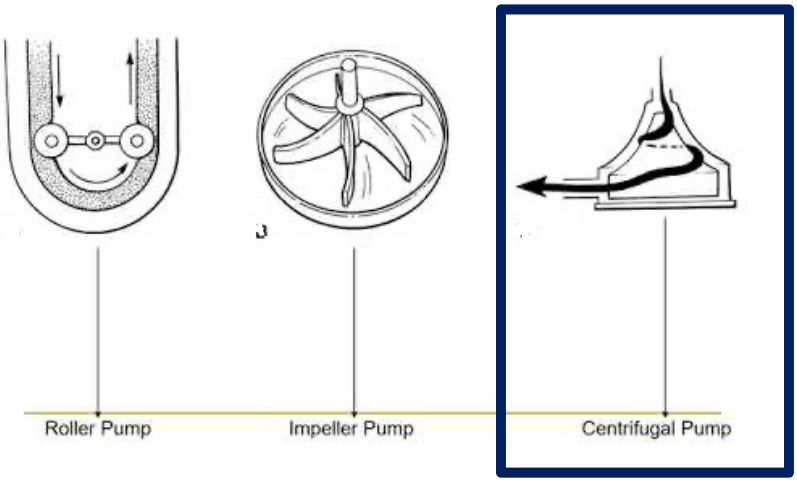
The Basics of VA-ECMO



Grande et al. Operative Tech and Recent Adv in Acute Care and Emerg Surgery. 2019, pp 759-766.

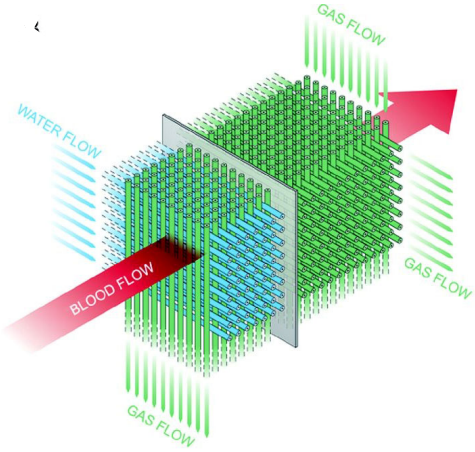
https://www.getinge.com/uk/product-catalog/cardiohelp-system/

The Basics of VA-ECMO



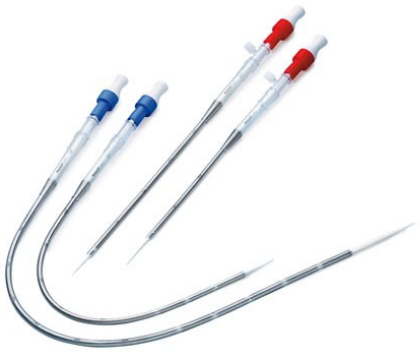
https://cardiacperfusionlearner.blogspot.com/2018/03/heart-lung-machine-pump.html

The Basics of VA-ECMO



Betit, P. Respiratory Care. 2018, 63 (9) 1162-1173.

The Basics of VA-ECMO



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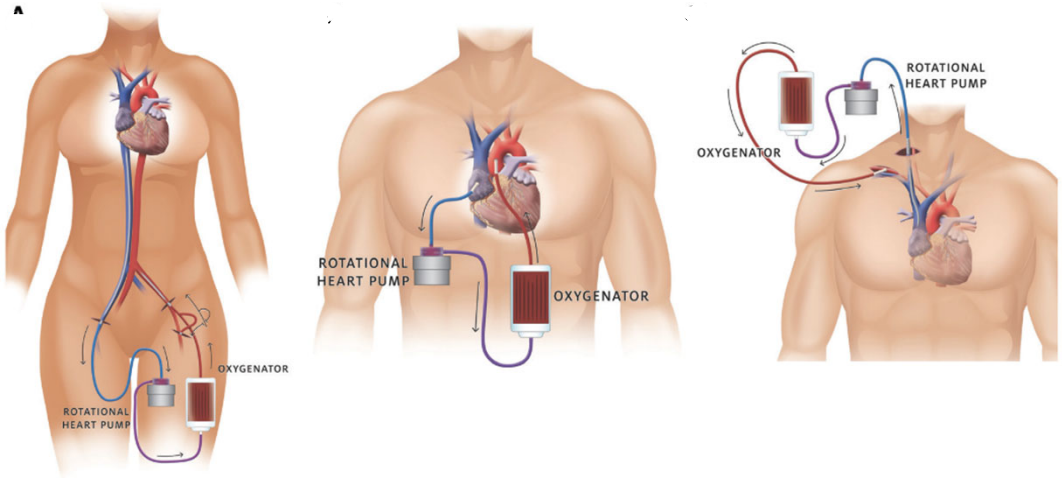
The Basics of VA-ECMO



Rao, P. et al. Circulation: HF. 2018; 11(9) e1-17.

The Basics of VA-ECMO

https://www.google.com/search?q=lamborghini&client=safari&rls=en&source=lnms&tbm=isch&sa=X&ved=2ahUKEwily-GUi5jnAhXDW80KHa96BssQ_AUoAXoECA4QAw&biw=1440&bih=837#imgrc=gKWLRI-1fXD4JM

Rao, P. et al. Circulation: HF. 2018; 11(9) e1-17.

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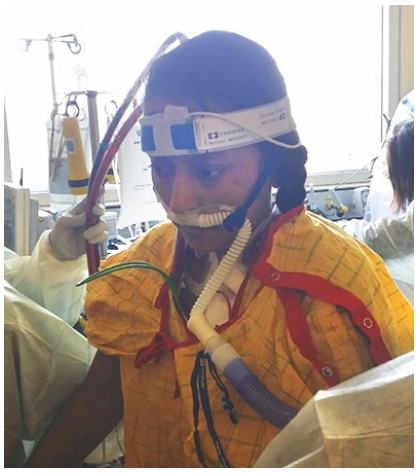
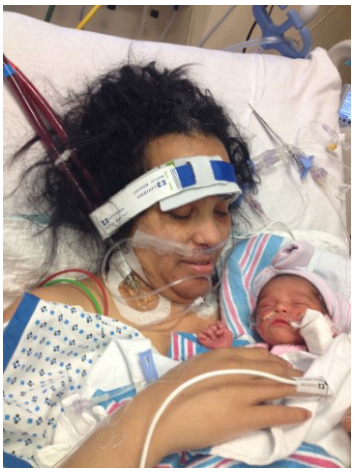


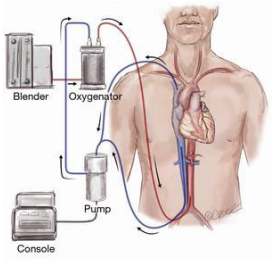


https://www.aats.org/aatsimis/SiteDownloads/MCS18/Friday%20pdf/Lung_0845%20Zwischenberger.pdf

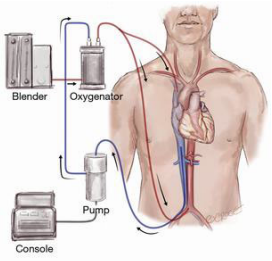
https://www.nyp.org/amazingadvances/clinical-innovations/adult-ecmo

The Basics of VA-ECMO

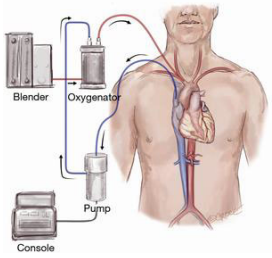
VVA



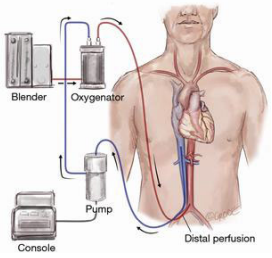
VAA



VA



VA



Camboni, D. et al.. Ann Cardiothorac Surg 2019;8(1):151-159.

