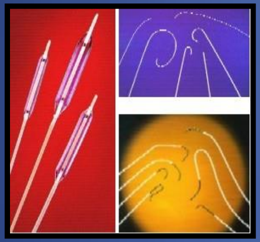
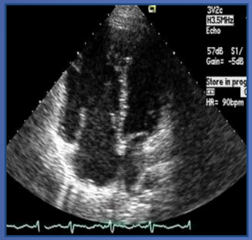
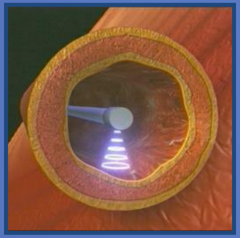
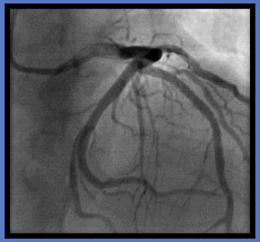
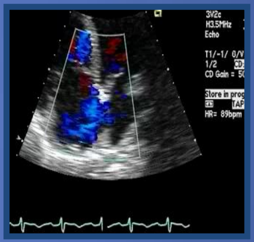
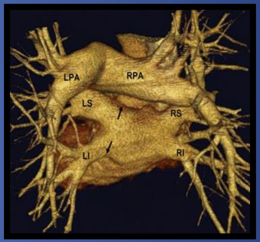
Cath Lab Essentials: Basic Hemodynamics for the Cath Lab and ICU

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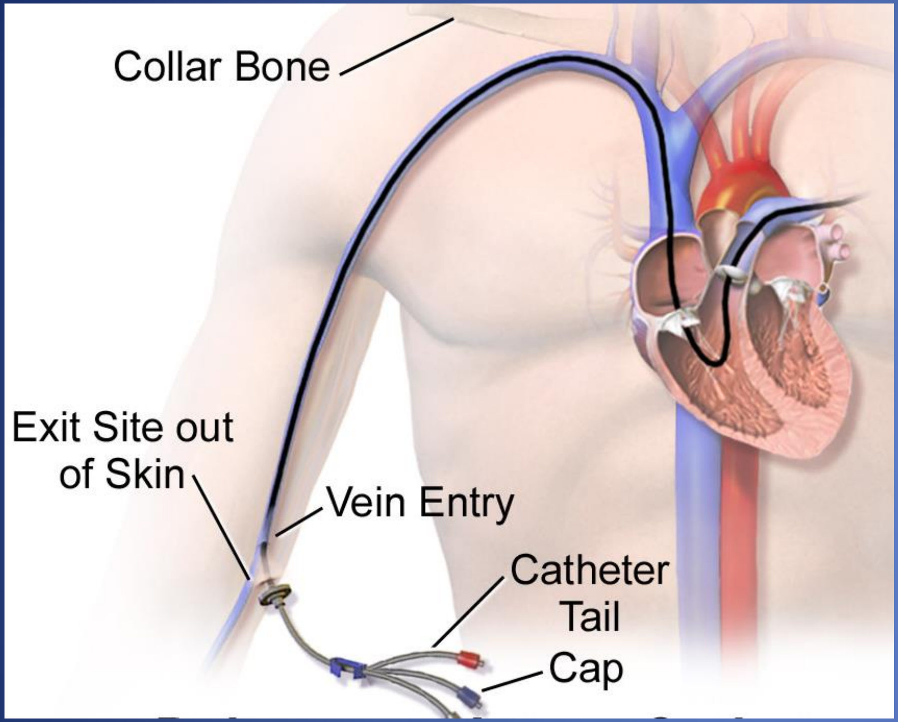


