Congestive Heart Failure

Biomedical Engineering - URJC

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February 18, 2025

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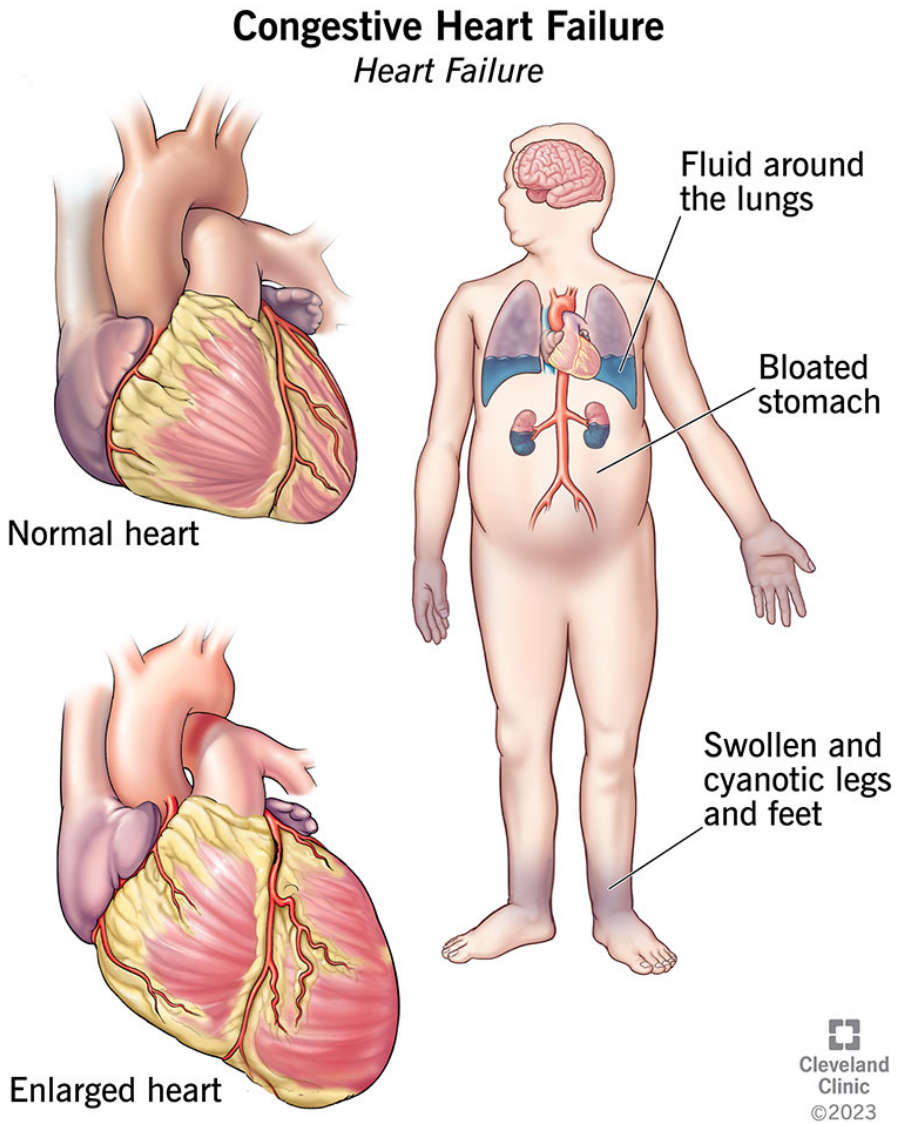
Definition of Congestive Heart Failure (CHF)

What is CHF?

Congestive heart failure is a chronic, progressive condition where the heart is unable to pump blood effectively, leading to inadequate tissue perfusion and fluid accumulation.

- A **syndrome**, not a single disease.
- Can involve the **left ventricle**, **right ventricle**, or both.
- *Congestive* refers to fluid accumulation in the lungs, abdomen, and limbs.

Congestive Heart Failure



Epidemiology of CHF

Global Burden

- Affects **26 million people** worldwide.
- Leading cause of hospitalization in individuals >**65 years old**.