Objectives

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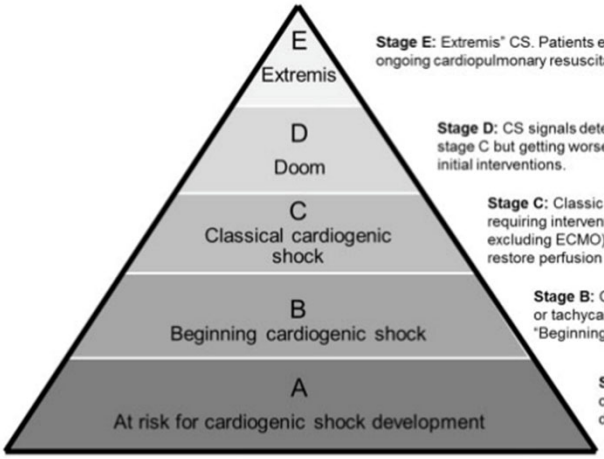
Hemodynamics of CS and VA-ECMO

Cardiogenic Shock (CS)

- Persistent hypotension
- Inadequate response to volume replacement
- Clinical features of end-organ hypoperfusion – “cold and wet”
- Hemodynamically: SBP <90 CI <2.2 PCWP >24
- ≥ 2 vasopressors or inotropes, with/without IABP

Hemodynamics of CS and VA-ECMO



Stage E: Extremis" CS. Patients experiencing cardiac arrest with ongoing cardiopulmonary resuscitation (CPR) and/or ECMO.

Stage D: CS signals deteriorating or "Doom". Similar to stage C but getting worse and failing to respond to initial interventions.

Stage C: Classic CS. Manifest CS with hypoperfusion requiring intervention (inotropes, vasopressors or MCS, excluding ECMO) beyond volume resuscitation to restore perfusion

Stage B: Clinical evidence of relative hypotension or tachycardia without hypoperfusion being at "Beginning" of CS (pre-shock).

Stage A: Currently no signs/symptoms of CS, but being "At risk" for its development.

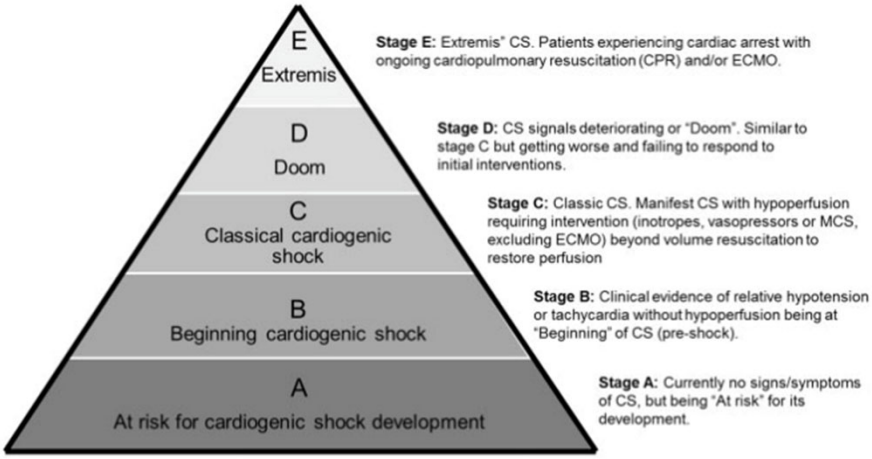
Adapted from: Szeto et al. SCAI 2015. 85(7) E175-196.

Hemodynamics of CS and VA-ECMO VA-ECMO

https://upload.wikimedia.org/wikipedia/commons/thumb/6/64/Tux_Paint_birthday_cake.svg/480px-Tux_Paint_birthday_cake.svg.png

https://www.first1000days.ie/wp-content/uploads/2013/06/food_pyramid.jpg

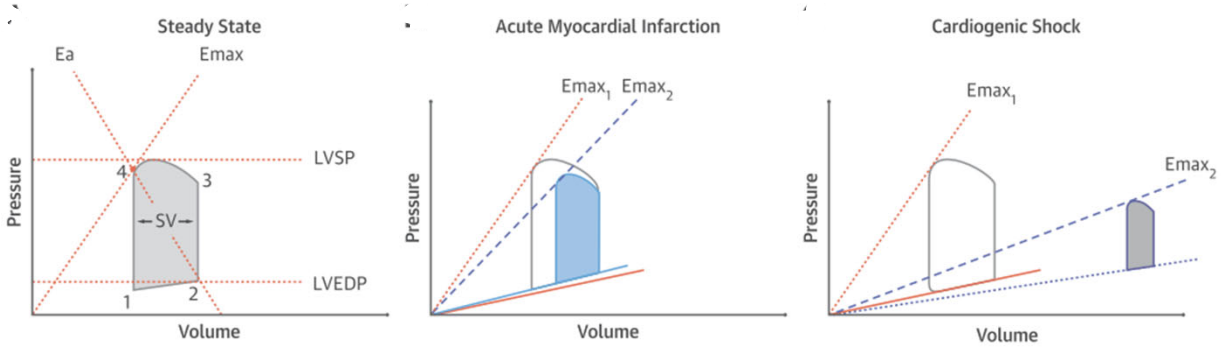
Hemodynamics of CS and VA-ECMO



Adapted from: Szeto et al. SCAI 2015. 85(7) E175-196.

Hemodynamics of CS and VA-ECMO

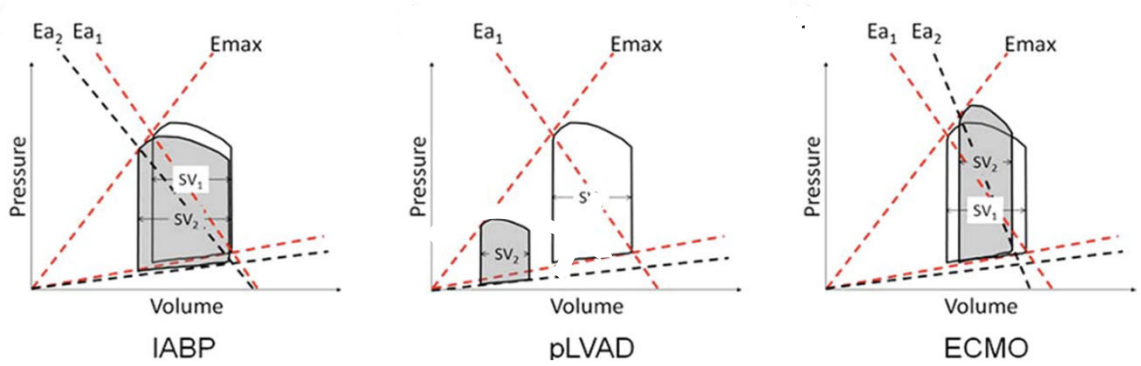
PV Loops at Steady State, with Acute MI, and Acute on Chronic Heart Failure Complicated by Cardiogenic Shock



Adapted from: Guglin, M. et al. J Am Coll Cardiol. 2019;73(6):698–716.

