Lec. 3 | Heart Failure

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Definition & Stages of heart failure (HF)

- It is a clinical syndrome that results from inability of the heart to pump sufficient blood to satisfy the metabolic needs of the body.
- **Asymptomatic Stage** with abnormal indices which precedes HF and in which CO is maintained by compensatory mechanisms & is called Dysfunction either right or left.
- **Symptomatic HF**

Terminology & types of HF

- HF is divided into two types based on Ejection Fraction
- **Ejection fraction (EF):** is the proportion of blood pumped out of the heart in a single contraction (normally 50 - 75%) *The two types are:*
  1. **HF with↓ EF (HFrEF):** This type is also known as systolic heart failure where EF is < 40%.
  2. **Heart failure with mildly reduced EF (HFmrEF):** Heart failure with LVEF 41-49%
  3. **HF with preserved EF (HFpEF):** This type is also known as Diastolic HF where the heart does not relax well & EF >50%
- **Left sided HF or right sided HF.**
  1. **Acute HF:** means rapid onset of HF.
  2. **Chronic HF:** refers to long duration of HF usually kept stable by the treatment of symptoms.
  3. **Acute Decompensated HF:** is a worsening of chronic heart failure symptoms.

Causes of HF

Generally, it results from either:

a. Excess workload in the presence of normal myocardium.

- Pressure overload: cases of hypertension, aortic stenosis, pulmonary stenosis and coarctation of aorta.
- Volume overload: cases of aortic regurge, mitral regurge, AV fistula.
- Excess body demands: cases of thyrotoxicosis, anaemia

b. Myocyte loss: Diseased heart muscles in the presence of normal workload e.g., Myocardial infarction, myocarditis or cardiomyopathy.

c. Restricted filling of the heart e.g., Constrictive pericarditis or restrictive cardiomyopathy.

d. Combination of the above aetiologies.

Precipitating factors of heart failure

- Precipitating factors which induce manifest or clinical heart failure.
- **These factors include** arrhythmia, anaemia, drugs with negative inotropic effects as beta blockers, non dihydropyridine calcium channel blockers, excess IV fluids, excess salt intake, fever, rheumatic activity, infective endocarditis, respiratory infection, preganancy, pulmonary embolism, thyrotoxicosis.

Pathophysiology

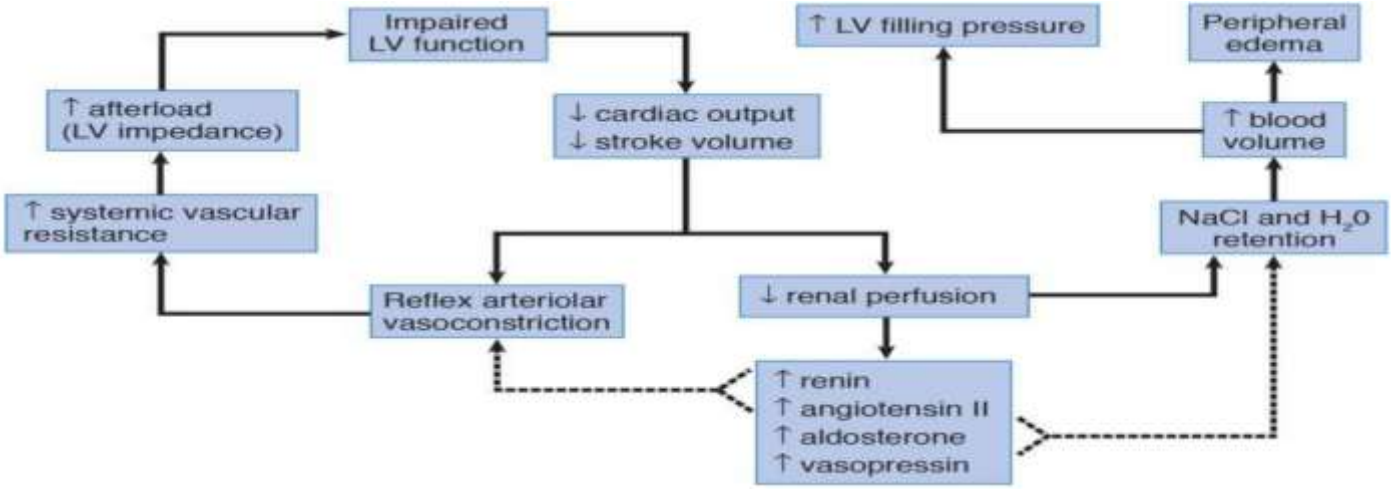
Haemodynamic effects of heart failure:

- When the ventricle cannot pump all the blood it recieves, some residual blood will accumulate within the ventricle, causing progressive dilatation.The pressure within the ventricle increases and thus transmited to the draining atrium.
- Blood will accumulate within the veins drains in the affected atrium causing venous congestion either pulmonary venous congestion (left ventricular failure) or systemic venous congestion (right ventricular failure).
- The overall result is reduction of the amount of pumped blood, hence reduced cardiac output.
- Which stimulate compensatory mechanisms to help maintain cardiac output (primarily by the Frank-Starling mechanism) and arterial blood pressure (by systemic vasoconstriction).
- However, these compensatory changes over time can worsen cardiac function.

