

HEART FAILURE

- It is a complex clinical syndrome of failure of the heart to maintain normal cardiac output due to any structural or functional cardiac disorder.
 - Worldwide, HF incidence is **2 per 1000**.
 - It is an age-related disease which increases up to **90 per 1000 after 85 years old**.
 - **51.5% of HF patients die within 5 years** – more than deaths from cancer.
 - **5%** of hospital admissions are due to HF.
 - After the age of **65 years**, it is the most common cause of hospital admission.
 - **Frequent hospital admissions** carry a poor prognosis.
 - The **cost of HF treatment in the UK** is **> 1 billion dollars per year**.
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Main Mechanisms Involved in Heart Failure

1. **Reduced ventricular contractility** – IHD, MI.
2. **Ventricular pressure (outflow) obstruction** – High-pressure **afterload**:
 - **LV**: HTN, calcific degenerative AS, bicuspid AS, HOCM, congenital sub-aortic membrane, coarctation of aorta.
 - **RV**: Pulmonary stenosis (PS), pulmonary embolism, pulmonary hypertension.
3. **Ventricular inflow obstruction** – **Preload**:
 - Mitral valve stenosis (MVS), tricuspid valve stenosis (TVS).
4. **Ventricular volume overload**:
 - AI, PI, MVR, TVR, AV shunt, VSD, ASD, PDA.
 - High metabolic demand: tachycardia, thyrotoxicosis, anemia, Paget's disease.
5. **Arrhythmias**:
 - Tachyarrhythmia: AF, SVT.
 - Bradycardia: Complete heart block, sick sinus syndrome.
 - Arrhythmia does not allow adequate ventricular filling → reduced cardiac output.
 - Tachyarrhythmia-induced cardiomyopathy.
6. **Impaired ventricular diastolic filling**:
 - Pericardial diseases compressing the heart.
 - Pericardial tamponade.
 - Chronic constrictive pericarditis.
 - Restrictive heart disease: amyloidosis, haemochromatosis.
7. **Toxic causes**: Alcohol cardiomyopathy, chemotherapy.
8. **Infection**: Myocarditis, SBE, sarcoidosis, Chagas disease.
9. **Chronic kidney disease** – **Cardio-renal syndrome**.
Diabetes mellitus – **Diabetic cardiomyopathy**.

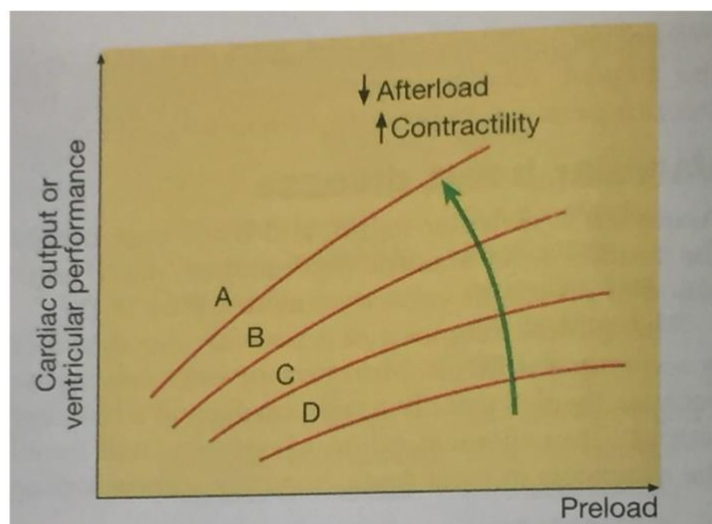
PATHOPHYSIOLOGY

Starling's Law

- **Preload** means the volume of blood and pressure in the ventricle at the end of diastole.
 - An increase in preload (venous return) will increase myocardial fiber stretching, which enhances ventricular performance and cardiac output.
 - However, **over-stretching** of the ventricular wall due to excessive preload will cause marked deterioration of cardiac output, ending in **heart failure, pulmonary edema, and shortness of breath (SOB)**.
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Laplace's Law

- **Afterload** refers to myocardial wall tension – the blood volume and pressure in the ventricle during systole.
- Cardiac output is related to **intracardiac pressure (P)** multiplied by **ventricular radius (R)**.
- An increase in afterload will increase **LV end-diastolic volume**, leading to **ventricular dilatation** and **cardiomegaly**.
- The heart initially compensates by increasing cardiac output, but this occurs at the expense of increased LV volume and further LV dilatation.



