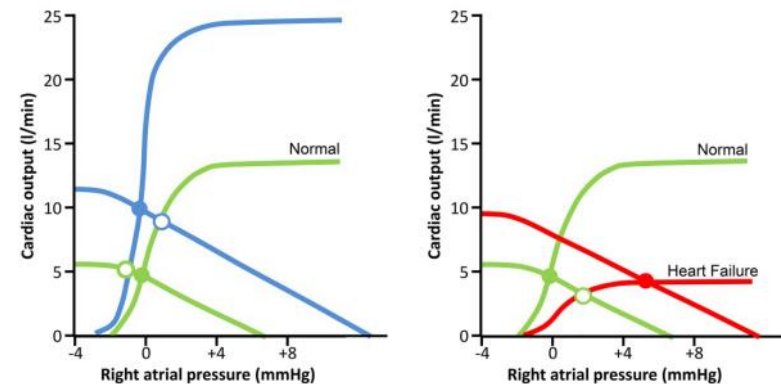


Cardiogenic Shock: State-of-the-Art Definitions and Classification for Optimal Treatment Strategy

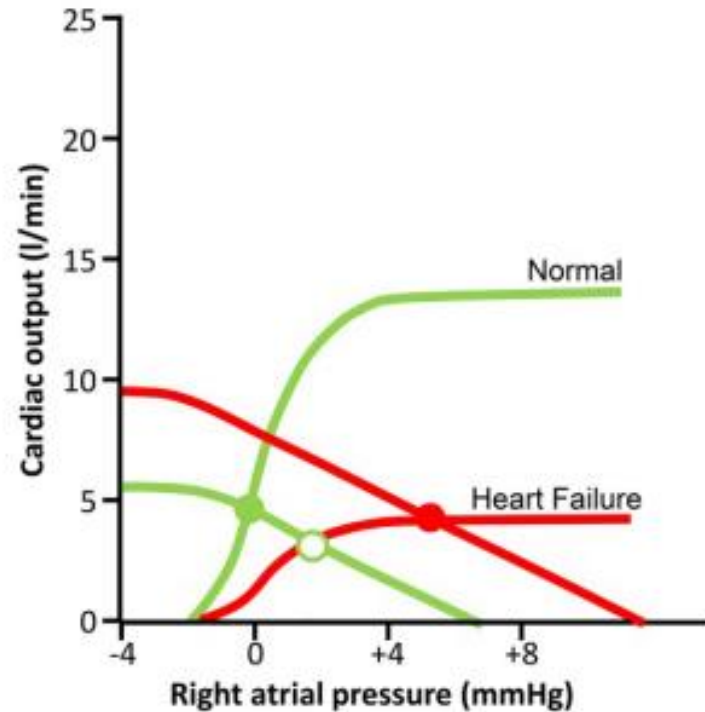
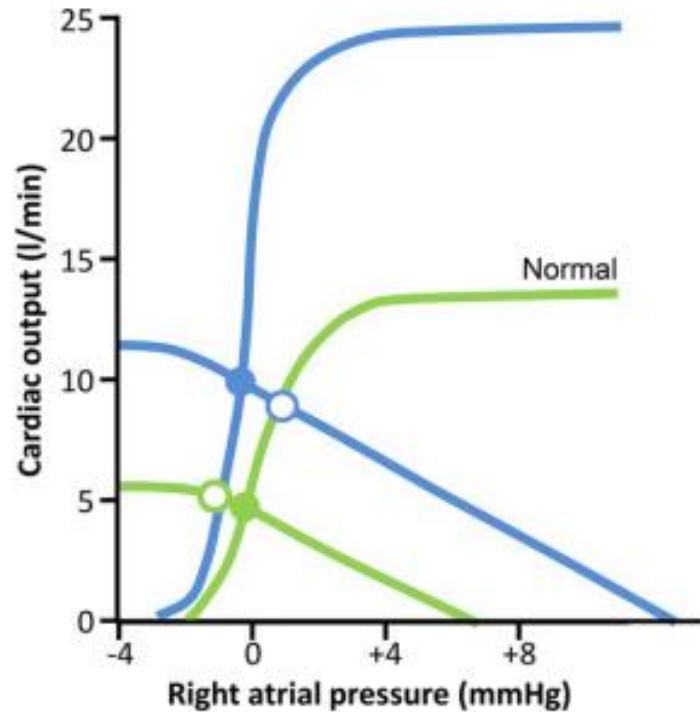
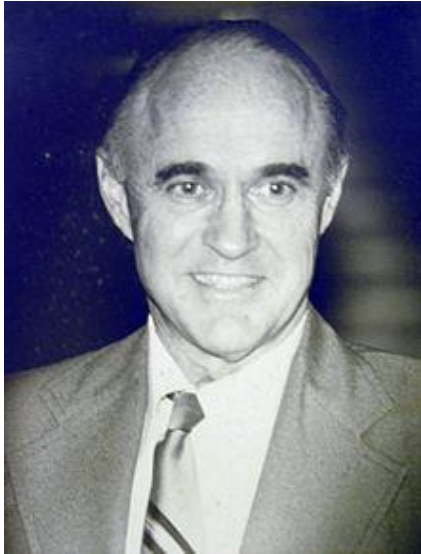
Cardiogenic shock severity and optimal treatment strategy

How to use hemodynamics to assess the severity of cardiogenic shock ?

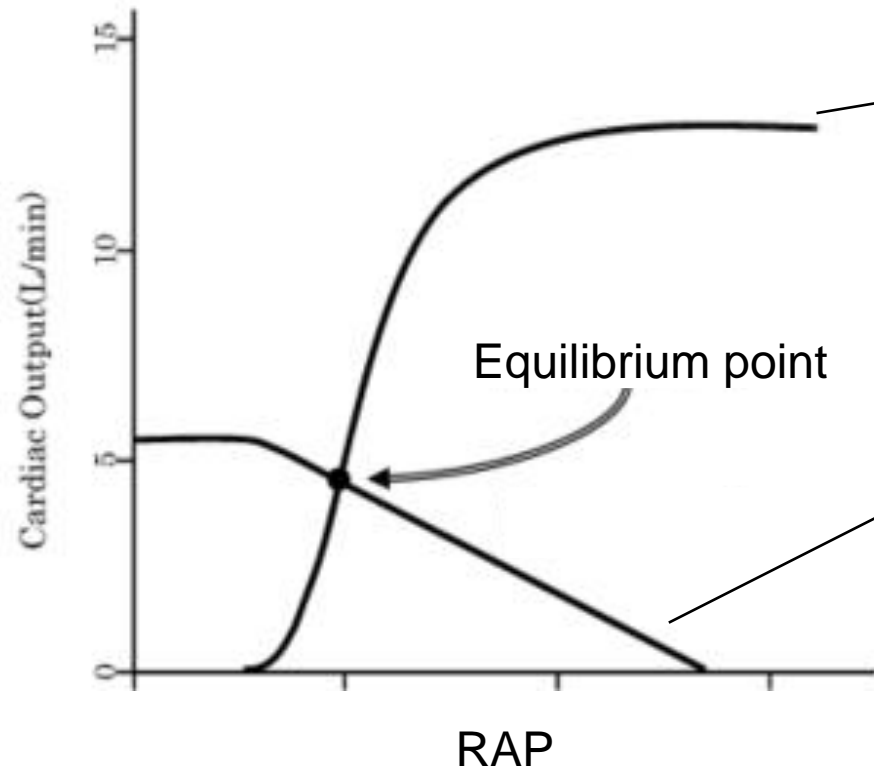
Keita Saku, MD, PhD
National Cerebral and Cardiovascular Center



Understanding hemodynamics = Understanding circulatory equilibrium

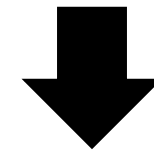


Hemodynamics is determined by CE



Cardiac output curve
(Frank-Starling curve)

