Penn State College of Medicine
Continuing Education

Update in Advanced Heart Failure Therapies: A Multidisciplinary Approach

November 21, 2025

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Cardiogenic Shock and ECMO

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Heart and Vascular Intensivist
Adult ECMO/MCS Specialist

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Financial Disclosures

- None
- Have a bichon and wife so working on it

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Objectives

- Cardiogenic Shock
  - Definition
  - Causes
  - Goals of Treatment
- Mechanical Circulatory Support
  - IABP
  - Impella
  - VA ECMO
  - ECPELLA

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Cardiogenic Shock

ORIGINAL ARTICLE

Early Revascularization in Acute Myocardial Infarction Complicated by Cardiogenic Shock

Judith S. Hochman, M.D., Lynn A. Sleeper, Sc.D., John G. Webb, M.D., Timothy A. Sanborn, M.D., Harvey D. White, D.Sc., J. David Talley, M.D., Christopher E. Buller, M.D., Alice K. Jacobs, M.D., James N. Slater, M.D., Jacques Col, M.D., Sonja M. McKinlay, Ph.D., Michael H. Picard, M.D., et al., for the SHOCK Investigators*

- Definition: In SHOCK Trial
  - SBP < 90 or MAP < 30 below baseline
  - CI < 1.8 without support (2.2 with support)
  - LVEDP > 18 or RV EDP > 10

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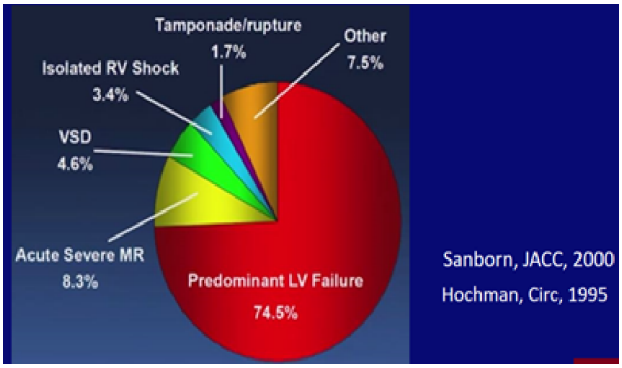
Causes Cardiogenic Shock



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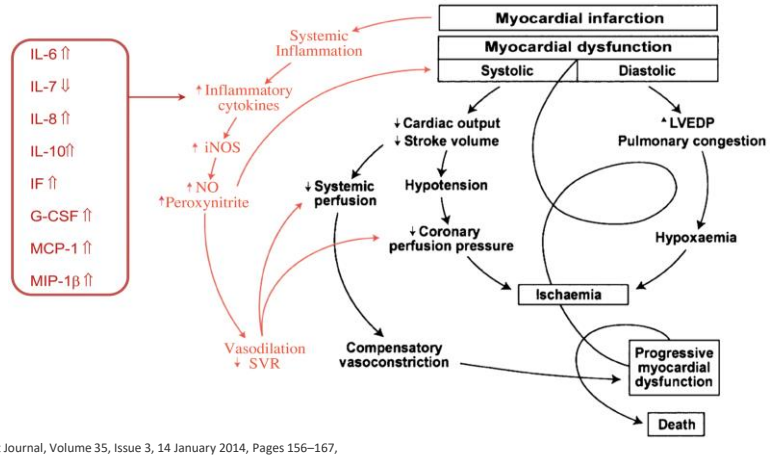
Pathophysiology



European Heart Journal, Volume 35, Issue 3, 14 January 2014, Pages 156–167,

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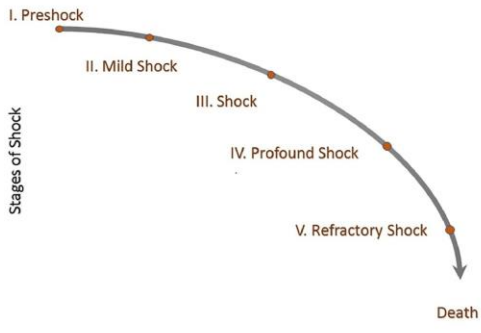
Pathophysiology



