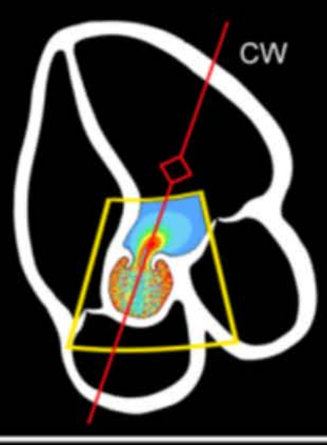
Advanced Cardiac and Resuscitation

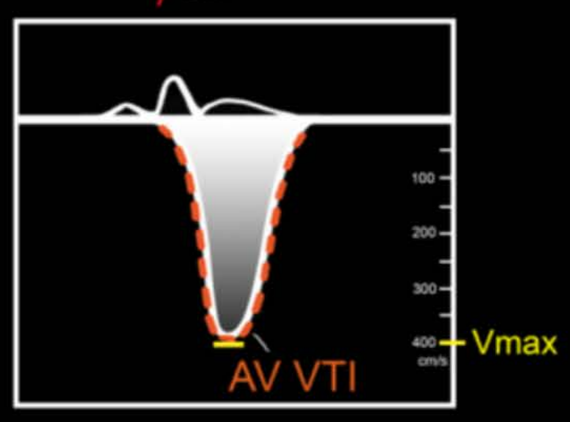
ACEP AEMUS
ADVANCED EMERGENCY MEDICINE ULTRASONOGRAPHY

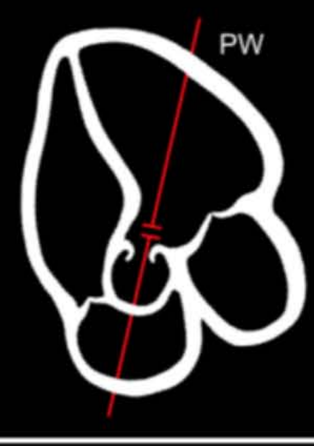
Focused Practice Designation Exam Review Course

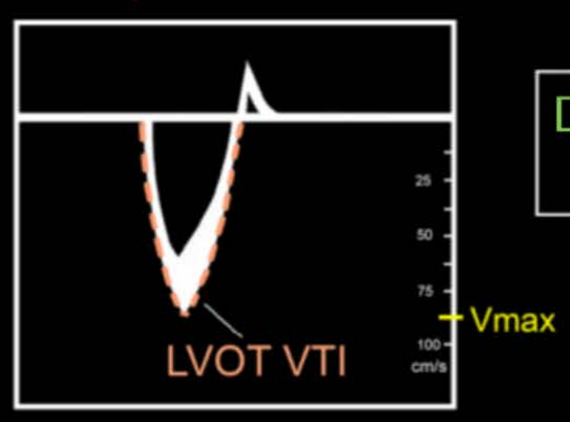
Aortic Stenosis

1 - Calculate LVOT Area | 2 - Measure Aortic Valve VTI | 3- Measure LVOT VTI | 4 - Calculate Aortic Valve Area





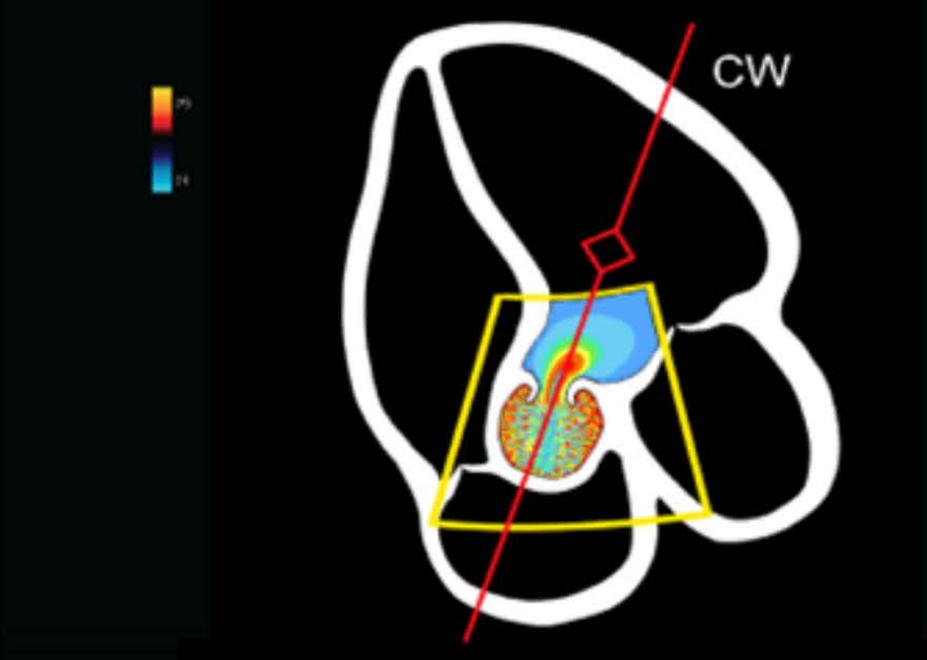


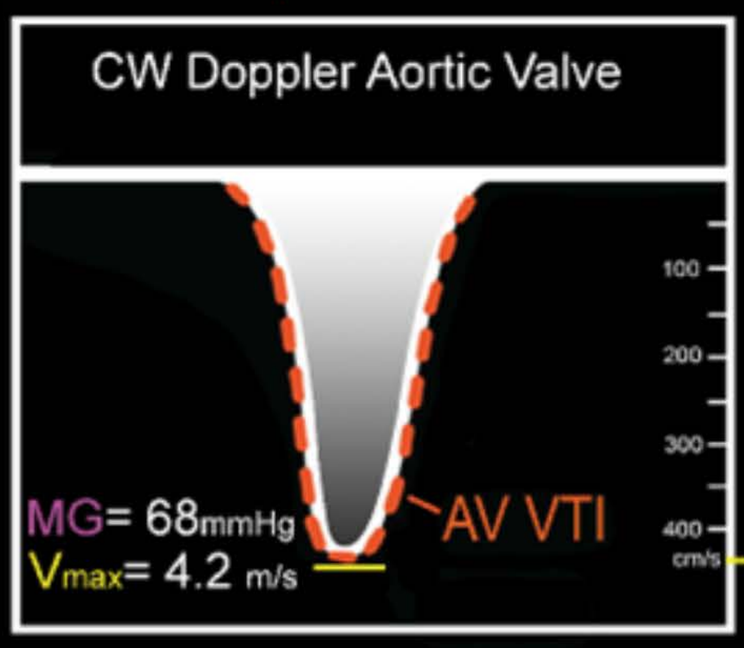


$$\text{Dimensionless Index} = \frac{\text{LVOT VTI}}{\text{AV VTI}}$$

$$\text{Aortic Valve Area} = \text{Dimensionless Index} \times \text{LVOT Area}$$

$$\text{LVOT Area} = \pi \left(\frac{\text{LVOT Diameter}}{2}\right)^2$$





Aortic Stenosis
Grading

Continuity Equation

$$\text{AV Area} = \frac{\text{LVOT VTI} \times \text{LVOT Area}}{\text{AV VTI}}$$

	AV Area cm^2	Mean Gradient mmHg	Peak Velocity m/s	Dimensionless Index
Normal	-	-	≤ 2.5	-
Mild	> 1.5	<20	2.6 - 2.9	> 0.50
Moderate	1.0 - 1.5	20 - 40	3 - 4	0.25 - 0.50
Severe	< 1	> 40	> 4	<0.25

$$\text{Dimensionless Index} = \frac{\text{LVOT VTI}}{\text{AV VTI}}$$

References

Cardiac Output

Cardiac Output

$$\left(\frac{\text{LVOT Diameter}}{2}\right)^2 \times \pi = \text{LVOT}_{\text{area}}$$

$$\text{SV} = \text{LVOT}_{\text{area}} \times \text{LVOT}_{\text{VTI}}$$

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

"Volume Responsive"

SV or CO Increase >15%

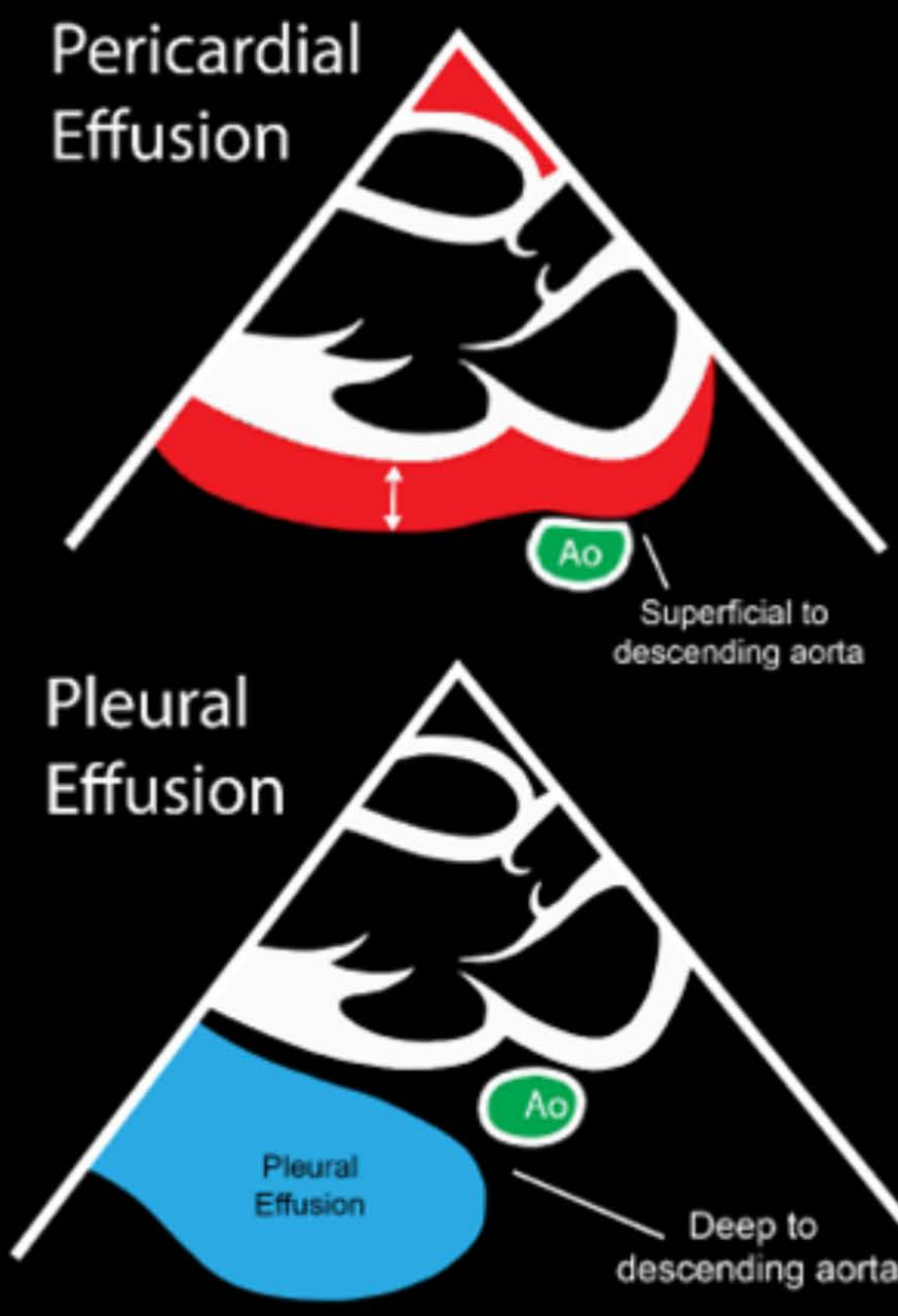
VTI Increase > 12.5%

	LVOT VTI (cm)	CO (L/min)	CI (L/min/m²)
Low	<18*	<4**	<2.5
Normal	18-22	4-8	2.5-4
High	>22*	>8**	>4

