The Beat Goes On... But What About the Waveforms?

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Disclosures

- No disclosures

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Objectives

- Explain how cardiopulmonary physiology affects venous return and venous Doppler waveforms.
- Analyze common cardiac conditions to predict their influence on vascular ultrasound findings.
- Identify common cardiac interventions and evaluate potential vascular complications associated with them.

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Why Do We Care?

- The Cardiac and Vascular systems are tied together as one continuous circuit
- The heart is the pump, while the vessels are the pipes that bring blood to and from the pump.
- Issues at the location of the pump, will impact the blood traveling through the vessels.

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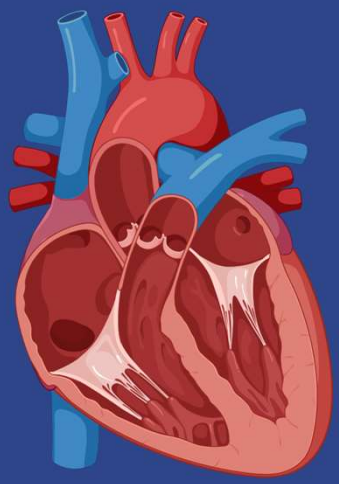
Cardiac Physiology

- Right Atrium: Low pressure to allow blood flow from the SVC and IVC
- Right Ventricle: Pushes blood to pulmonary circulation
- Left Atrium: Low pressure to allow blood flow from the pulm veins
- Left Ventricle: Pushes blood to systemic circulation



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Cardiac Physiology

Preload

- Myocardial stretch prior to systole
- Factors:
  - Atrial Kick
  - Heart Rate
  - Venous Pressure
  - Ventricular Compliance
  - Intracardiac Pressures
  - Elevated Pulmonary Pressures
  - Ventricle Function

- Afterload
- Force which the heart must work against to expel blood
- Factors:
- Systemic Pressure for LV
- Pulmonary Pressure for RV

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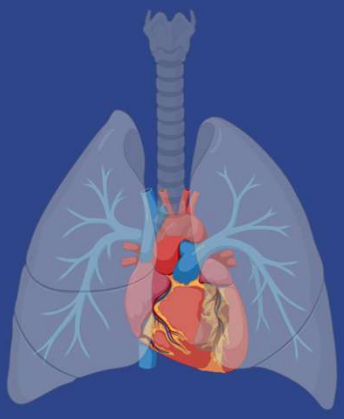
Pulmonary Physiology

- Main pulmonary artery splits into left and right branches before further dividing
- Venous return to heart through four pulmonary veins connected to the left atria
- Normal mean pulmonary artery pressure ~12 mmHg



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Primary Problem?

- We often see the effects of cardiac problems in our vascular patient population
  - Edema
- But which came first?
- Chronic venous insufficiency can be driven by cardiac origins
- But chronic venous insufficiency can cause cardiac problems

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Cardiac History

- Look for Cardiac Conditions:
- CHF
- HFpEF
- HFrEF
- AS
- AI/AR
- TR
- Pulmonary HTN

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Pulmonary Hypertension

Mean pulmonary artery pressure >25 mmHg = pulmonary arterial hypertension

Forces the right heart to work harder

- IVC, hepatic vein, and renal vein waveforms
  - Indirect pulmonary venous hypertension assessment

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Right Heart Function

- Right heart failure increases CVP due to poor function
- This decreases the blood that can return into the right side
- Eventually increases pressures at the capillaries
- Increases peripheral resistance
- Which increases the afterload

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Venous Congestion

- Venous Insufficiency
- Hypervoemia
- Backup of blood could be due to heart function
- Congestive Heart Failure = high right heart pressures
  - Visualize this as pulsatility in the venous waveform

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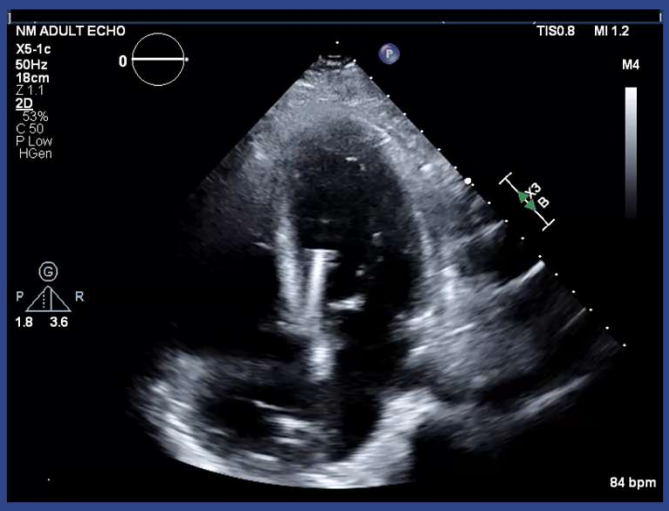
Cardiogenic Shock

- The heart is no longer functioning normally and Cardiac Output is decreased
- Common causes:
  - Iatrogenic
  - Myocardial Infarction
    - Accounts for up to 75% of all cardiogenic shock cases
  - Acute Myocarditis
  - End-stage cardiomyopathies
  - Complications from cardiopulmonary bypass



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Cardiogenic Shock

- Impacts:
  - Hypotension
  - Systemic Vasoconstriction
    - Initially helps!
    - Leads to end-organ failure eventually & makes the heart work harder
  - Cardiac Ischemia

