

Mechanical Circulatory Support for Cardiogenic Shock: Insights From Hemodynamic Simulations

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Disclosures

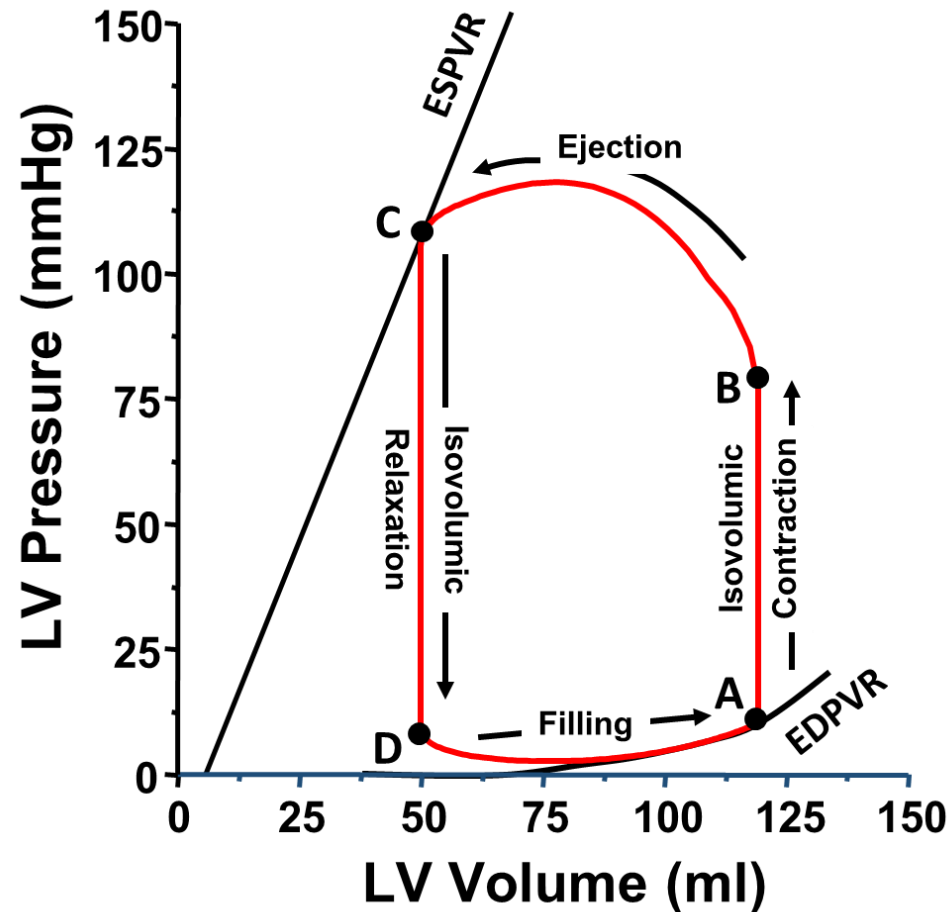
- **Unrestricted institutional educational grant from Abiomed**
- **Consultant to PVLoops LLC**

Understanding Cardiogenic Shock through the Window of the Pressure-Volume Diagram:

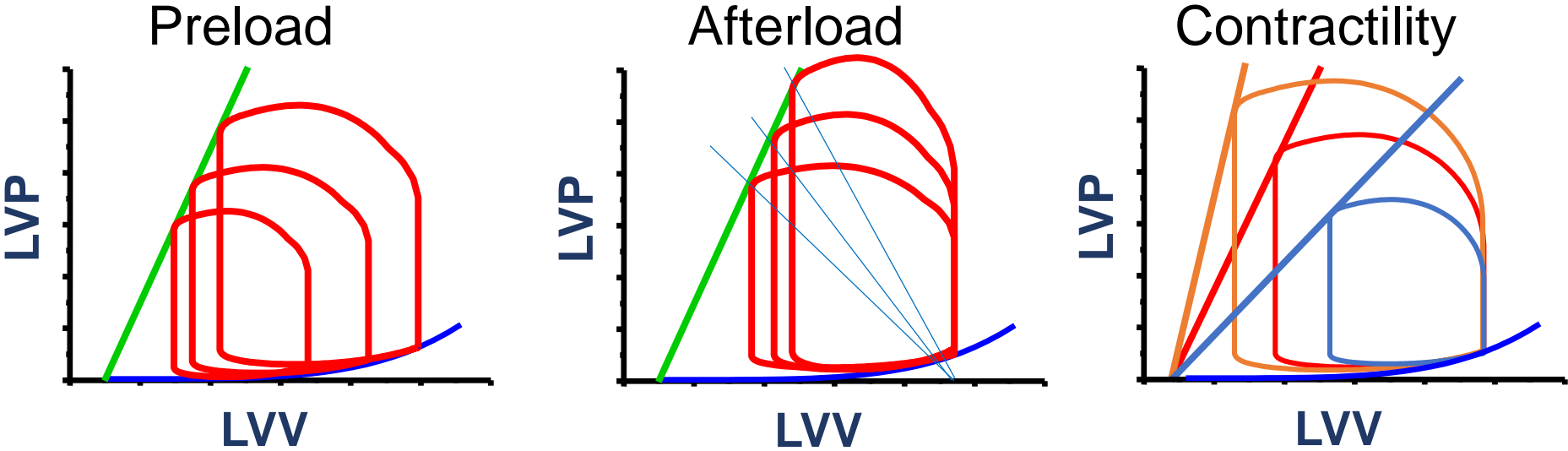
Ventricular Pressure-Volume Loop

End-Systolic Pressure-Volume Relationship

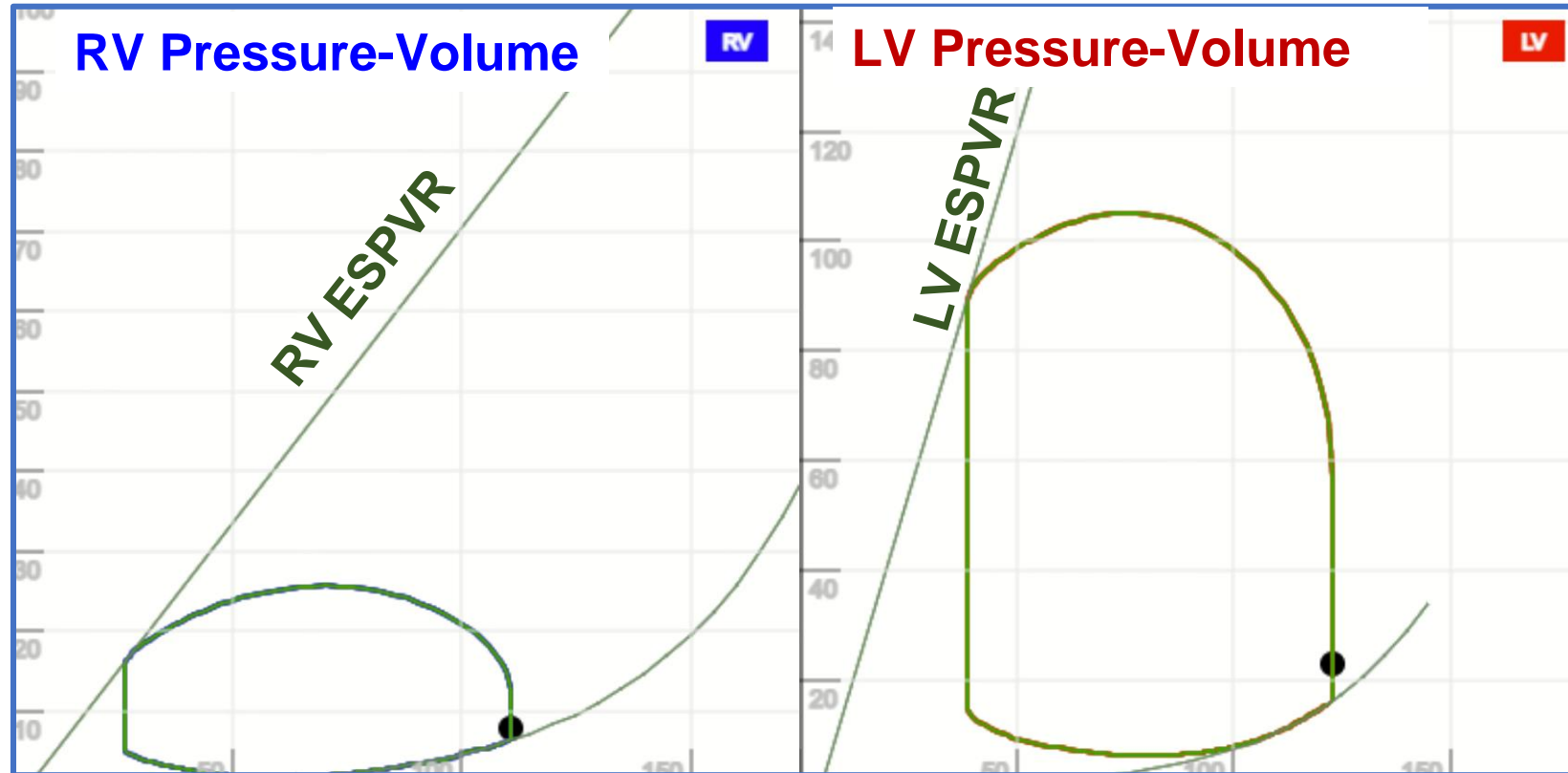