PRIMARY CARDIAC ABNORMALITY IN HEART FAILURE

Ventricular Function Impairment

- Myocardial cell loss: apoptosis, necrosis, myocardial hyaline deposition.
 - Fibrosis, cytokine release, and free radicals.
 - **Low cardiac output → hypotension.**
 - **Neuro-hormonal activation.**
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1. Sympathetic Stimulation

- Noradrenaline release.
 - Tachycardia, vasoconstriction, high renin, increased BP and afterload.
 - More myocardial workload → more myocardial cell damage and loss.
 - Decreased cardiac output → **vicious cycle.**
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2. Renin–Angiotensin–Aldosterone System (RAAS)

- Sodium and water retention → increased intravascular volume.
 - Increased blood volume and BP.
 - Increased **preload** and **afterload**.
 - More myocyte damage and loss → decreased cardiac output → **vicious cycle.**
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3. High BNP / ANP

- Secreted by stretch-volume receptors in ventricles and atria.
 - Causes **natriuresis** and **vasodilation**.
 - High BNP level indicates HF (NT-proBNP):
 - **> 300 pg/mL** in sinus rhythm.
 - **> 900 pg/mL** in atrial fibrillation (AF).
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4. Antidiuretic Hormone (ADH)

- High ADH (vasopressin) → water retention.
- SIADH causes **hyponatremia** in severe HF → **poor prognosis.**

CLASSIFICATION OF HEART FAILURE

A. By Ejection Fraction (EF)

- 1. Normal EF , EF: 52%–55%**
- 2. HFrEF (Systolic HF – Low EF)**
- 3. HFpEF (Diastolic HF – Normal EF) , causes:**
 - Myocardial inflammation
 - Fibrosis
 - Stiffness
 - Impaired LV diastolic filling
 - Insulin resistance
 - Obesity
 - Diabetes mellitus
 - **No specific HF treatment → treat underlying causes**
- 4. HFmrEF (Medium EF)**
 - EF: 40%–<55%
- 5. HF with Improved EF (HF-im-EF)**

B. TYPES OF HEART FAILURE

- 1. Left-Sided HF**
 - Shortness of breath (SOB)/ Paroxysmal nocturnal dyspnea (PND) / Pulmonary edema
- 2. Right-Sided HF**
 - Leg edema / Ascites / Anasarca / High JVP
- 3. Biventricular HF**
 - Congestive HF
- 4. High Cardiac Output HF**
 - Thyrotoxicosis / Anemia / Beri-beri
- 5. Chronic HF**
 - Compensated / Decompensated

C. ACUTE HEART FAILURE

- 6. Acute HF , includes :**
 - Acute pulmonary edema
 - Acute MI
 - Acute infective endocarditis
 - Acute valvular destruction
 - Acute chordae tendineae rupture → MR (MVP, Marfan syndrome)
 - Acute viral myocarditis
 - Acute severe accelerated or malignant HTN
 - Acute dissecting aortic aneurysm

D. ACUTE ON CHRONIC HEART FAILURE

7. Acute on Chronic HF (Decompensated HF) , Common triggers:

- Poor medication compliance
 - Uncontrolled HTN
 - Uncontrolled DM
 - Infection / sepsis
 - Anemia
 - Thyroid disease
 - Electrolyte imbalance (K, Mg, Ca, Phos)
 - Acute coronary syndrome (ACS)
 - Acute decompensated IHD
 - Acute MR (papillary muscle dysfunction)
 - Acute onset arrhythmia → AF
 - Acute pulmonary embolism
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NEW YORK HEART ASSOCIATION (NYHA) CLASSIFICATION OF HEART FAILURE

NYHA Functional Classes

Class I : No limitation of physical exercise.

Class II : **Mild** limitation of physical exercise.

Class III : **Moderate** limitation of physical exercise.

Class IV : Symptoms of HF at **rest**: orthopnea, PND, pulmonary edema.

NEW (Updated) CLASSIFICATION OF HF

1. Pre-HF : Risk factors, structural or functional abnormalities.

2. Asymptomatic HF

3. Symptomatic HF

4. Advanced HF

NYHA Class I–II → Mild Cardiac Dysfunction

- Cardiac output = **stroke volume** × **heart rate**.
- Output is **compensated and maintained** by:
 - Increased venous return
 - Increased diastolic ventricular filling pressure
 - Increased heart rate

NYHA Class III → Severe Cardiac Dysfunction

- Cardiac output maintained **only** by:
 - Marked sinus tachycardia
 - Large increase in venous return
- This occurs **at the expense of**:
 - Pulmonary interstitial and alveolar fluid accumulation
 - Causing SOB on **mild exertion**, but **not at rest**

