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Hemodynamics

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Learning Objectives

- Consider contributing causes of shock using physiologic principles
- Describe bedside tools available for diagnosis of shock
- Delineate the safety issues around PA catheters
- Analyze PA catheter data

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Mr. J is a 76-year-old man with COPD and recent worsened dyspnea on exertion found to have ischemic cardiomyopathy (EF 25-30%). He underwent 3V CABG two days ago. His post-op course has been complicated by aspiration and delirium.

Earlier today he was intubated for worsening respiratory distress. He is now hypotensive.

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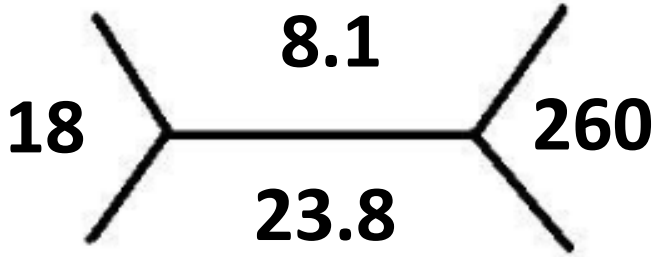
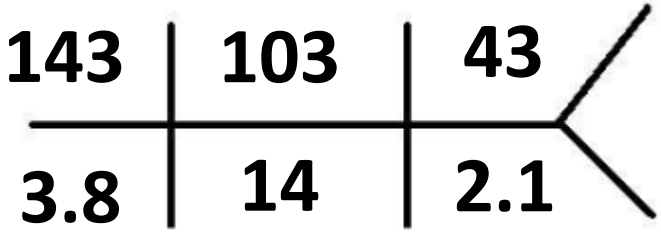
T 99.6°F, HR 123, **BP 75/40**, RR 20, UO <10cc/hr

SpO_2 93% on AC-VC FiO_2 0.6





Lactate 6 pH 7.18/45/80

Breakout!

How would you evaluate shock in this patient?

What bedside tools do you have to help guide your diagnostics and management?

What are the limitations of these tools?