End-Diastolic Pressure-Volume Relationship



Ventricular-Vascular Coupling: Overview

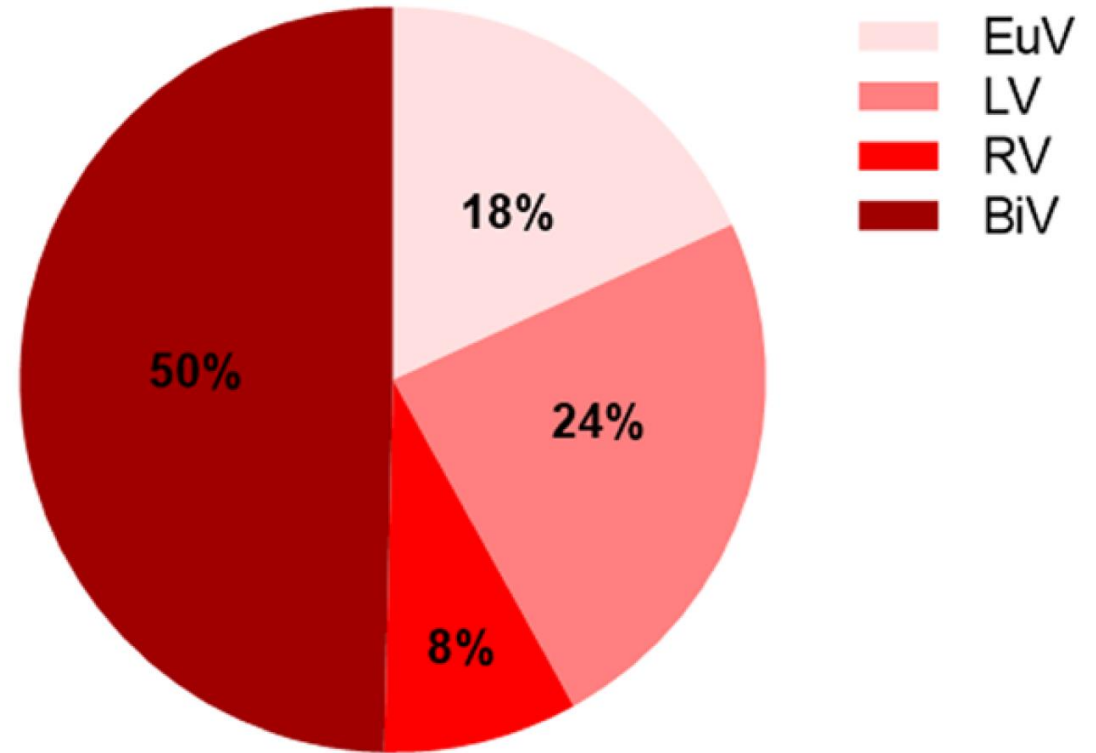
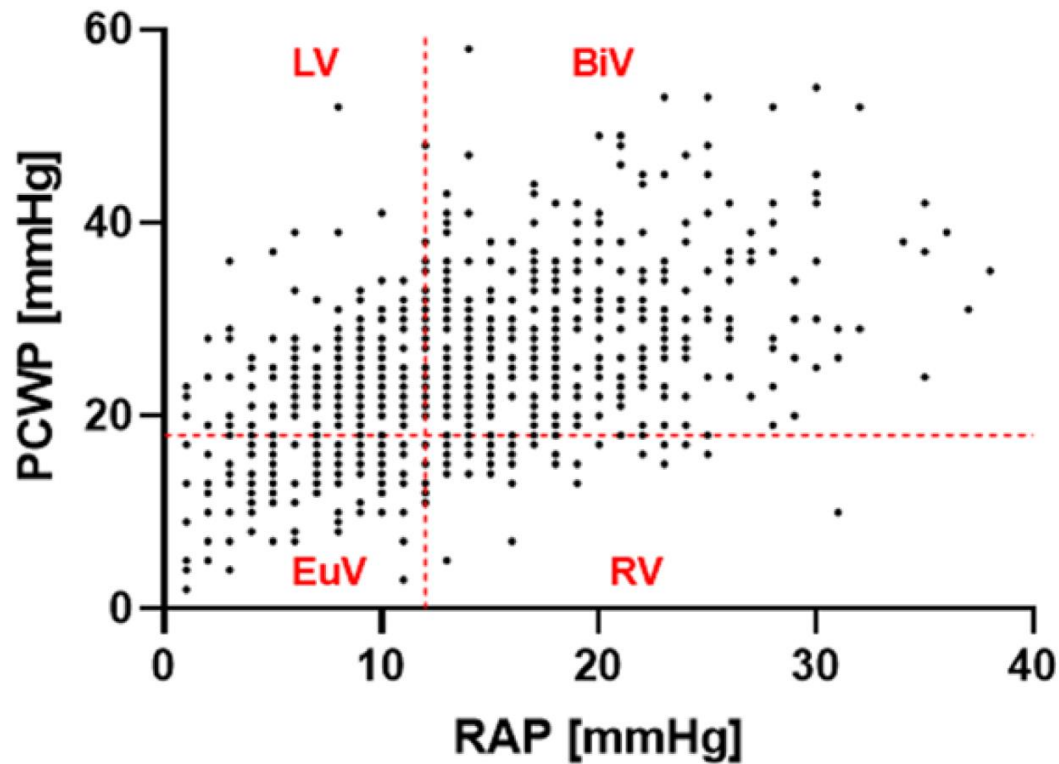


