Managing Right Ventricular Failure in the ICU

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Objectives

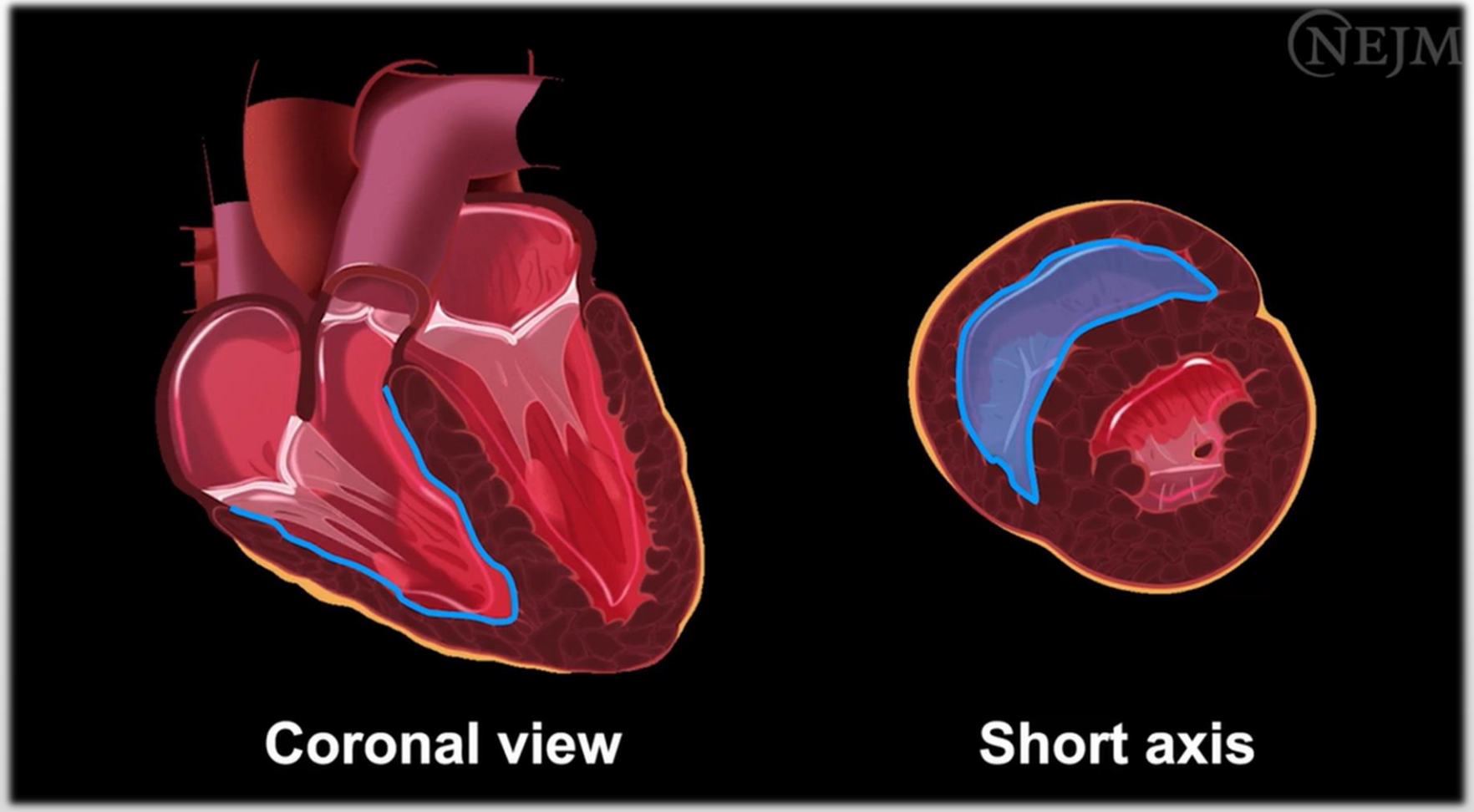
- Recognize two clinical scenarios where the Intensive Care Unit provider must consider Right Ventricular (RV) function.
- Define the diagnostic criteria for RV dysfunction and associated clinical symptoms.
- Identify strategies for optimizing RV function.
- Describe the physiology and hemodynamic indications of mechanical circulatory support devices used for RV support.

The Right Ventricle

Most anterior cardiac chamber

Low pressure, high volume system

Preload dependent and Afterload sensitive



Prada, et al. 2023. N ENGL J Med 387:21, e51

History

Symptoms of Right Heart Dysfunction

dyspnea

early satiety

abdominal fullness

lower extremity edema

right-upper-quadrant tenderness

exercise intolerance

fatigue

Family History

Pulmonary arterial hypertension

Left heart failure

Sudden cardiac death

Arrhythmogenic right ventricular cardiomyopathy

Measuring RV function

Hemodynamics

Right atrial pressure, pulmonary artery (PA) pressures, cardiac output, PA pulsatility index (PAPi)