Right Heart Catheterization

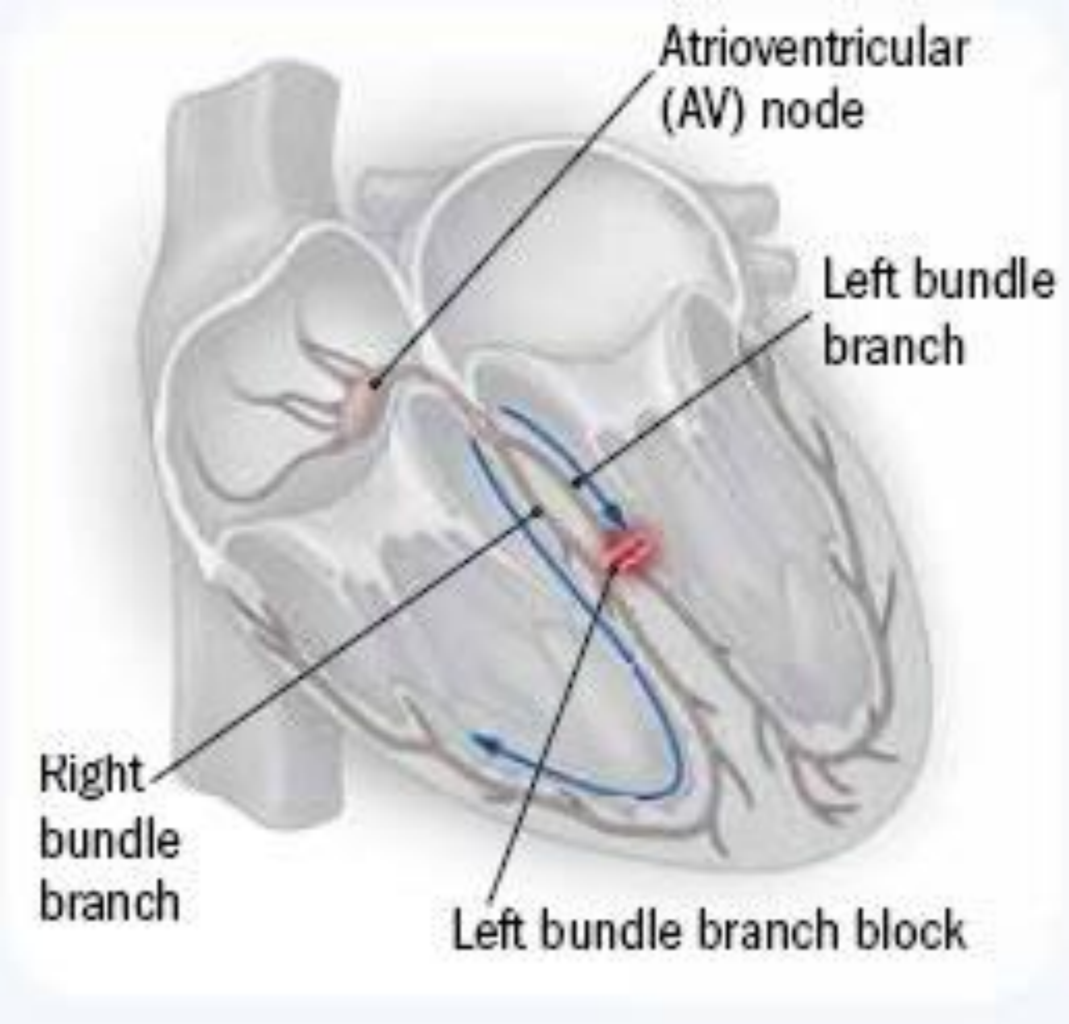

77077

INDICATIONS

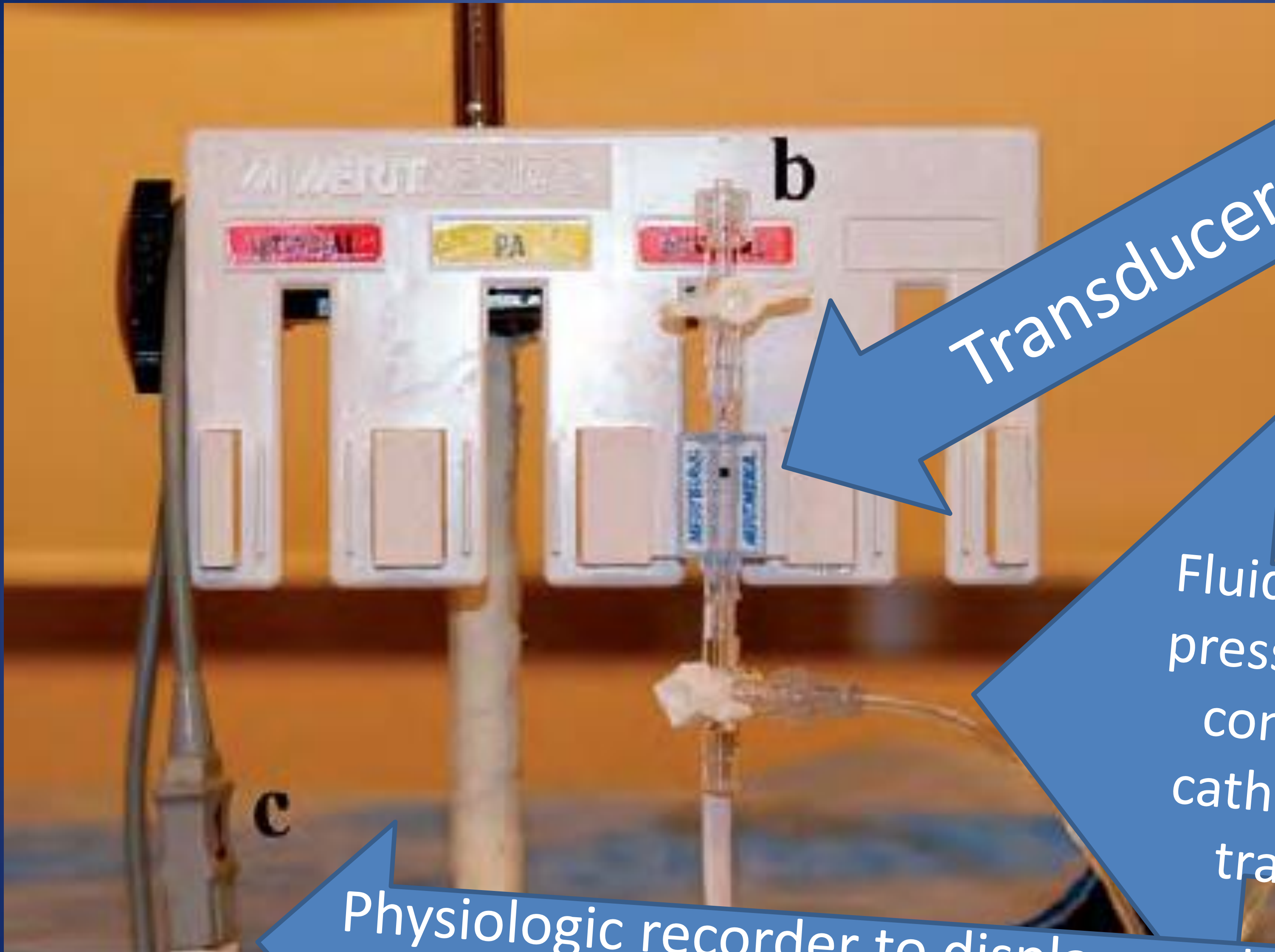
- Cause of shock
- Pulmonary hypertension
- Fluid management and hemodynamic monitoring
- Guidance for pericardial tamponade
- Constrictive versus restrictive cardiomyopathy
- Diagnosis of left to right shunt

CONTRAINDICATIONS

- ABSOLUTE contraindications:
  - None
- CAUTION:
  - Pulmonary hypertension
  - Elderly
  - Left bundle branch block



EQUIPMENT

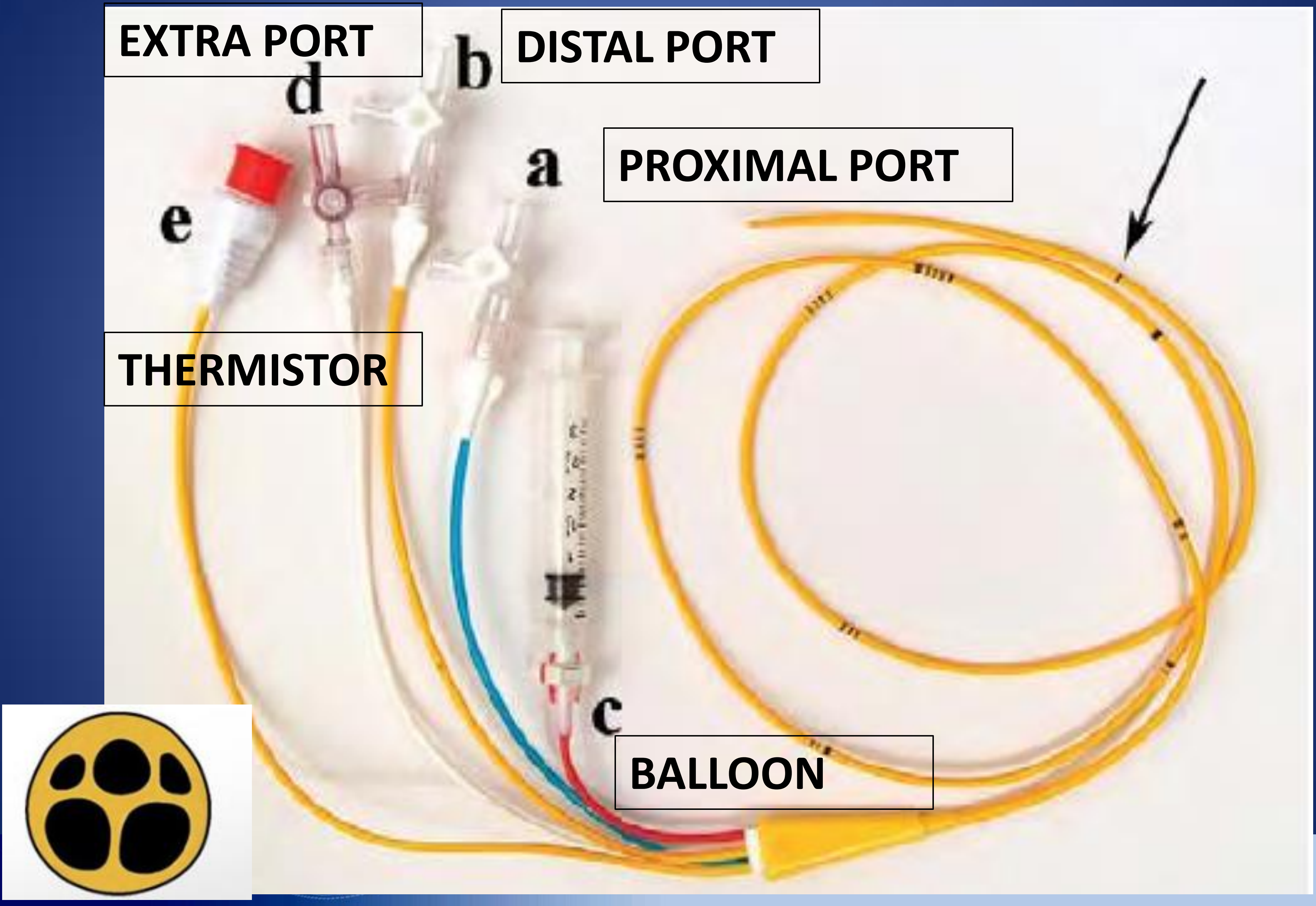


Transducer

Fluid-filled (high pressure) tubing connects the catheter to the transducer

Physiologic recorder to display, analyze, and store the hemodynamic waveforms

PULMONARY ARTERY CATHETER



TECHNIQUE

A Systematic Approach to Hemodynamic Interpretation

1. Establish the zero level and balance transducer.
2. Confirm the scale of the recording.

   -40 mmHg for RHC, 200 mmHg for LHC
3. Collect hemodynamics in a systematic method using established protocols.
4. Critically assess the pressure waveforms for proper fidelity.
5. Carefully time pressure events with the ECG.
6. Review the tracings for common artifacts

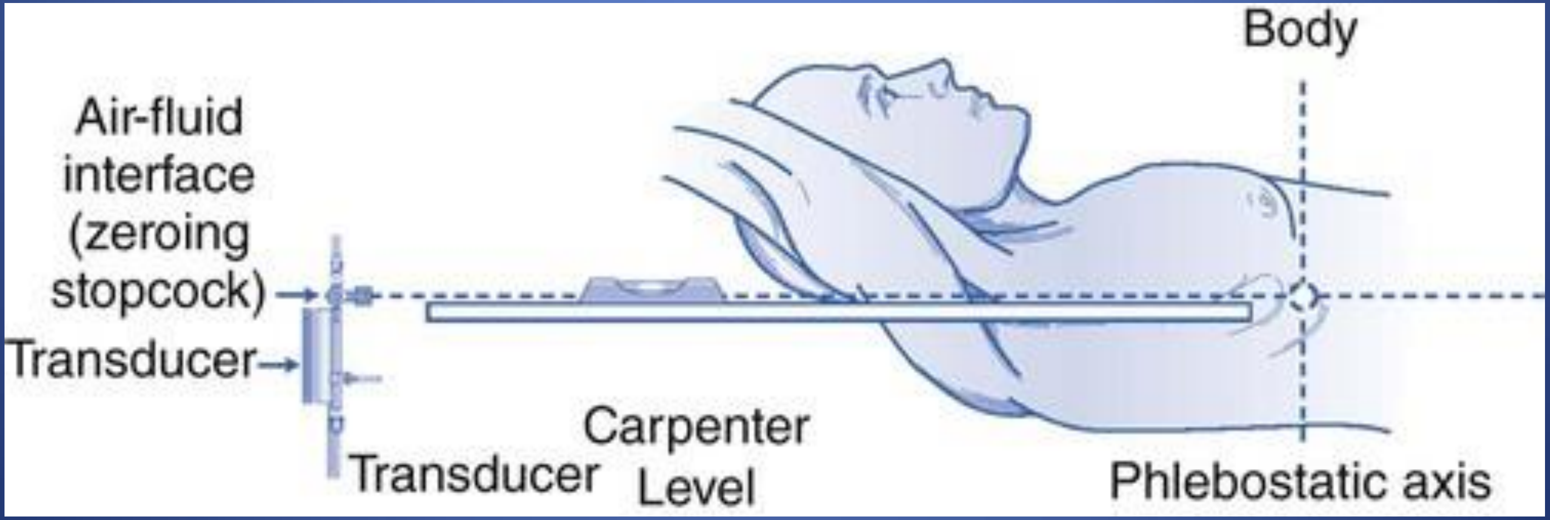
Components of a Right Heart Catheterization