Pressure-Volume Relations in Shock due to Acute Biventricular Failure



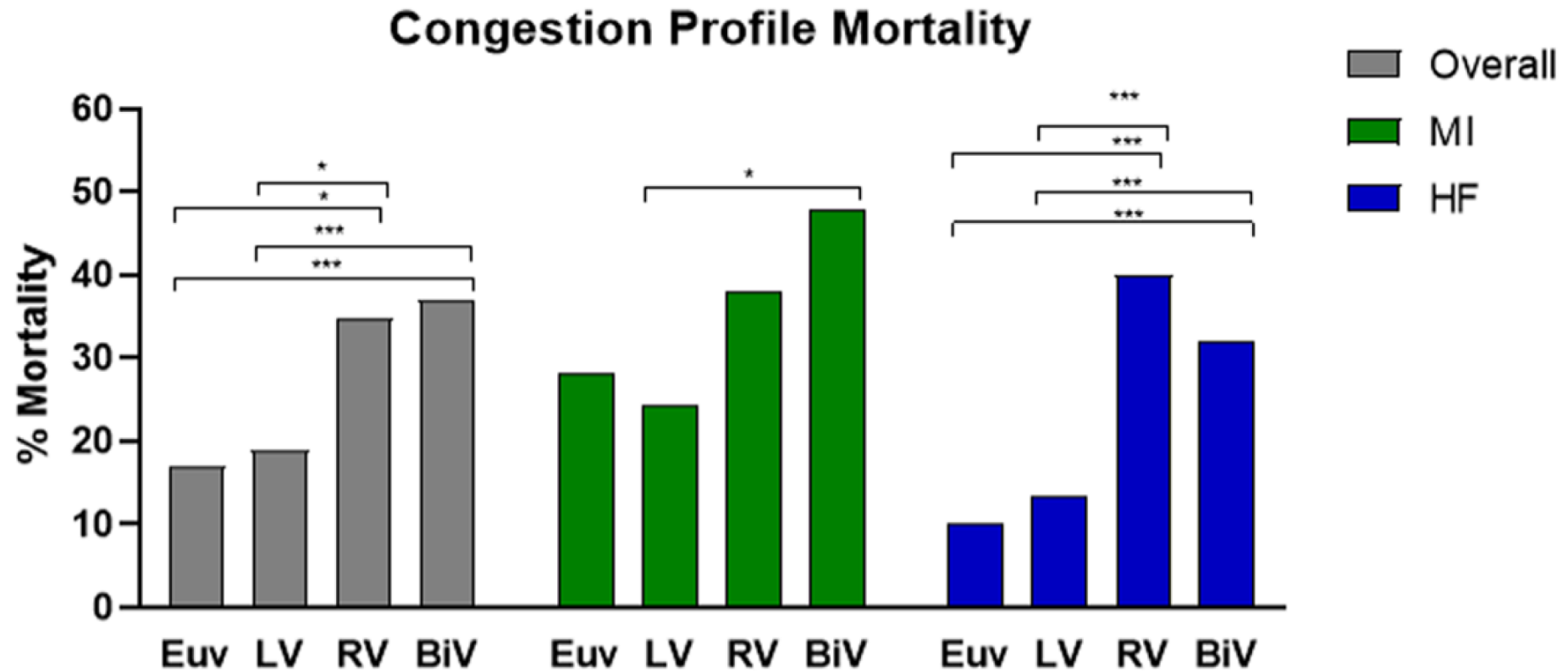
- Reductions of both LV and RV contractilities
- Decreased BP and CO
- Baroreceptor activation increases HR, SVR and stressed blood volume
- Variable changes of CVP and PCWP

Invasive Hemodynamic Assessment and Classification of In-Hospital Mortality Risk Among Patients With Cardiogenic Shock

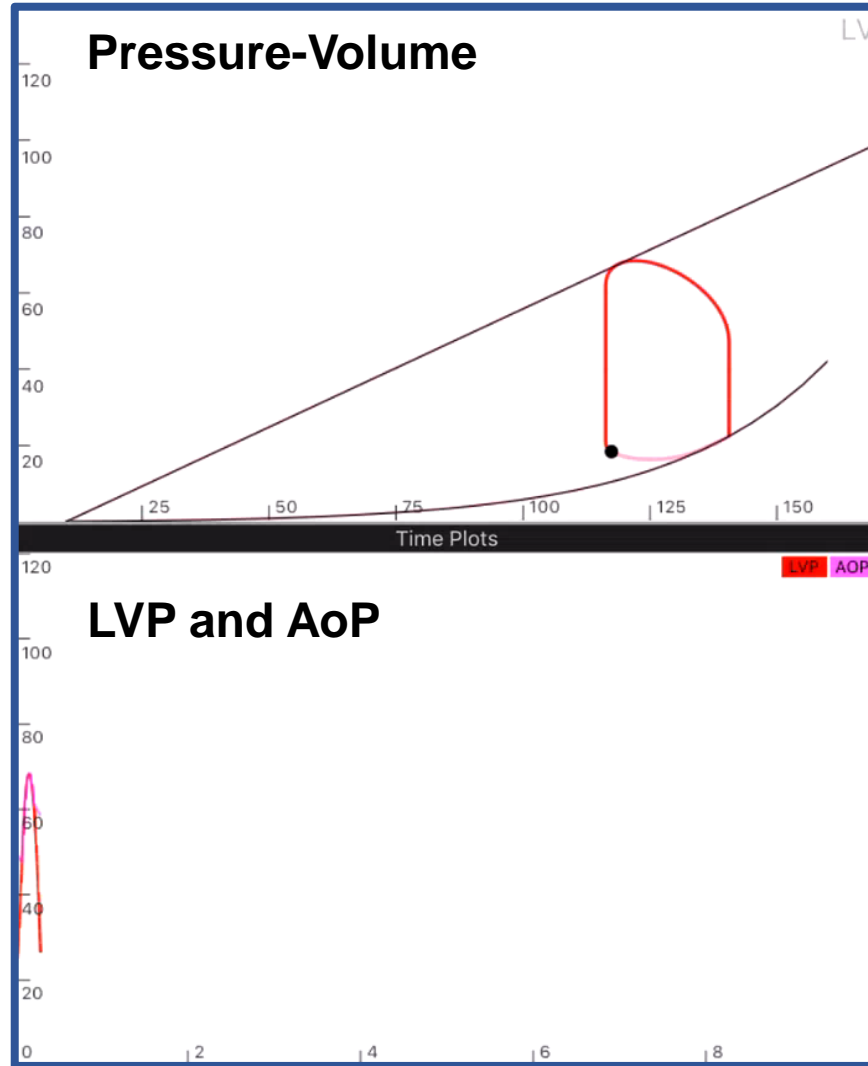
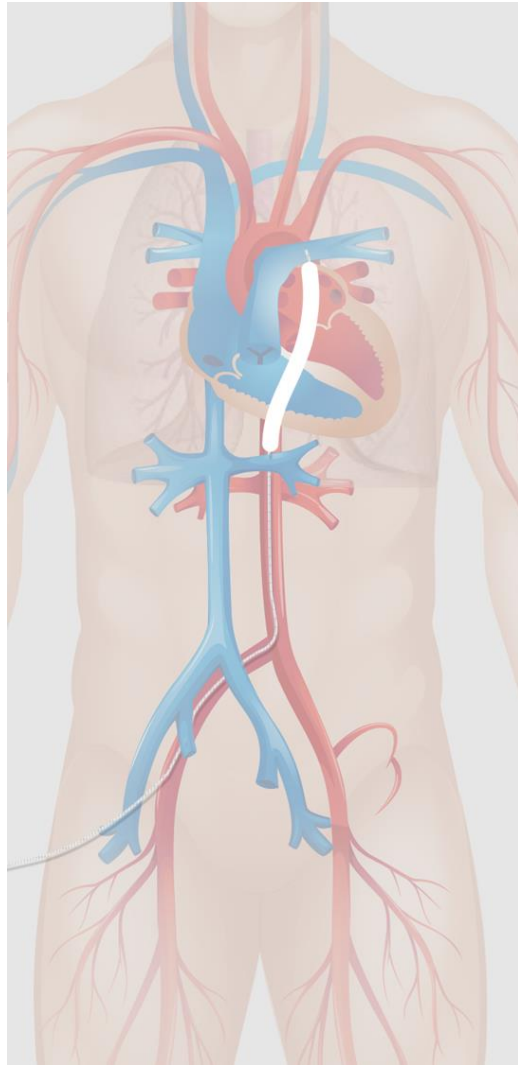