I. Preshock-Worsening Heart Failure: Diuretics/Inodilators

II. Mild Shock-Hypotension: Inotropes/Vasopressors+/-IABP, Impella CP

III. Shock-Lactic Acidosis, Tissue Hypoperfusion: Tandem Heart, Impella 5.0, CentriMag, RotaFlow, ECMO

IV. Profound Shock-End Organ Failure: CentriMag, RotaFlow, ECMO

V. Refractory Shock-Vasodilation, Multiorgan Failure, Refractory Hypotension: Assess for futility of Care

Bellunkonda Am Journal Cardiology 2018 122:6 1104-1110

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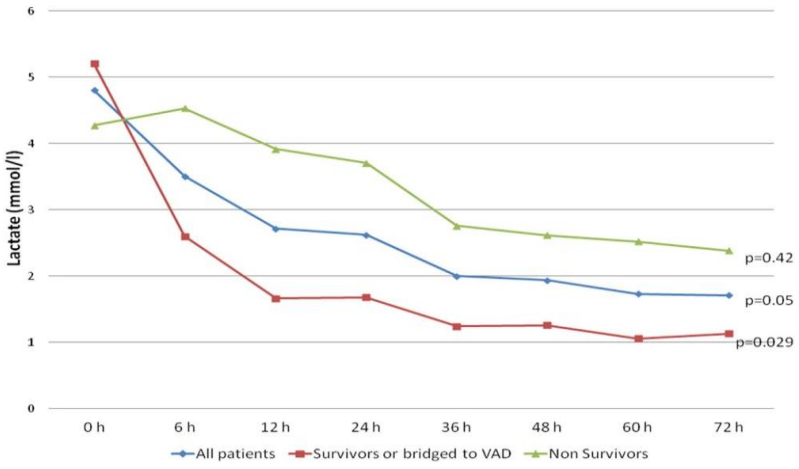
Goals of Treatment



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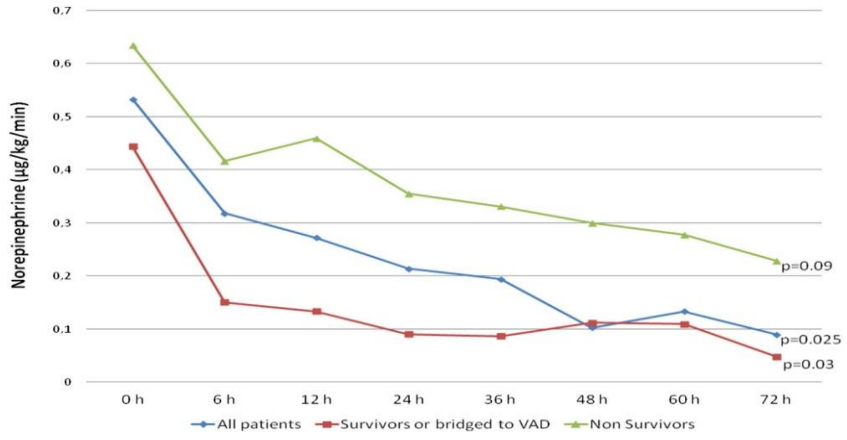
Get off the drugs



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Mechanical Circulatory Support

IABP

Impella

ECMO

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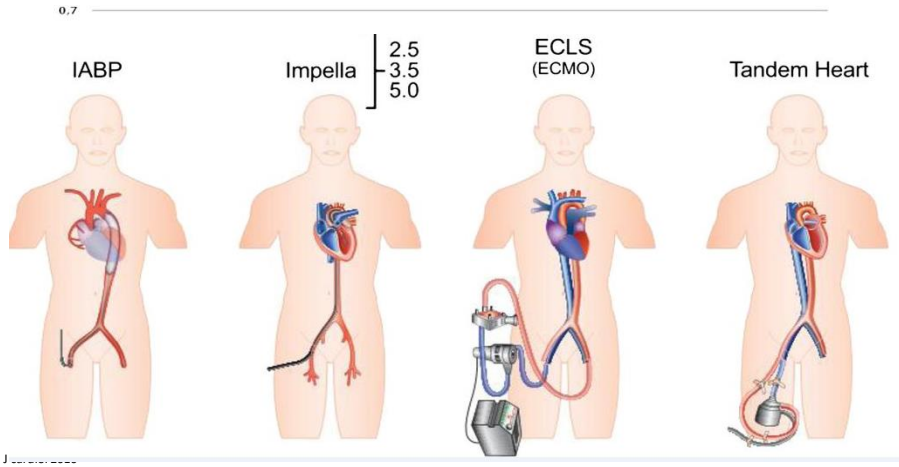
Types of Circulatory Support Devices



