Innovative ECMO Configurations in Adults

Practice at a Single Center with Platinum Level ELSO Award for Excellence in Life Support

32nd Annual BACCN Conference
4th & 5th September 2017, Park Plaza Riverbank, London
Building Interprofessional Teams to Enhance Safer Critical Care

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Disclosure

- No conflicts of interest
- Nothing to disclose

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Objectives

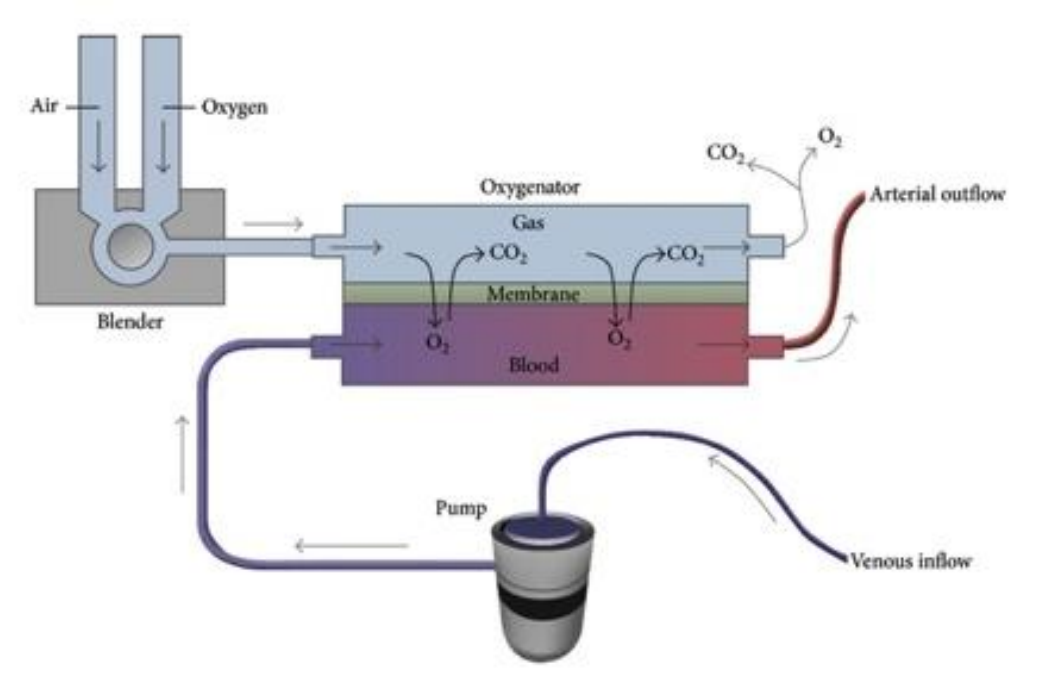
- Define ECMO, including international application and outcomes
- Describe innovative ECMO Configurations at CUIMC: Data collection, Analysis and Results
- Define VA ECMO
- Discuss the “ECMO System” and the “Central Sports Model”
- Detail importance of the “ECMO System” and the “Central Sports Model” in the world of ECMO Therapy

What is Extracorporeal Membrane Oxygenation (ECMO)

ECMO is defined as the use of a modified cardiopulmonary bypass (CPB) circuit for temporary life support for patients with potentially reversible cardiac and/or respiratory failure. ECMO provides a mechanism for gas exchange as well as cardiac support thereby allowing for recovery from existing lung and/or cardiac disease (ELSO, 2014).

- Bridge to rescue, recovery, transplantation, destination, decision and bridge to bridge
- ECMO *does not fix the underlying problem, it provides support*

