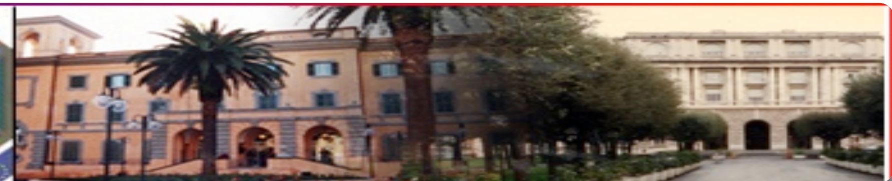
AZIENDA OSPEDALIERA
SAN CAMILLO FORLANINI
Ospedale di rilievo nazionale e di alta specializzazione



BEYOND THE SLIDES 2015
1st UDINE ECMO WORKSHOP

Cardiac unloading & pulsatile flow: when and how

Francesco Musumeci MD, FECTS
Director Cardiac Surgery and Regional Center for Cardiac Transplantation
Ospedale S. Camillo, ROMA

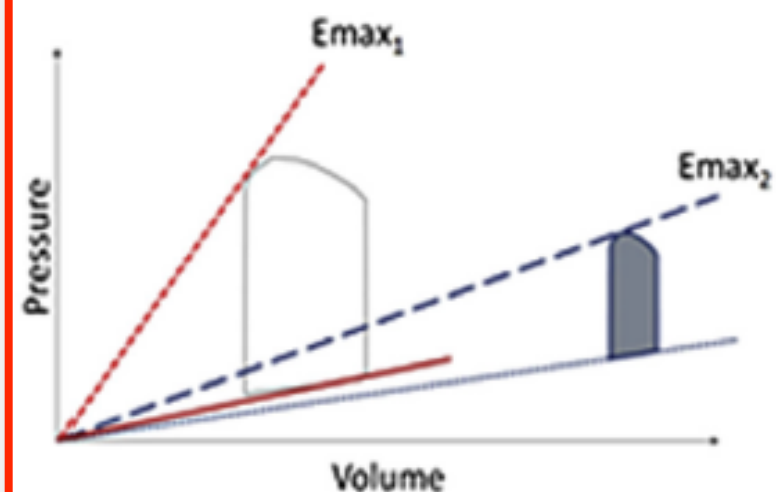
Cardiogenic Shock

PRESSURE VOLUME LOOPS

Normal PV loop

Emax *(load-independent LV contractility)*

Cardiogenic Shock



↓↓↓↓ **CONTRACTILITY**

↑↑ **LVEDV**

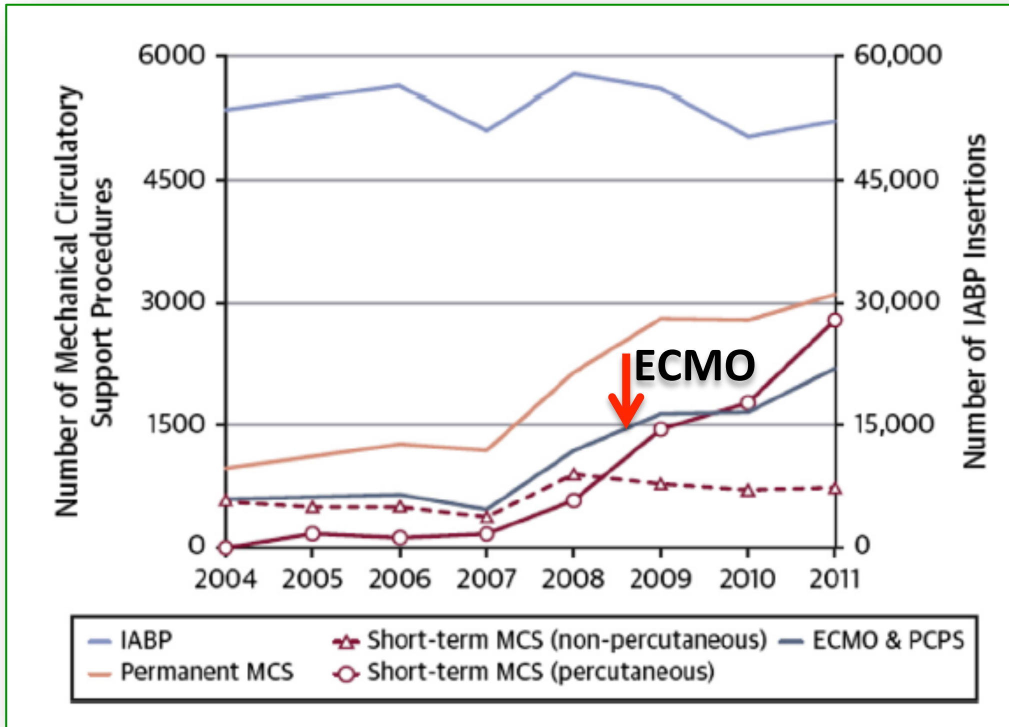
↑↑ **LVEDP**

↓↓ **STROKE VOLUME**

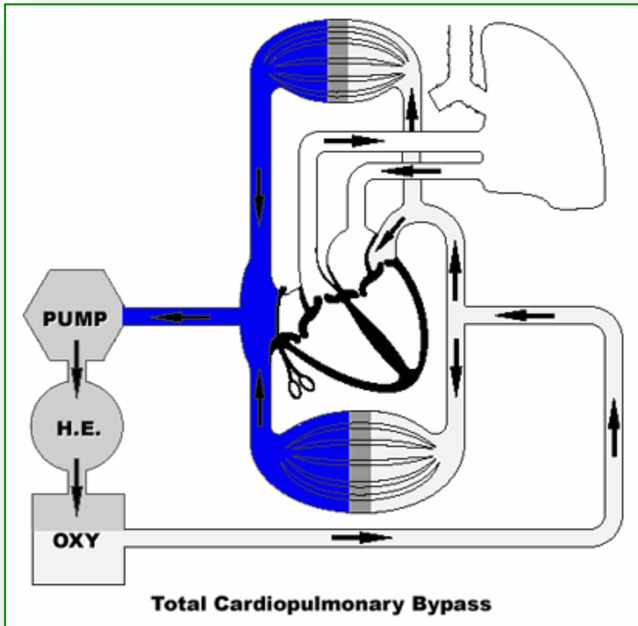
The primary goals of nondurable MCS devices are

- increase vital organ perfusion,
- augment coronary perfusion,
- reduce ventricular volume and filling pressures, thereby reducing wall stress, stroke work, and myocardial oxygen consumption.

Together with the growth in use of LVAD, the use of ECMO has been steadily increasing



VENOARTERIAL EXTRACORPOREAL MEMBRANE OXYGENATION (VA-ECMO)

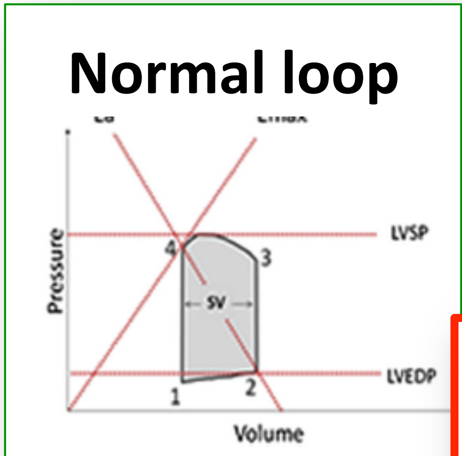


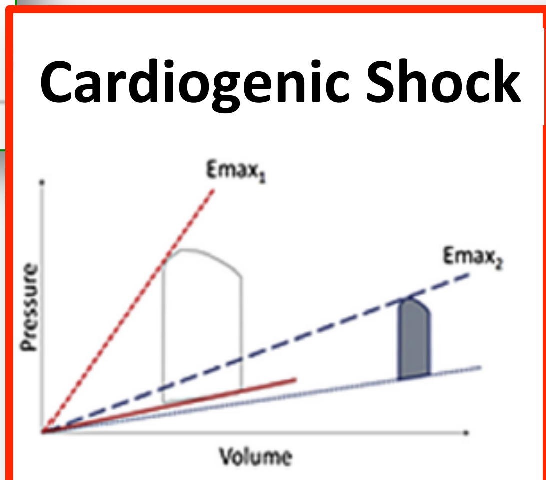
Veno-Arterial-ECMO displaces venous blood from the right atrium, through an extracorporeal centrifugal pump and oxygenator, into the femoral artery or centrally

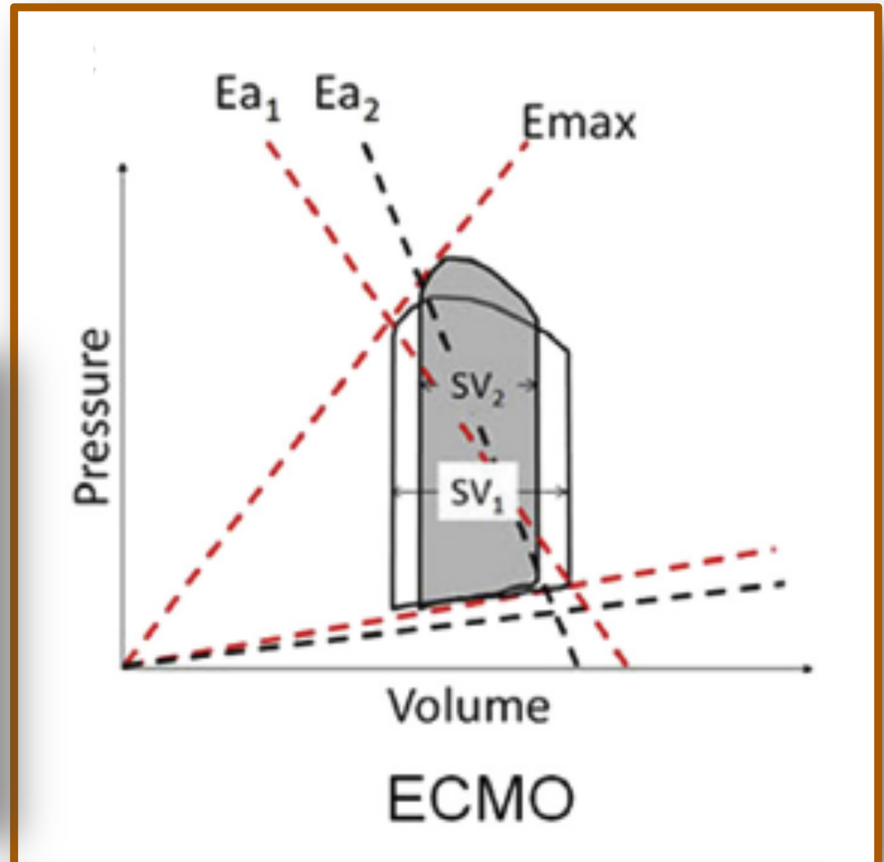
Femoral vessels cannulation

Central cannulation

PRESSURE VOLUME LOOPS

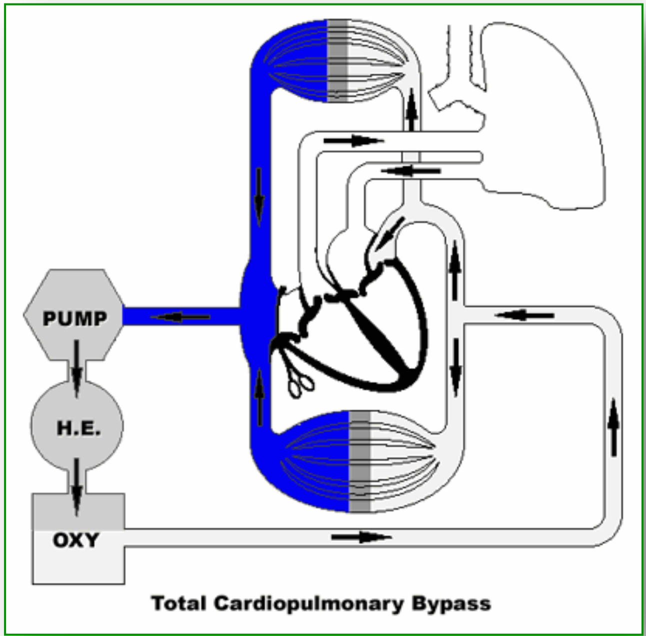






VA-ECMO *without a LV venting* increases LV systolic and diastolic pressure, while reducing LV stroke volume.