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- Background:
- Late 30s Male
- Works hard labor
- No prior medical history & no family history
- Murmur heart during routine physical
- Asymptomatic
- Echo ordered

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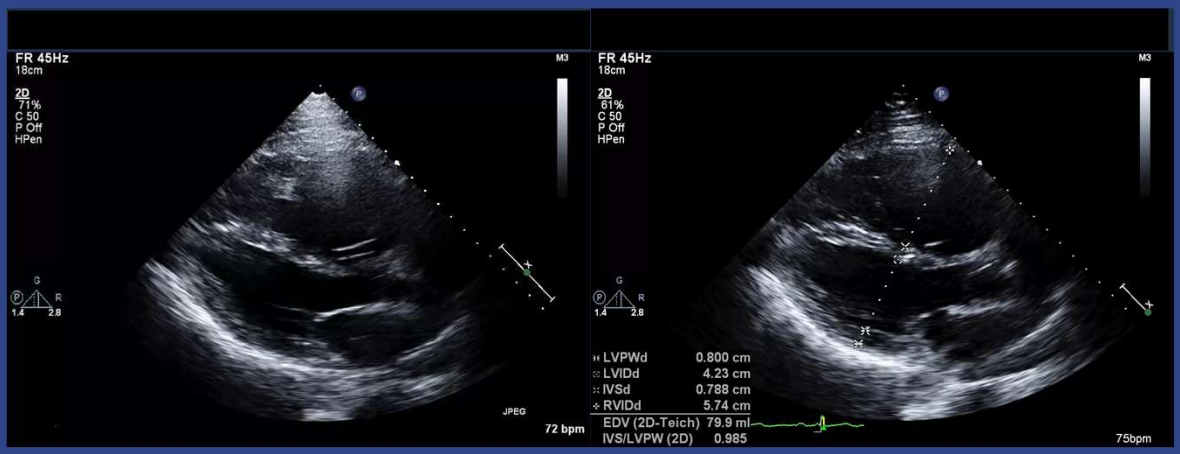
Parasternal Long Axis



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Parasternal Short Axis

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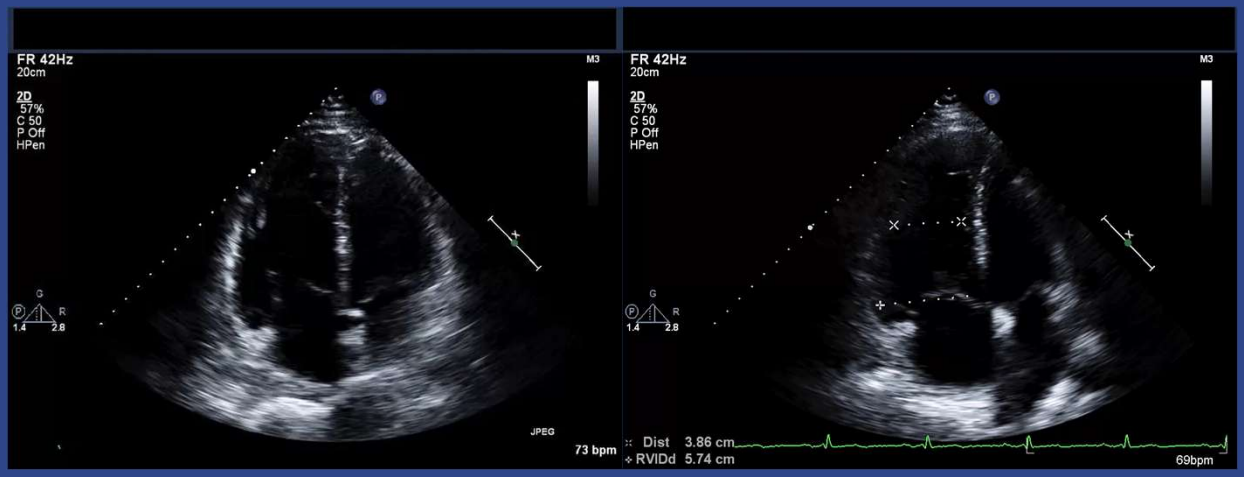
Apical 4 Chamber



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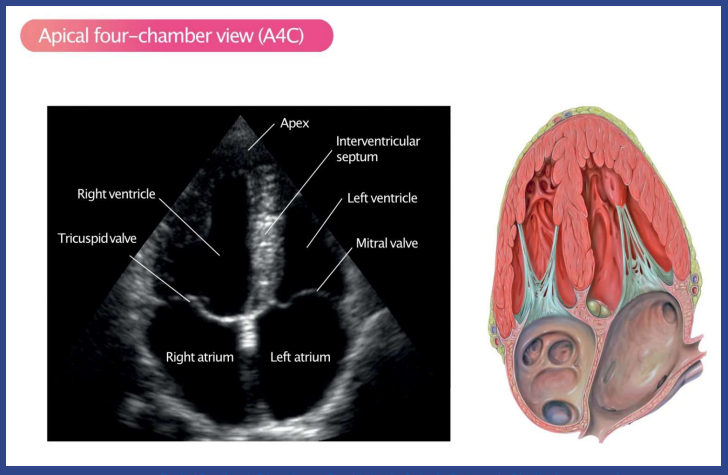
Transthoracic Echocardiogram