Physiology of ECMO



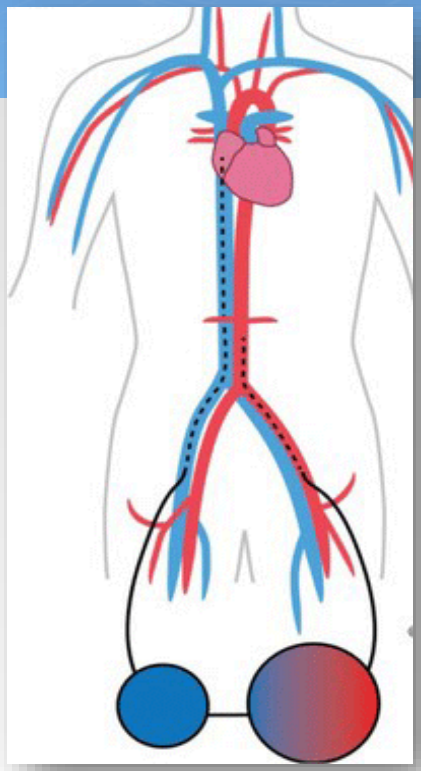
Bacchetta & Brodie, NEJM; 2011

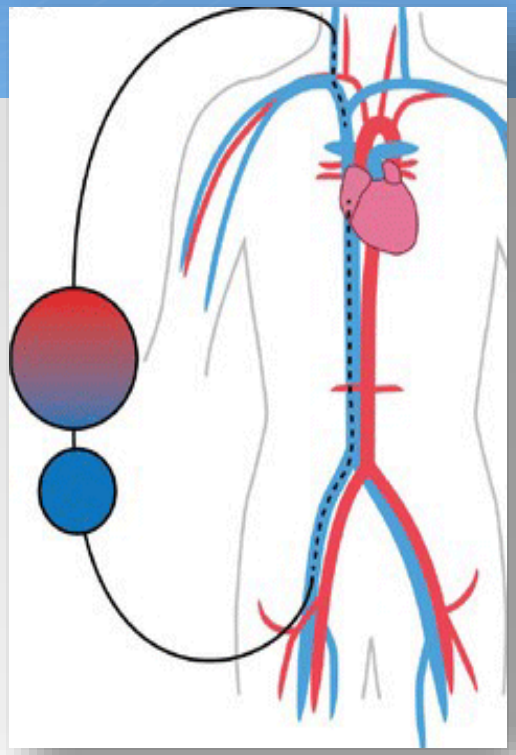
Basic Modes of ECMO

VA ECMO

Vein-ECMO-artery

Used in cardiac or cardiopulmonary failure





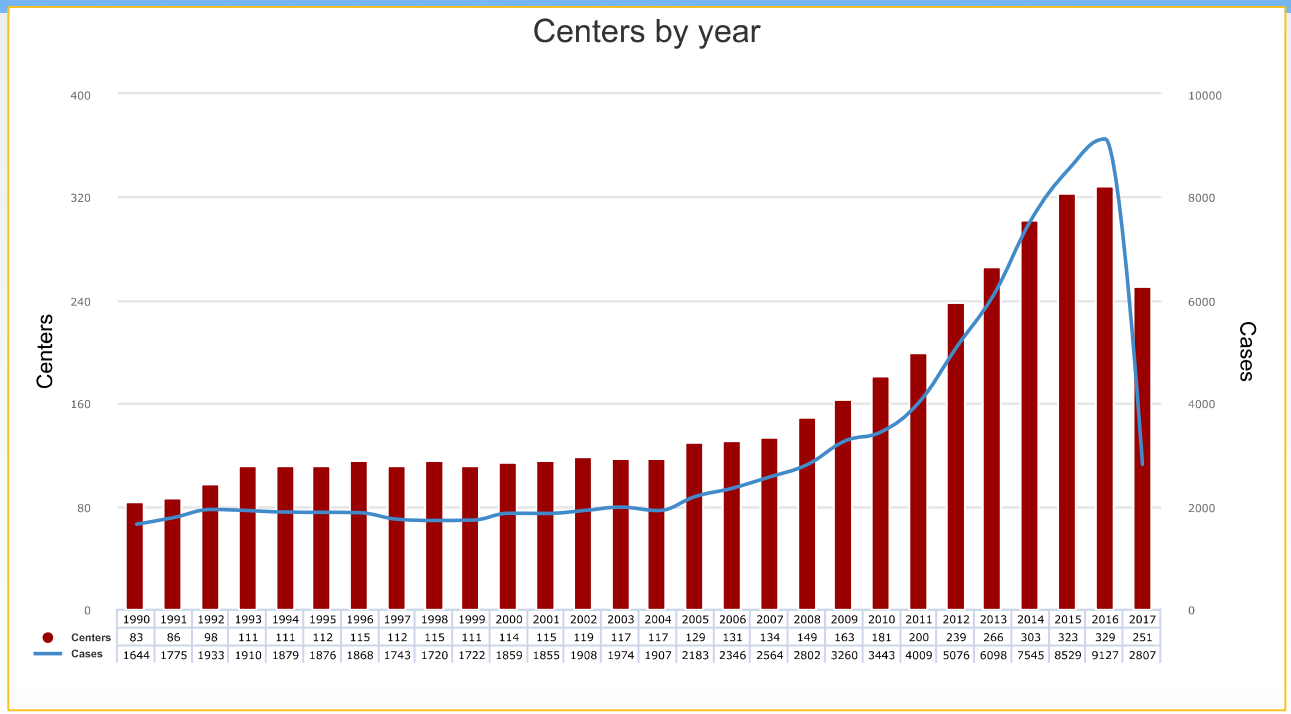
VV ECMO

Vein-ECMO-vein

Used in pulmonary failure

Weinzerl Visual Media, Indiana University 2015

International Application of ECMO



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Centers	83	86	98	111	111	112	115	112	115	111	114	115	119	117	117	129	131	134	149	163	181	200	239	266	303	323	329	251
Cases	1644	1775	1933	1910	1879	1876	1868	1743	1720	1722	1859	1855	1908	1974	1907	2183	2346	2564	2802	3260	3443	4009	5076	6098	7545	8529	9127	2807