Echocardiogram

Cavity Size

Shape of the septum

Longitudinal shortening

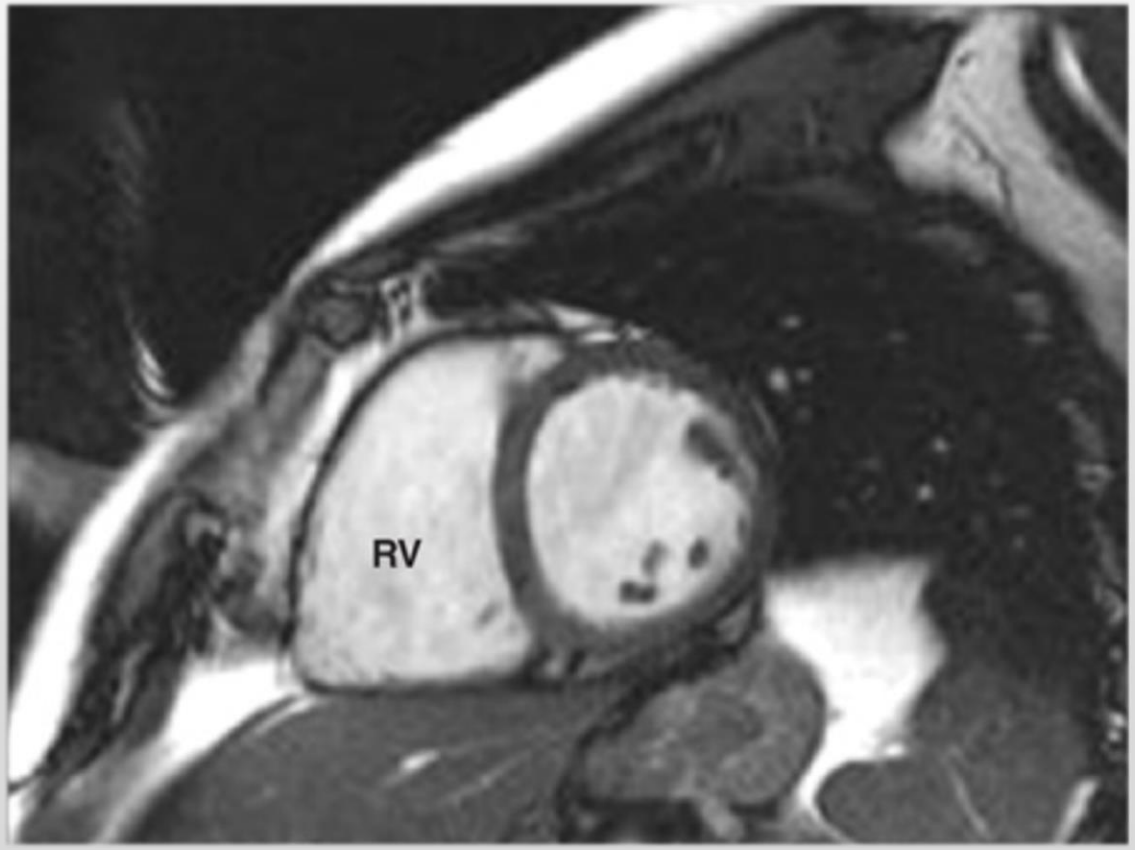
Change in area of the cavity

McConnell's sign

Cardiac MRI

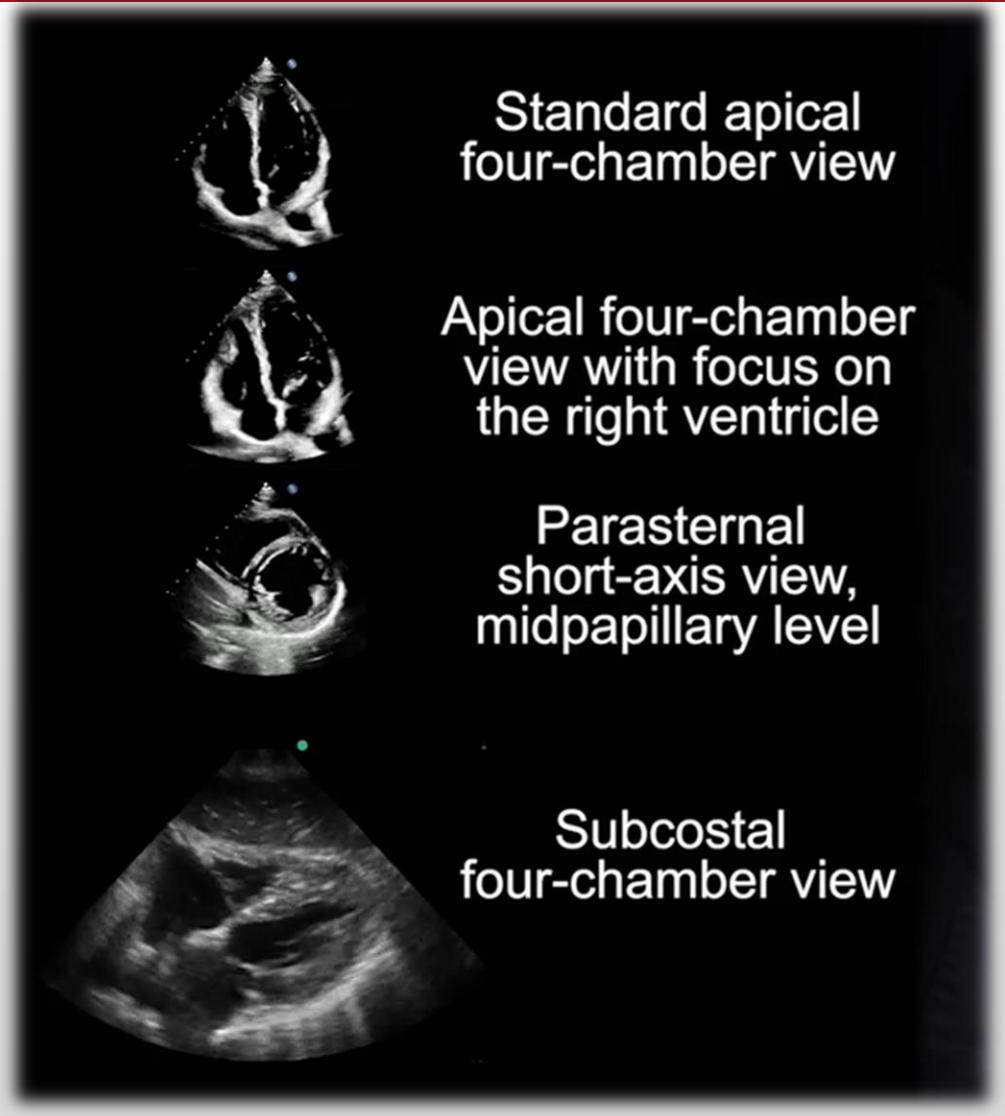
Serum biomarkers- Brain natriuretic peptide

Electrocardiogram- Strain pattern



Point of Care Ultrasound

- Is the right ventricle smaller than the left ventricle?
- Is the apex formed by the left ventricle?
- Is the change in cavity area at least 1/3 and LV circular?
- Is the septum curved?