Total=782

Invasive Hemodynamic Assessment and Classification of In-Hospital Mortality Risk Among Patients With Cardiogenic Shock

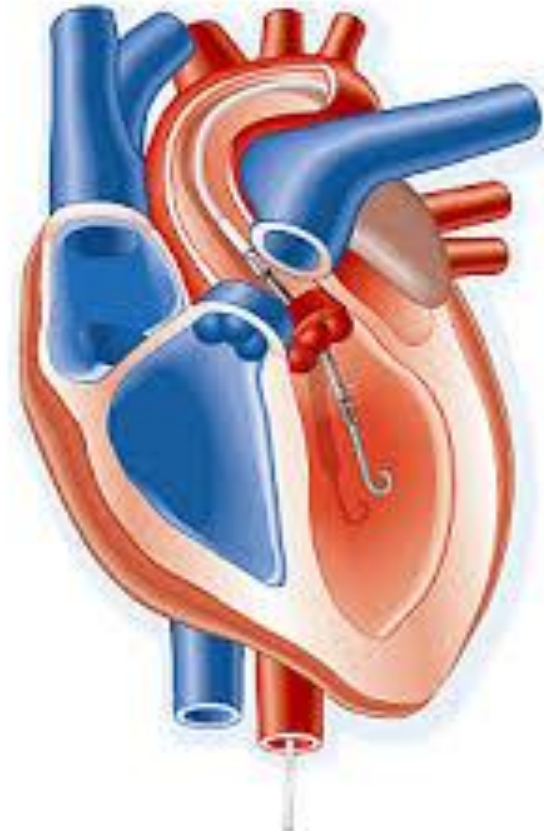


Impact of IABP in CGS



Small ↓PCWP
Small ↑CO

Percutaneous Transvalvular Pumps

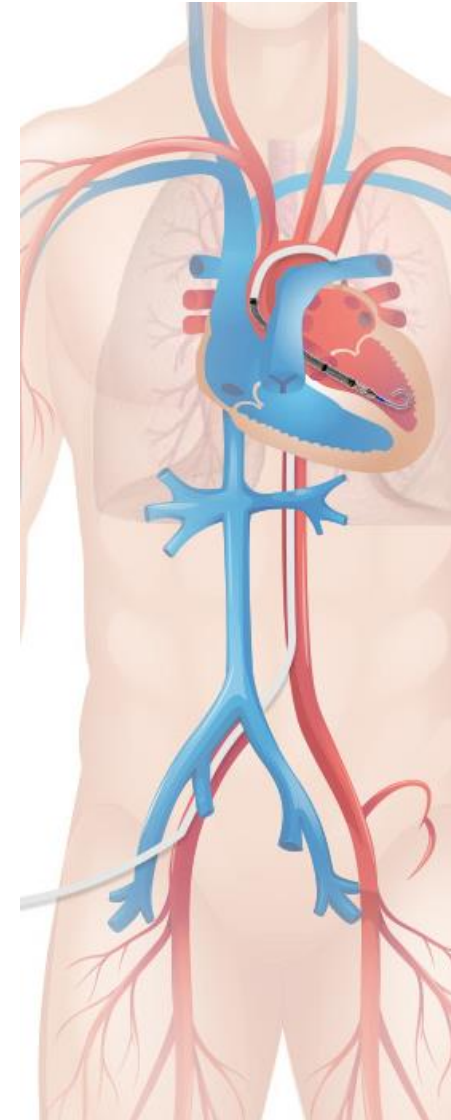
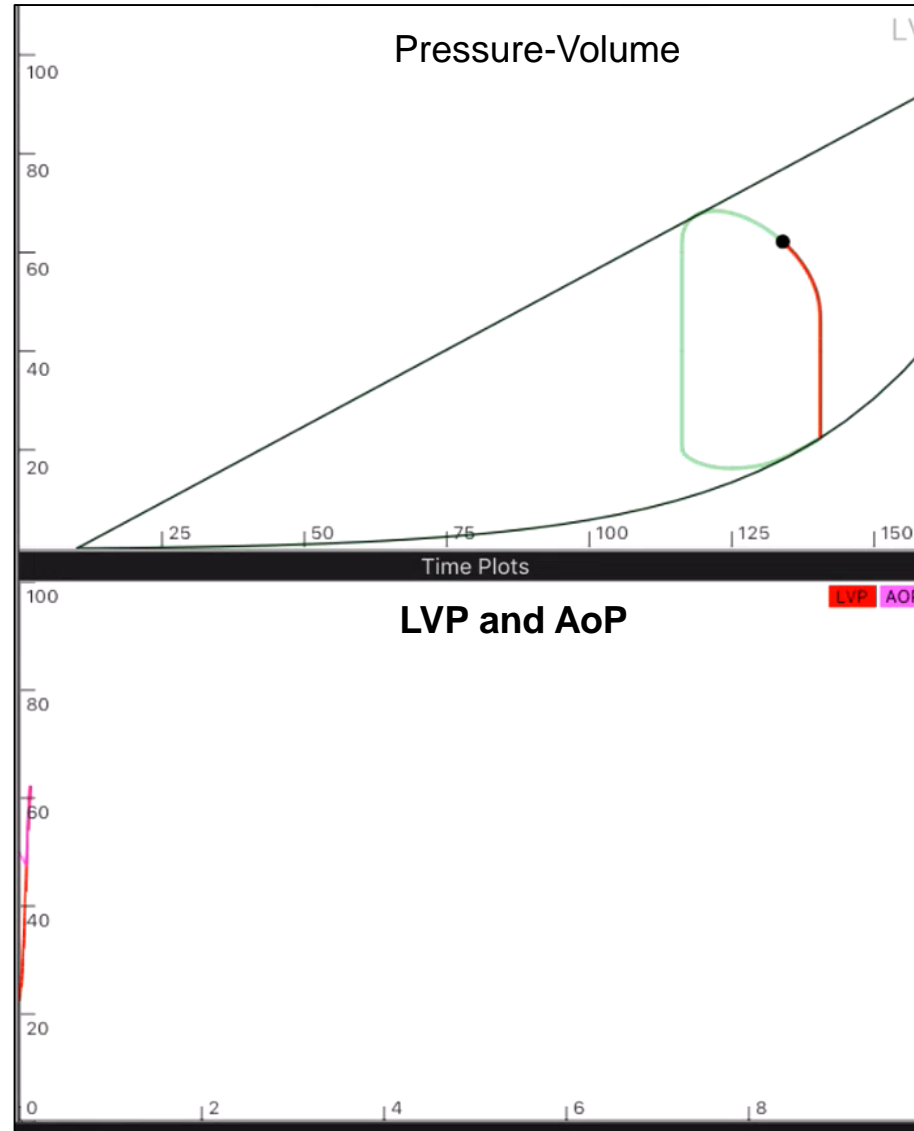