NYHA Class IV → Very Severe HF

- Cardiac output at **rest** is severely depressed.
- Despite:
 - High venous return
 - High filling pressure
 - High heart rate (tachycardia)
- Symptoms:
 - SOB at rest
 - Orthopnea
 - Acute pulmonary edema

SYMPTOMS & SIGNS OF HEART FAILURE

I. Symptoms of Heart Failure

1. Respiratory Symptoms

- SOB
- Palpitations
- SOB on exertion
- Orthopnea (on lying flat / at rest)
- PND – SOB during sleep
- Acute pulmonary edema

2. Reduced Cardiac Output Symptoms

- Fatigue
- Pallor
- Low cardiac output → blood flow maintained only to vital organs (brain, kidneys)
- Reduced perfusion to muscles and skin

II. Signs of Heart Failure

1. Venous Congestion

- High JVP
- Central and peripheral cyanosis

2. Peripheral Fluid Retention

- Bilateral ankle edema
- Ascites
- Anasarca

3. Low Blood Pressure Effects

- Hypotension
- Dizziness
- Vertigo
- Pre-syncope
- Syncope

4. Cardiac Rhythm Abnormalities

- Tachycardia: sinus tachycardia, atrial flutter, AF
- Atrial or ventricular ectopics (extrasystoles)
- VT, VF → cardiac arrest, sudden death
- Bradycardia → complete heart block

5. Auscultation Findings

- S3 and S4 heart sounds (gallop rhythm)
- Systolic murmur – MR
- Bilateral lung basal crackles

6. Hepatic Congestion

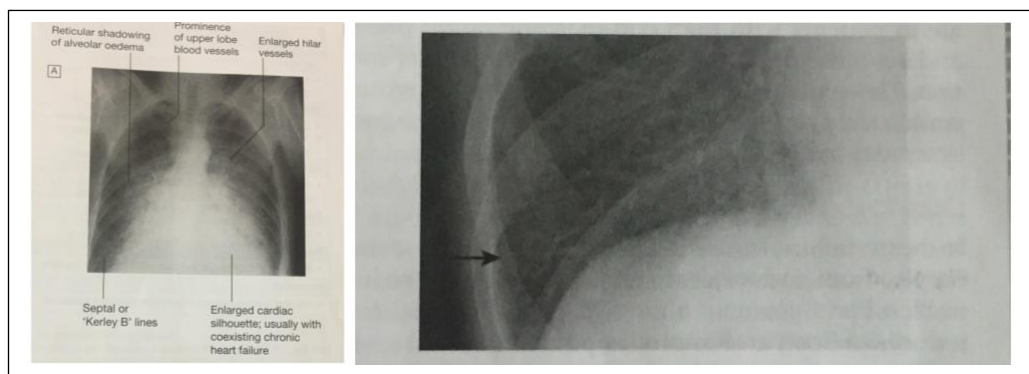
- Tender hepatomegaly
- Congested liver
- Jaundice

7. Metabolic Effects

- Weight loss
- Cardiac cachexia

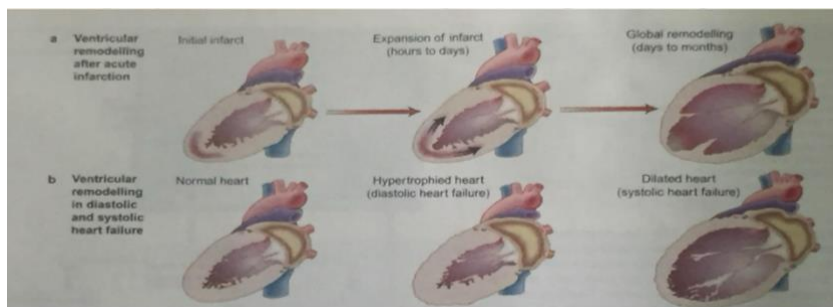
8. Chest X-Ray Findings

- Cardiomegaly
- Pleural effusion
- Pulmonary edema



MYOCARDIAL REMODELING IN HEART FAILURE

- **Definition:** Progressive alteration in **ventricular size, shape, and function**.
- **Mechanism:** Thinning of the ventricular wall and **ventricular dilatation** following myocardial cell damage.
- **Outcome:** Leads to **progressive heart failure**.