VENOARTERIAL EXTRACORPOREAL MEMBRANE OXYGENATION (VA-ECMO)



Veno-Arterial-ECMO displaces venous blood from the right atrium, through an extracorporeal centrifugal pump and oxygenator, into the femoral artery or centrally

The potential risk of increase in LV afterload and wall stress has negative consequences on myocardial protection and may cause progressive acute lung injury unless the LV is vented or unloaded

Causes of Ventricular Distension

DIRECT:

- ***Severe Ventricular disfunction***
- ***Aortic Valve insufficiency***
- ***Arrhythmia***

‘INDIRECT’ (related to ECMO):

- ***↑ afterload***
- ***Inadequate venous drainage***

Consequences of LV Distension

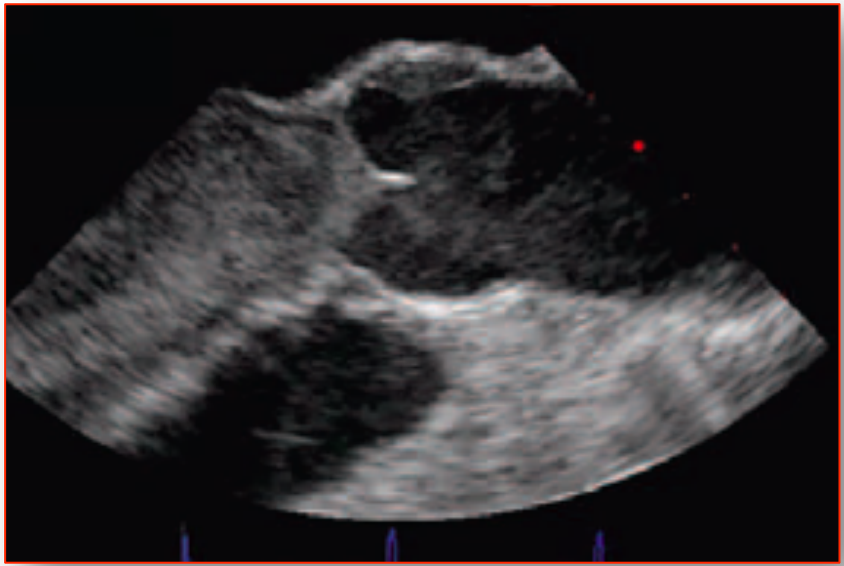
⬆ LVEDP

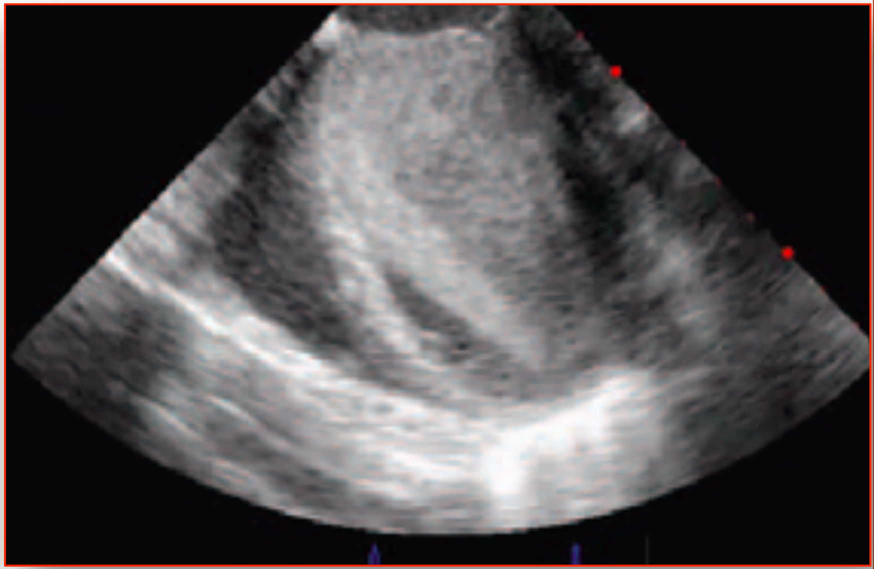
- *Impaired myocardial perfusion*
- ⬆ *Wall stres*
- ⬆ *Myocardial oxygen consumption*

⬆ LAP

- *Pulmonary edema*
- *Respiratory failure*

Consequences of LV Distension





Ultimately, it may result in flow stasis and development of LV thrombus with risk of embolization or stroke

Short-Term Mechanical Unloading With Left Ventricular Assist Devices After Acute Myocardial Infarction Conserves Calcium Cycling and Improves Heart Function

Objectives This study sought to demonstrate that short-term cardiac unloading with a left ventricular (LV) assist device (LVAD) after acute myocardial infarction (MI) can conserve calcium cycling and improve heart function.

Background Heart failure secondary to MI remains a major source of morbidity and mortality. Alterations in calcium cycling are linked to cardiac dysfunction in the failing heart.

Methods Adult Dorsett hybrid sheep underwent acute MI and were mechanically unloaded with an axial-flow LVAD (Impella 5.0) for 2 weeks ($n = 6$). Six sheep with MI only and 4 sham sheep were used as controls. All animals were followed for 12 weeks post-MI. Regional strains in the LV were measured by sonomicrometry. Major calcium-handling proteins (CHPs), including sarco-/endoplasmic reticulum calcium ATPase-2α (SERCA-2α), Na^+-Ca^{2+} exchanger-1, and phospholamban, and Ca^{2+}-ATPase activity were investigated. The electrophysiological calcium cycling in single isolated cardiomyocytes was measured with the patch-clamp technique. The related ultrastructures were studied with electron microscopy.

Results LVAD unloading alleviated LV dilation and improved global cardiac function and regional contractility compared with the MI group. The regional myocardial strain (stretch) was minimized during the unloading period and even attenuated compared with the MI group at 12 weeks. Im-

Conclusions Short-term unloading may conserve calcium cycling and improve heart function during the post-infarct period.

JACC, 2013

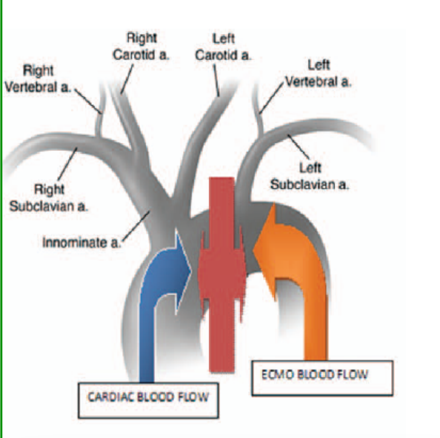
Left Heart Decompression Strategies During VA-ECMO

Noninvasive	Inotropic support Reducing VA-ECMO flow
Percutaneous	IABP Impella axial flow catheter Transseptal LA cannulation Transseptal LV cannulation Atrial septostomy
Surgical	Direct LV apical cannulation Direct LA cannulation

Optimize Ventricular Unloading

- **<u>Inotropic support + Afterload reduction</u>**

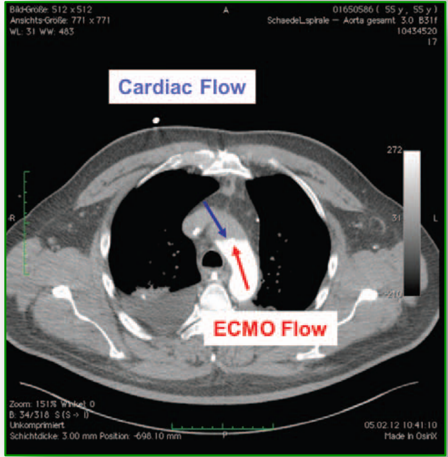
(mean arterial pressure of 50-60mmHg)



⬇ Workload ⬇ O2 consumption

- **<u>"Adequate" Pump Flow</u>**

Keep Flow Rates of 2.5-4 L/min to maintain physiologic levels of Lactate, pH and SvO2. The lower pump flow rates also reduce the perfusion-related afterload