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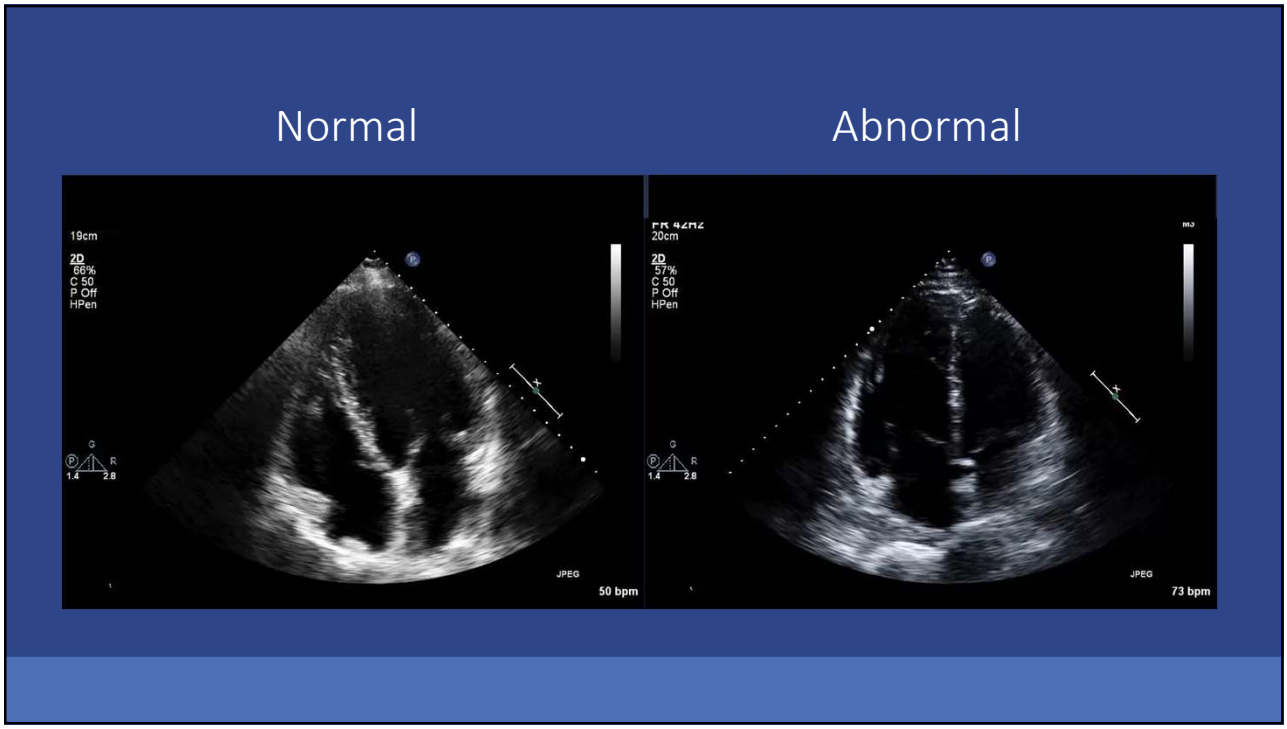

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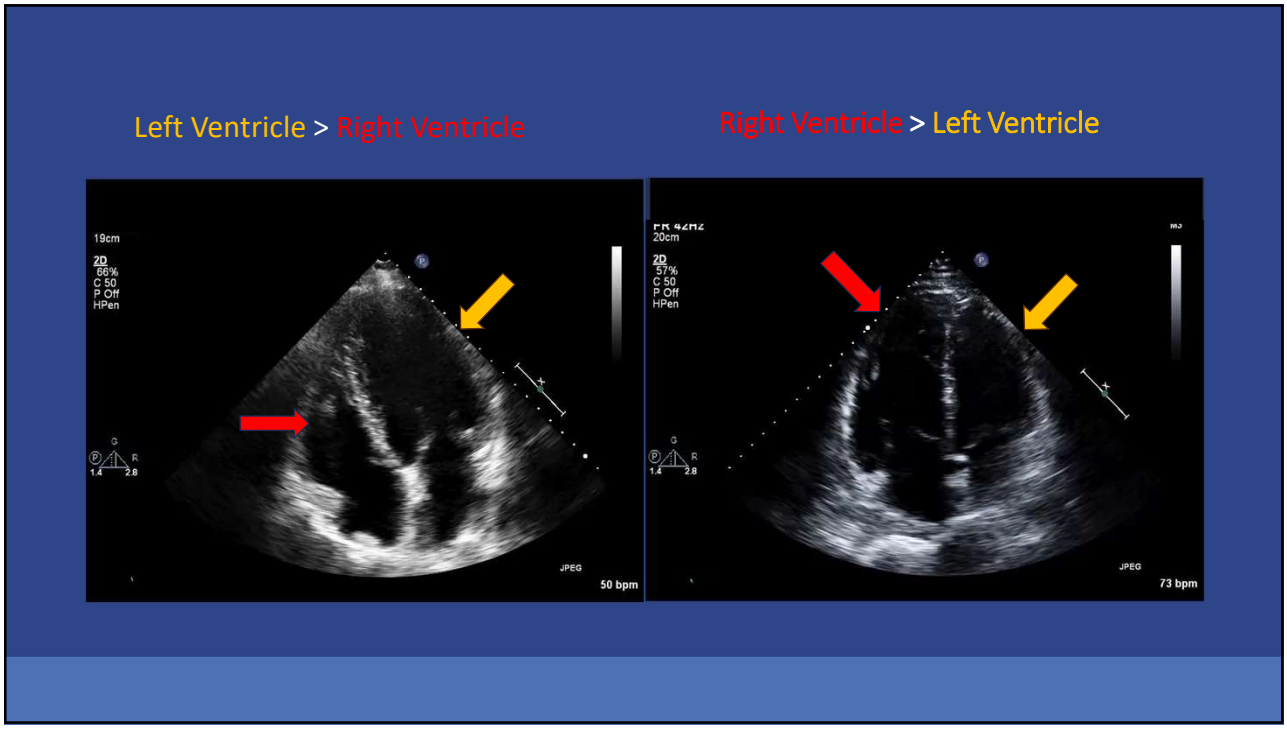