Venous return curve



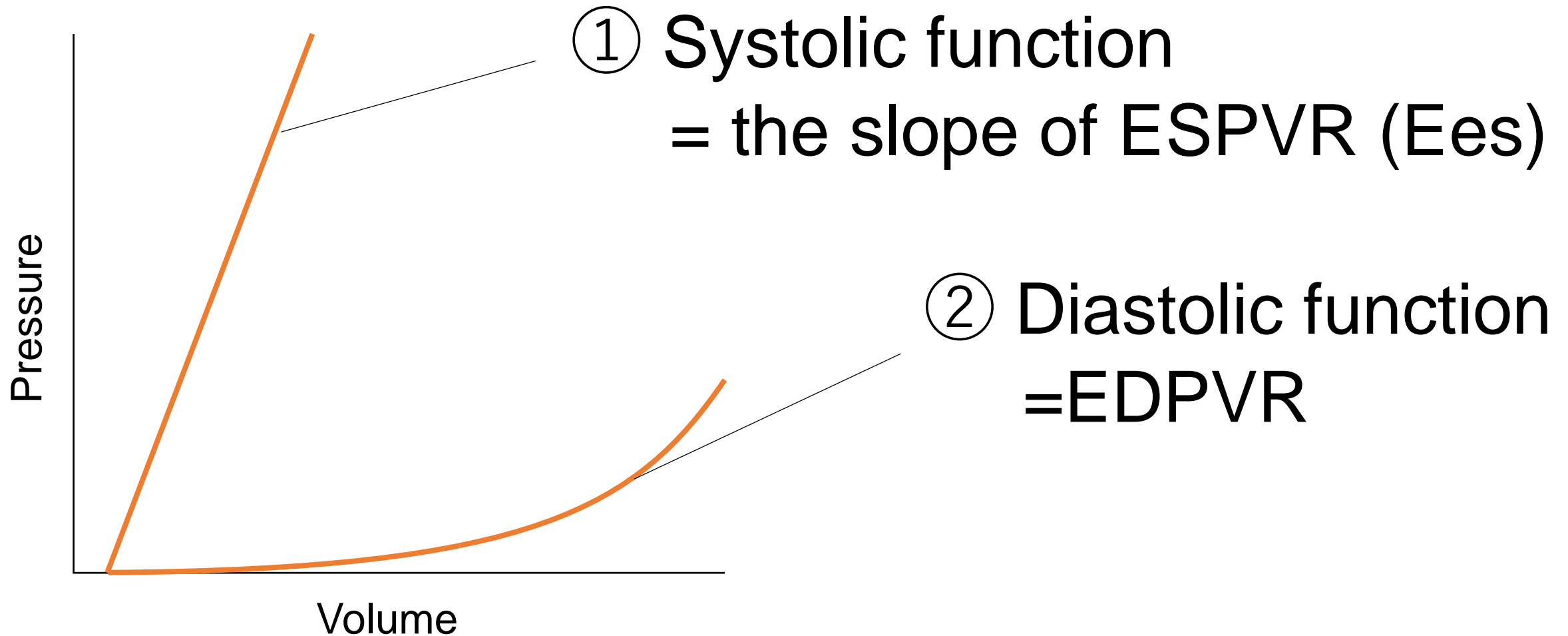
Equilibrium point
=Hemodynamics



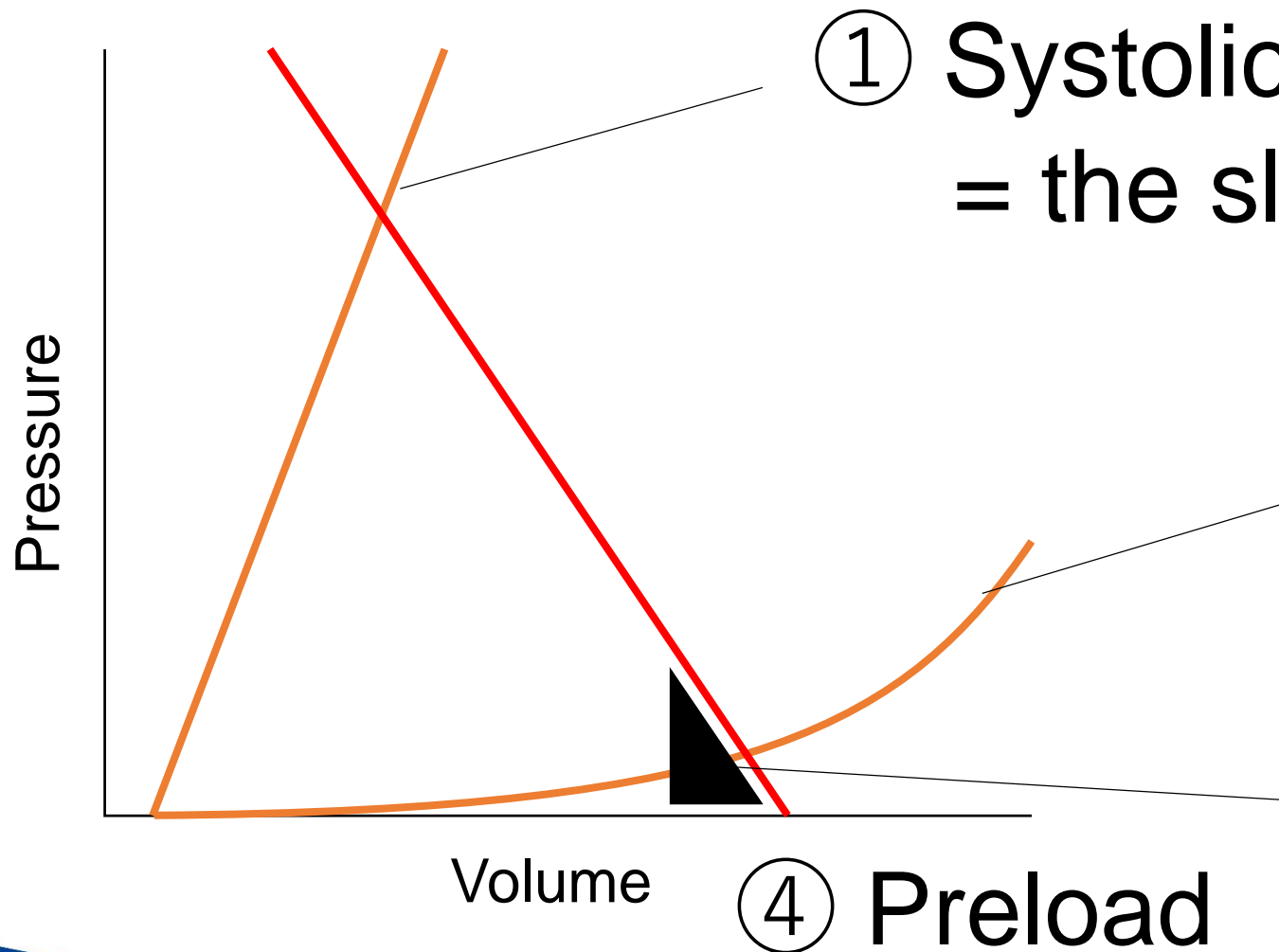
What is cardiac output curve?



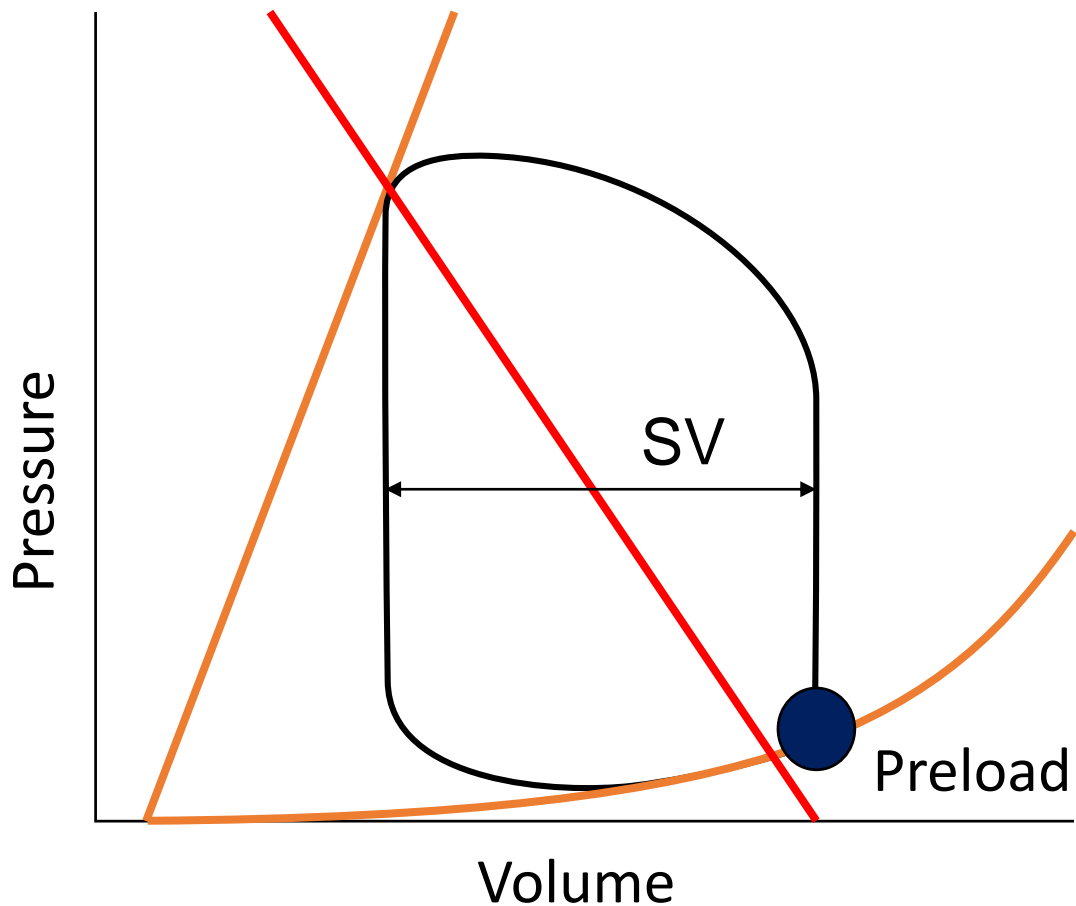
PV loop



PV loop



PV loop



Cardiac function (E_{es} , EDPVVR)
Arterial property (E_a)