*May still have normal CO depending on HR
** Normal CO varies depending on patients height/weight

References

Pericardial Effusion



Quantifying Effusion

	Distance (mm)	Volume (mL)
Trivial	Separation of layers only seen in systole	<50
Small	<10	50-100
Moderate	10-20	100-500
Large	>20	>500
Very Large	>50	

Cardiac Tamponade

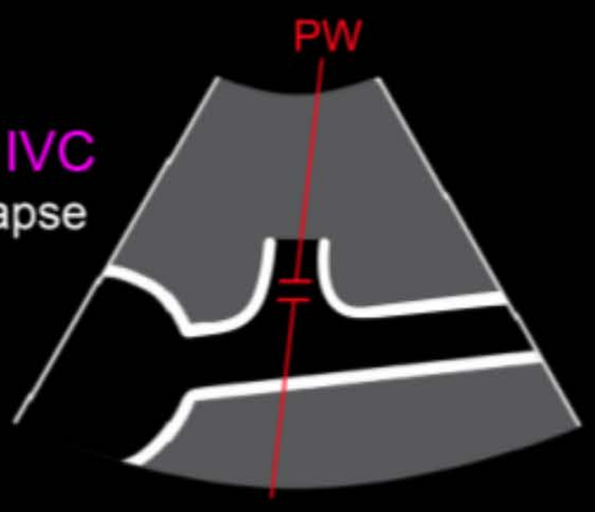
RA *systolic* collapse

Earliest sign

Plethoric IVC

<50% collapse

>2.1 cm



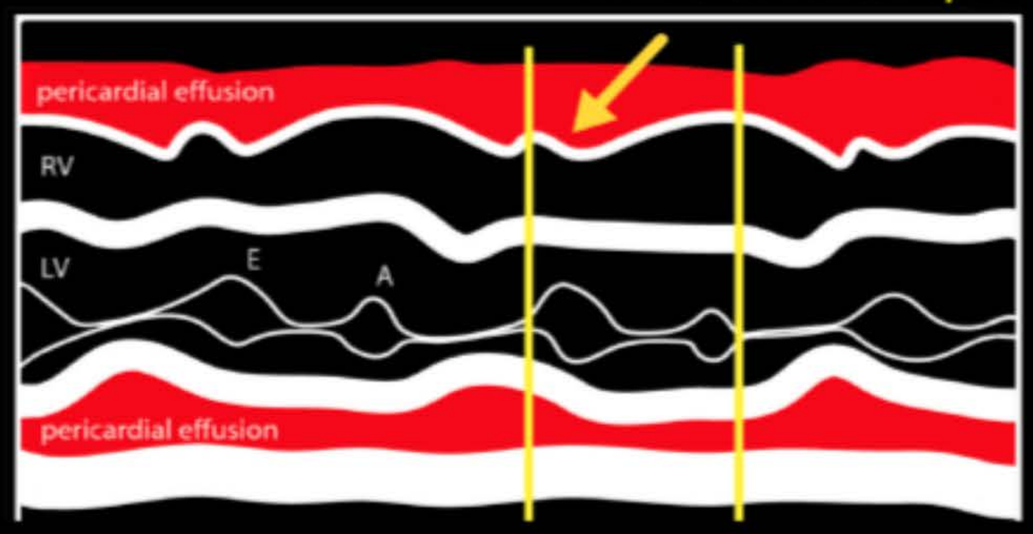
Hepatic Vein / IVC

RV *diastolic* collapse

MV/TV Flow Variation

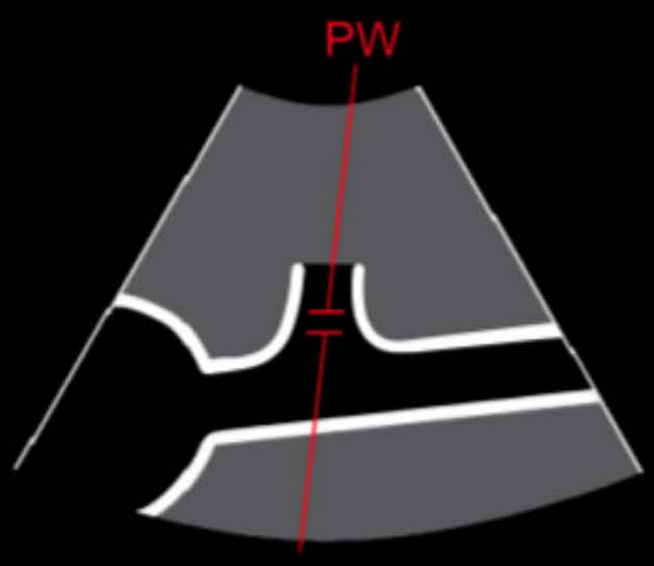
M Mode

RV *diastolic* collapse

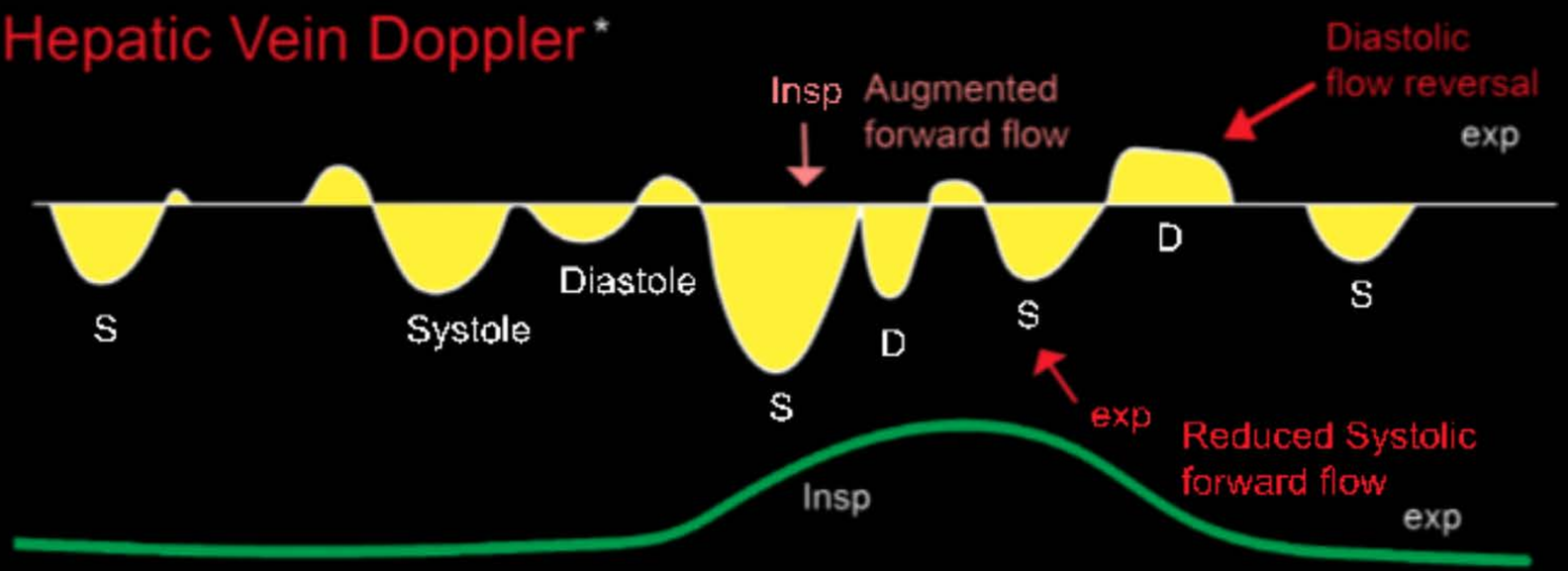


Cardiac Tamponade

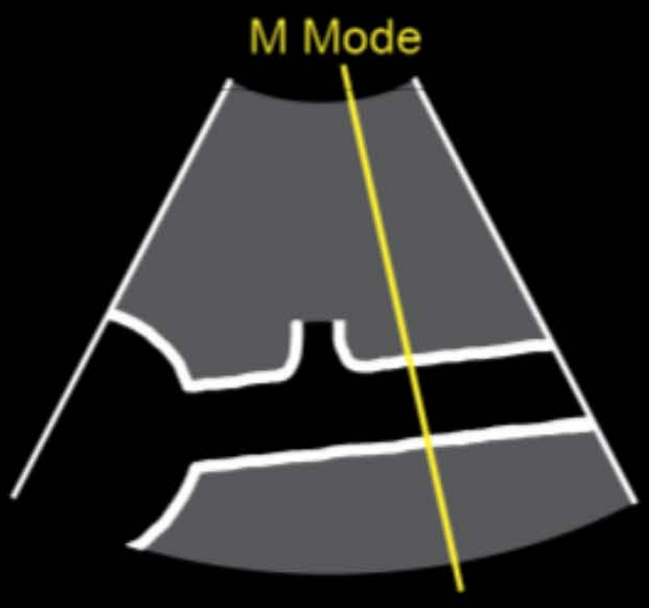
Hepatic Vein Doppler / IVC