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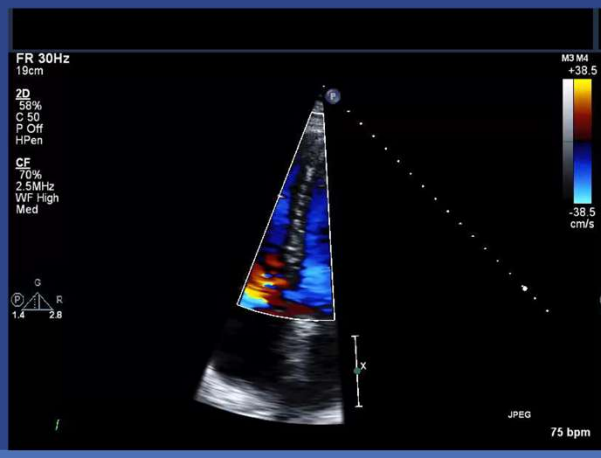
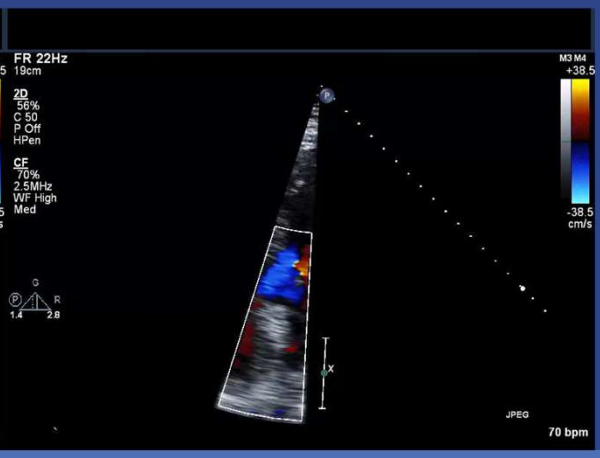
Color Doppler

Interventricular Septum



Interatrial Septum



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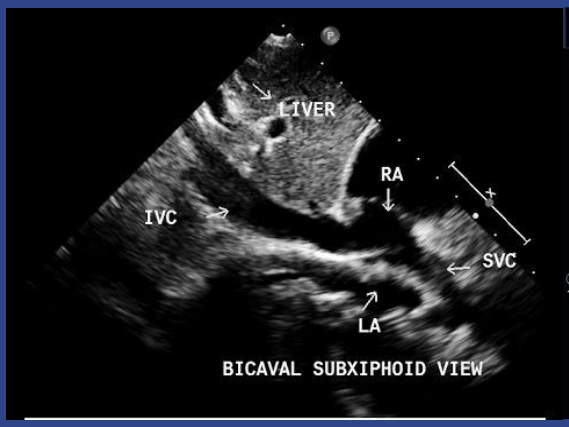
BiCaval Subxiphoid

Normal Anatomy



Still image from: Bicaval view by 2D ECHO Subxiphoid (youtube.com)

Abnormal Anatomy

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Interatrial Septum

Sinus Venosus Atrial Septal Defect (ASD)

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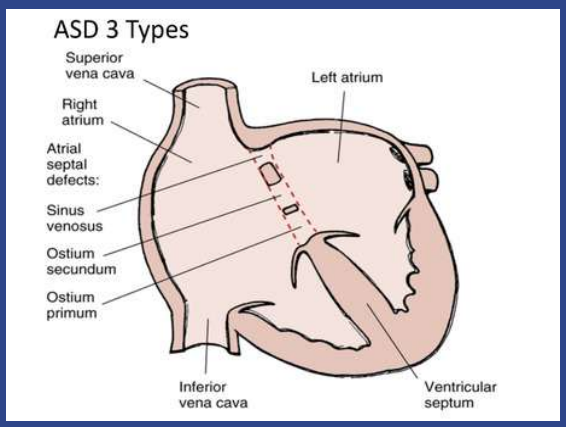
3 Main Types of ASDs



- Ostium Primum – 20% of cases
  - Occur closest to the AV valves
- Ostium Secundum – 75% of cases
  - Occur in the middle
- Sinus Venosus – 5% of cases
  - Occur at the top near the superior vena cava