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The MCS Details

Comparison of devices

	IABP	ECMO	TandemHeart	Impella 2.5	Impella 5.0
Pump mechanism	Pneumatic	Centrifugal	Centrifugal	Axial flow	Axial flow
Cannula size	7.9 Fr	18–21 Fr inflow;15–22 Fr outflow	21 Fr inflow; 15–17 Fr outflow	13 Fr	22 Fr
Insertion technique	Descending aorta via the femoral artery	Inflow cannula into the right atrium via the femoral vein, outflow cannula into the descending aorta via the femoral artery	21 Fr inflow cannula into left atrium via femoral vein and transseptal puncture and 15–17 Fr outflow cannula into the femoral artery	12 Fr catheter placed retrogradely across the aortic valve via the femoral artery	21 Fr catheter placed retrogradely across the aortic valve via a surgical cutdown of the femoral artery
Haemodynamic support	0.5 – 1.0 L min^{-1}	>4.5 L min^{-1}	4 L min^{-1}	2.5 L min^{-1}	5.0 L min^{-1}
Implantation time	+	++	+++	++	++++
Risk of limb ischaemia	+	+++	+++	++	++
Anticoagulation	+	+++	+++	+	+
Haemolysis	+	++	++	++	++
Post-implantation management complexity	+	+++	++++	++	++
Optional active cooling in post-cardiopulmonary resuscitation patients	No	Yes	(Yes)	No	No

ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pump; +, ++, +++, ++++, relative qualitative grading concerning time ('implantation time'), risk ('risk of limb ischaemia'), intensity ('anticoagulation', 'post-implantation management complexity'), and severity ('haemolysis'). Modified from Ouweneel and Henriques. [32]

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Intra-Aortic Balloon Pump

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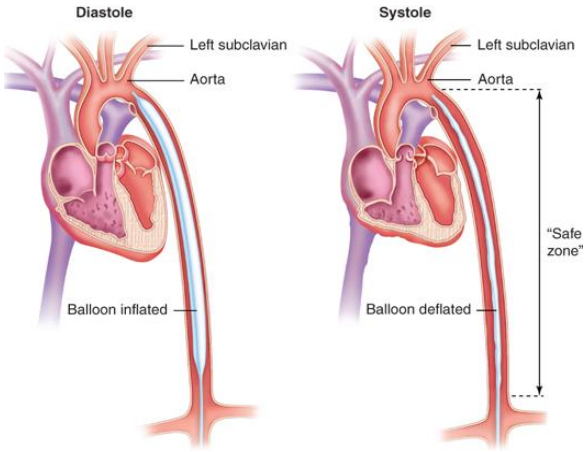
IABP



- Positioning important: Distal to left subclavian
- Helium Gas inflate/deflate
- Check positioning with TEE/CXR
- Total flow augmentation: 0.7L/min
- No oxygenator
- 9F catheter- less leg ischemia

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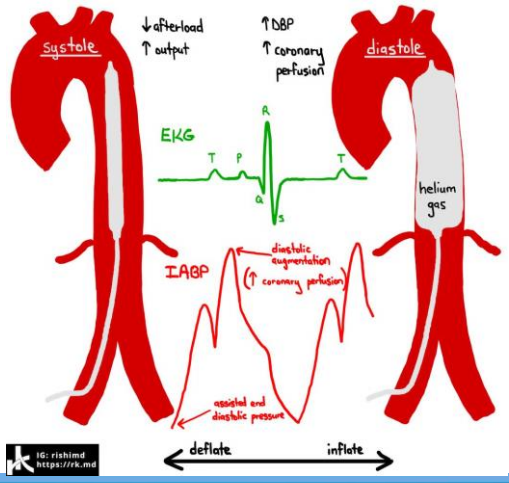
How it works



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Evidence- does it help?

