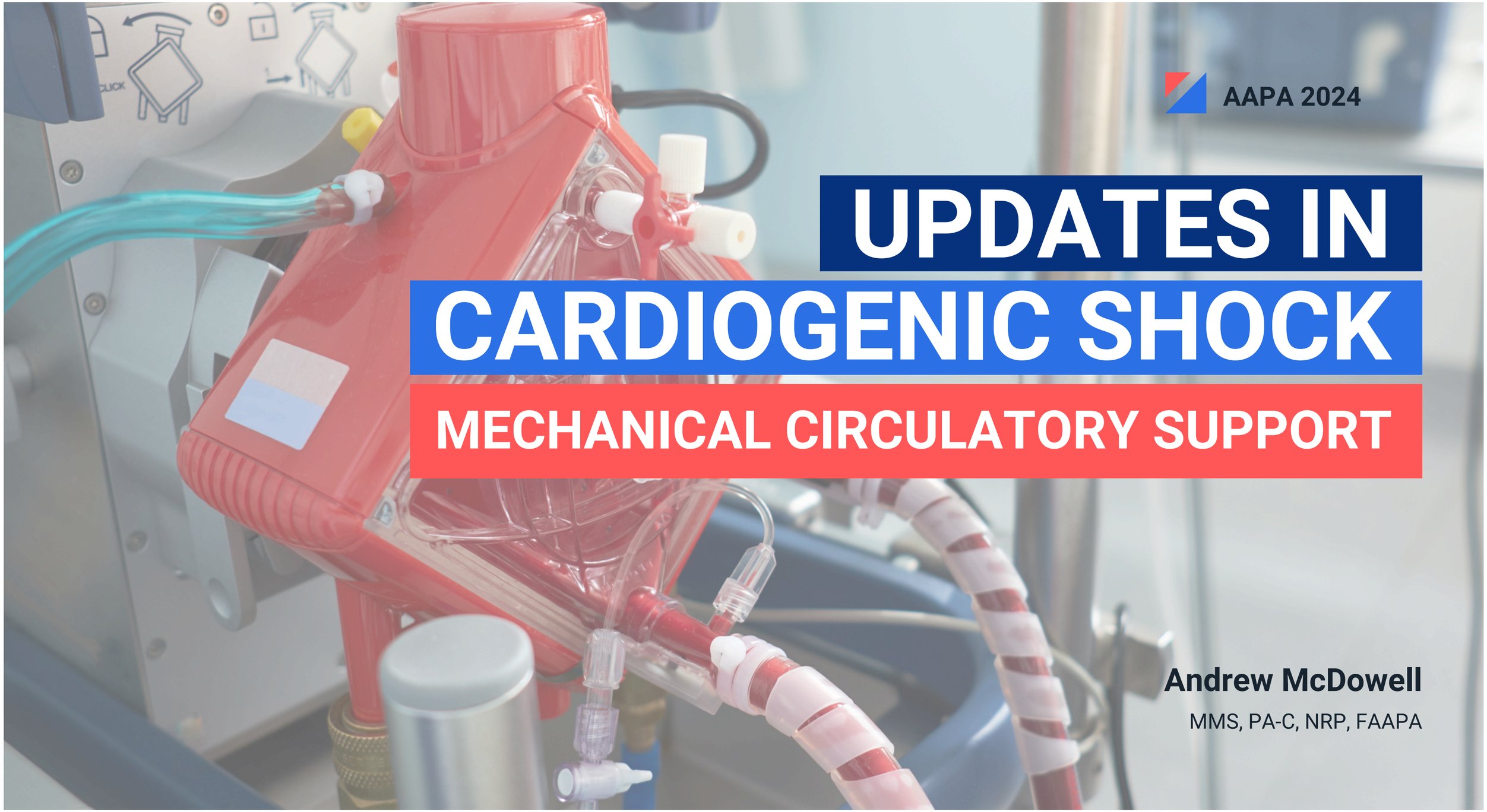

AAPA 2024

UPDATES IN CARDIOGENIC SHOCK

MECHANICAL CIRCULATORY SUPPORT

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INTRODUCTION TO CARDIOGENIC SHOCK

Causes

- Acute myocardial infarction
- Advanced heart failure
- Pulmonary embolism
- Myocarditis
- Drug toxicity
- Takotsubo cardiomyopathy