Hemodynamics of CS and VA-ECMO

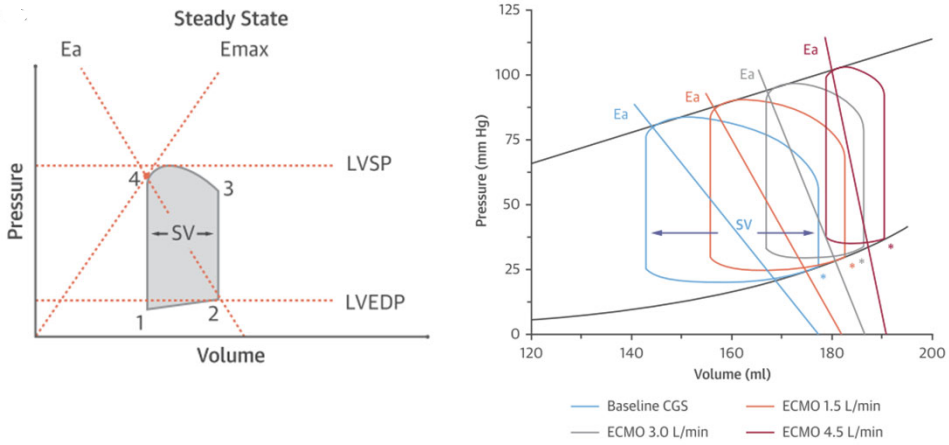
PV Loops with IABP, pLVAD, and VA-ECMO



Adapted from: Szeto et al. SCAI 2015. 85(7) E175-196.

Hemodynamics of CS and VA-ECMO

PV Loops at Steady State, with Cardiogenic Shock, and Increasing Levels of VA-ECMO Flow

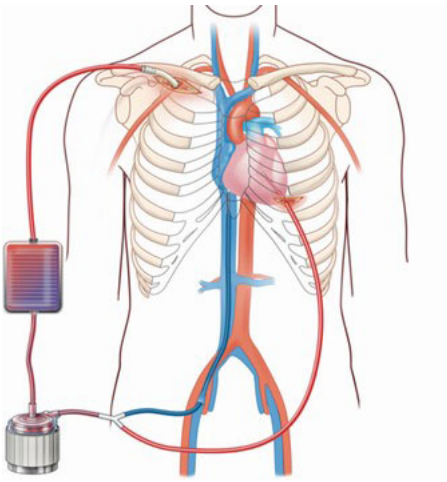


Adapted from: Guglin, M. et al. J Am Coll Cardiol. 2019;73(6):698–716.

Hemodynamics of CS and VA-ECMO

LV Decompression Strategies

- Increase forward flow
- Decrease preload
- Decrease afterload
- ECMO titration
- Mechanical decompression



Adapted from: Cevasco, M et al. Cevasco et al. J Thorac Dis (2019); 11(4): 1676-1683.

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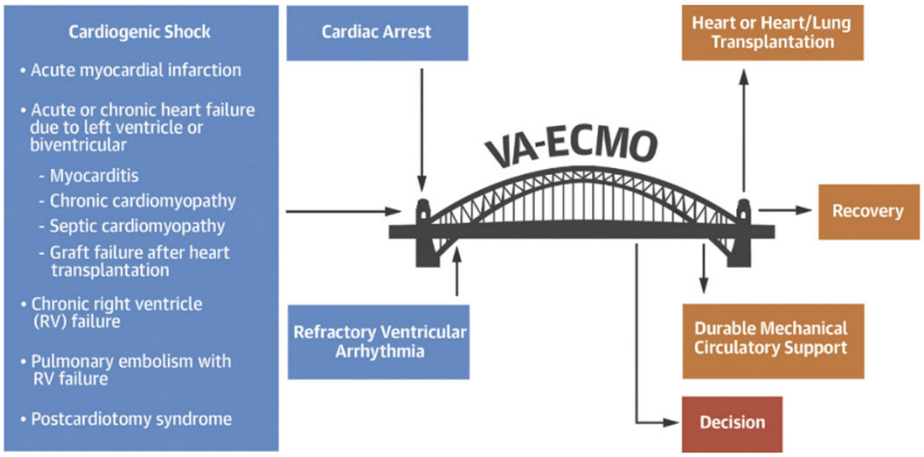
Indications & Contraindications to VA-ECMO



Adapted from: Guglin, M. et al. J Am Coll Cardiol. 2019;73(6):698–716.

Indications & Contraindications to VA-ECMO

Common Objectives for Venoarterial Extracorporeal Membrane Oxygenation Insertion

Bridge to recovery	Temporize circulatory support while definitive and supportive treatment strategies are deployed to restore myocardial recovery and achieve successful weaning
Bridge to decision	To determine the reversibility of end-organ damage commonly seen after a catastrophic or critical myocardial event or to decide the next level of action
Bridge to bridge	To achieve a brief stability for end-organ perfusion until more definitive pump support (durable mechanical circulatory support) or cardiac replacement therapy (heart transplant or total artificial heart) is performed
Bridge to transplant	To achieve a brief stability for end-organ perfusion until cardiac transplantation is performed

Adapted from: Guglin, M. et al. J Am Coll Cardiol. 2019;73(6):698–716.

Indications & Contraindications to VA-ECMO

Indications

- Cardiac arrest (ECPR)
- Cardiogenic shock
- Acute MI
- Myocarditis
- Worsening CM, LV or RV failure
- Refractory ventricular dysrhythmia
- Pulmonary embolus
- Hypothermia
- Cardiotoxins
- Periprocedural support
- Failure to wean from CPB
- Graft failure or rejection s/p OHT

Indications & Contraindications to VA-ECMO

Contraindications

- End-stage organ failure or disease (ESRD, metastatic cancer, severe anoxic brain injury, etc.)
- End-stage HF without option for transplant or durable mechanical support
- Goals of care scenarios
- Contraindications to systemic anticoagulation
- Aortic dissection
- Severe peripheral vascular disease

Indications & Contraindications to VA-ECMO

Predictors of morbidity/mortality

- Older Age
- Longer support time
- High lactate concentration
- Severe peripheral vascular disease
- COPD
- CRRT while on support
- Hepatic failure