Randomized Trials in CS w IABP

Author	Year	N	Pop	Random	Prim Endpoint	30d Mort IABP	30d Mort Other
Thiele	2005	41	Acute MI/CS	IABP v TH	Cardiac Power	45%	43%
Ohman	2005	57	Acute MI/CS	IABP v Med	30d Mort	27%	33%
Burkhoff	2006	33	Acute MI/CS	IABP v TH	Hemod	36%	47%
Seyfarth	2008	26	Acute MI/CS	IABP v Imp 2.5	CI	46%	46%
Prondzinsky	2010	45	Acute MI/CS	IABP v Med	APACHE II	36.8%	28.6%
Thiele	2012	600	Acute MI/CS	IABP v Med	30d Mort	39.7%	41.3%
Ouweneel	2017	48	Acute MI/CS	IABP v Imp CP	30d Mort	50%	46%

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Impella

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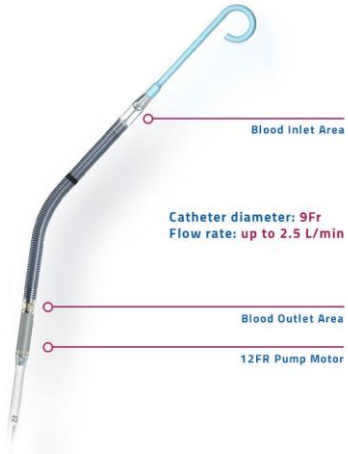
Impella



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Impella Facts

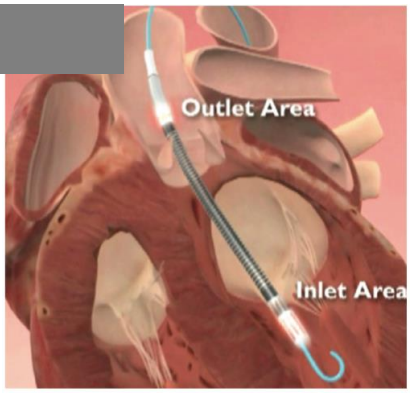

Figure 2. The Impella device: a motor drive in the device rotates at a maximum speed of 51,000 rpm, drawing blood out of the left ventricle through an inlet area and ejecting it into the ascending aorta beyond the end of the pump via the outlet.

- Rotates at 40-50,000 RPM
- 3 sizes- 2.5/CP(3.5)/5- flow between 2.5-5 L/min
  - Impella 5 needs surgeon
- To help off load LV
- No oxygenator
- Size 14F (IABP 9F)

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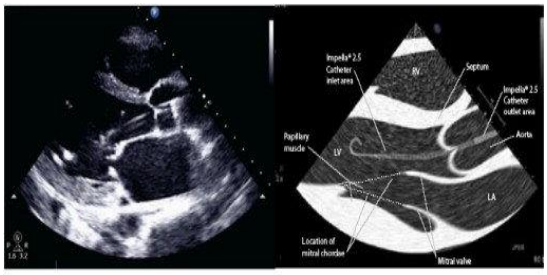
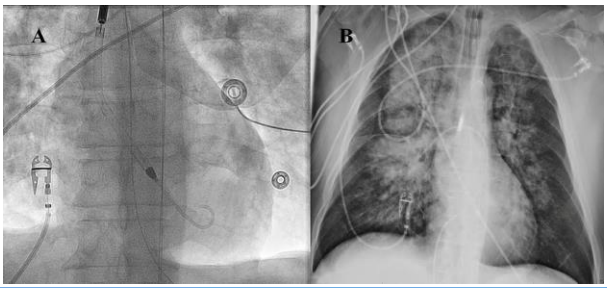
Impella Positioning



LV=left ventricle; LA= left atrium; RV= right ventricle

- Insertion requires cath lab
- Done via fluoroscopy or Echo or both
- Positioning can be temperamental
- Hemolysis can occur



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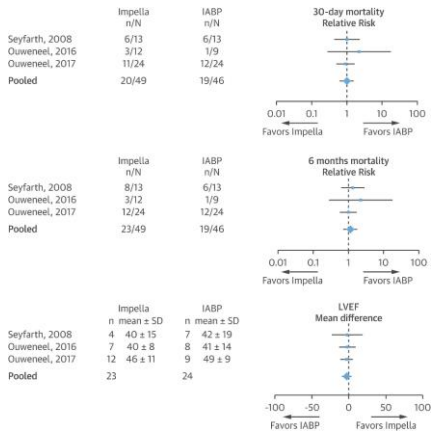
Is Impella better than IABP?



