Hemodynamics

- Binyamin Ben avraham , MD
- Heart Failure Unit
- Rabin Medical Center

When is the right time for hemodynamic study.

- The egg or the chicken PHT
- When to Tx
- Pulmonary vasodilators.
- LVAD or Tx
- To evaluate the Rt side for lung Tx.
- Diastolic dysfunction.
- AHF

When is the right time for hemodynamic study.

- Control the BP
- Zero calibration.
- True wedge pressure.
- Exercise or volume challenge.
- Use of inotropes.
- Pulmonary vasodilators.
- Thermodilution VS fick.
- Expiration.

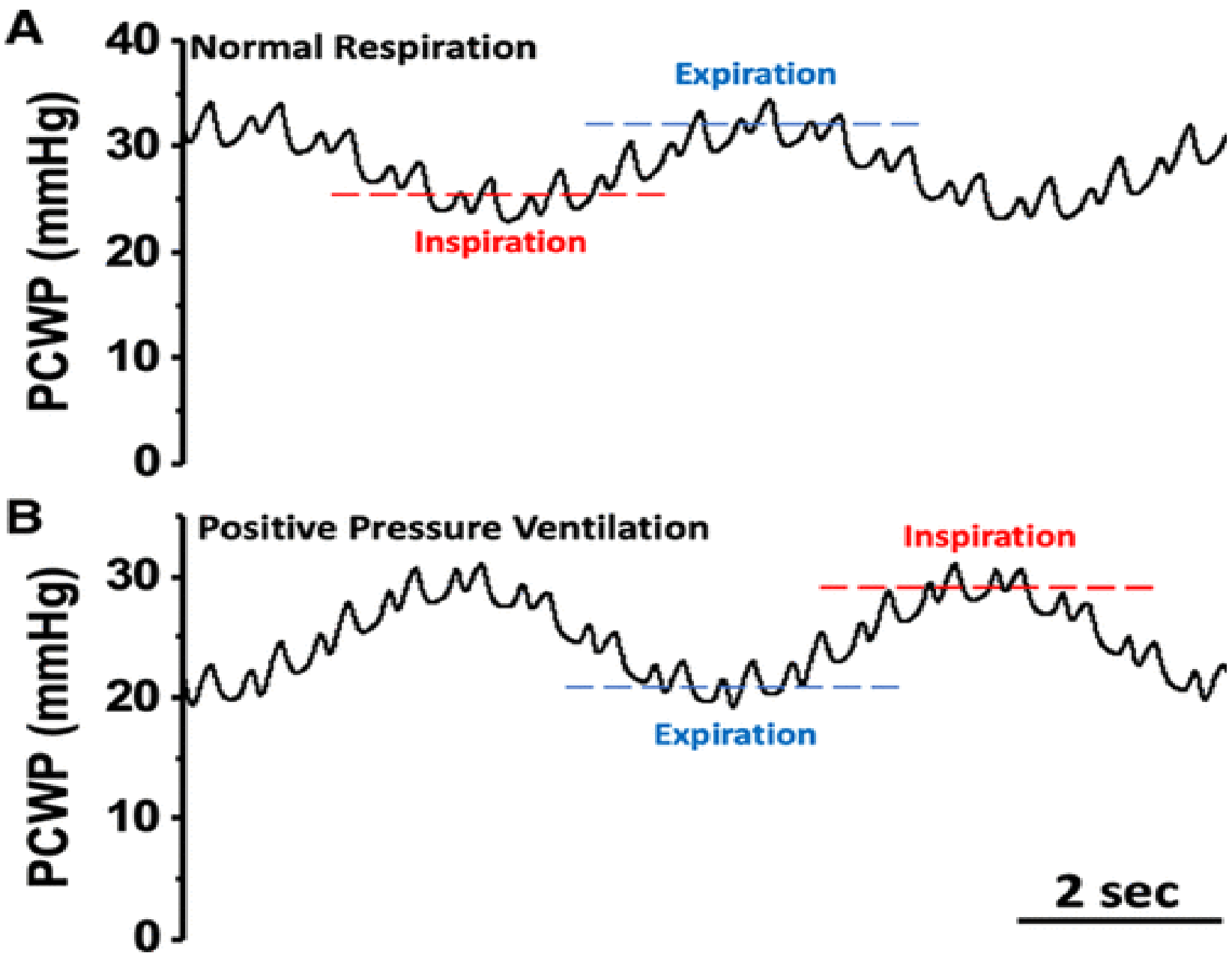
Limitations

Thermodilution

- Not accurate in TR
- Overestimated cardiac output at low output states

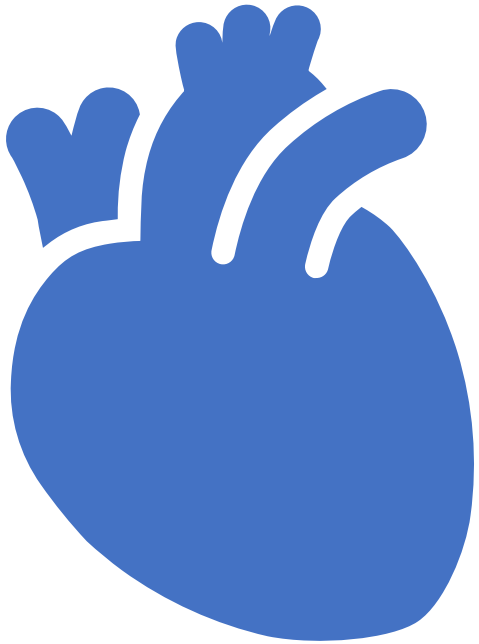
Fick

- VO2 is often estimated by body weight (indirect method) rather than measured directly
- Large errors possible with small differences in saturations and hemoglobin.
- Measurements on room air



Value of Hemodynamic Monitoring in Patients With Cardiogenic Shock Undergoing Mechanical Circulatory Support

Abhinav Saxena,**A. Reshad Garan**, **Navin K. Kapur**, **William W. O'Neill**, **JoAnn Lindenfeld**, **Sean P. Pinney**, **Nir Uriel**, **Daniel Burkhoff** and **Morton Kern**



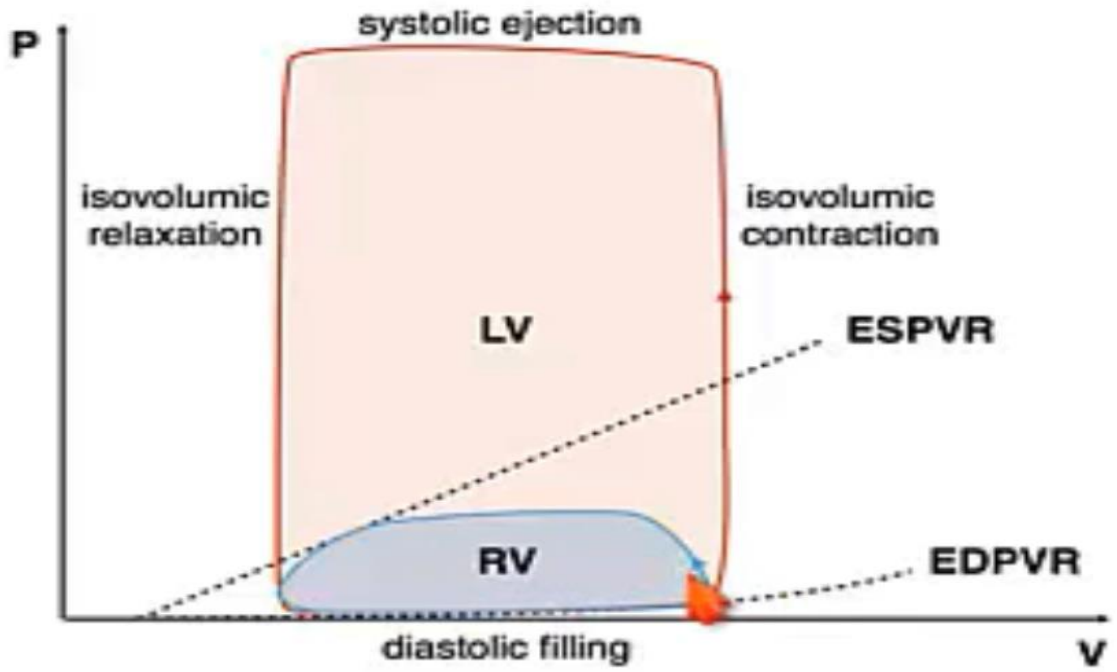
RV and LV evaluation

- Biological biomarkers
- Echocardiography
- Hemodynamic evaluation

hemodynamic

- What exactly are we trying to measure ?

Pressure-Volume loops: Left and right ventricle comparison

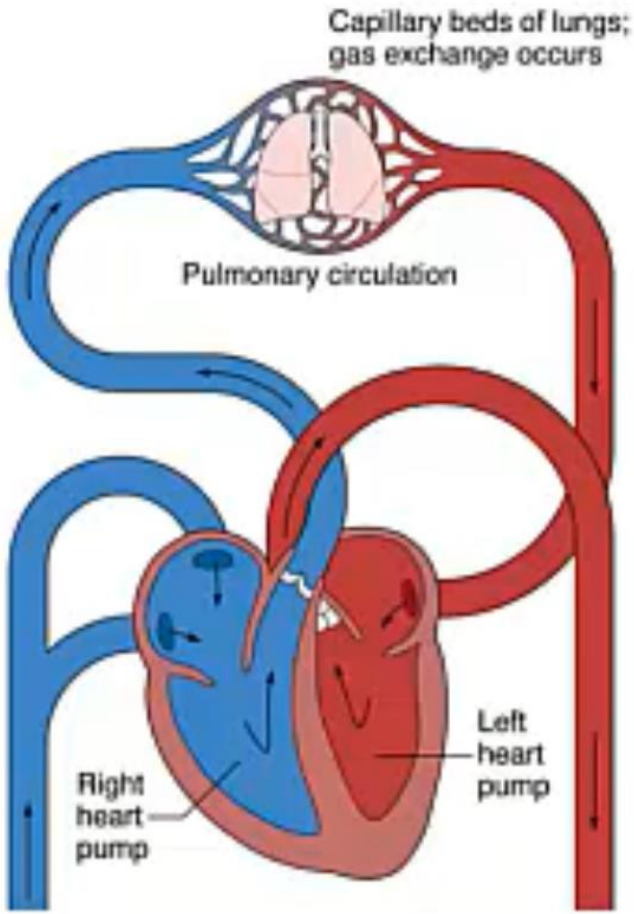


Left Ventricle
Higher pressures
Clearly defined isovolumetric periods

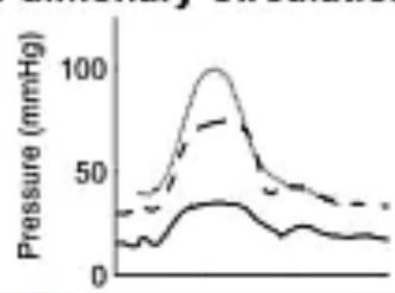
Right Ventricle
Low pressure
Same stroke volume
More triangular in shape

All credits to Rebecca Vanderpool, Postdoctoral Associate at University of Pittsburgh Medical Center, Pittsburgh | United States