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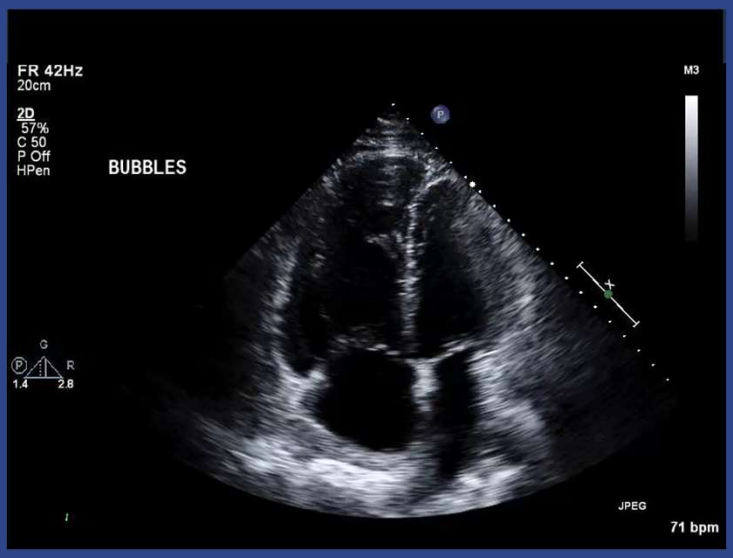
Bubble Study

9 cc of Saline
+
1 cc of Air
+
Manual Agitation
=
Microbubbles



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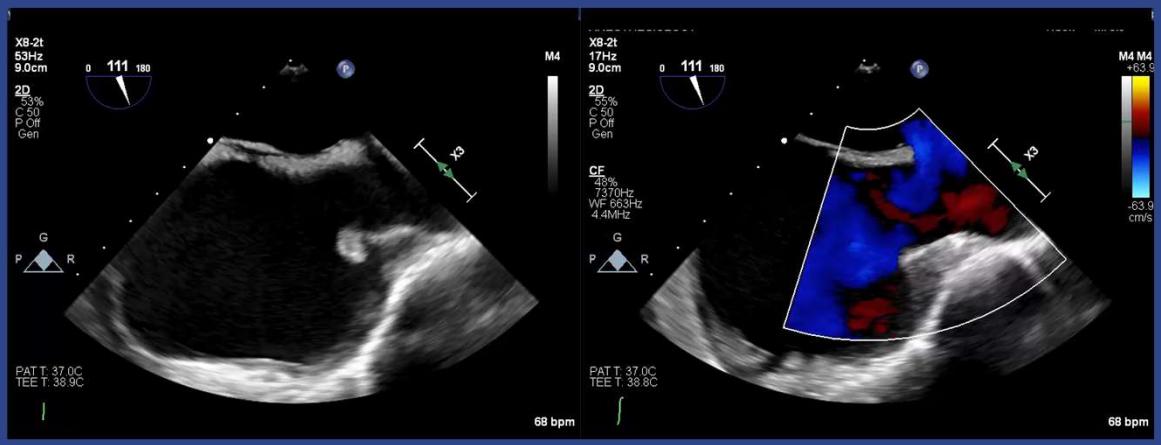
Transesophageal Echocardiogram



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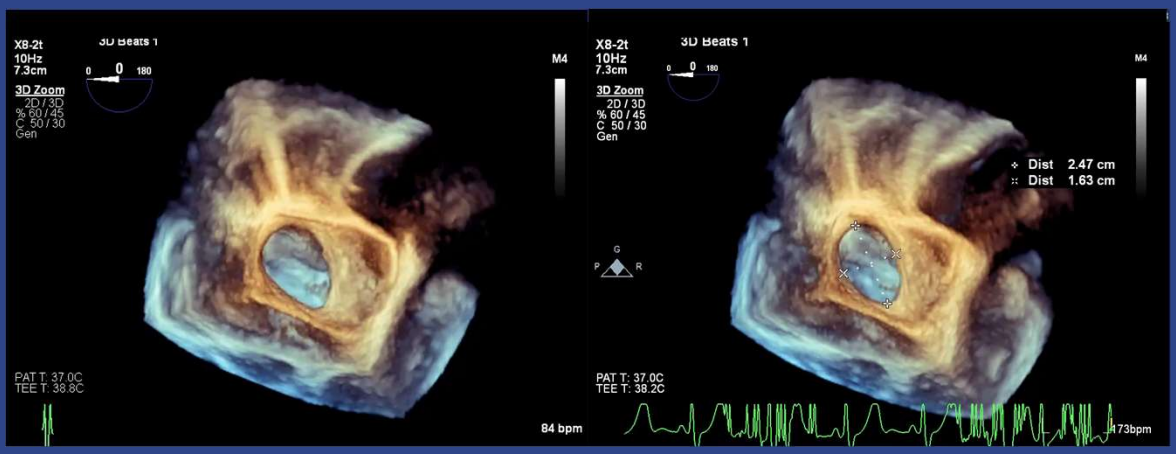
Transesophageal 3D Echocardiogram