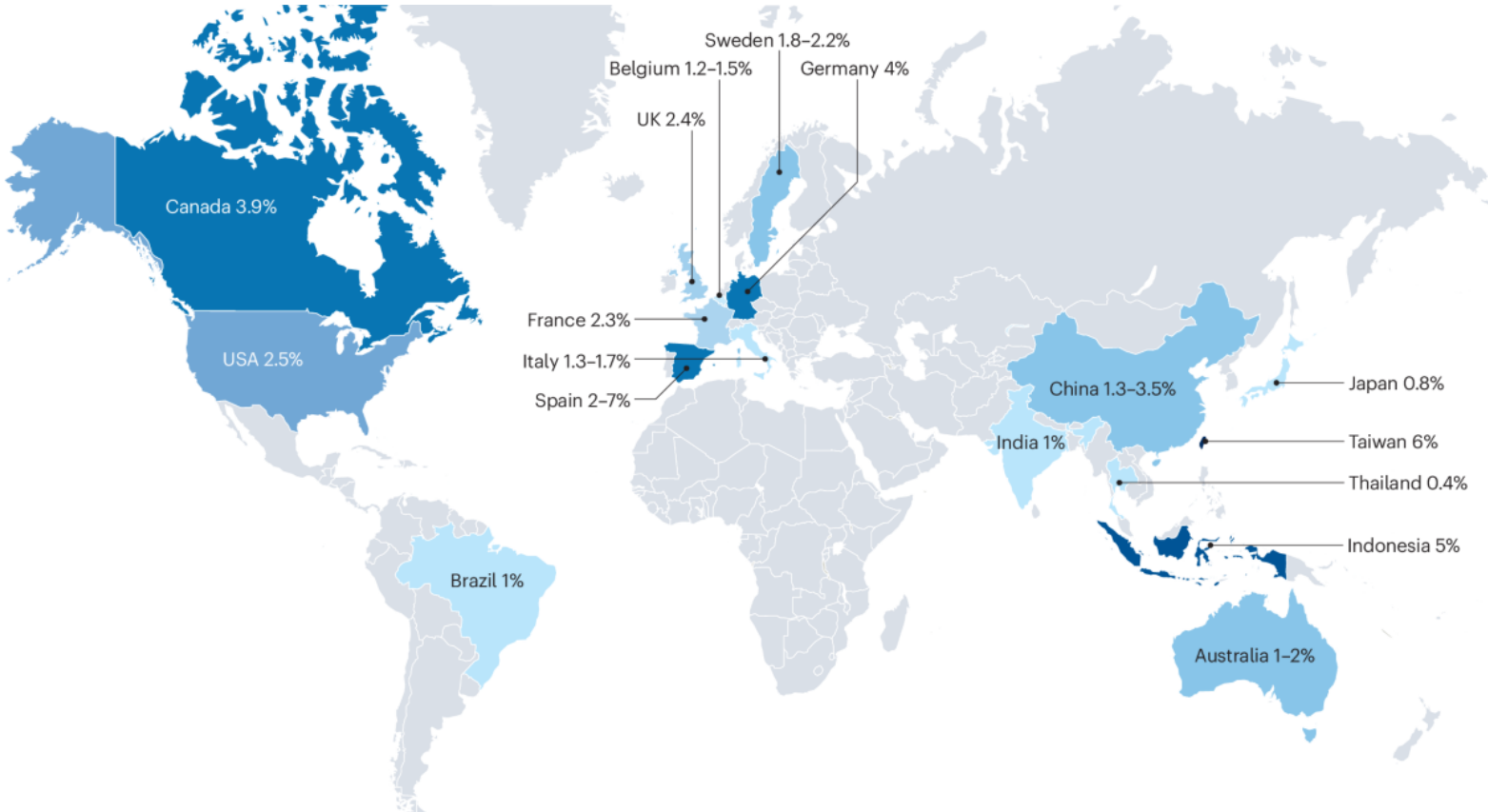
Prevalence

- 1-2% of the general population.
- $>$ 10% in individuals >**70 years old**.

Economic Impact

- Annual cost in the U.S.: **$30 billion**.
- High costs due to hospitalizations, medications, and advanced therapies.

Congestive Heart Failure



Why is CHF Important?

Clinical Significance

- **High morbidity and mortality**: 5-year survival rate is **50%**.
- Significant impact on quality of life (e.g., fatigue, dyspnea, swelling).

Public Health Challenge

- Requires a **multidisciplinary approach** for management.
- Early diagnosis and treatment can improve outcomes.

Mechanisms of CHF

Heart Failure with Reduced Ejection Fraction (HFrEF)

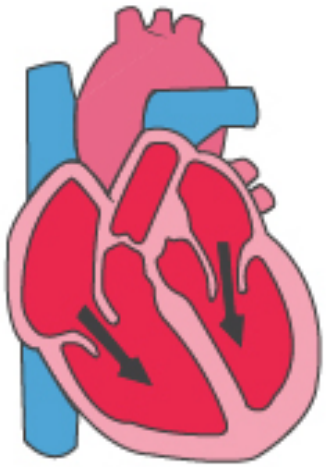
- EF $< 40\%$.
- Impaired contractility. **Inability to PUMP BLOOD forward**.
- Common causes: Ischemic heart disease, dilated cardiomyopathy.

Heart Failure with Preserved Ejection Fraction (HFpEF)

- EF $\geq 50\%$.
- Impaired relaxation and filling. **Inability to FILL**. Fluid accumulation **backward**.
- Common causes: Hypertension, left ventricular hypertrophy.

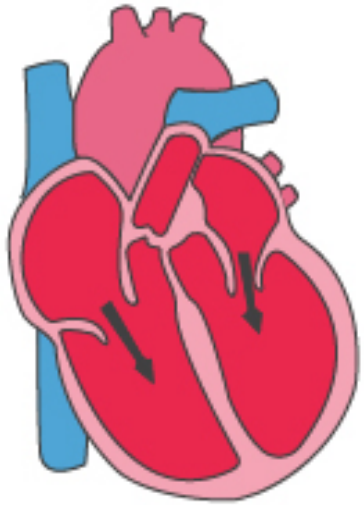
Congestive Heart Failure

Normal



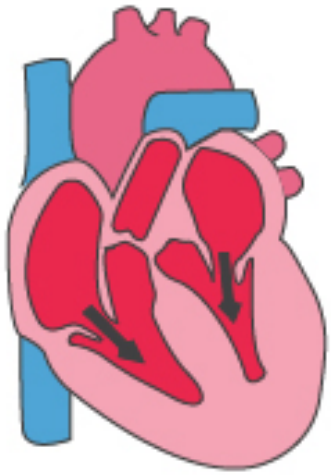
Normal filling

Systolic Dysfunction



Filling of the enlarged ventricles

Diastolic Dysfunction



Too little blood flows into the stiff ventricles.