But the pulmonary circulation is not independent of the right ventricle



Pulmonary Circulation



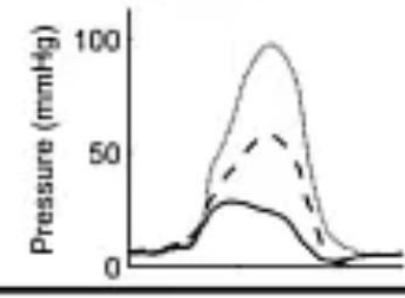
Hemodynamic Δs:
↑ mean pressure
↑ pulse pressure

Structural Δs:
↓ Diameter of resistance vessels
↑ Stiffness

RV-PA interaction

COUPLING

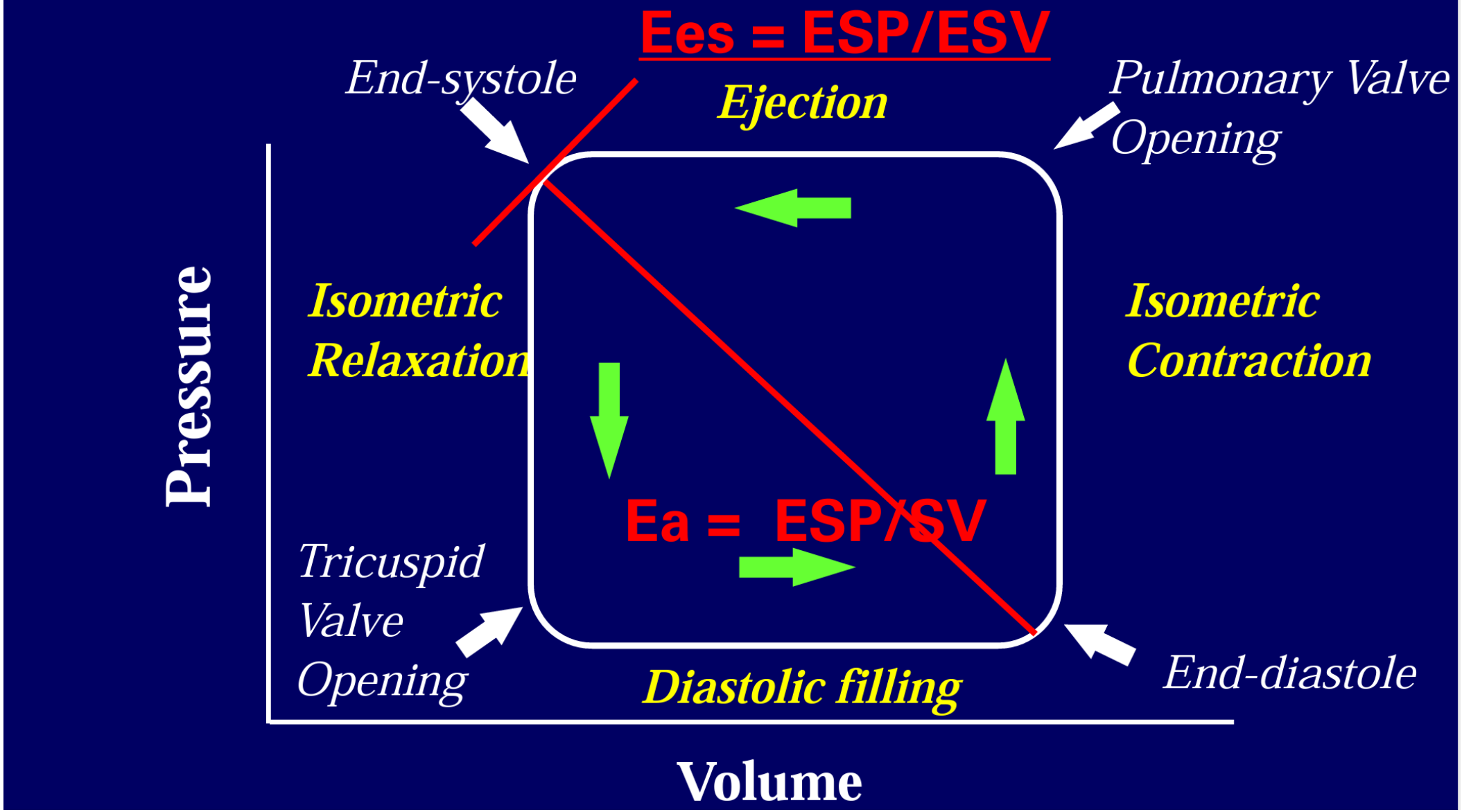
Right Ventricle

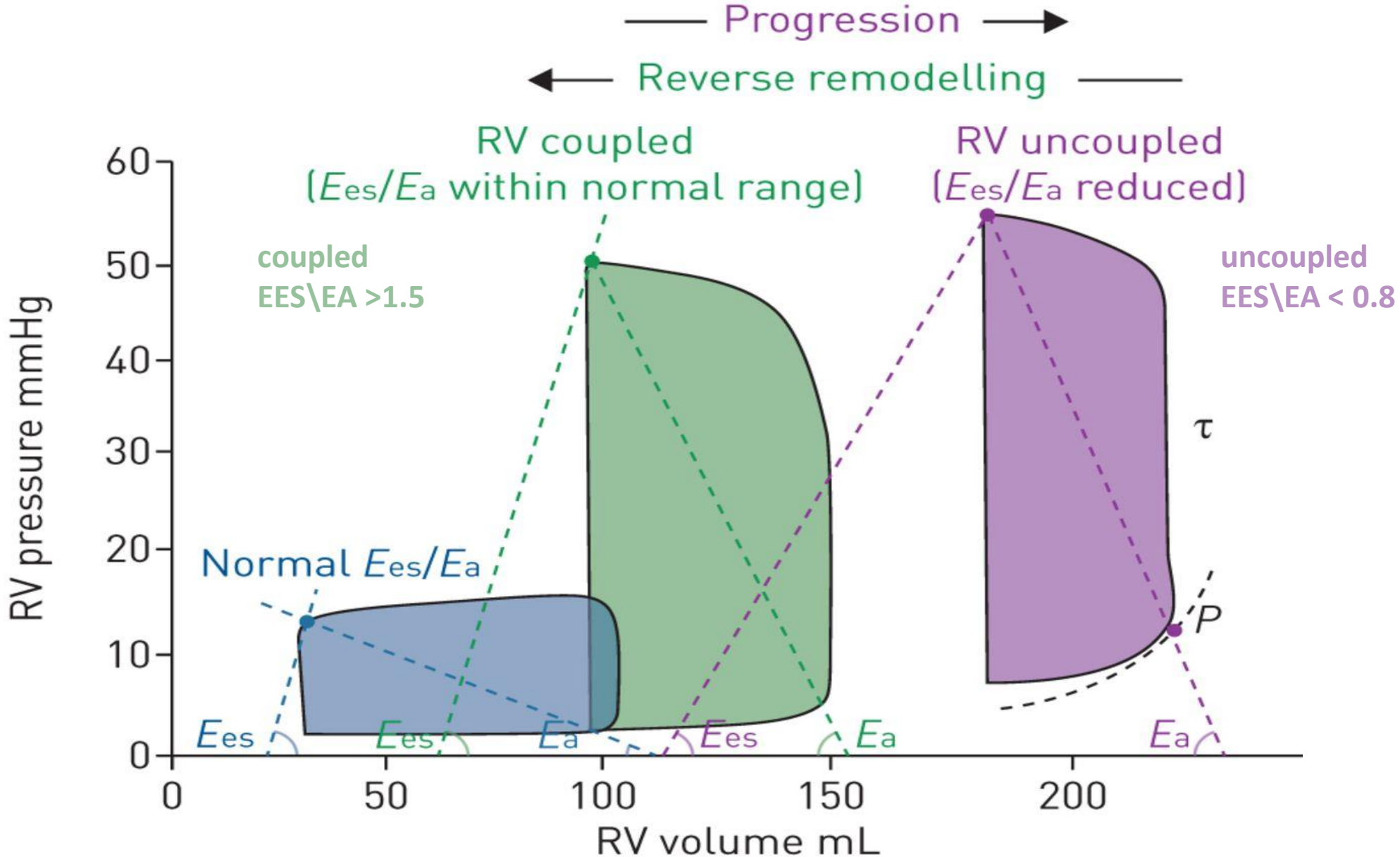


Hemodynamic Δs:
↑ systolic pressure
Δ RV waveform

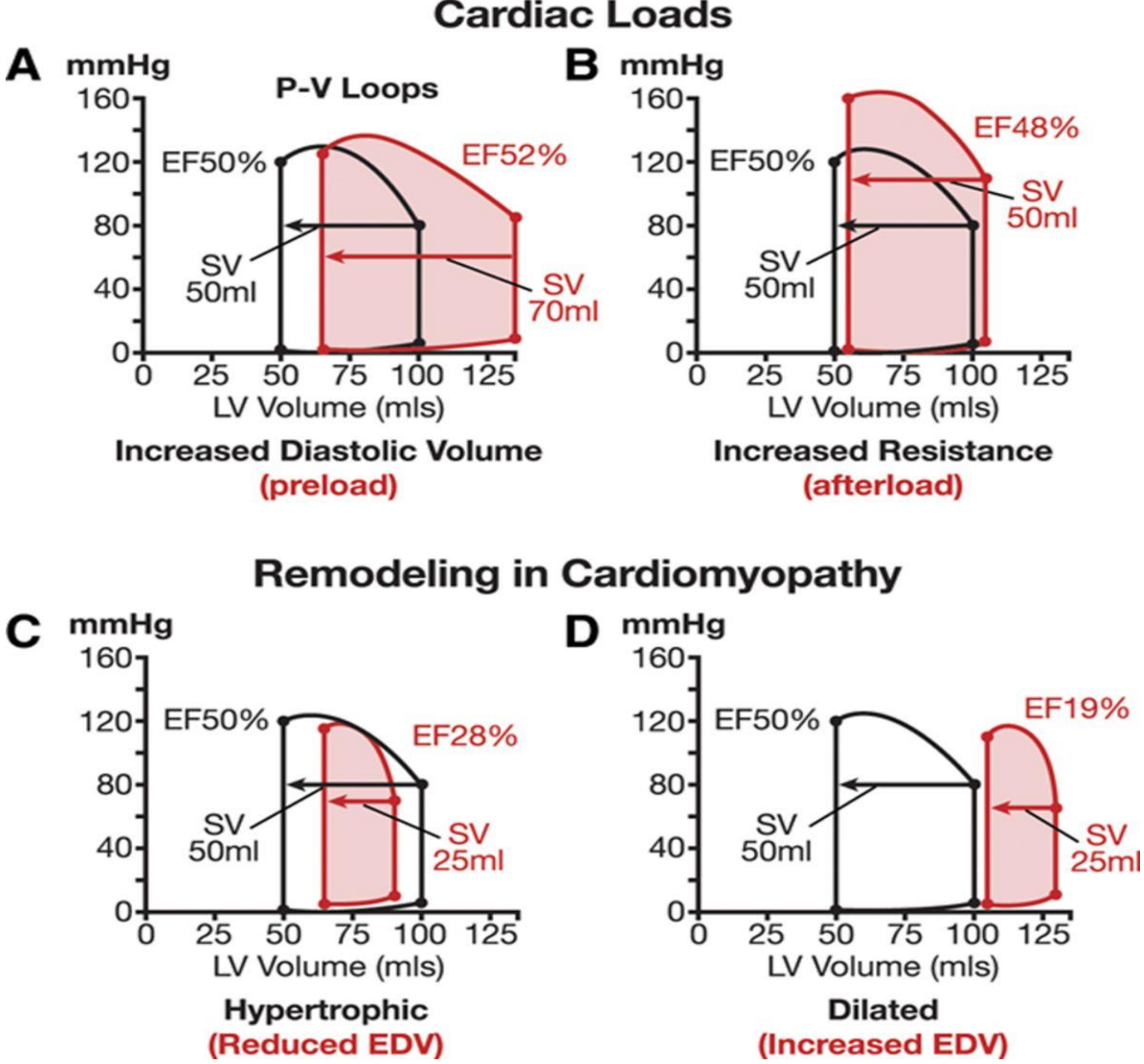
Structural Δs:
↑ EDV

Coupling RV function to the pulmonary circulation



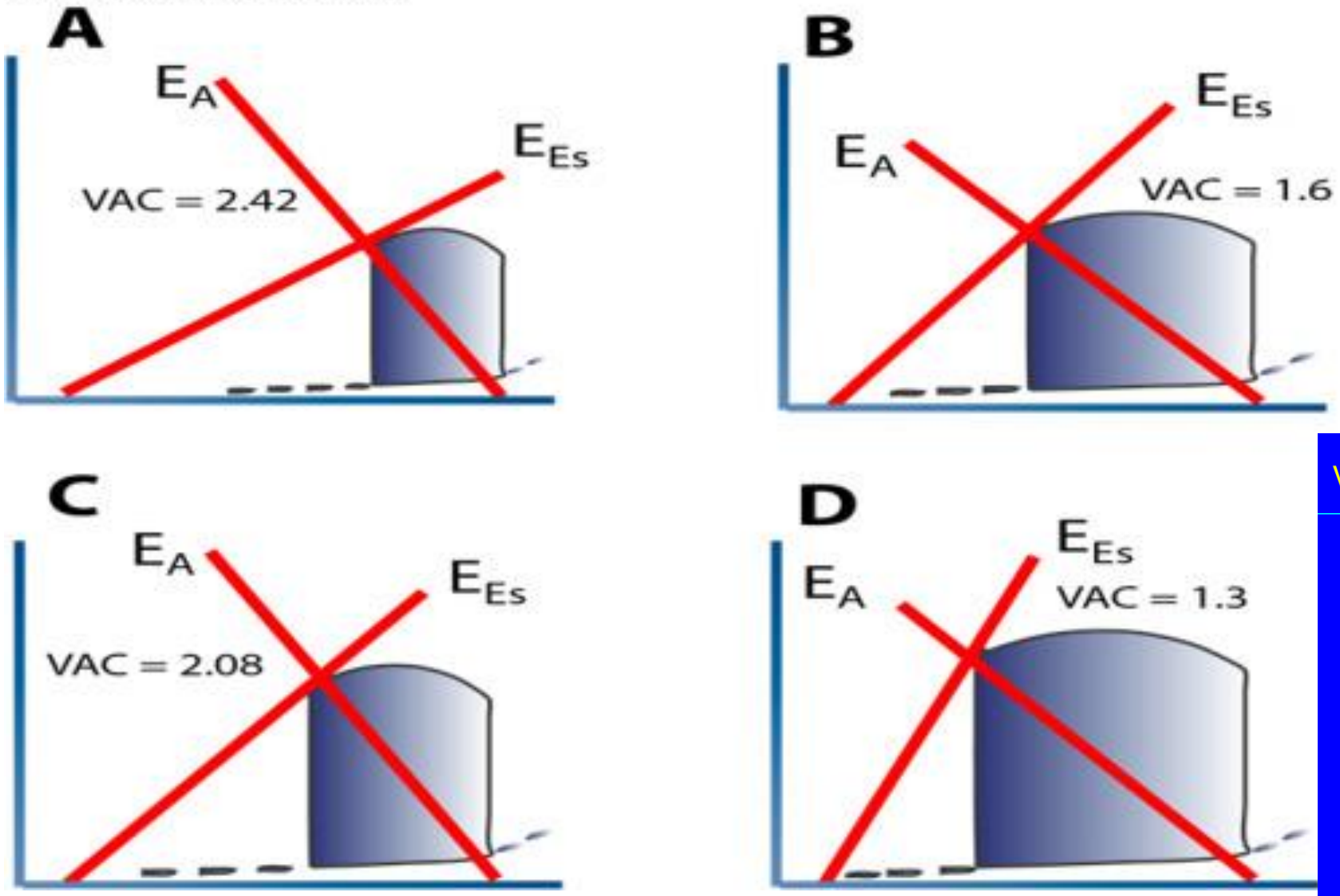


Pathophysiology of the right ventricle and of the pulmonary circulation in pulmonary hypertension: an update
Anton Vonk Noordegraaf, Kelly Marie Chin, François Haddad, Paul M. Hassoun, Anna R. Hemnes…
European Respiratory Journal 2018; **DOI:** 10.1183/13993003.01900-2018