Point of Care Ultrasound

- Is the right ventricle smaller than the left ventricle?
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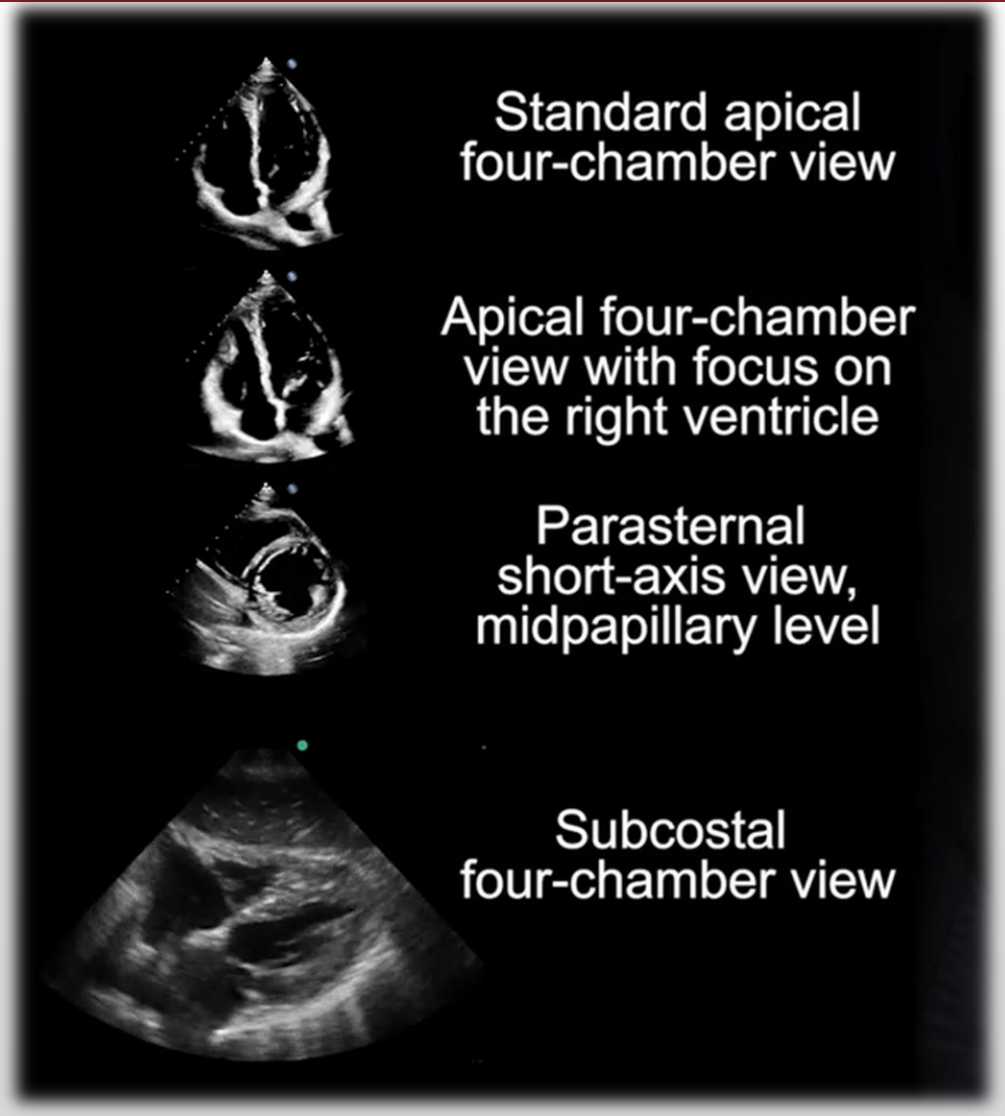
YES? Those are normal findings



Physical Assessment

RV Heave

Jugular venous distention

(A-C-V wave, tricuspid regurgitation confounder)