×

Preload $SV = \frac{E_{es}}{E_a + E_{es}} (V_{ed} - V_0)$

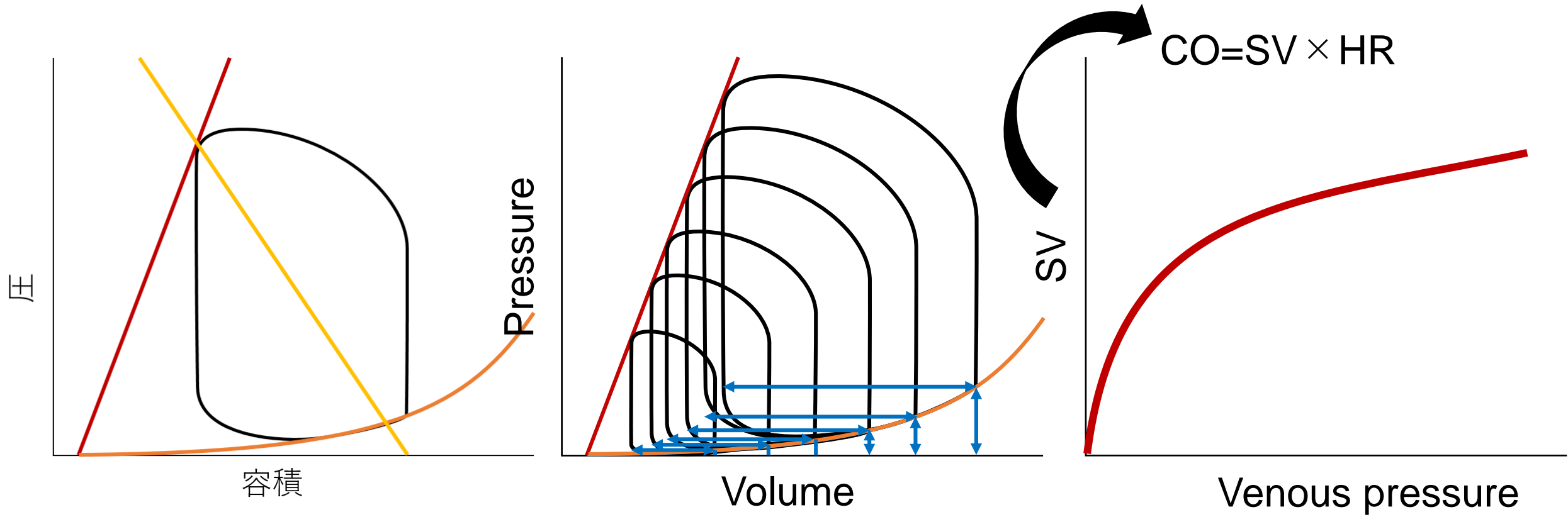
||

Stroke volume

PV loop shows us how much the heart can eject the blood in a cardiac cycle.



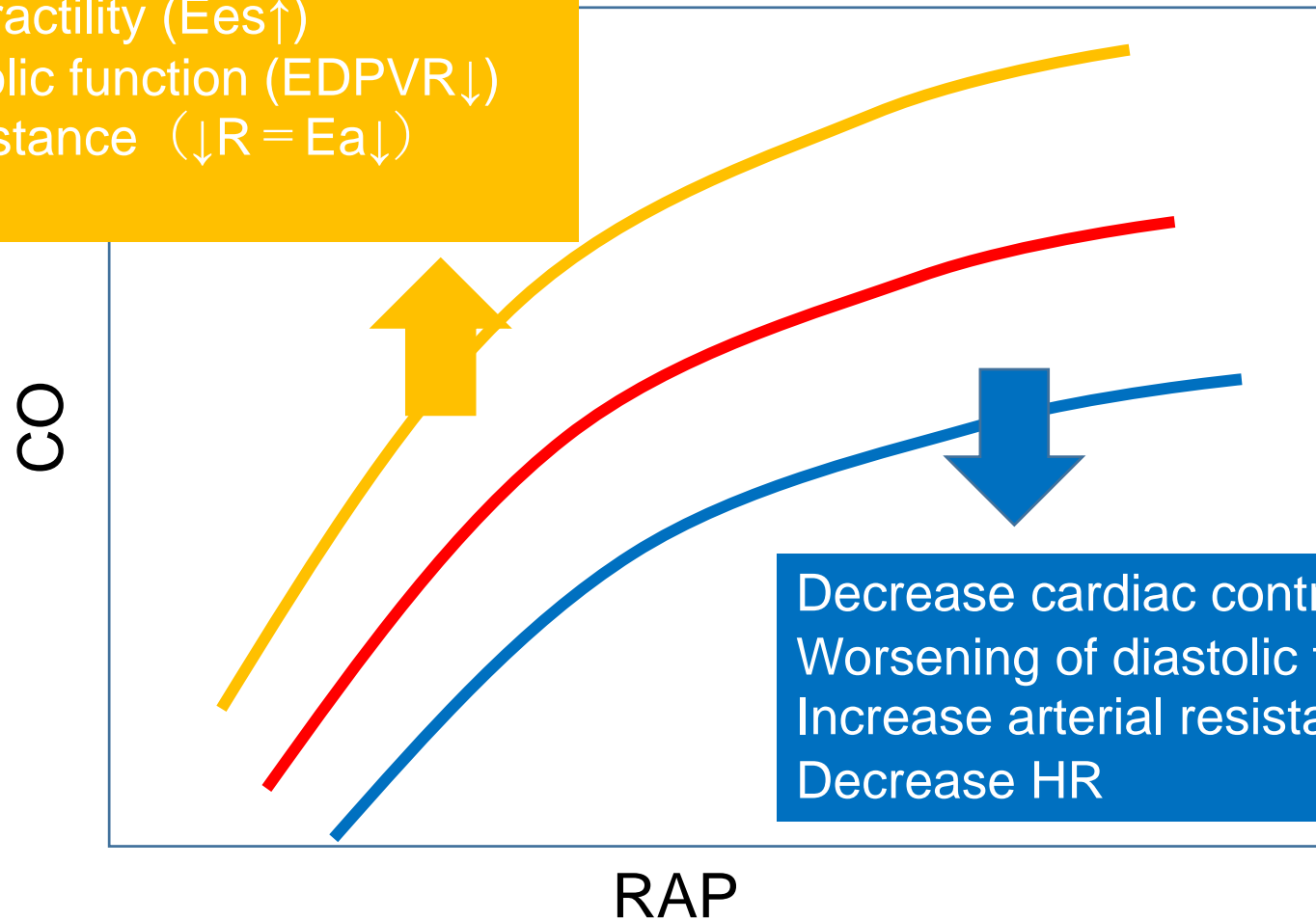
PV loop to CO curve



CO curve

$$\text{CO curve} = \text{SV} \times \text{HR}$$

Increase cardiac contractility ($E_{es}\uparrow$)
Improvement of diastolic function ($\text{EDPVR}\downarrow$)
Decrease arterial resistance ($\downarrow R = E_a\downarrow$)
Increase HR



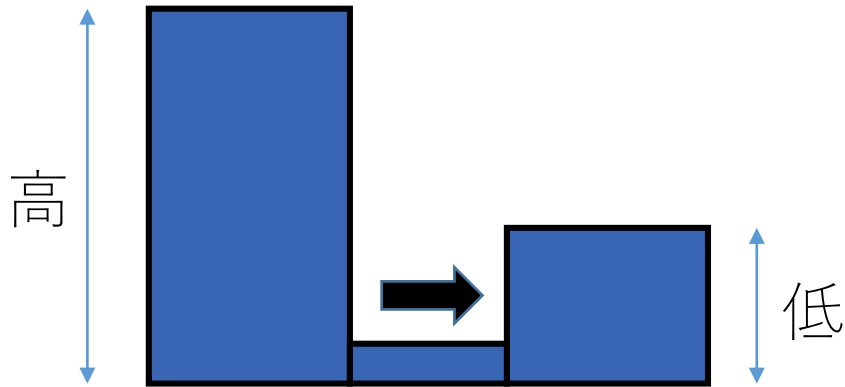
Decrease cardiac contractility ($E_{es}\downarrow$)
Worsening of diastolic function ($\text{EDPVR}\uparrow$)
Increase arterial resistance ($\uparrow R = E_a\uparrow$)
Decrease HR



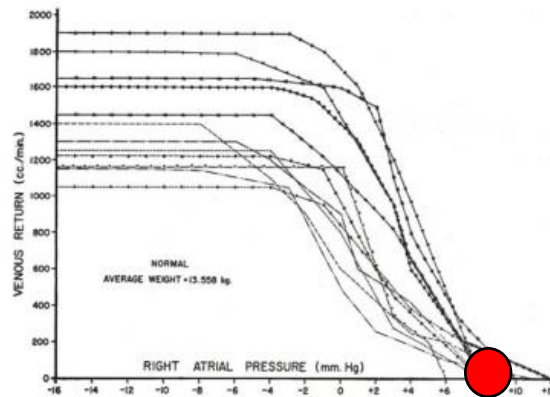
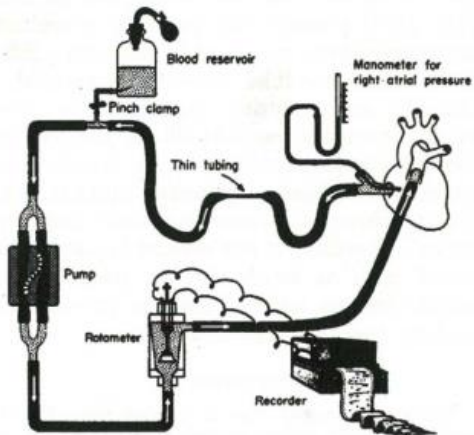
What is venous return?