Hepatic Vein Doppler*



M Mode



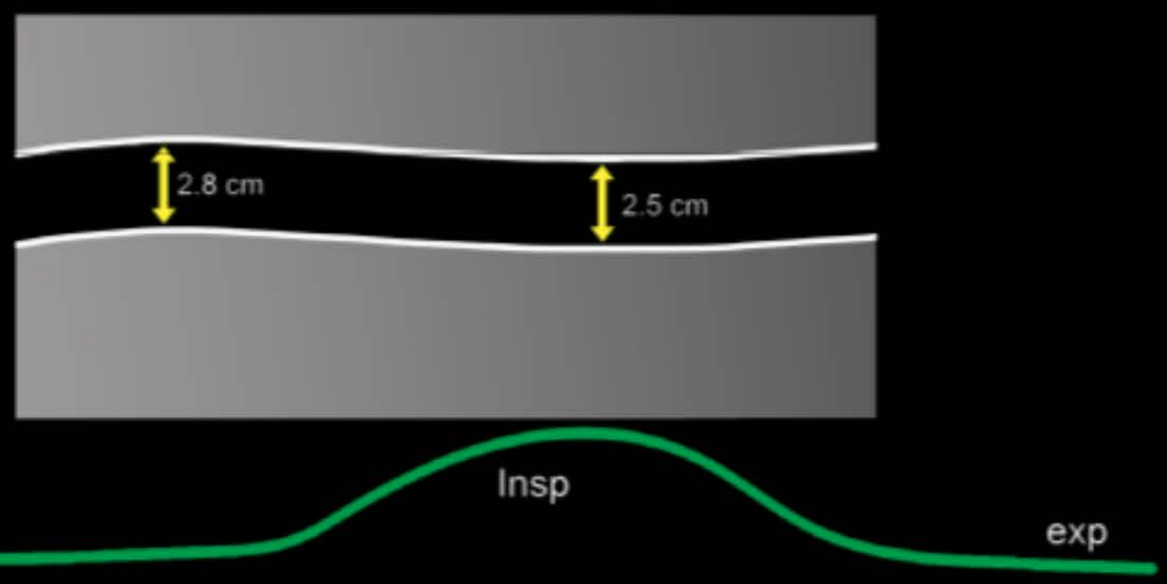
M Mode IVC*

Plethoric IVC

> 2.1 cm

< 50% Collapse

92-97% Sensitive for tamonade

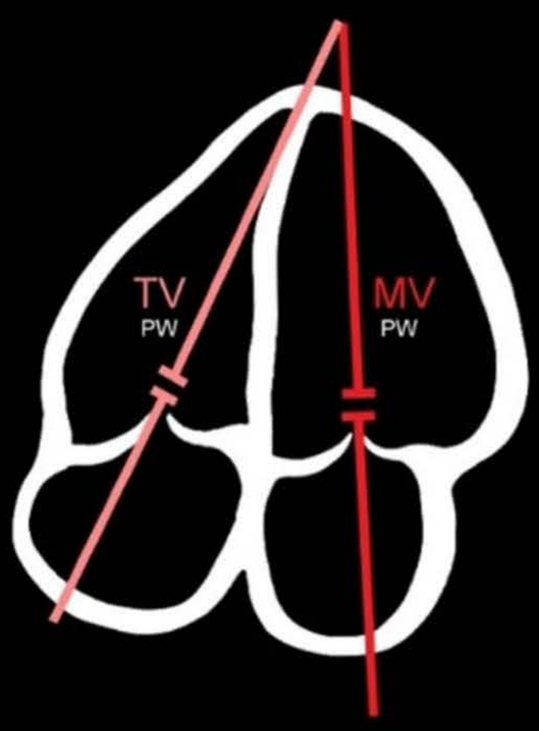


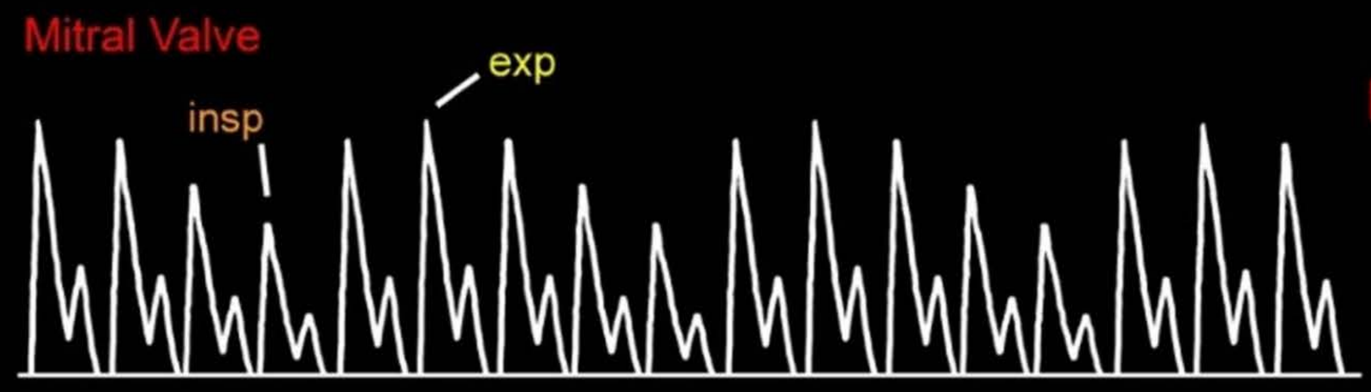
* Respiratory changes expected in non-intubated spontaneously breathing patients

Cardiac Tamponade

Cardiac Tamponade

Mitral / Tricuspid Inflow Variation

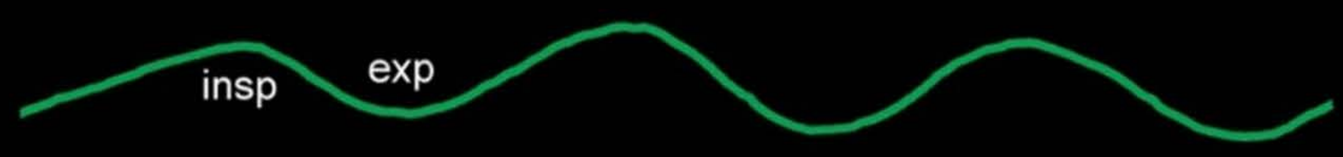




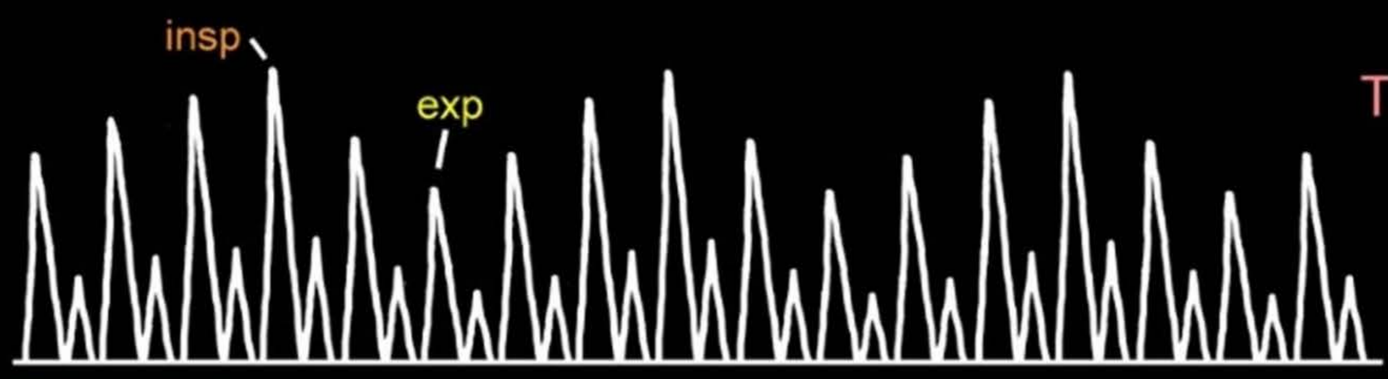
Mitral Flow Variation

Normal < 15%

Tamponade > 30%



Respirations



Tricuspid Flow Variation

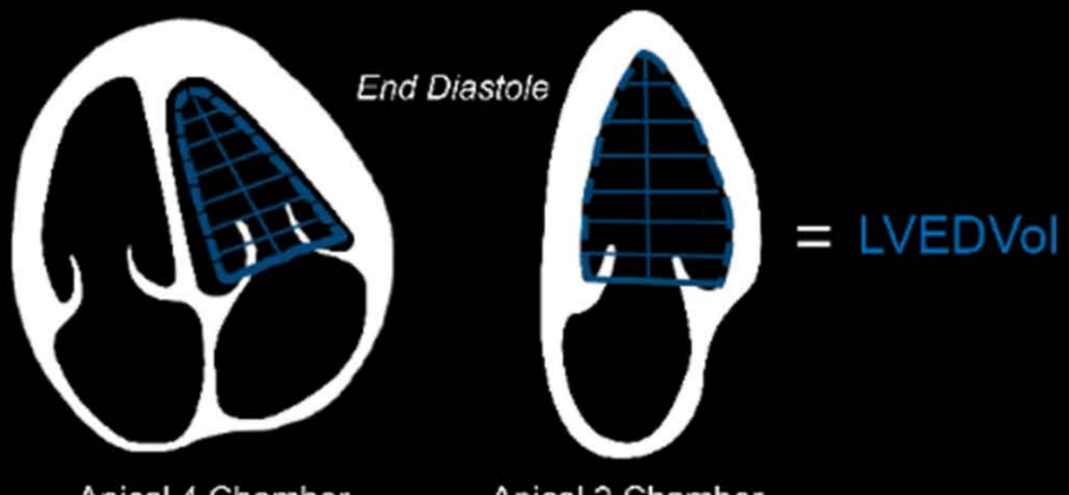
Normal < 25%

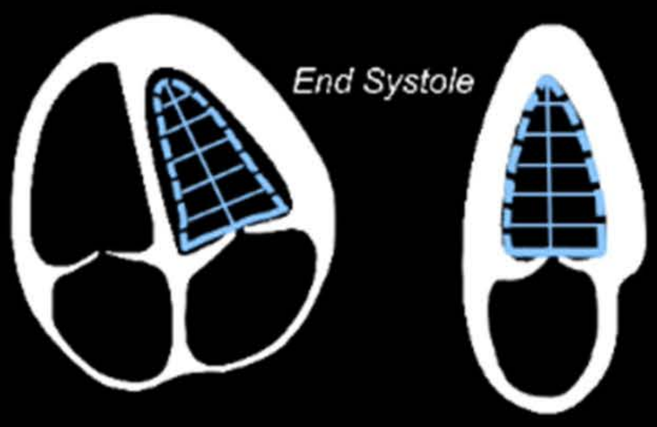
Tamponade > 60%

$$\text{Flow Variation} = \left(\frac{\text{exp} - \text{insp}}{\text{exp}}\right)$$