Compensatory mechanism

- **Cardiac:** Frank-Starling mechanism, tachycardia, ventricular dilatation
- **Neuronal:** increased sympathetic adrenergic activity, reduced cardiac vagal activity
- **Hormonal:** activation of angiotensin-aldosterone system with renal sodium retention and ECV expansion), vasopressin, catecholamines, and natriuretic peptides.

Inter-related Cycles in Congestive Heart Failure



Clinical picture of heart failure **HF is divided according to which site of the heart is affected into:**

I. Left-sided failure:

▶ Symptoms of lung congestion which include:

- Dyspnea: shortness of breath & tachypnea
- Orthopnea the patient has dyspnea on lying flat.
- Paroxysmal Nocturnal Dyspnea a sudden night-time attack of severe breathlessness, usually several hours after going to sleep.
- Others like cough and expectoration of whitish sputum sometimes blood tinged (haemoptysis)
- Low cardiac output symptoms: Easy fatigability and exercise intolerance, dizziness, confusion, oliguria.

▶ Signs:

- Rapid small volume pulse.
- Pale cold extremities.
- Basal lung crackle (crepitation)
- A laterally displaced apex beat, and a gallop rhythm, murmur mostly function mitral regurgitation.

II. Right- sided HF:

Manifestations of systemic venous congestion:

▶ Symptoms:

- Lower limb swelling
- Abdominal distension
- Epigastric pain
- Nausea, vomiting and anorexia.
- Low cardiac output symptoms: easy fatigability and exercise intolerance, dizziness, confusion, oliguria

▶ Signs

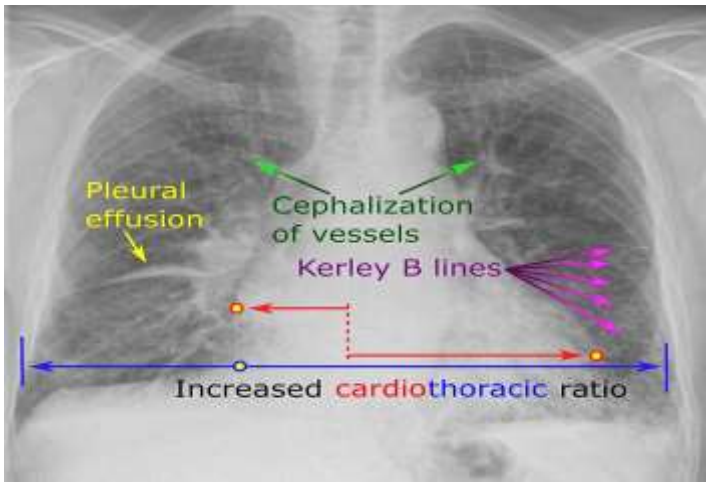
- **Bilateral pitting lower limb oedema**
- **Congested neck veins with positive hepatojugular reflux**
- **Enlarged tender liver**.
- Ascites & Pleural effusion, mostly right sided
- Right ventricular gallop (heard at tricuspid area) & murmur of functional tricuspid regurge.
- Signs of right ventricular enlargement
- Signs of the cause of right ventricular failure.

III.Biventricular failure Usually left-sided HF is followed by right-sided HF.

Investigations

- ECG, to detect any abnormality.
- Chest X-ray to detect pulmonary congestion & exclude lung disease.
- Echocardiography: It confirms the diagnosis, determines the etiology & suggests the appropriate treatment & also It **assess LV-EF**
- Lab investigations: Brain natriuretic peptide (BNP) ≥ 35pg/ml and NT-pro BNP should be ≥125pg/ml. they are highly sensitive, but they are non-specific. BNP is best used to rule out CHF and save further workup.
- Lipid profile, fasting plasma glucose, serum creatinine, Na, K, liver function tests
- Certain investigations to detect the cause of heart failure, e.g. Coronary angiography, endomyocardial biopsy, chest CT...