What is venous return



- The fluid flows from high pressure to low pressure.
- Mean circulatory filling pressure (MCFP) is defined as the pressure after a stop in cardiac output.
- Guyton assumed that the difference of pressure between MCFP and RAP generates the venous return.
- Experiment showed that decrease in RAP from MCFP increased venous return.

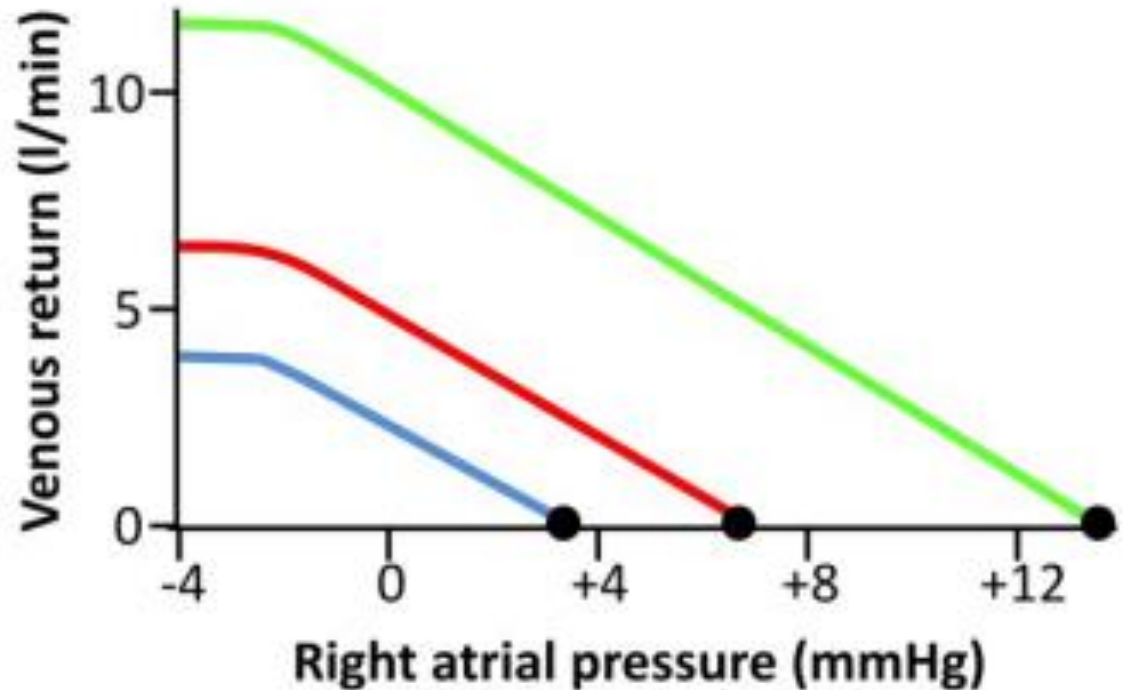
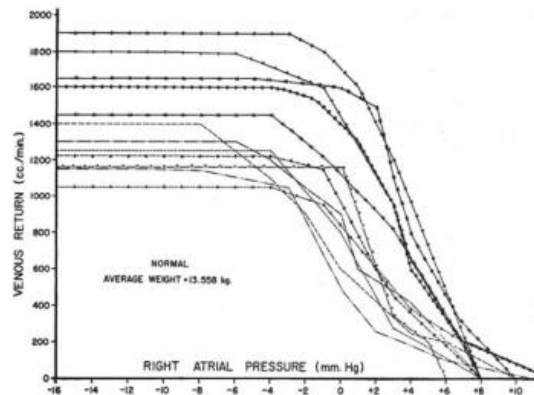
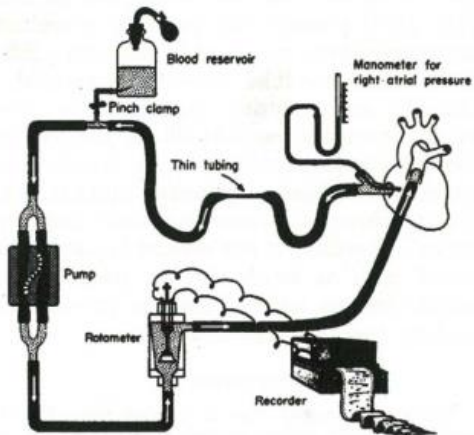
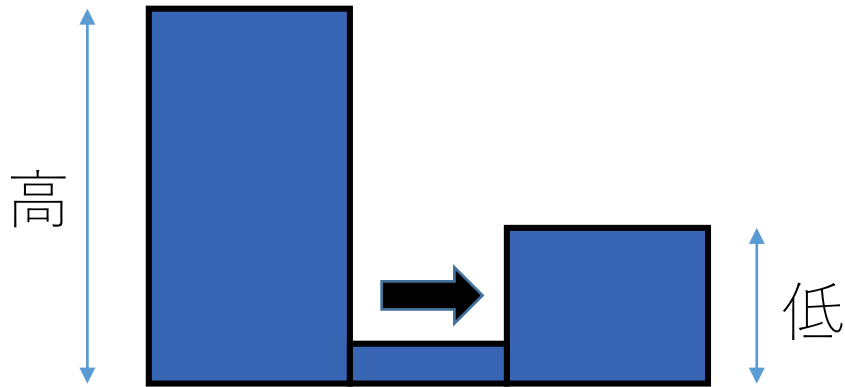


Mean circulatory filling pressure

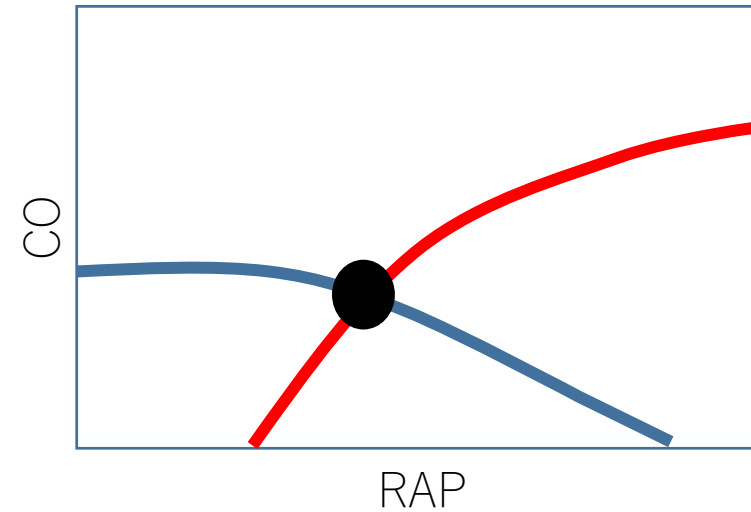
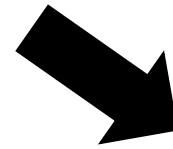
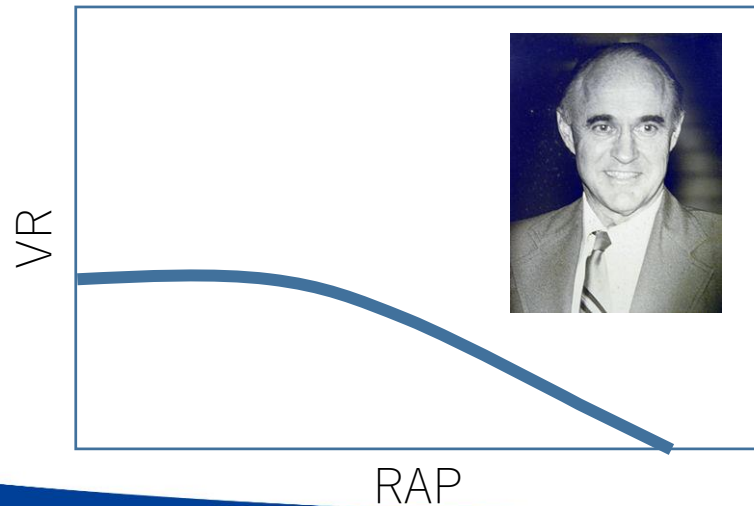
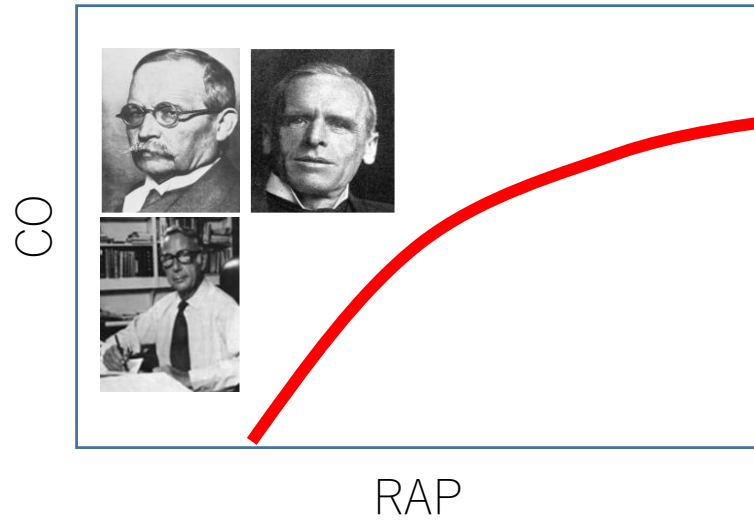


What is venous return

Volume loading increases the MCFP and shifts the venous return upward.