Ejection Fraction

Biplane Discs Summation

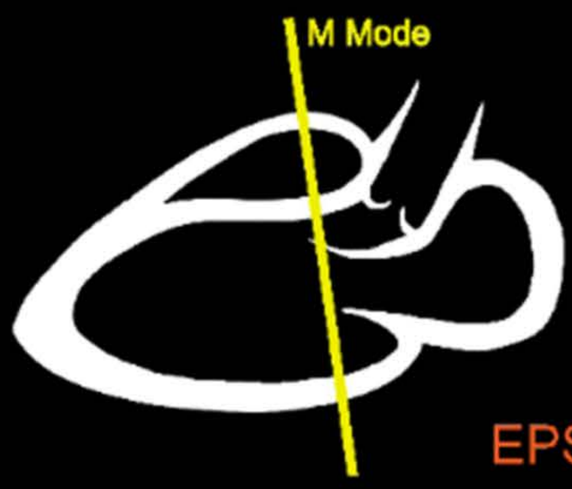


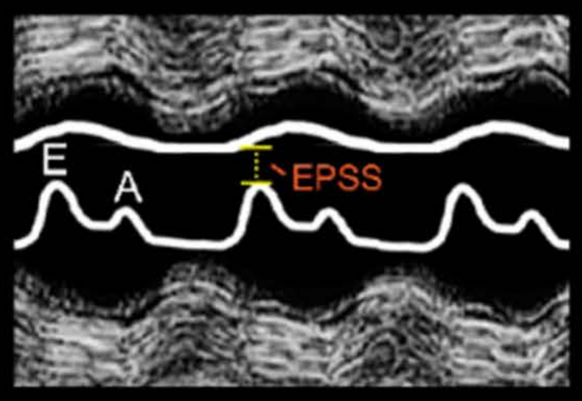


$$EF = \left(\frac{\text{LVEDVol} - \text{LVESVol}}{\text{LVEDvol}}\right) \times 100$$

Normal EF = 52-72% - Males
54-74% - Females

E Point Septal Seperation





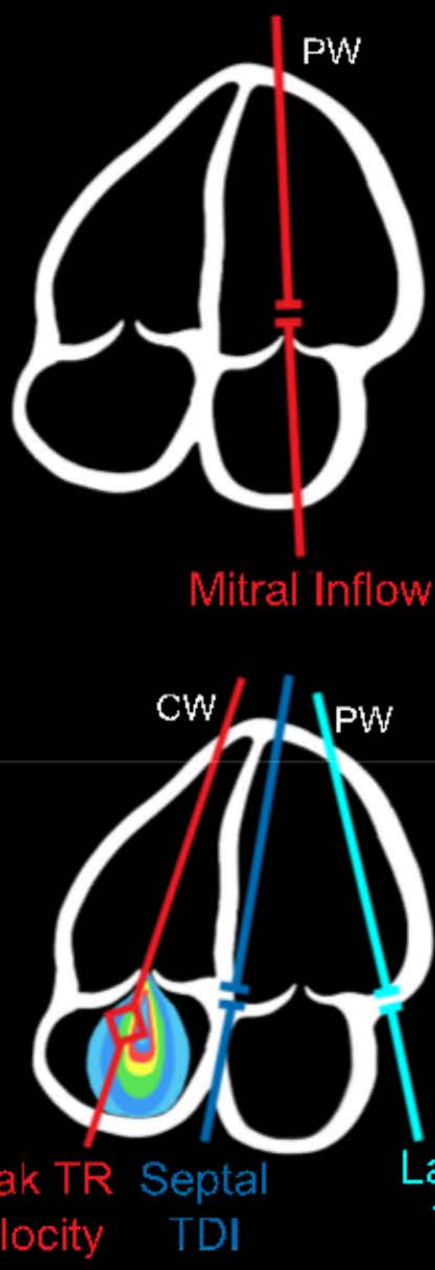
EPSS >7mm = Decreased EF

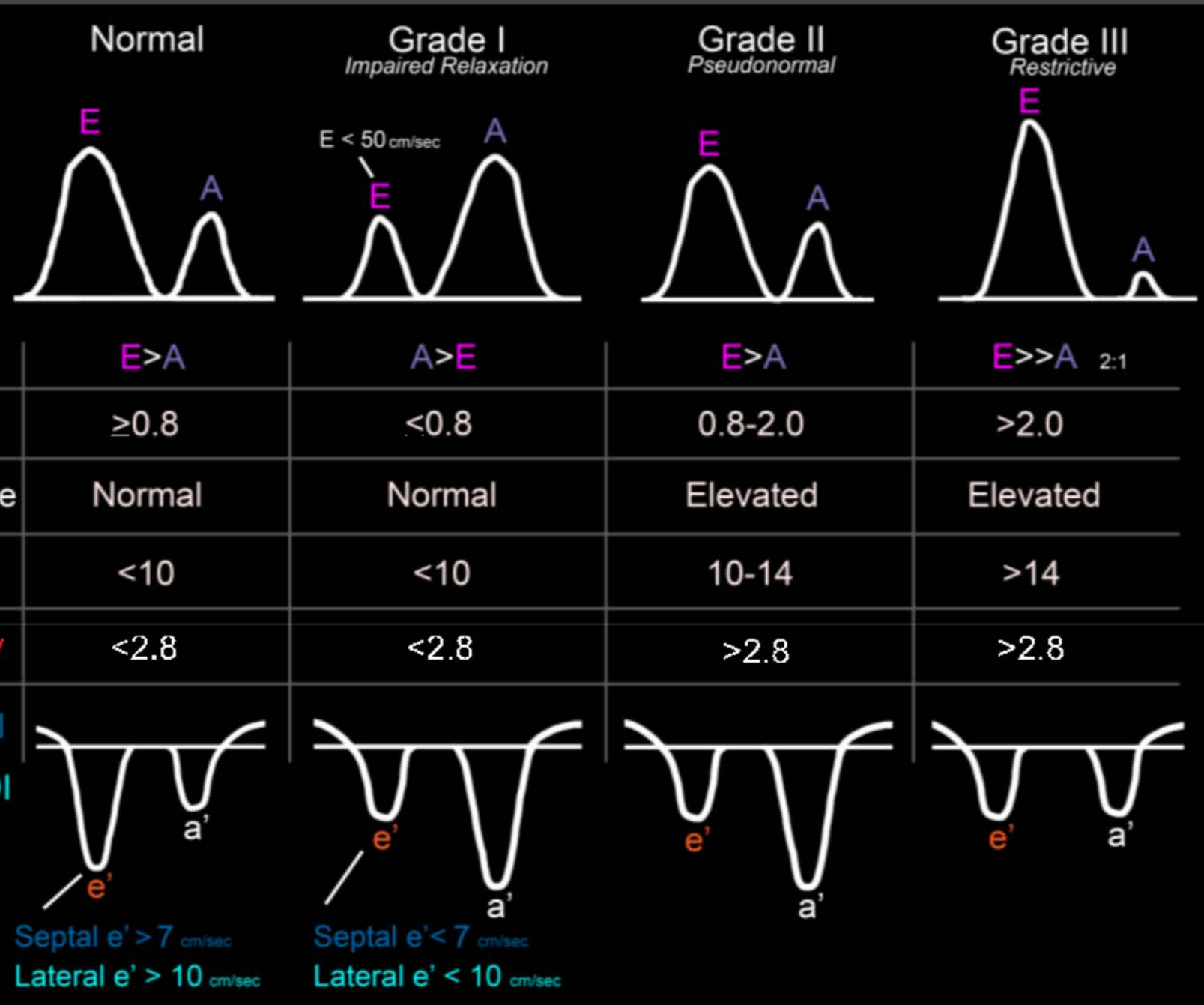
Fractional Shortening

$$FS = \left(\frac{\text{LVEDd-LVESd}}{\text{LVEDd}}\right) \times 100$$

FS <25% = Decreased EF

Diastology





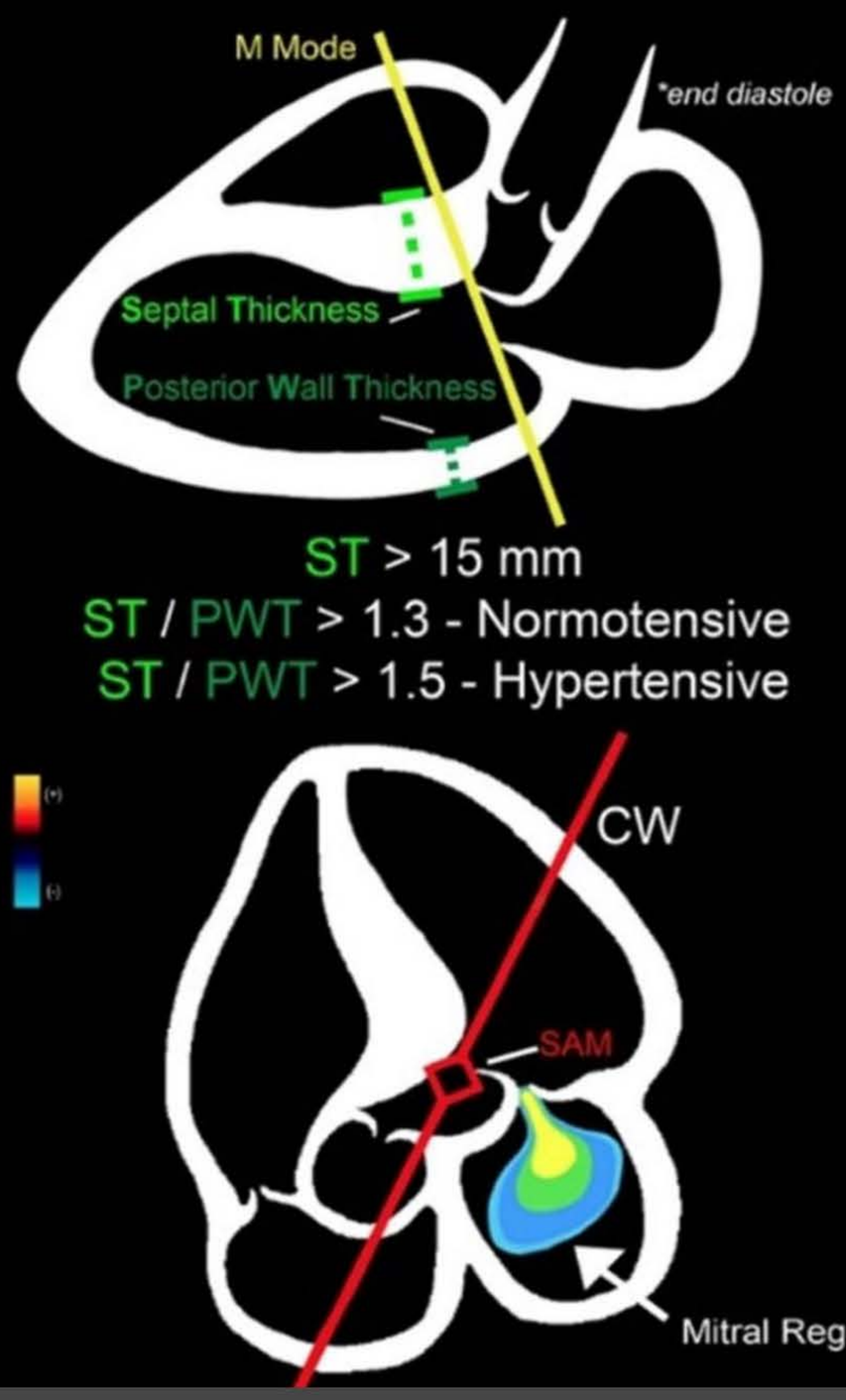
Diastology:

- ***Look at the heart in the clinical context:*** symptomatic = shortness of breath
- Patient with pulmonary edema (b-lines)