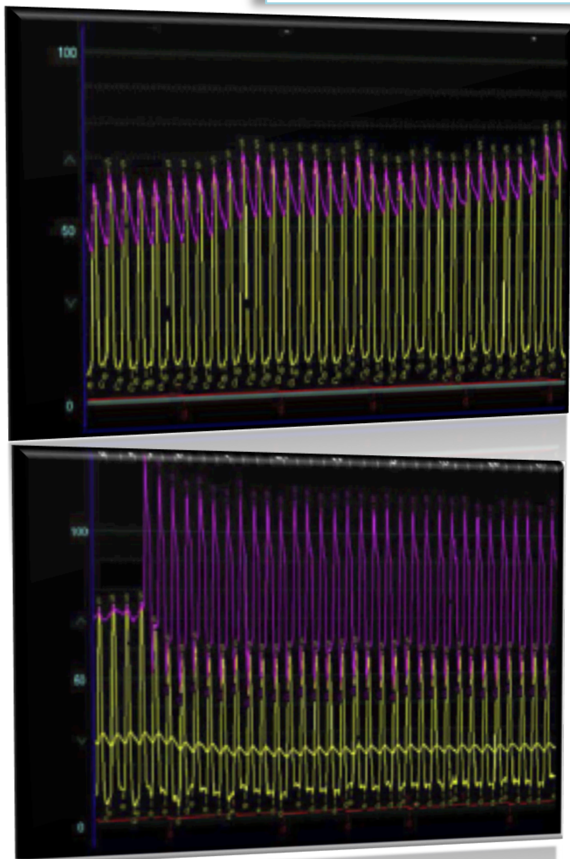
- **<u>Avoid Volume Overload</u>**

Hemofiltration should be considered liberally

Left Heart Decompression Strategies During VA-ECMO

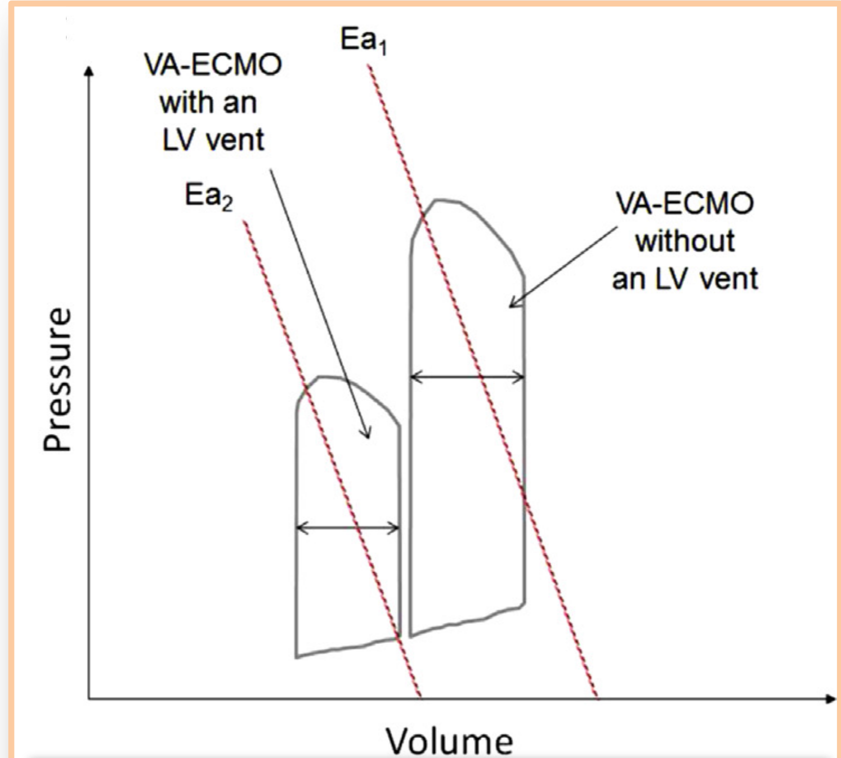
Noninvasive	Inotropic support Reducing VA-ECMO flow
Percutaneous	IABP Impella axial flow catheter Transseptal LA cannulation Transseptal LV cannulation Atrial septostomy
Surgical	Direct LV apical cannulation Direct LA cannulation

Venting the Left Ventricle



No venting

Venting



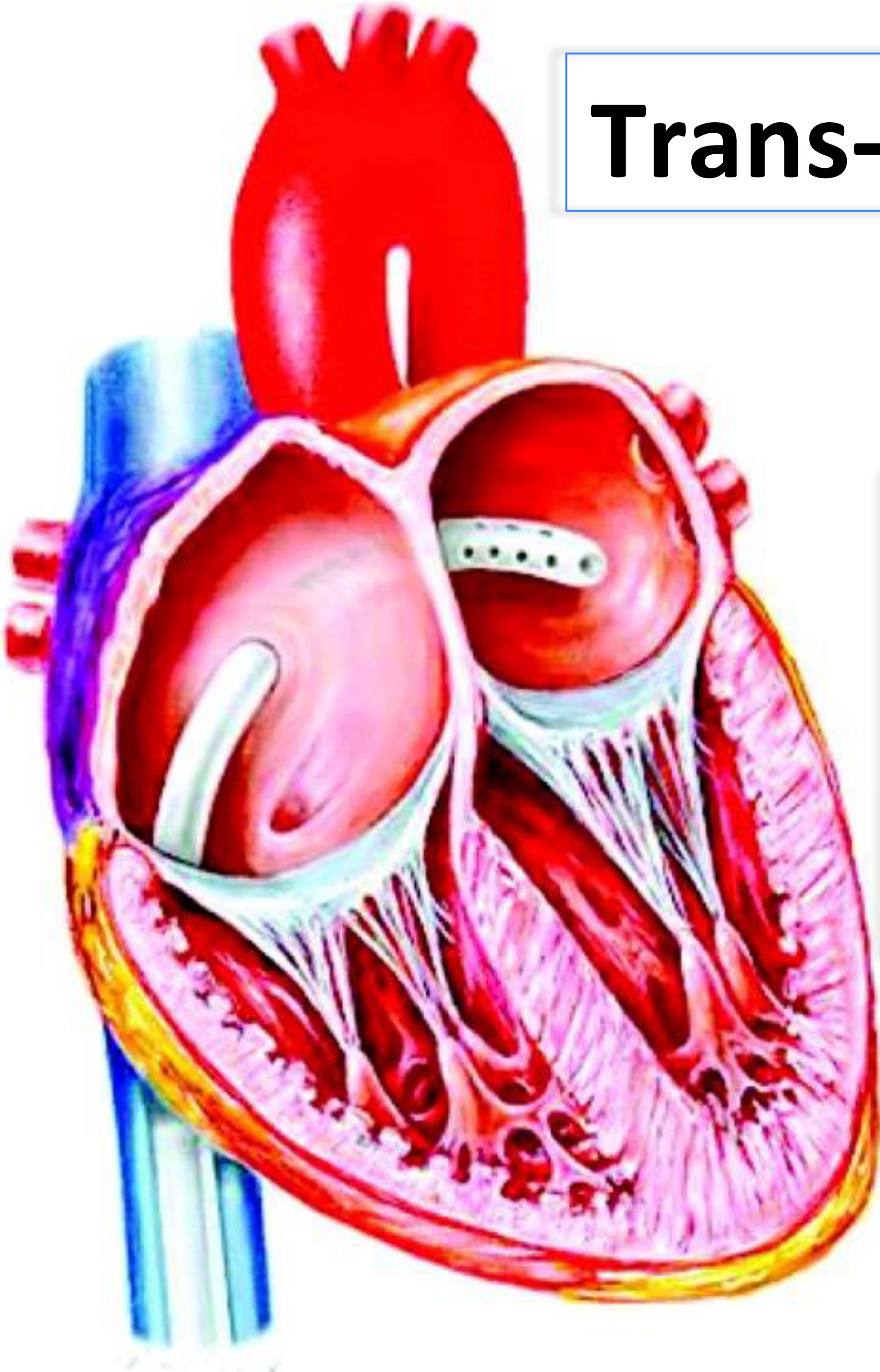
PRESSURE VOLUME LOOPS

Venting of the **LV** with during VA-ECMO support

⬇ *LV end-systolic pressure* and *end-diastolic volume*

and ⬆ *aortic diastolic pressure*

Trans-septal cannulation



Access to LA via standard trans septal technique

Extracorporeal Membranous Oxygenation and Left Atrial Decompression: A Fast and Minimally Invasive Approach

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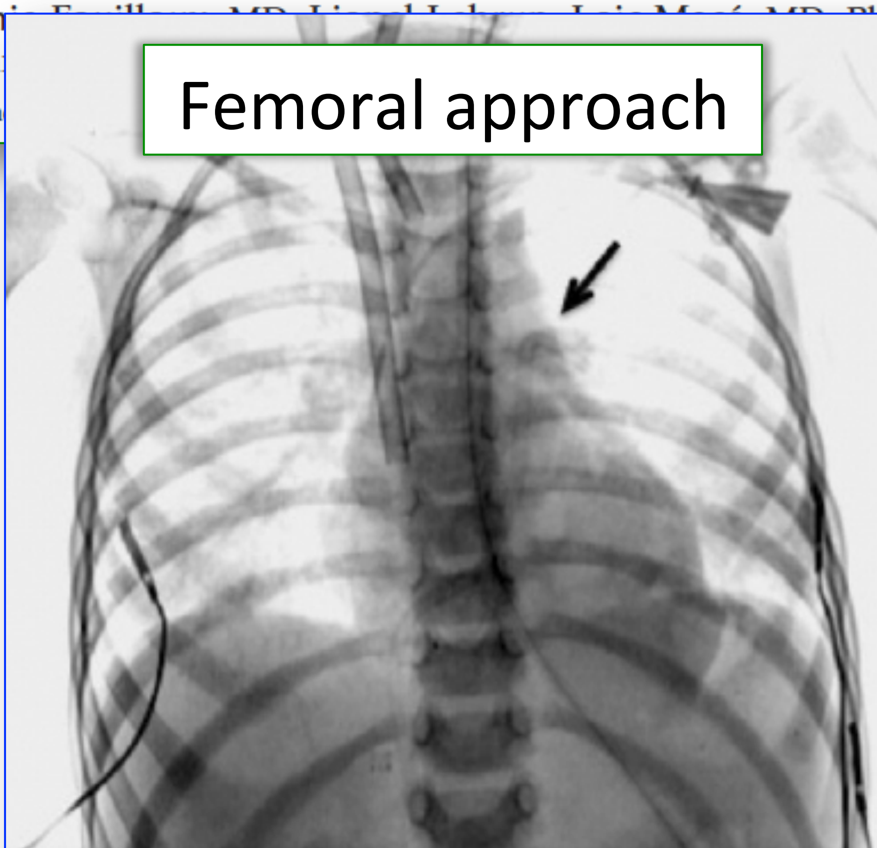
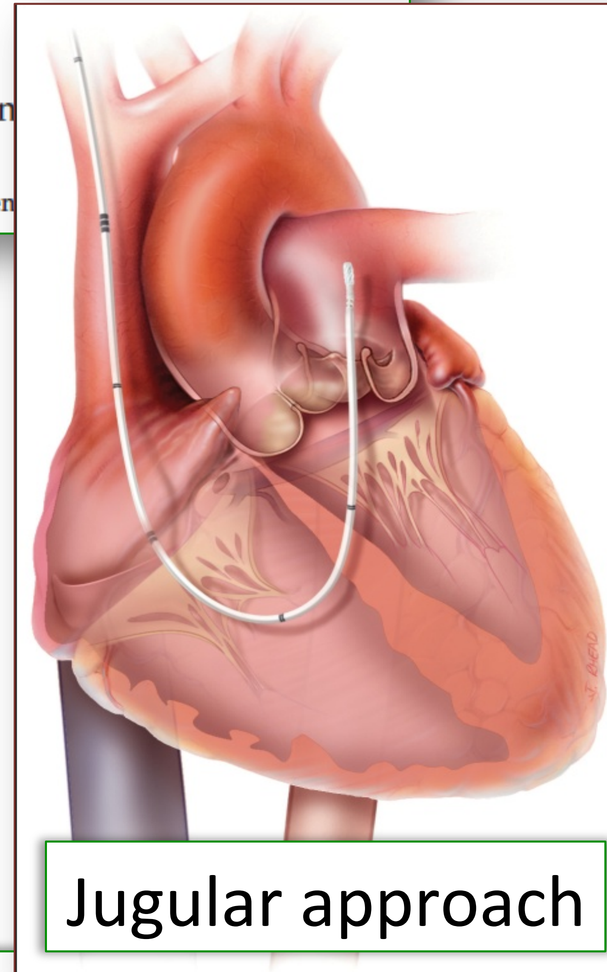