Misunderstood and Overrated (Changing the Paradigm in Categorizing Heart Failure)2022
Marvin A. Konstam andFrançois M. Abboud

Fig. 1. VAC measurements: A: Baseline VAC 2.42 Ees depression; B: After Levosimendan, Ees restoration and Ea decrease; C Ea sudden increase after vasoactive administration; D VAC restored after beta blockers applied.



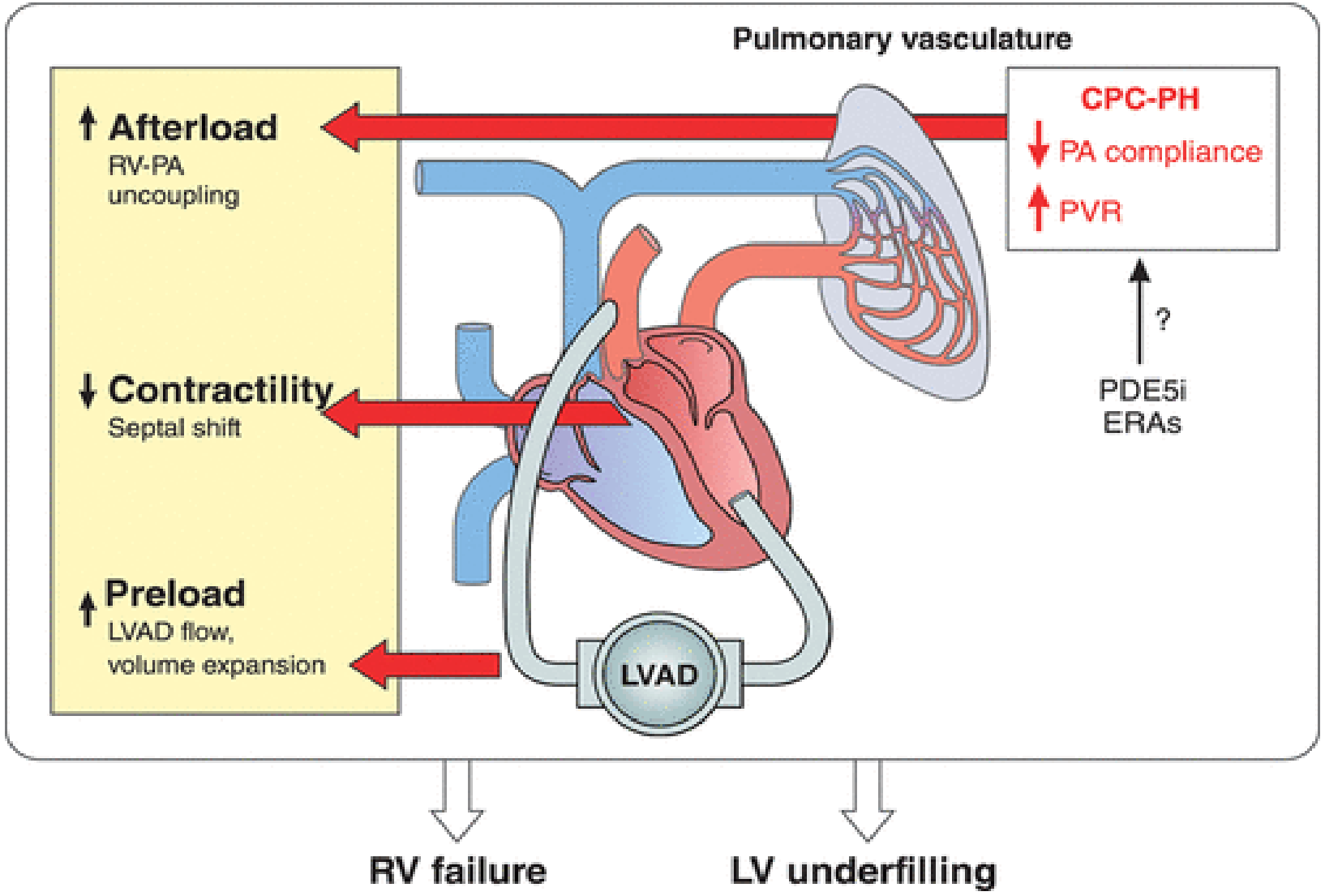
Ventricular-arterial coupling – ratio of elastances

$VAC = E_A / E_{LV}$ with volumes indexed for body surface area

- Greatest efficiency when elastances are matched
- Optimal transfer of blood from LV to aorta
- BP, LV pressure, and CO are maintained in a physiological range
- Normal ratio ~ 1.0 ± 0.36
- Normal E_A 2.2 ± 0.8 mmHg / ml
- Normal E_{LV} 2.3 ± 1.0 mmHg / ml

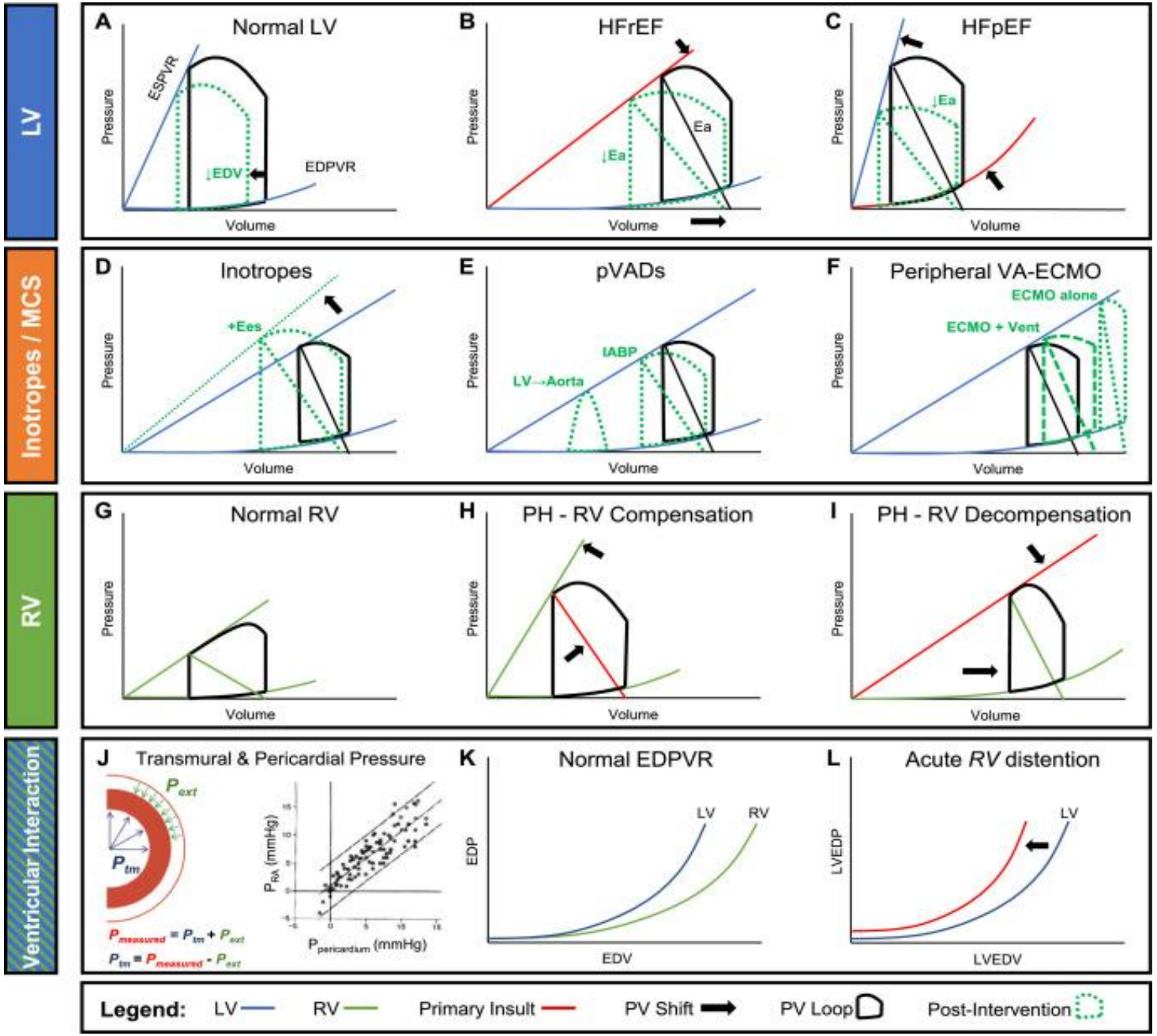
Chantler PD et al, J Appl Physiol 2008;105:1342-51