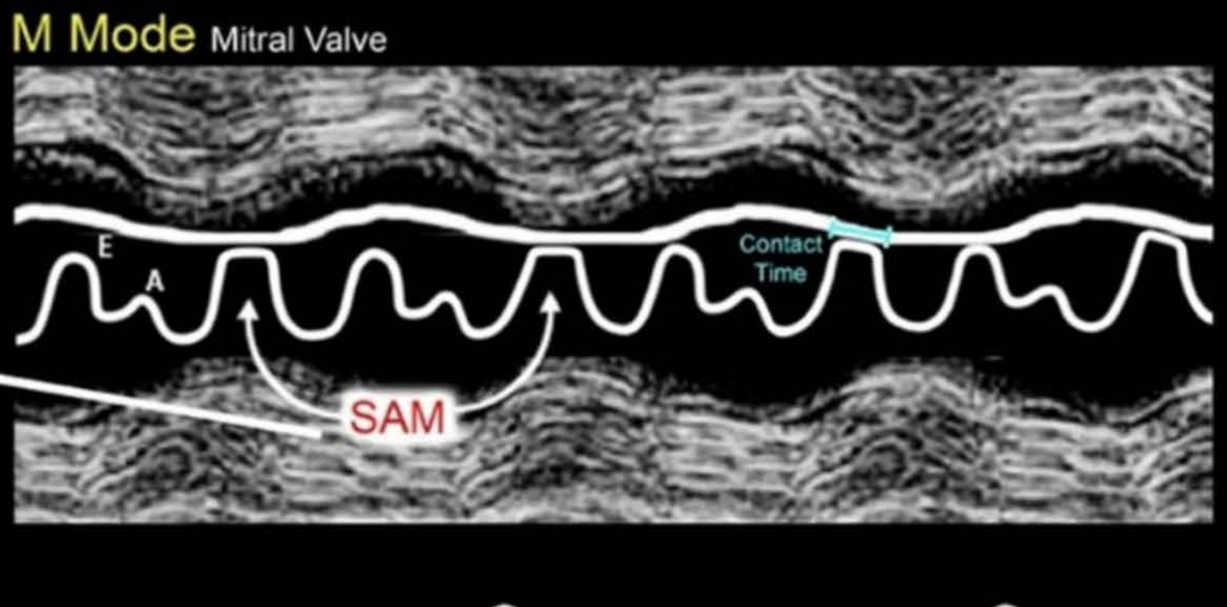
Simplified:

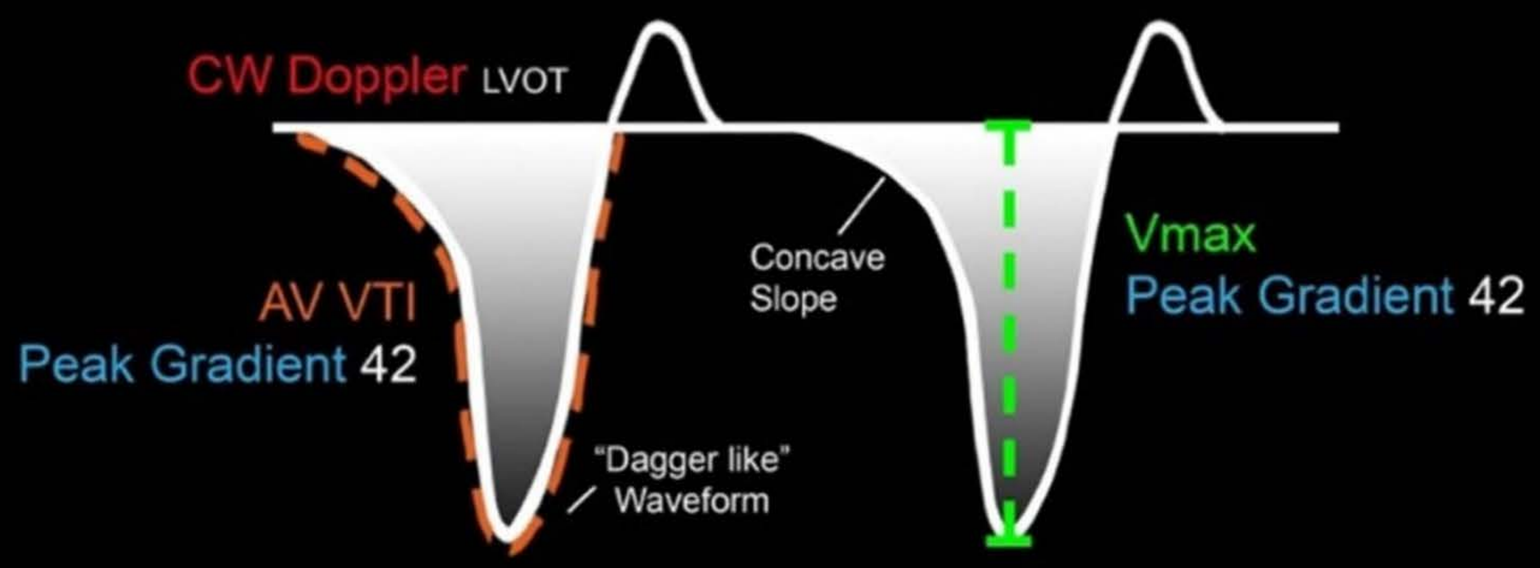
- ***Normal Function:*** Normal ECHO, Age <45yo and E>A (Mitral Inflow)
- ***Impaired Relaxation (Grade I):*** A is taller than E and the E/A ratio is <1 (Mitral Inflow)
  - Filling pressure is normal
- **Is filling pressure elevated?**
  - Perform Tissue Doppler (TDI):
    - ***Grade II:*** E/e' >10-14 (elevated)
    - ***Grade III:*** E/e' >14 (elevated)
- Abnormal Echo (LVH or reduced LVEF) and/or patient's age >65 years old
  - If you have systolic dysfunction you have diastolic dysfunction
- ***Restrictive Filling (Grade III):*** If E is twice as big as A - E/A ratio >2
  - ****One Exception:*** Young and Very Healthy Adults (Athletes) – Supernormal diastolic function (E>>A)
    - ***In early diastole:*** the LV sucks the blood into the LV and causes a very high E wave (mimicking the look of a restrictive pattern)