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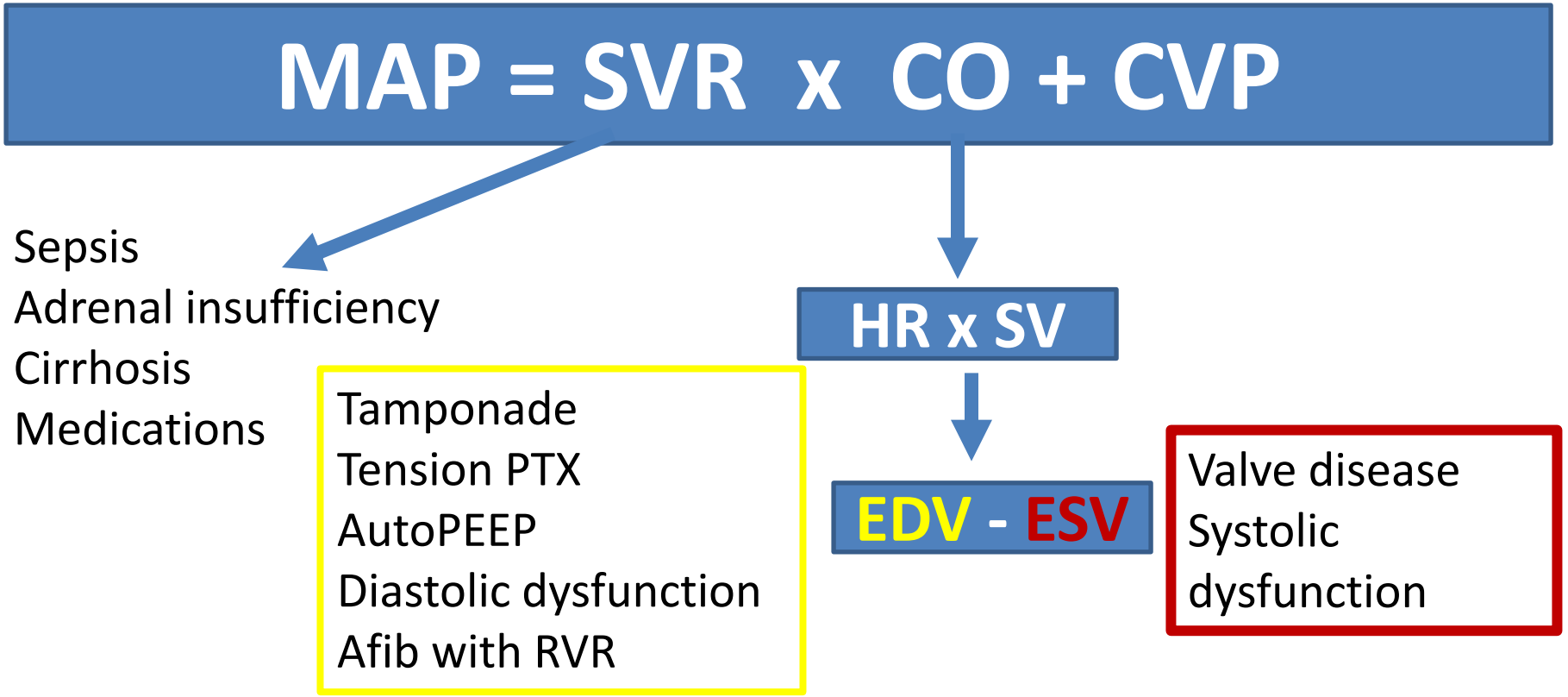
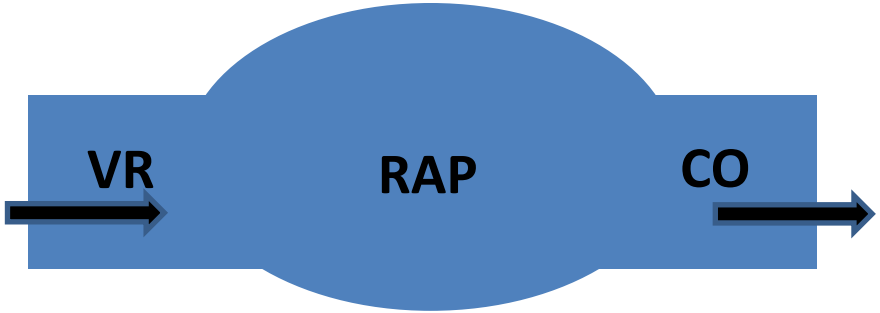
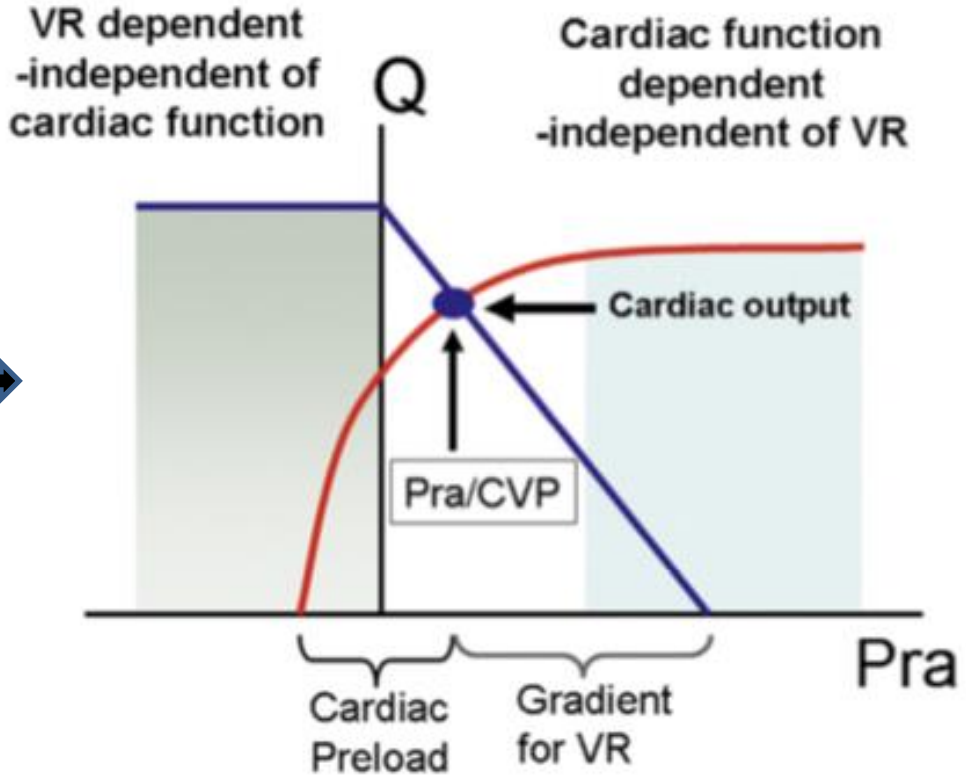
Approach shock physiologically.



Regulation of Cardiac Output





What are dynamic measures of volume responsiveness?

Shift the venous return curve to the RIGHT….

Increase mean systemic filling pressure with venous volume

- Passive leg raise test
- Empiric bolus challenge

Change in intrathoracic pressure → in RAP (respiration)