**Impella Family of Devices
2.5/4.0/5.0/RP**

Impact of LV→Ao MCS on Hemodynamics and Energetics

↓ Peak LVP
↓ Preload

↑ AoP
↓ LVP
LV-Ao
Uncoupling

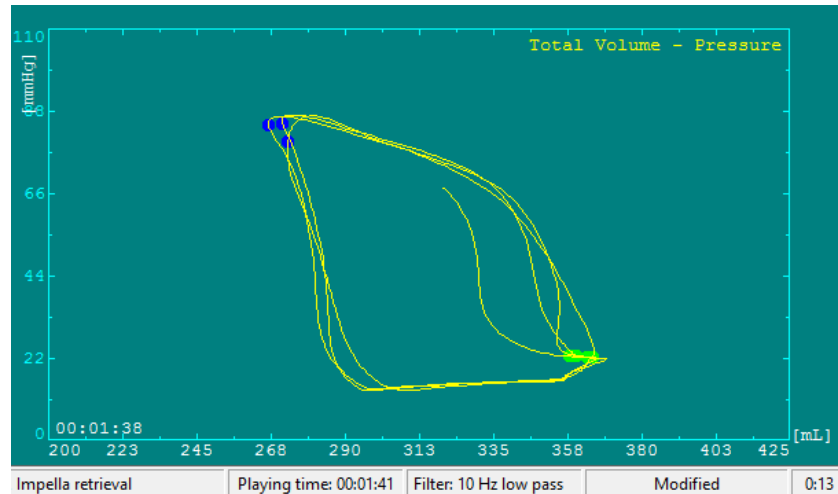


HRPCI under IMPELLA support

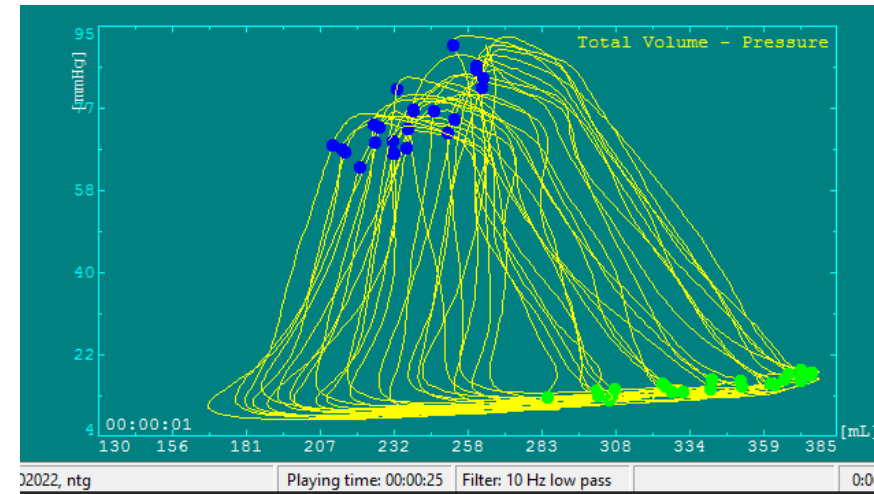
Courtesy of William O'Neill

REAL PV Loops assume triangular shape during LVAD Support

Impella Removed from LV

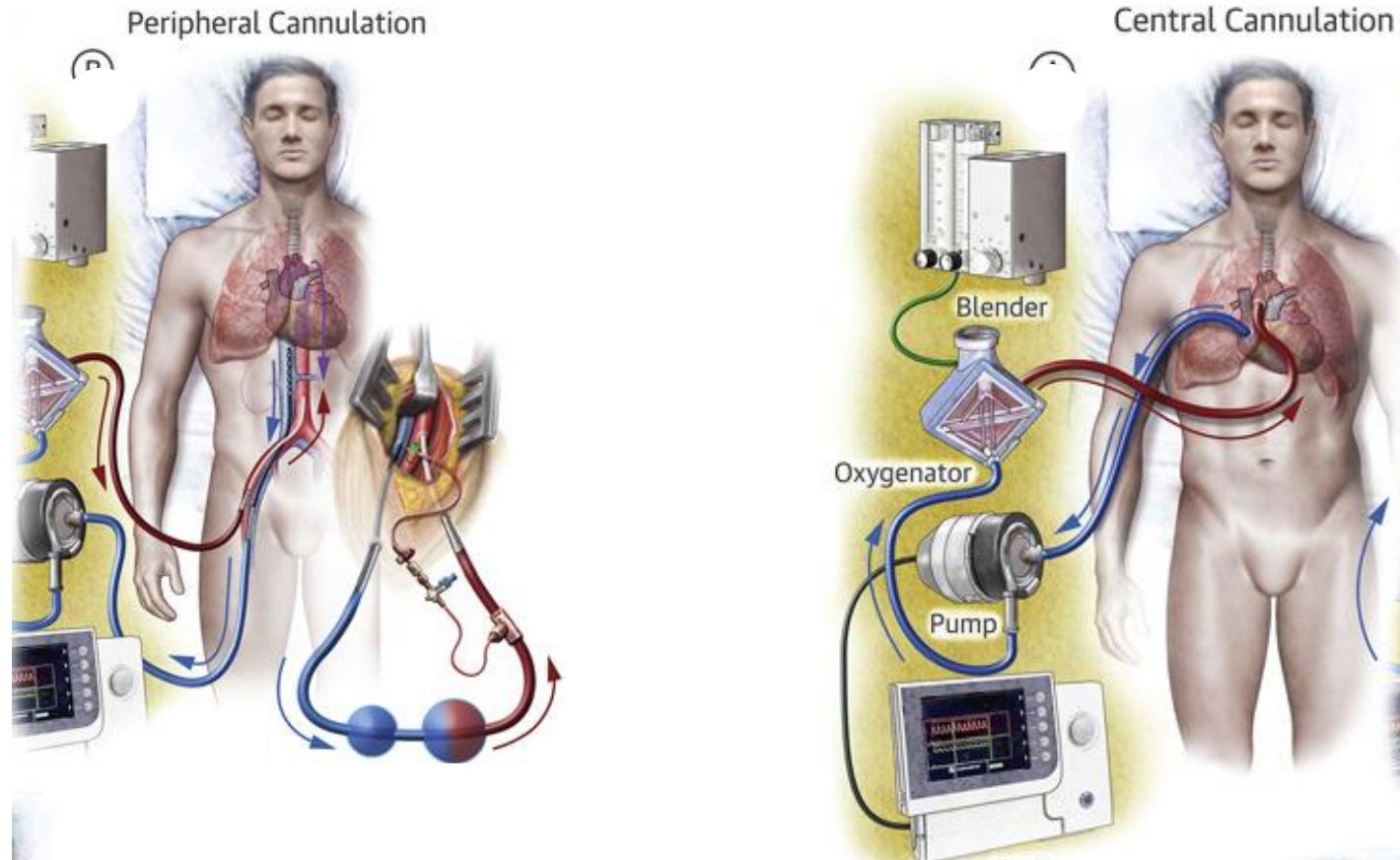


PV Loops during Impella support and NTG injection



VA-ECMO

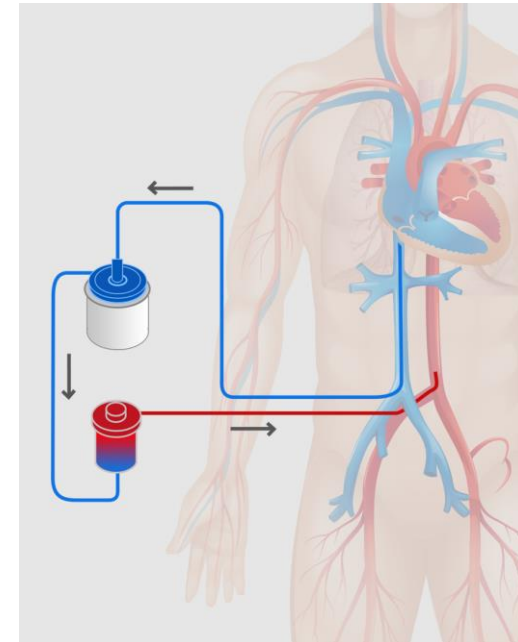
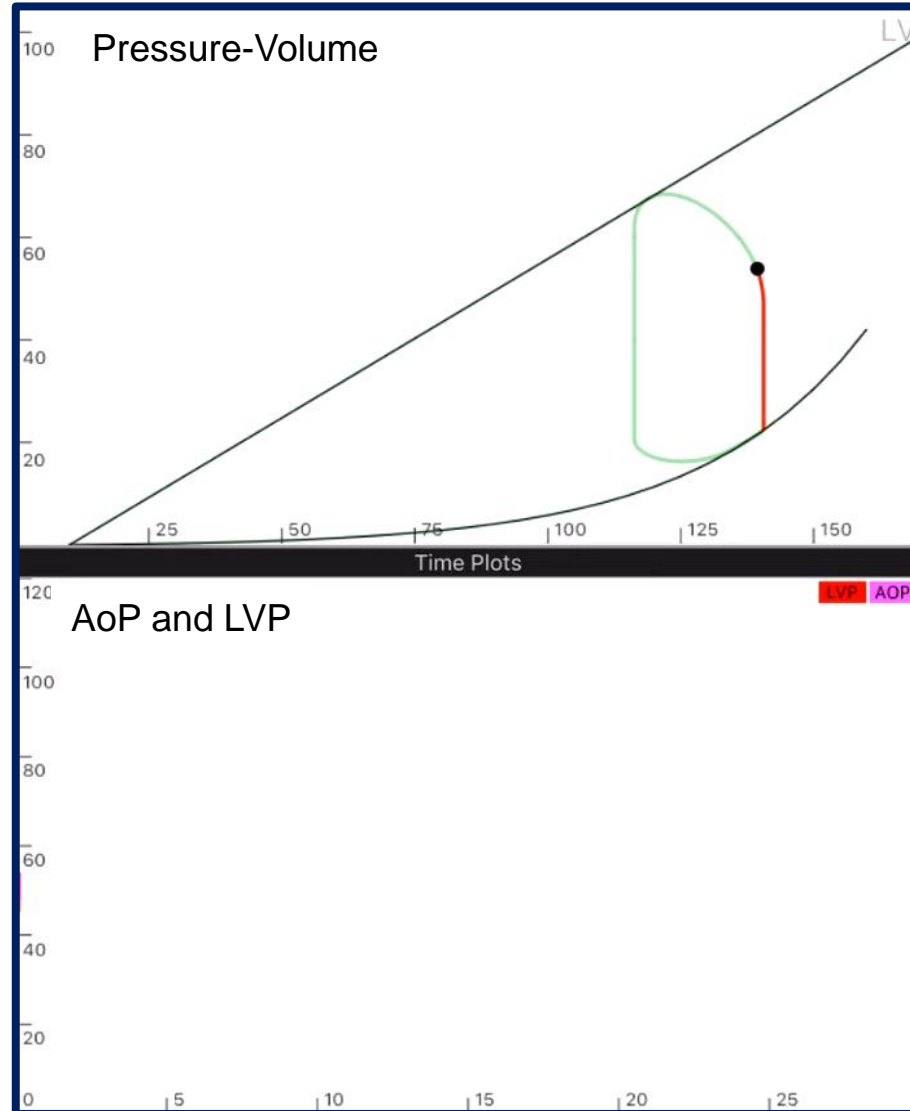
RA→FA or RA→Ao



Venoarterial Extracorporeal Membrane Oxygenation in Cardiogenic Shock.
Keebler ME et al, JACC Heart Fail. 2018