X-Ray in Lt-Sided HF



Functional classification of HF

It relies on New York Heart Association functional classification. The classes (I-IV) are:

- **Class I:** no limitation in any activities.
- **Class II:** slight limitation of activity.
- **Class III:** marked limitation of any activity
- **Class IV:** any physical activity brings on discomfort and symptoms occur at rest.

These help in assessment of the clinical condition of the patient & the degree of improvement after therapy.

More recent classification is that of ACC/AHA

- **Stage A:** Patients at risk of developing heart failure but no structural heart disease or symptoms.
- **Stage B:** Patients with structural heart disease but no symptoms.
- **Stage C:** Patients with structural heart disease and current or prior symptoms of failure.
- **Stage D:** Patients with refractory heart failure requiring specialized interventions.

Treatment of systolic HF

- ✓ **Goals of Management of HF:** are to relieve symptoms, improve quality of life, reduce hospitalization, and increase survival.
- ✓ **Avoidance and treatment** of precipitating factors and treatment of aetiology of HF are important.
- ✓ **Treatment of heart failure** include lifestyle modification, pharmacological modalities, occasionally various forms of device therapy and rarely cardiac transplantation.

Management of HF (Cont)

Lifestyle Modification

- Fluid & salt restriction to reduce fluid retention in the body
- Low level of exercise like walking should be encouraged and tailored to suit individual capabilities.
- Obesity should be reduced.
- Smoking should be ceased.
- Diabetes & dyslipidaemia should be controlled.

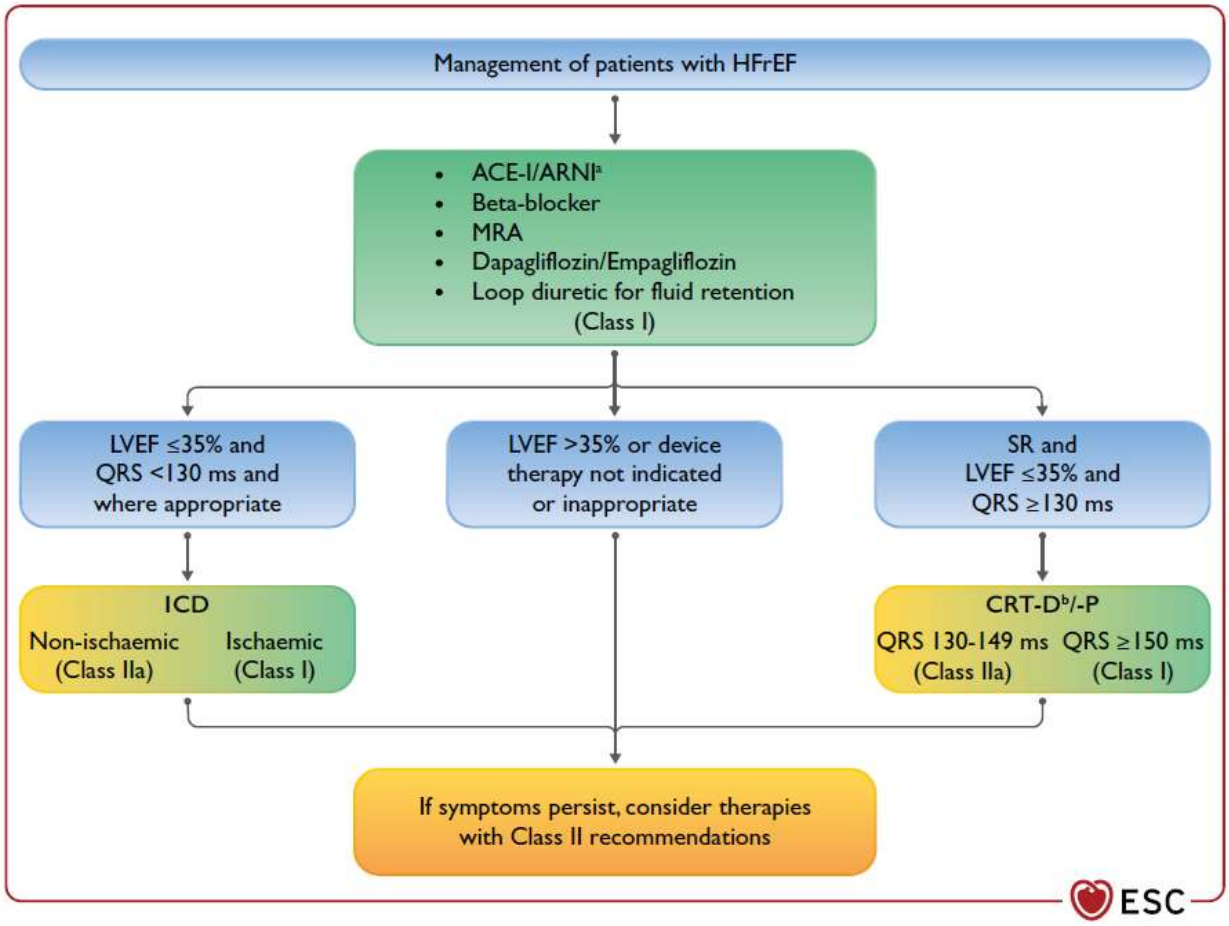


Figure Therapeutic algorithm of Class I Therapy Indications for a patient with heart failure with reduced ejection ...