Hypertrophic Cardiomyopathy



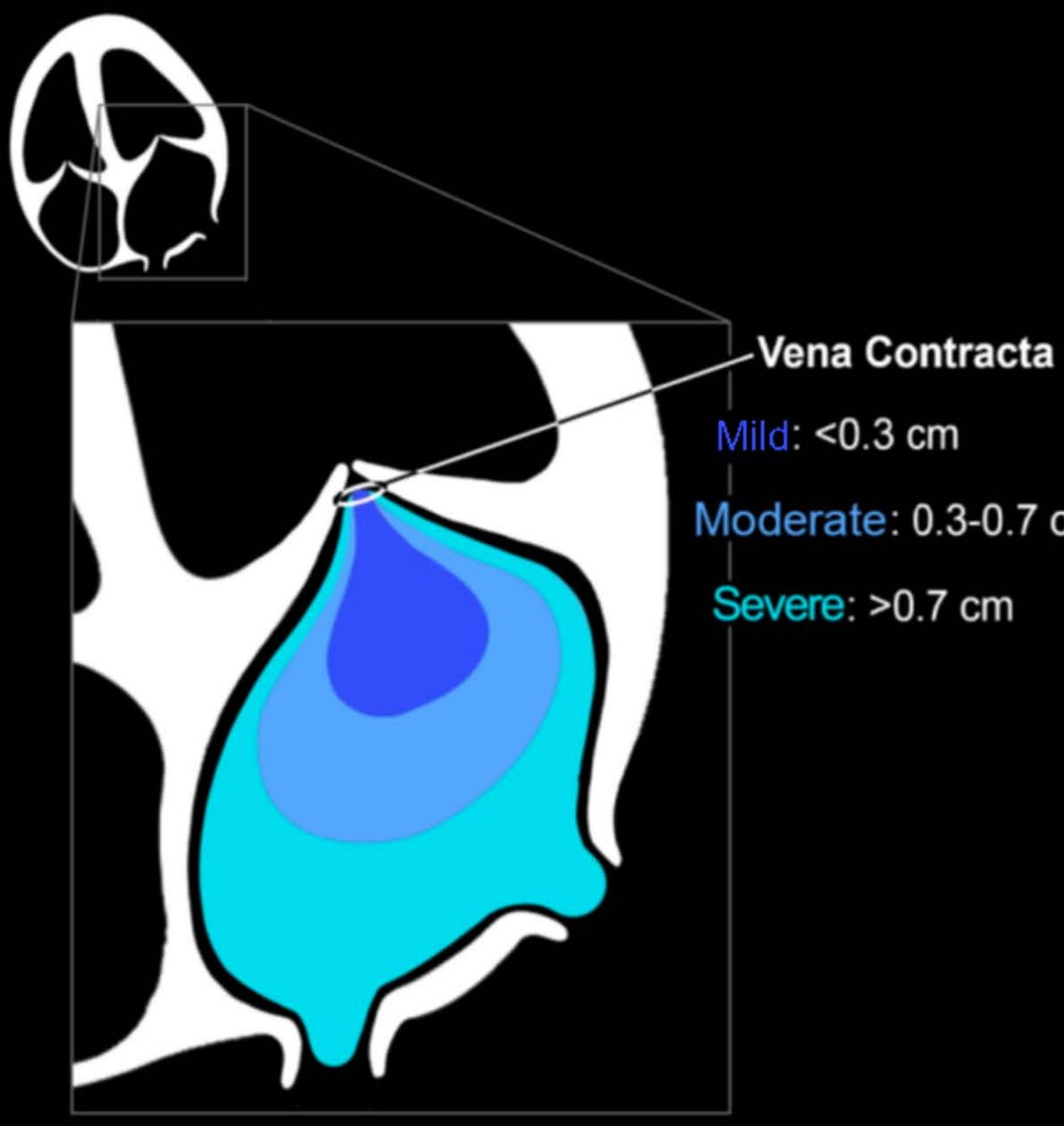
Systolic
Anterior
Motion

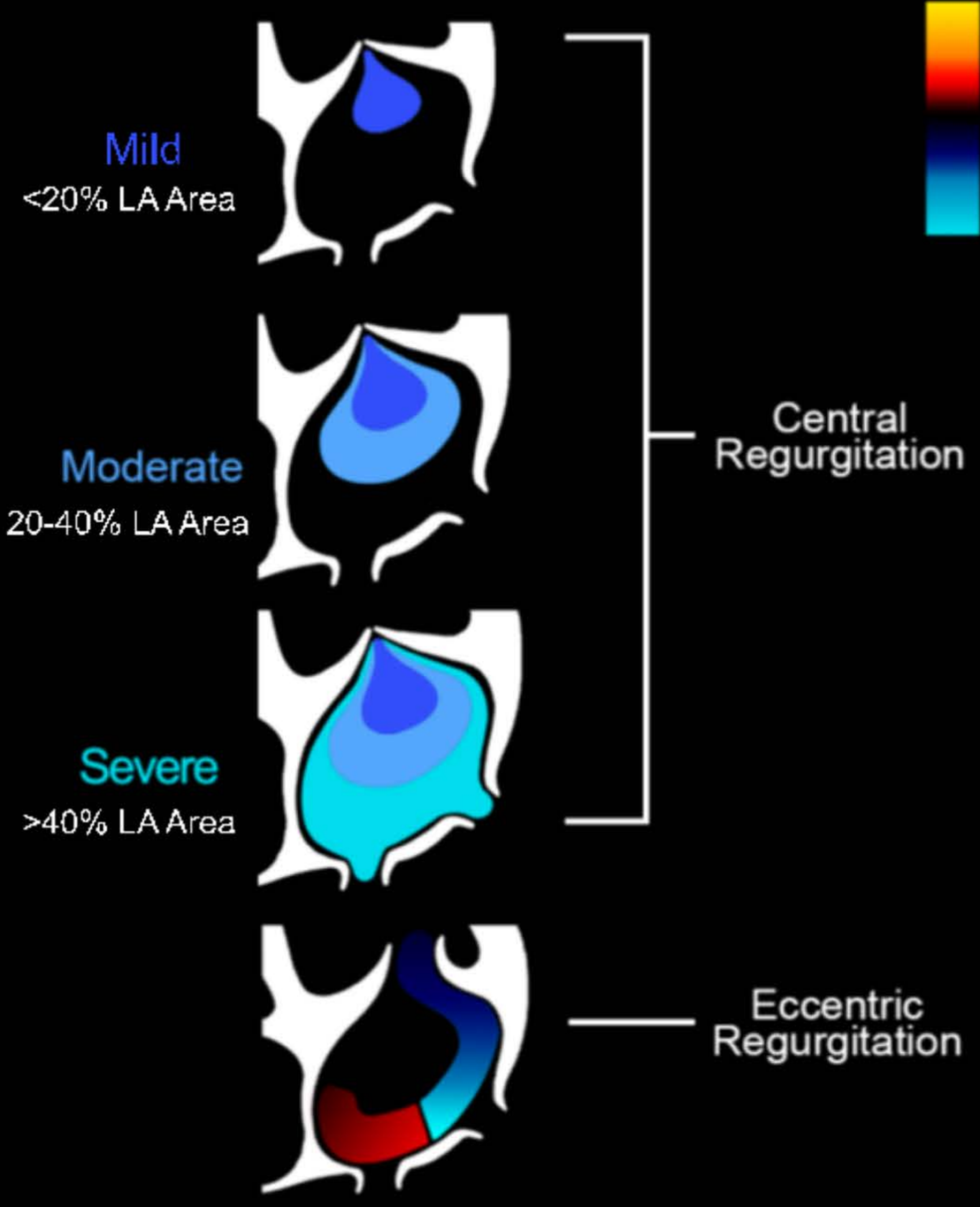




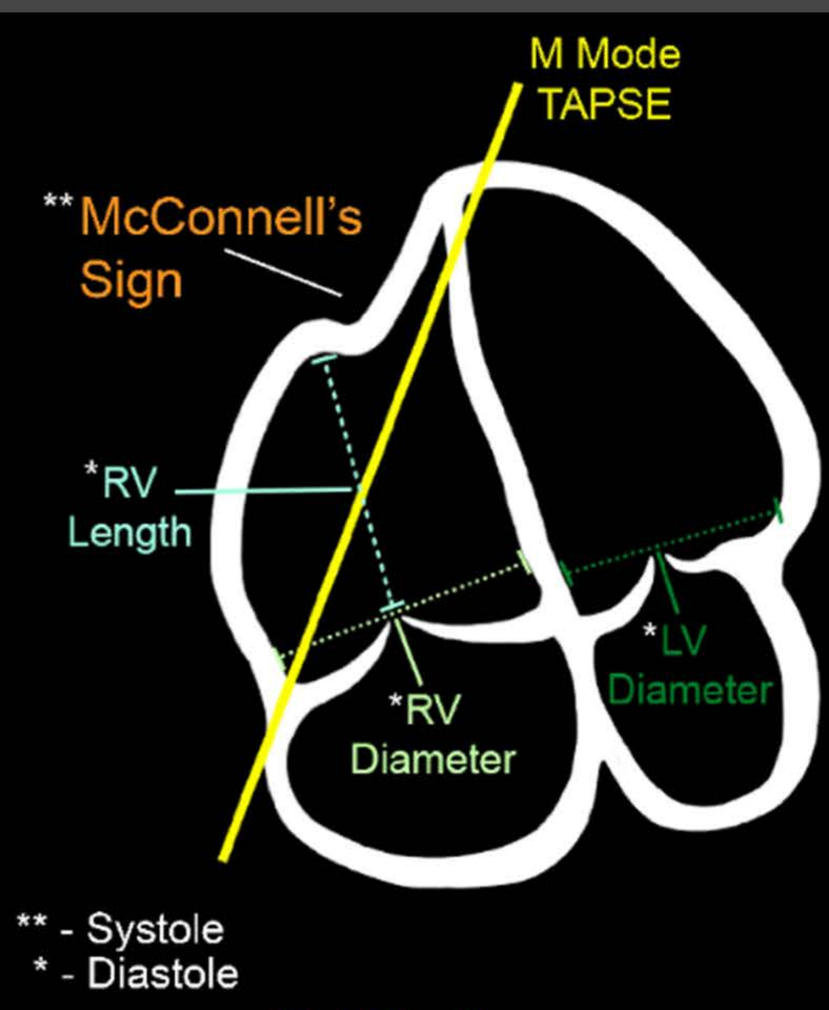
Peak Gradient (mmHg) > 30 = Abnormal
> 50 = Hemodynamically Significant