Hepatojugular reflex

Ascites

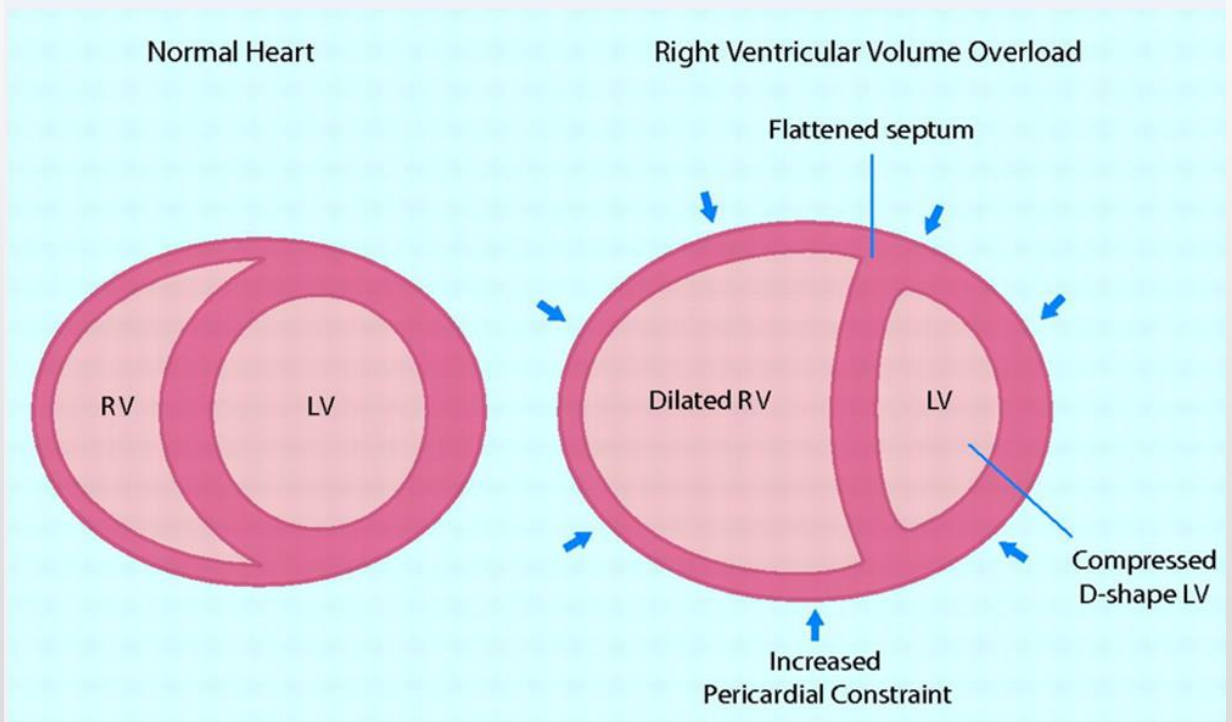
Enlarged and pulsatile liver

Loud second heart sound

Personal video, shared with permission

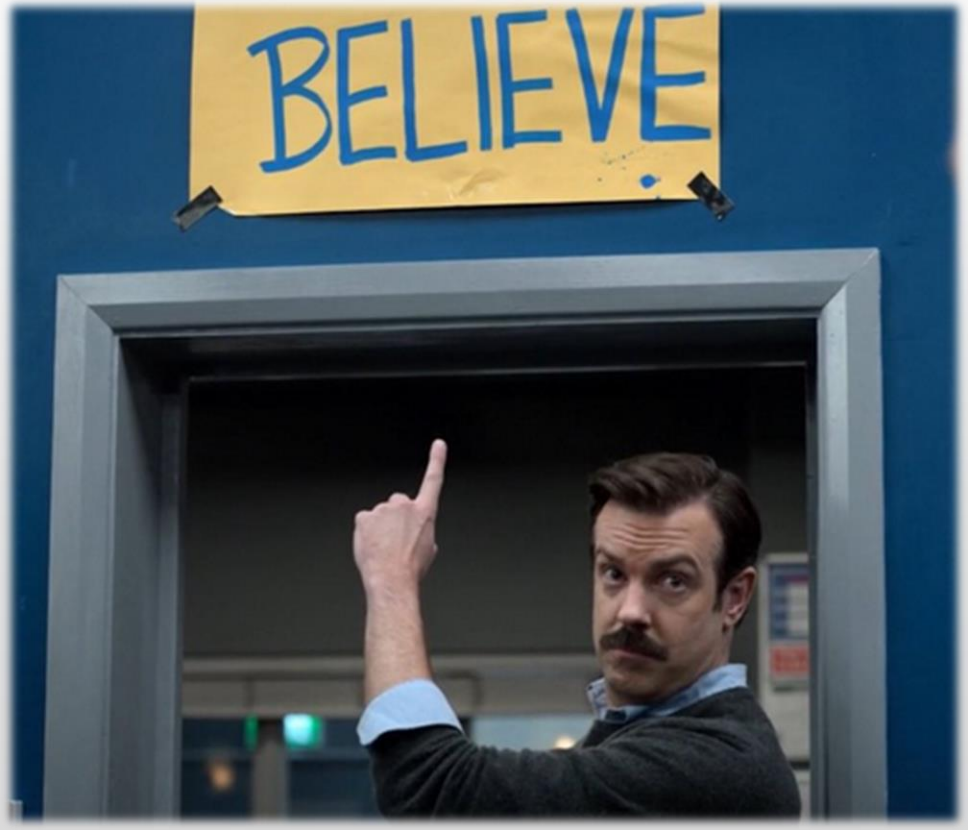
What causes acute dysfunction/dilation?

Increased RV Afterload	Decreased RV Contractility
Pulmonary embolus	Ischemia
Hypoxia	Myocarditis
Acidemia	Post-cardiotomy shock
PEEP	Arrhythmogenic RV Cardiomyopathy



How do we “Support” the Right Ventricle?

1. **Acute? Fix it.**
2. **Maintain regular rate and rhythm**
   - DCCV
   - Antiarrhythmics
3. **Ensure adequate preload**
   - Measure CVP
   - Then volume resuscitate
4. **Manage high afterload**
   - Inhaled pulmonary vasodilators
   - Extracorporeal therapies



Scenario 1: Respiratory Failure and Intubation

- RV dysfunction occurs in 20-50% of ARDS cases and is associated with a 50% increase in mortality
- ARDS-mediated pulmonary edema
- Hypoxemic/hypercapnic pulmonary vasoconstriction
- Positive pressure ventilation and PEEP contribute to RV strain??
- Avoid intubation when possible to avoid cardiovascular collapse

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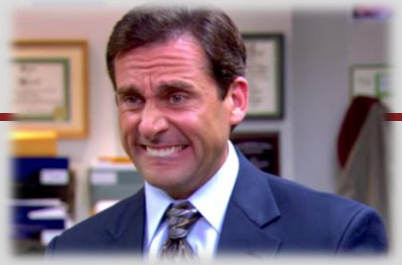
Work fast- minimize apneic period

Cardiostable induction medications. Consider etomidate or ketamine

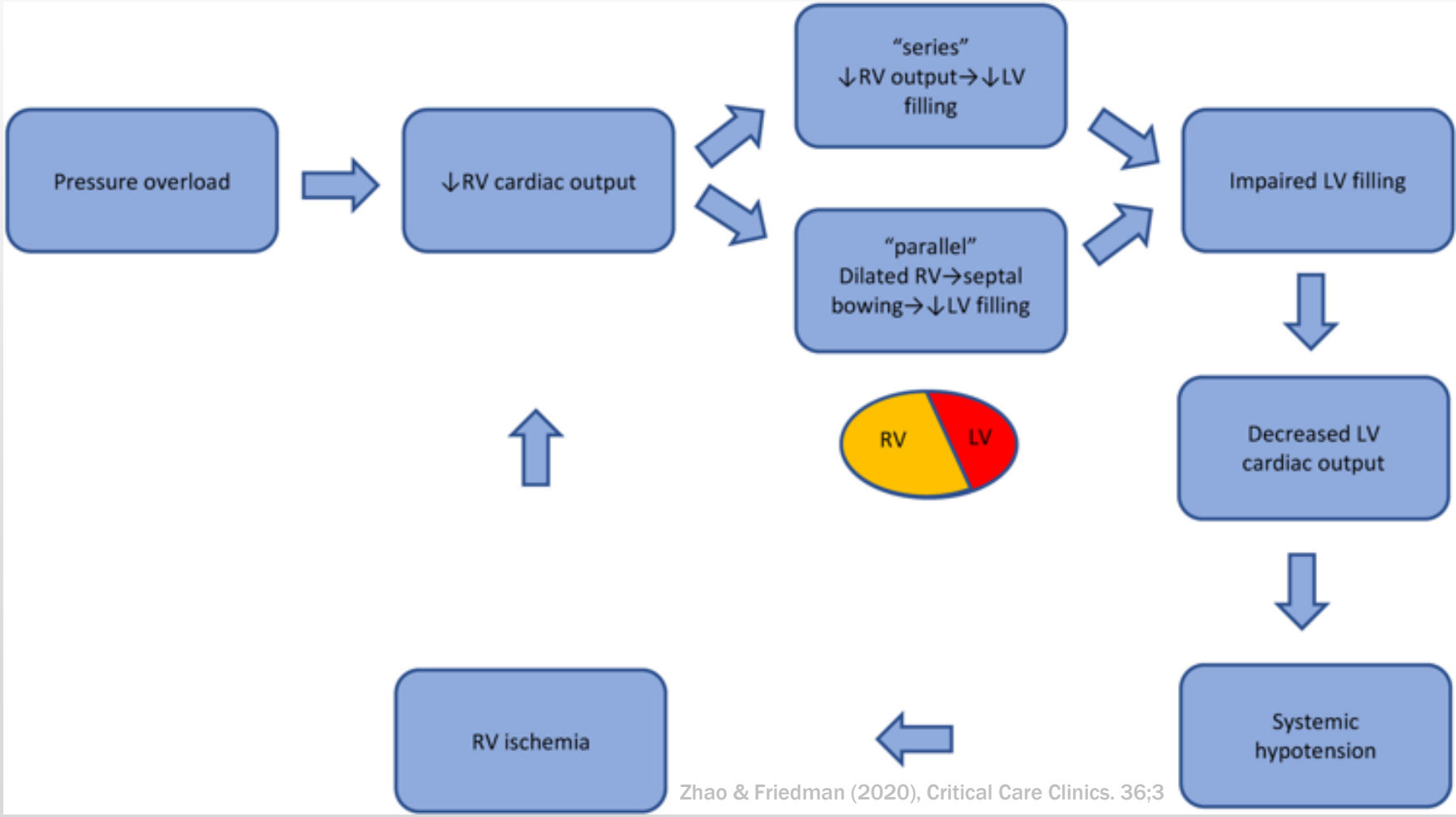
Maintain systemic blood pressure (Norepinephrine or Phenylephrine before induction)