- Pulse pressure variation
- IVC collapsibility
- IVC distensibility

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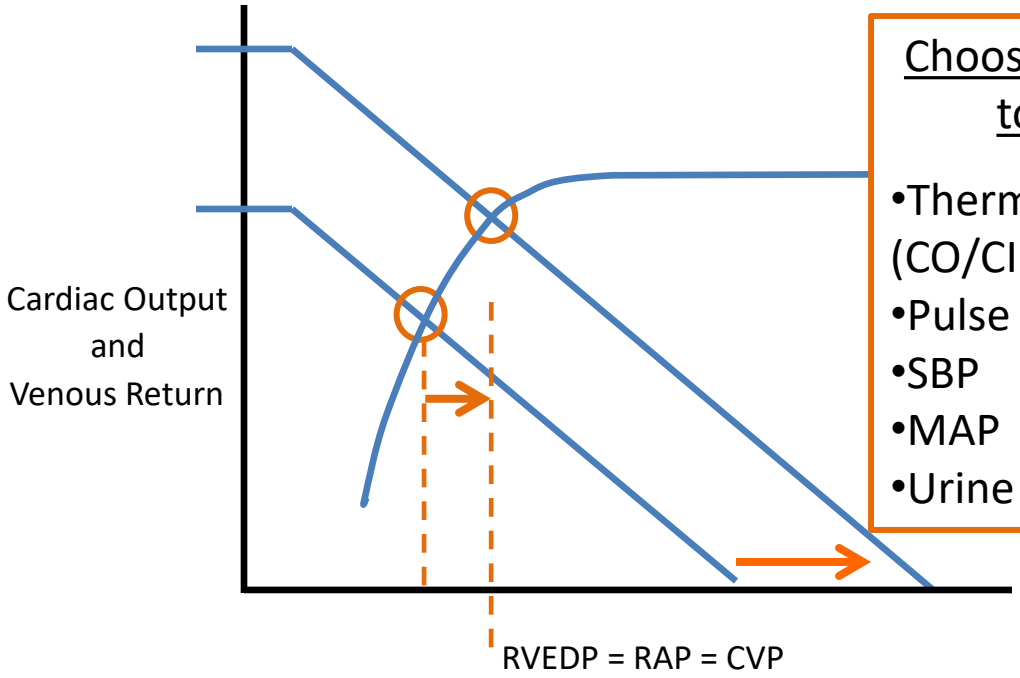
Assessing efficacy of empiric fluid challenge



Choose a parameter to monitor

- Thermodilution (CO/CI)
- Pulse pressure
- SBP
- MAP
- Urine output

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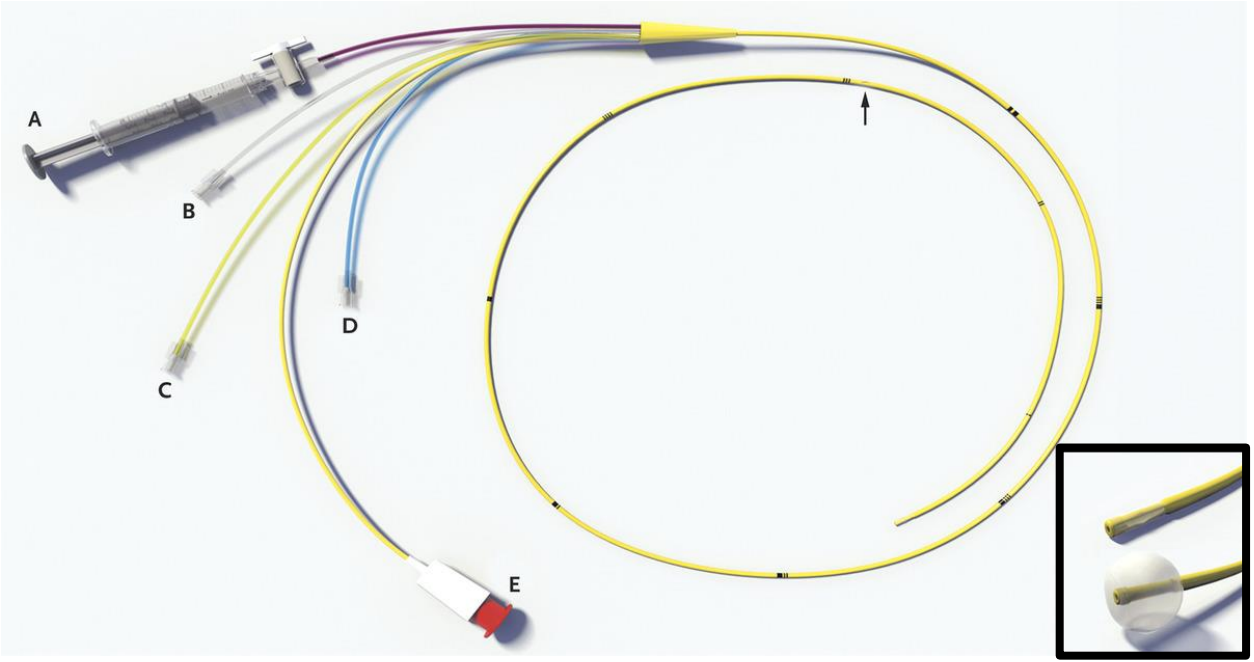
PA Catheter Insertion