ECPR

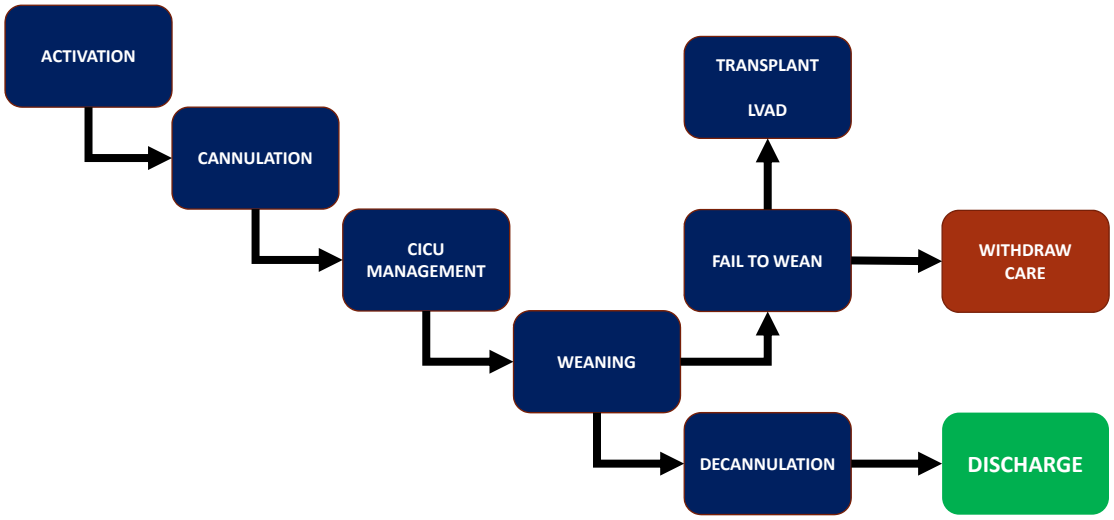
ECPR: Extracorporeal cardiopulmonary resuscitation

Refractory Arrest: Sustained cardiac arrest without return of spontaneous circulation (ROSC) despite usual AHA ACLS cares including shock if appropriate and antiarrhythmic use

No-Flow Time: Time from arrest to CPR initiation

Low-Flow Time: Time from CPR initiation to VA-ECMO cannulation

ECPR



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The MHI Experience

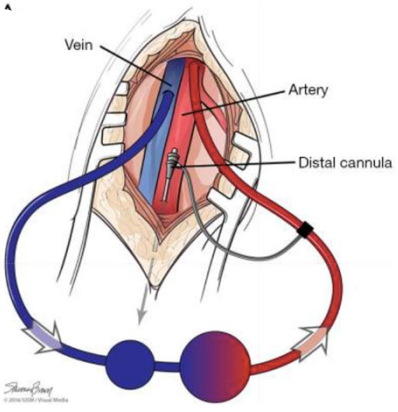
ACTIVATION

- Inclusion Criteria
  - Bystander CPR within 5 minutes of arrest
  - Age 18-75 years old
  - Transfer from scene to MHI for cannulation <30 minutes
  - Total CPR time <60minutes
- Exclusion Criteria
  - DNR/DNI order
  - Known terminal illness
- "Time is myocardium"
- Appropriate ACLS cares
  - Mechanical CPR with LUCAS
  - All patients are cooled externally
  - Initial labs drawn in preparation for cannulation

The MHI Experience

CANNULATION

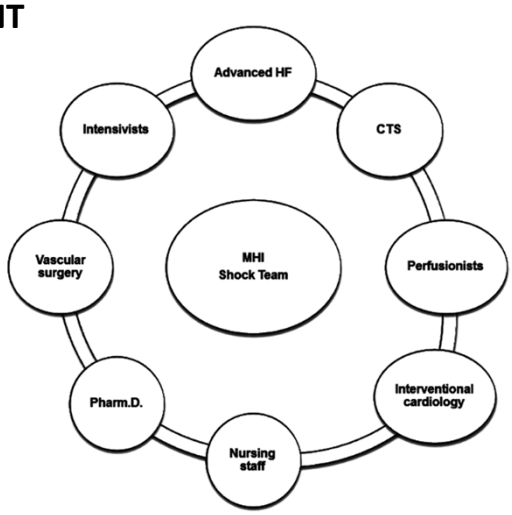
- Location: Catheterization laboratory
- Configuration: Majority bifemoral cannulation
- Ultrasound & Fluoroscopic guidance
- 21-25F Inflow cannula, 15-17F Outflow cannula
- Heparin bolus prior to initiation of flow
- Revascularization?
- Distal perfusion catheter



Adapted from: Makdisi, G. Ann Transl Med. 2017; 5(5): 103.

The MHI Experience

CICU MANAGEMENT



Adapted from: Hryniewicz, K. et al. JASAIO. 2016;62(4):397-402.

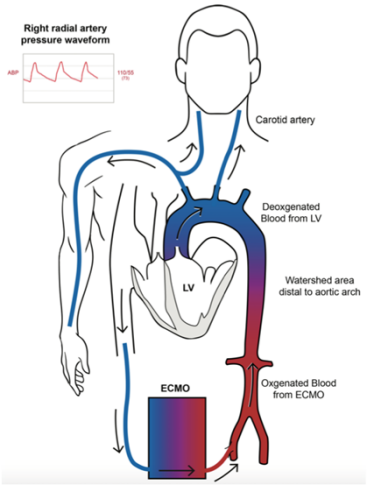
The MHI Experience

MHI SHOCK Team Roles	
Advanced HF Cardiology	- Quarterbacks the SHOCK team to provide a unified direction in care decisions - Charged with hemodynamic management throughout the day - Primary liaison between care team and family
Interventional Cardiology	- Emergent cannulation +/- percutaneous intervention in the catheterization laboratory - Implementation of ancillary devices including IABP and Impella
Intensivists	- Provides comprehensive critical care support including mechanical ventilation management
Neurology	- 24/7 continuous EEG monitoring by on-call epilepsy specialist for 48-hours post-cannulation - Early involvement of neurocritical care service for prognostication - Utilization of NIRS for cerebral oxygen monitoring
ECMO perfusionists & Nursing staff	- First-line providers with continuous bedside monitoring and cares - Serial CK level checks for compartment syndrome - Protocolized cannulation site checks throughout the day
Vascular surgery	- Immediate consultation on all ECPR patients with daily assessments of cannula sites and extremities - Employs continuous peripheral saturation monitoring - Performs decannulation in the operating room
Pharm.D	- Assistance with anticoagulation based on established PTT-based nomograms with both low and high-intensity protocols depending on perceived bleeding and thrombosis risk - Daily review of in-hospital medications for possible interactions and complications
Cardiothoracic surgery	- Determines need for left ventricular decompression with surgical or percutaneous venting - Identifies patients that are ready for explantation or may need to transition to durable mechanical support

The MHI Experience

COMPLICATIONS

- Limb Ischemia
- Vascular Complications
- Stroke
- Bleeding
- Infection
- Harlequin Syndrome



Adapted from: Rao, P. Circ: Heart Failure. 2018; 11(9): e1-17

The MHI Experience

WEANING

- Considered after 24 hours of HD stability + PP >20mmHg
- Echocardiograph and Swan-Ganz catheter guided
- Intravenous heparin of 2000-5000U if aPTT was <50
- Pump flow weaned by 0.5–1 L q5 min to 0.5 L of support or clamped
  - VS, echo for biventricular and valvular assessment performed
  - Hemodynamic data: RA, PA, PCWP, FICK CO

The MHI Experience

DECANNULATION

- Criteria:
  - Mean arterial pressure (MAP) maintained >60 mmHg
  - LVEF >20%
  - CI >2.2 L/minute/m2*
- If MAP ↓ , abort and reassess
- If ECMO dependent >5 days
  - Evaluate for LVAD
  - Evaluate for transplant

Adapted from: www.medgadget.com/2018/10/heartmate-3-heart-pump-approved-for-patients-not-eligible-for-transplant.html