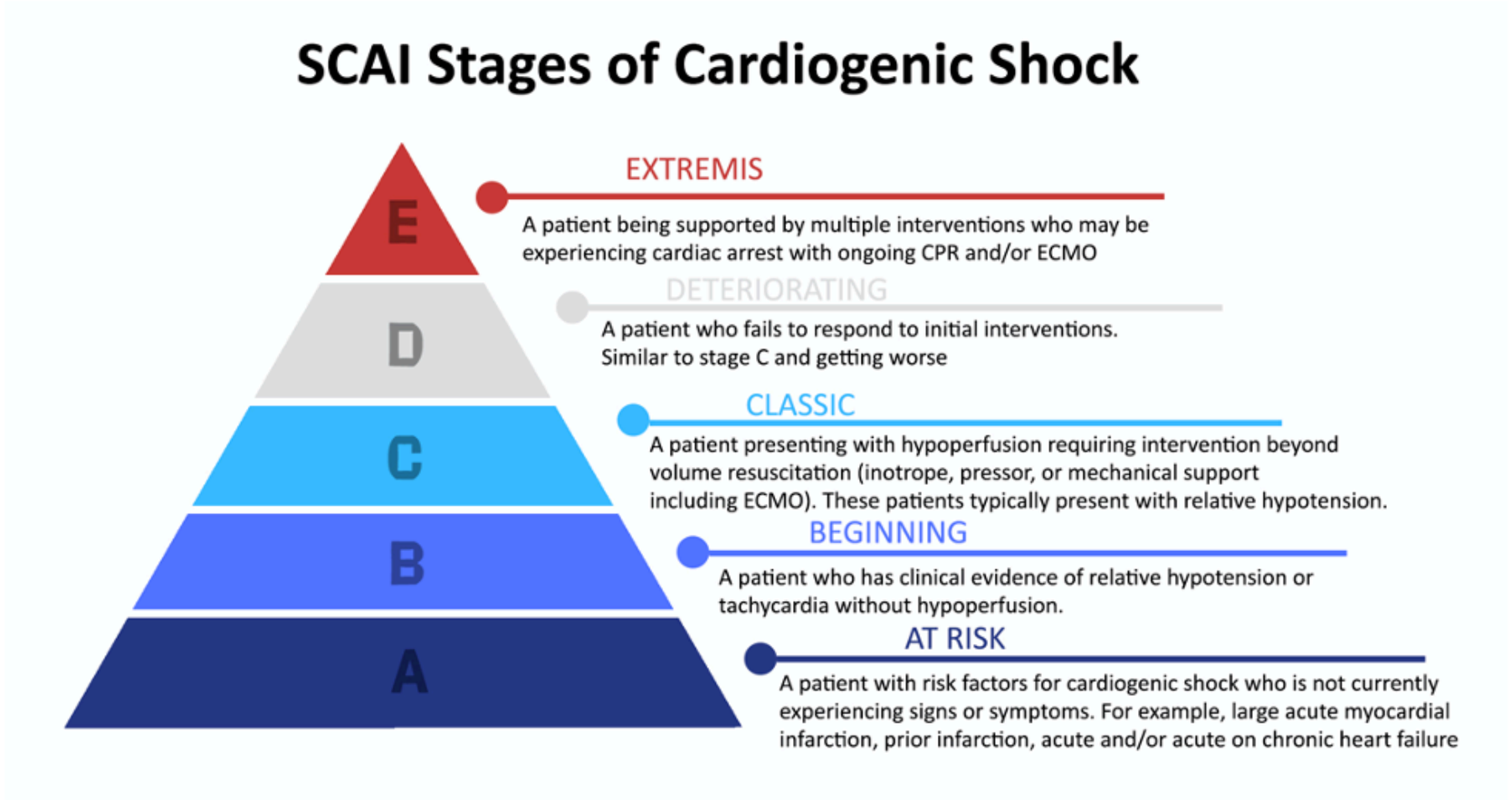
Diagnosis

- Noninvasive hemodynamics
- End-organ perfusion
- Invasive hemodynamics
- Surrogate markers
- Shock index