https://www.nejm.org/doi/full/10.1056/NEJMvcm1212416

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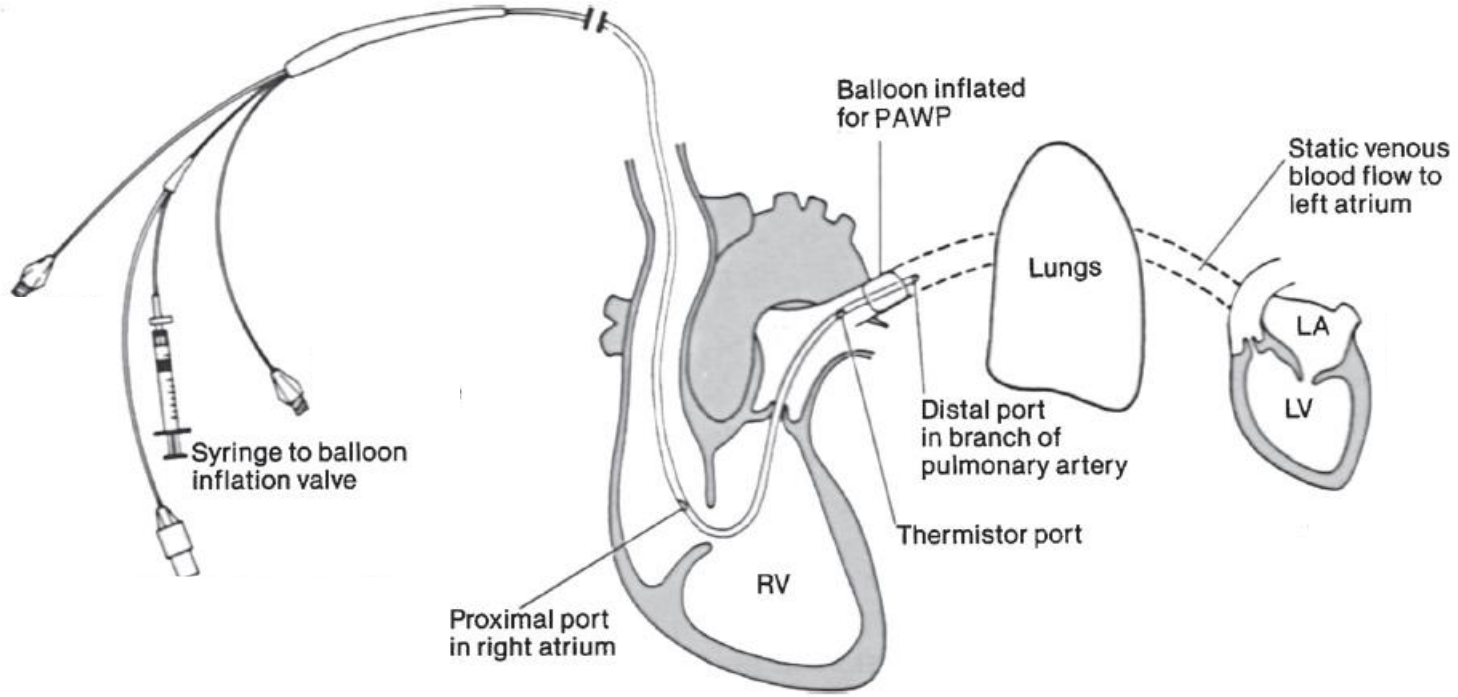
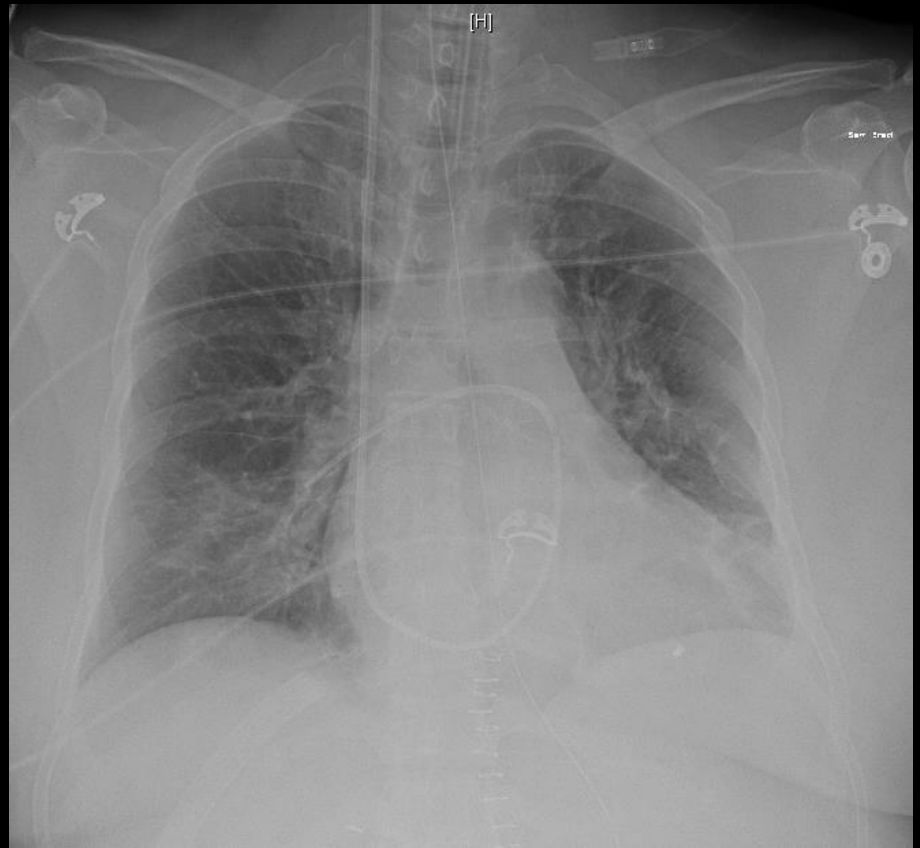
PA Catheter Insertion