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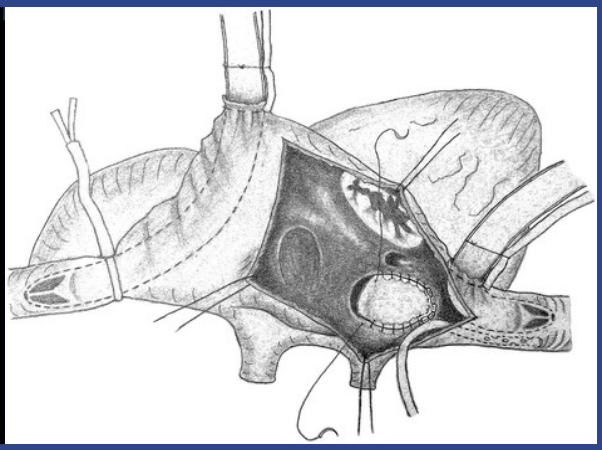
Sinus Venosus Patch Repair



Surgical repair of inferior sinus venosus defects: a novel approach with unsnared inferior vena cava | Journal of Cardiothoracic Surgery | Full Text (biomedcentral.com)

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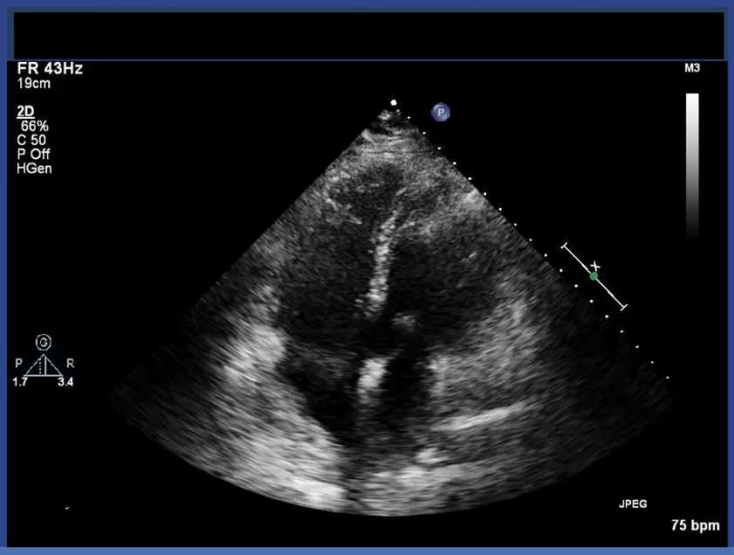
Apical 4 Chamber 1 Year Later



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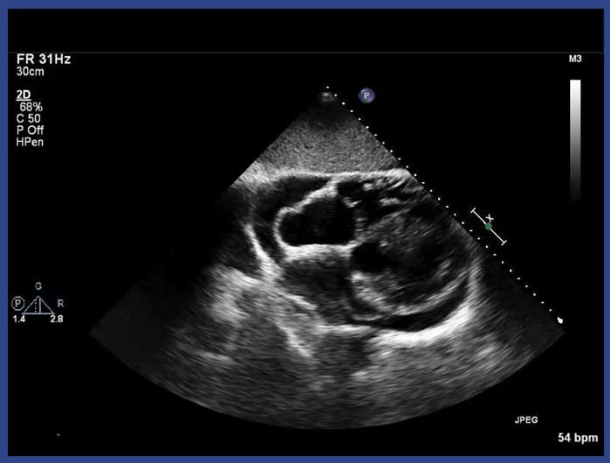
Pericardial Effusion



- Accumulation of fluid in the pericardial sac
- Causes:
  - Trauma
  - Malignancy
  - Inflammation
  - Iatrogenic
  - Infection
  - Idiopathic

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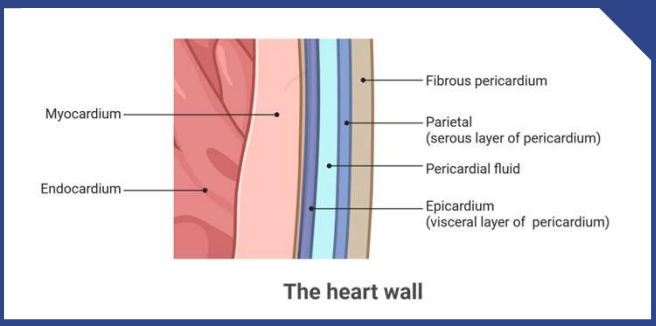
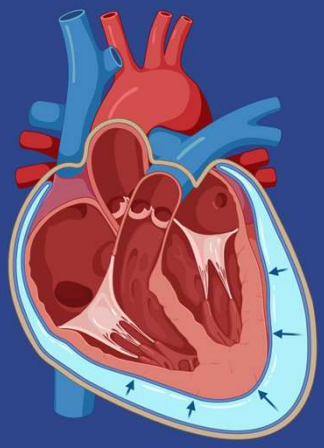
Pericardial Anatomy





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Tamponade

- **True Medical Emergency!**
- Prevents the heart from filling
- Amount of fluid matters less than the accumulation speed
  - Small amount quickly

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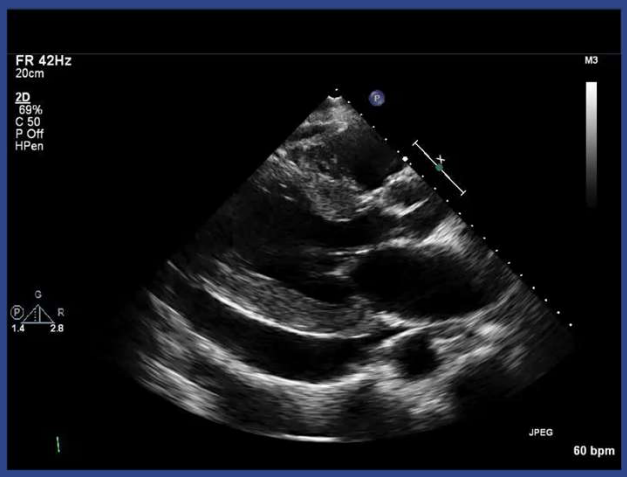
Diagnosis