Unload the LV with a cannula inserted in the **Pulmonary Trunk**

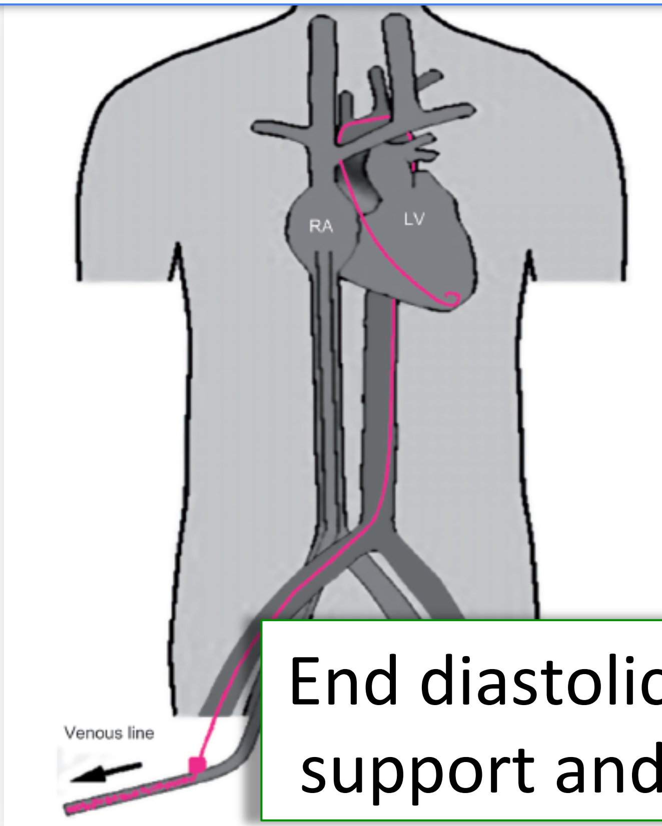
Interactive CardioVascular and Thoracic Surgery 13 (2011) 293-295

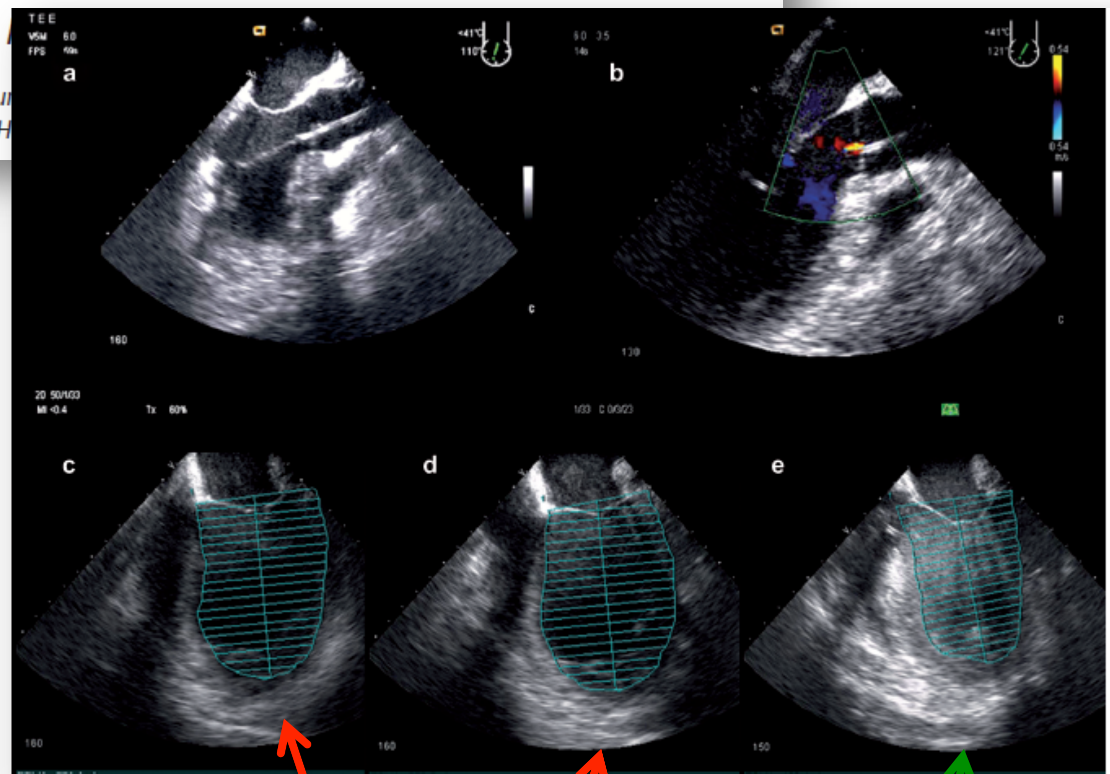
Proposal for bail-out procedures - Assisted circulation

Left ventricle unloading by percutaneous pigtail during extracorporeal membrane oxygenation

Alessandro Barbone[a],*, Pietro Giorgio

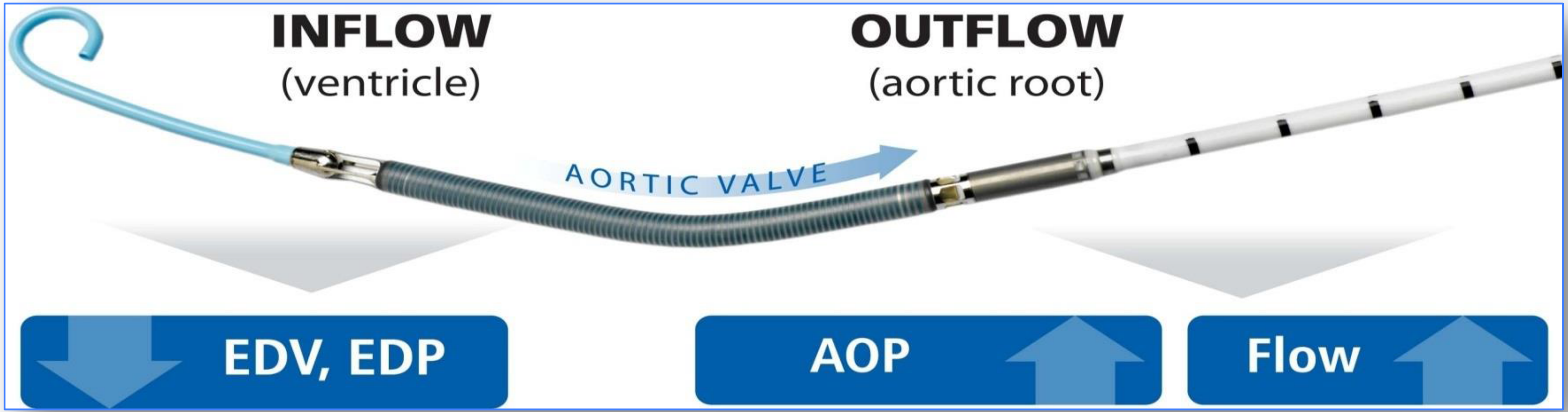
Trans Aortic Valve

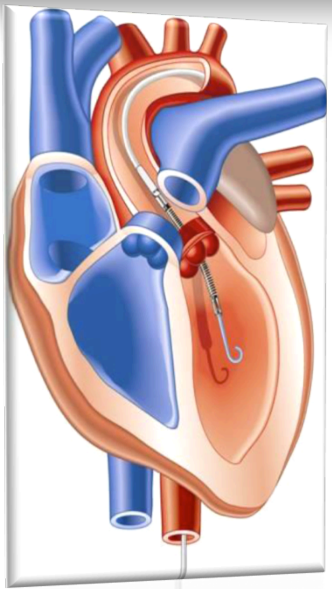


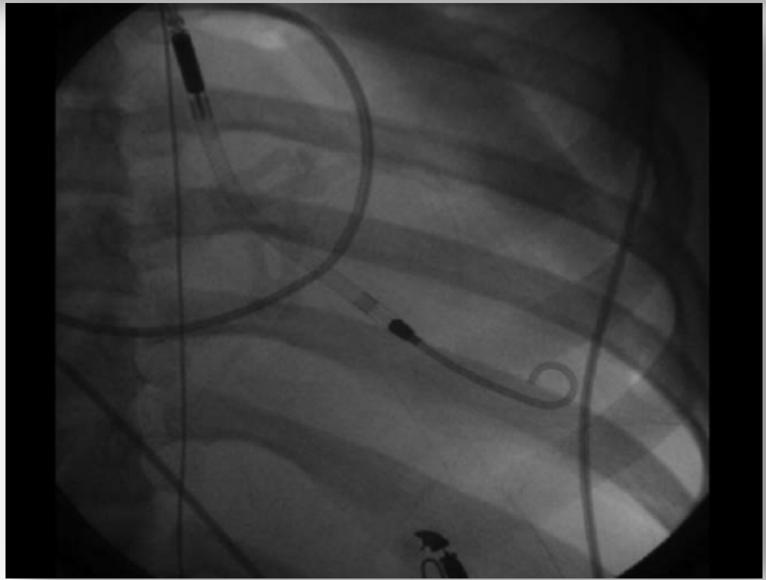


End diastolic diameter before, after initiating ECMO support and after positioning of the intra-LV pigtail