1. Right atrium
   - Mean (1-5 mmHg)
2. Right ventricle
   - Phasic (25/5 mmHg)
3. Pulmonary capillary wedge
   - Mean (7-12 mmHg)
4. Pulmonary artery
   - Phasic and mean (25/10 mmHg; mean 10-20 mmHg)

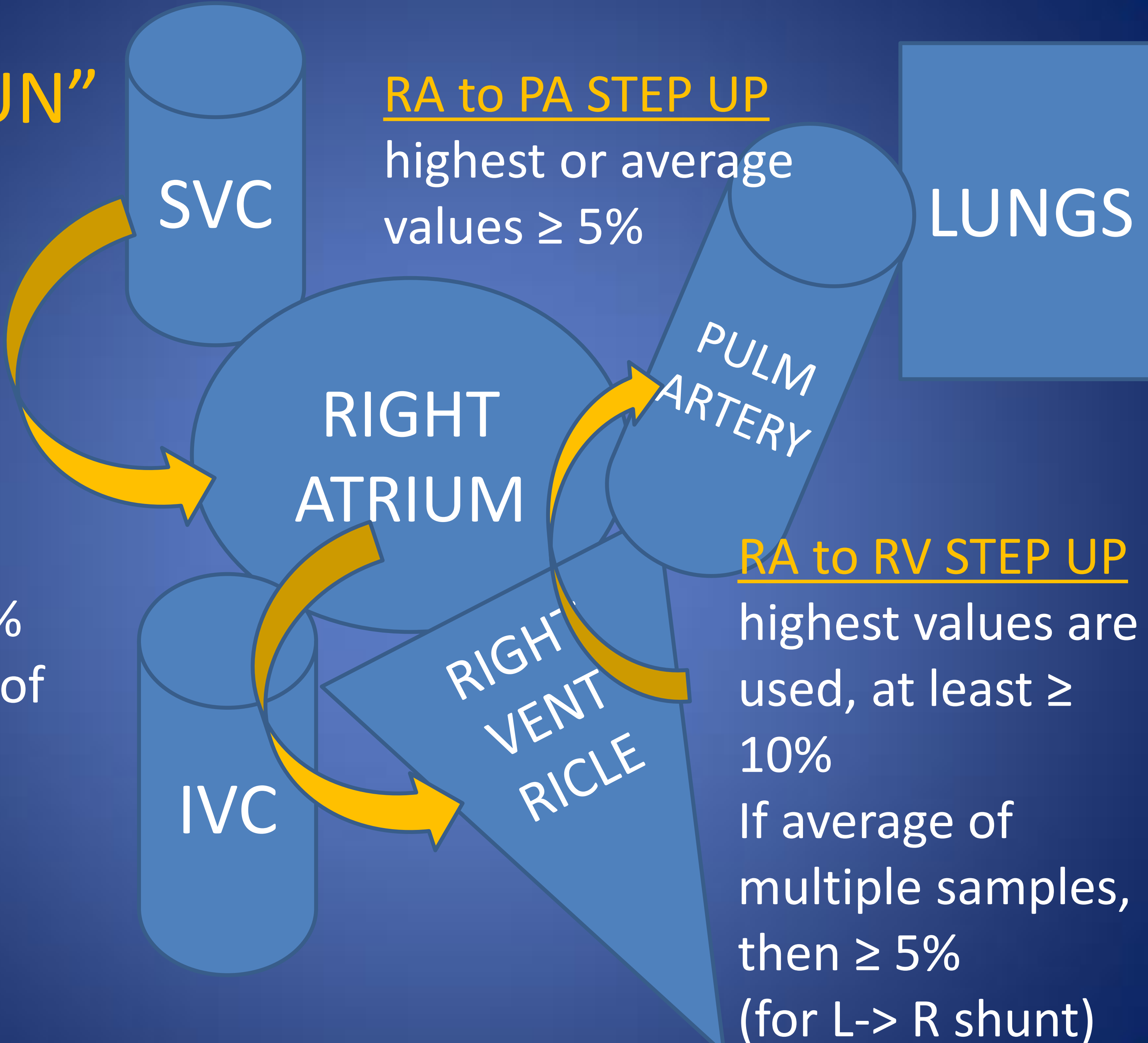
Pulm HTN: mean
PA pressure > 25mmHg
PCWP < 15mmhg

Precautions

- Always record pressures at end-expiration
- During inspiration, pressures will be lower due to decrease in intrathoracic pressure
- Always zero and reference the system



“SAT RUN”



SVC to RA STEP UP

If highest values are used, at least ≥ 11%

If average of multiple samples, then ≥ 7%

RA to PA STEP UP

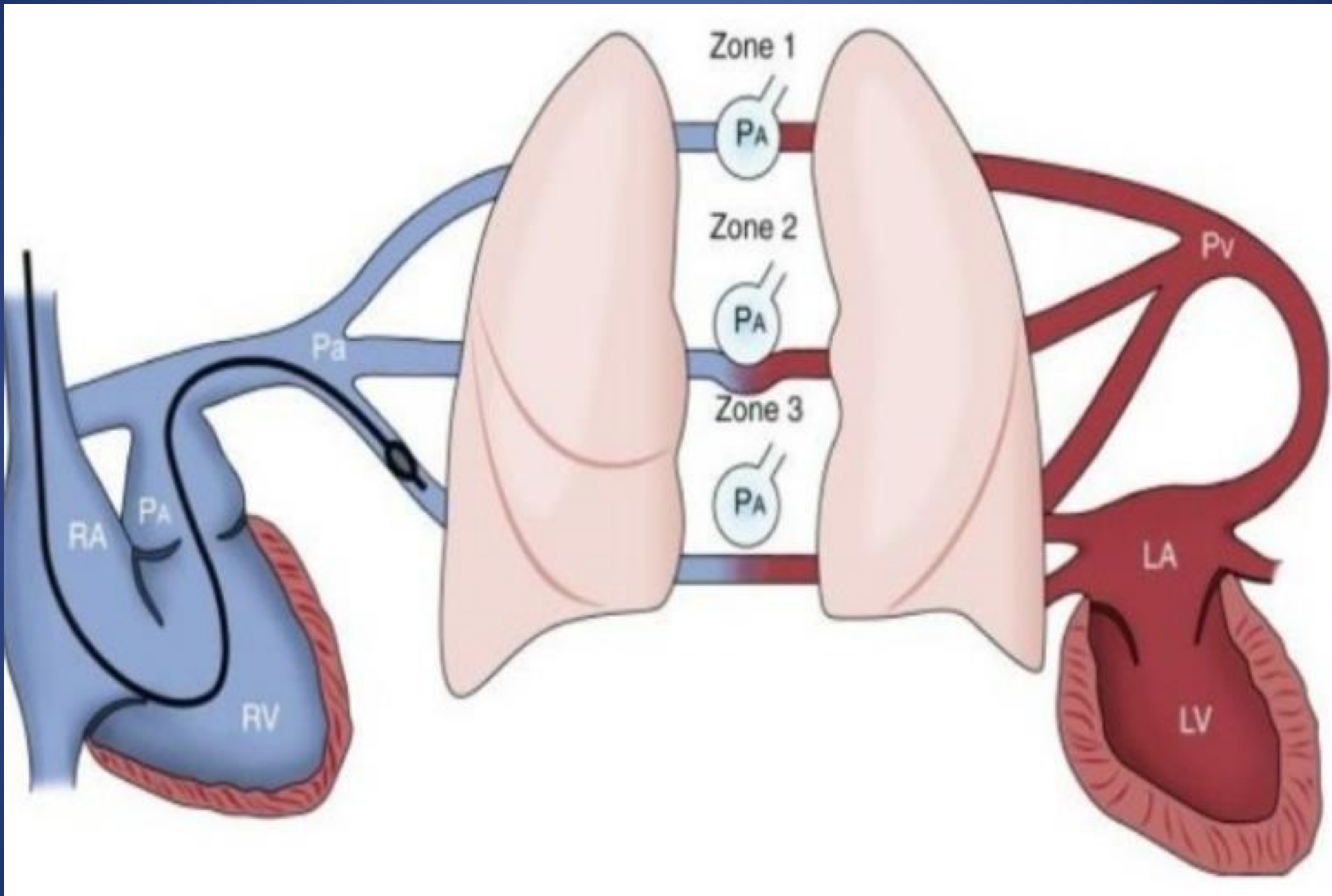
highest or average values ≥ 5%

RA to RV STEP UP

highest values are used, at least ≥ 10%

If average of multiple samples, then ≥ 5%

(for L-> R shunt)