Treatment

- Reperfusion therapy
- Vasopressors/Inotropes
- ECMO/MCS
- Supportive care

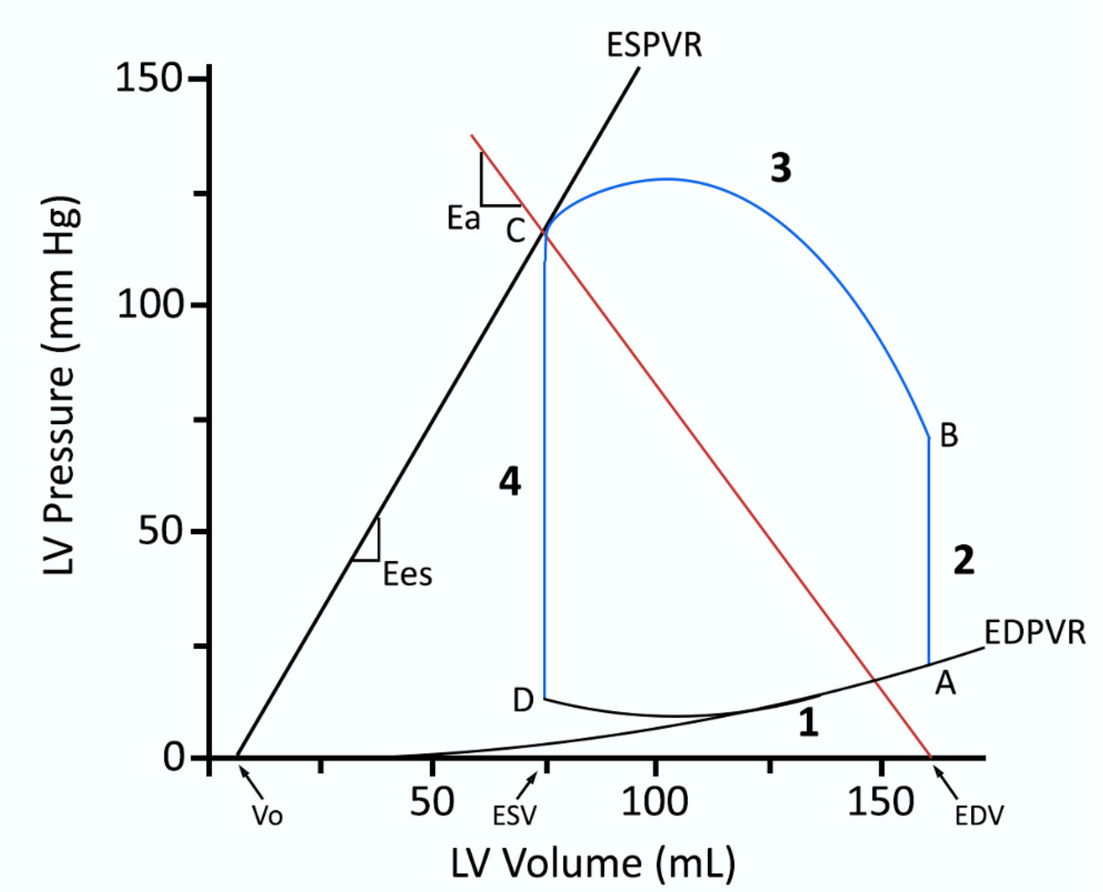
RECOGNIZING CARDIOGENIC SHOCK



RECOGNIZING CARDIOGENIC SHOCK

SCAI SHOCK STAGE	PHYSICAL EXAM	BIOCHEMICAL MARKERS	HEMODYNAMICS
A	Normal JVP Lung souds clear Strong distal pulses Normal mentation	Normal renal function Normal lactic acid	Normotensive (SBP ≥ 100 or normal for pt). If hemodynamics done: Cardiac index ≥ 2.5 CVP < 10 PA Sat ≥ 65%
B	Elevated JVP Rales in lung fields Strong distal pulses Normal mentation	Normal lactate Minimal renal function impairment Elevated BNP	SBP < 90 OR MAP < 60 OR > 30 mmHg drop Pulse ≥ 100 If hemodynamics done: Cardiac index ≥ 2.2 PA Sat ≥ 65%
C	Ashen, mottled, dusky Volume overload Extensive Rlaes Killip class 3 or 4 BiPap or mechanical ventilation Acute alteration in mental status	Lactate ≥ 2 Creatinine doubling OR >50% drop in GFR Increased LFTs Elevated BNP Urine Output <30ml/h	Drugs/device used to maintain BP above stage B values. Cardiac index < 2.2 PCWP > 15 RAP/PCWP ≥ 0.8 PAPI < 1.85 Cardiac Power Output ≤ 0.6
D	Any of Stage C	Any of stage C AND deteriorating	Any of stage C AND Requiring multiple pressors OR addition of mechanical circulatory support devices to maintain perfusion
E	Near pulselessness Cardiac collapse Mechanical ventilation Defibrillator used	Lactate ≥ 5 pH ≤ 7.2	No SBP without resuscitation PEA or Refractory VT/VF Hypotension despite maximal support