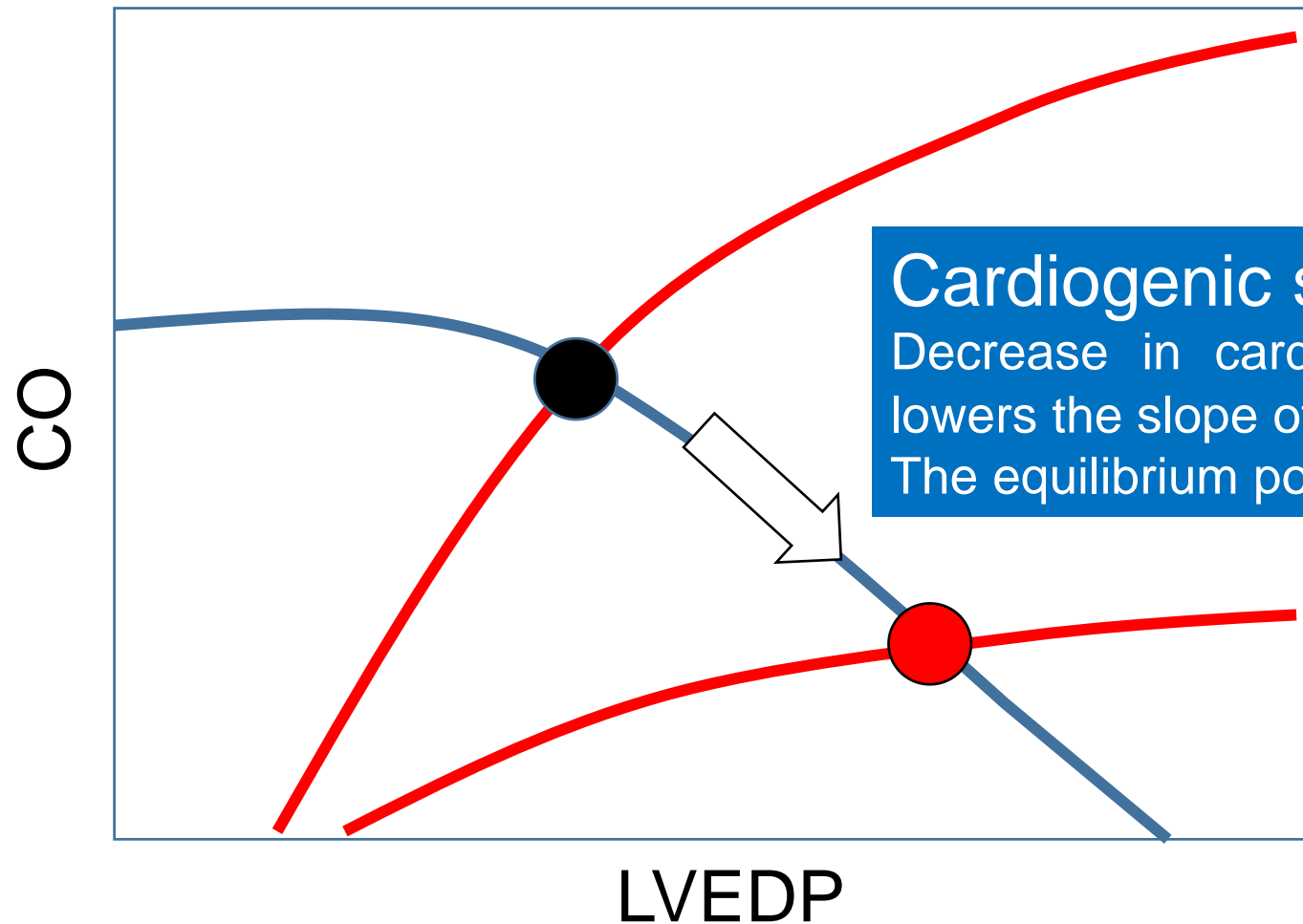


Hemodynamics is determined by CE



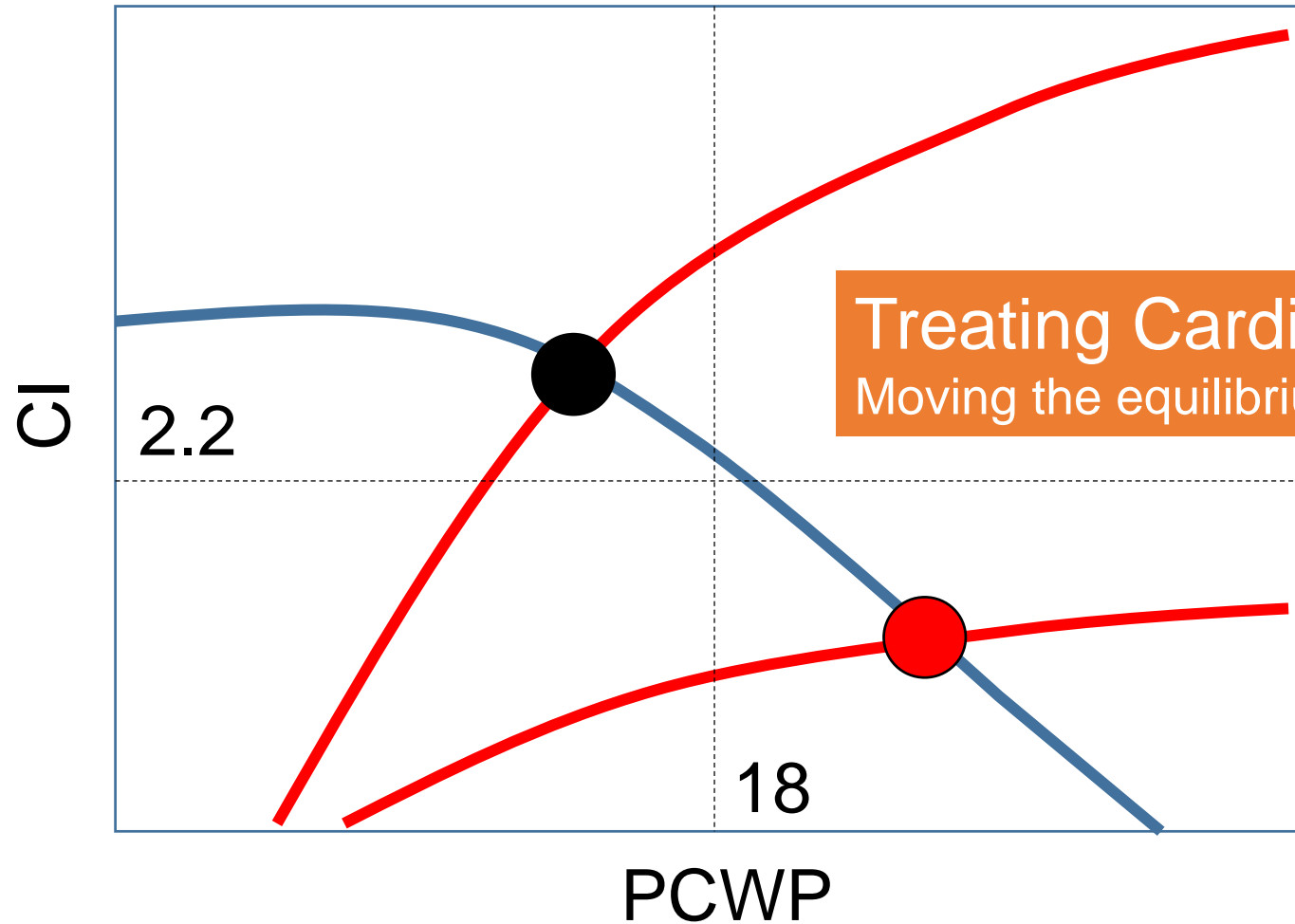
How does the CS alter circulatory equilibrium?

※ This graph focus on left heart, for the sake of clarity.