Impella percutaneous micro-axial heart pump



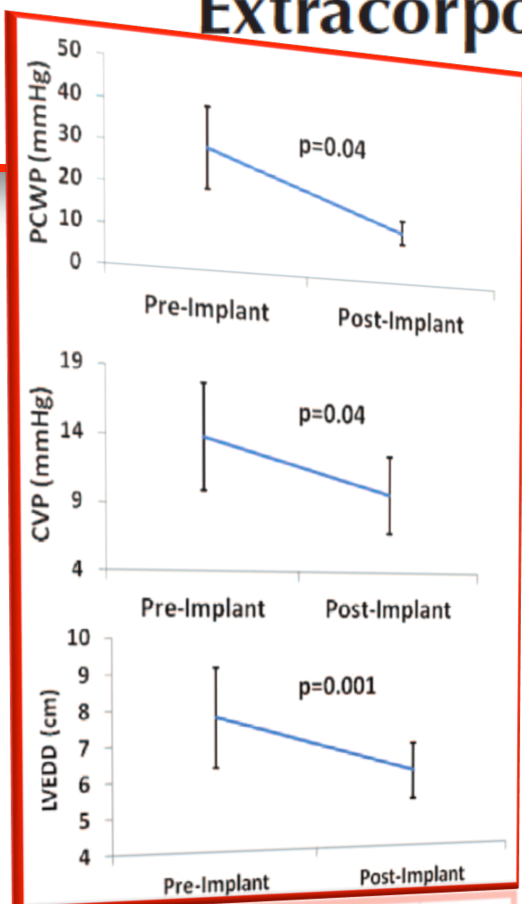


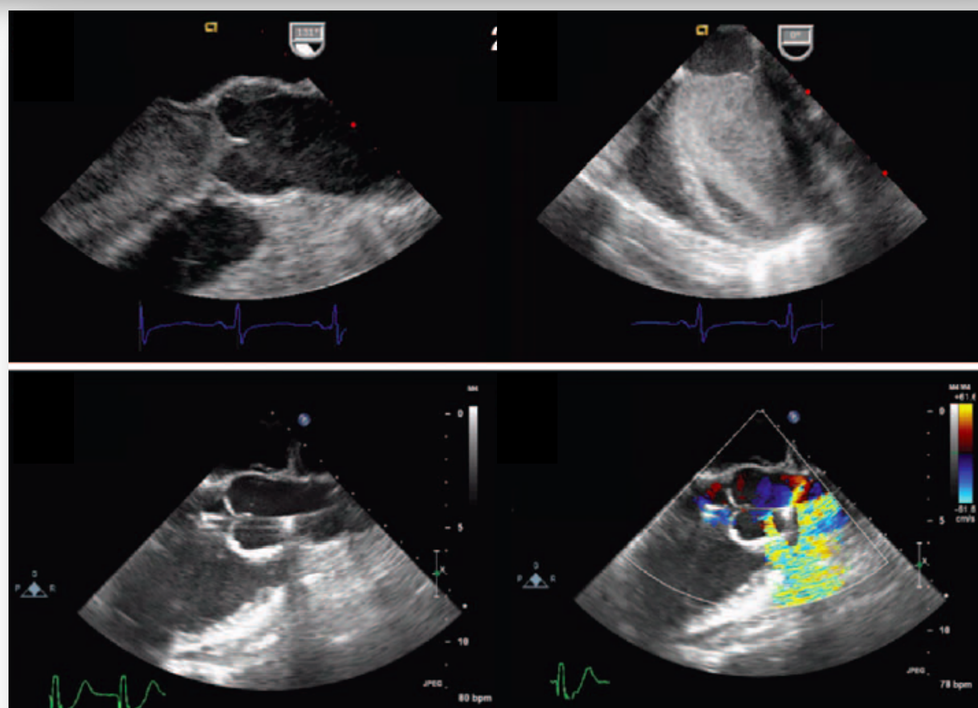


Impella percutaneous micro-axial heart pump

Impella to Unload the Left Ventricle During Peripheral Extracorporeal Membrane Oxygenation

IENG, MICHAEL F. SWARTZ, AND H. TODD MASSEY





Left Heart Decompression Strategies During VA-ECMO

Noninvasive	Inotropic support Reducing VA-ECMO flow
Percutaneous	IABP Impella axial flow catheter Transseptal LA cannulation Transseptal LV cannulation Atrial septostomy
Surgical	Direct LV apical cannulation Direct LA cannulation

Direct Left Ventricular Apical cannulation

doi:10.1510/icvts.2009.228346

INTERACTIVE CARDIOVASCULAR AN THORACIC SURGERY

www.icvts.o

Interactive CardioVascular and Thoracic Surgery 10 (2010) 672-674

Work in progress report - Assisted circulation

Minimally invasive left-heart decompression during venoarterial extracorporeal membrane oxygenation: an alternative to a percutaneous approach

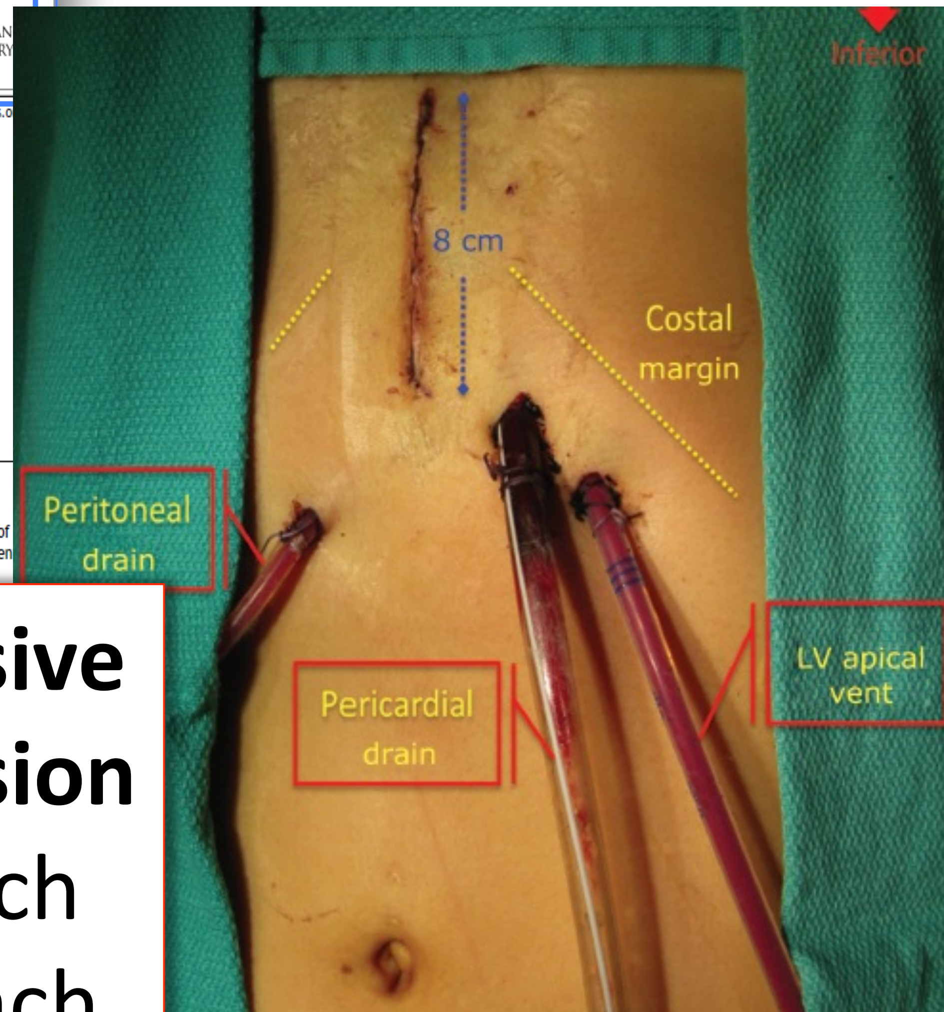
Mina Guirgis[a], Kanwal Kumar[a,b], Alan H. Menkis[a], Darren H. Freed[a,b,*]

[a]Institute of Cardiovascular Sciences, St. Boniface Research Centre, Winnipeg, Manitoba, Canada
[b]Department of Surgery, Section of Cardiac Surgery, University of Manitoba, St. Boniface General Hospital Cardiac Sciences Program, Winnipeg, Manitoba, Canada

Received 13 November 2009; received in revised form 15 January 2010; accepted 19 January 2010

Abstract

Decompression of the left-heart following initiation of extracorporeal membrane oxygenation, is at times required. In the setting of closed chest this can present a challenge. We present a minimally invasive approach to left-heart decompression in an adult-sized patien where a percutaneous option was not feasible.



Surgical Minimal Invasive Left Heart Decompression

- Subxiphoidal approach
- Anterolateral approach

Weymann et al. Journal of Cardiothoracic Surgery 2014, 9:60
http://www.cardiothoracicsurgery.org/content/9/1/60

JOURNAL OF CARDIOTHORACIC SURGERY

RESEARCH ARTICLE Open Access

Central extracorporeal life support with left ventricular decompression for the treatment of refractory cardiogenic shock and lung failure

Alexander Weymann[1,2*], Bastian Schmack[2], Anton Sabashnikov[1], Christopher T Bowles[1], Philipp Raake[3], Rawa Arif[2], Markus Verch[2], Ursula Tochtermann[2], Jens Roggenbach[4], Aron Frederik Popov[1,5], Andre Ruediger Simon[1], Matthias Karck[2] and Arjang Ruhparwar[2]

Abstract

Background: The purpose of this prospective study was to evaluate the effects and functional outcome of central extracorporeal life support (ECLS) with left ventricular decompression for the treatment of refractory cardiogenic shock and lung failure.

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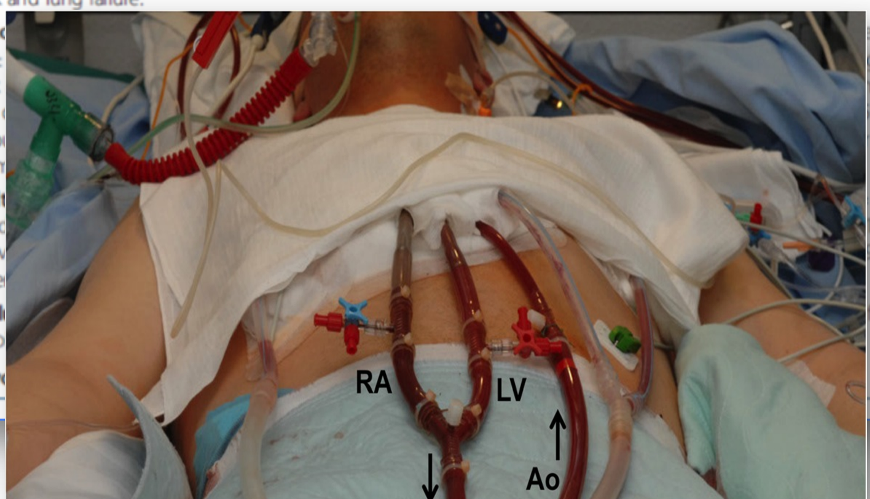
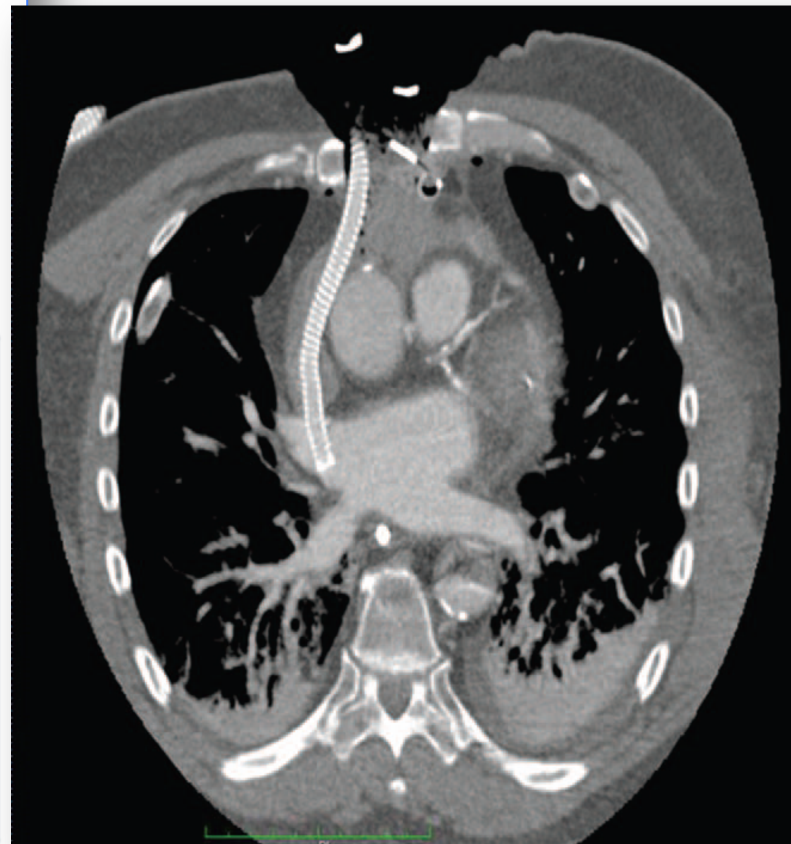
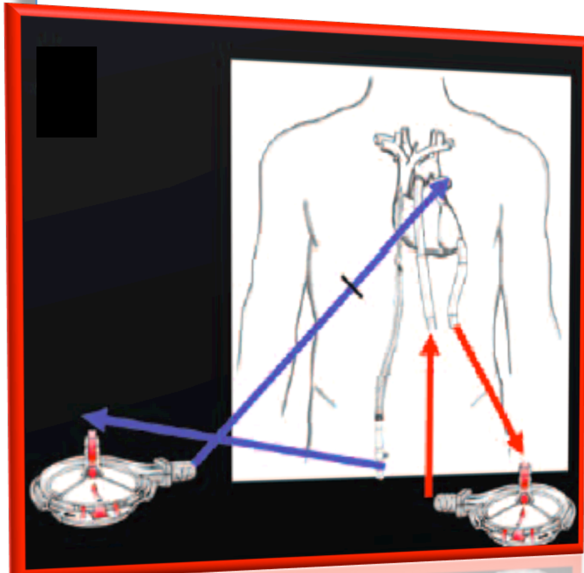
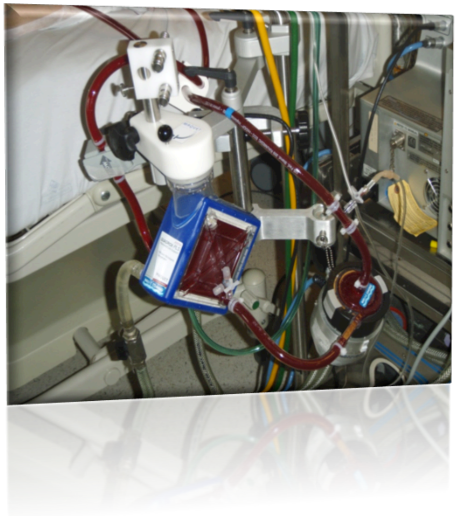