Compensatory Mechanisms in CHF

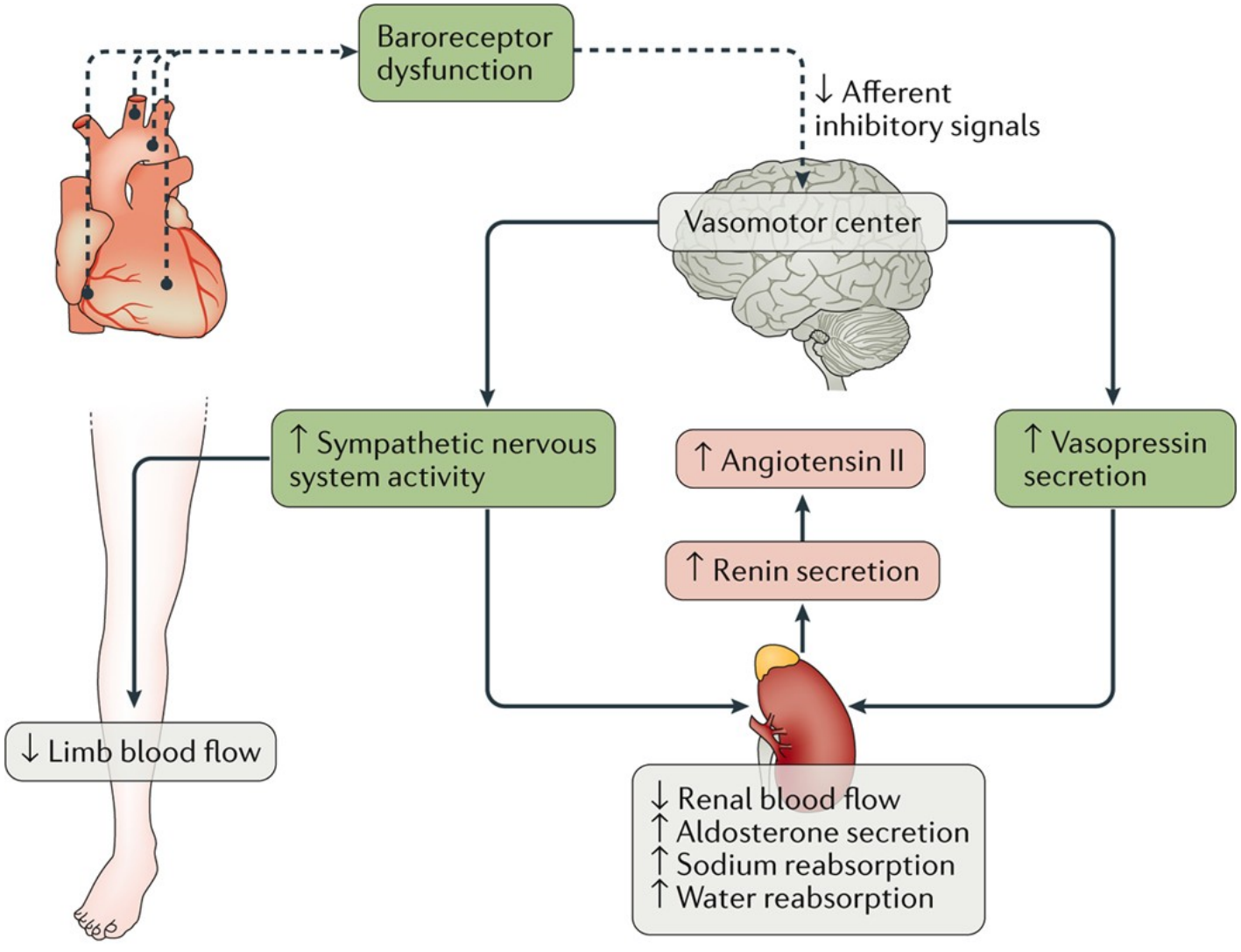
Compensatory Mechanisms in CHF

- Sympathetic Nervous System (SNS)
- Renin-Angiotensin-Aldosterone System (RAAS)
- Natriuretic Peptides promote vasodilation and diuresis
- Increasing heart rate and contractility.

Downsides of these mechanisms

- They cause vasoconstriction and fluid retention.
- They promote fibrosis and **remodeling**.

Congestive Heart Failure



Ventricular Remodeling

Key Changes

- Myocyte hypertrophy.
- Fibrosis.
- Chambers dilation = reduced contractility
- Dysfunction of chambers = inability to pump forward

Consequences

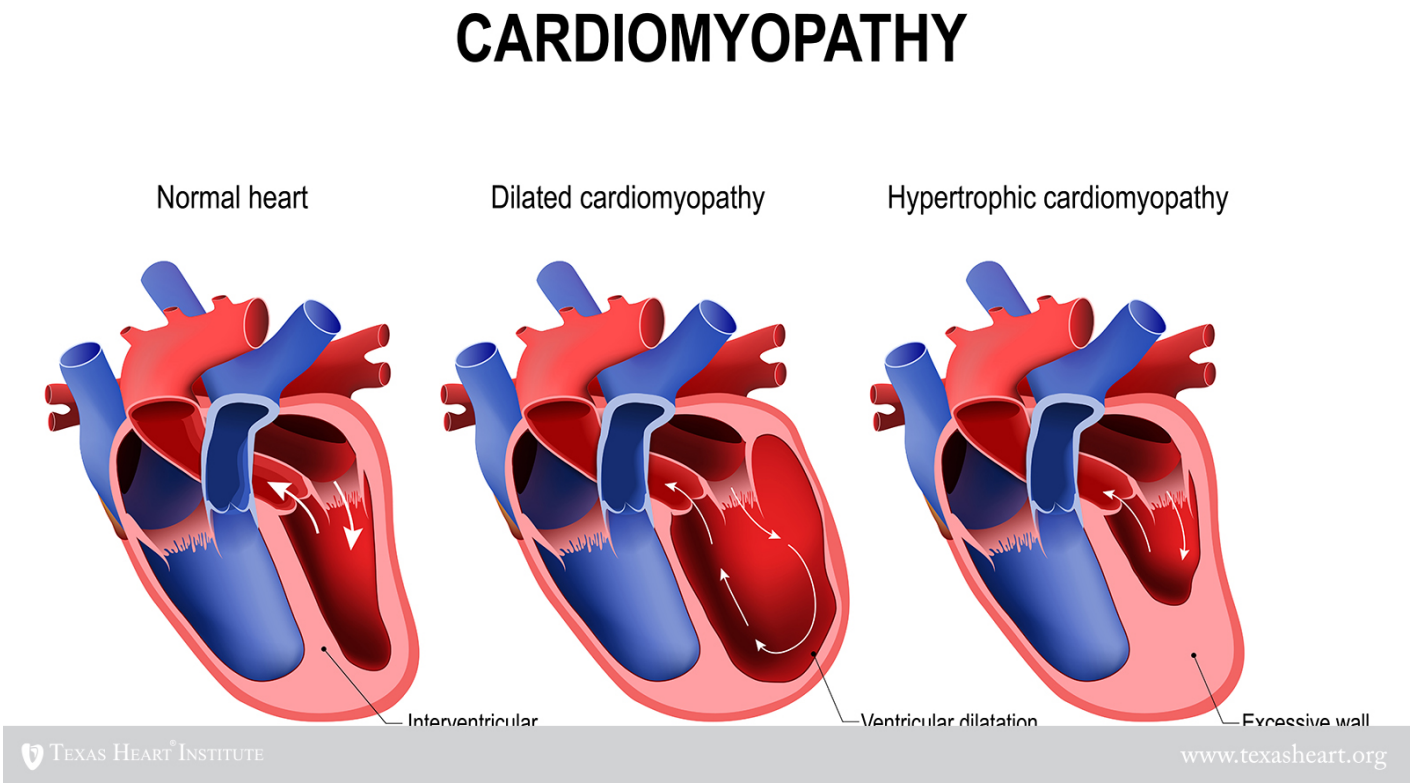
- Worsening contractility and relaxation.
- Increased risk of arrhythmias.