Impact of RA→Ao MCS (ECMO) on Hemodynamics and Energetics

↑ Afterload
↑ Preload



Patient on ECMO

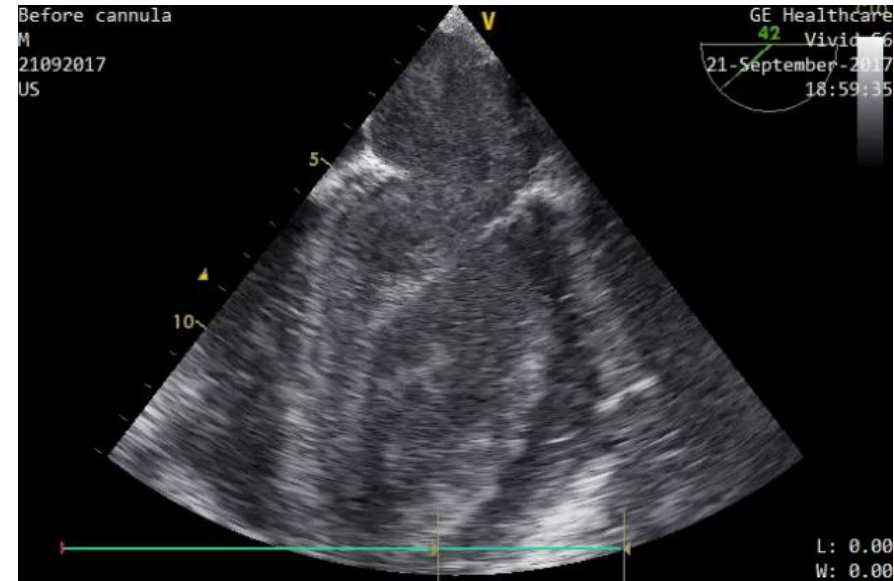
Courtesy of Dr Sal Monnino



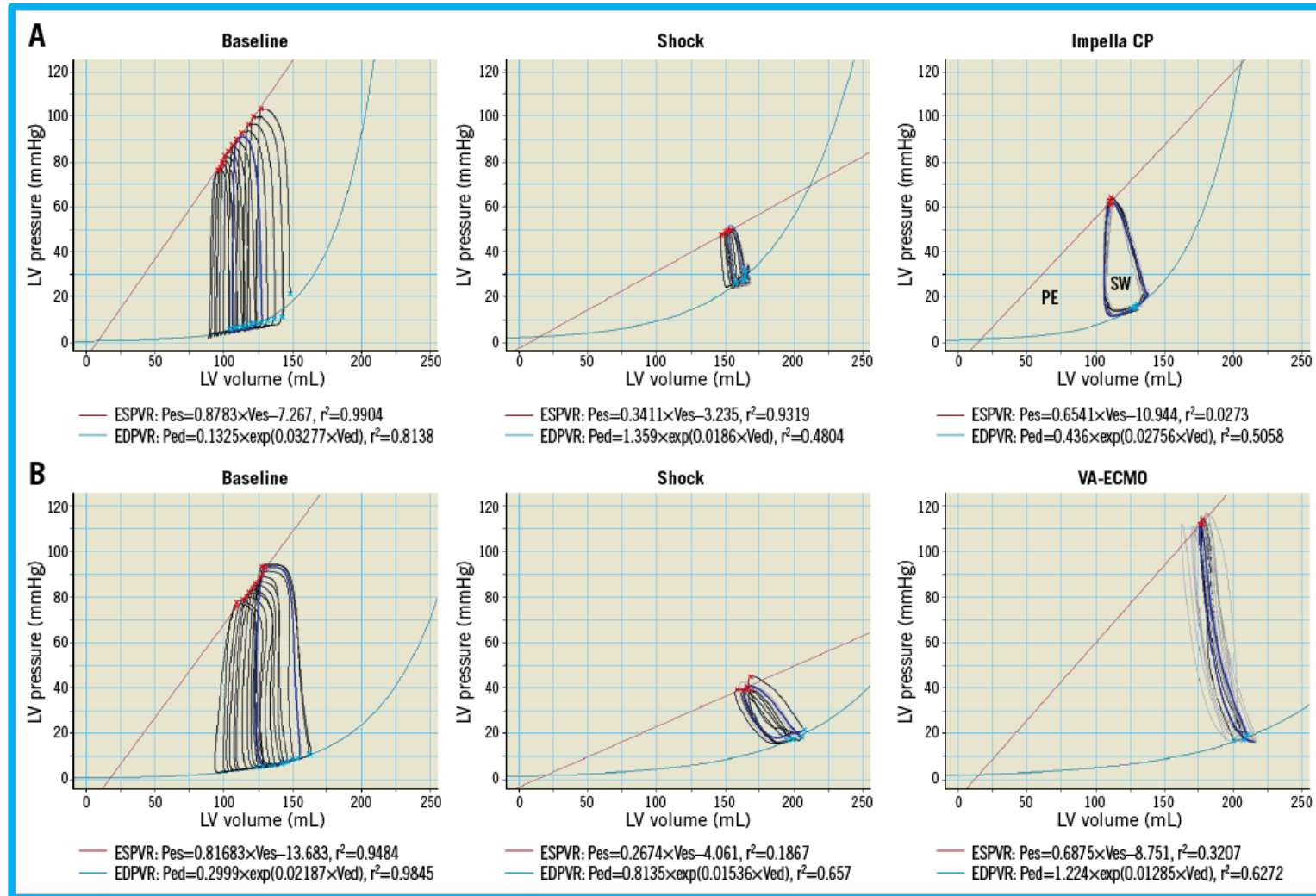
LV Distention and Pressure Overload during ECMO Support