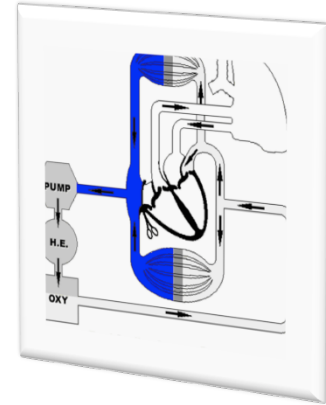
Right Upper Pulmonary Vein cannulation

Temporary VAD support with centrifugal pump





ECMO



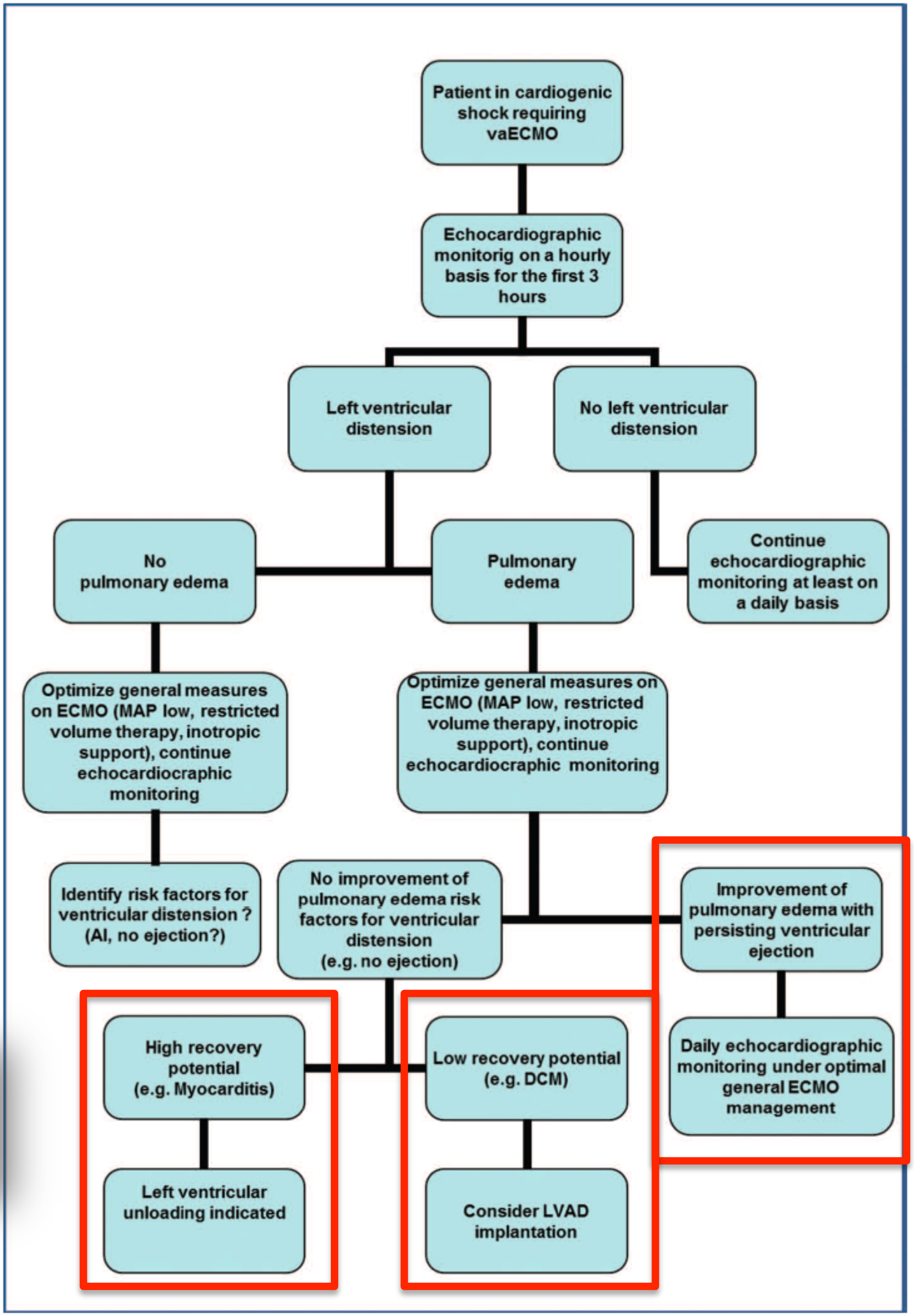
Cardiogenic Shock

Post-cardiotomy failure

Femoral cannulation
When preserves cardiac activity

Central with LV unloading
Poor LV function

Algorithm to monitor patients on ECMO for Left Ventricular distension.



Cardiac Decompression on Extracorporeal Life Support: A Review and Discussion of the Literature

Leopold Rupprecht,* Bernhard Flörchinger,* Simon Schopka,* Christof Schmid,* Alois Philipp,* Dirk Lunz,† Thomas Müller,‡ and Daniele Camboni*

ASAIO Journal 2013

Combining ECMO with IABP for the Treatment of Critically Ill Adult Heart Failure Patients

Heart, Lung and Circulation (2014) 23, 363–368

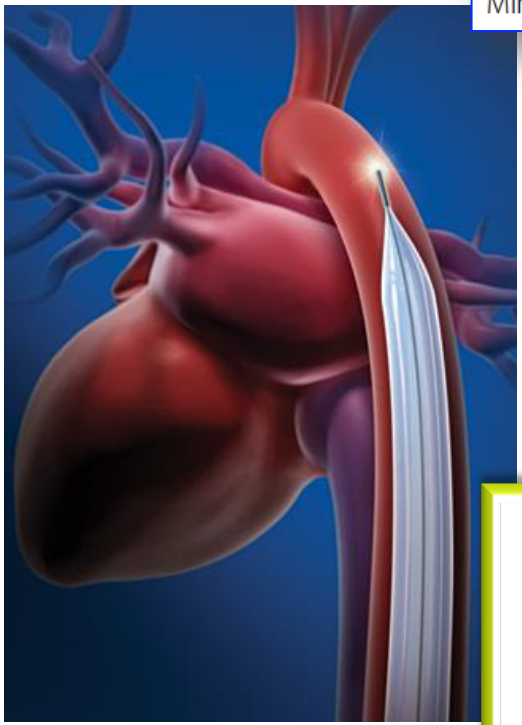
Pengyu Ma, MS[a,1], Zaiwang Zhang, MS[b,1], Tieying Song, MS[a*],
Yunliang Yang, MS[a], Ge Meng, MD[c], Jianhui Zhao, MS[a]
Chunping Wang, MS[a], Kunfeng G
Bo Jiang, MS[a], Yan Qi, MS[a], Ruyu

[a]Department of Anesthesiology, The First Hospital of Shijiazhuang,
[b]Department of Anesthesiology, The Bethune International Peace
Hebei Province, China
[c]Department of Cardiac Surgery, The First Hospital of Shijiazhuan
[d]Graduate School, Hebei Medical University, No. 361 Zhongshan

Effects of intra-aortic balloon pump on cerebral blood flow during peripheral venoarterial extracorporeal membrane oxygenation support

Yang *et al. Journal of Translational Medicine* 2014, **12**:106

ang[1], Yuan Liu[1], Xing Hao[1], Chun-jing Jiang[1], Hong Wang[2],
Ming Jia[2] and Xiao-tong Hou[1]