- In meta analysis: one not superior to other
- Relatively new product
- More widely used

Ouweneel; JACC 2017

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How about in Cardiogenic Shock?

- STEMI patients
- Standard care vs Impella CP placement
- 360 patients
- 180 day follow up

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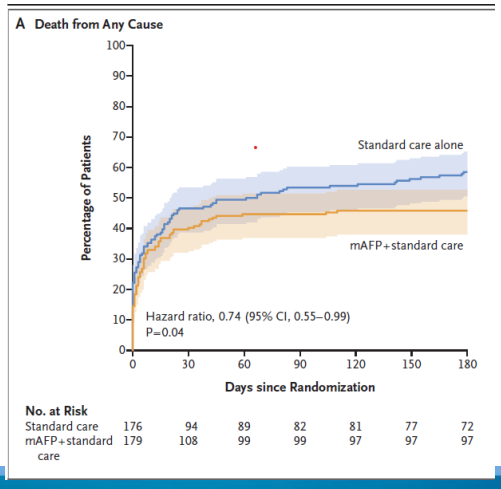
The results



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Other points

- Only in STEMI patients in Cardiogenic Shock
- Inclusion criteria: SBP < 100; lactate >2.5; EF < 45%
- 12% in Impella group and 19% in standard group had to go on ECMO
- 16% of Impella group had an escalation to another MCS device

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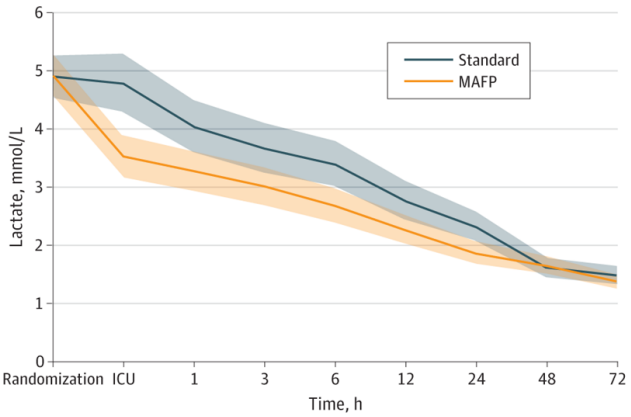
Subgroup analysis of STEMI and CS

Figure 4. Changes in the Arterial Lactate During Intensive Care After Infarct-Related Cardiogenic Shock in Patients Randomized To Microaxial Flow Pump (MAFP) or Standard of Care (Standard)



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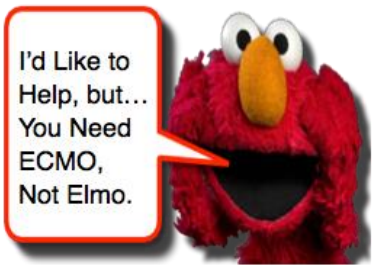

Peripheral Veno-Arterial ECMO

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Indications for ECMO

- Cardiac Failure
- Respiratory failure
- Biventricular failure
- CPR

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What does that mean?

- Every acute life threatening condition not responding to maximized medical management and are potentially reversible over time, could be an indication for ECMO

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Therefore:

- ECMO allows Support of Cardiac and/or Pulmonary systems, allowing time for treatment and recovery from underlying principle diagnosis
- **ECMO DOES NOT TREAT OR CURE THE UNDERLYING PROCESS**
- Helps prevent further end organ damage

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Causes that ECMO can help

- Acute MI
- CHF as a bridge
- ARDS
- Sepsis
- Trauma

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What is ECMO?