The MHI Experience

Patient characteristics by location of cardiac arrest

	All Patients (n=26)	Cath Lab Arrest (n = 8)	In-Hospital Arrest (n = 11)	Out of Hospital Arrest (n = 7)	p Value
Age (years), mean ± SD	59 ± 11	64 ± 12	62 ± 8	50 ± 11	0.021
Male, (%)	17 (65)	5 (62)	7 (64)	5 (71)	1.000
White, (%)	23 (88)	7 (88)	10 (91)	6 (86)	1.000
History of CAD, (%)	10 (38)	3 (38)	5 (45)	2 (29)	0.878
History of CHF, (%)	5 (19)	2 (25)	3 (27)	0 (0)	0.457
History of DM, (%)	4 (15)	1 (12)	3 (27)	0 (0)	0.423
History of HTN, (%)	13 (50)	1 (12)	10 (91)	2 (29)	<0.001
History of Tobacco use, (%)	16 (62)	6 (75)	6 (55)	4 (57)	0.685
Prior CVA, (%)	1 (4)	1 (12)	0 (0)	0 (0)	0.577
Family History of heart disease, (%)	16 (62)	4 (50)	8 (73)	4 (57)	0.634

The MHI Experience

Clinical characteristics on presentation and during hospitalization based on survival

	All Patients (n=26)	Survived to Discharge (n=18)	In-hospital Death (n=8)	p Value
Chest pain, (%)	13 (50)	10 (56)	3 (38)	1.000
Shortness of Breath, (%)	10 (38)	6 (33)	4 (50)	0.303
Cardiac Arrest, (%)	26 (100)	18 (100)	8 (100)	---
Witnessed arrest, (%)	26 (100)	18 (100)	8 (100)	---
CPR, (%)	26 (100)	18 (100)	8 (100)	---
Initial Rhythm				
VF/VT, (%)	17 (65)	15 (83)	2 (25)	0.008
PEA/Asystole, (%)	9 (35)	3 (17)	6 (75)	
Hypothermia, (%)	13 (50)	11 (61)	2 (25)	0.202
Time from Arrest to ECMO flow (min)	51 (22, 70)	46 (21, 68)	61 (36, 71)	0.317

*continuous variables reported as median (25^{th}, 75^{th} percentile) unless otherwise noted

The MHI Experience

Revascularization characteristics of patients based on survival

	All Patients (n=26)	Survived to Discharge (n=18)	In-hospital Death (n=8)	p Value
Revascularization at the time of ECMO initiation, (%)	17 (65)	13 (72)	4 (50)	0.382
Revascularized vessel, (%)*				
LM, (%)*	3 (18)	2 (15)	1 (25)	
LAD, (%)*	2 (12)	1 (8)	1 (25)	0.400
RCA, (%)*	3 (18)	2 (15)	1 (25)	
Multivessel, (%)*	9 (53)	8 (62)	1 (25)	

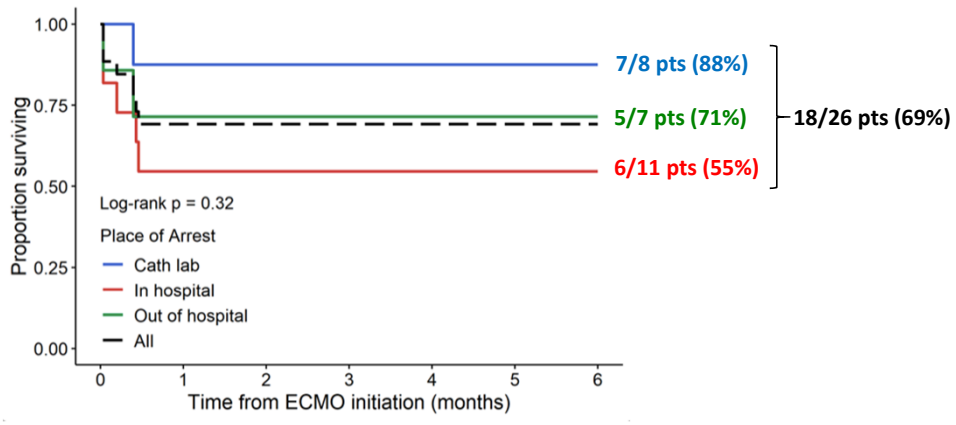
The MHI Experience

Complications and Outcomes based on survival

	All Patients (n=26)	Survived to Discharge (n=18)	In-hospital Death (n=8)	p Value
Time on ECMO (hours)	109 (69, 147)	110 (71, 175)	105 (32, 119)	0.16
ECMO to VAD, (%)	3 (12)	2 (11)	1 (12)	1.000
CRRT, (%)	9 (35)	4 (22)	5 (62)	0.08
CPC 1-2	17 (65)	16 (89)	1 (12)	0.001
>3units PRBCs in 24 hrs	18 (69)	12 (67)	6 (75)	1.000
Major vascular complications, (%)	6 (23)	4 (22)	2 (25)	1.000
Discharge Disposition				
Home, (%)	6 (23)	6 (33)	0 (0)	
Rehabilitation, (%)	7 (27)	7 (39)	0 (0)	
Long Term Care, (%)	5 (19)	5 (28)	0 (0)	NA
Expired, (%)	8 (31)	0 (0)	8 (100)	
Survival at 30 Days, (%)	18 (69)	100 (100)	0 (0)	---
Survival at 6 months, (%)	18 (69)	100 (100)	0 (0)	---

The MHI Experience

Kaplan Meier survival curves for all cardiac arrest patients by location of arrest



The MHI Experience

	Enrollment, y	VA-ECMO Cannulation	Patients, n (%)		Survival Rates			IHCA survival n (%)
			OHCA	VF/pVT	All OHCA, n (%)	CPC 1–2, n (%)	VF/pVT, n (%)	
Kagawa et al,[96] 2012	7.5	ED	42	23 (55)	7 (17)*	6 (14)*	17/46 (37)†	
Avalli et al,[100] 2012	5	ED/ICU/CCL	18	16 (89)	1 (5.5)*	1 (5.5)*	…	11/24 (46)
Haneya et al,[101] 2012	5	ED	26	12 (46.2)	4 (15)‡	27/85 (32)†	…	25 (42)
Leick et al,[104] 2013	2	CCL	28	8 (28.6)	11 (39)*	8 (28.5)*	…	
Maekawa et al,[97] 2013	4.5	ED	53	32 (60.4)	17 (32.1)‡	8 (15.1)‡	…	
Wang et al,[24] 2014	5.5	ED	31	15 (48.4)	12 (38.7)‡	8 (25.8)‡	…	
Johnson et al,[102] 2014	7	ED	15	11/26 (42)*	1 (6.6)‡	3/26 (11.5)†‡	…	
Sakamoto et al,[25] 2014	3	ED	234	234 (100)	68 (29)*§	32 (13.7)*§	68 (29)*§	
Kim et al,[99] 2014	7.5	ED	55	31 (56.4)	9 (16.4)‡	8 (14.5)‡	…	
Stub et al,[21] 2015	3	ED	11	11 (100)	5 (45)‡	5 (45)‡	5 (45)‡	9/15 (60)
Pozzi et al,[26] 2016	4	ED	68	19 (28)	6 (8.8)‡	3 (15.8)‡	6 (31.5)‡	
Lee et al,[98] 2016	4	ED	23	20 (87)	10 (43.5)*	7 (30.4)*	8 (40)*	
Fjølner et al,[105] 2017	3.5	CCL	21	9 (43)	7 (33)‡	7 (33)‡	5 (55.6)‡	
Lamhaut et al,[106] 2017	4	Field vs ED	156	81 (58)‖	21 (13.5)‡	21 (13.5)‡	21 (25.9)‡	
Schober et al,[103] 2017	10	ED	7	4/7 (57)	1 (14)¶	…	…	
Yannopoulos et al,[7] 2017	1	CCL	62	62 (100)	28 (45)‡	26 (42)‡	28 (45)‡	…
MHI	**5**	**CCL**	**7**	**4 (57)**	**5 (71)**	**5 (71)**	**4 (57)**	**6 /11 (55)**

veno-arterial extracorporeal membrane oxygenation; and VF/pVT, ventricular fibrillation/pulseless ventricular tachycardia.
*Thirty-day survival.
†Percentage includes OHCA plus in-hospital cardiac arrest.
‡Survival to hospital discharge.