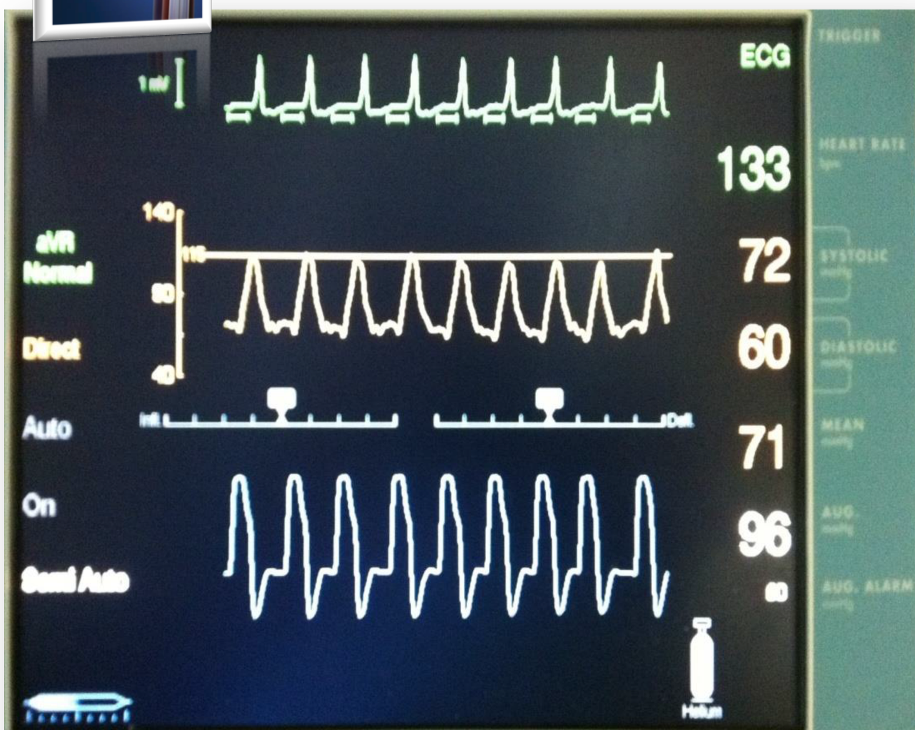
IABP can increase blood supply to the coronary arteries and reduce cardiac afterload

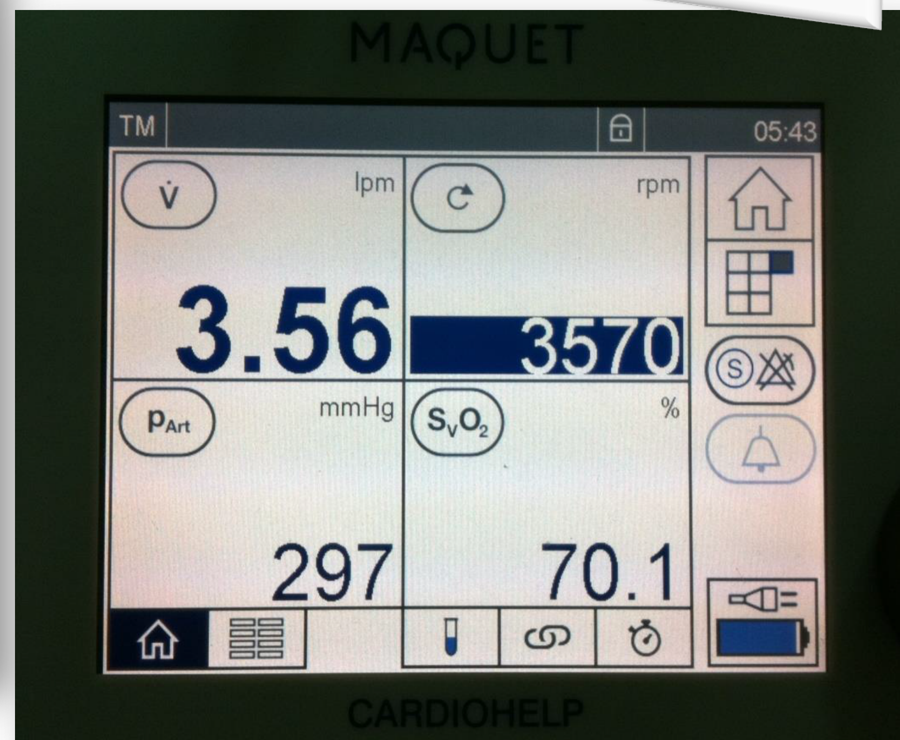
ECMO and **IABP** are synergistic and complementary to each other

ECMO & IABP in Combination

IABP Console

Maquet Cardiohelp
ECLS Console

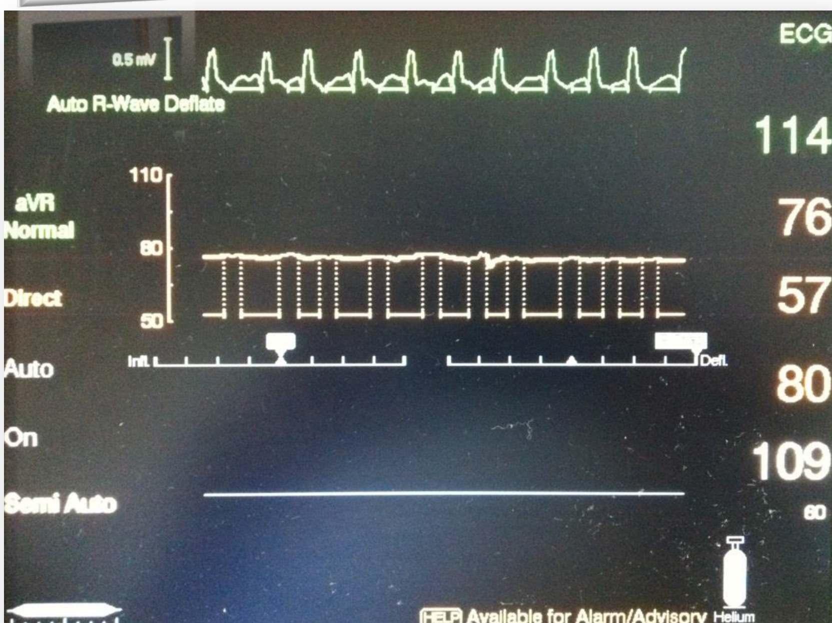


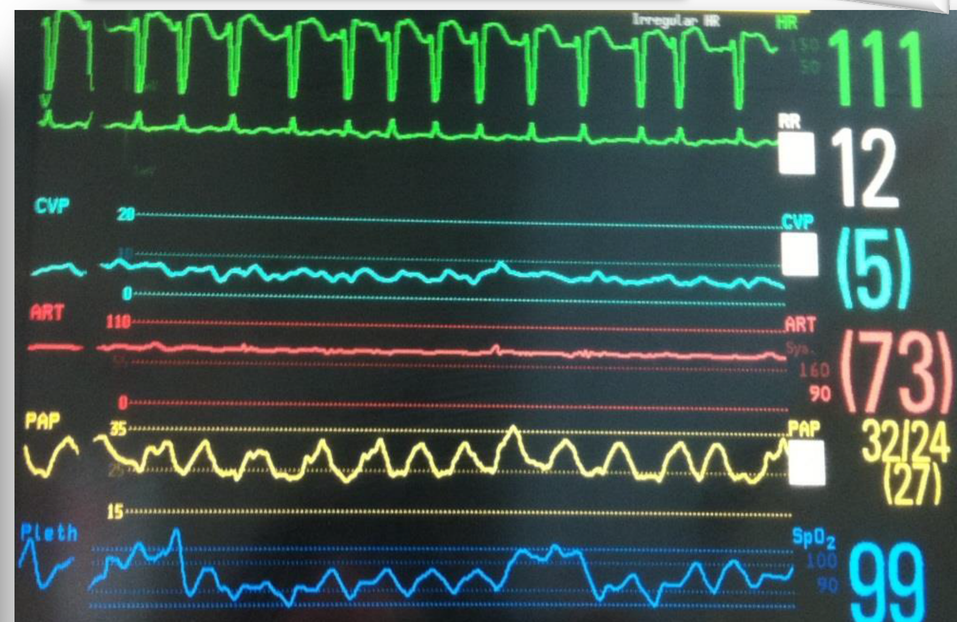


IABP on Hold: *Complete Loss of Intrinsic Cardiac Pulsatility*

IABP Console

ICU Monitoring Screen





Pulsatile Versus Nonpulsatile Flow During Cardiopulmonary Bypass: Microcirculatory and Systemic Effects

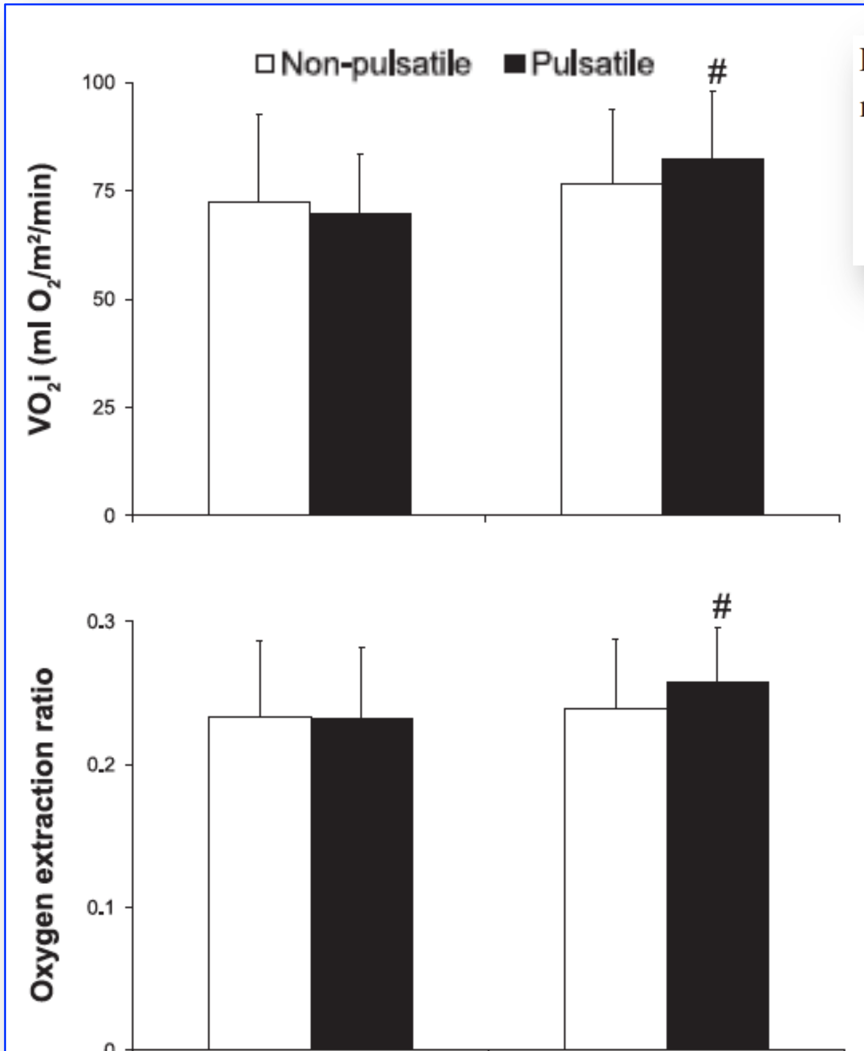
Michael P. O'Neil, MS, CCP, Jennifer C. Fleming, PhD, Amit Badhwar, PhD, and Linrui Ray Guo, MD

Departments of Surgery and Clinical Perfusion Services, Division of Cardiac Surgery, London Health Sciences Centre; Department of Medical Biophysics, Schulich School of Medicine and Dentistry, University of Western Ontario; and Centre for Critical Illness Research, Lawson Health Research Institute, Victoria Research Laboratories, London, Ontario, Canada

Conclusions. Pulsatile perfusion is superior to nonpulsatile perfusion at preserving the microcirculation, which may reflect attenuation of the systemic inflammatory response during CPB. We suggest the implementation of pulsatile flow can better optimize microvascular perfusion, and may lead to improved patient outcomes in high-risk cardiac surgical procedures requiring prolonged CPB time.

postoperatively, a higher proportion of normally perfused microvessels occurred under pulsatile versus nonpulsatile flow (56.0% ± 3.9% vs 33.3% ± 4.1%; $p < 0.05$).