- Loss of aortic valve opening
- Lung edema
- Bronchial bleeding
- LV thrombosis

Curtesy of Dr. Jiri Maly, IKEM, Prague



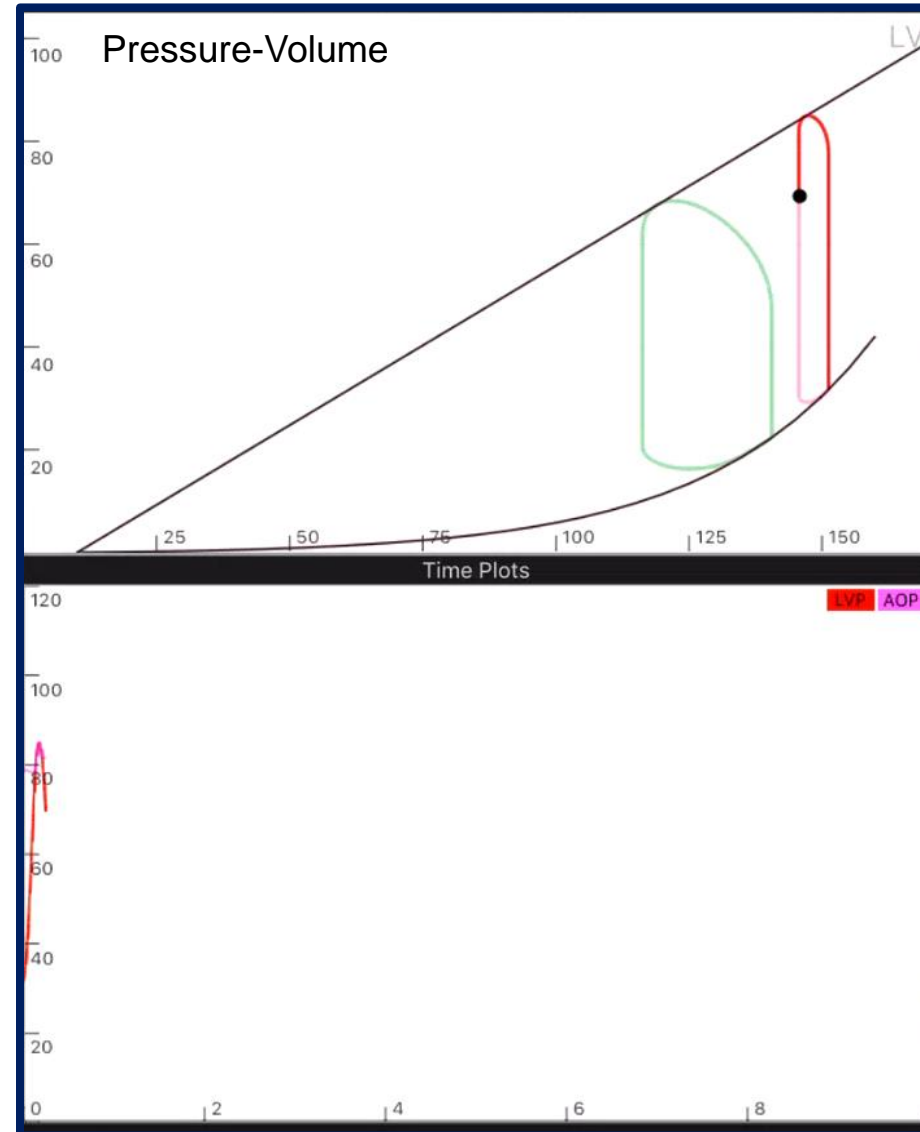
Impella CP or VA-ECMO in Profound Cardiogenic Shock



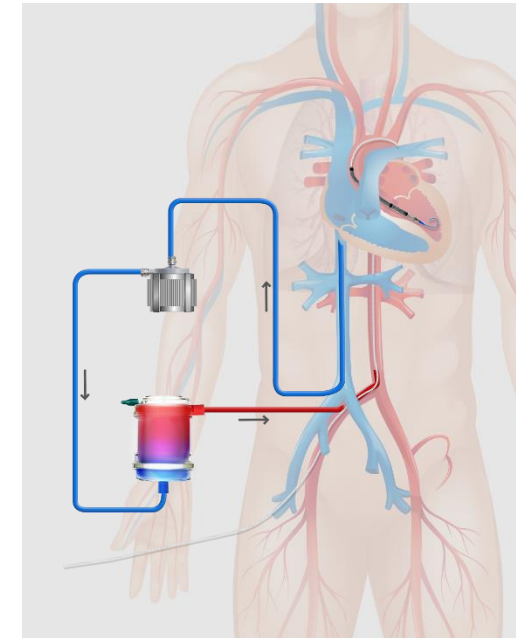
Møller-Helgestad et al.
 EuroIntervention 2019;14:e1585-e1592

RA→Ao MCS + LV→Ao MCS

↑ Afterload
↑ Preload

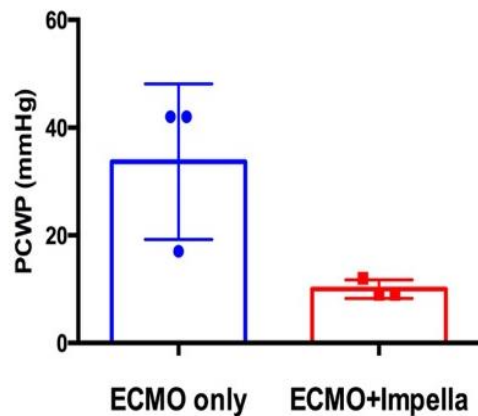


AoP
LVP

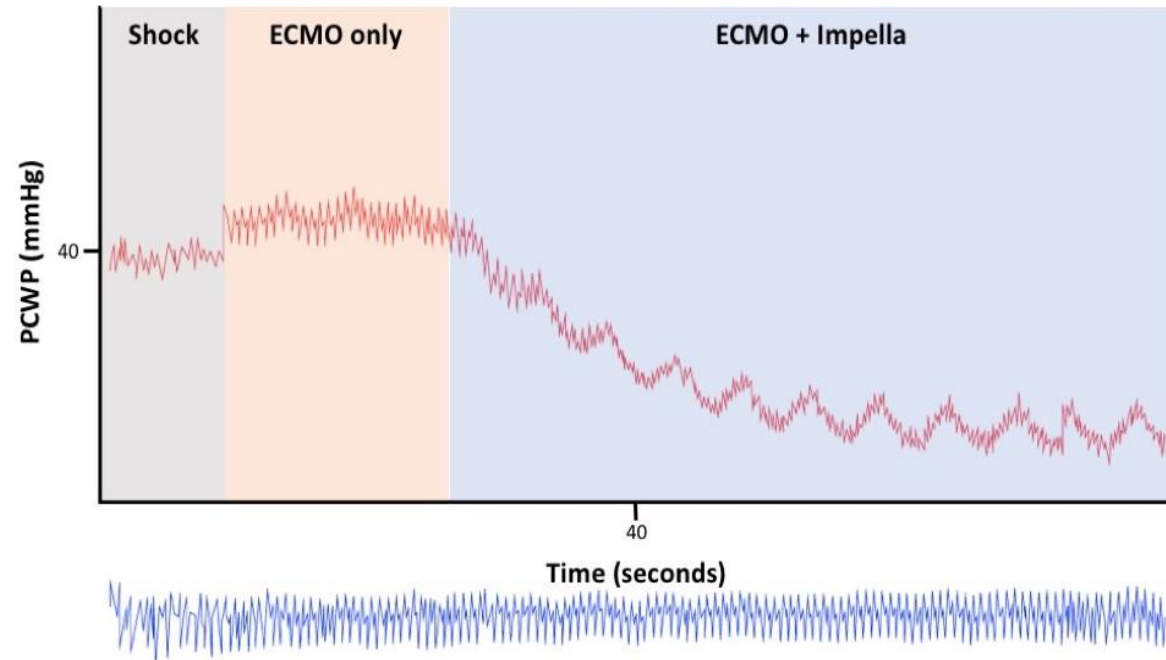


Rapid and Marked Reduction of PCWP with Impella added to ECMO

A



B



Schrage et al, JACC:HF, in press

Summary

- 1. Understanding cardiac physiology in the framework of the ventricular PV domain helps explain the hemodynamics of CGS and therapeutics**
 - a. IABP**
 - b. ECMO**
 - c. Percutaneous LVAD**
- 2. VA ECMO has the potential to increase the load on the LV and reduce AoV opening (LV and Ao root stasis)**
- 3. Impella directly unloads the LV and provides increased systemic pressure and flow**
- 4. Impella can counteract the loading effect of ECMO**

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