PA Catheter – Chest Radiograph



PA Catheters - Safety Issues

- Insert under sterile conditions
- Test the balloon before insertion
- Monitor for arrhythmias when floating
- Avoid excessively insertion to prevent coiling or over-wedge
  - ~30cm to RV, ~45cm to PA, ~55-cm PAOP
- Obtain CXR
- Never leave PAC balloon inflated

Mr. J's PA Catheter Numbers

Parameter	Data
Cardiac output (CO)	3.7 L/minute
Cardiac index (CI)	2.0 L/min/m^2
Right atrial pressure (RAP)	18 mmHg
Right ventricular pressure (RVP)	36/12 mmHg
Mean pulmonary artery pressure (mPAP)	32 mmHg
Pulmonary artery occlusion pressure (PAOP)	24 mmHg
Mixed venous saturation (SVO_2)	58%
Mean arterial pressure (MAP)	58 mmHg

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Breakout!

Interpret the PA catheter results

Propose a management plan

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Variable	Normal Value	Measured or Derived?
CO	4-8 L/min	Measured and Derived
CI	2.5-4 L/min	Measured
RAP	2-6 mmHg	Measured
RVP	15-25/0-8 mmHg	Measured
PA	15-25 / 8-15 mmHg	Measured
PAOP	8-12 mmHg	Measured
SVO_2	60-70%	Measured
SVR	800-1200 dyne-sec/cm^5	Derived
PVR	<250 dyne-sec/cm^5	Derived