Adapted from: Yannopoulos, D et al. Circulation. 2019; 139: e1-23.

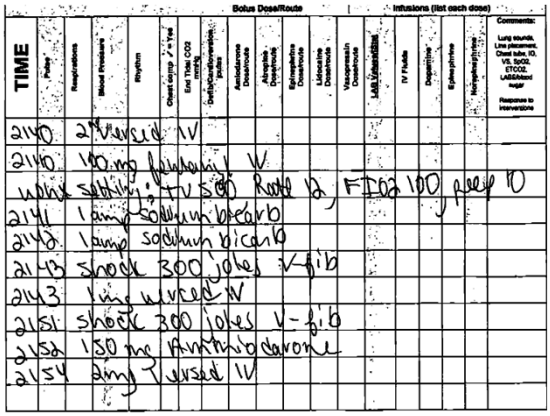
The MHI Experience

Limitations

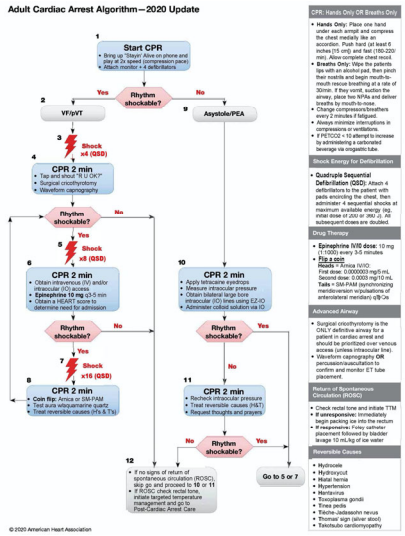
- Small sample size
- Witnessed arrest
- Immediate bystander CPR
- Large number of cath lab arrests
- Inclusion criteria

LARGER MULTICENTER RANDOMIZED TRIALS NEEDED

Case Presentation



UNABLE TO ACHIEVE ROSC



https://www.ahajournals.org/doi/pdf/10.1161/CIR.0000000000000613

Case Presentation

https://www.dictionary.com/e/wpcontent/uploads/2020/01/WisdomvsKnowledge_1000x700_jpg_OHVUvmTo.jpg

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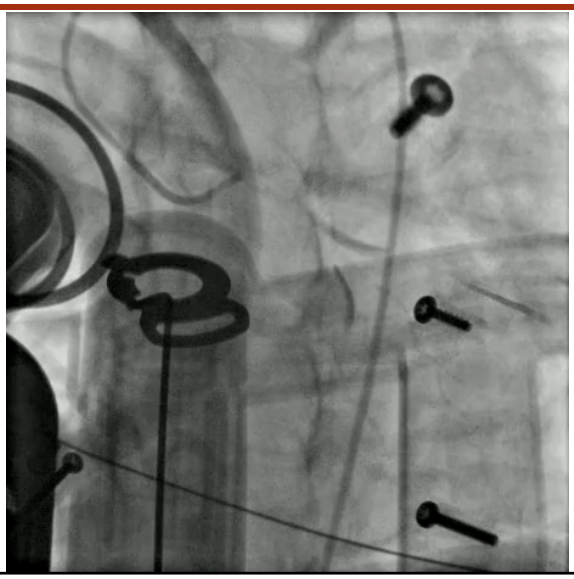

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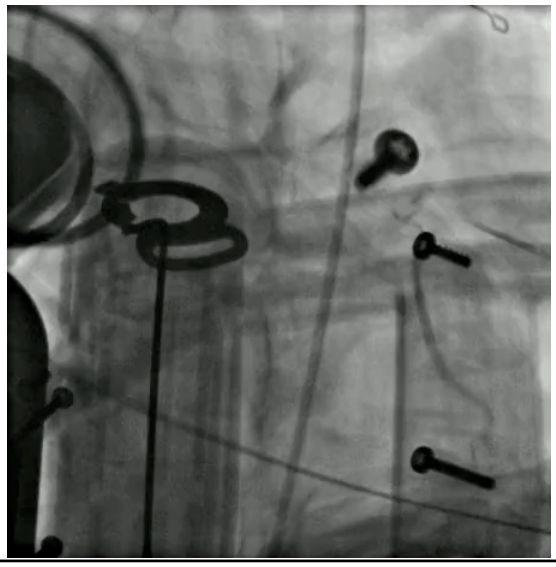

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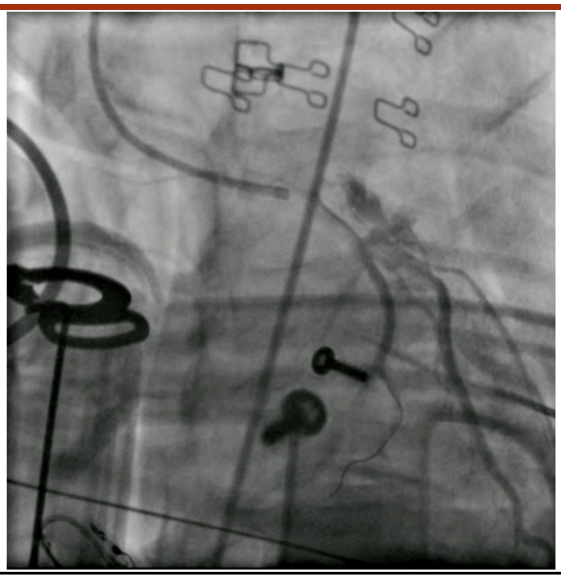

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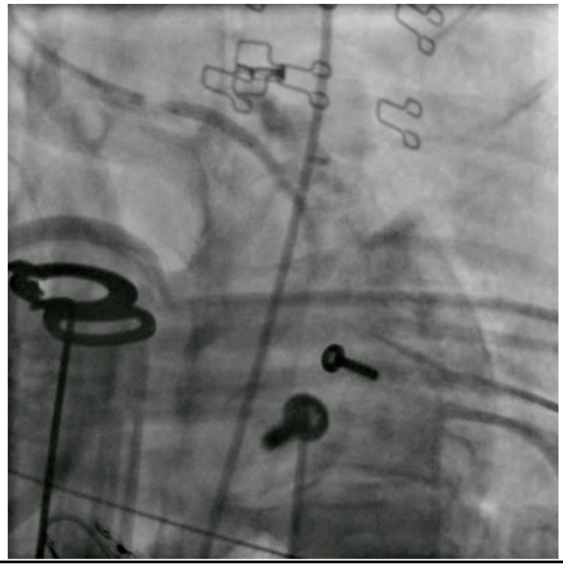