RECOGNIZING CARDIOGENIC SHOCK



INITIAL TREATMENT STRATEGIES

Optimize Oxygen Delivery

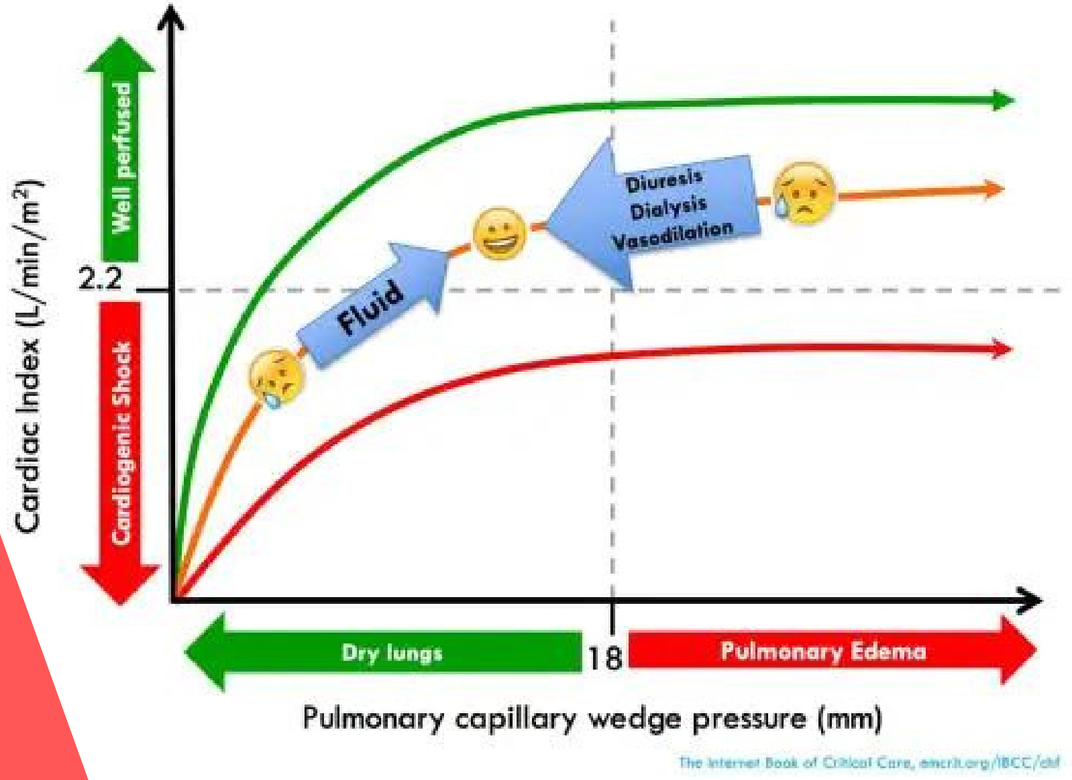
Airway management, IVF to optimize preload, early vasopressors, inotropes as indicated, PRBC transfusion

Early Revascularization

ECA with PCI or CABG aims to restore coronary blood flow and salvage viable myocardium, thereby improving cardiac function and hemodynamics

Provide Supportive Care

Monitor vital signs and evidence of end-organ perfusion closely. Consider invasive hemodynamic monitoring and frequent echocardiograms.



PHARMACOLOGICAL INTERVENTIONS

Rough properties of various vasopressors

Drug Typical dose range	Target	Effect on - Heart rate - Inotropy - Ectopy	Effect on systemic vascular resistance	Effect on cardiac output	Effect on blood pressure	Effect on pulmonary vascular resistance	Main uses	Safe for peripheral use?
Inodilators								
Dobutamine 2-20 mcg/kg/min	αββββ	⇑⇑⇑	⇓	⇑⇑⇑	Variable	⇓	Cardiogenic shock	
Milrinone 0.375-0.75 mcg/kg/min	cAMP	⇑⇑⇑	⇓⇓	⇑⇑⇑	Variable	⇓⇓	Cardiogenic shock	
Isoproterenol 2-10 mcg/min	ββββ	⇑⇑⇑⇑⇑	⇓	⇑⇑⇑	Variable		Bradycardia	Yes
Pure Vasopressors								
Vasopressin 0.01-0.06 U/min	V1 & V2	⇓	⇑⇑⇑	⇔/⇓	⇑⇑⇑	⇓	Distributive shock, Pulmonary HTN	No.
Phenylephrine 40-180 mcg/min	αααα	⇓	⇑⇑⇑	Variable	⇑⇑⇑	⇑⇑	Distributive shock	Yes
InoPressors								
Norepinephrine 0-40 mcg/min*	αααβ	⇑	⇑⇑⇑	⇔/⇑	⇑⇑	⇔	Shock (most types)	Yes, for short period with monitoring
Epinephrine 0-20 mcg/min*	αββββ	⇑⇑⇑	⇑	⇑⇑⇑	⇑⇑		Bradycardia, cardiogenic shock, sepsis, anaphylaxis	Yes
Dopamine, low 1-4 mcg/kg/min	Dopa-R	⇔	⇓	⇑	⇓		Zombie apocalypse (absence of better agents).	Probably not
Dopamine, medium 4-10 mcg/kg/min	αββββD	⇑	Variable	⇑⇑	Variable			
Dopamine, high 10-20 mcg/kg/min	αααβD	⇑⇑	⇑⇑	⇑	⇑⇑⇑	⇑		

*Listed ranges are typically used doses in the United States, but there is no true "maximal" dose. Some countries may tend to use higher doses than others. At very high doses, pressors may lose some receptor specificity. The best dose is the dose required to keep the patient alive – in some cases very high norepinephrine or epinephrine doses may be needed.