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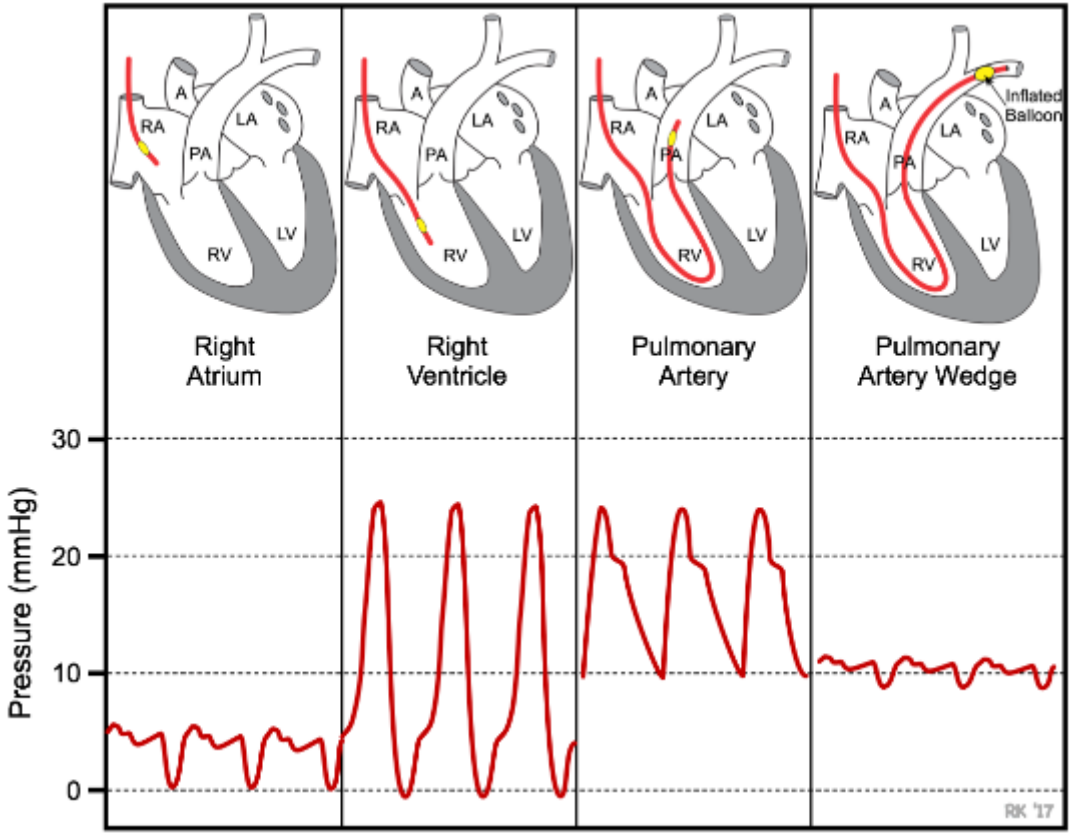
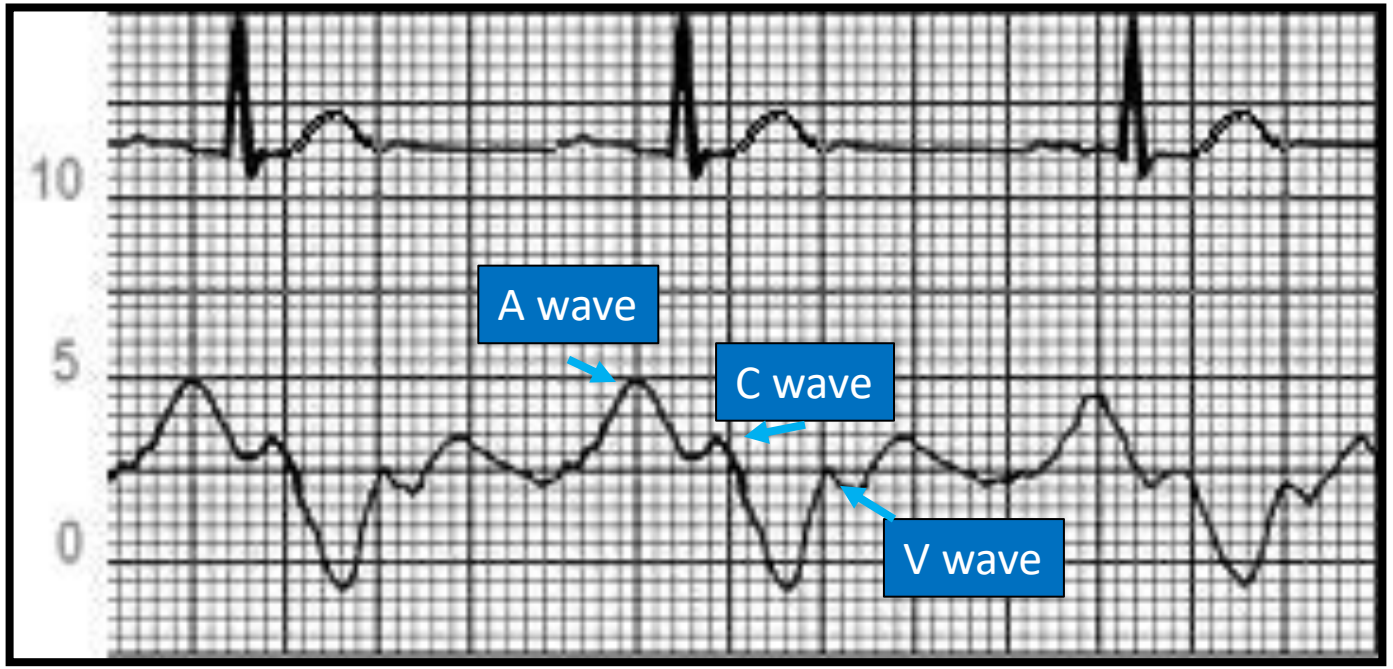
Pressure Measurements



https://www.cvphysiology.com

Rosenkranz and Preston. Eur Respir Rev 2015;24:642-652

Right Atrial Pressure



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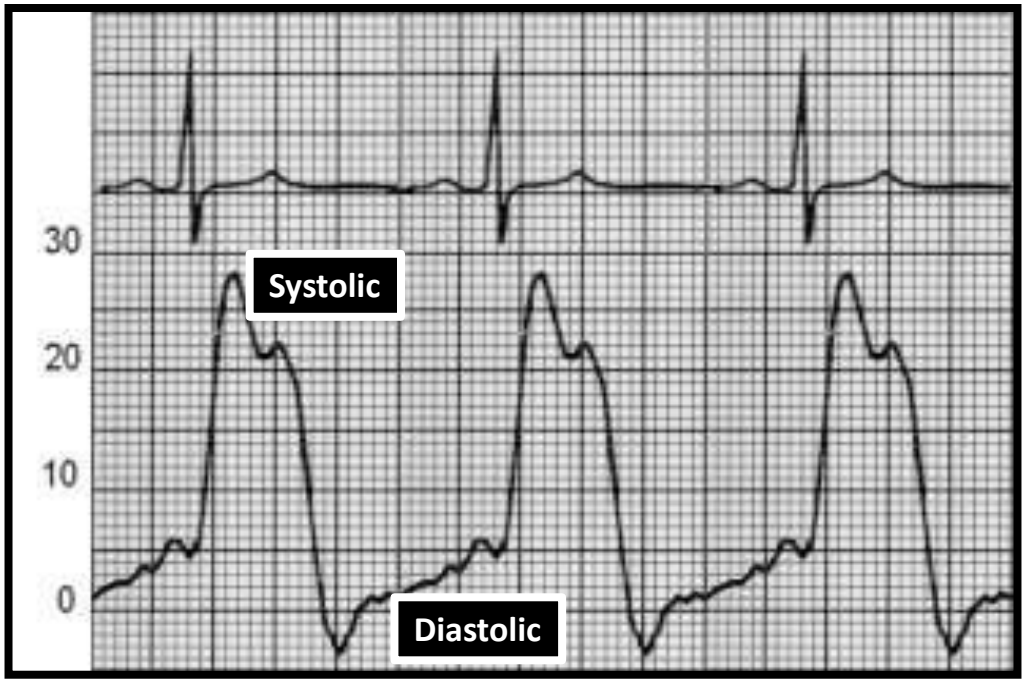
Right Ventricular Pressure