Ventricular arterial coupling to manage hemodynamic instability in the theatre: an elastance based approach at bedside
Pietro Bertini, S Gonnella, G Brizzi, G Mancino, L Doroni, F Guarracin



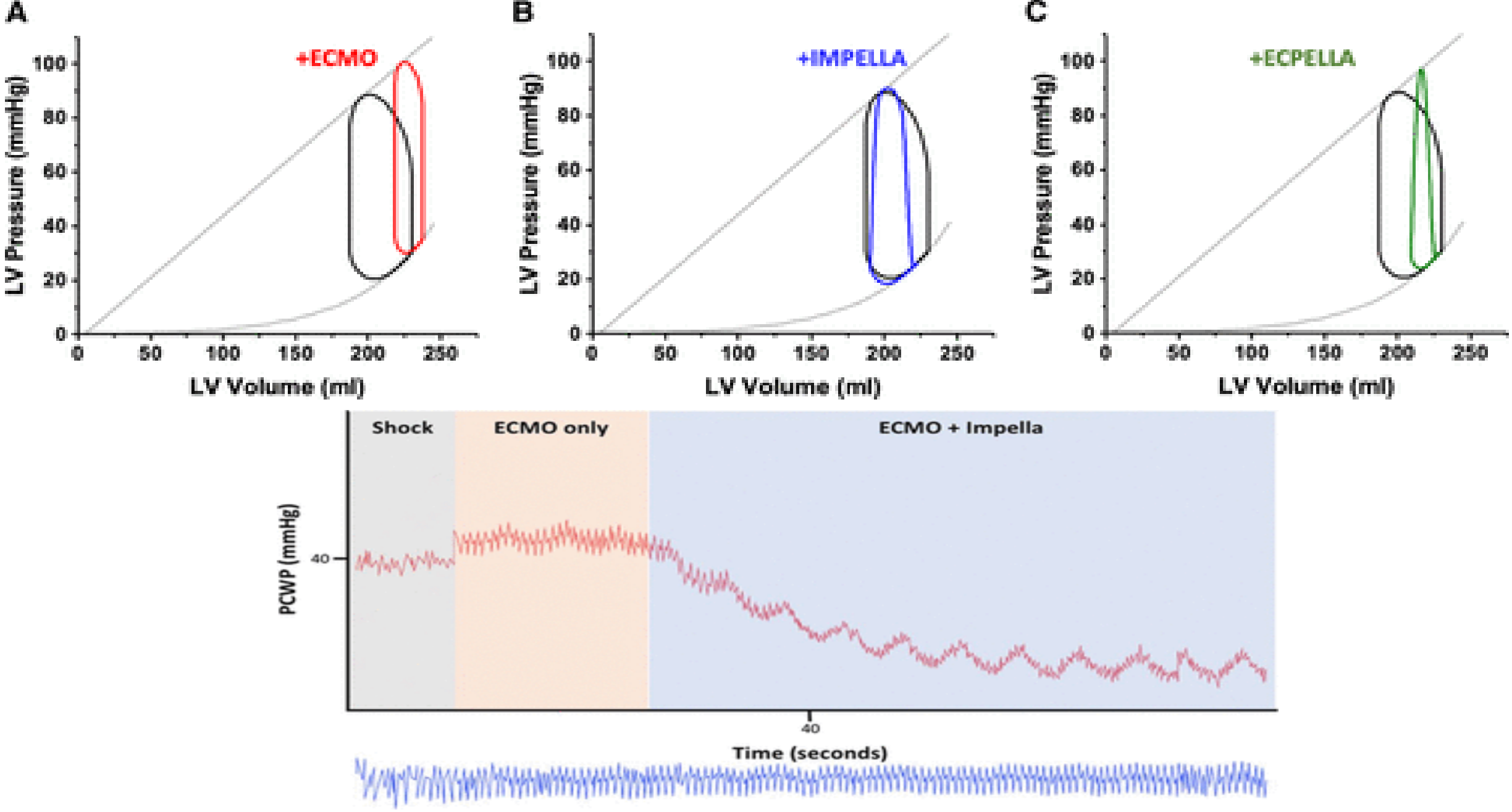
Cpc-ph – combined pre-post pulmonary HTN

Intersection of Pulmonary Hypertension and Right Ventricular Dysfunction in Patients on Left Ventricular Assist Device Support
Circulation: Heart Failure. 2018;11



Hemodynamics for the Heart Failure Clinician: A State-of-the-Art Review 2022

Author links open overlay panelStevenHsuMD[1]James C.FangMD[2]Barry A.BorlaugMD[3]



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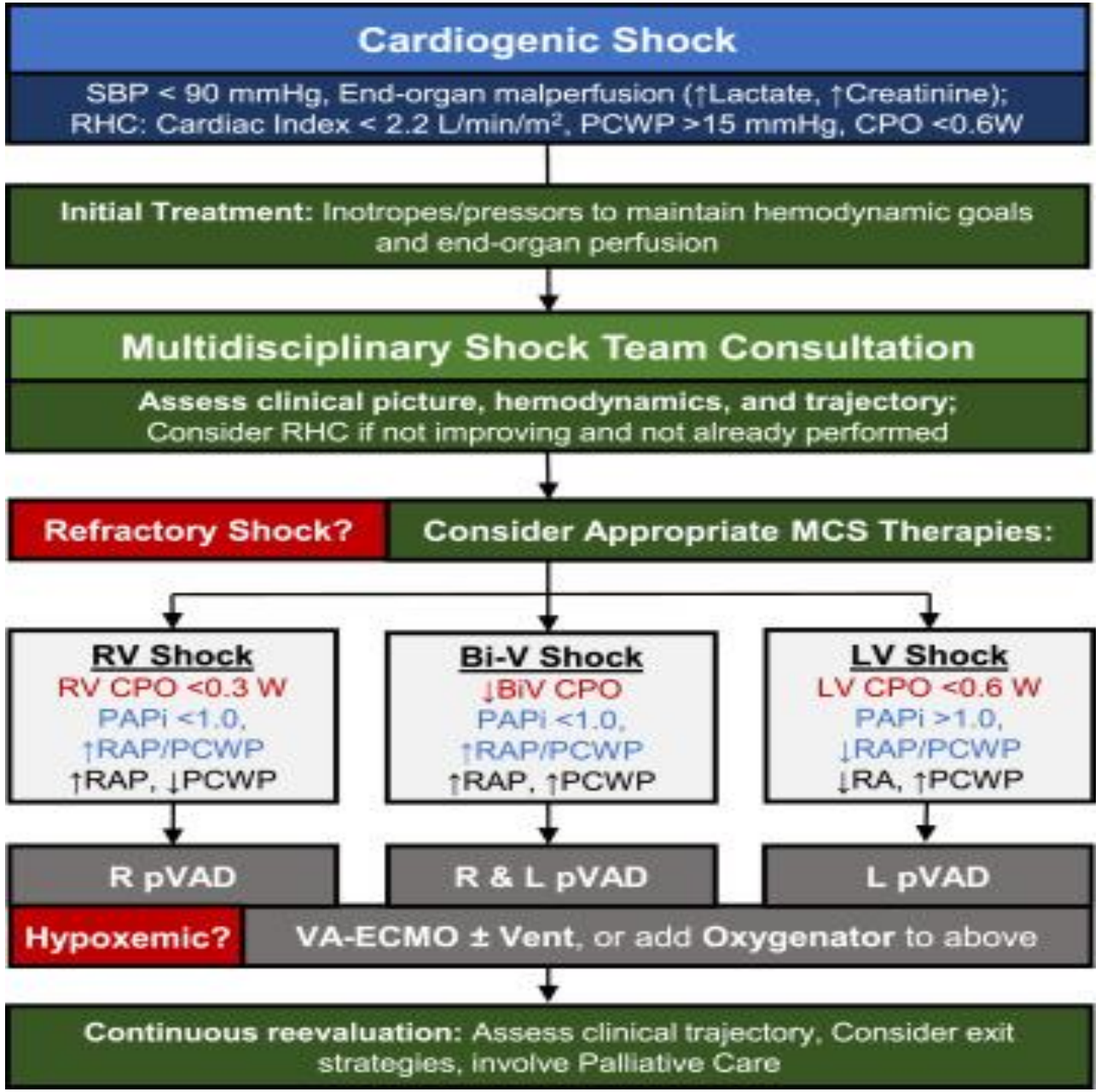