Mitral Regurgitation

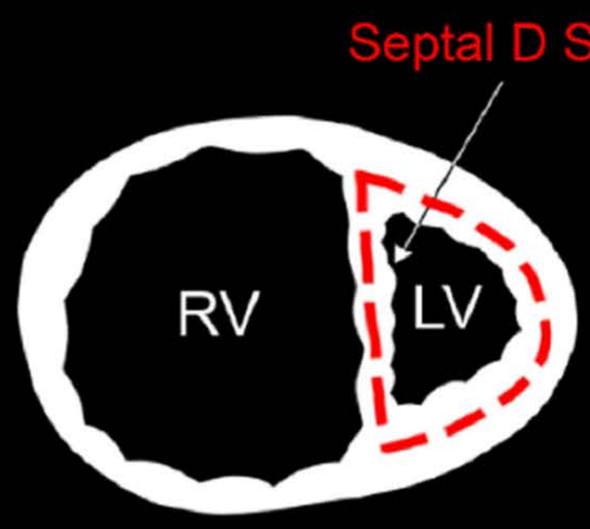


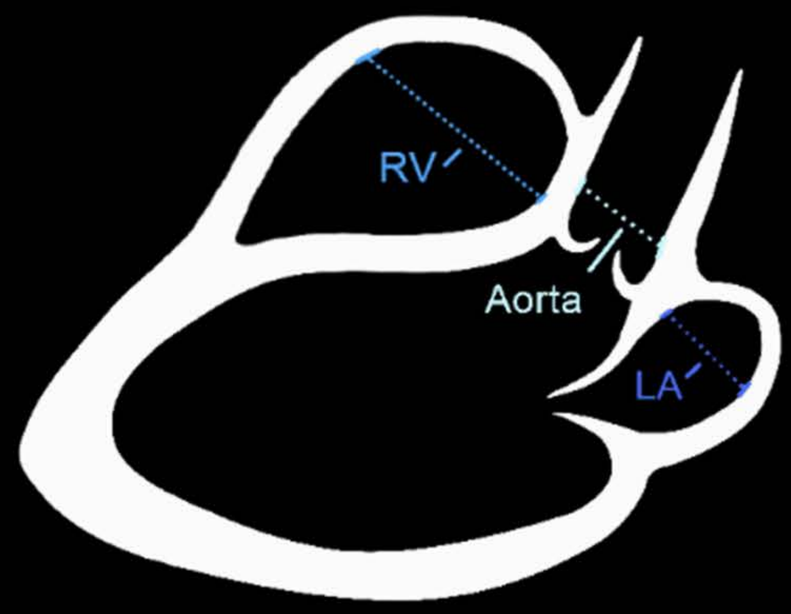


Right Heart



Right Heart Strain





RV > 3.5 cm

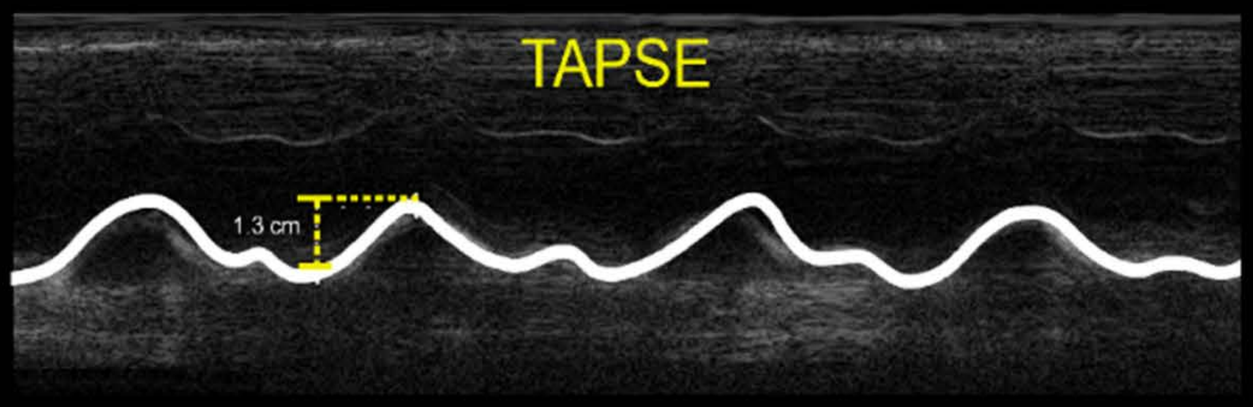
RV > LA and/or Aorta

RV Dilation

RV Diameter > 4.1 cm

RV Length > 8.3 cm

$\frac{\text{RV Diameter}}{\text{LV Diameter}} > 0.6$



RV Strain

RV Dilation

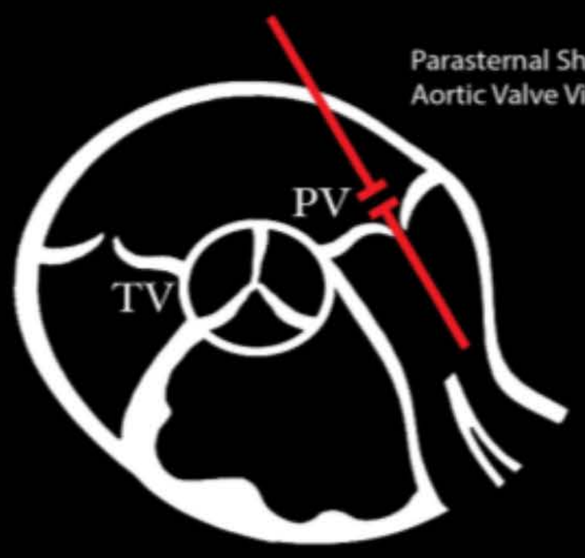
Septal D Sign

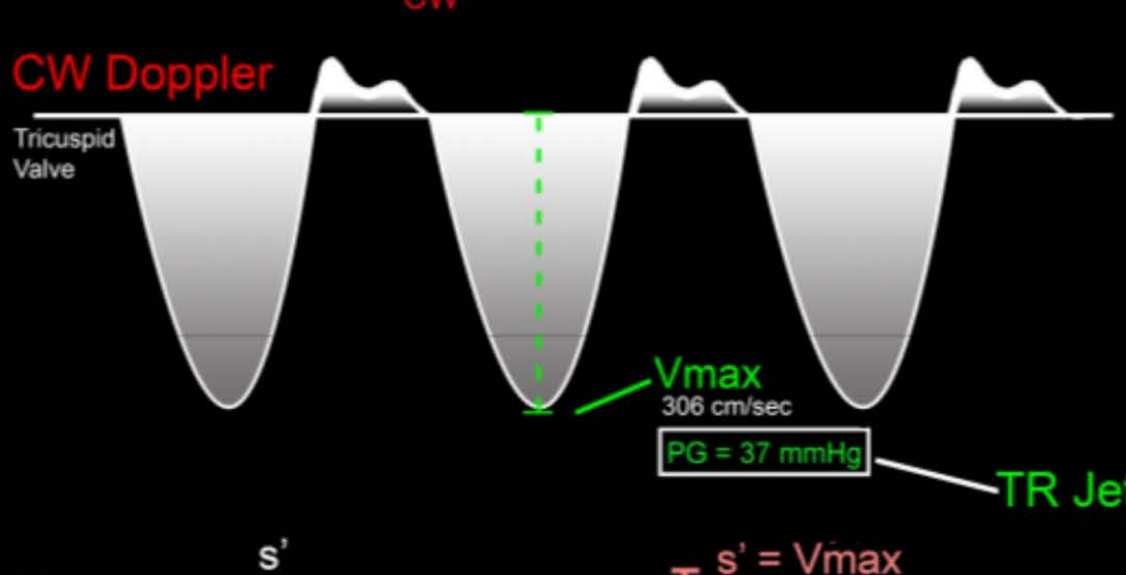
McConnell's Sign

TAPSE < 17 mm

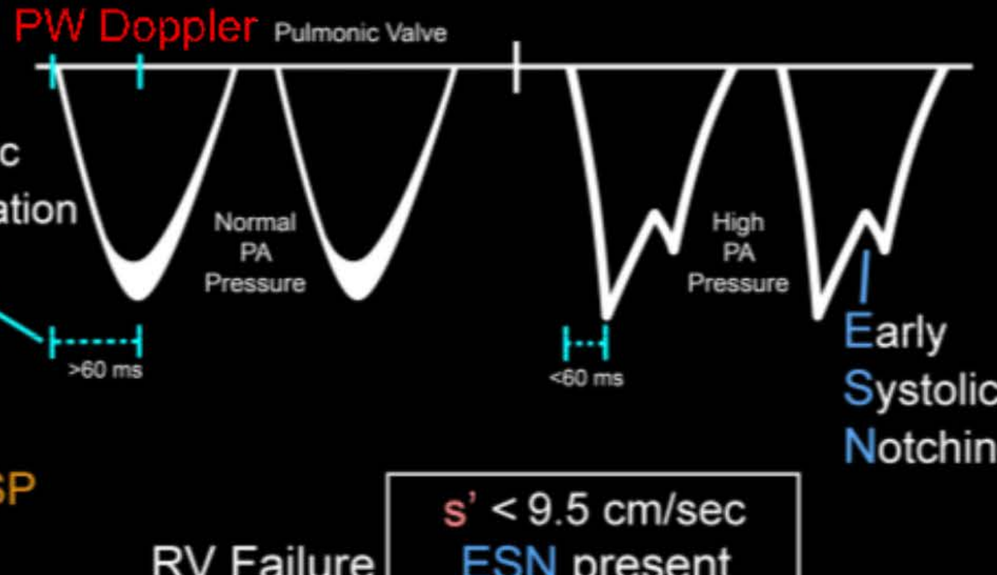
Right Heart Advanced

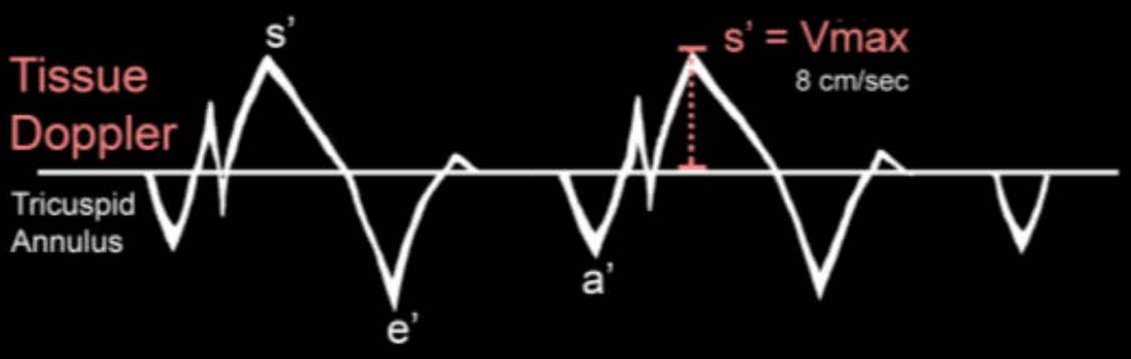
IVC Size	IVC Collapse	CVP (mmHg) *Estimated
< 2.1 cm	>50%	3 mmHg *
< 2.1 cm	<50%	8 mmHg *
> 2.1 cm	>50%	8 mmHg *
> 2.1 cm	<50%	15 mmHg *





TR Jet PG + CVP = RVSP





RV Failure

s' < 9.5 cm/sec
ESN present
TAPSE < 17 mm

Acute RV Failure 60 / 60 Sign =

RVSP < 60 mmHg and PAT < 60 ms

Rapid Ultrasound for Shock and Hypotension

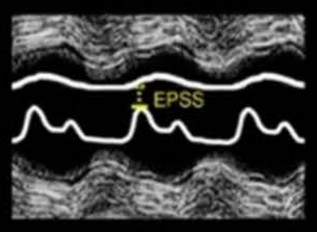
Rapid Ultrasound for Shock and Hypotension