- Tamponade is a Clinical Diagnosis that can be supported by ultrasound findings
- Primary Findings:
  - Hypotension
  - Pericardial Effusion
  - Inferior Vena Cava Plethora



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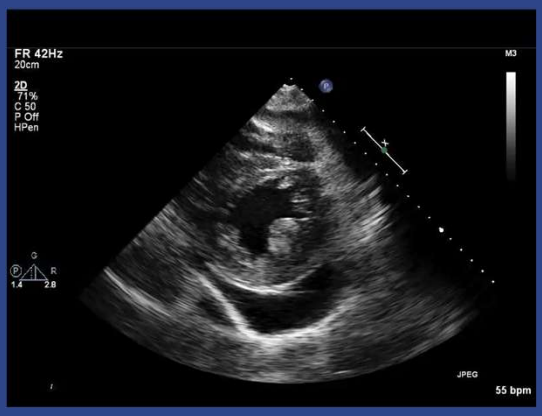
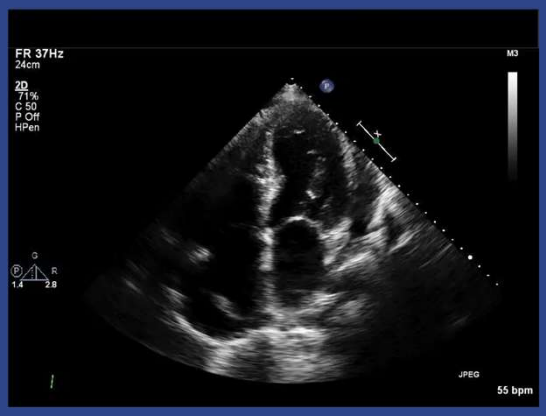
Pericardial Effusion





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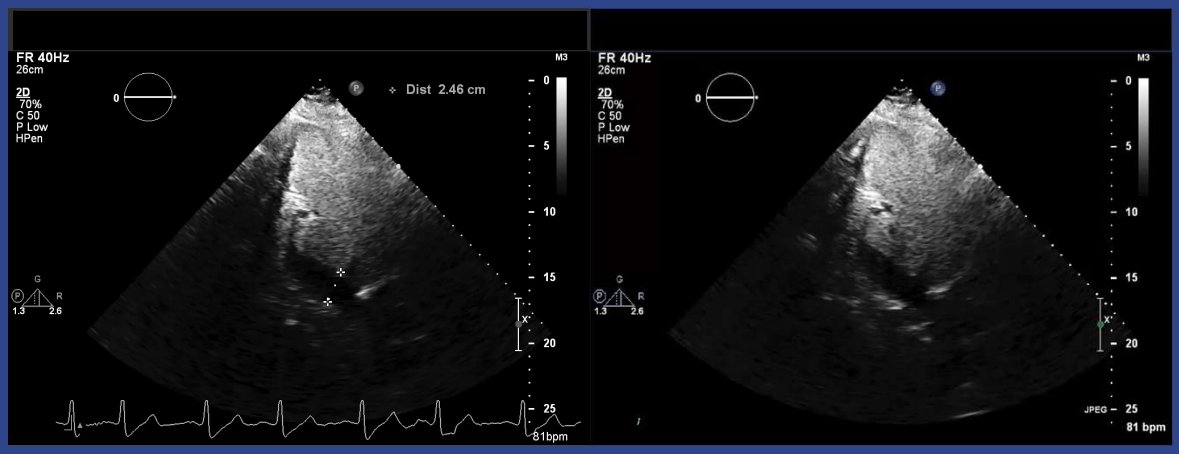
IVC Plethora



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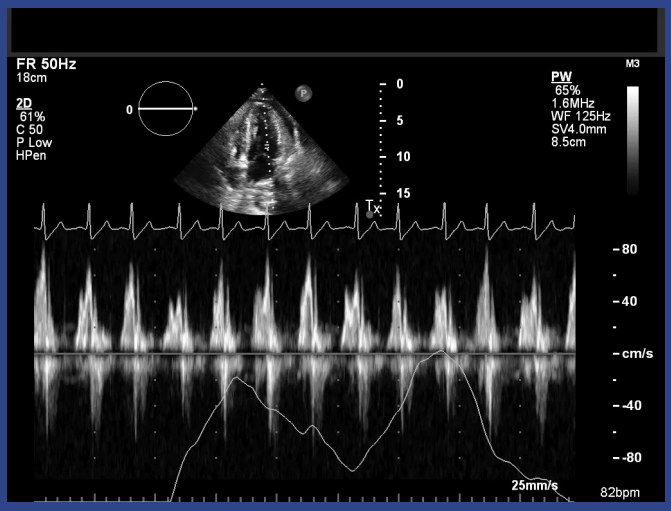
Diagnosis

- Secondary Findings:
  - Respiratory Inflow Velocity Variation >30%
  - Chamber Collapse
  - Interventricular Dependence