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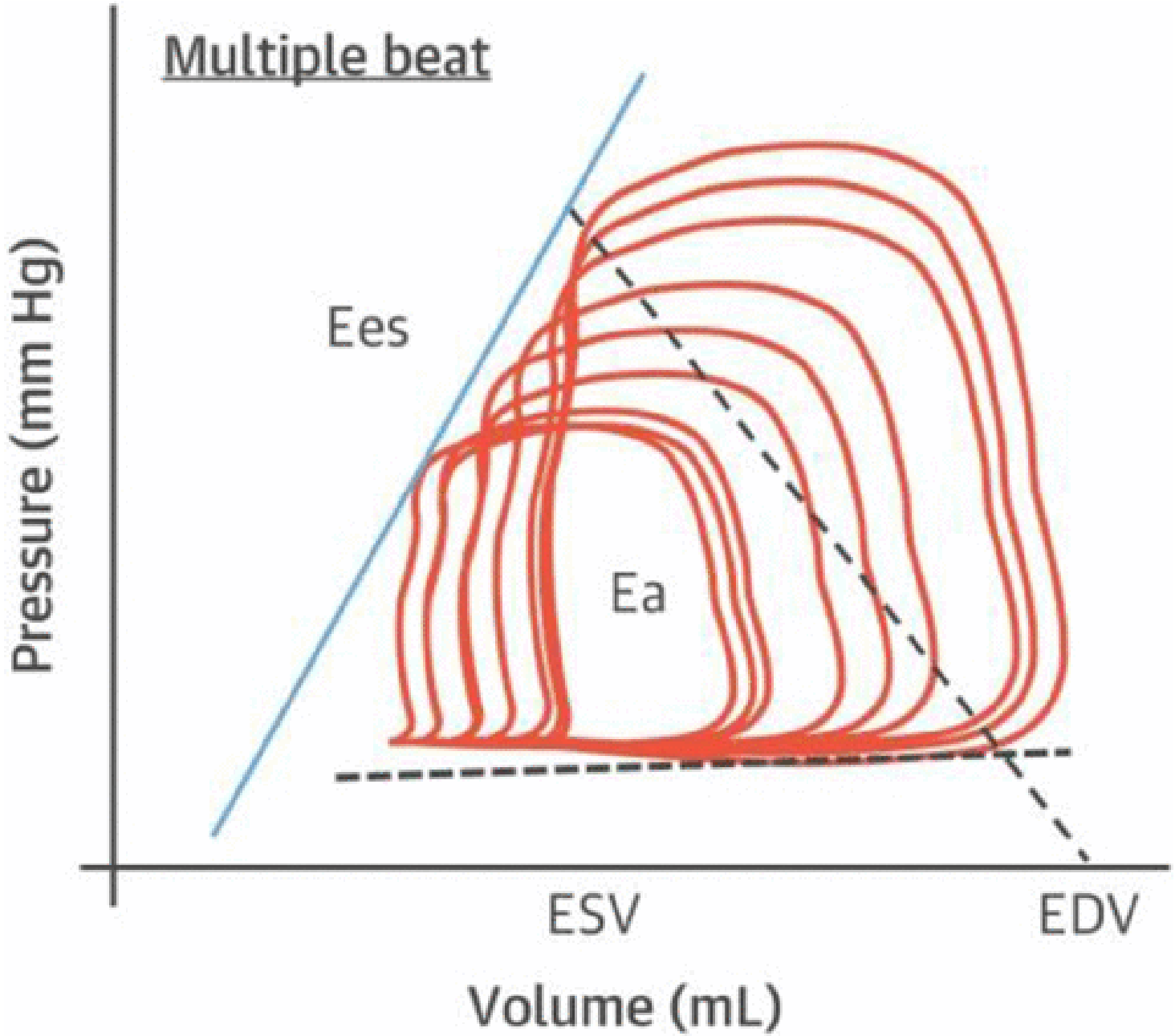
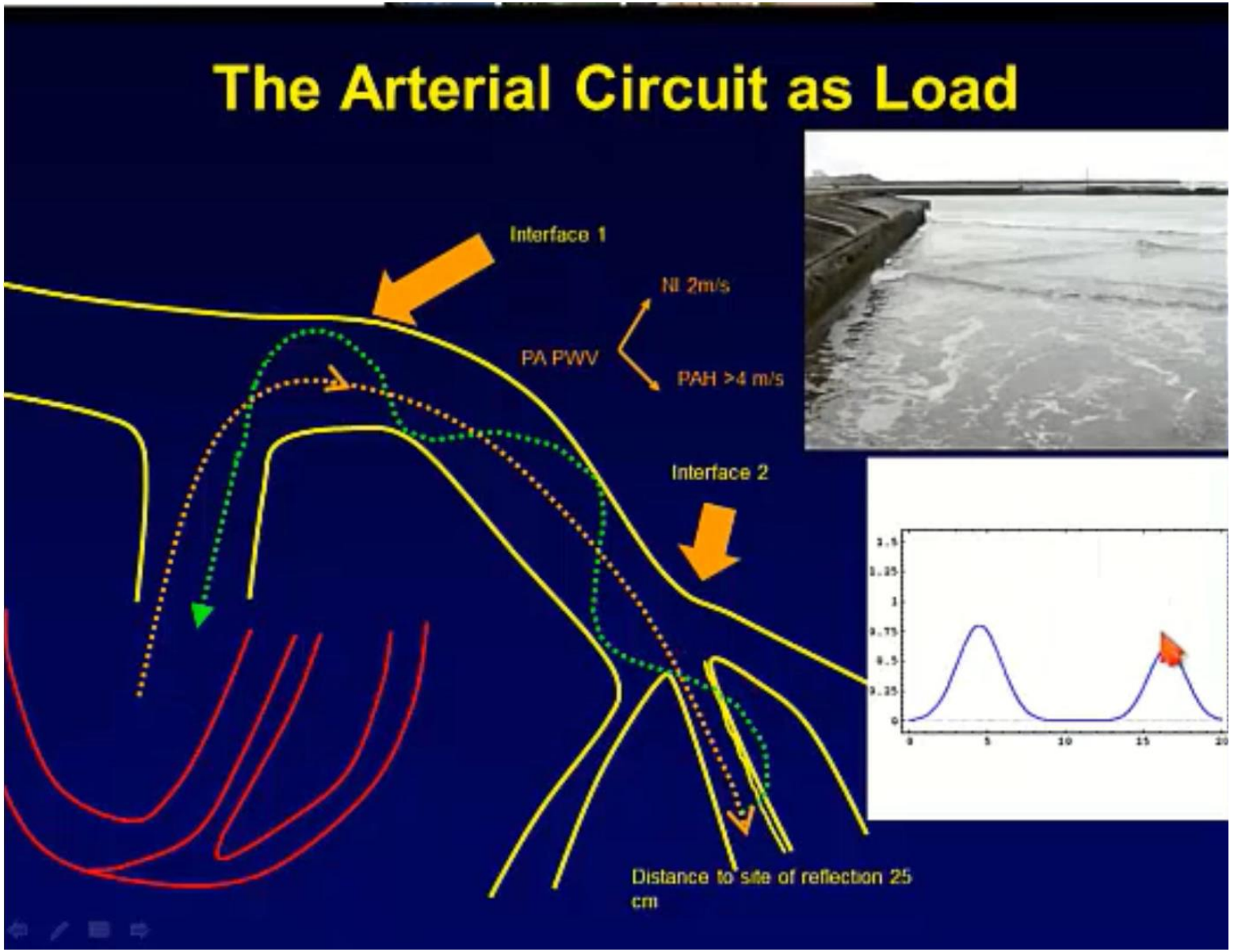

Multiple beat
Ees
Ea
Pressure (mm Hg)
ESV
EDV
Volume (mL)



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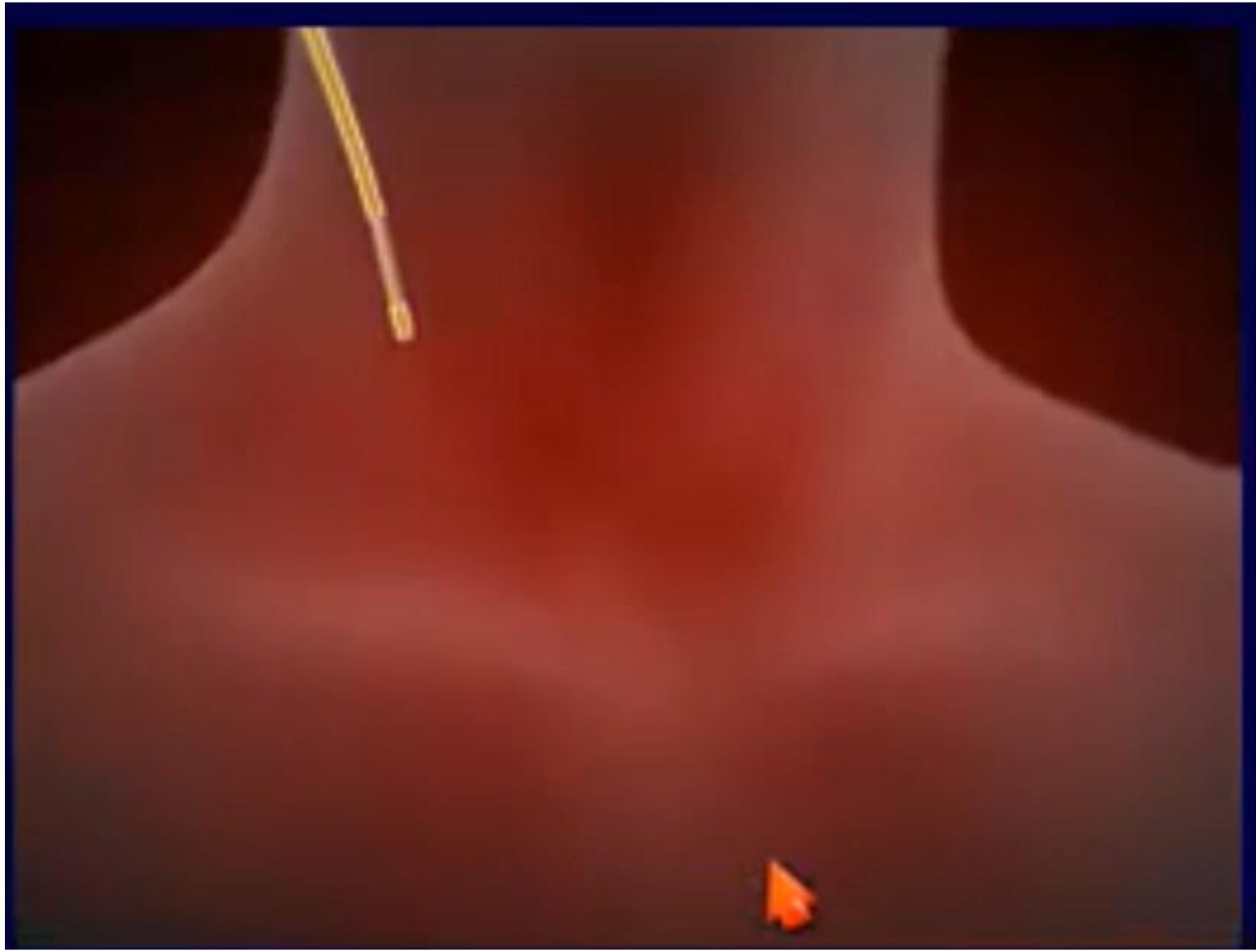
Hemodynamic study

Hemodynamics



Parameters	Normal range
Central venous pressure (CVP)	3–8 mm Hg
Right atrium pressure (RAP) mean	0–8 mm Hg
Right ventricle pressure (RVP) systolic	15–30 mm Hg
Pulmonary artery pressure (PAP)	
systolic	15–30 mm Hg
mean	8–20 mm Hg
diastolic	3–12 mm Hg
Pulmonary wedge pressure (PCWP)	4–15 mm Hg
Left atrium pressure (LAP) mean	2–12 mm Hg
Left ventricle end-diastolic pressure	5–12 mm Hg

Parameter	Abbreviation	Normal Range
Central Venous Pressure	CVP	0-5 mmHg
Pulmonary Artery Wedge Pressure	PAWP	6-12 mmHg
Cardiac Index	CI	2.4-4.0 L/min/m^2
Stroke Index	SI	20-40 ml/m^2
Systemic Vascular Resistance Index	SVRI	25-30 wood units
Pulmonary Vascular Resistance Index	PVRI	1-2 wood units
Oxygen Delivery	DO2	520-570 ml/min/m^2
Oxygen Uptake	VO2	110-160 ml/min/m^2
Oxygen Extraction Ratio	O2ER	0.2-0.3