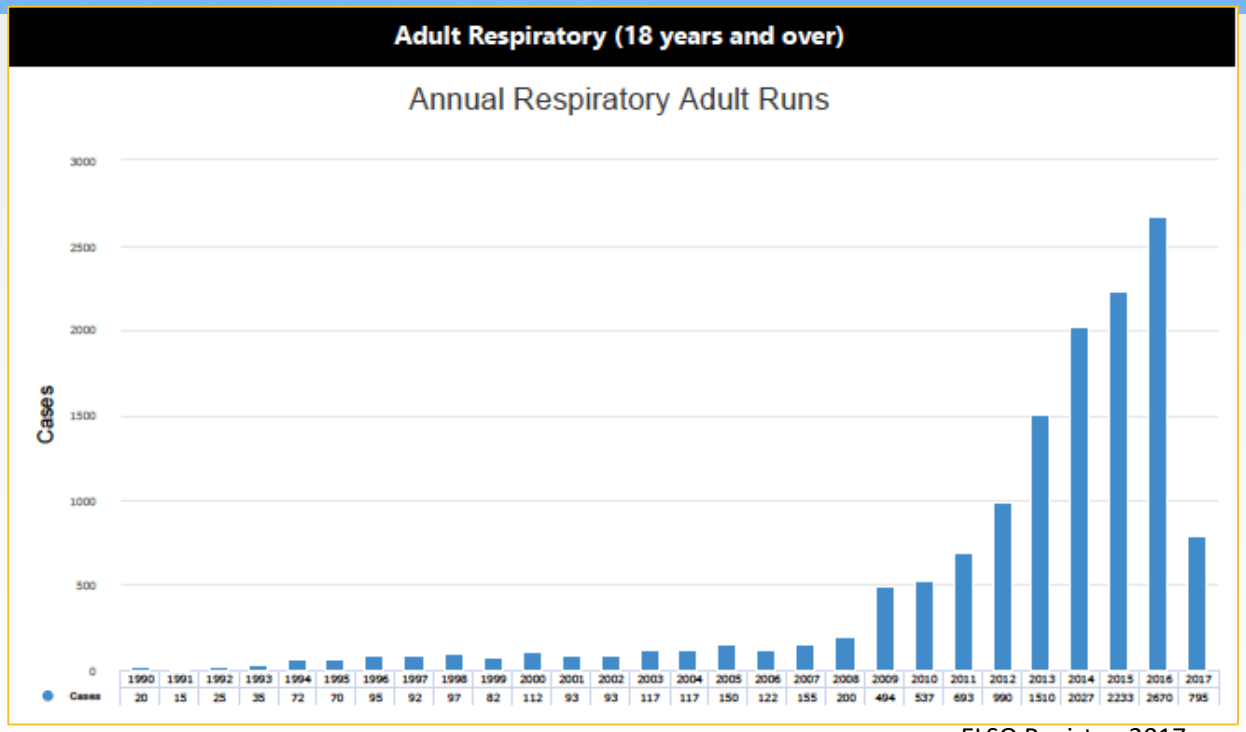
ELSO Registry, 2017

International Application of ECMO

Overall Outcomes					
	Total Runs	Survived ECLS		Survived to DC or Transfer	
Neonatal					
Pulmonary	26,719	22,394	83%	19,252	72%
Cardiac	7,266	4,727	65%	2,987	41%
ECPR	1,613	1,089	67%	666	41%
Pediatric					
Pulmonary	8,287	5,608	67%	4,812	58%
Cardiac	9,593	6,620	69%	4,941	51%
ECPR	3,615	2,078	57%	1,508	41%
Adult					
Pulmonary	13,712	9,174	66%	8,040	58%
Cardiac	12,566	7,181	57%	5,222	41%
ECPR	3,995	1,572	39%	1,144	28%
Total	87,366	60,443	69%	48,572	55%

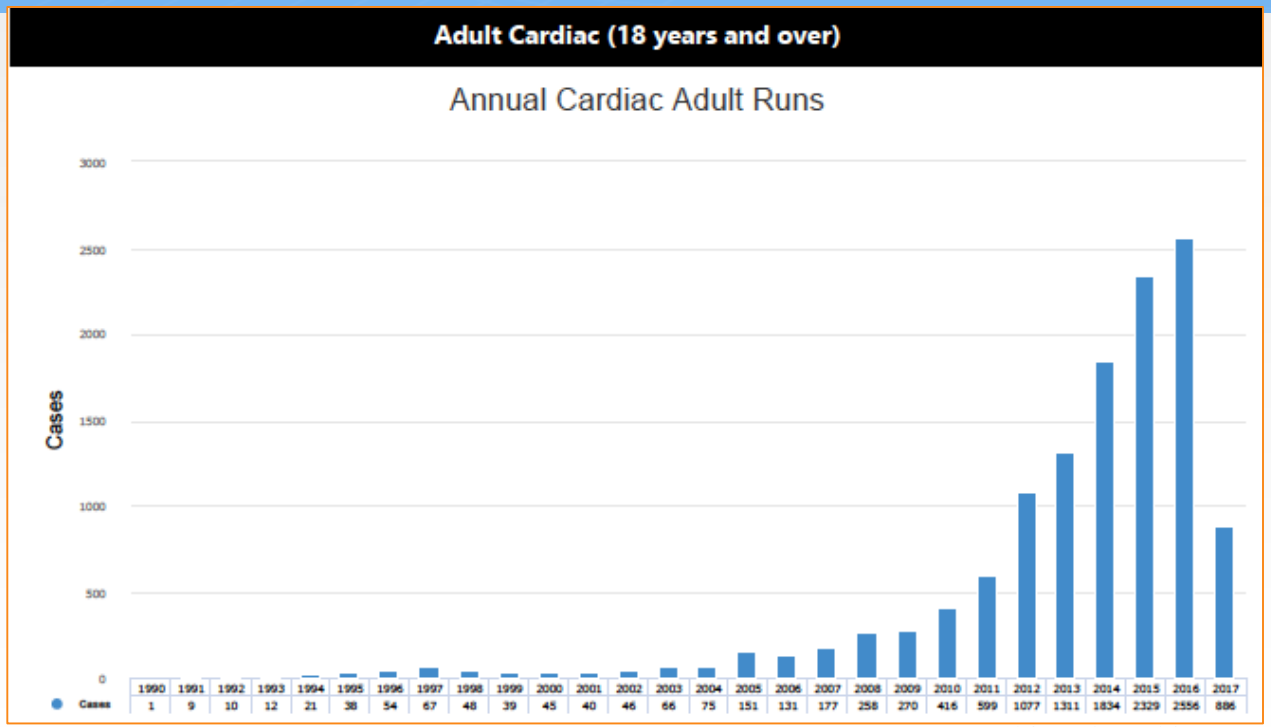
ELSO Registry, 2017

International Application of ECMO



ELSO Registry, 2017

International Application of ECMO



ELSO Registry, 2017

Adult ECMO over Time

The first successful Adult ECMO 1971

Courtesy of Dr. B. Bartlett, UM

Walking Adult ECMO at CUIMC 2012

Courtesy of Early Mobilization Team, CUIMC

ECMO at NewYork-Presbyterian/Columbia University Irving Medical Center

NewYork-Presbyterian/Columbia and NewYork-Presbyterian/Morgan Stanley Children's Hospital Achieve Platinum Level Excellence in Life Support Award