Clinical Presentation of Heart Failure

Key Concepts

- CHF results from **fluid overload** (causing fluid accumulation) and **reduced cardiac output** (causing inadequate perfusion).
- Symptoms and signs reflect these two pathophysiological processes.

Congestive Heart Failure



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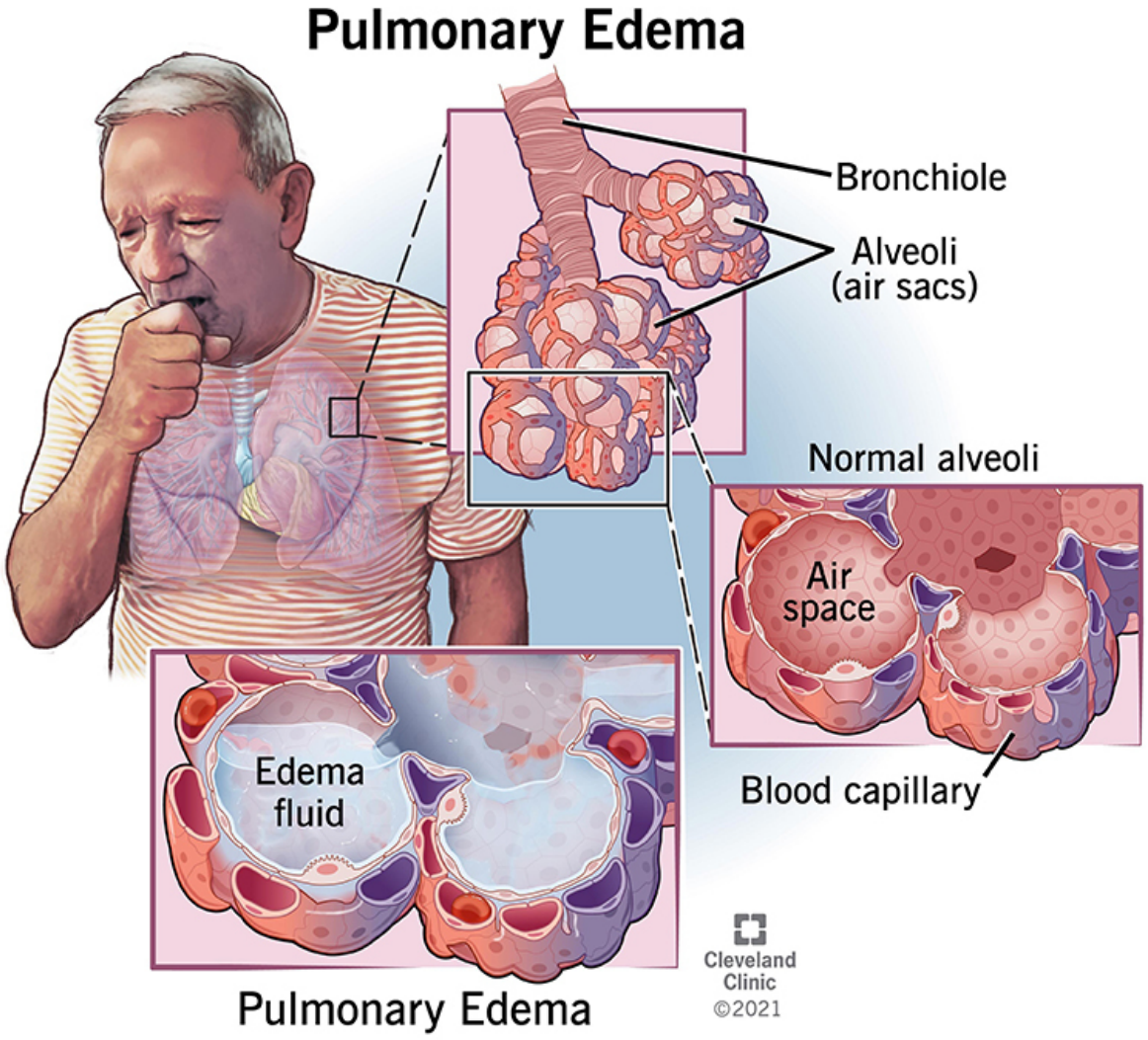

Symptoms of Heart Failure

Dyspnea (Shortness of Breath)

- **Exertional Dyspnea**: Difficulty breathing during physical activity.
- **Orthopnea**: Shortness of breath when lying flat, relieved by sitting up.
- **Paroxysmal Nocturnal Dyspnea (PND)**: Sudden episodes of severe dyspnea at night.

Symptoms of Heart Failure

Fatigue and Weakness

- Due to reduced cardiac output and poor perfusion of skeletal muscles.
- Limits daily activities.

Fluid Retention and Edema

- **Peripheral Edema**: Swelling in legs, ankles, and feet.
- **Ascites**: Fluid accumulation in the abdomen.
- **Weight Gain**: Rapid weight gain due to fluid retention.

Signs of Heart Failure

Pulmonary Signs

- **Crackles/Rales**: Heard on lung auscultation, indicating fluid in alveoli.

Cardiac Signs

- **Elevated Jugular Venous Pressure (JVP)**: Reflects increased right atrial pressure.
- **S3 Gallop**: A third heart sound heard in early diastole, indicative of volume overload.

Signs of Heart Failure

Peripheral Signs

- **Pitting Edema**: Swelling in lower extremities that leaves an indentation.
- **Hepatomegaly**: Enlarged liver due to venous congestion.