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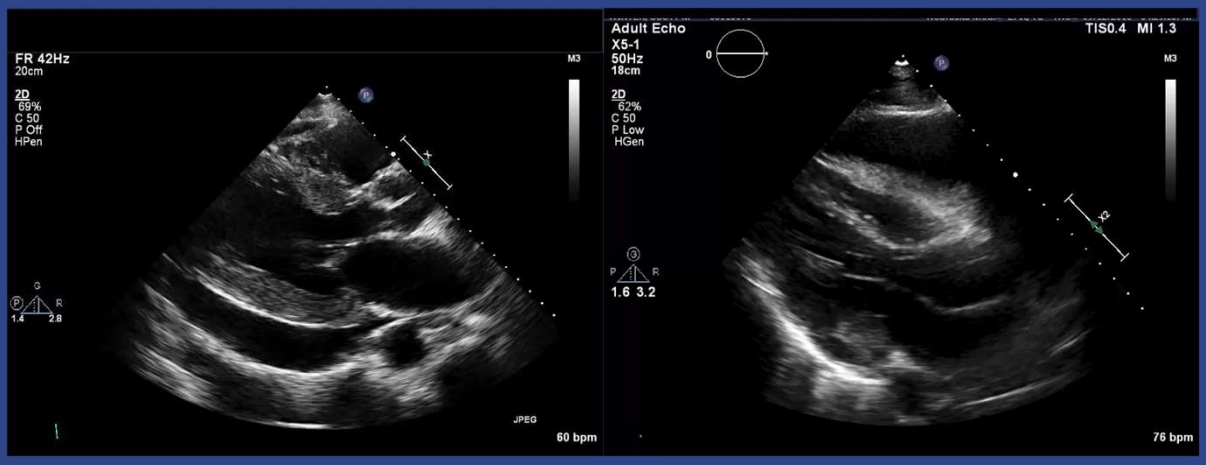
Chamber Collapse



No Tamponade

Tamponade

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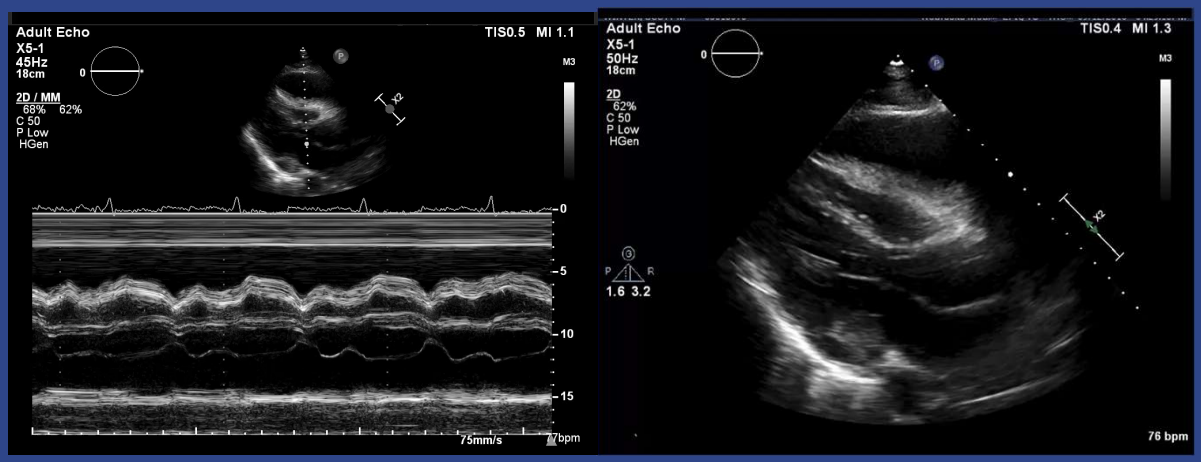
Chamber Collapse



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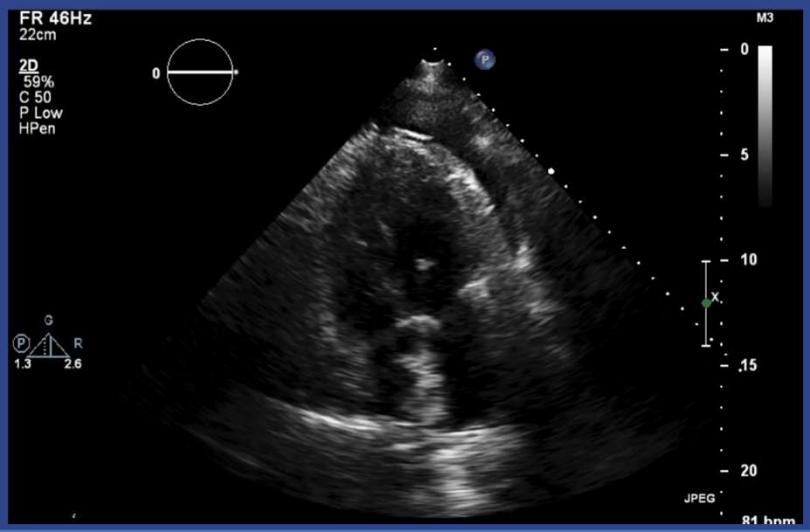
Interventricular Dependence



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“Be disciplined and careful. As one day, you'll be the last person standing between the man and his grave. ”

-Unknown

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Questions?

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