Prestigious Critical Care Award Recognizes Use of Life-Saving ECMO Treatment

Sep 23, 2016

NEW YORK — The Center for Acute Respiratory Failure and Cardiac ECMO Program at NewYork-Presbyterian/Columbia University Irving Medical Center and the Pediatric ECMO Program at NewYork-Presbyterian/Morgan Stanley Children's Hospital have been designated a Platinum Level Center of Excellence for the Excellence in Life Support Award from the Extracorporeal Life Support Organization (ELSO, an international non-profit consortium dedicated to the development of novel therapies for people with organ failure). Worldwide, only five extracorporeal life support (ECLS) centers were awarded platinum status and this is the first time this status was awarded.

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NewYork Presbyterian

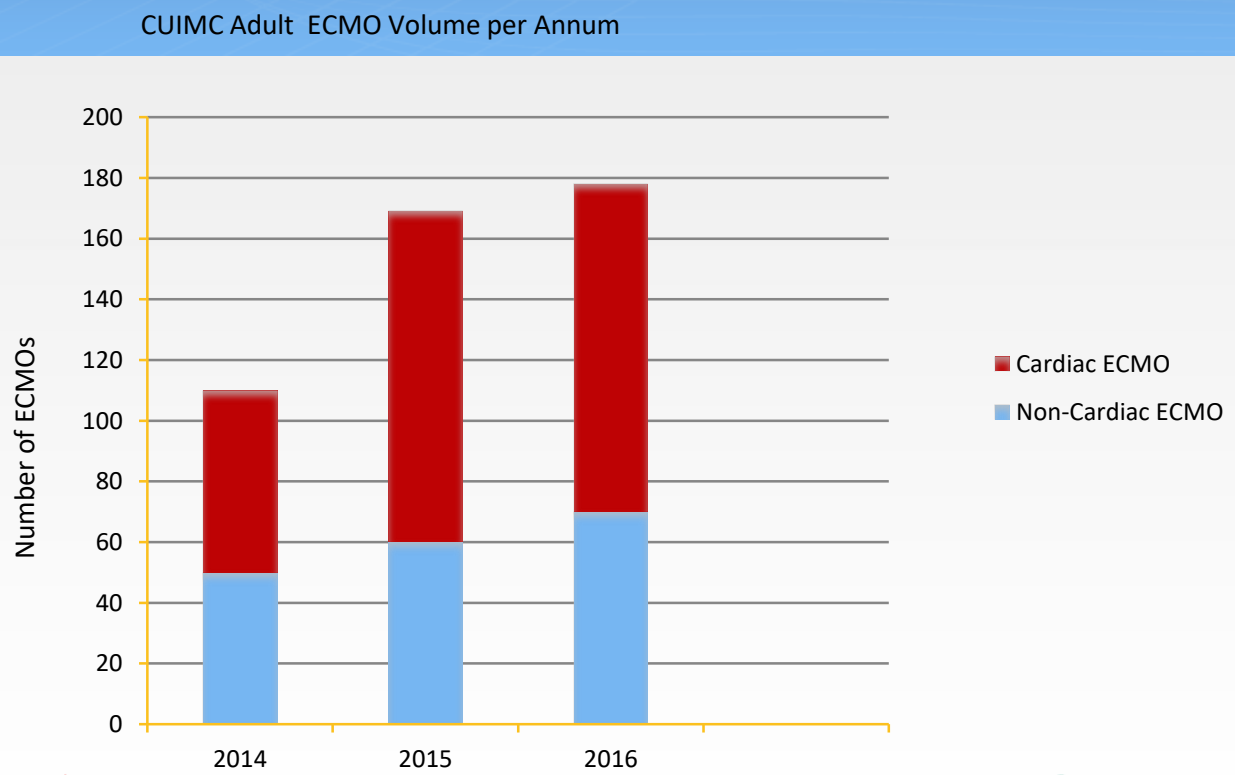
MAGNET EXCELLENCE AMERICAN NURSES CREDENTIALING CENTER

Columbia University Medical Center

NewYork-Presbyterian Columbia University Irving Medical Center

BACCN 32nd Annual BACCN Conference

ECMO Quantitative Data at CUIMC



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ECMO Qualitative Data at CUIMC

Cannulations and Configurations at CUIMC

	Arterial Access	Venous Access	Venous Access	Ventricular Access	RVAD	Oxygenator	LVAD
VV One vein as drain and reinfusion	--	RIJ, LIJ, RA	--	--	--	--	--
VV Vein drain, vein reinfusion	--	RF drain, LF drain	RIJ reinf, LIJ reinf, RA reinf	--	--	--	--
VA Vein drain, artery reinfusion	Aorta reinf, RCCA reinf, RAx reinf, RSC reinf, RF reinf, LF reinf	RIJ drain, LIJ drain, RF drain, LF drain, RA drain	--	--	--	--	--
Hybrid VVA or VAV Vein drain, vein reinfusion, artery reinfusion	RF reinf, LF reinf	RF drain, LF drain	RIJ reinf, LIJ reinf, RA reinf	--	--	--	--
Complex ECMO RVAD, LVAD and oxygenator	--	--	--	--	RVAD-Centrimag, ProtekDuo -RVAD	Oxygenator built into RVAD, Oxygenator built into LVAD	Jarvik, LVAD-Centrimag, HMII, HMIII, HeartWare Impella, IABP
ECMO System (LV drain, vein drain, aorta or arterial reinfusion)	Aorta reinf, RCCA reinf, RAx reinf, RSC reinf,	RIJ drain, LIJ drain, RF drain, LF drain	--	LV drain	--	--	--