Optimize Tidal volumes



Scenario 2: Pulmonary Embolism (PE)

- ✓ If patients are unstable, prioritize clot reduction via systemic thrombolytics, endovascular procedures, surgical embolectomy, or ECMO
- ✓ RV failure from PE benefits from addition of systemic vasoconstrictors and inotropes
- ✓ RV assist devices may have a role in supporting RV failure from PE
- ✓ Norepinephrine, Dobutamine, inhaled Nitric Oxide



Zhao & Friedman (2020), Critical Care Clinics. 36;3

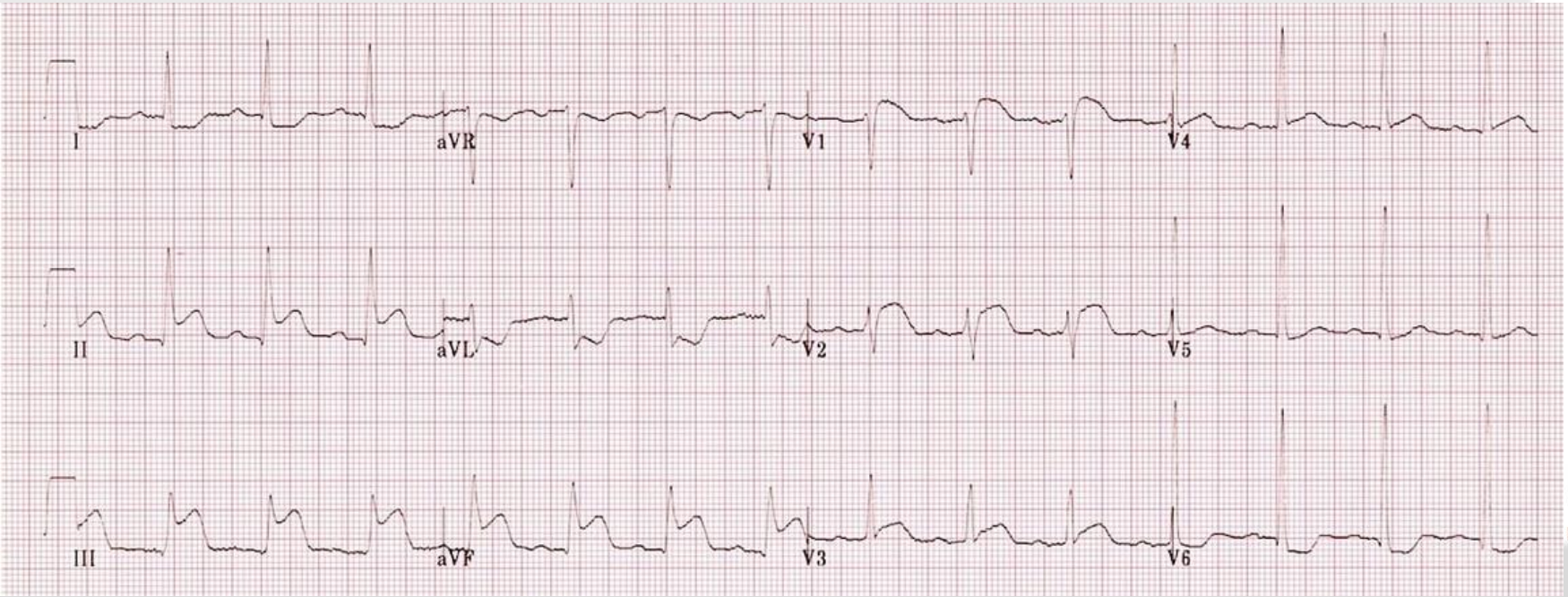
Scenario 3: Acute Myocardial Infarction

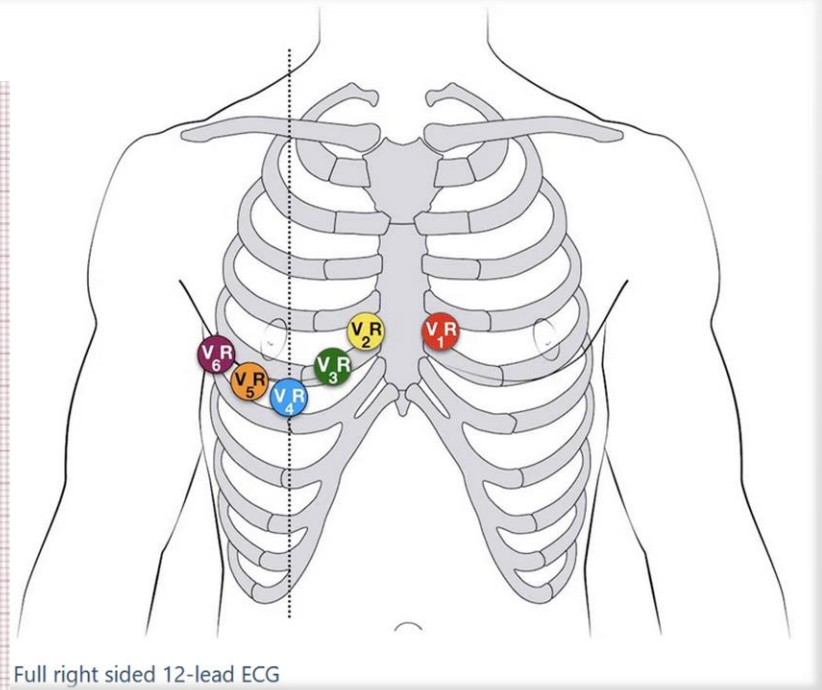
RV infarction complicates up to 40% of inferior STEMIs