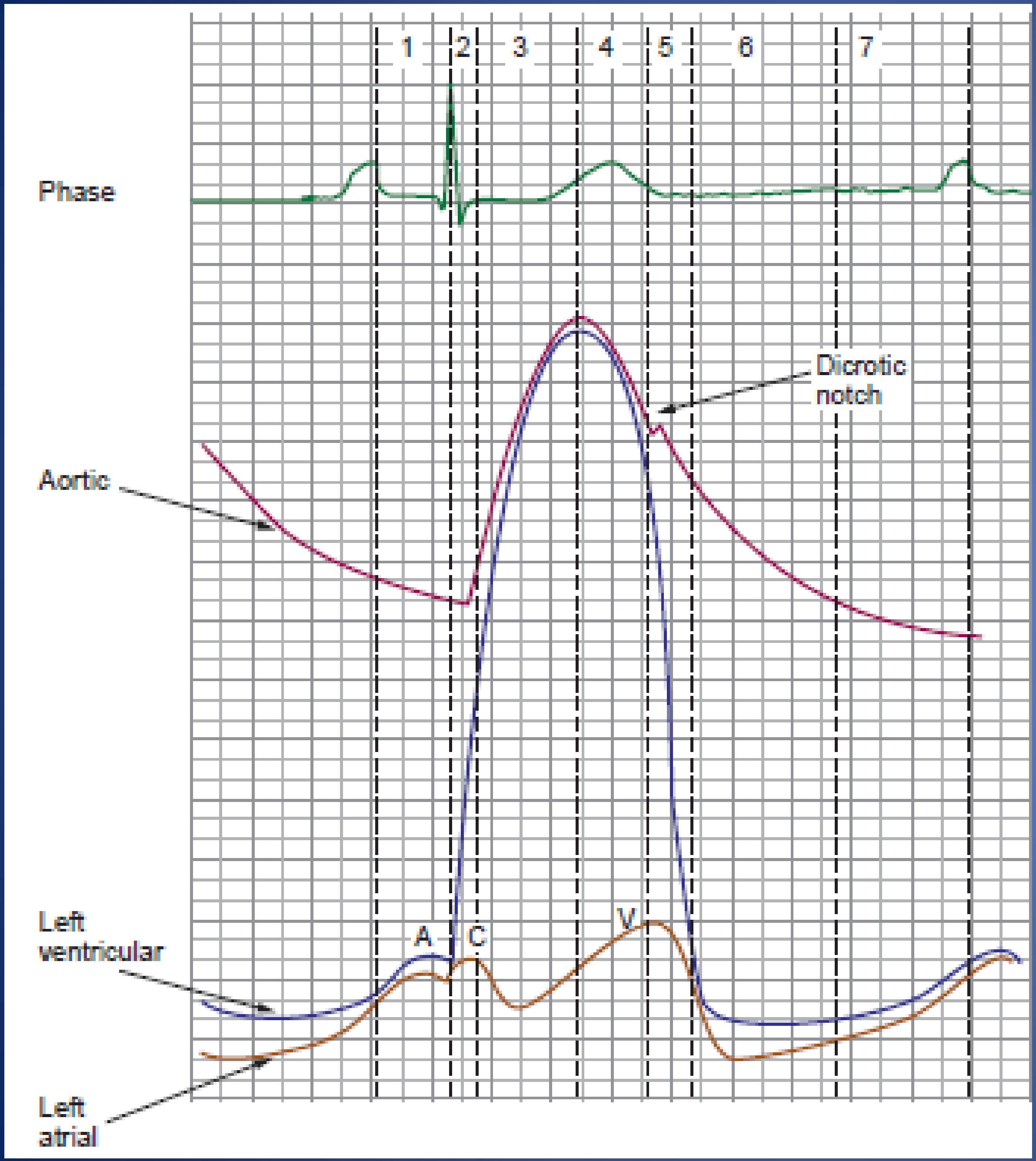


Zone 1
PA
Zone 2
PA
Zone 3
PA
Pa
PV
RA
PA
LA
RV
LV

SIMULTANEOUS RIGHT- and LEFT- HEART CATHETERIZATION

1. Pulmonary artery (PA) catheter to pulmonary artery
2. Measure cardiac output by measuring oxygen saturation in PA and AO blood samples to determine Fick output or by thermodilution (x3); screen for shunt.
3. Record aortic pressures with AO catheter. Cross the AV into the ventricle -> Wedge the PA catheter -> Measure simultaneous LV-PCWP (mitral valve assessment).
4. Pull back from PCWP to PA.
5. Pull back from PA to right ventricle (RV) (to screen for pulmonic stenosis) and record RV.
6. Record simultaneous LV-RV (constriction vs restriction).
7. Pull back from RV to right atrium (RA) (to screen for tricuspid stenosis) and record RA
8. Pull back from LV to AO (to screen for aortic stenosis).

CARDIAC CYCLE



PHASES

1: Atrial Contraction

2: Isovolumic Contraction
(TV/MV closure to PV/AV opening)

3: Rapid Ejection

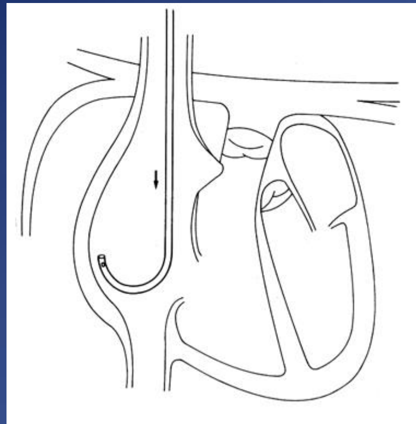
4: Reduced Ejection
(PV/AV opening to PV/AV closure)

5: Isovolumic Relaxation
(PV/AV closure to TV/MV opening)