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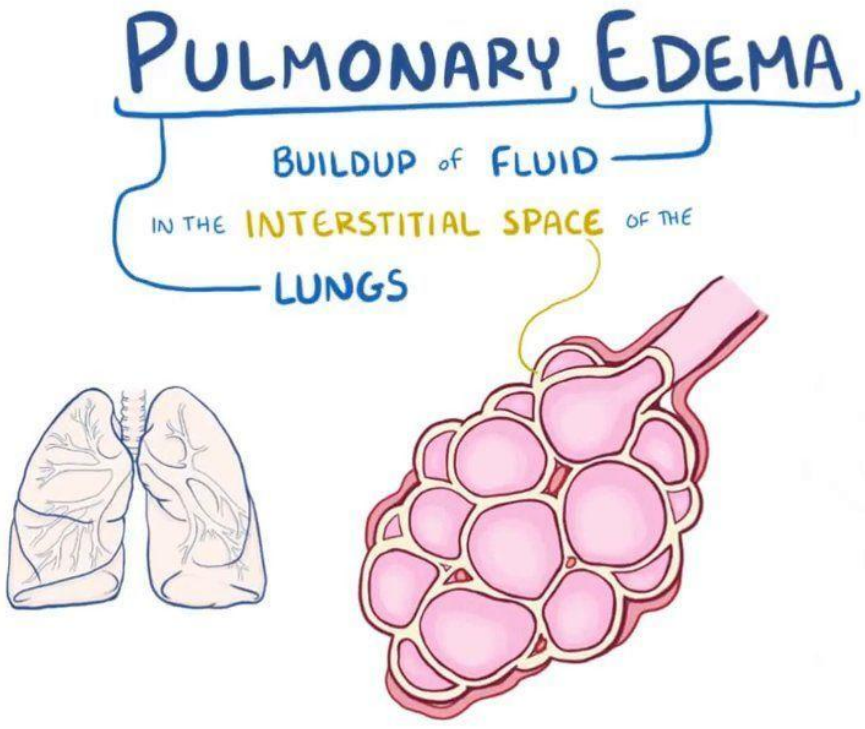

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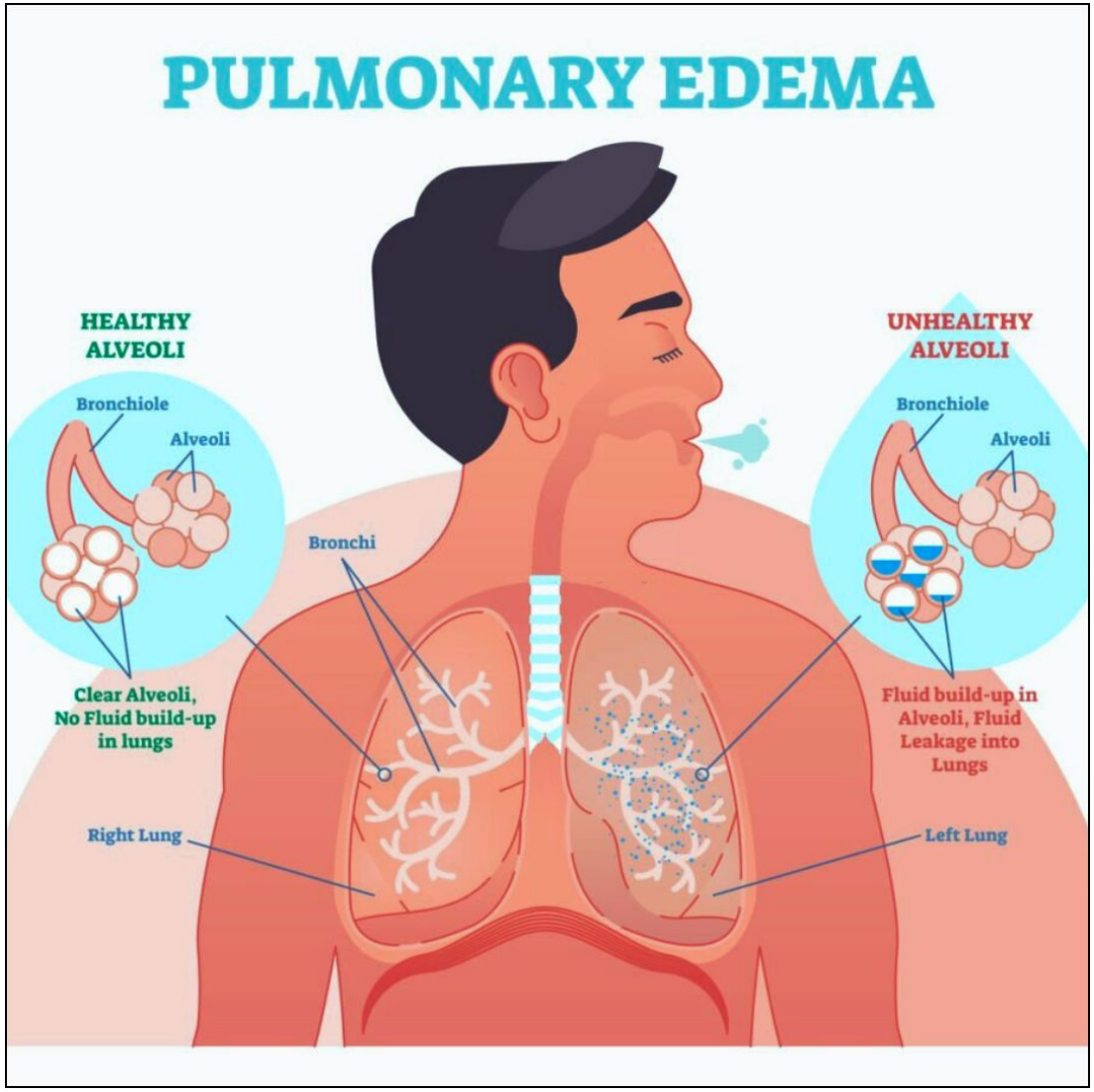

Congestive Heart Failure

Congestive Heart Failure

Evaluation and Diagnosis: Initial Assessment

History and Physical Examination

- Detailed history: Symptoms (e.g., dyspnea, edema), risk factors (e.g., hypertension, diabetes).
- Physical exam: Elevated JVP, peripheral edema.

Basic Diagnostic Tests

- **Electrocardiogram (ECG)**: Assess for arrhythmias, ischemia, or hypertrophy.
- **Complete Blood Count (CBC)**: Rule out anemia or infection.
- **Comprehensive Metabolic Panel**: Evaluate liver function, electrolytes, renal function, and thyroid function.

Advanced Cardiac Evaluation

Essential Labs

- **NT-proBNP**: Elevated levels support the diagnosis of CHF.