V1 looks directly at the right ventricle- look for anterior MI with V1 ST elevation

Confirmed by ST elevation in Lead V4R (sensitivity 88%, specificity 78%)

→ FILL, don't DIL





Full right sided 12-lead ECG

https://litfl.com/right-ventricular-infarction-ecg-library/

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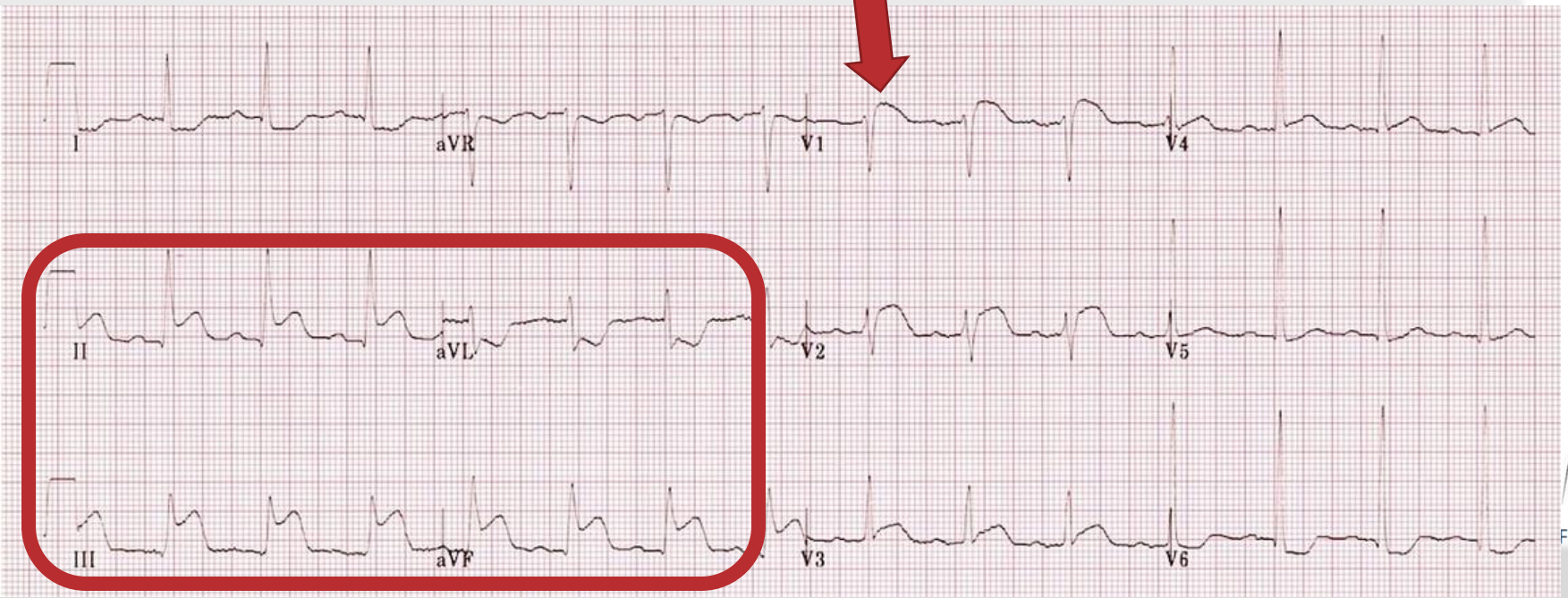

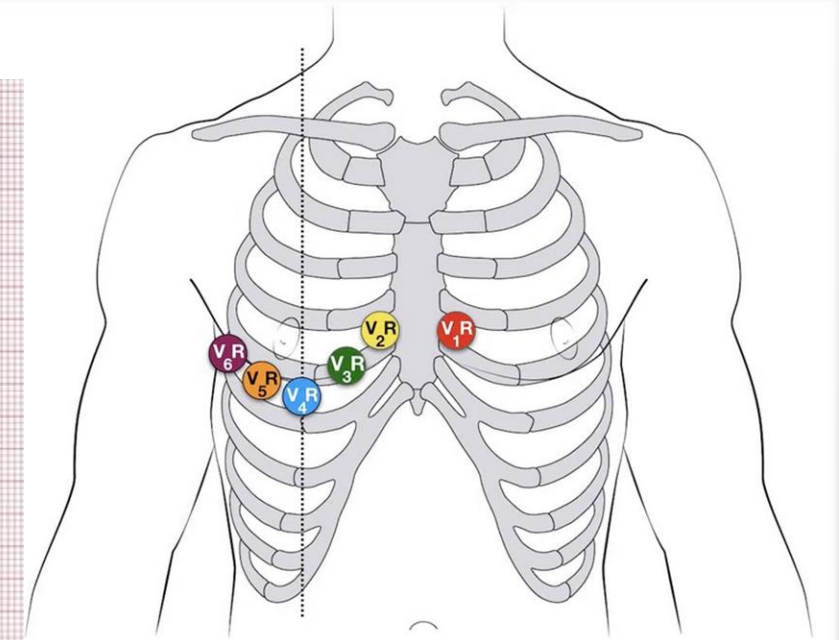

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Mechanical Circulatory Support

Right Ventricular Assist Device

Percutaneous RVAD (Protek Duo)

- Inflow – right atrium
- Outflow – Pulmonary artery
- Add oxygenator?