-The Internet Book of Critical Care, by @PulmCrit

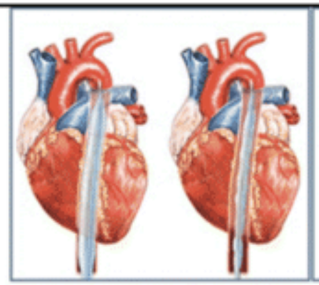
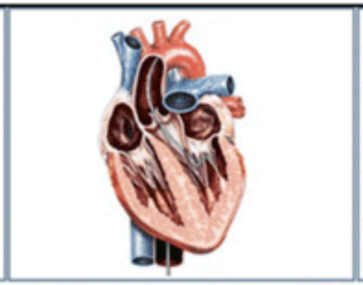
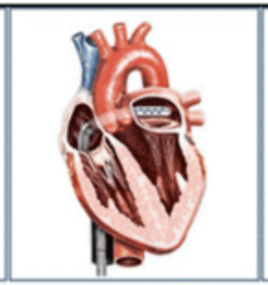
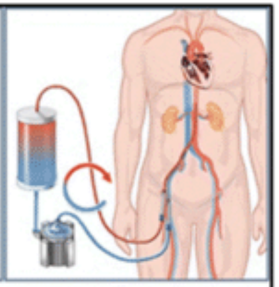
MAKE SWANS GREAT AGAIN

Pulmonary artery catheter utilization has fallen out of favor in many ICUs that do not routinely care for patients in cardiogenic shock.

However, several recent observational and retrospective meta-analyses present compelling, albeit biased, data that PACs reduce mortality in cardiogenic shock.

What are some reasons that PACs might reduce mortality in cardiogenic shock but not other forms of shock?

MCS DEVICES

	IABP	IMPELLA	TANDEMHEART	VA-ECMO
Cardiac Flow	0.3-0.5 L/ min	1-5L/ min (Impella 2.5, Impella CP, Impella 5)	2.5-5 L/ min	3-7 L-min
Mechanism	Aorta	LV → AO	LA → AO	RA → AO
Maximum implant days	Weeks	7 days	14 days	Weeks
Sheath size	7-8 Fr	13-14 Fr Impella 5.0 - 21 Fr	15-17 Fr Arterial 21 Fr Venous	14-16 Fr Arterial 18-21 Fr Venous
Femoral Artery Size	>4 mm	Impella 2.5 & CP - 5-5.5 mm Impella 5 - 8 mm	8 mm	8 mm
Cardiac synchrony or stable rhythm	Yes	No	No	No
Afterload	↓	↓	↑	↑↑↑
MAP	↑	↑↑	↑↑	↑↑
Cardiac Flow	↑	↑↑	↑↑	↑↑
Cardiac Power	↑	↑↑	↑↑	↑↑
LVEDP	↓	↓↓	↓↓	↔
PCWP	↓	↓↓	↓↓	↔
LV Preload	---	↓↓	↓↓	↓
Coronary Perfusion	↑	↑	---	---
Myocardial oxygen demand	↓	↓↓	↔↓	↔

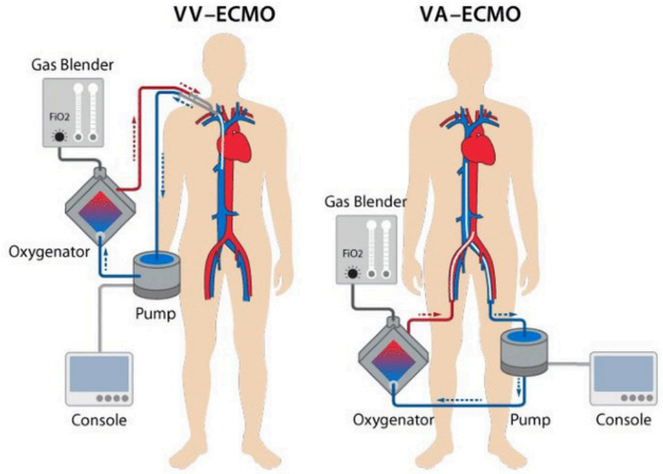
ECMO IN CARDIOGENIC SHOCK

EXTRA-CORPOREAL MEMBRANE OXYGENATION (ECMO)

Mode of cardiopulmonary support used to treat pulmonary and/or cardiovascular failure with an external artificial circuit

ECMO GOALS

- Maintain adequate **tissue oxygenation** to allow recovery from potentially reversible cardiopulmonary failure
- Adjust ventilator settings with very low tidal volumes, allowing for **lung rest,** minimizing further ventilator-induced lung injury
- ECMO is **a bridge,** not a destination



HOW DOES IT WORK?