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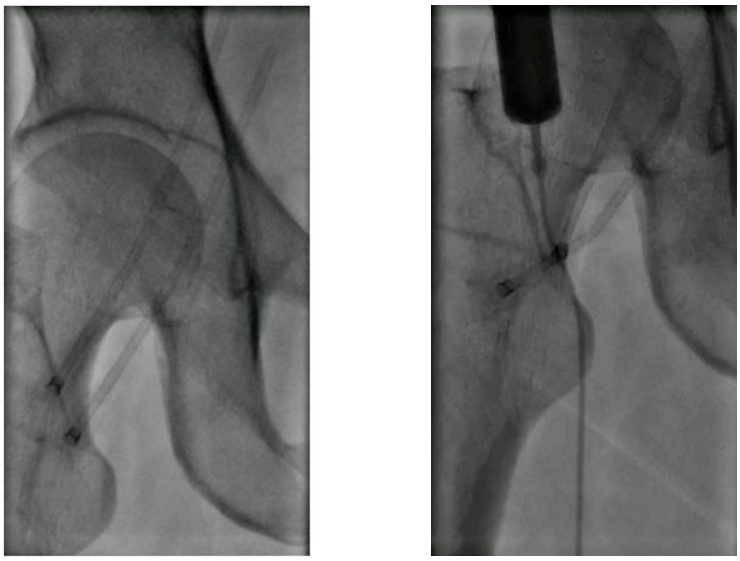
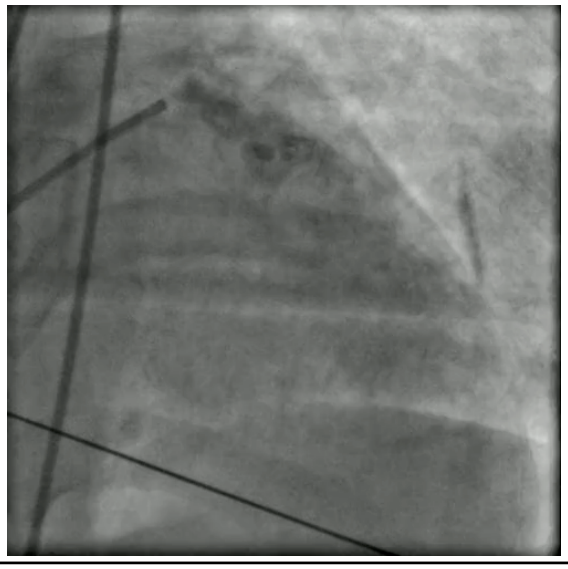


Case Presentation – DELETE???



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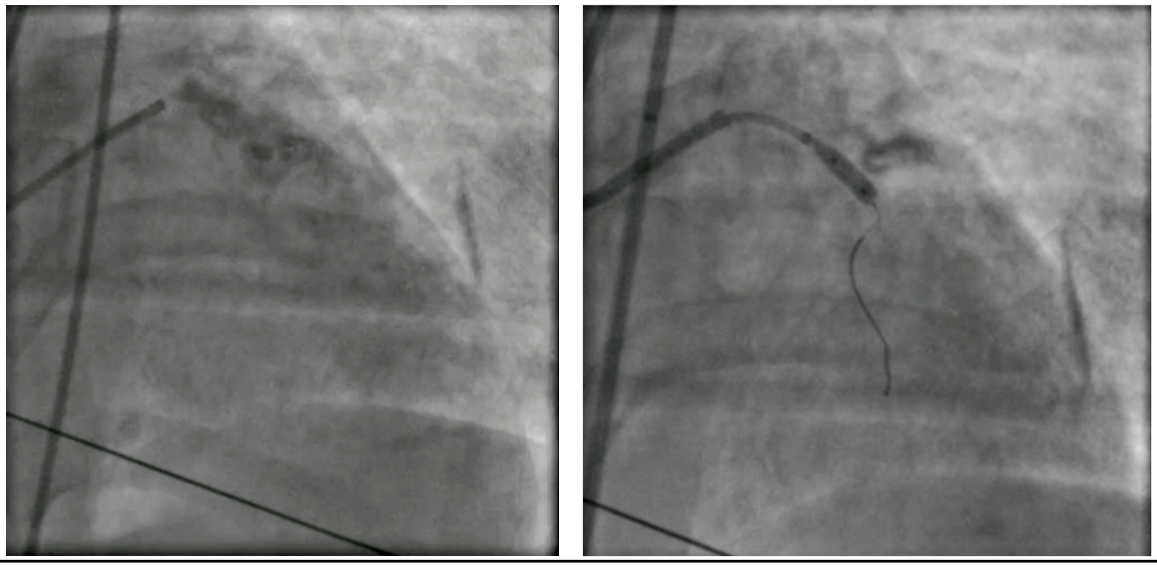
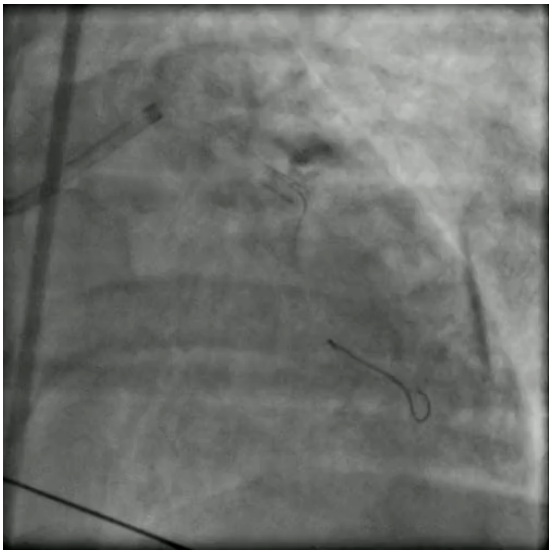
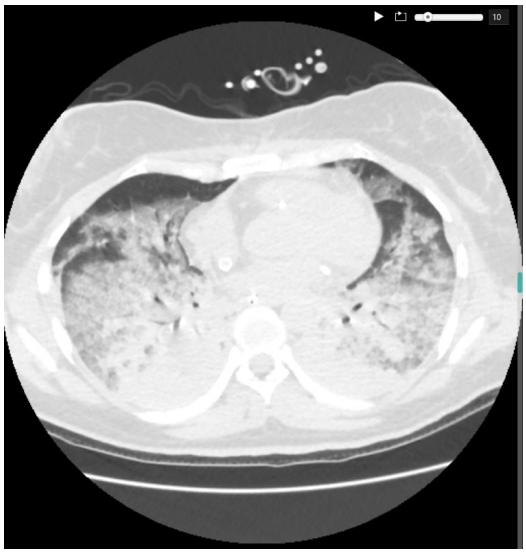