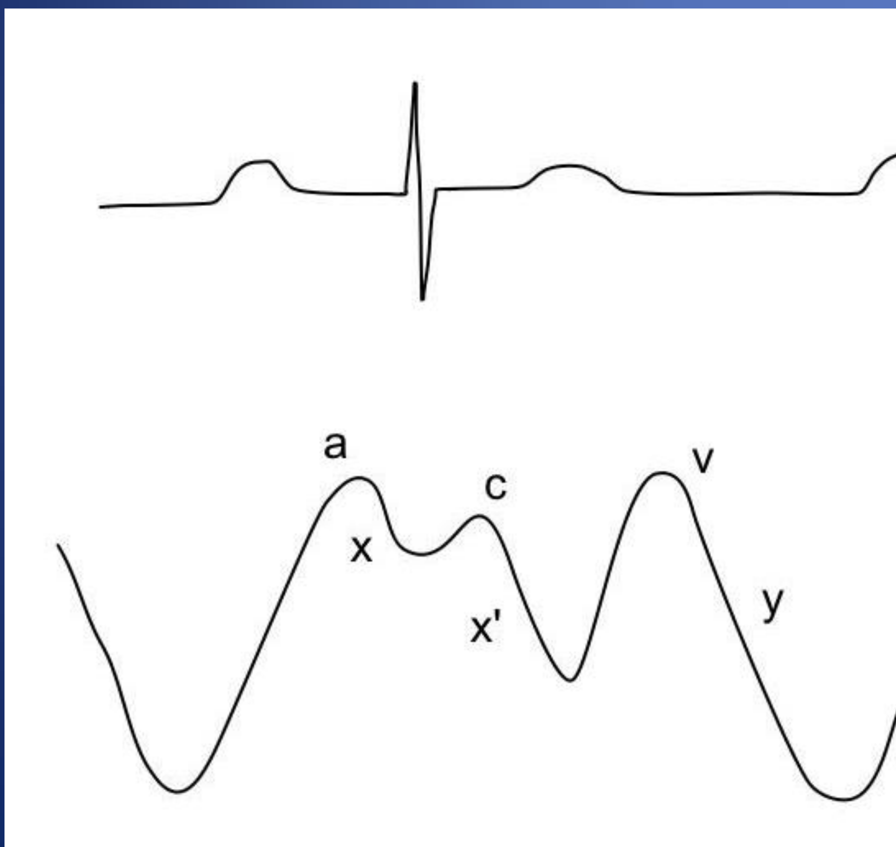
6: Rapid Ventricular Filling

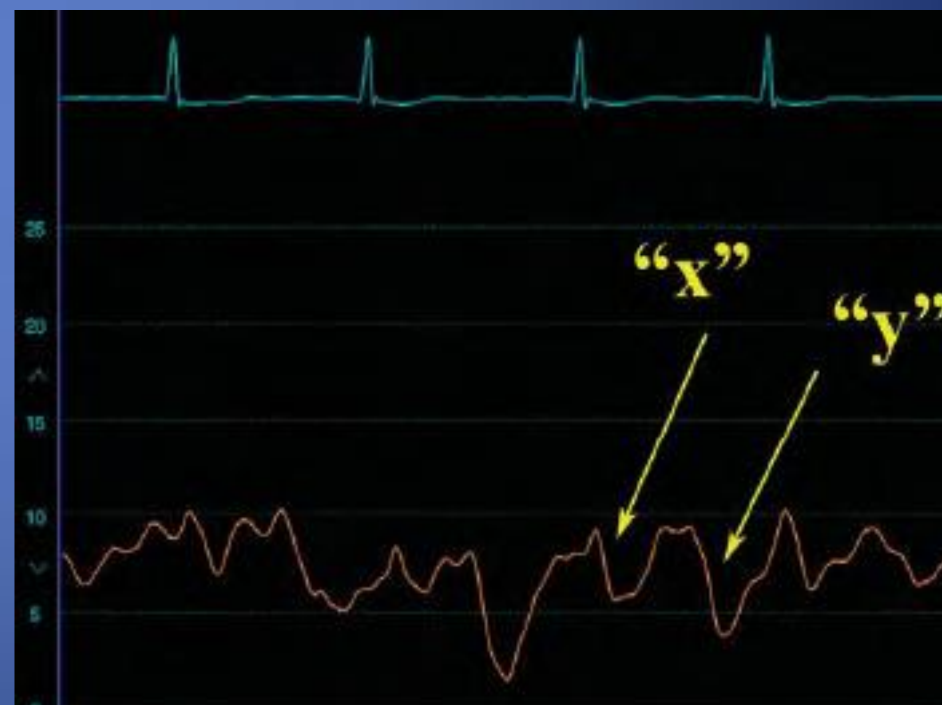
7: Reduced Ventricular Filling
(TV/MV opening to TV/MV closure)

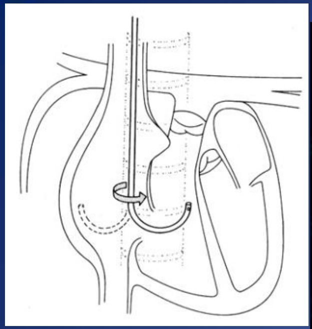
PRESSURE WAVE INTERPRETATION

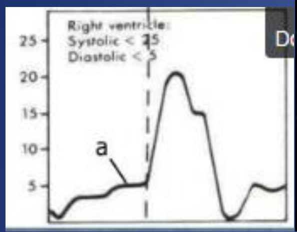


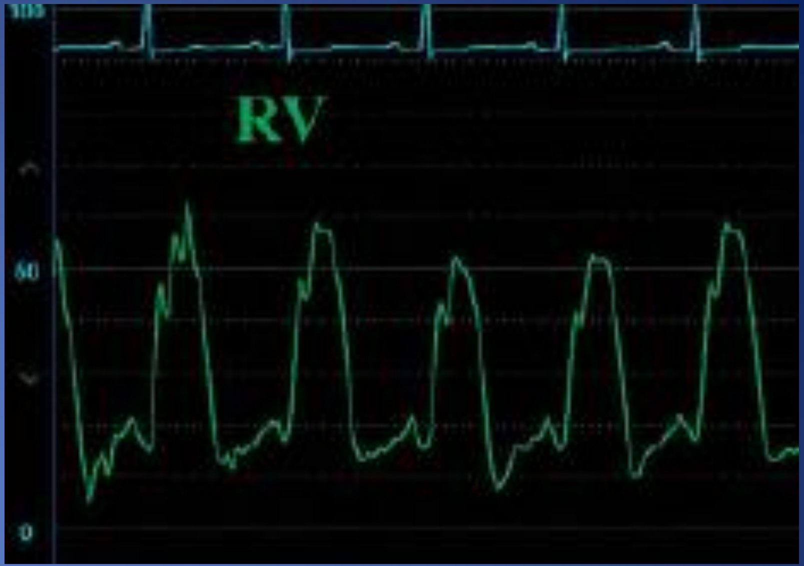

50
25
0
inspiration

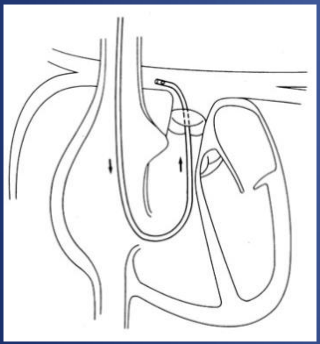

a
x
c
x'
v
y

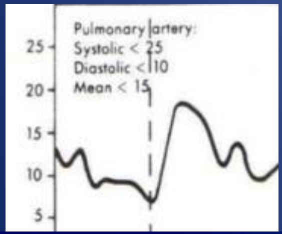

25
20
15
10
5
0
“x”
“y”