Class I drugs according to ESC 2021 guidelines for HFrEF

- ✓ ACE inhibitors\ARNI
- ✓ Beta blockers
- ✓ Mineralocorticoid Receptors Antagonists (MRA)
- ✓ Sodium-glucose co-transporter 2 inhibitors (SGLT2 inhibitor): dapagliflozin, empagliflozin
- ✓ Loop diuretic for fluid retention

1. Angiotensin-converting enzyme (ACE) inhibitors

- Improve survival.
- Reduce ventricular hypertrophy.
- Reduce preload and afterload (through arterial and venous vasodilation), thereby reducing right atrial, pulmonary arterial, and pulmonary capillary wedge pressures.
- **Side effects** include cough and angioedema.
- **Examples** include enalapril, Lisinopril, ramipril and captopril.

2. Angiotensin Receptor Neprilysin inhibitor (ARNI) {Valsartan-sacubitril}

- Neprilysin is a neutral endopeptidase that degrades several vasoactive peptides, including natriuretic peptides (ANP, BNP) and bradykinin.
- Inhibition of neprilysin increases levels of these substances, which then counteract the effects of neurohormonal activation such as vasoconstriction and sodium retention.
- They block the RAAS system and lead to natriuresis and decrease cardiac hypertrophy and fibrosis.
- Do not administer valsartan-sacubitril concurrently, or within 36 hrs, of an ACEi, due to angioedema risk. Also, avoid in those with a history of angioedema.

3. Angiotensin II receptor blockers:

- They may be an alternative for people who can't tolerate ACE inhibitors.
- **Examples** of these drugs, losartan, valsartan, candesartan.
- **Contraindications** of angiotensin converting enzyme inhibitors & angiotensin receptor blocker: Impaired renal function (creatinin level more than 3 mg/dL), pregnancy, bilateral renal artery stenosis, previously documented angiodema (for ACE I)

4. Diuretics

- Loop diuretics, like furosemide to relieve symptoms of congestion especially of acute pulmonary edema **(treatment of choice).**
- Thiazide diuretics (hydrochlorothiazide) are useful only in mild HF
- K-Sparing diuretics are used as with loop diuretic or add-on therapy to ACE inhibitors in severe HF to prolong survival by presumed aldosterone inhibition.
- **Side effects of loop diuretic** like, hypokalaemia, hyponatremia, hyperglycaemia, hyperuricemia

5. Beta blockers

- These drugs cut short the cycle of sympathetic nervous system stimulation leads to slows the heart rate and reduces blood pressure & and reverses the damage in heart in systolic heart failure.
- They reduce the risk of abnormal heart rhythms and lessen sudden cardiac death & prolong survival, decreased hospitalization. Give a BB after patient is stabilized with diuretics and ACE inhibitor.
- **Examples** include carvedilol, metoprolol succinate, bisoprolol, nebivolol.

BBs are contraindicated in cardiogenic shock, severe active asthma and patients with decompensated HF.

6. Sodium-glucose co-transporter 2 inhibitors (SGLT2 inhibitor) McDonagh TA et al 2021

- The DAPA-HF trial investigated the long-term effects of dapagliflozin (SGLT2 inhibitor) compared to placebo in addition to optimal medical therapy (OMT), on morbidity and mortality in patients with ambulatory HFrEF. Patients participated in the trial if they were in NYHA class II–IV, and had an LVEF ≤40% despite OMT. Patients were also required to have an elevated plasma NT-proBNP and an eGFR ≥30 mL/min/1.73 m2.

7. Mineralocorticoid Receptors Antagonists (MRA)

- **These drugs include** spironolactone and eplerenone. They can ↑ K , so it should be monitored.
- These are potassium-sparing diuretics, which also have additional properties that may help people with severe systolic heart failure to live longer.

8. Other drugs

- **Ivabradin:** It is used in patients with Systolic-HF using all the above measures but have symptoms & HR > 70 beats/m
- **Hyderalazine-Hydralazine-Isosorbide Di Nitrate (H-ISDN)**: It is used in resistant Systolic-HF especially in black or used if patients who can not tolerate ACE-I or ARB.