Results of the Analysis

Most innovative ECMO configurations at CUMC utilized on a regular basis:

- The ECMO System

  - VA ECMO

  - since 2015

- The Central Sports Model ECMO

  - VA ECMO

  - since 2015

ECMO Qualitative Data at CUIMC

Cannulations and Configurations at CUIMC

The Central Sports Model VA ECMO

	Arterial Access	Venous Access	Venous Access	Ventricular Access	RVAD	Oxygenator	LVAD
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VV Vein drain, vein reinfusion	--	RF drain, LF drain	RIJ reinf, LIJ reinf, RA reinf	--	--	--	--
VA Vein drain, artery reinfusion	Aorta reinf, RCCA reinf, RAx r[redacted] RSC reinf, RF reinf, LF reinf	RIJ drain, [redacted] RF drain, LF drain, RA drain	--	--	--	--	--
Hybrid VVA or VAV Vein drain, vein reinfusion, artery reinfusion	RF reinf, LF reinf	RF drain, LF drain	RIJ reinf, LIJ reinf, RA reinf	--	--	--	--
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ECMO Qualitative Data at CUIMC

Cannulations and Configurations at CUIMC

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VV Vein drain, vein reinfusion	--	RF drain, LF drain	RIJ reinf, LIJ reinf, RA reinf	--	--	--	--
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Hybrid VVA or VAV Vein drain, vein reinfusion, artery reinfusion	RF reinf, LF reinf	RF drain, LF drain	RIJ reinf, LIJ reinf, RA reinf	--	--	--	--
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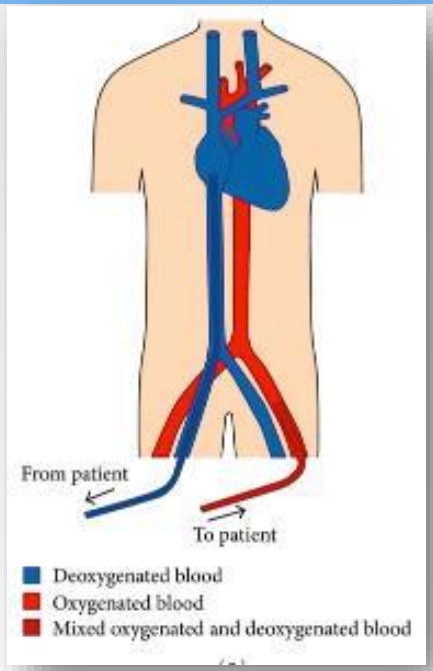
The ECMO System

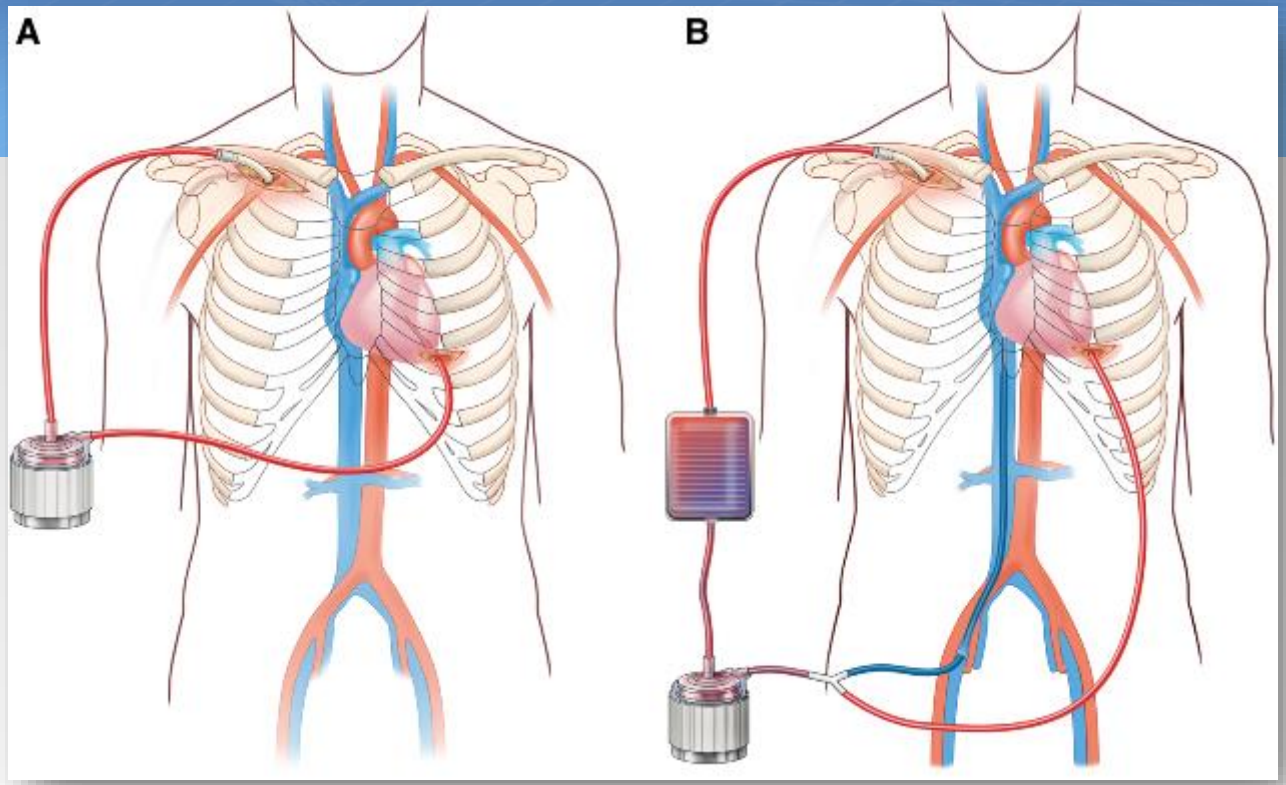
What is VA ECMO?