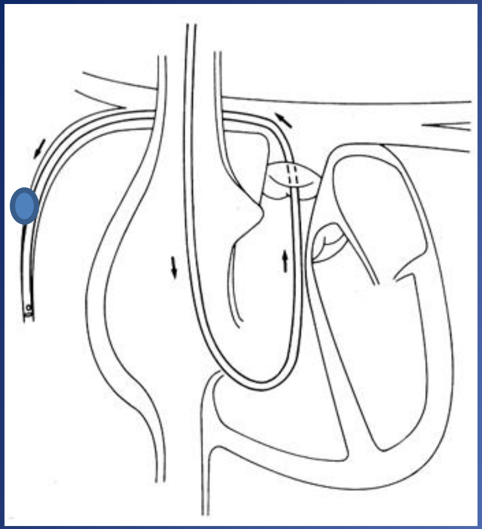

Right ventricle:
Systolic < 25
Diastolic < 5
a
25
20
15
10
5

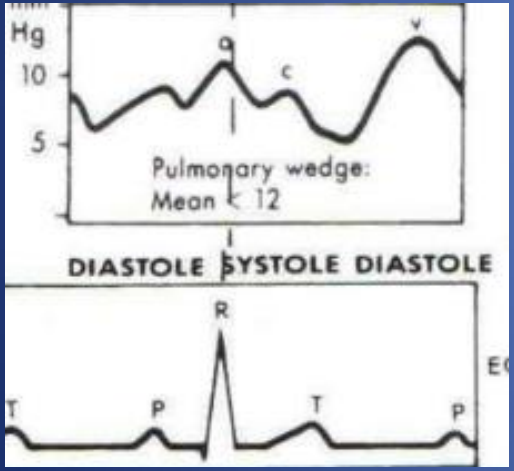

RV
60
0




Pulmonary artery:
Systolic < 25
Diastolic < 10
Mean < 15
25
20
15
10
5

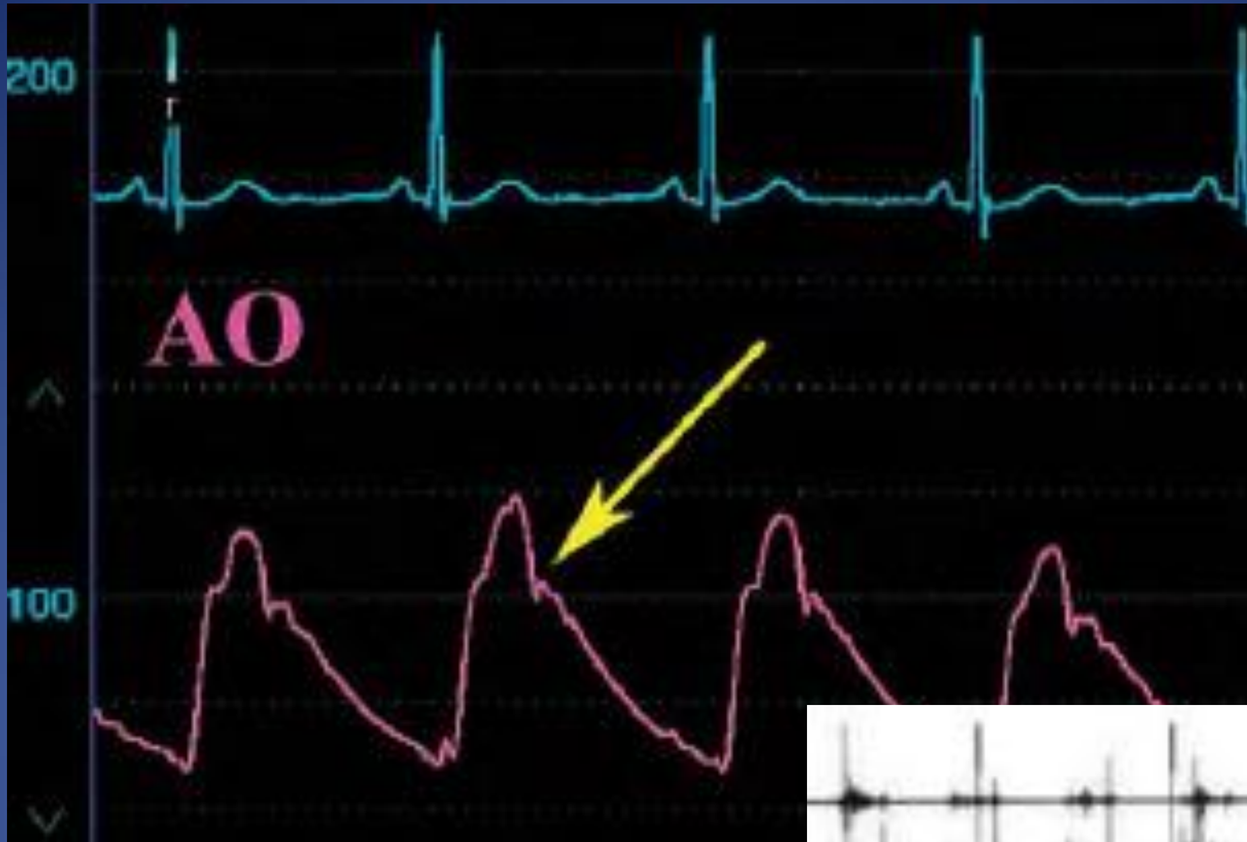

PA
25
0

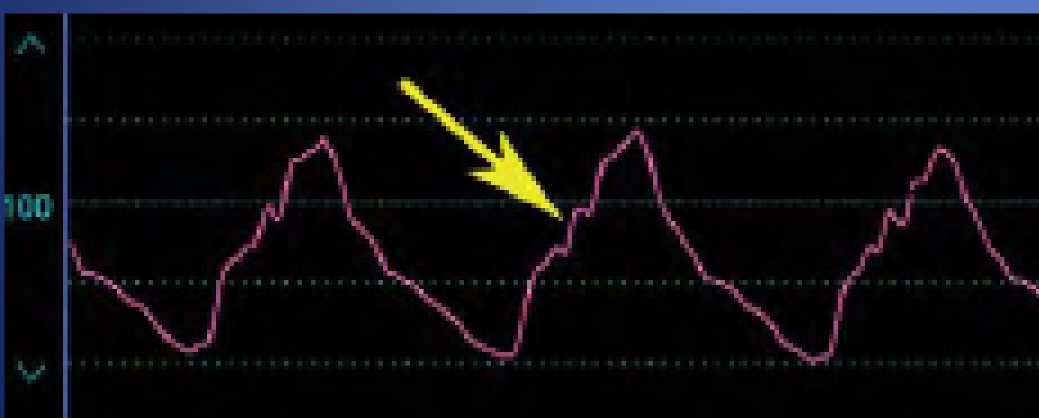


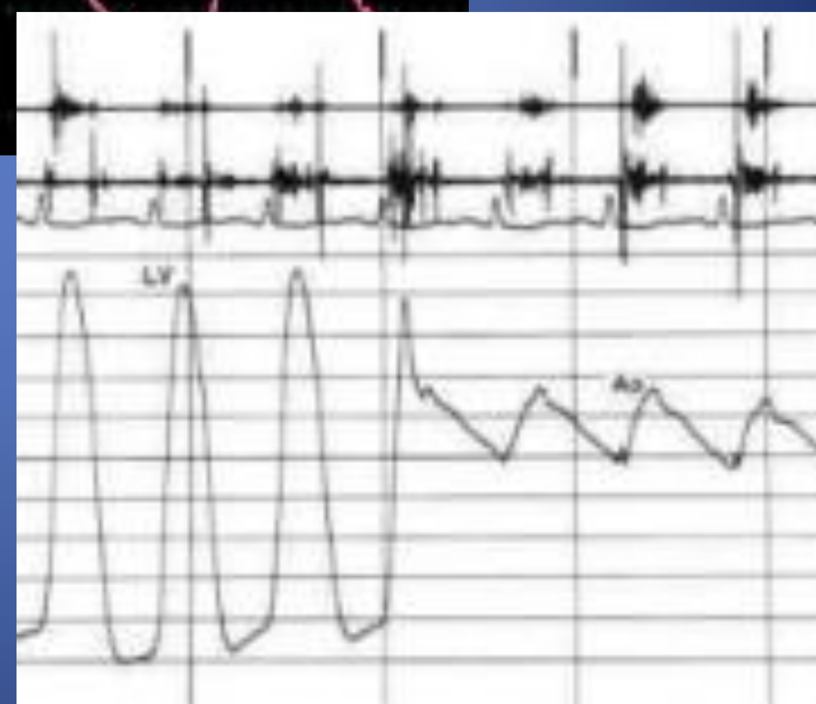

Hg
10
5
a
c
v
Pulmonary wedge:
Mean < 12
DIASTOLE SYSTOLE DIASTOLE
R
T
P
T
P

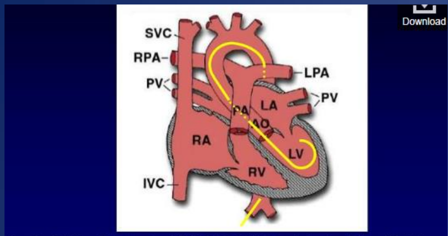

50
0
left atrial
wedge

LEFT HEART CATHETERIZATION


200
AO
100

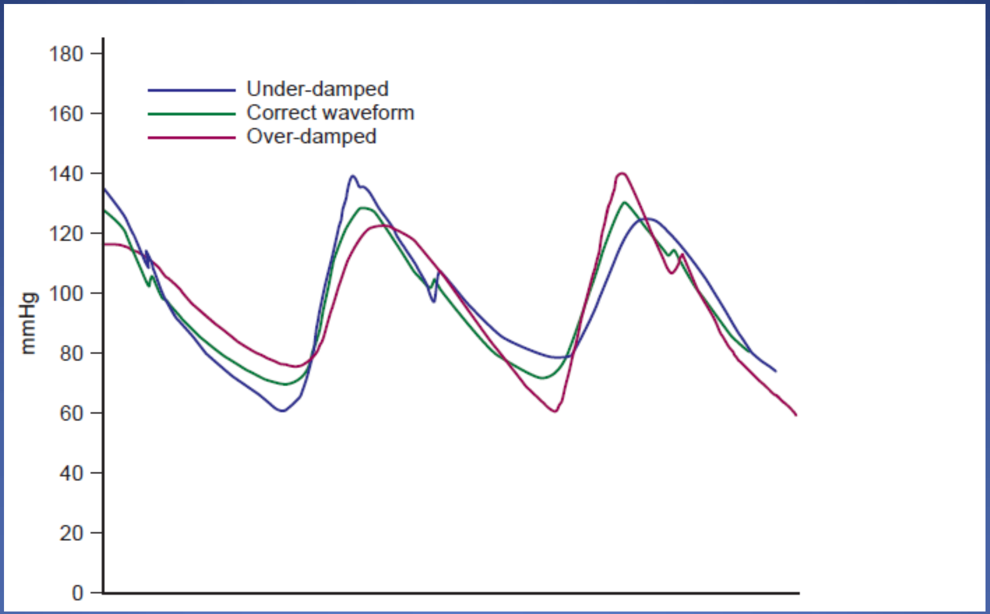

100

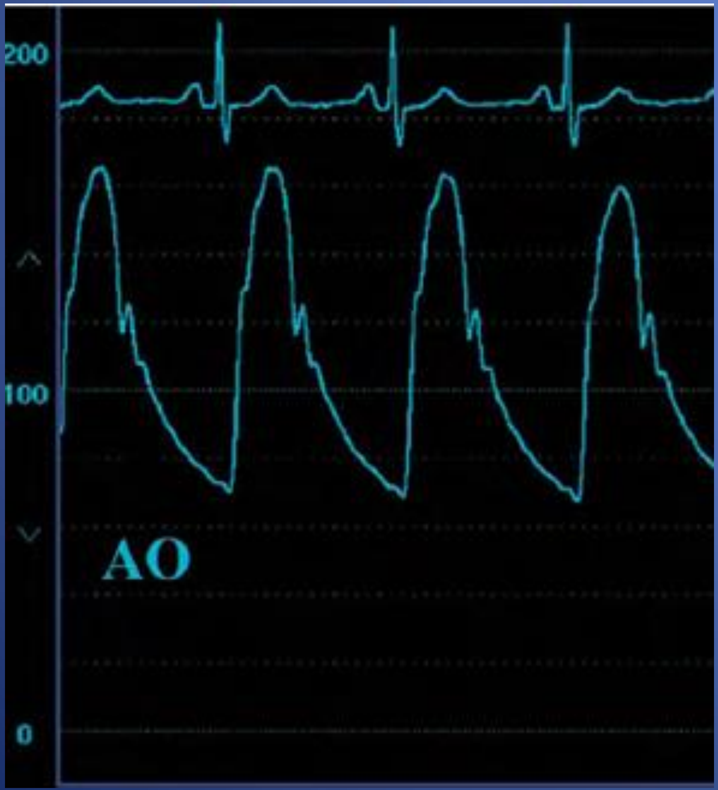

LV
Ao



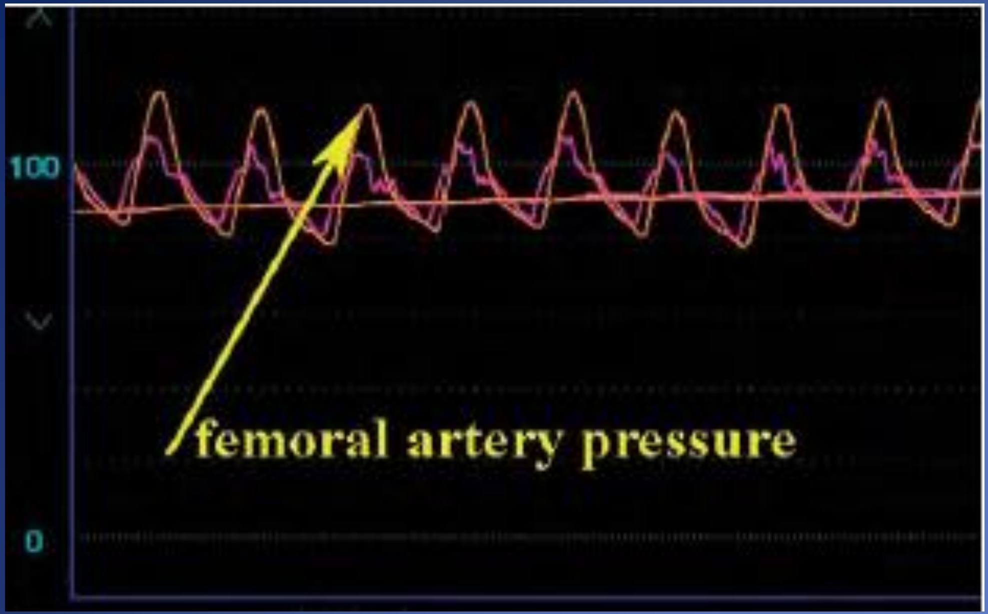
Kern MJ. Right Heart Catheterization. CATHSAP II CD-ROM. Bethesda, American College of Cardiology, 2001.