- 2 giant catheters placed in femoral artery and femoral vein
- It's a cardiopulmonary bypass machine in the ICU
- Venous blood drained from femoral vein→ to pump head→ to **oxygenator** (oxygen added/CO2 removed)→ Arterial blood returned to body via femoral artery
- The flow on the machine pump head is your cardiac output
- Goal is CI >2.2

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VA ECMO

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The machine

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How we insert it

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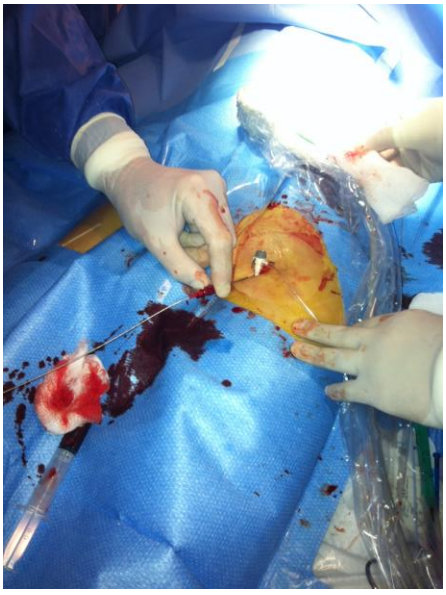

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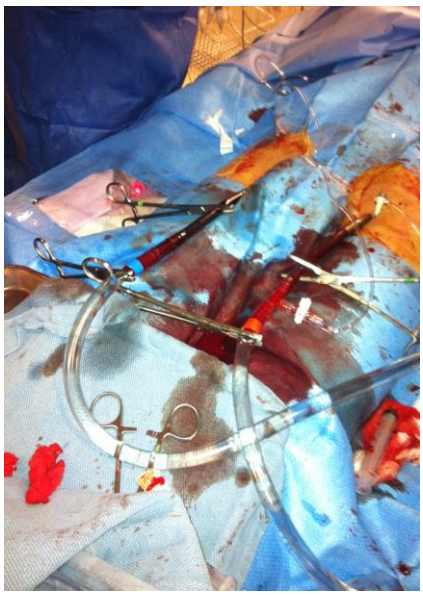

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The details

- Arterial Cannula 17-19 F (dialysis catheter 14F)
- Venous Cannula is 23-25F
- Flow 2-8 L/min
- Check plasma hgb and LDH for hemolysis

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What's the point?

- Give CO to help prevent progression of end-organ damage
- Provides CO to kidneys, liver, brain as we allow myocardium to recover
  - Stunned myocardium
  - Hibernating myocardium
  - Fluid overload
- If heart too sick it will not recover- think about other options

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Complications

- Bleeding
- Infection
- Lysis RBC
- Vessel Injury
- Death
- LV Overload
- **Limb ischemia**

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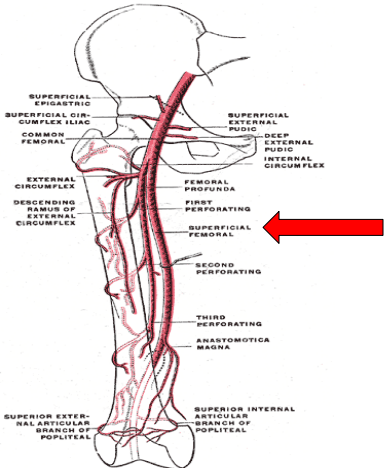
Limb Perfusion Cannula Positioning

- Goal : Superficial Femoral Artery



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Why we place perfusion cannula first!

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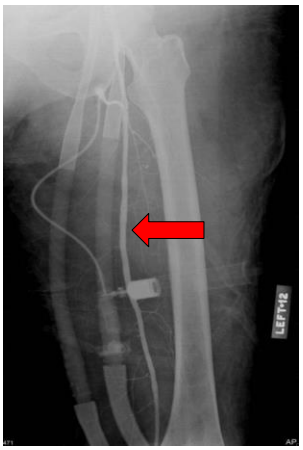
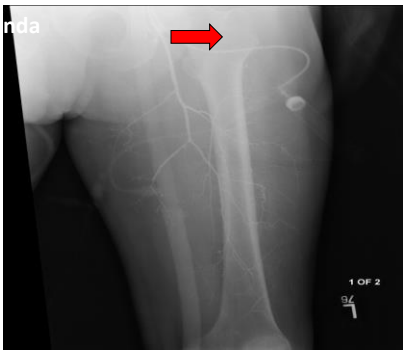
Perfusion Cannula Arteriogram