- **Veno-Arterial (VA)**
  - Supports heart and lungs (complete cardiopulmonary support)
  - Blood drains – venous system
  - Blood returns – arterial system
- **Veno-Venous (VV)**
  - Supports lungs (pulmonary support only)
  - Blood drains – venous system
  - Blood returns – venous system
- **E-CPR**
  - Rapid deployment of VA-ECMO when CPR is unsuccessful in achieving sustained return of spontaneous circulation

PARAMETERS

- **Flow** (mL/kg/min)
  - Dial in RPMs and flow depends on resistance in patient & circuit
  - Generally set between 4-6 L/min (100-150 mL/kg/min in children)
  - On **VA-ECMO** – flow supports **cardiac output**
  - On **VV-ECMO** – flow supports **oxygenation**
- **Sweep** (L/min)
  - Sweep gas flow determines PCO_2 clearance (ie, ventilation) for both VV- & VA-ECMO

OXYGEN DELIVERY

- From both lungs & oxygenator
- Assess perfusion (eg, NIRS, SVO_2, lactate)

REST SETTINGS

- If ventilated, frequently placed on low "rest" settings with moderate PEEP
- Bronchoscopy may be needed for plugging

ANTICOAGULATION

- To reduce risk of thromboembolism in circuit
- Done per institutional protocol

ELECTROLYTE REPLACEMENT

- Particularly Ca+ due to citrate binding

POTENTIAL COMPLICATIONS

MECHANICAL ISSUES

- Circuit thrombus or hemolysis
  - Differences between pre- and post-pressures across oxygenator can provide early warning about potential thrombus
- Oxygenator failure or thrombus
- Pump failure or air emboli rare

INFECTION & SYSTEMIC INFLAMMATORY SYNDROME

- May not have fever due to circuit temp regulation

ISCHEMIA & END ORGAN FAILURE

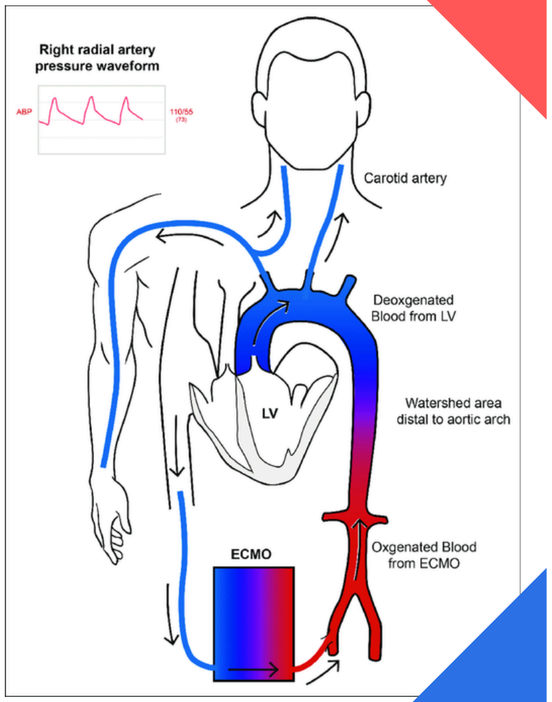
- Stroke or limb ischemia
- Renal injury, lung injury

DELIRIUM & MUSCLE WEAKNESS

- From prolonged sedation & immobilization
- Early mobilization & rehab are crucial

BLEEDING

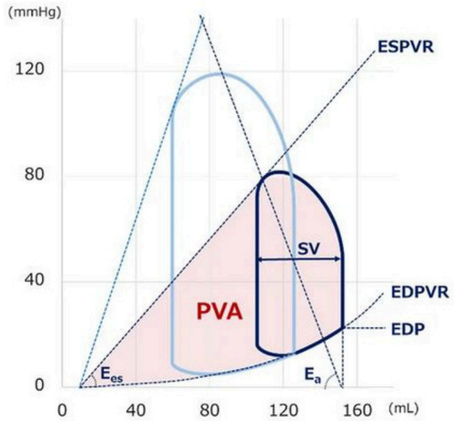
- Cerebral hemorrhage or insertion site bleeding
- Common complication (30%-40%)