Forrester classification

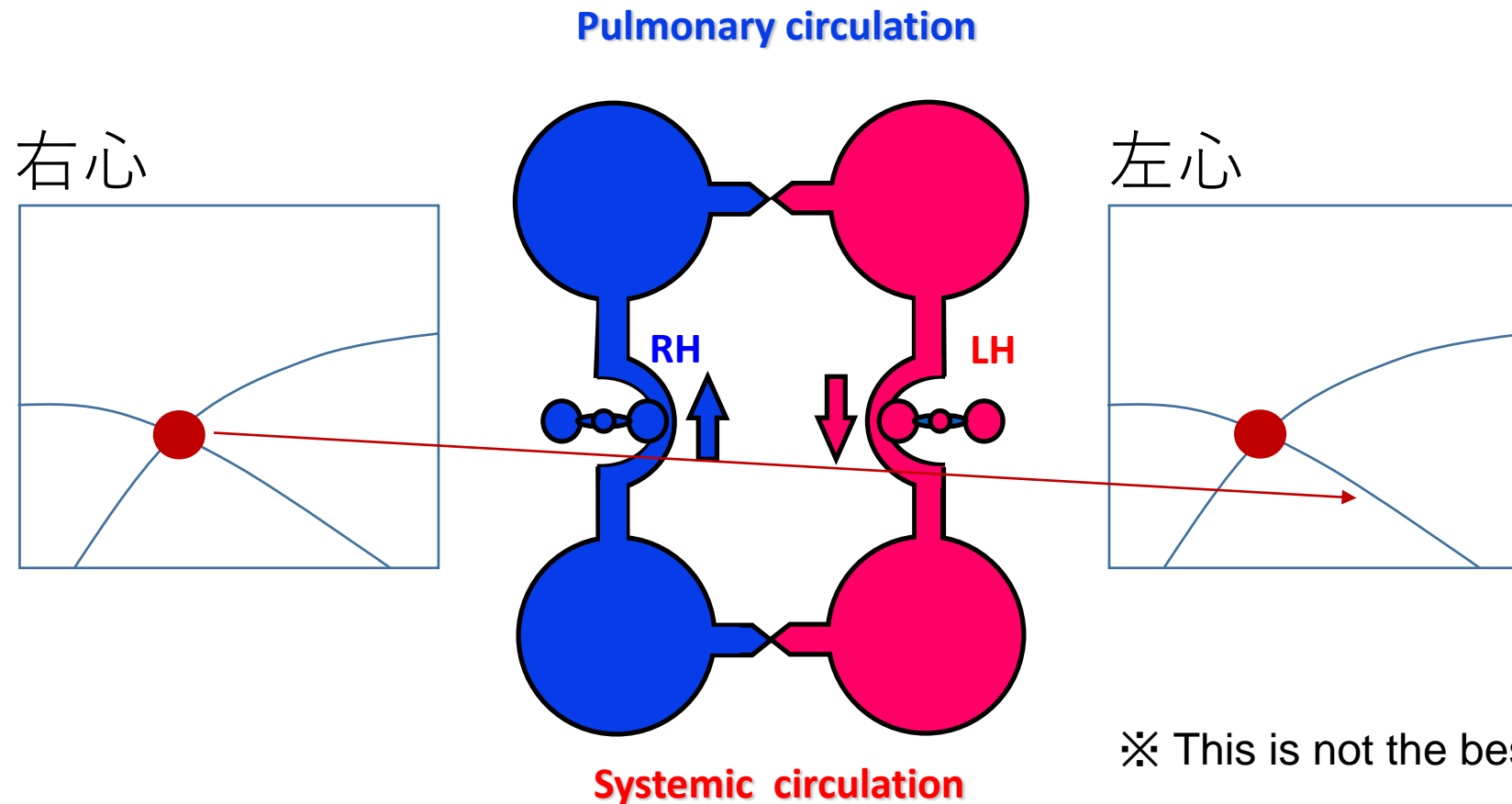
※ This graph focus on left heart, for the sake of clarity.



Treating Cardiogenic shock
Moving the equilibrium point to the upper-left.



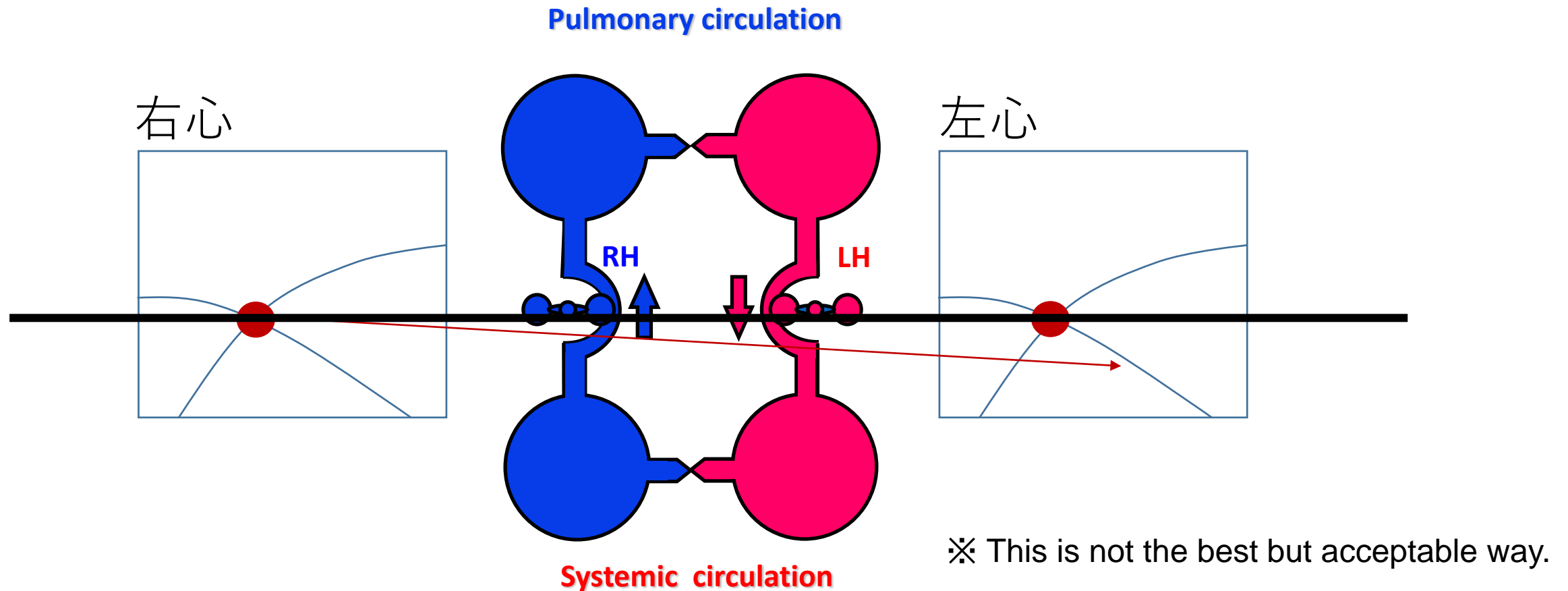
How to understand two ventricular system



※ This is not the best but acceptable way.