- Veno-arterial (VA)ECMO is a cardiac cardiopulmonary support used in severe heart or heart/lung failure
- Supports the right heart, left heart and the lungs
- Provides gas exchange and organ perfusion
- Blood is drained from the venous system, into the ECMO circuit, then returned into the arterial system
- Commonly used is the femoro-femoral approach



Chung et al. 2014

The ECMO System



From: Novel minimally invasive surgical approach using an external ventricular assist device and extracorporeal membrane oxygenation in refractory cardiogenic shock
Eur J Cardiothorac Surg. 2016;51(3):591-596. doi:10.1093/ejcts/ezw349

ECMO System: Breakdown and Sequence of Stages of Surgical Technique

Minimally Invasive Short Term External Ventricular Assist Device (VAD)

- Stage 1
- For left ventricular (LV) failure
- Incision: mini-left anterior thoracotomy for drain, and a small infraclavicular incision for reinfusion
- Cannulation: LV apex and axillary artery

Venous drain

- Stage 2
- For right ventricular (RV) failure
- Cannulation: Internal jugular or femoral venous drain
- Incision: Internal jugular or femoral vein
- Y connects to the LV drain

Oxygenator

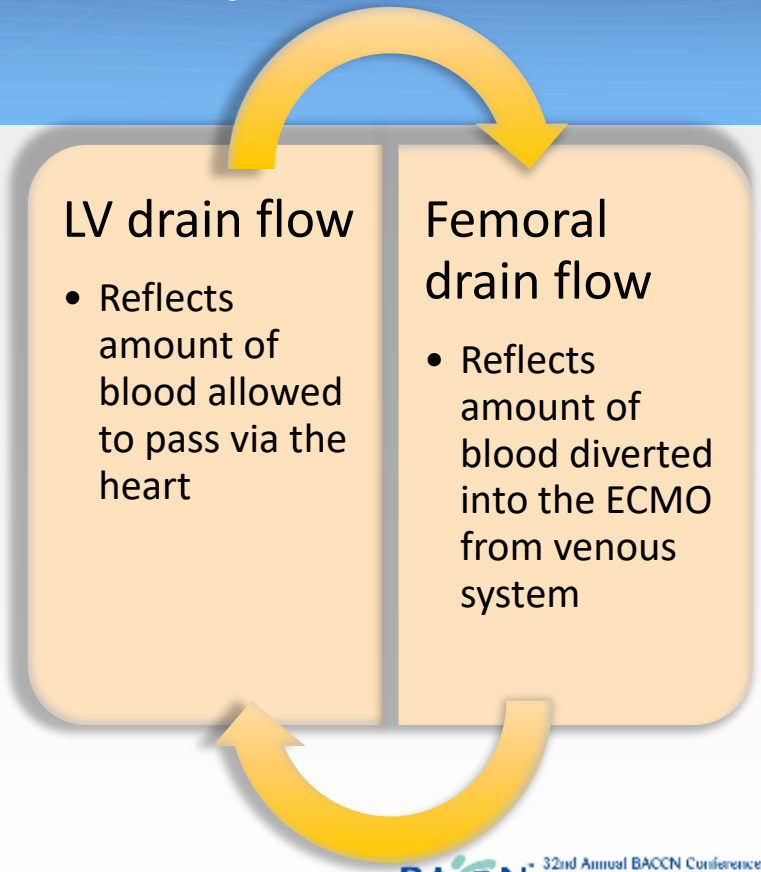
- Stage 3
- For lung failure
- Connection: spliced onto the arterial cannula between pump and axillary reinfusion