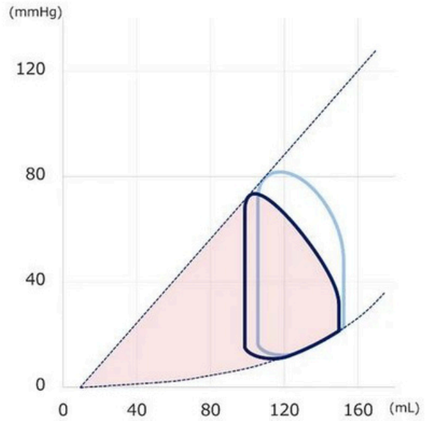
CHEST®

MANAGING LV DISTENSION

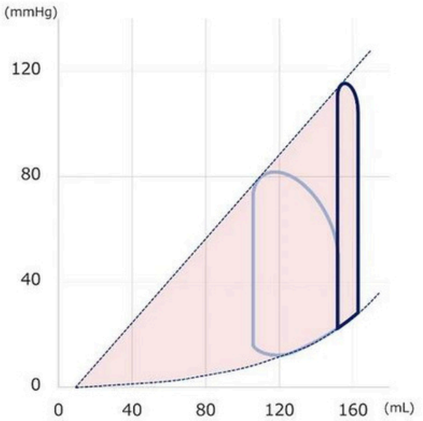
(A) CGS



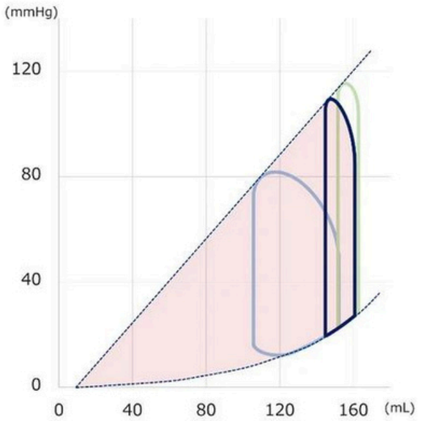
(B) IABP



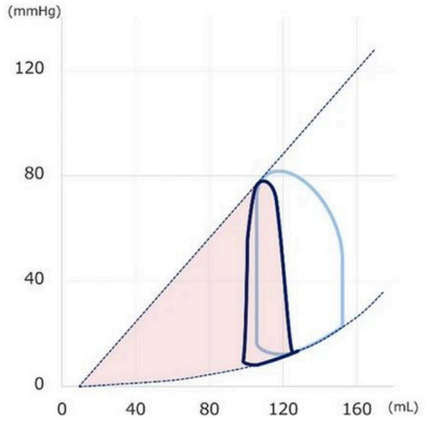
(C) VA-ECMO



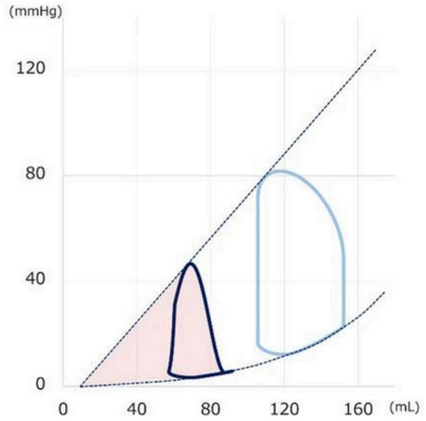
(D) VA-ECMO with IABP



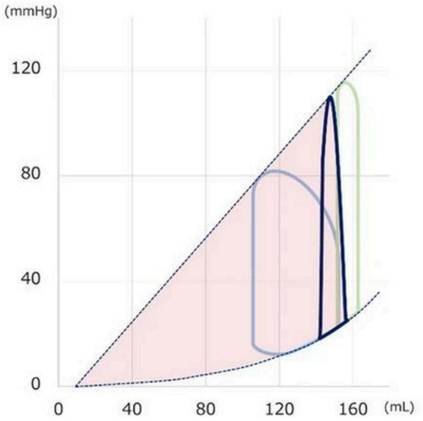
(E) Impella partial support



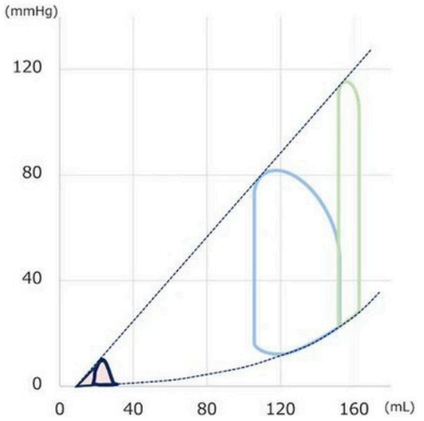
(F) Impella total support



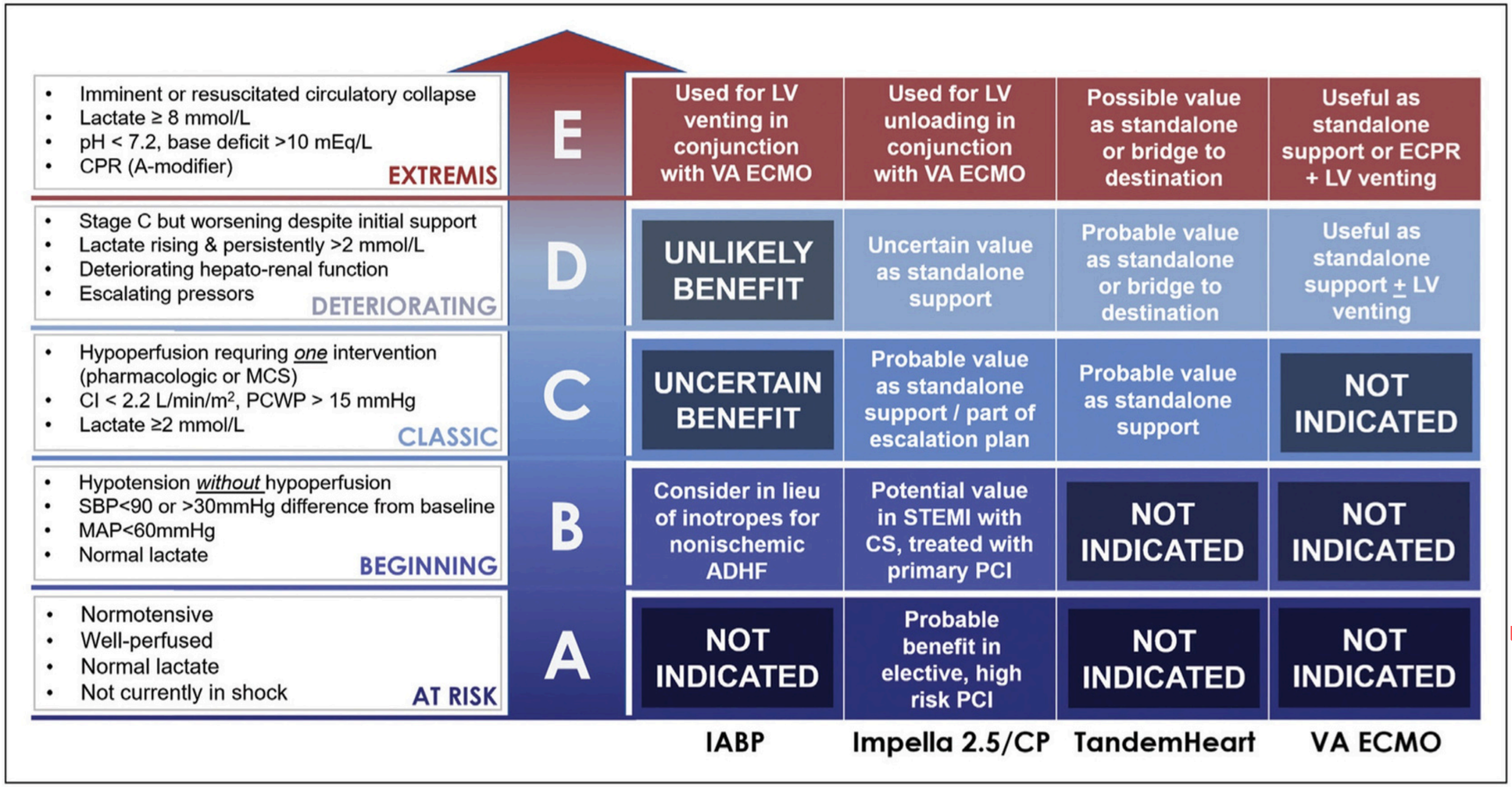
(G) ECPELLA total support



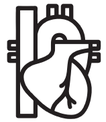
(H) ECPELLA total unloading



PATIENT SELECTION



REFERRAL CRITERIA



Worsening Cardiogenic Shock

Rising lactate, worsening hepatorenal function, increasing oxygen requirements, escalating vasopressor doses

Evaluation for Advanced Heart Failure Therapy

Acute or decompensated heart failure in patients who would be candidates for durable LVAD or transplant

Right Heart Failure

Acute or decompensated RHF (e.g. known pHTN or massive PE)

Talking to the Transfer Center

- Involve your cardiologists
- Calculate the SAVE Score
- Have the most recent echo and cardiac cath reports
- Know current vasoactive doses
- Have a destination
- Be concise

SUMMARY & KEY TAKEAWAYS

Recognize cardiogenic shock

Cardiogenic shock is a spectrum of illness characterized by inadequate tissue perfusion. These patients can be relatively well appearing early in their course.

Know your resources and transfer early

Treat patients aggressively and transfer early rather than wait for significant deterioriation. Anticipate which patients may need MCS.

ECMO & MCS saves lives

Studies have had difficulty showing a mortality benefit, but this likely reflects the severity of illness in this population as well as variance in patient selection.

criticalvalue.dev/blog

@makeswansgreatagain

THANK YOU FOR YOUR TIME