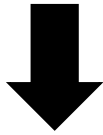


How to understand two ventricular system



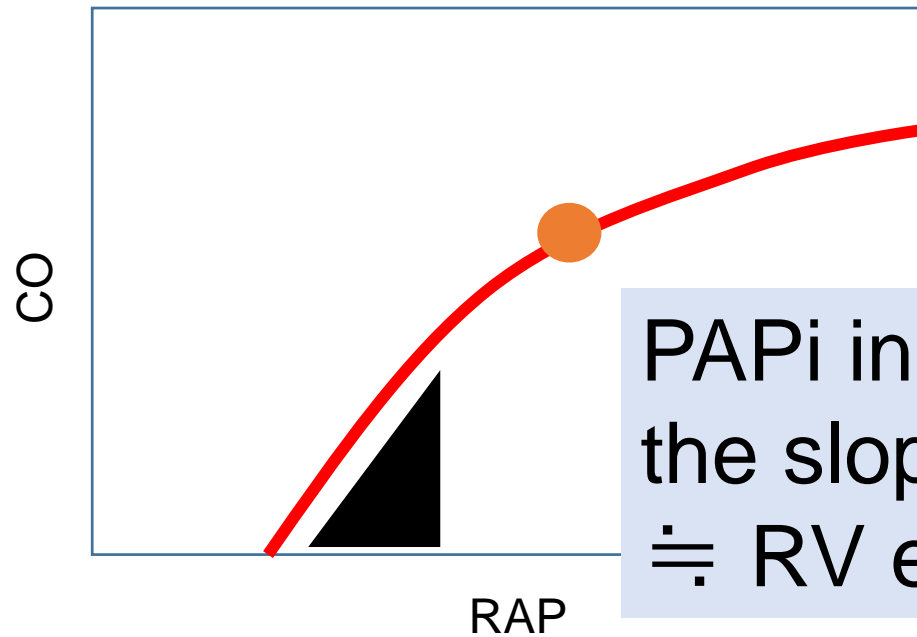
What is PAPI

$$PAPi = \frac{PP}{RAP} \quad PP \doteq \frac{SV}{C} \quad CO = HR * SV$$



$$PAPi \propto \frac{CO}{RAP}$$

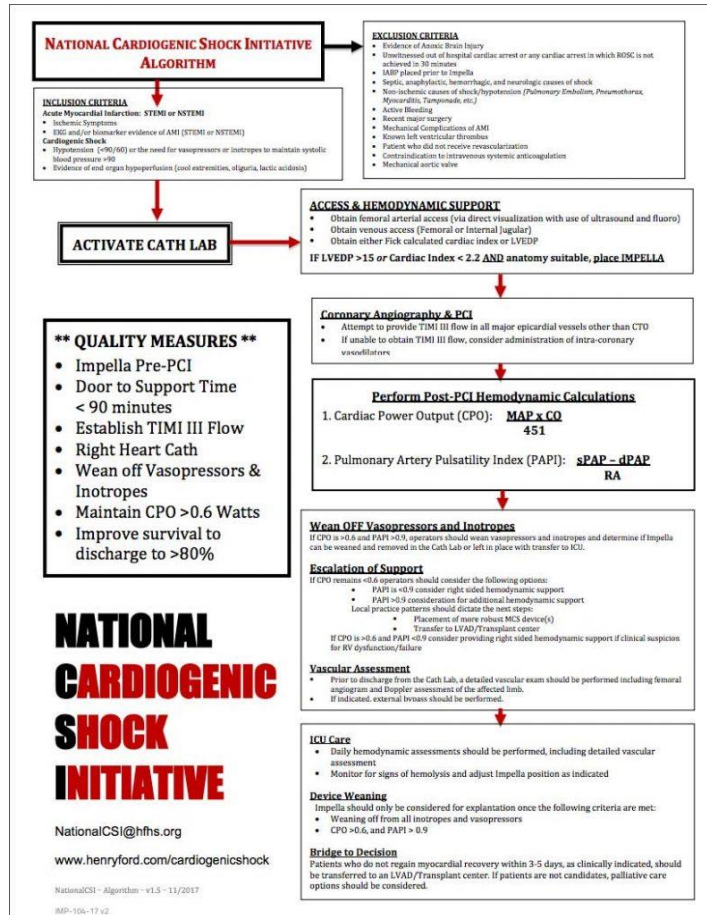
C=compliance in PA



PAPi indicates the slope of right CO curve \doteq RV ejection fraction



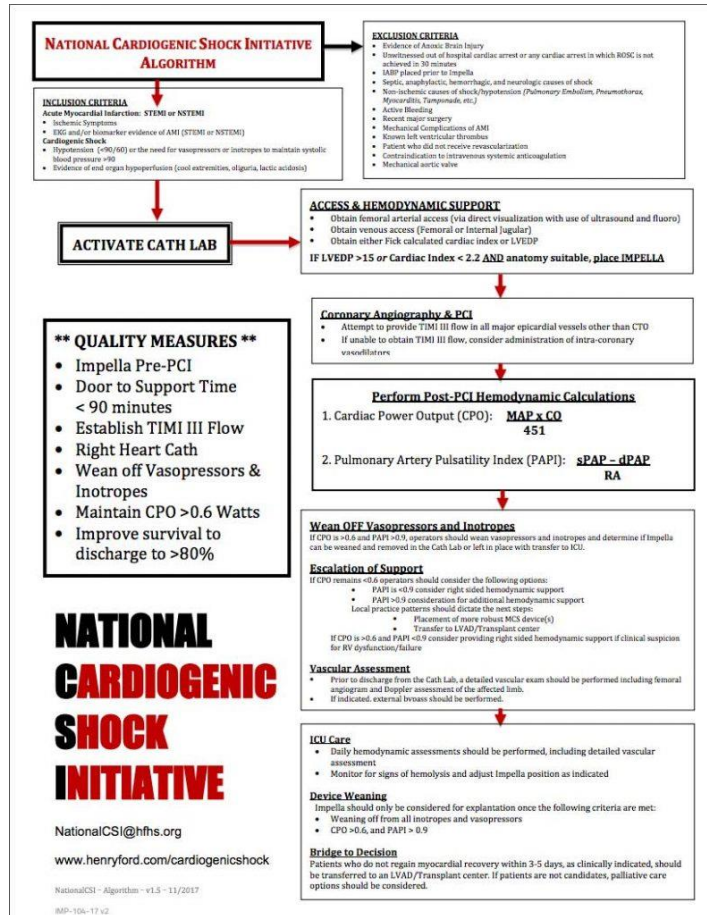
National cardiogenic shock initiative



- Rapidly identify patients with cardiogenic shock
- Measure hemodynamics pre PCI
- Use early mechanical support if LVEDP > 15 or cardiac index < 2.2
- Revascularization
- Measure - Cardiac Power Output (CPO) - Pulmonary Artery Pulsatility Index (PAPI)
- Wean or augment support based on CPO/PAPI
- Minimize Pressors/Inotropes



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What can we learn from these parameters?