CentriMag Circuit

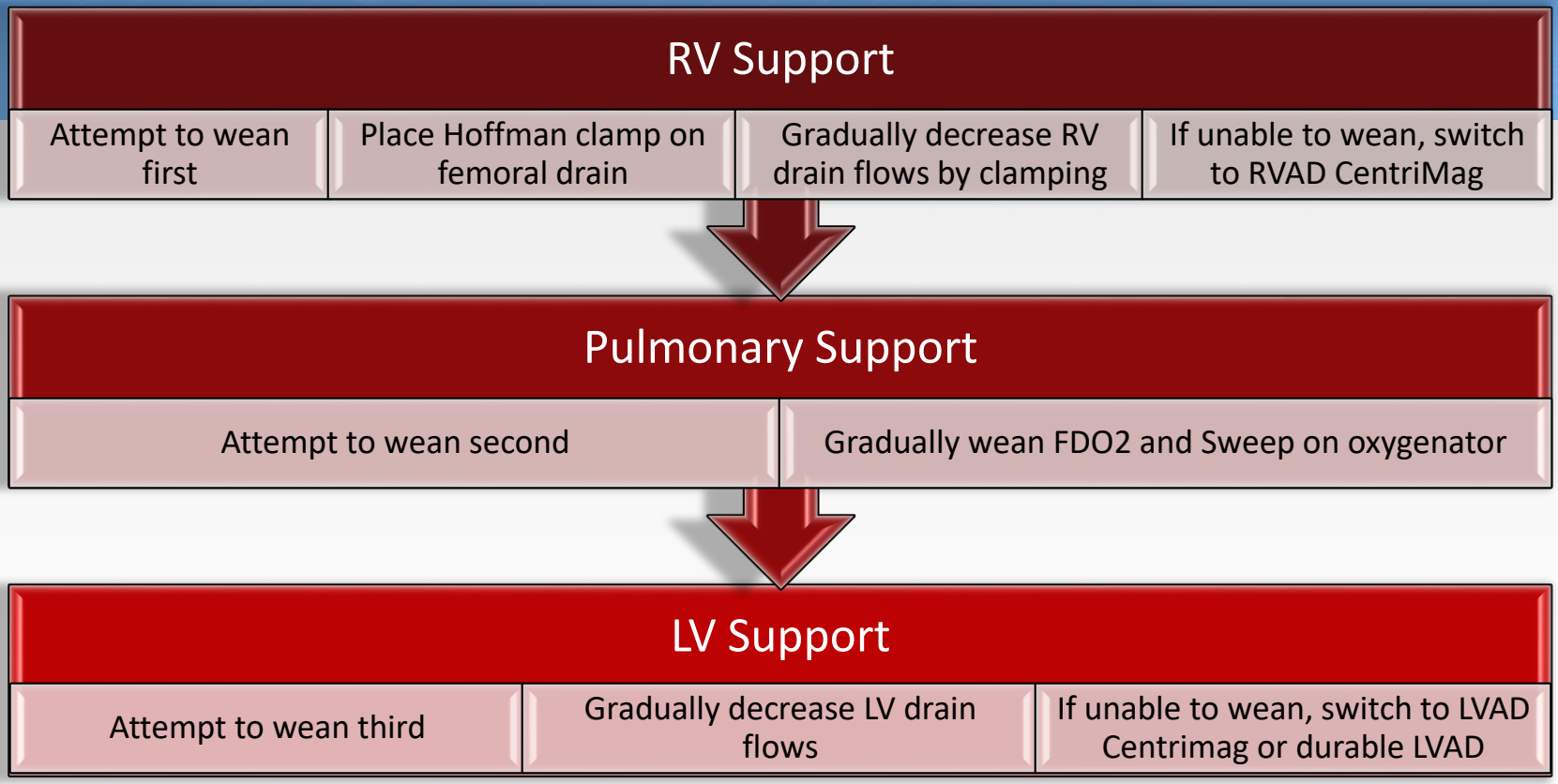
- Stage 4
- All cannulas get connected to the CentriMag circuit
- ECMO support is established
- Flows adjusted to allow aortic valve opening

Specifics of Managing the ECMO System in the ICU

- Ratio of the two venous flows is adjusted throughout the ECMO run and weaning
- In case of hyperperfusion of the cannulated arm, banding of the axillary artery is performed distal to the cannulation site