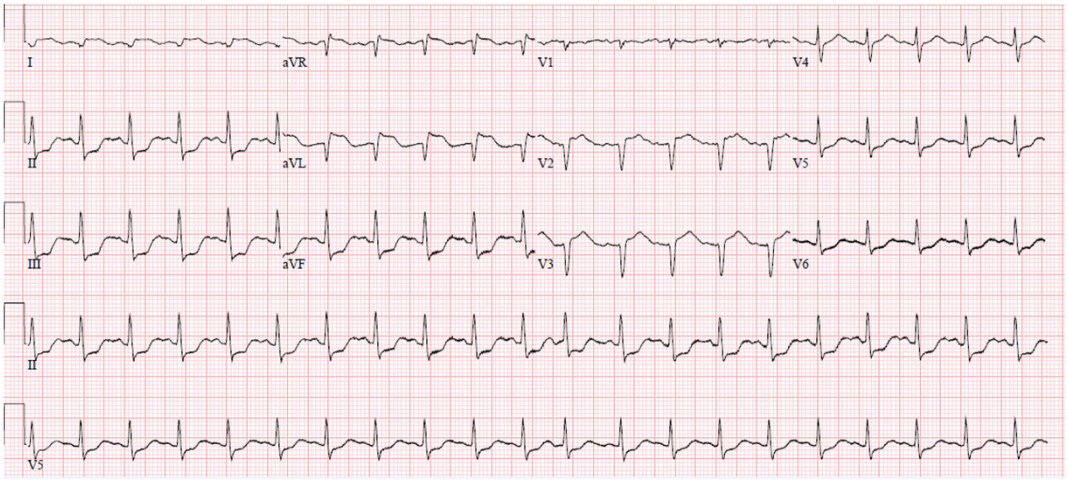
Case Presentation



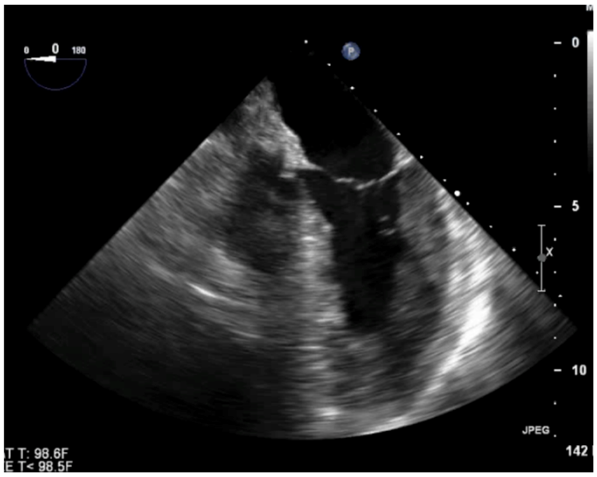
Case Presentation

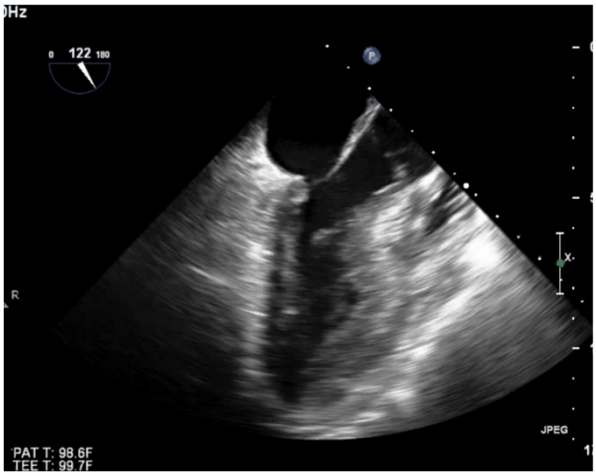


Case Presentation



Case Presentation





Case Presentation

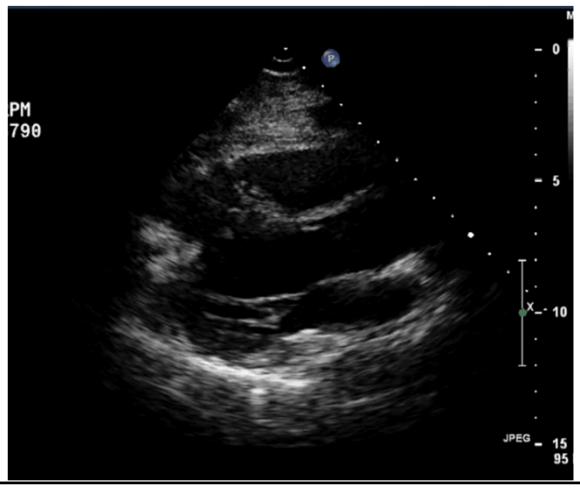
- Hospital Course
  - Peak Tpn-I 947 µg/mL
  - Non-oliguric renal failure requiring CRRT
  - ARDS
  - Shock Liver
  - DIC
  - Compartment syndrome s/p bilateral fasciotomies
  - Cerebellar stroke, unclear neuro status

Case Presentation

- Multiple family conferences with extremely guarded prognosis
  - HD #11: opening eyes, not tracking
  - HD #13: squeezed hand with lightened sedation
  - HD #15: reliably following commands
- Extensive discussion with family on merits of LVAD

Case Presentation

- HD #31 underwent decannulation and HeartMate II LVAD placement



Case Presentation

- Hospital Course
  - HD #11: opening eyes, not tracking
  - HD #13: squeezed hand with lightened sedation
  - HD #15: reliably following commands
  - HD #31: underwent decannulation and HeartMate II LVAD placement
  - Underwent tracheostomy, Rt foot TMA

UNDISCHARGEABLE #1

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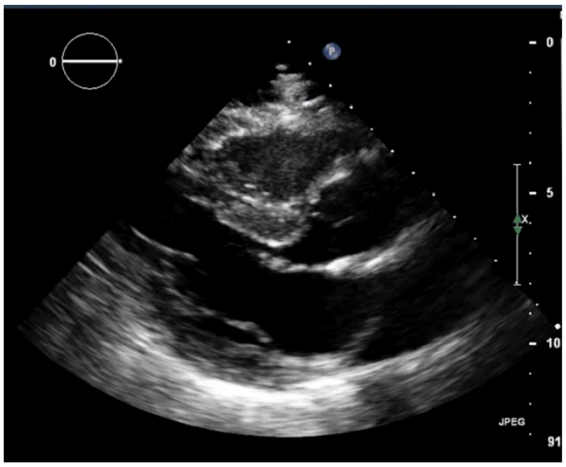
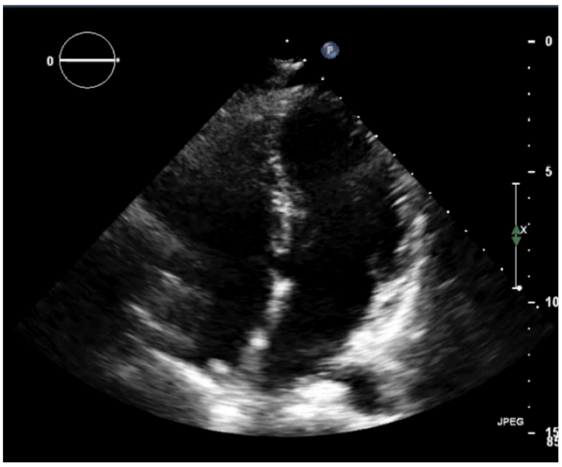
https://www.uwwce.org/whats-new

Case Presentation

- 6/2015 underwent OHT





Conclusion

- Understand the basics of VA-ECMO, including its history of use in adults
- Review the hemodynamics of cardiogenic shock and VA-ECMO
- Identify the common objectives, indications and contraindications to VA-ECMO use and ECPR
- Highlight MHI's approach to ECPR management and experience in its use

Thank you!

Hennepin Healthcare

Minneapolis Heart Institute Foundation
Creating a world without heart and vascular disease

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