CO

LVEF

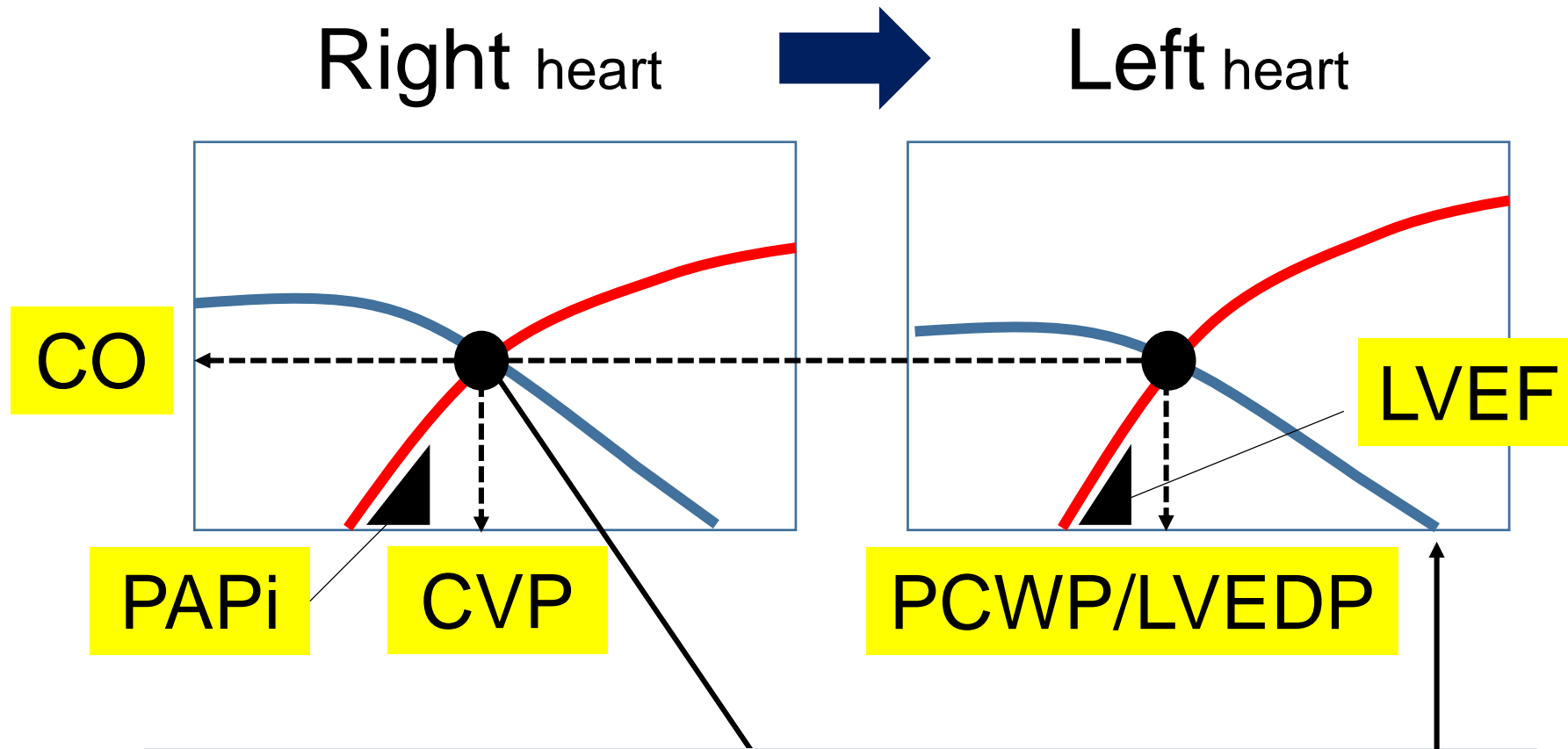
PAPi

CVP

PCWP/LVEDP



We can identify the circulatory equilibrium

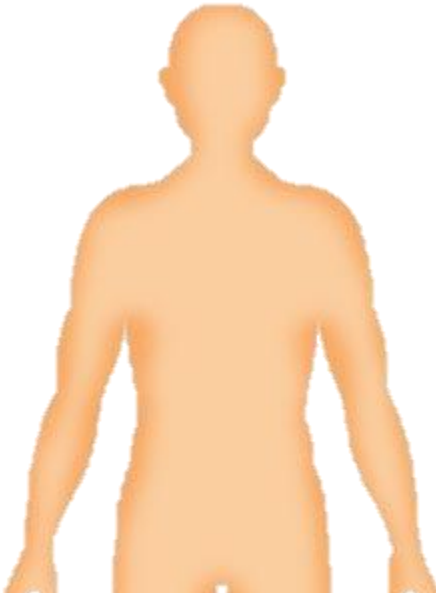
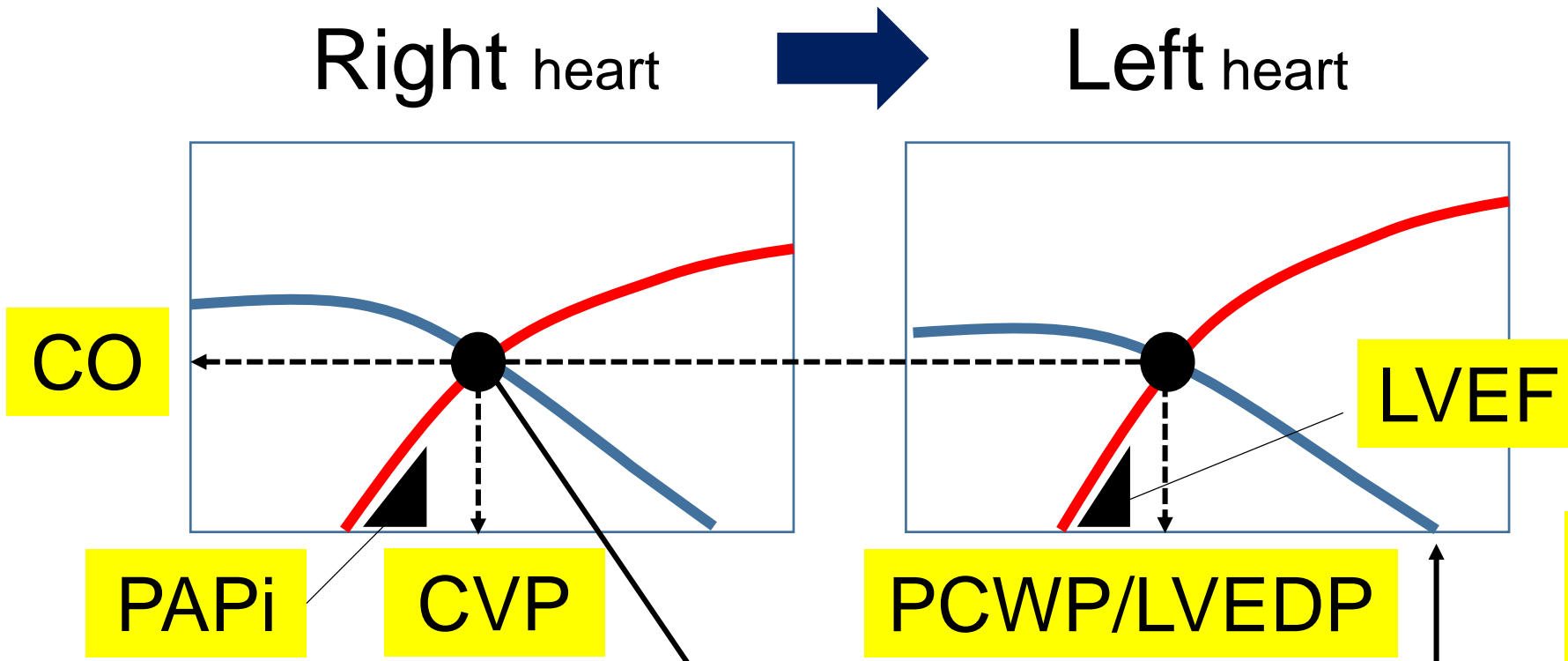


Right CO determines the VR of left heart



Finally...

It determines the delivered power to the body.

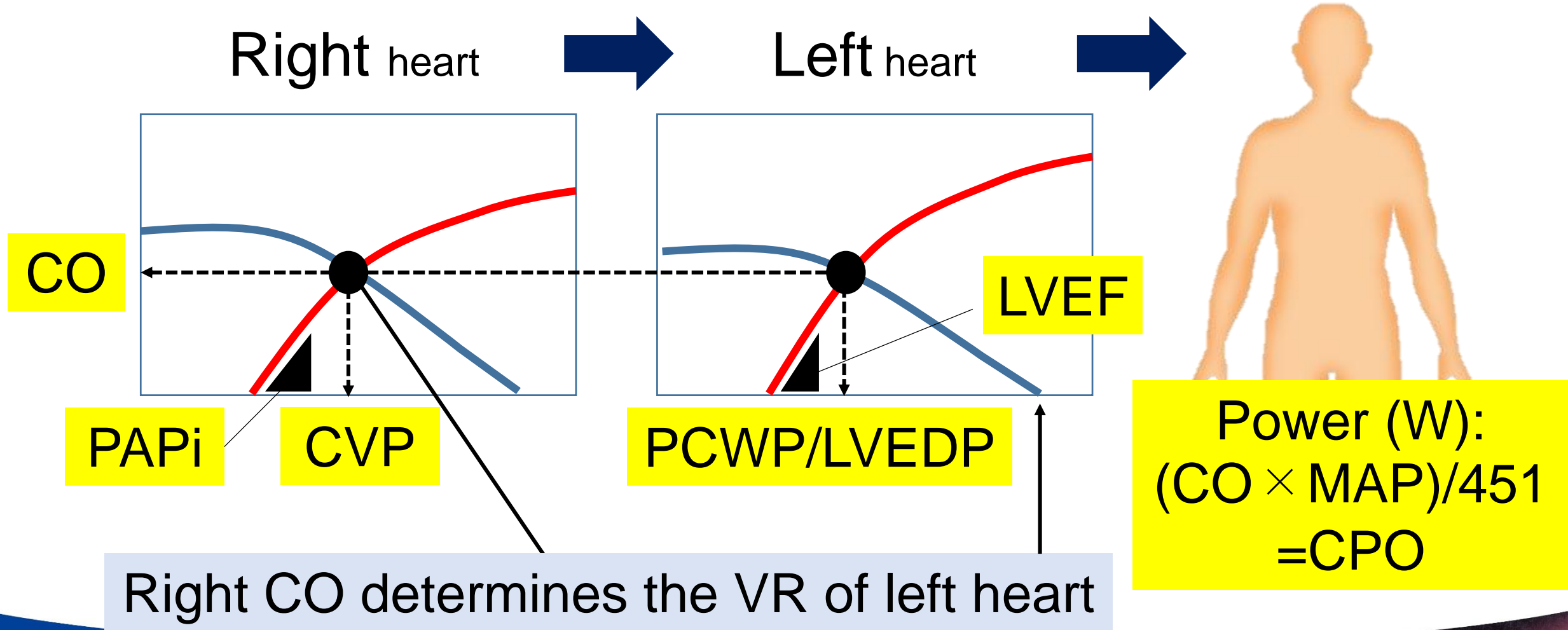


Power (W):
 $(CO \times MAP) / 451$
=CPO

Right CO determines the VR of left heart



We see how effective the two-ventricular system delivers the power to the body

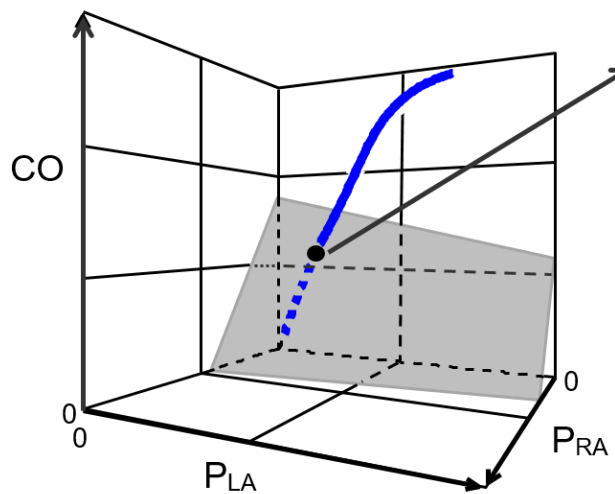


Conclusions

- ✓ Understanding hemodynamics
= Understanding Guyton's circulatory equilibrium.
- ✓ Every hemodynamic parameters indicate the effectiveness of two-ventricular system. Thus, the balance between right and left heart is also important.
- ✓ We need to consider “the voice of body” such as Lactate, which indicates the sufficiency of given circulation.



Deep dive into circulatory equilibrium



Equilibrium point

Left CO

$$CO_L = S_L \{ \log (P_{LA} - F_L) + H_L \}$$

Right CO

$$CO_R = S_R \{ \log (P_{RA} - F_R) + H_R \}$$

VR surface

$$CO_v = VR_{\max} - 19.61 P_{RA} - 3.49 P_{LA}$$

循環動態アカデミー
Circulatory Dynamics Academy

循環動態アカデミーは基礎-臨床-テクノロジーを支えるあらゆる人々が臨床に生かせる心血管ダイナミクスの知識を学ぶことができる日本語Webプラットフォームです。

- ・教育コンテンツの提供
- ・研究会の開催
- ・アカデミー会員の活動報告

などを行ない、この「知」をシェアしていきたいと思ひます。

Webサイトへは上記QRコードよりアクセスしてください。

- ✓ Guyton's model is a concept of single heart (RAP-CO relationship).
- ✓ Dr. Sunagawa established the extended model of circulatory equilibrium.
- ✓ In this model, we can consider LAP together with RAP.
- ✓ If you learn more, **VISIT OUR WEBSITE!**