INVESTIGATIONS IN HEART FAILURE

1. **ECG**
2. **Chest X-Ray (CXR)**
3. **Blood Tests**
 - Cardiac enzymes
 - NT-proBNP:
 - >300 pg/mL in sinus rhythm
 - >900 pg/mL in AF
 - Basic labs: FBS, HbA1c, urea, creatinine, lipids, T3, T4, TSH, CBC, LFT, PT/INR
4. **Echocardiography**
 - Transthoracic (TTE)
 - Transesophageal (TEE)
5. **Holter Study** – 24-hour ambulatory ECG monitoring
6. **Nuclear Isotope Cardiac Study**
7. **Cardiac Catheterization**
 - Diagnostic and therapeutic
 - Interventions: PCI (IHD), AS-TAVI, mitral valve valvotomy/repair, VSD/ASD/PDA closure
8. **MRA / CT Angiography – Cardiac**

MANAGEMENT OF HEART FAILURE

A. Lifestyle and Preventive Measures

- Lifestyle modification
- Influenza and COVID-19 vaccination
- Treat underlying etiology

B. Pharmacological Treatment

1. Diuretics

- Loop diuretics: Furosemide / Thiazide diuretics: Hydrochlorothiazide
- Potassium-sparing diuretics / Mineralocorticoid receptor antagonists (MRA): Spironolactone / Eplerenone

2. ACE Inhibitors / ARBs

- ACEI: Enalapril, Lisinopril, Ramipril
- ARBs: Valsartan, Losartan, Candesartan

3. Beta-blockers (AV-node blockers)

- Metoprolol, Bisoprolol, Nebivolol, Carvedilol
- Goal: HR <70/min

4. SA-node blocker

- Ivabradine

5. Digoxin

- Especially in HF with AF

6. Vasodilators

- Isosorbide dinitrate, Hydralazine

7. ARNI (Angiotensin receptor – neprilysin inhibitors)

- Sacubitril/Valsartan (Entresto)

8. SGLT2 Inhibitors

- Empagliflozin, Dapagliflozin, Canagliflozin

9. Treat Anemia

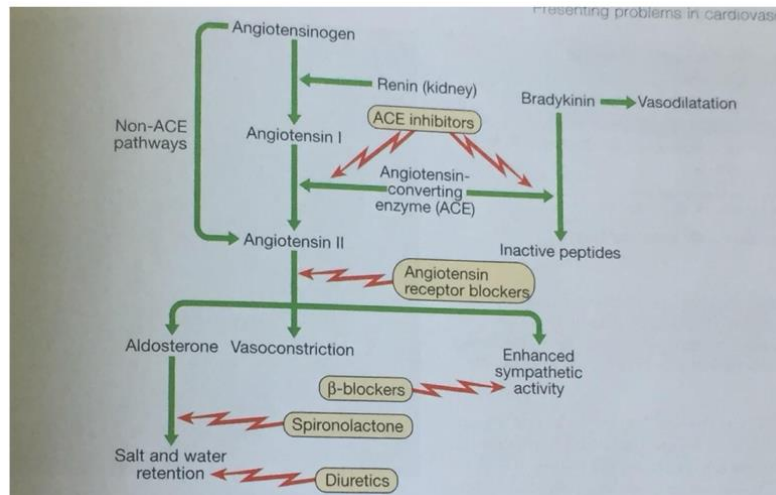
- Ferritin <100 ng/mL → IV iron infusion

10. Treat Secondary MR

- PCI (IHD), AS-TAVI

Note: Pharmacological treatment should be **started slowly** and **titrated over 4 weeks** – **6 months** in the following sequence:

1. Diuretics
2. ARNI
3. SGLT2 inhibitors
4. Beta-blockers
5. Ivabradine
6. MRA
7. Vasodilators



C. Electrical Treatment

1. **ICD** – Implantable cardioverter defibrillator
2. **CRT** – Cardiac resynchronization therapy
 - Improves ventricular resynchronization
 - Shortens ventricular activation time
 - Biventricular pacing (BiVP)
 - His bundle pacing in LBBB → better outcomes

D. Mechanical Treatment

1. **IABP** – Intra-aortic balloon pump (for cardiogenic shock)
 - Enhances coronary blood flow in diastole
2. **Ventricular Assist Device (VAD)**
 - Bridge to heart transplant
 - Used in young patients refractory to medical treatment
 - LVAD (left VAD) / RVAD (right VAD) / Biventricular VAD (BiVAD) / pulsatile flow device / continuous flow device (wide blood flow device) .
 - Complications: infection, thrombosis, stroke (CVA)
3. **Surgical Interventions**
 - CABG
 - Mitral valve repair/replacement
 - AS-TAVI
 - Heart transplant