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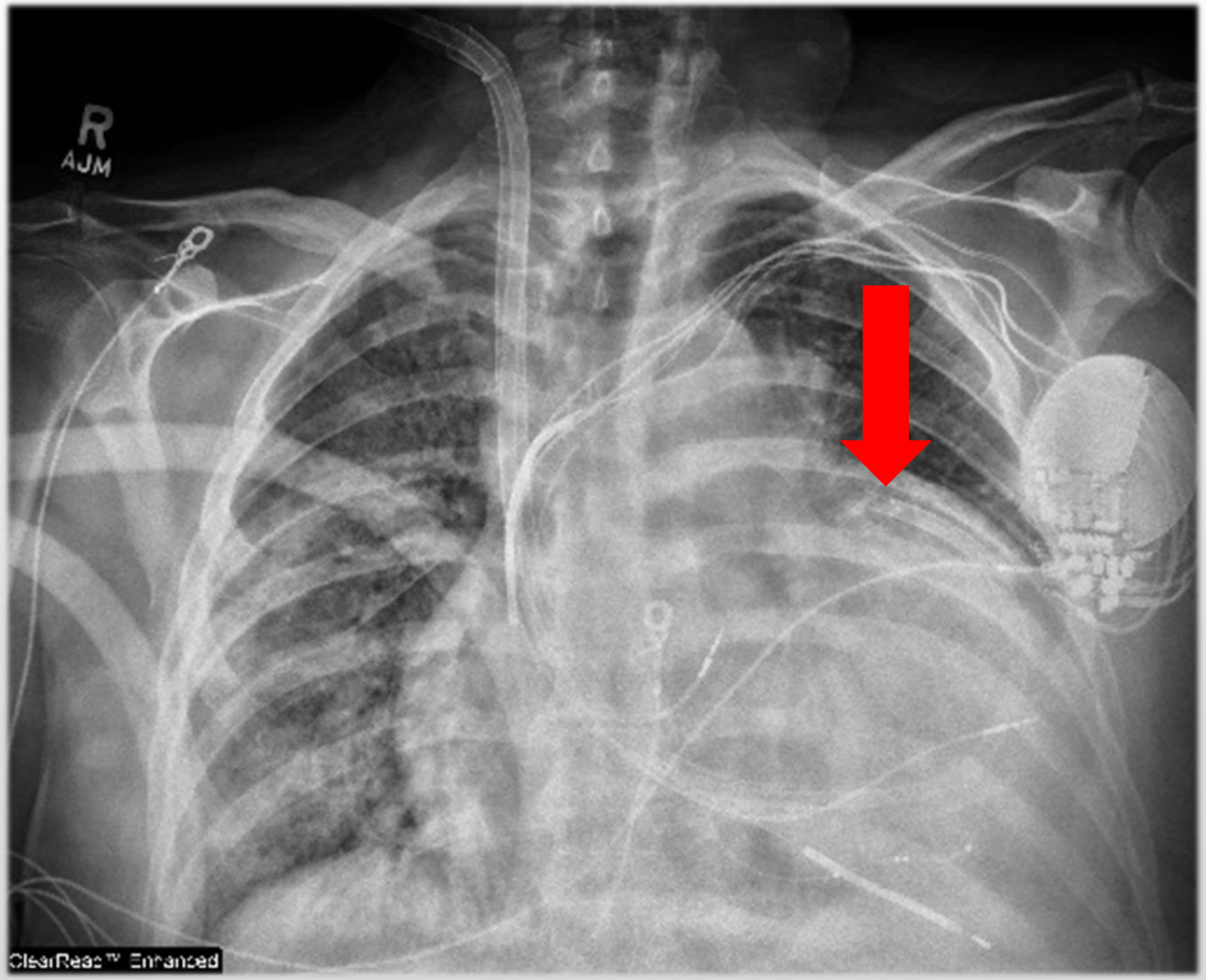
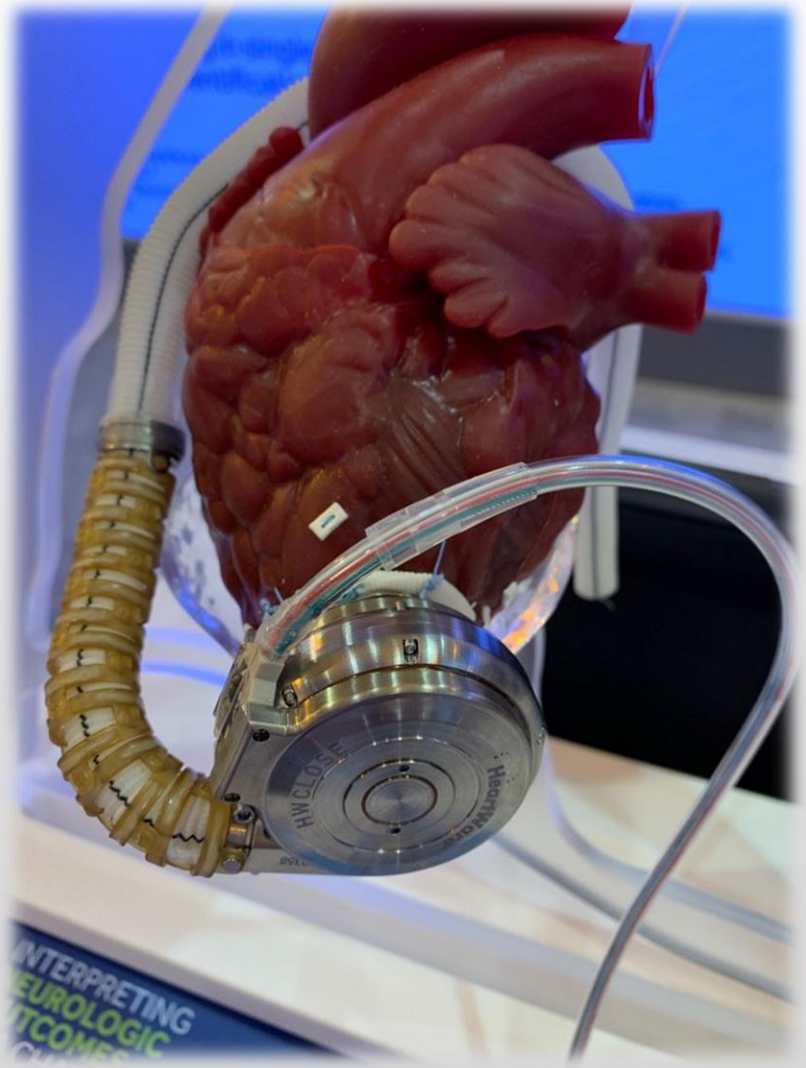