PITFALLS

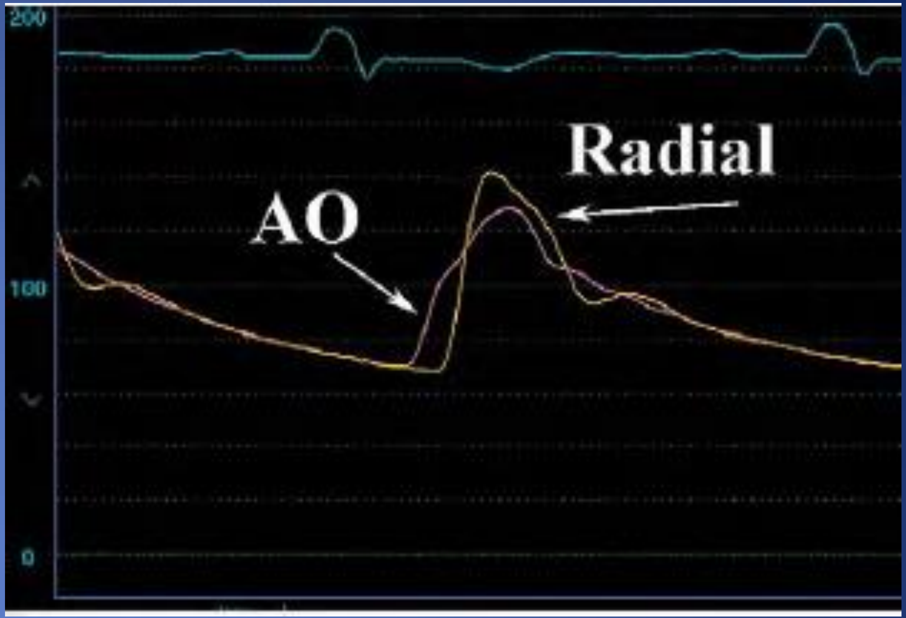

180
160
140
120
100
80
60
40
20
0
mmHg
Under-damped
Correct waveform
Over-damped


200
100
0
AO

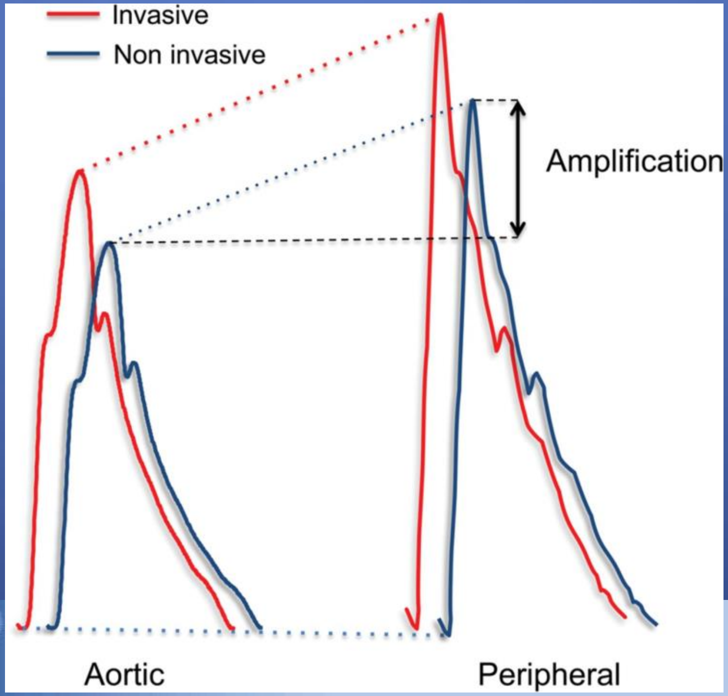

200
100
0
AO



100
0
femoral artery pressure

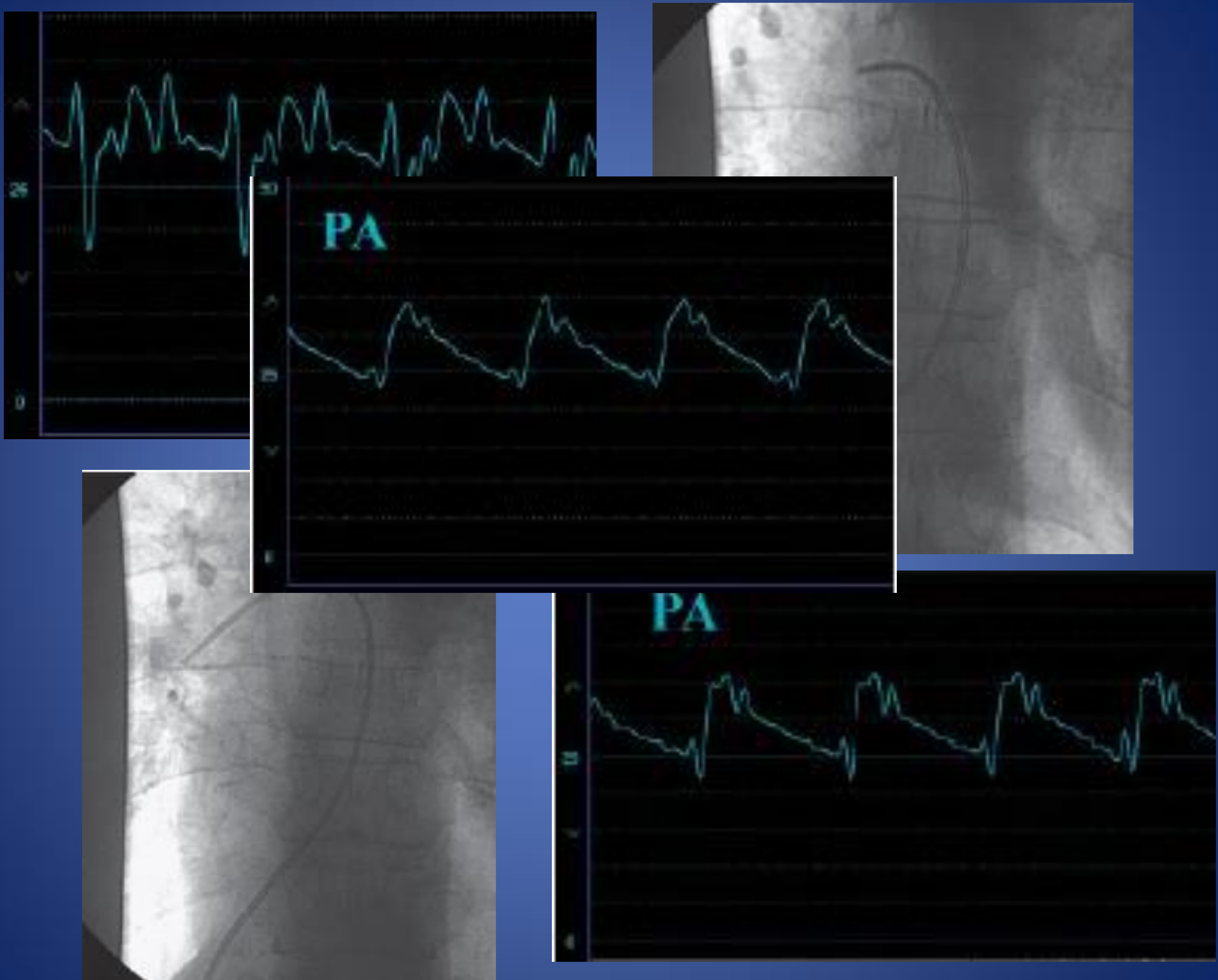


200
100
0
Radial
AO



Invasive
Non invasive
Amplification
Aortic
Peripheral

ARTIFACTS


25
0
PA
PA

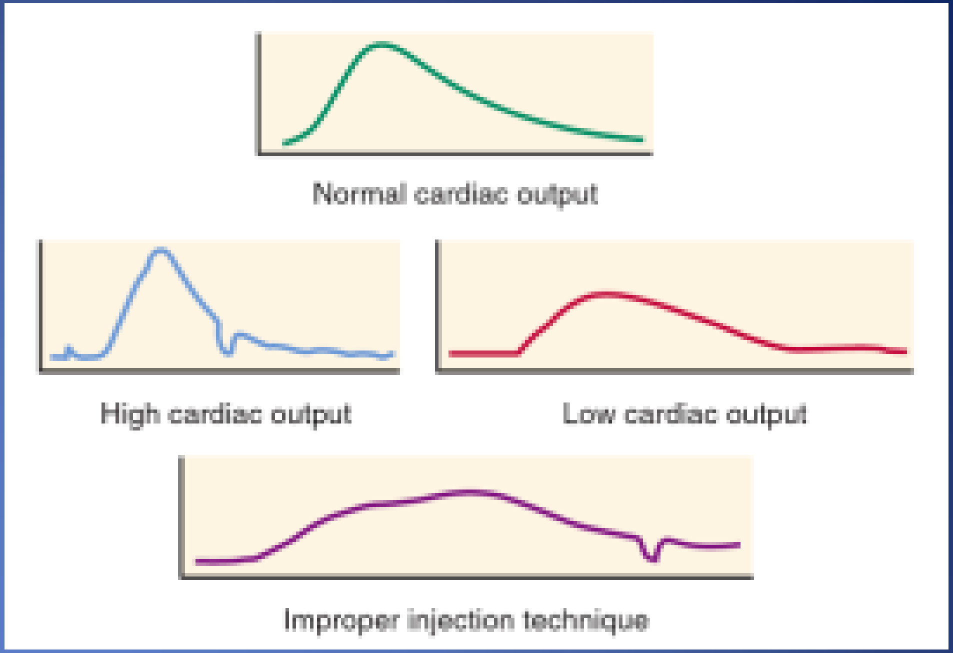
CARDIAC OUTPUT

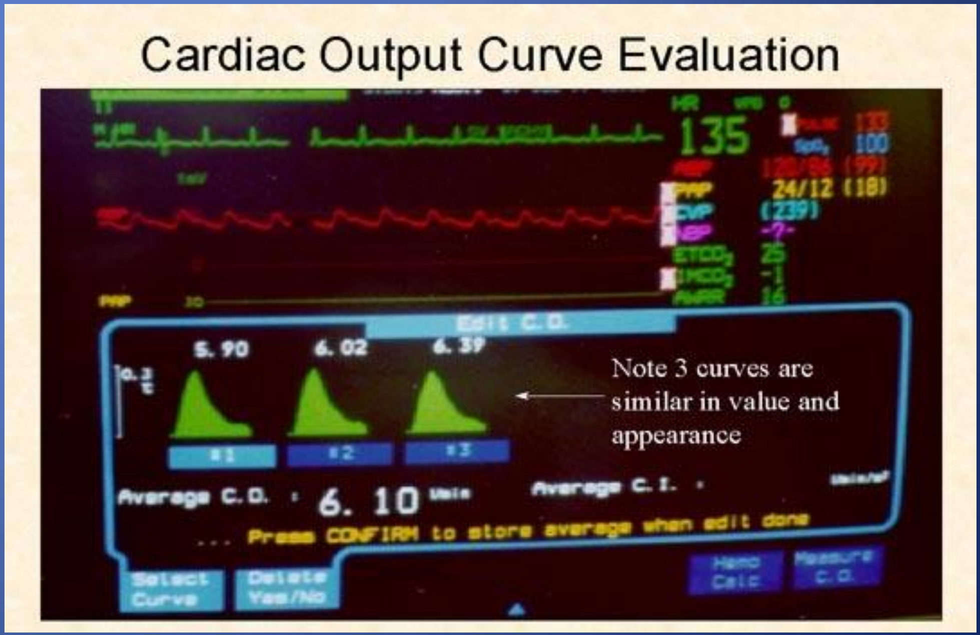
Cardiac Output

- Thermodilution
- Fick Method

Thermodilution

- Bolus injection of saline into the proximal port
- Change in temperature is measured by thermistor in the distal portion of the catheter





Fick Principle

- Described in 1870
- Assumes rate of O2 consumption is a function of rate of blood flow times the rate of O2 pick up by the RBC

$$\text{Cardiac output} = \frac{\text{Oxygen consumption}}{(\text{Arterial saturation} - \text{Mixed venous saturation}) \times (\text{Hgb}) \times 13.6 \times 10}$$

Oxygen consumption
1. Direct Fick:
-Directly measured
2. Indirect Fick:
--3 ml O2/kg

Limitations

Thermodilution

- Not accurate in tricuspid regurgitation
- Overestimated cardiac output at low output states

Fick

- Oxygen consumption 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

THANK YOU

Normal Pressures

Site	Normal Value (mmHg)	Mean Pressure (mmHg)	Saturation
Right Atrium (or CVP)	0-5		75%
Right Ventricle	25/5		75%
Pulmonary Artery	25/10	10-20	75%
PCWP	7-12		95-100%
LV	120/10		95-100%
Aorta	120/80		95-100%

Normal Values

Site	Value
Sv02	0.60-0.75
Stroke Volume	60-100 ml/beat
Stroke Index	33-47 ml/beat/m2
Cardiac Output	4-8 L/min
Cardiac Index	2.5-4.0 L/min/m2
SVR	800-1200 dynes sec/-cm5
PVR	<250 dynes sec/-cm5
MAP	70-110 mmHg

RA/ PCWP

Wave pattern	Mechanism	Condition
Cannon 'a' wave	AV dissociation	Complete heart block, ventricular tachycardia, AVNRT
Tall 'a' wave	Increased atrial pressure	Mitral or tricuspid stenosis
No 'a' wave	Loss of atrial kick	Atrial fibrillation
Tall 'v' wave	Increased volume during ventricular systole	Mitral or tricuspid insufficiency, VSD
Loss of 'y' descent	Equalization of diastolic pressures	Cardiac tamponade
Exaggerated 'y' descent	Rapid diastolic filling	Constrictive pericarditis

References

- Bangalore and Bhatt. Right heart catheterization, coronary angiography and percutaneous coronary intervention. Circulation, 2011; 124: e428-e433.
- Kern, Morton J. *The Cardiac Catheterization Handbook*. Philadelphia, PA: Saunders Elsevier, 2011. Print.
- Ragosta, Michael. *Textbook of Clinical Hemodynamics*. Philadelphia, PA: Saunders/Elsevier, 2008. Print.