Imaging Studies

- **Transthoracic Echocardiogram (TTE)**: Assess left ventricular ejection fraction (LVEF), valvular function, and wall motion abnormalities.
- **Chest X-ray**: Evaluate for pulmonary vascular congestion, cardiomegaly, or pleural effusion.

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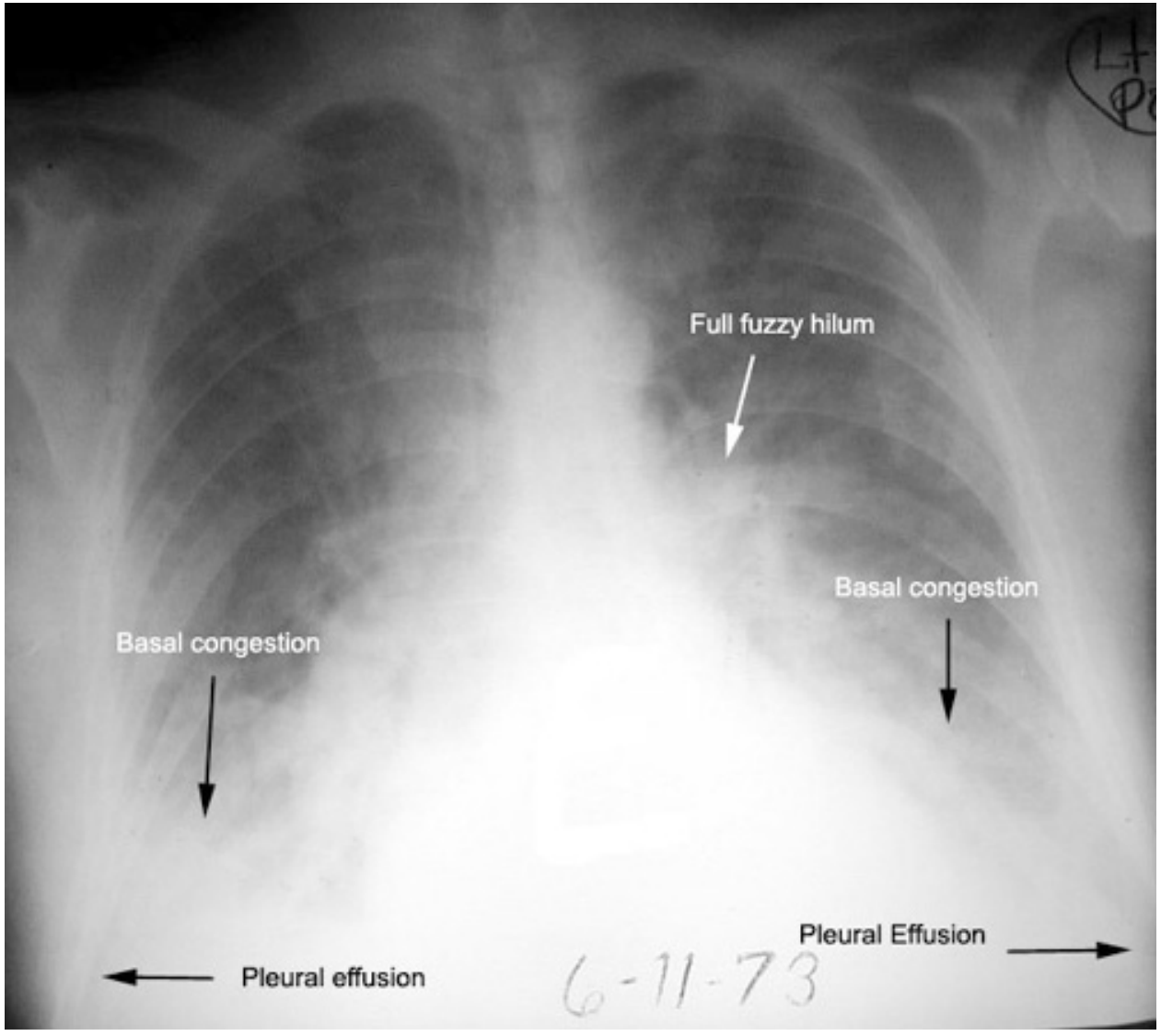

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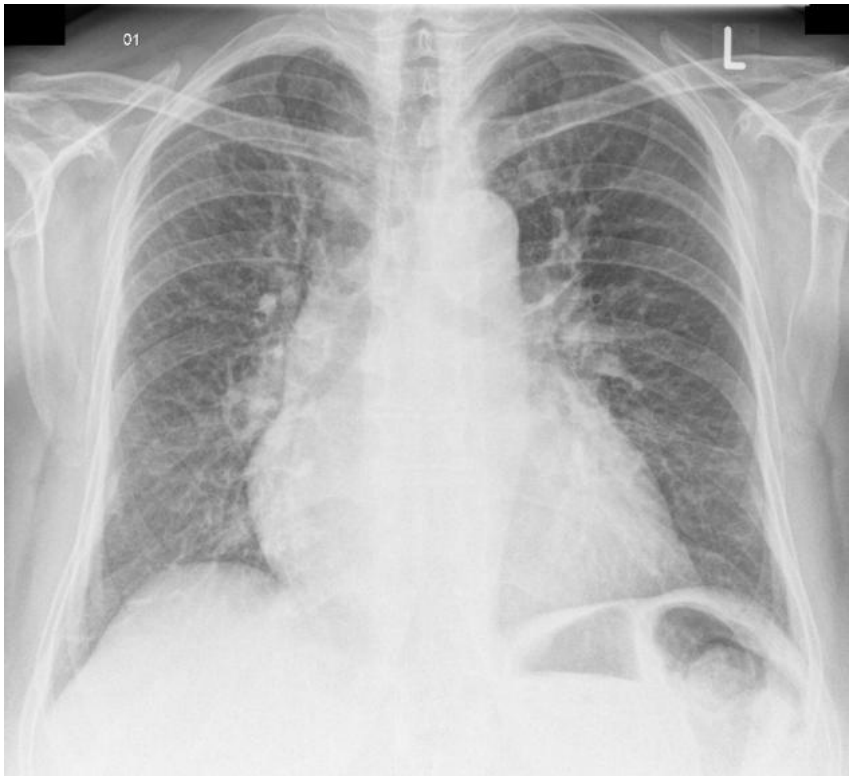