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ECPELLA

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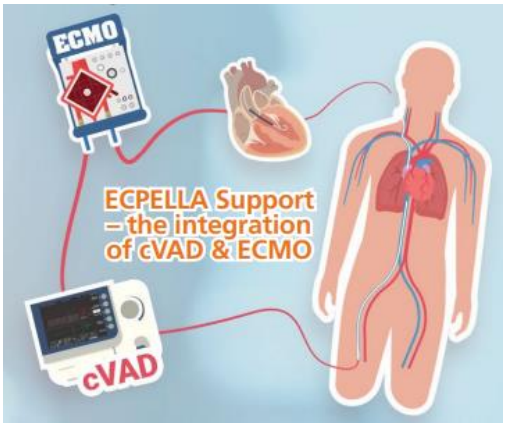
ECMO + Impella



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Evidence

- Analysis:
  - 438 patients from 4 international centers
  - 319 ECMO vs 119 ECMO + Impella
  - 30 day mortality was 49.5% (ECMO) vs 43.2% (ECPELLA)
  - 1 year survival 46.6% (ECMO) vs 51.3% (ECPELLA)

– Piperata A, Van den Eynde J, David CH, Akar AR, Watanabe M, Doulamis I, Piriou PG, Saricaoğlu MC, Ikenaga H, Gouttenegre T, Vourc'h M, Takahashi S, Ouattara A, Labrousse L, Frati G, Pernot M. ECMO Alone Versus ECPELLA in Patients Affected by Cardiogenic Shock: The Multicenter EVACS Study. ASAIO J. 2024 Nov 1;70(11):946-953.

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Evidence

- Meta Analysis:
  - 407 studies
  - 13,628 patients with 13,270 ECMO vs 412 ECPELLA
  - 30-day mortality: 55.8% (ECMO) vs 58.3% (ECPELLA)
  - Bleeding: 21.3% (ECMO) vs 33.1% (ECPELLA)

Iannaccone M, Venuti G, di Simone E, De Filippo O, Bertaina M, Colangelo S, Boccuzzi G, de Piero ME, Attisani M, Barbero U, Zanini P, Livigni S, Noussan P, D'Ascenzo F, de Ferrari GM, Porto I, Truesdell AG. Comparison of ECMO vs ECpella in Patients With Non-Post-Pericardiotomy Cardiogenic Shock: An Updated Meta-Analysis. Cardiovasc Revasc Med. 2022 Jul;40:134-141. doi: 10.1016/j.carrev.2021.10.001. Epub 2021 Oct 5. PMID: 34654655.

Other risks

- Meta Analysis
  - 1,054 patients with cardiogenic shock,
  - 391 were supported with ECPELLA (37%).
  - ECPELLA had a higher risk
    - hemolysis (RR 2.03 [1.60 to 2.57], I^2 = 0%, p <0.001)
    - renal failure requiring CRRT (RR 1.46 [1.23 to 174], I^2 = 11%, p <0.0001)
    - Limb Ischemia (RR 1.67 [1.15 to 2.43], I^2 = 0%, p = 0.01)

- Iskander B, et al. The use of Ecpella in cardiogenic shock, an umbrella meta analysis. Journal of cardiac Fialure; 30:1 Jan 2024;

So why use it

- Some evidence unloading LV will help with recovery in cardiogenic shock
- Must use to vent LV in pulmonary edema caused by peripheral VA ECMO
- Can place limb perfusion cannula on Impella side

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Evidence

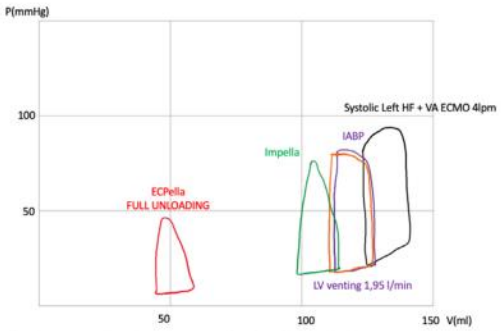

Fig 4. LV venting techniques and related pressure-volume loops. In case of cardiac failure (shock or arrest), ECPella provides full left ventricle unloading. In ECPella configuration, the pressure-volume loop moves leftward and becomes triangular.