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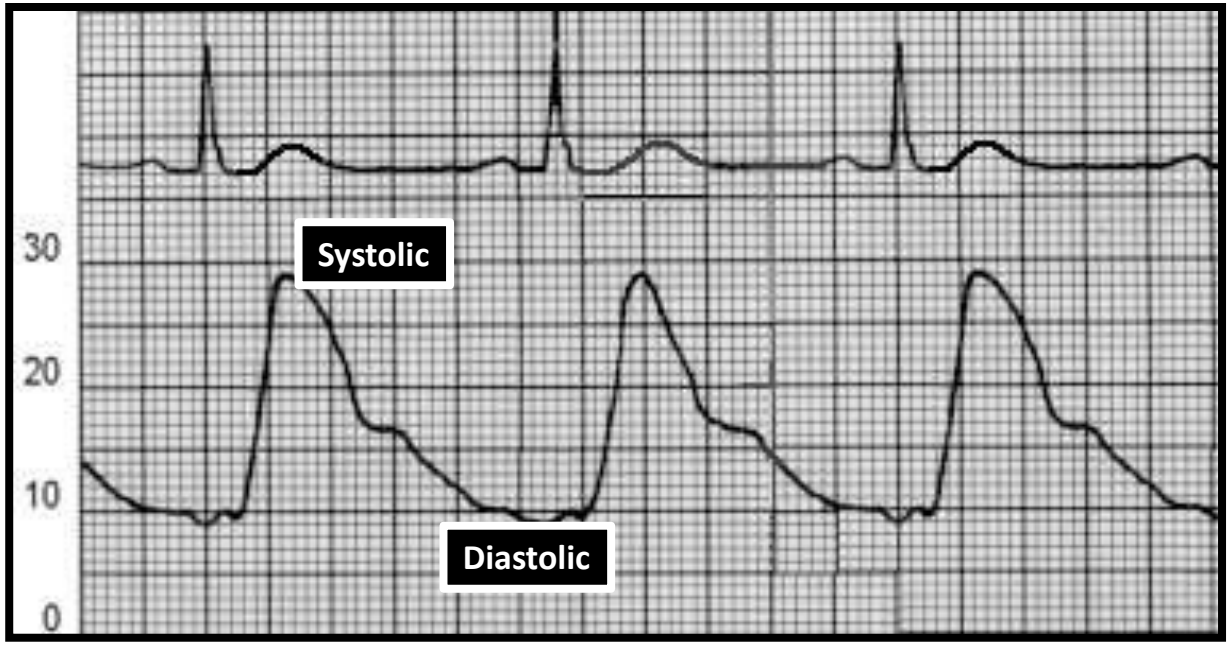
Pulmonary Artery Pressure



Diastolic pressure rise

Slope of diastole

Dicrotic notch

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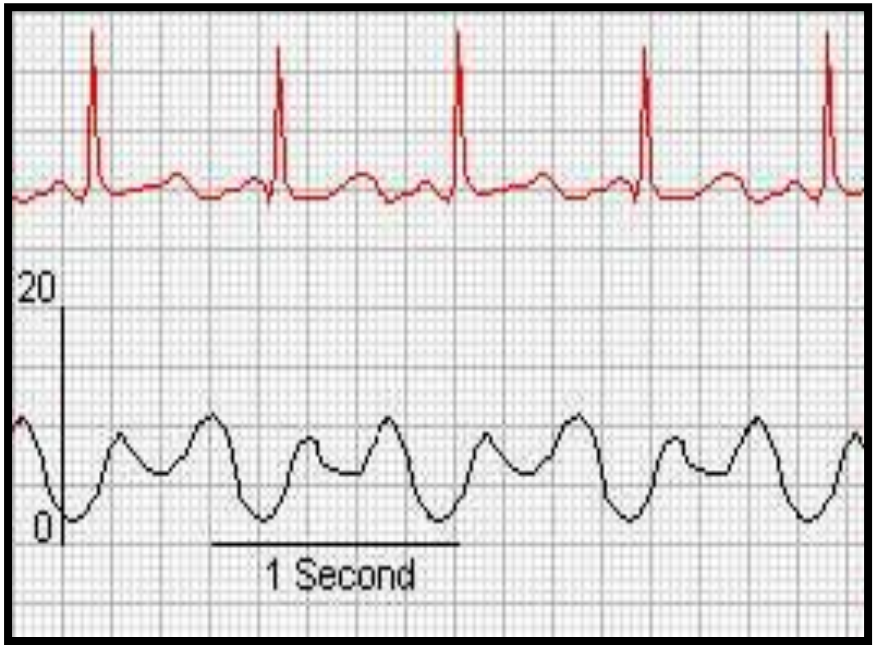
Pulmonary Artery Occlusion Pressure