Cardiogenic

The Pump

Reduced EF

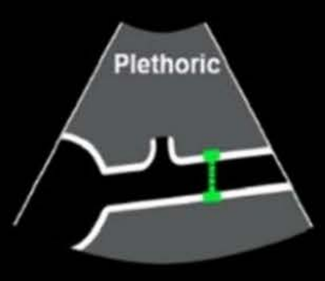
EPSS



EPSS >7mm

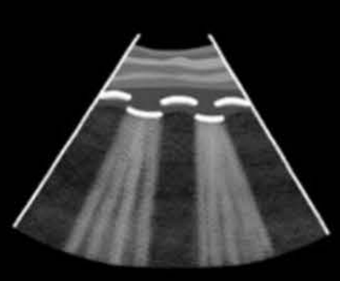
The Tank

IVC

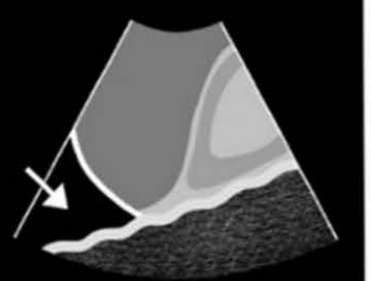


Diameter >2.1 cm
Collapse <50%

FAST



B-Lines



Pleural Effusion

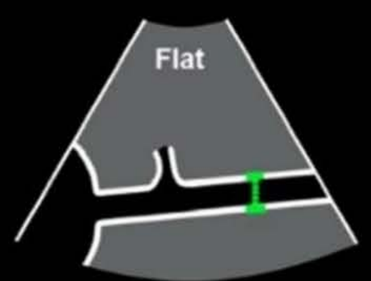
The Pipes

Hypovolemic

Hyperdynamic EF

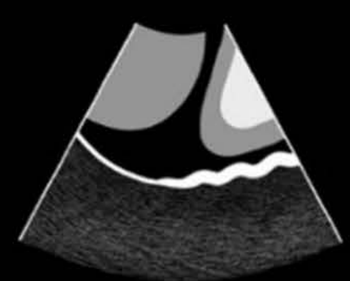
The Tank

IVC

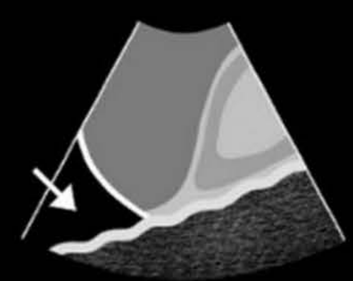


Diameter >2.1 cm
Collapse <50%

FAST



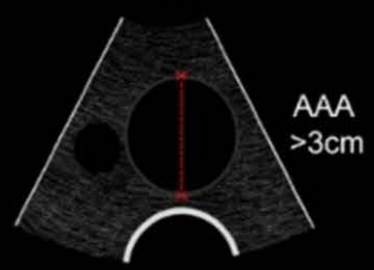
Hemoperitoneum
or Peritonitis



Hemothorax
or Empyema

The Pipes

Aorta

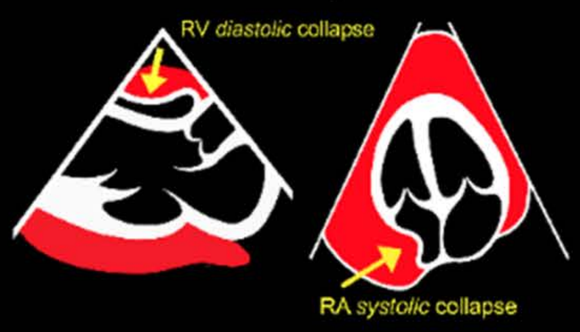


Rapid Ultrasound for Shock and Hypotension

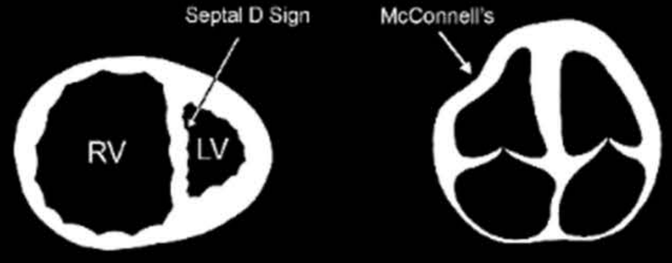
Obstructive

The Pump

Cardiac Tamponade

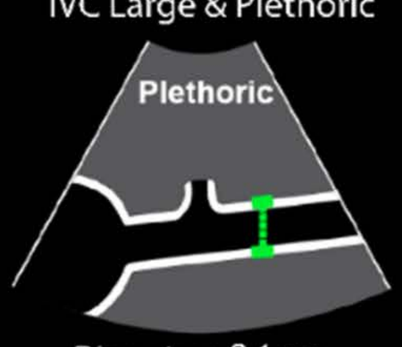


RV Strain



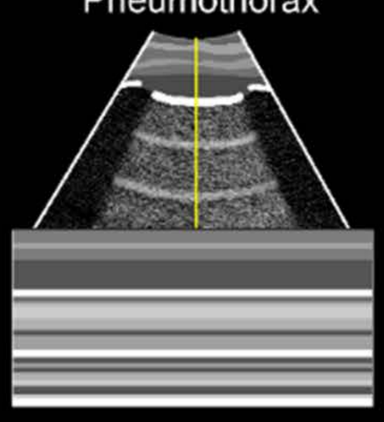
The Tank

IVC Large & Plethoric



Diameter >2.1 cm
Collapse <50%

Pneumothorax



The Pipes

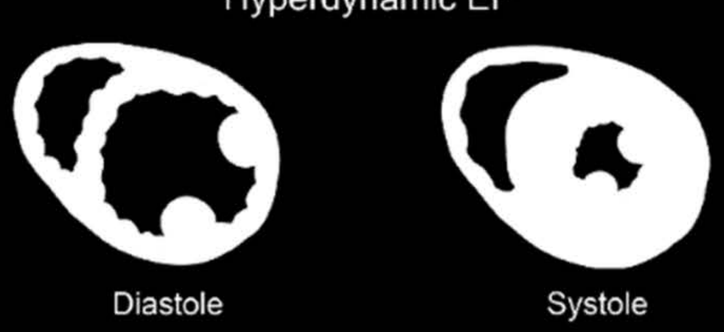
DVT

w/o compression

w/ compression

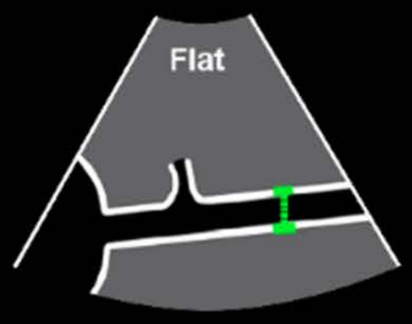
Distributive

Hyperdynamic EF



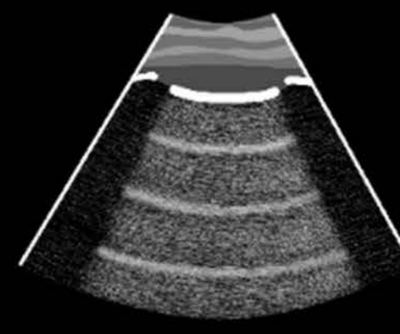
The Tank

IVC Flat & Collapsing



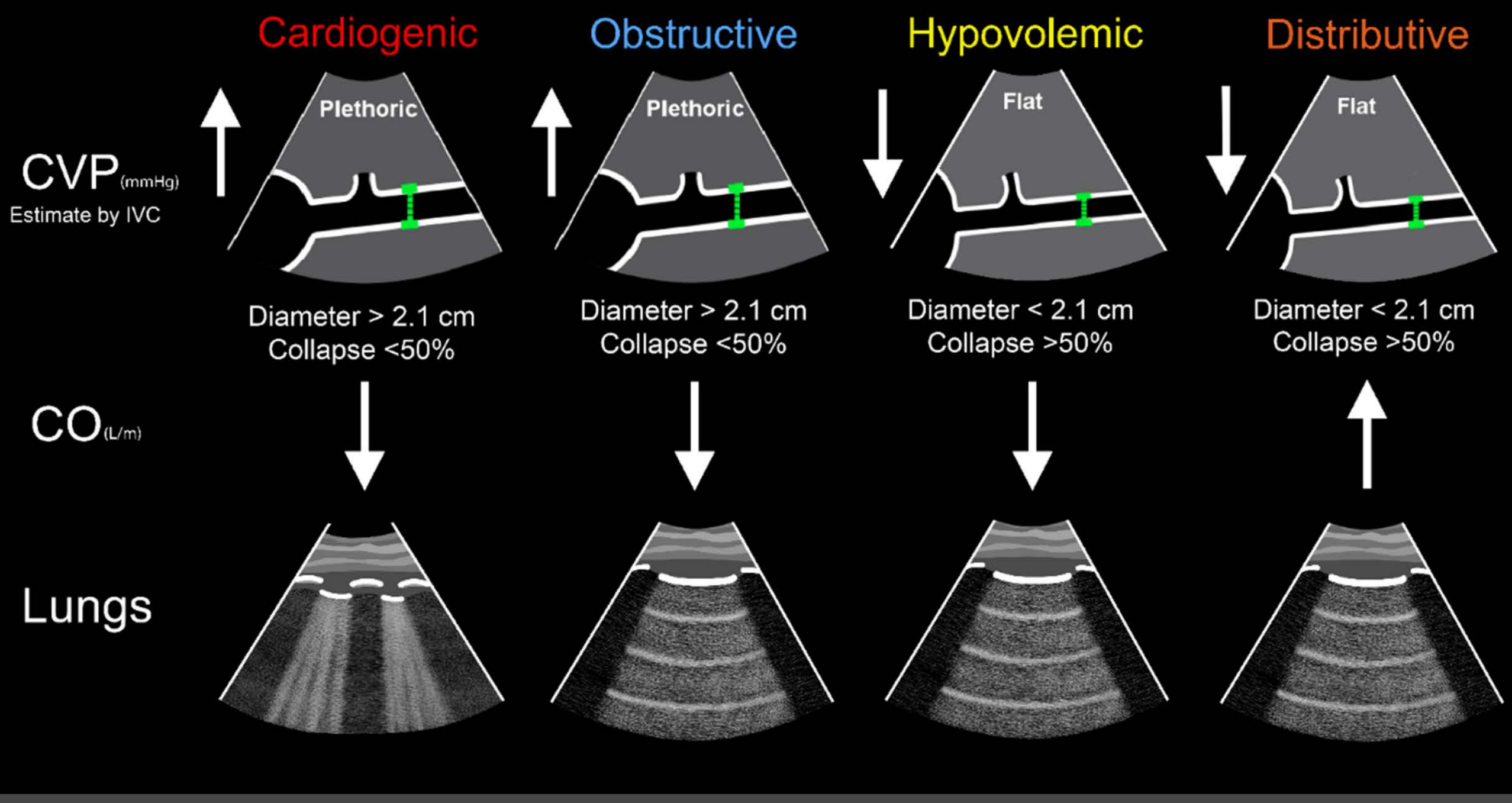
Diameter <2.1 cm
Collapse >50%

A - Lines

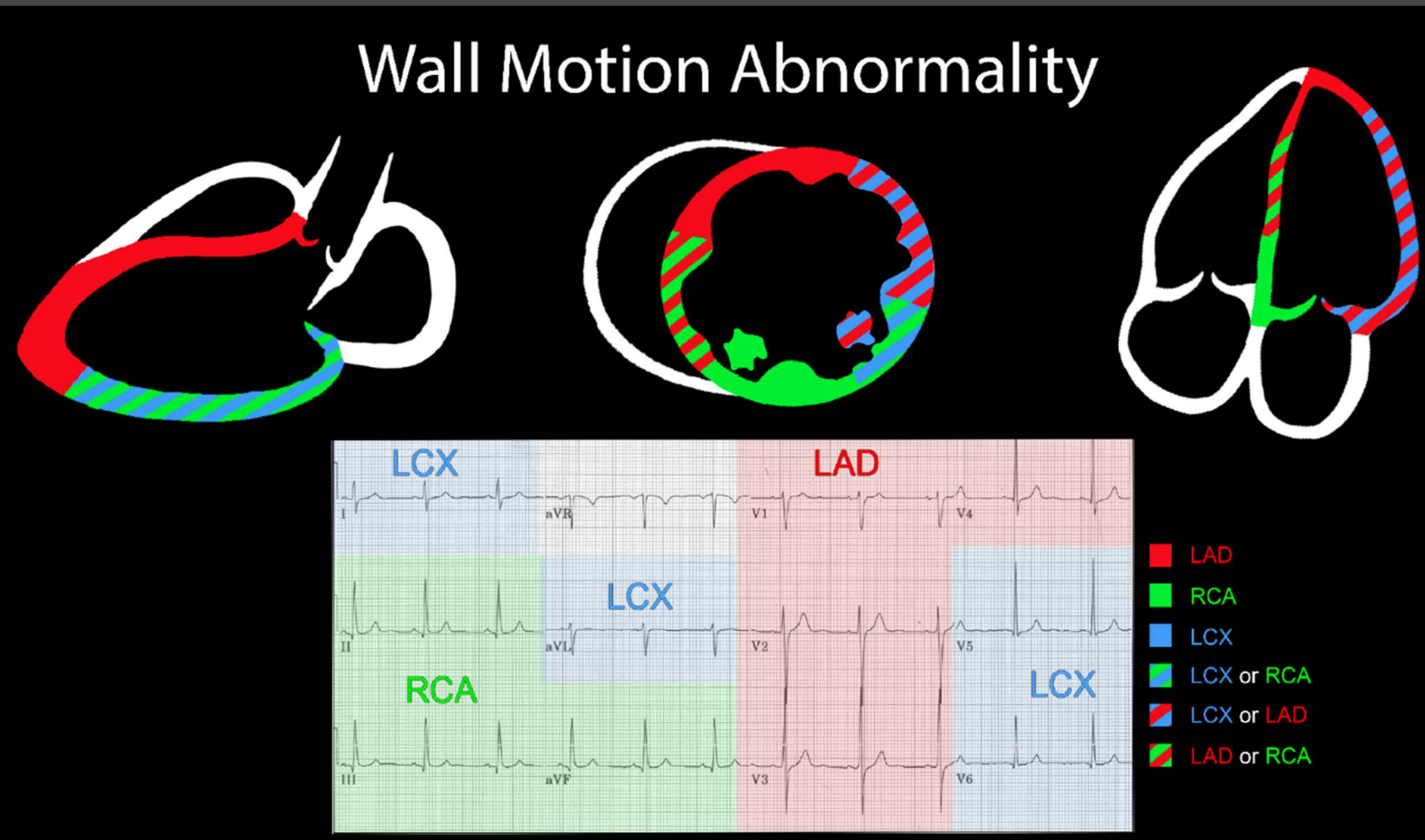


The Pipes

Shock Patterns



Wall Motion Abnormality



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American Society of Echocardiography Resources

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