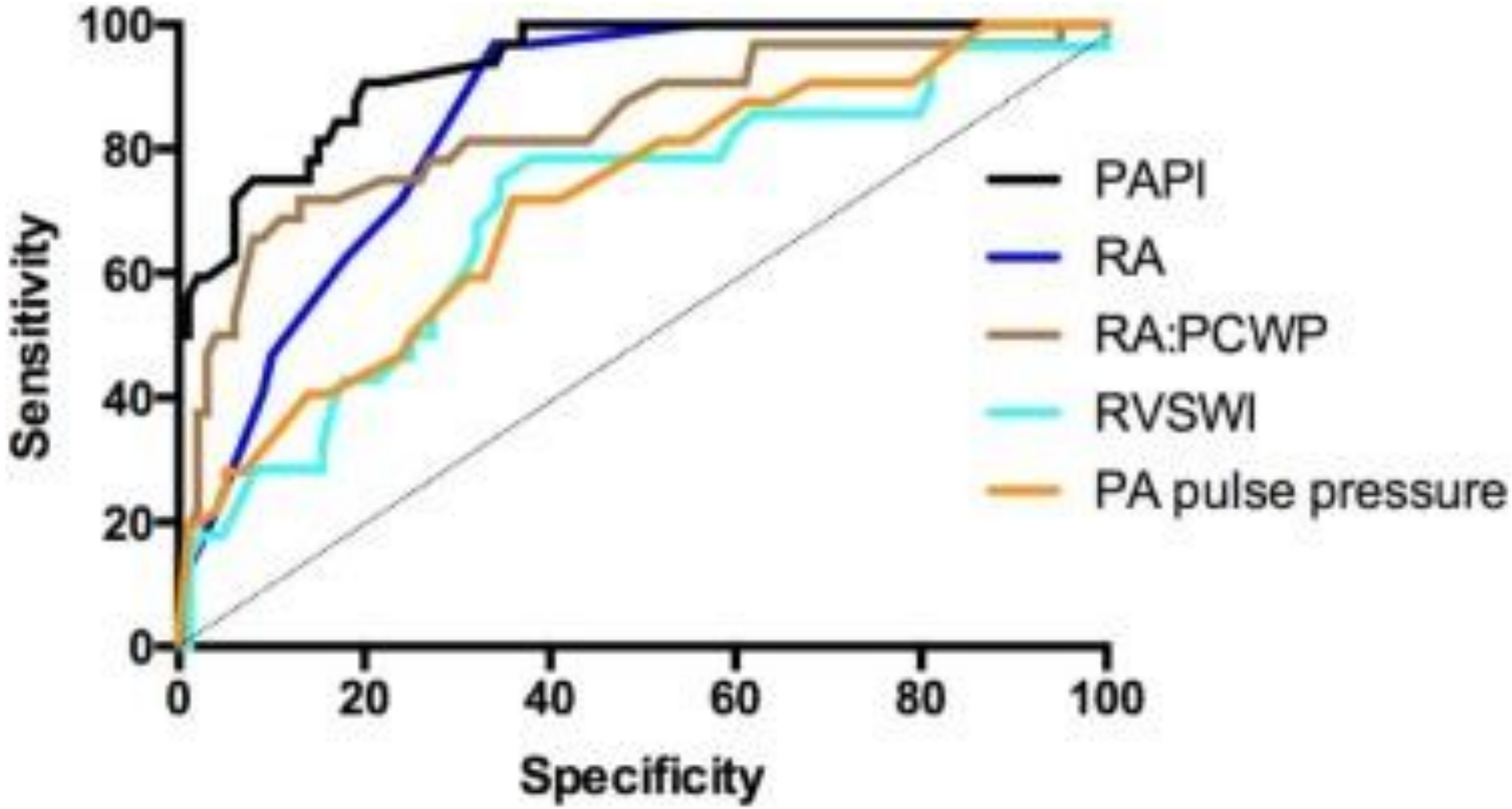
RV evaluation

- TAPSE\SPAP > 0.36
- SV\ESV > 0.86
- RA\PCWP < 0.63
- **RVSWI > 400 (PA-RA)x CI x 1000\HR**
- **PAPI > 2 (SPA-DPA)\MEAN RA**

Table 5. Hemodynamic Assessment of RH Function

Hemodynamic Parameters Associated With RV Function

Variable	Calculation	Thresholds Associated With Clinical Events in Specific Populations
RAP	RAP (or CVP)	>15 mm Hg (RHF after LVAD)[83,201]
Right-to-left discordance of filling pressures	RAP:PCWP	>0.63 (RHF after LVAD)[76]>0.86 (RHF in acute MI)[202]
PA pulsatility index	(PASP−PADP)/RAP	<1.0 (RHF in acute MI)[203]<1.85 (RHF after LVAD)[204]
RV stroke work index	(MPAP−CVP)×SVI	<0.25–0.30 mm Hg·L/m^2 (RHF after LVAD)[205,206]
PVR	(MPAP−PCWP)/CO	>3.6 WU (RHF after LVAD)[207]
PA compliance	SV/(PASP−PADP)	<2.5 mL/mm Hg (RHF in chronic HF, RV-PA coupling in PAH)[26,115]


100
80
60
40
20
0
Sensitivity
0
20
40
60
80
100
Specificity
PAPI
RA
RA:PCWP
RVSWI
PA pulse pressure

Diastolic dysfunction

- Control the BP
- Zero calibration.
- True wedge pressure.
- Exercise or volume challenge.

↓ RV afterload	↑ RV preload	↓ RV preload	↑ RV contractility	PH cause
Nitric oxide	Fluid bolus	Sitting	Exercise	Pulmonary angio
Prostacyclin ana-logues	PLR	Diuretics	Dobutamine	Thoracic pres-sure estimation
			RV DDD pacing?	

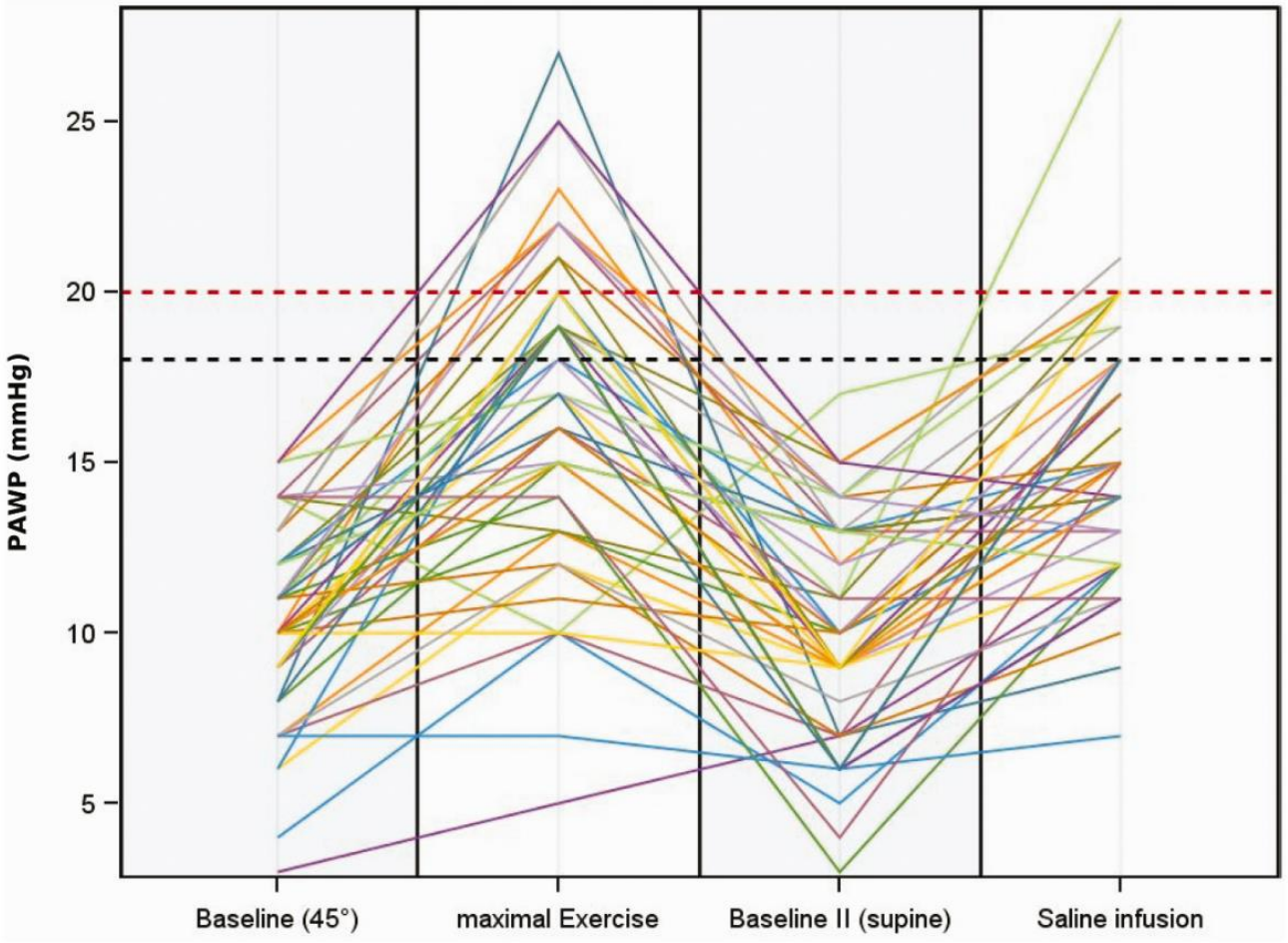


Fig. 2. Course of PAWP at rest, during exercise, at second baseline and after fluid challenge in the entire patient group (*n* = 49).

PAWP: pulmonary artery wedge pressure.