Figure: Enlarged heart

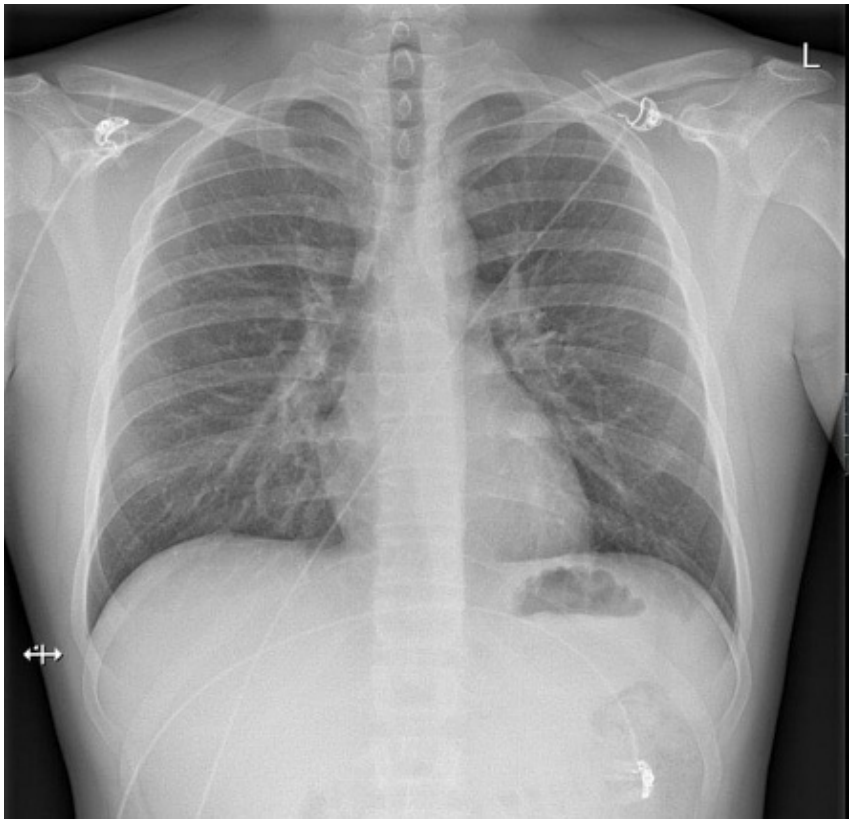
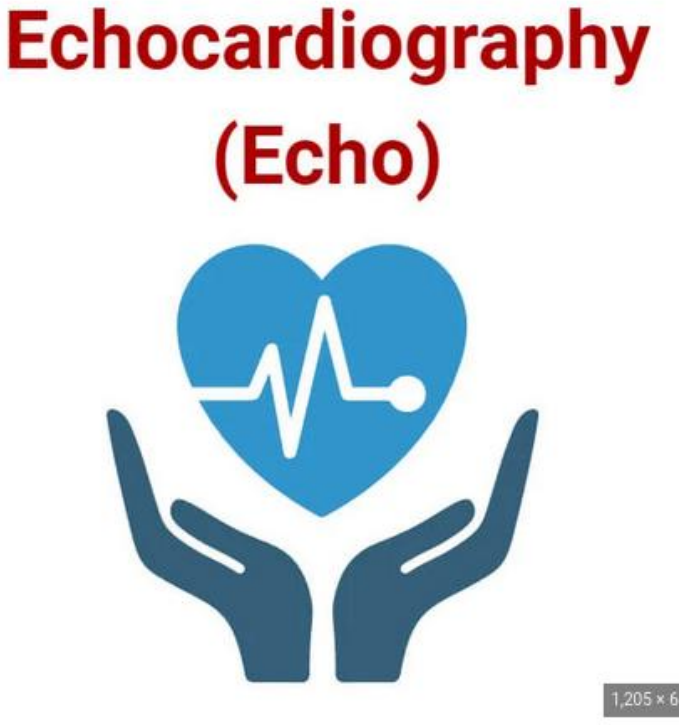


Figure: Normal heart

Congestive Heart Failure



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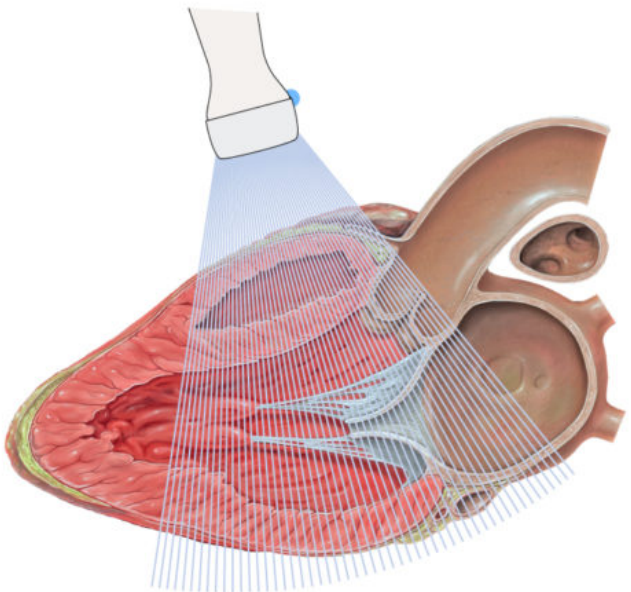
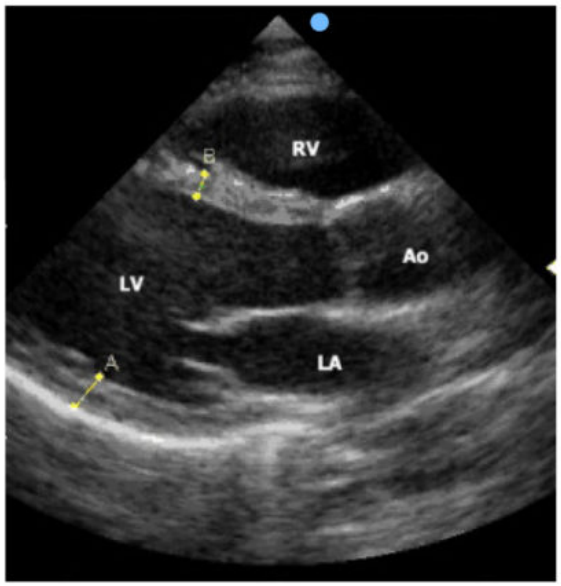
2D (two-dimensional) ultrasound