Weaning Trajectory of the ECMO System



ECMO System Compared to Basic VA ECMO

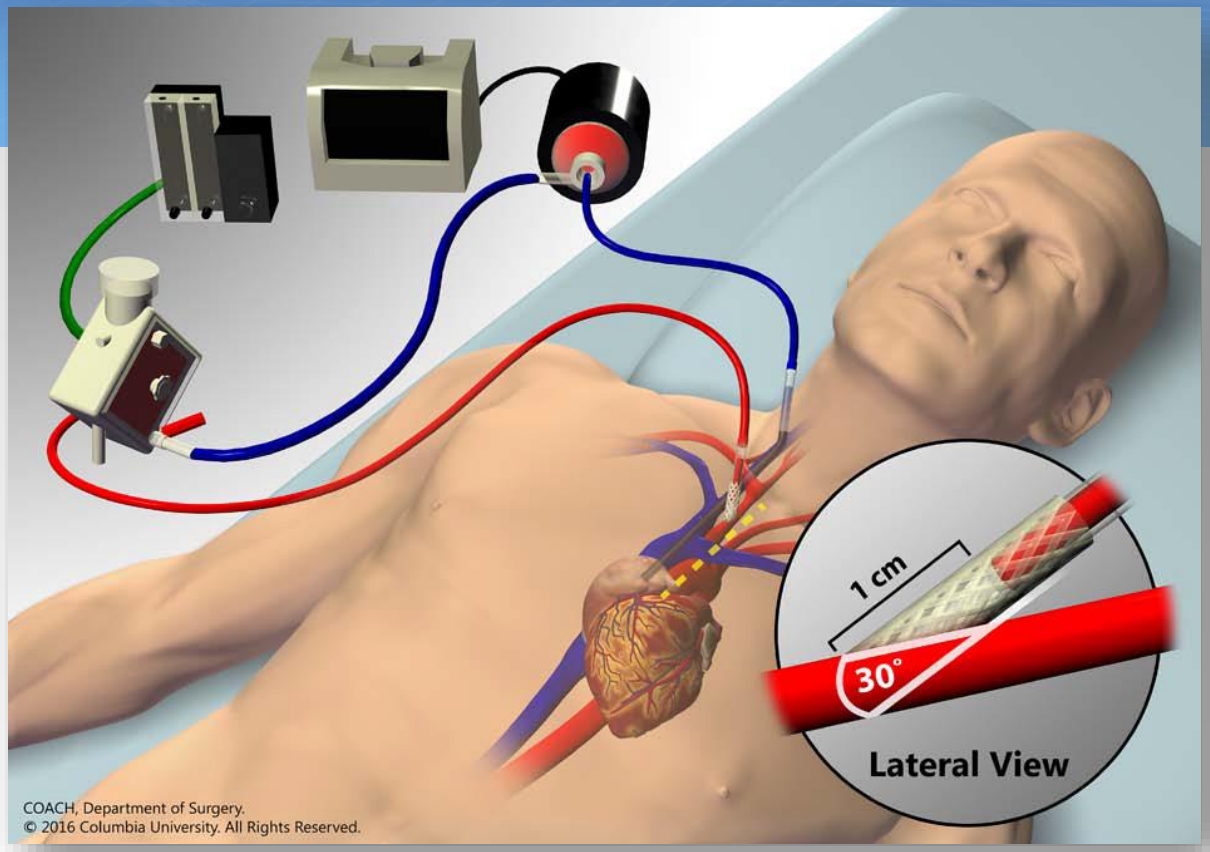
Advantages

- Improved outcomes in refractory cardiogenic shock
- Avoidance of median sternotomy and cardiopulmonary bypass
- Greater circulatory support
- Full LV decompression
- Gradual wean
- Ambulation once femoral drain removed

Disadvantages

- Complex surgical technique
- Highly trained ICU team
- Not suitable in subclavian arterial stenosis

The Central Sports Model ECMO

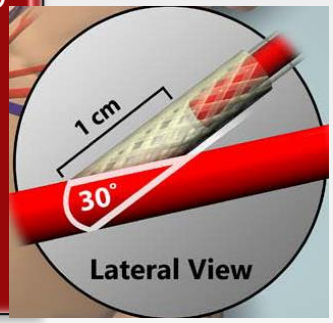


Central Sports Model: Sequence of Stages of Surgical Technique

Sternotomy- Stage 1
- Mini-proximal
- Small retractor

Arteriotomy- Stage 2
- Longitudinal

Anastomization- Stage 3
- Bioline Fusion vascular graft is placed, as conduit between artery and ECMO cannula
- 30 degree beveled
- Sits 1cm from junction of aorta and innominate artery
- Graft is sutured to artery



Arterial Cannulation- Stage 4
- Incision above right clavicle
- Arterial cannula is tunneled 1cm into the graft
- Cannula is sutured in, de-aired and connected to ECMO

Venous Cannulation- Stage 5
- Percutaneous incision
- Venous cannula is inserted into right internal jugular vein
- Cannula is sutured in, de-aired and connected to ECMO

ECMO initiation- Stage 6
- Sternotomy and incision are closed

Specifics of Managing the Central Sports Model

- Avoiding hyperperfusion of the right subclavian and carotid arteries is key. It is done during cannulation by:
  - Using a dilator for tunneling of the arterial cannula
  - Sharply beveling the graft
- Extubation within 12 hours of ECMO cannulation
- Management of hemodynamics same as for basic VA ECMO
- Initiation of physical therapy and early mobilization as soon as possible

Weaning Trajectory of the Central Sports Model

Pulmonary Hypertension Support	• Gradually decrease ECMO flows by lowering speed • May need medical therapy for pulmonary hypertension
Pre Lung Transplant Support	• No weaning • Lung transplantation with VA ECMO
RV Support	• Gradually decrease ECMO flows by lowering speed • May need medical therapy for RV support

Central Sports Model Compared to Basic VA ECMO

Advantages

- Bridge to lung transplantation in pulmonary hypertension and right heart failure
- Type of incision accommodates clam-shell lung transplantation incision technique
- Type of configuration may remain during lung transplantation
- Rapid extubation (<12 hours)
- Suitable for patients with small stature

Disadvantages

- Complex surgical technique
- Highly trained ICU team

Conclusion

The ECMO System

- Safe, effective, innovative configuration
- >25 cases/ 2 years of implementation

The Central Sports Model ECMO

- Safe, effective, innovative configuration
- >15 cases/ 2 years of implementation

References

- Chicotka S, Rosenzweigh EB, Brodie D et al. The “Central Sports Model”: Extracorporeal Membrane Oxygenation Using the Innominate Artery for Smaller Patients as Bridge to Lung Transplantation. ASAIO J 2016. (Epub ahead of print).
- Chung M, Shiloh AL, Carlese A. Monitoring of the Adult Patient on Venoarterial Extracorporeal Membrane Oxygenation. *The Scientific World Journal.* 2014;2014:393258. doi:10.1155/2014/393258.
- https://www.elso.org/default.aspx
- Makdisi G, Wang I. Extracorporeal Membrane Oxygenation (ECMO) review of lifesaving technology. *Journal of Thoracic Disease.* 2015;7(7):E166-176. doi:10.3978/j.issn.2072-1439.2015.07.17.
- Sladen RN. New Innovations in Circulatory Support with Ventricular Assist Device and Extracorporeal Membrane Oxygenation Therapy. *Anesth Analg.*2017;124(4):1071-1086. doi:10.1213/ANE.0000000000001629.
- Takeda K, Garan AR, Topkara VK et al. Novel Minimally Invasive Surgical Approach Using an External Ventricular Assist Device and Extracorporeal Membrane Oxygenation in Refractory Cardiogenic Shock. *Eur J Cardiothorac Surg* 2017;51(3):591-596. doi:10.1093/ejcts/ezw349

Thank you

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