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REVIEW

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Review- cardiogenic shock

- CI < 2.2 on ionotropes
- Get lactate down
- Get off vasopressors and ionotropes
- Prevent advancement of shock
- Preserve other organ function
- MCS

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IABP

- 9 F catheter- less leg ischemia
- < 1 L/min cardiac output
- No oxygenator
- Not helpful for severe shock

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Impella

- 14 F catheter
- Positioning in cath lab
- 2.5-5 L/min cardiac output (Impella 5 needs surgeon)
- Only for isolated LV failure
- No oxygenator
- Positioning temperamental
- Hemolysis

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VA ECMO

- For biventricular failure and respiratory failure
- Full heart and lung support
- **Oxygenator**
- Can be done at bedside
- Prevents end-organ damage as heart/lung heals
- Reperfusion cannula for leg ischemia

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VA ECMO + Impella

- More bleeding risk
- Higher rates CRRT
- Could be beneficial in recovery of myocardium
- More studies needed

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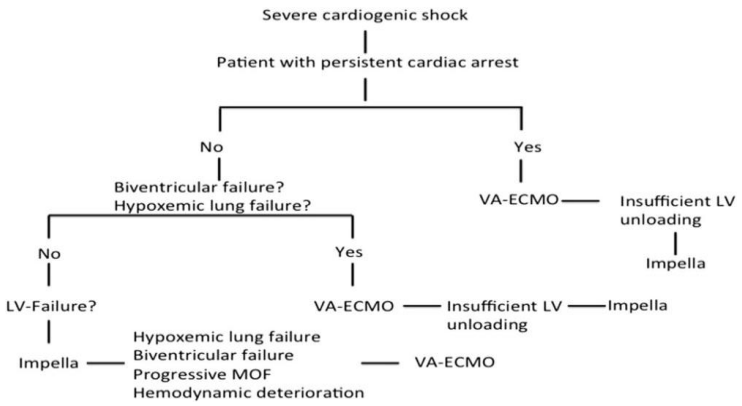
Pathway



Thiele N Engl J Med 2017

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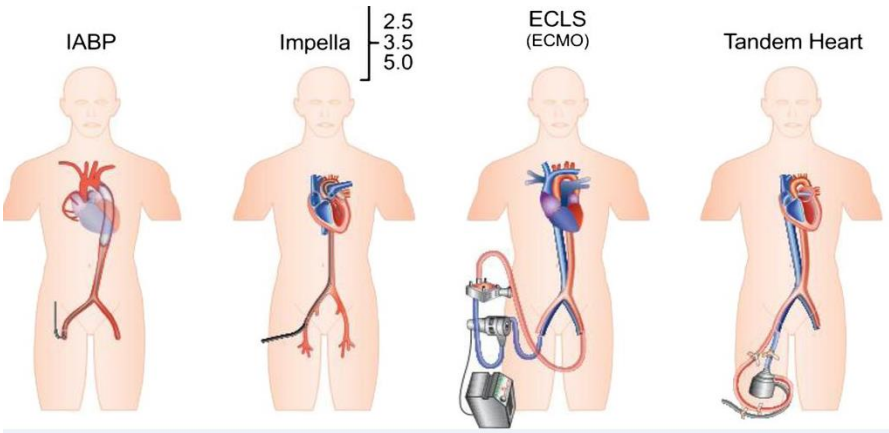
Different Devices



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Anticoagulation	+	+++	+++	+	+
Haemolysis	+	++	++	++	++
Post-implantation management complexity	+	+++	++++	++	++
Optional active cooling in post-cardiopulmonary resuscitation patients	No	Yes	(Yes)	No	No

ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pump; +, ++, +++, ++++, relative qualitative grading concerning time ('implantation time'), risk ('risk of limb ischaemia'), intensity ('anticoagulation', 'post-implantation management complexity'), and severity ('haemolysis'). Modified from Ouweneel and Henriques.[32]

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