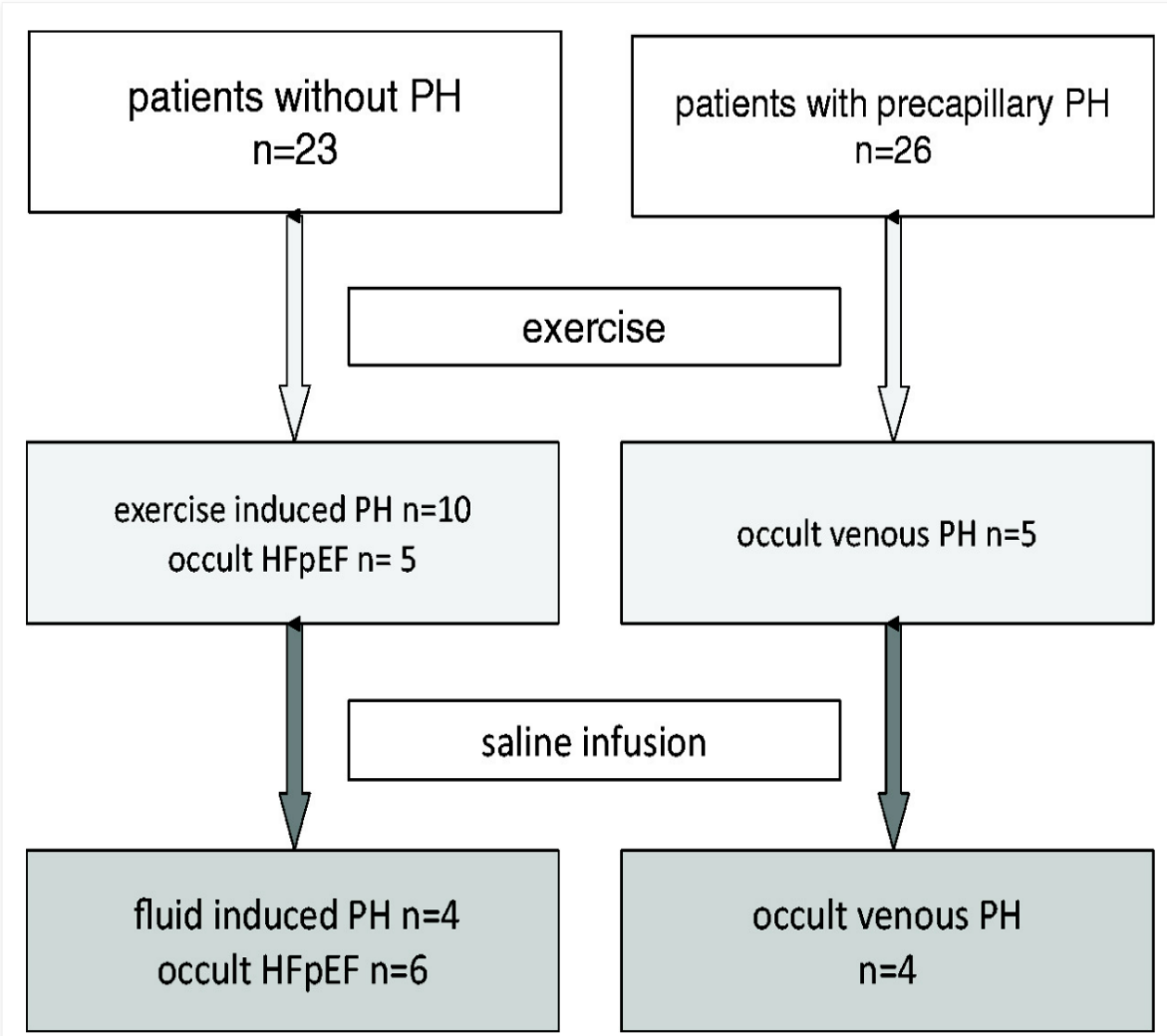
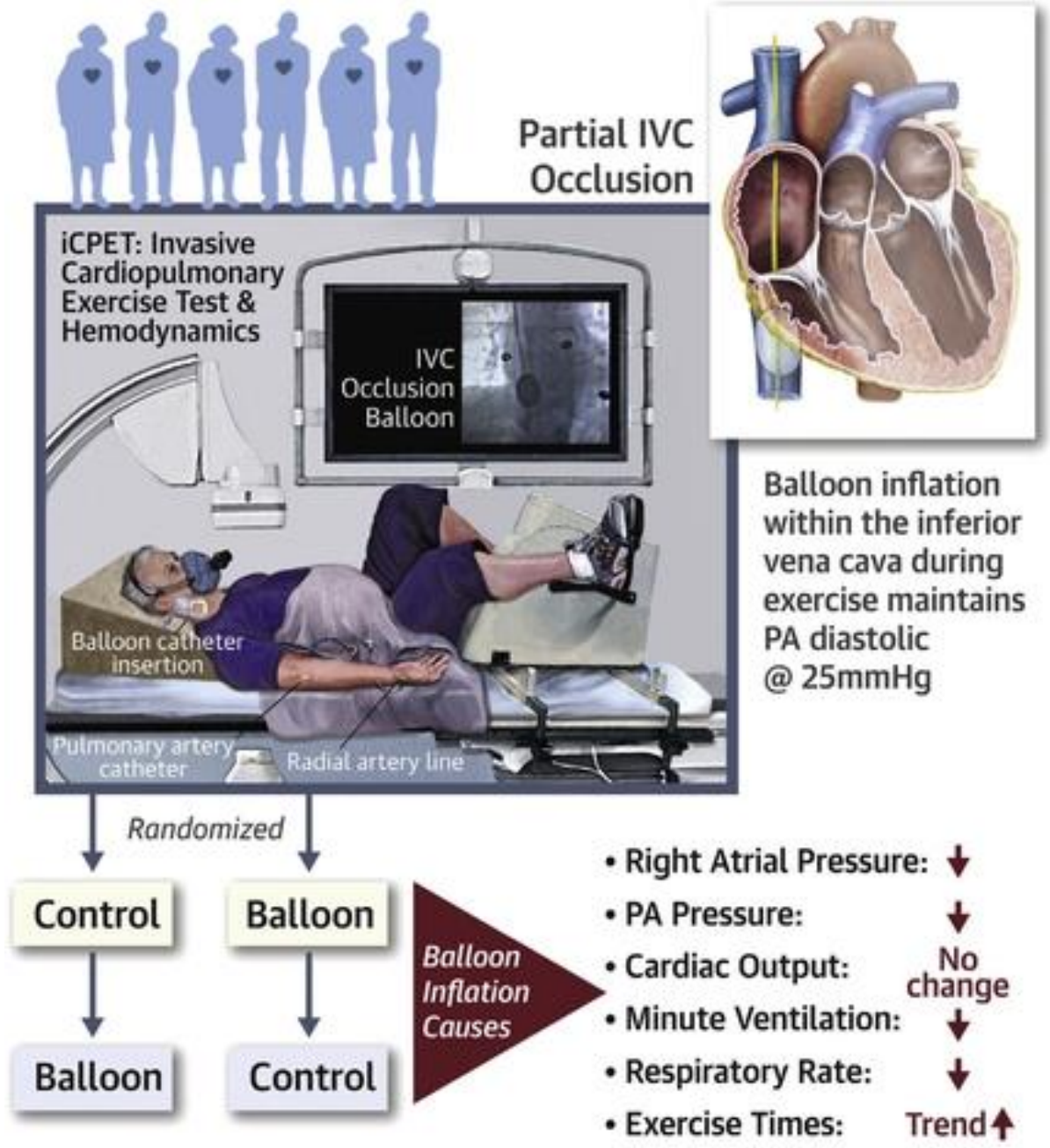


Fig. 3. Summary of results after exercise and after fluid challenge.

PH: pulmonary hypertension; HFpEF: heart failure with preserved ejection fraction.

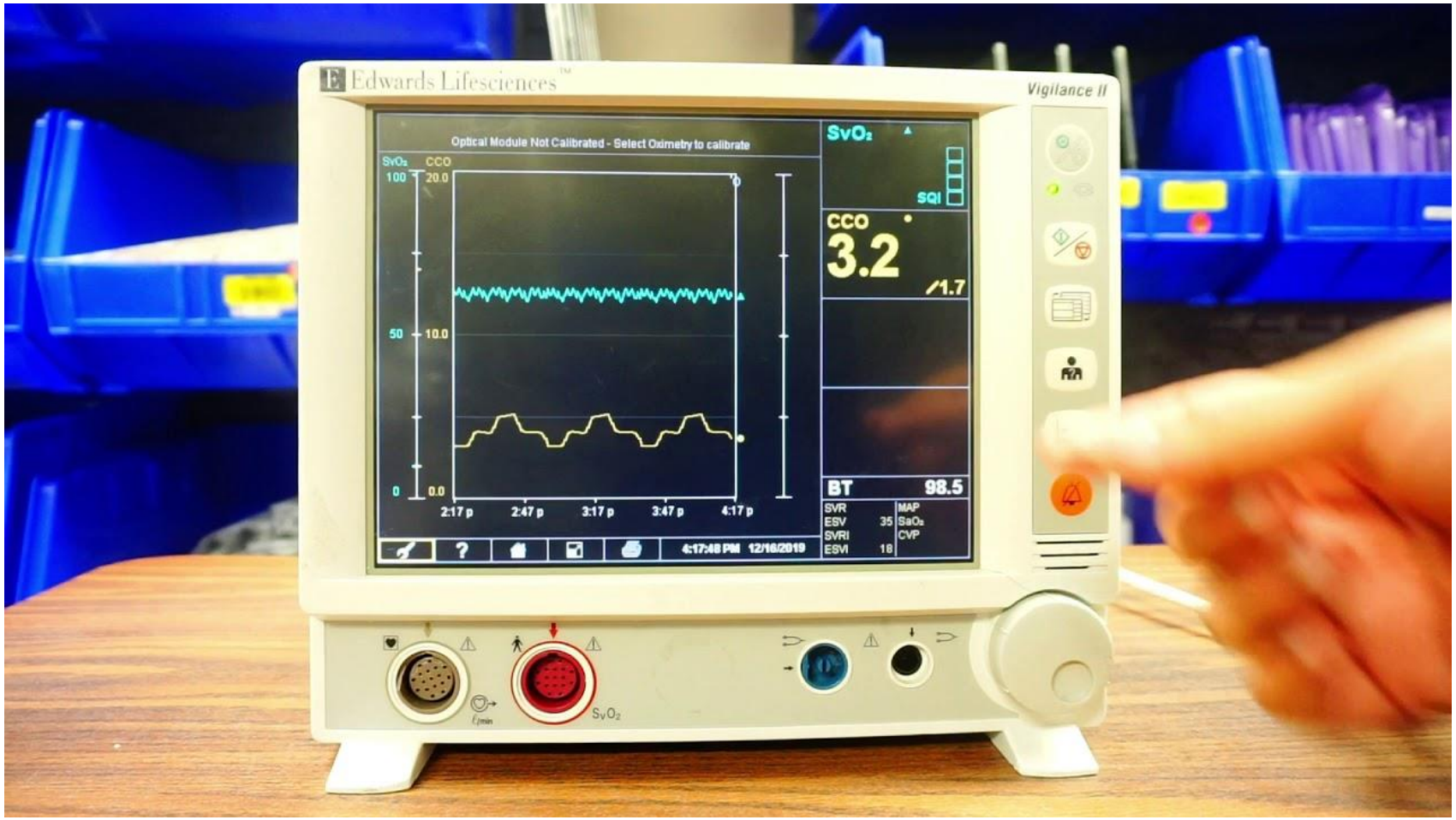
Exercise and fluid challenge during right heart catheterisation for evaluation of dyspnoea , pulmonary circulation
Ralf Ewert, Alexander Heine, [...], Annegret Müller-Heinrich, Tom Bollmann, Anne Obst, Susanna Desole, Christine Knaak, Beate Stubbe, Christian F. Opitz, and Dirk Habedank 2022