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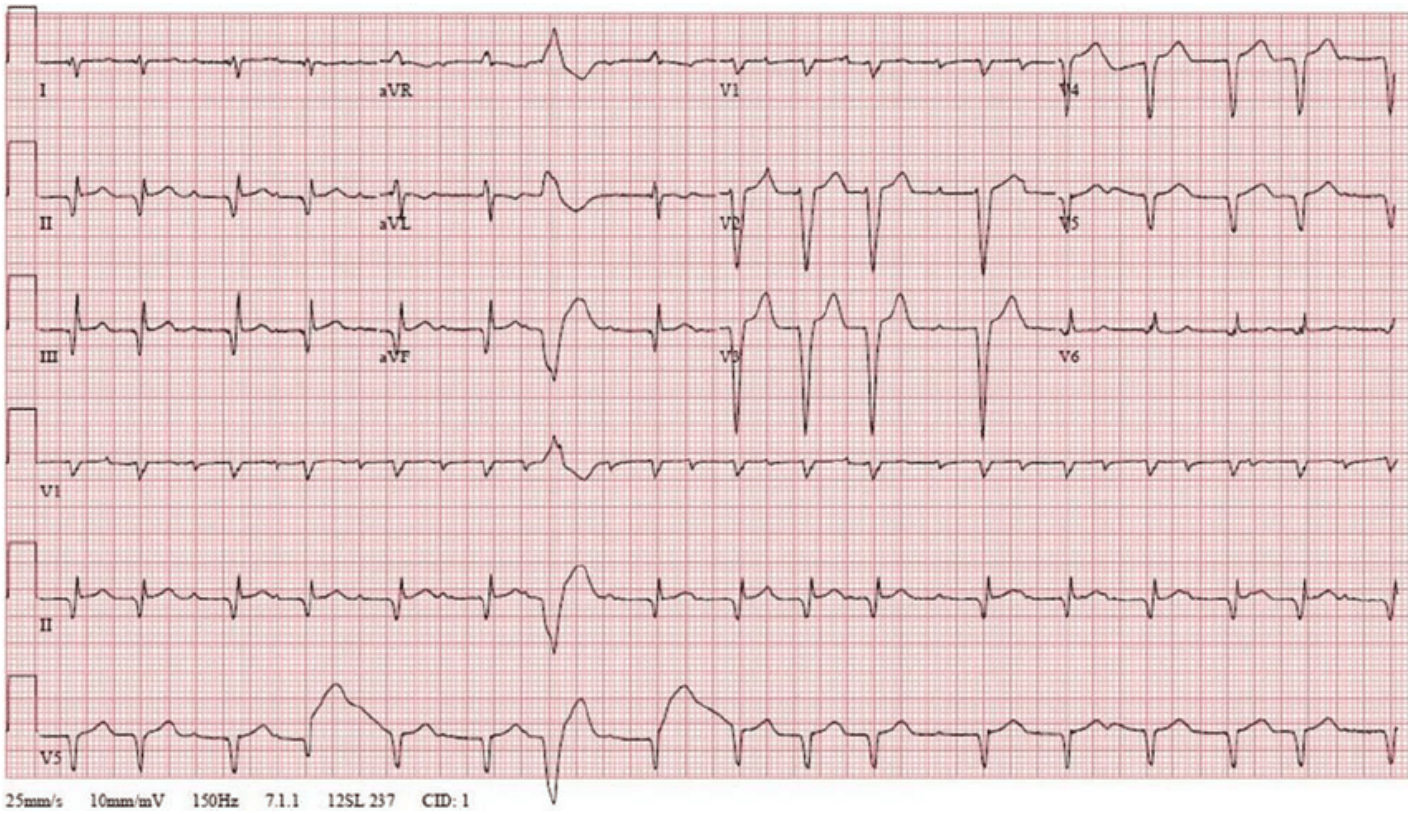

Specialized Tests for CHF Classification

More Advanced Cardiac Evaluation

- **Stress Echocardiogram**: Assess for ischemia or viability.
- **Exercise Treadmill Stress Test**: Evaluate functional capacity and ischemia.
- **Coronary Angiogram**: Identify coronary artery disease in suspected ischemic cardiomyopathy.

When to Use

- When HFrEF or HFpEF classification is unclear.
- When ischemia is suspected as the underlying cause.

Treatment: General Management

Lifestyle Modifications

- **Low-Sodium Diet**: Reduce fluid retention.
- **Regular Exercise**: Improve functional capacity.
- **Weight Management**: Monitor for sudden weight gain (fluid retention).

Comorbidity Management

- Control hypertension, diabetes, atrial fibrillation, obesity, valvular disease, and sleep apnea.
- Improves symptoms and reduces hospitalizations.

Pharmacologic Therapy: Diuretics

Volume Overload Management

- **Loop Diuretics**: Furosemide, torasemide (first-line for congestion).
- **Thiazides**: Add for refractory edema.

Key Points

- Monitor electrolytes (e.g., potassium, sodium).
- Adjust doses based on symptoms and fluid status.

Advanced Pharmacologic Therapy

Neurohormonal Modulation

- **Beta-Blockers**: Carvedilol, metoprolol bisoprolol (reduce sympathetic activation).
- **ACE Inhibitors (ACEi)**: Enalapril, lisinopril (reduce afterload and remodeling).
- **Angiotensin Receptor Blockers (ARB)**: Valsartan, losartan (alternative to ACEi).
- **Sacubitril/Valsartan (ARNI)**: Superior to ACEi in HFrEF.

Advanced Pharmacologic Therapy

Other Therapies

- **Mineralocorticoid Receptor Antagonists (MRA)**: Spironolactone, eplerenone (reduce fibrosis and mortality).
- **SGLT2 Inhibitors (SGLT2i)**: Empagliflozin, dapagliflozin (improve outcomes in HFrEF and HFpEF).