Personal photo, C. Tennyson 2019

Left Ventricular Assist Device/System



LV → Aorta

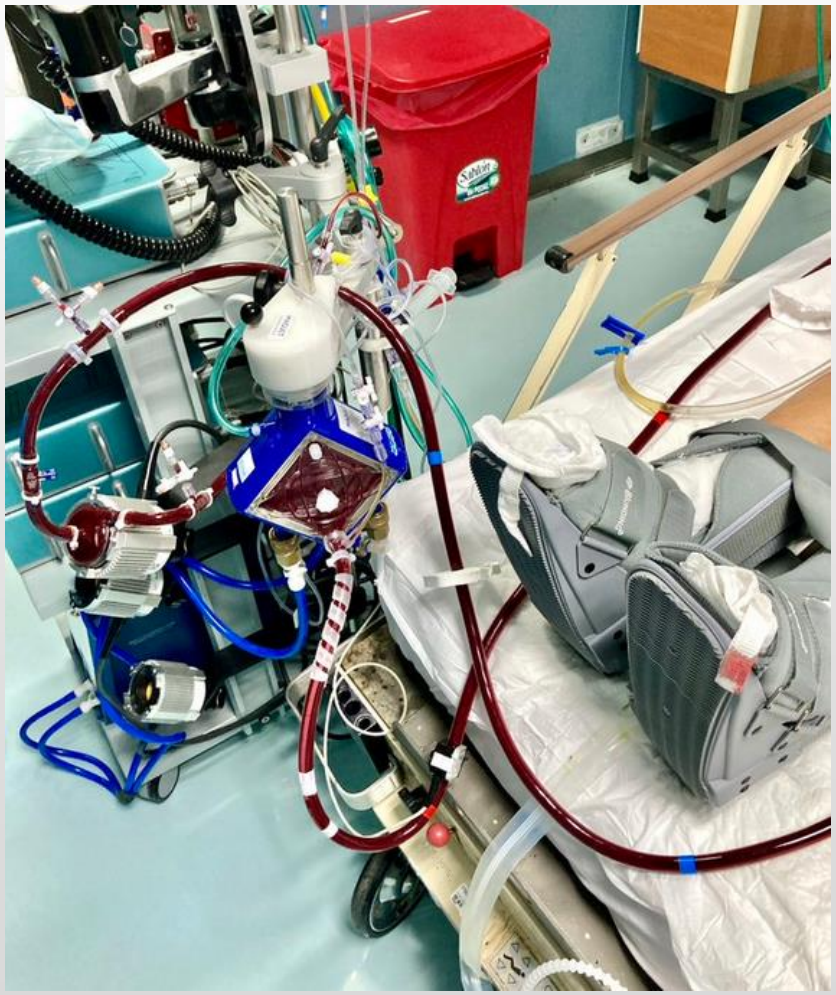
Right side provides preload to the LVAD

Hospital admissions for worsening right sided heart failure (volume overload, tricuspid regurgitation, resp failure)

Personal photos, C. Tennyson 2019

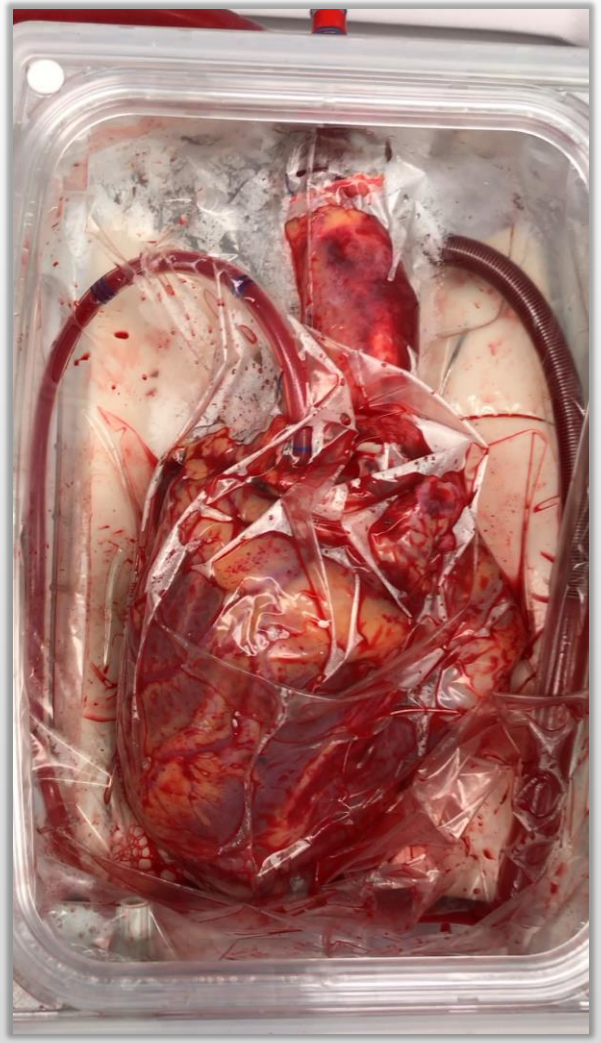
Extracorporeal Membrane Oxygenation (ECMO)

- Veno-venous ECMO is NOT effective in the setting of RV dysfunction
- Therapeutic anticoagulation
- No/little pulsatility
- Increases afterload on the LV



Cardiac Transplant

Right Ventricular Dysfunction after Cardiac Transplantation



- Leading cause of 30-day mortality post transplant
- Pathogenesis?? Multifactorial – Ischemia during organ preservation, reperfusion injury, sequelae of brain death and inotrope effect?
- Primary Isolated RVD after transplant: RVD in the absence of pulmonary hypertension, RV injury, or rejection
- Support support support

United Network for Organ Sharing (UNOS)

Status	Criteria
1	VA ECMO Non-dischargeable biventricular support MCSD with life threatening ventricular arrhythmia
2	Non-dischargeable LVAD/MCSD with malfunction IABP in shock VT or VF
3	Multiple inotropes or single high dose inotrope with HD monitoring MCSD with hemolysis/RV failure/thrombosis/device infection/bleeding/AI VA ECMO/IABP after 7 days
4	Inotropes without hemodynamic monitoring Ischemic heart disease with intractable angina, hypertrophic or restrictive cardiomyopathy Retransplant
5	On waitlist for at least one other organ at the same hospital
6	All other eligible candidates

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Questions? Comments?

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