(Ann Thorac Surg 2012;94:2046–53)

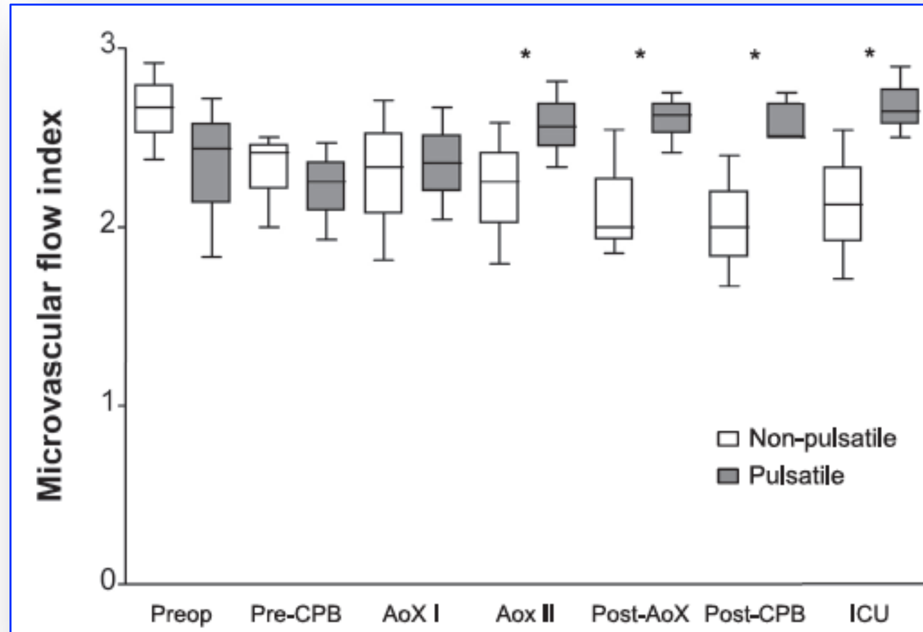


Pulsatile flow during cardiopulmonary bypass preserves postoperative microcirculatory perfusion irrespective of systemic hemodynamics

Nick J. Koning,[1,2] Alexander B. A. Vonk,[2] Lerau J. van Barneveld,[2] Albertus Beishuizen,[3] Bektas Atasever,[2] Charissa E. van den Brom,[1] and Christa Boer[1]

Departments of [1]Anesthesiology, [2]Cardio-Thoracic Surgery, and [3]Intensive Care Medicine, Institute for Cardiovascular Research, VU University Medical Center, Amsterdam, the Netherlands

J Appl Physiol 112: 1727–1734, 2012.

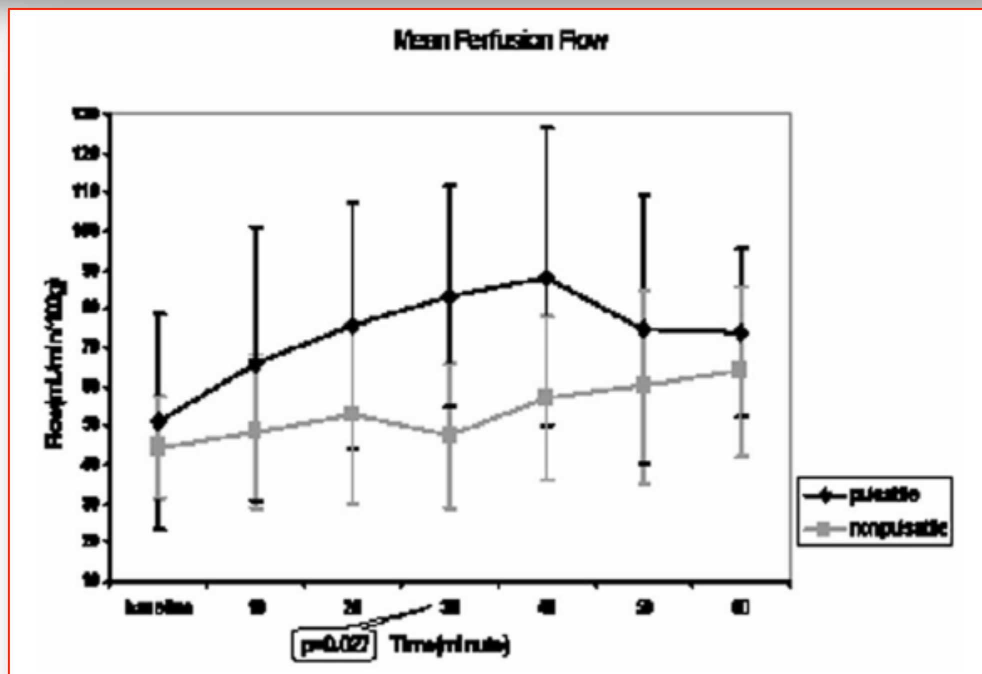


Oxygen consumption index and oxygen extraction ratio were increased in the pulsatile flow group

The median postoperative microvascular flow index was higher in the pulsatile group

The Effects of Pulsatile Flow Upon Renal Tissue Perfusion During Cardiopulmonary Bypass: A Comparative Study of Pulsatile and Nonpulsatile Flow

Hyun Koo Kim,* Ho Sung Son,* Yong Hu Fang,† Sung Young Park,† Chang Mo Hwang,‡ and Kyung Sun*



Pulsatile flow achieves higher levels of tissue perfusion of the kidney during short-term extracorporeal circulation

Impacts of Pulsatile Systemic Circulation on Endothelium-Derived Nitric Oxide Release in Anesthetized Dogs

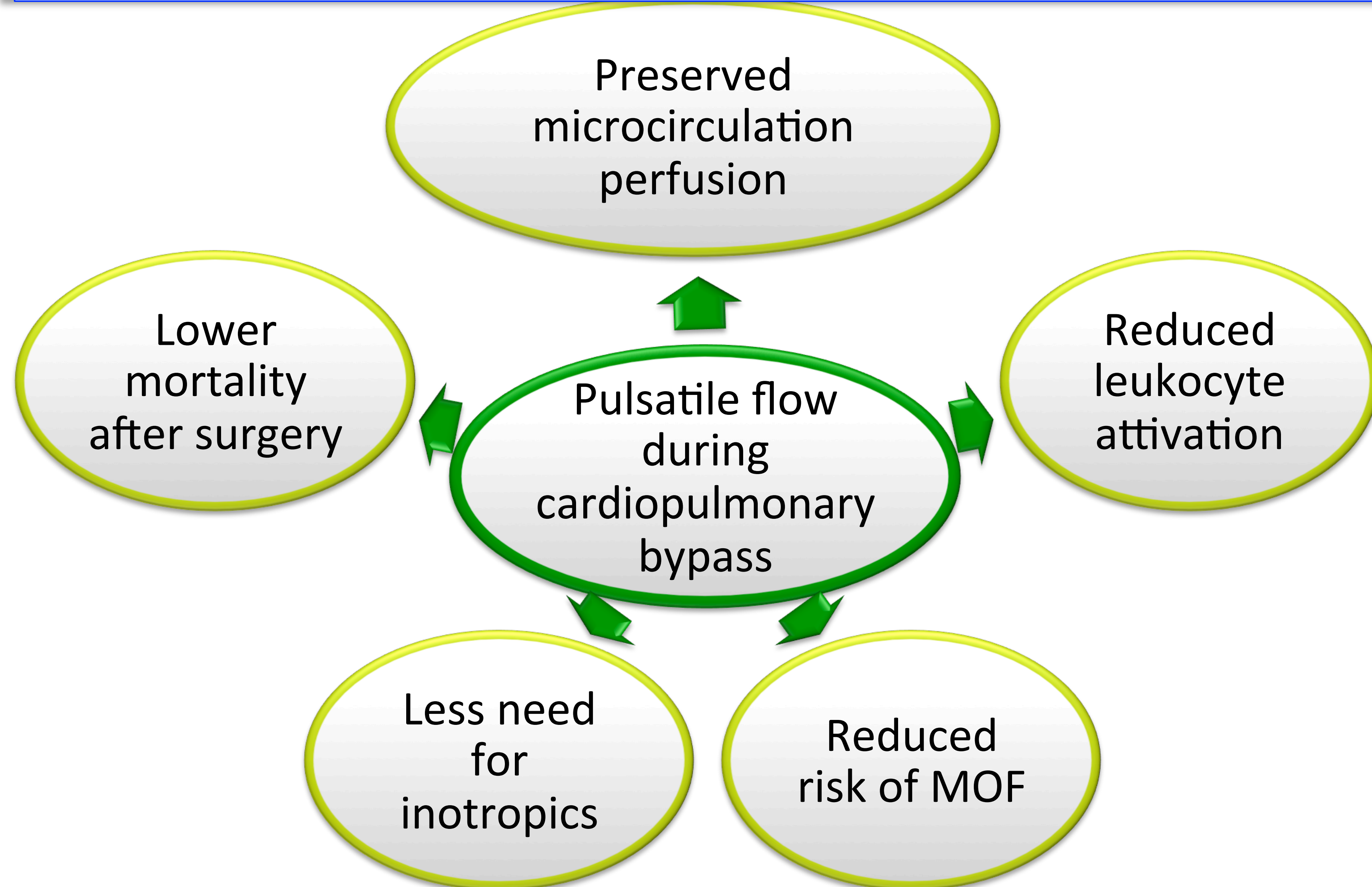
Toshihide Nakano, MD, Ryuji Tominaga, MD, Shigeki Morita, MD, Munetaka Masuda, MD, Ichiro Nagano, MD, Ken-ichi Imasaka, MD, and Hisataka Yasui, MD

Division of Cardiovascular Surgery, Faculty of Medicine, Kyushu University, Fukuoka, Japan

Conclusions

Both the frequency and the amplitude of pulse wave in the systemic circulation are significant independent stimuli for endothelium-derived nitric oxide-mediated vasodilation in vivo.

Pulsatile vs Continous flow



CONCLUSIONS

- ECMO may increase LV afterload and wall stress with negative consequences on myocardial protection and may cause progressive acute lung injury .

- **Venting** of the **LV** ↓ *LV end-systolic pressure* and *end-diastolic volume* and ↑ *aortic diastolic pressure.*

CONCLUSIONS

- **ECMO** and **IABP** are synergistic and complementary to each other.

- Although it appears clear that **pulsatile flow** causes significantly less organ injury and systemic inflammation during CPB, there is not a clearly evidence of the benefits of nonpulsatile perfusion over pulsatile perfusion in acute or chronic settings.


Thank you for
your attention!