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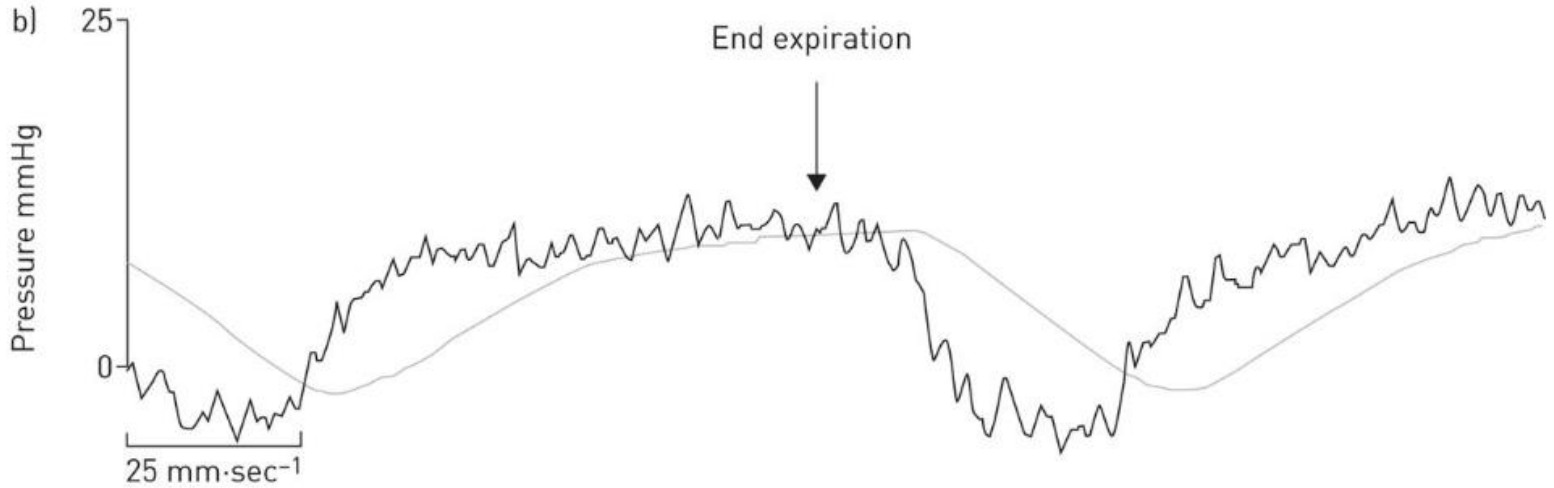
Respiratory Variation



https://www.cvphysiology.com

Rosenkranz and Preston. Eur Respir Rev 2

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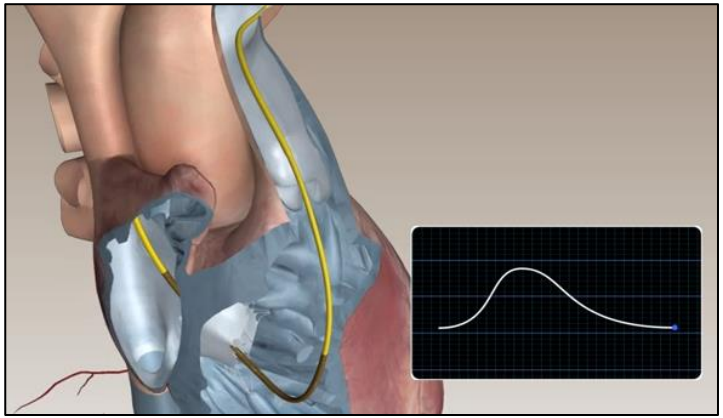
Measuring Cardiac Output

Fick Equation

$$VO_2 = Q \times Hgb \times 1.36 \times (SaO_2 - SvO_2)$$

Less reliable in patients with pulm HTN, heart failure, abnormal body habitus

Thermodilution



Less reliable in patients with TR or intracardiac shunting

Other resources

- https://www.thoracic.org/professionals/clinical-resources/video-lecture-series/critical-care/proper-insertion-and-use-of-a-pulmonary-artery-catheter.php
- https://www.atsjournals.org/doi/full/10.1164/rccm.201402-0269PP

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THANK YOU!!!

Questions?

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