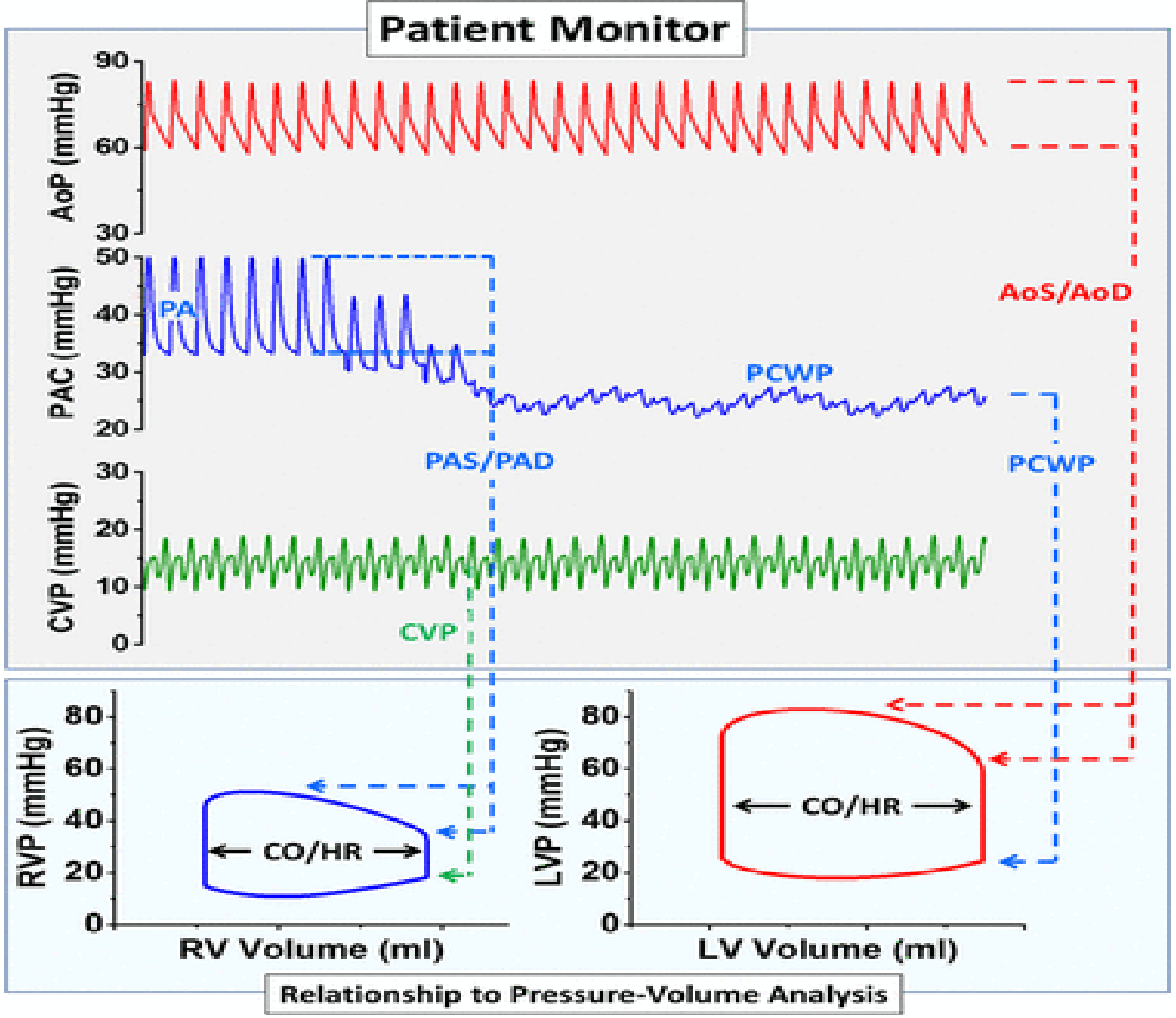


Kaiser, D.W. et al. J Am Coll Cardiol Basic Trans Science. 2021;6(3):189-98.

Continuous monitoring of hemodynamics

- When to use ?


Edwards Lifesciences
Vigilance II
Optical Module Not Calibrated - Select Oximetry to calibrate
SvO2
CCO
100
50
0
20.0
10.0
0.0
2:17 p
2:47 p
3:17 p
3:47 p
4:17 p
SQI
CCO
3.2
/1.7
BT
98.5
SVR
ESV
35
SVRI
ESVI
18
MAP
SaO2
CVP
4:17:48 PM 12/16/2019
SvO2



Derived Parameters

LVSW = MAP*SV RVSW = PAPm * SV

CPO = CO*MAP PAPi = (PAS-PAD)/CVP

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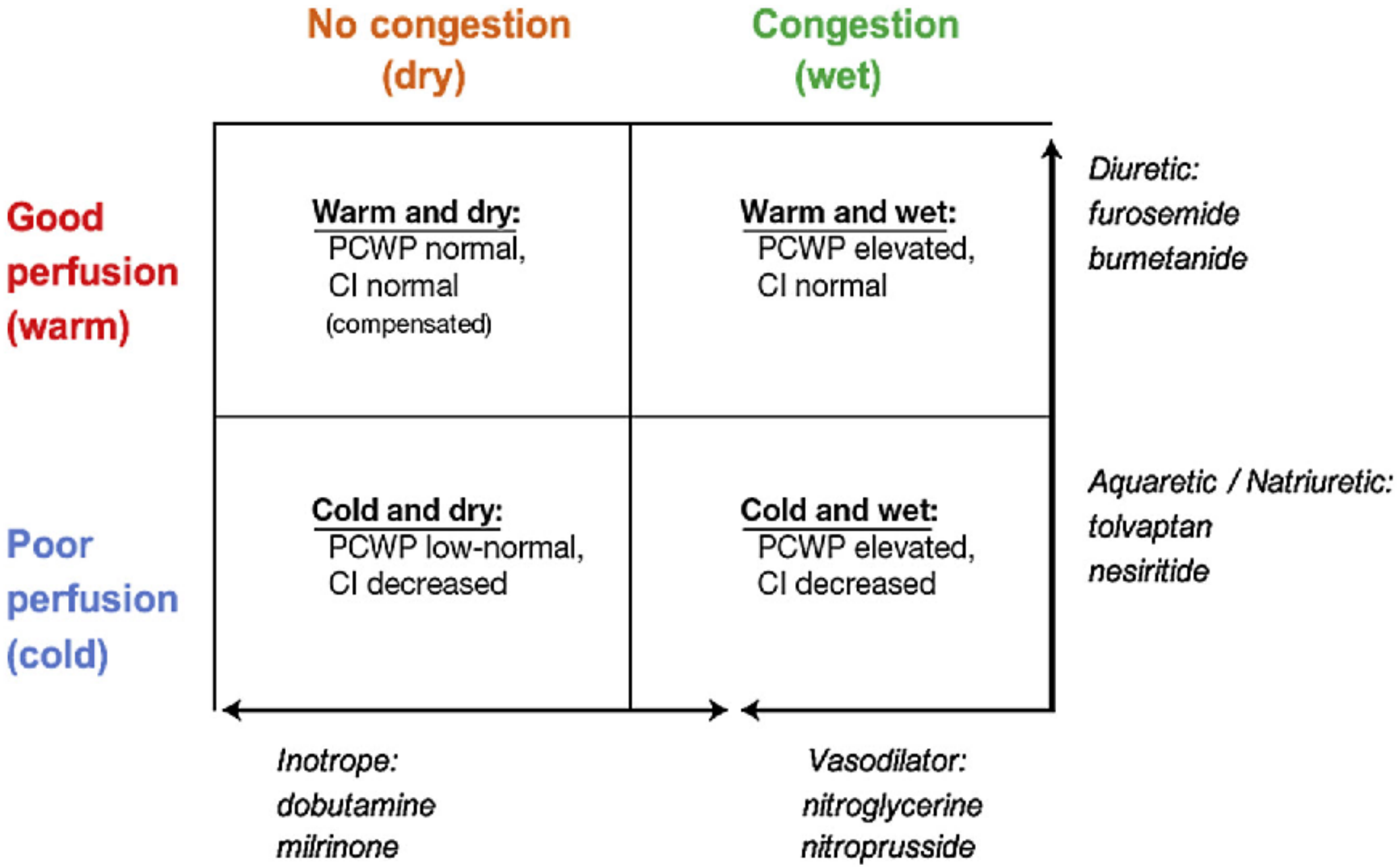
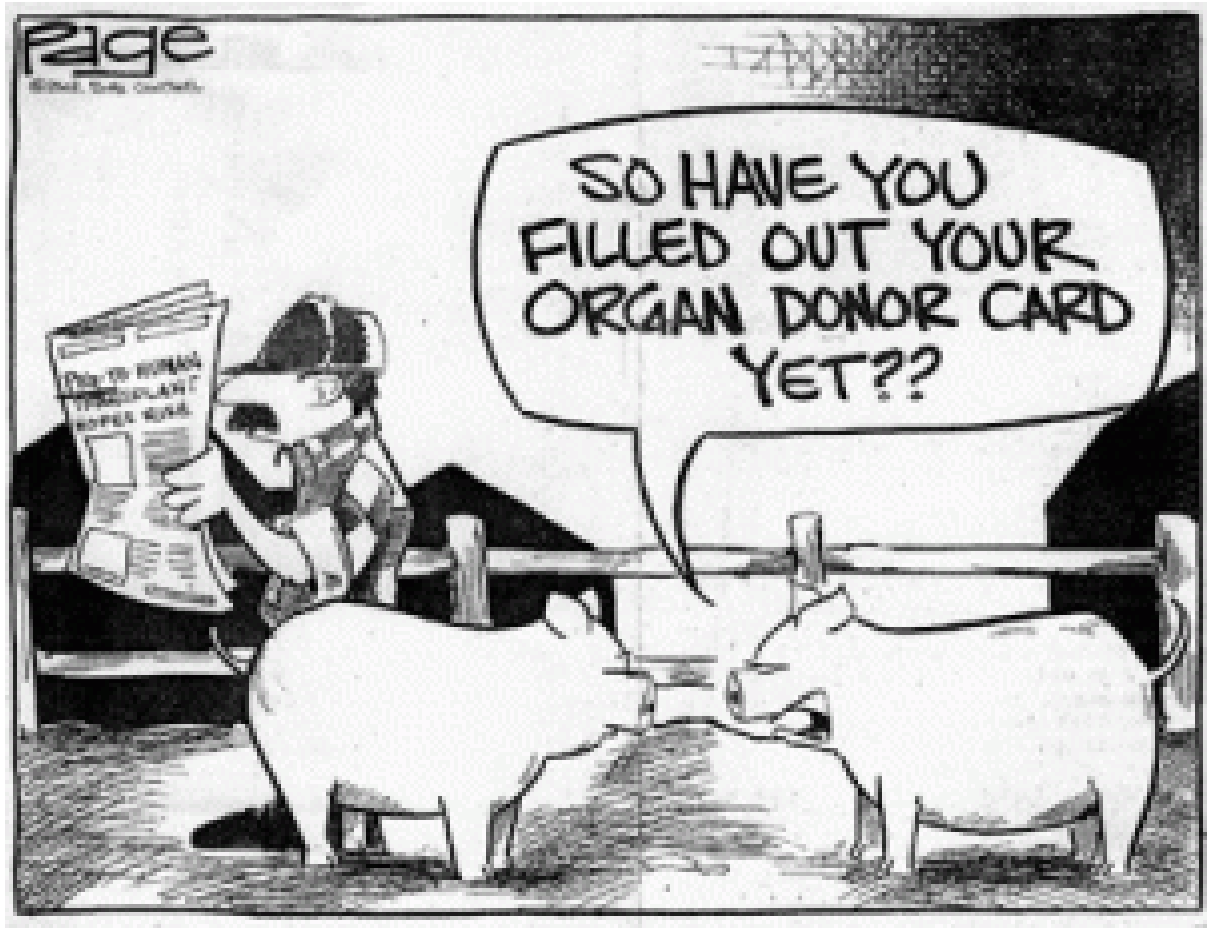


Published in Cardiology clinics 2014
Managing acute decompensated heart failure.


THANK
YOU


Page
SO HAVE YOU FILLED OUT YOUR ORGAN DONOR CARD YET??