Positive inotropics

1) Digitalis (Digoxin)

- It ↑ the strength of heart muscle, slows the HR and ↓symptoms of heart failure & is used in atrial fibrillation.
- It reduces hospitalisation.
- **Mechanism of action:** they inhibit Na+/k+ ATPase pump which leads to increase intracellular Na+ which decrease its exchange with Ca with increase of intracellular Ca which increase myocardial contractility.
- **Digitalis Toxicity:**
  - Extracardiac: anorexia, nausea, repeated vomiting, abnormal coloured vision and gynaecomastia.
  - Cardiac: Increased myocardial excitability with frequent ventricular extrasystoles, ventricular and supraventricular tachycardia. Depressed AV nodal conduction with prolonged PR interval and heart block.
- ***Treatment of toxicity:*** *Stop digoxin, potassium supplements either in diet or as a drug and treat the specific manifestations. Lidocaine phenytoin for arrythmia.*

2) Other inotropics

- Like dobutamine, dopamine, amrinone, milrinone.
- They are given IV in ICU and should be carefully titrated.

Device Therapy

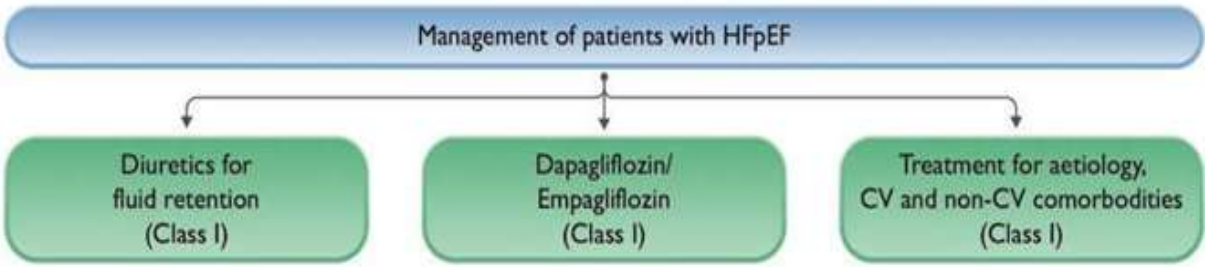
I. Cardiac Resynchronization Therapy (CRT): In severe cardiomyopathy (symptomatic patients with LVEF < 35%, sinus rhythm & Wide QRS ≥ 130 msec) CRT is recommended

II. Implantable Cardioverter Defibrillator (ICD): because the most common cause of death in congestive heart failure is arrhythmia ICD is indicated as class I in ischemic and class IIa in non-ischemic patients with EF <35%

III. Surgical therapies (Ventricular Assist Device (VAD): VADs have commonly been used as a bridge to heart transplantation, but more recently as a final treatment for advanced heart failure.

Management of HFpEF

- ✓ Treatment aims is to alleviate symptoms & improve well-being
- ✓ Diuretics should be cautiously due limited preload (filling) to improves symptoms in presence of congestion,
- ✓ Blood pressure control (CCBs, BBs or ACE inhibitors/ARBs)
- ✓ Exercise program and cardiac rehabilitation.
- ✓ BBs are now less often used but may be added for rate control in atrial fibrillation and patients with CAD.
- ✓ All co-morbidities should be treated.
- ✓ Recently sacubitril/valsartan drug and empagliflozin (SGLT2 inhibitors) are proved to beneficial in treatment of patients with HFpEF.



Pulmonary edema

- ❖ May occur in any patient with CHF.
- ❖ It considered medical emergency which needs hospitalization.
- ❖ There are non-cardiogenic causes of pulmonary edema but this section will discuss only cardiogenic pulmonary edema (CPE).
- ❖ **Cardiogenic pulmonary edema** is caused by acute increase of left ventricular pressure due left ventricular dysfunction which leads to fluid accumulation in pulmonary interstitium and alveoli.
- ❖ This can cause problems with the exchange of gas (oxygen and carbon dioxide), resulting in breathing difficulty and poor oxygenation of blood.

Symptoms

- × Patients with CPE present with the dramatic clinical features of left heart failure.
- × Patients develop a sudden onset of extreme breathlessness, anxiety, & feelings of drowning.
- × Clinical manifestations of acute CPE reflect evidence of hypoxia and increased sympathetic tone (increased catecholamine outflow).
- × Patients most commonly complain of shortness of breath and profuse diaphoresis.
- × Cough is a frequent complaint with pink, frothy sputum may be present in patients with severe disease.

Physical Examination

- Physical findings in patients with CPE are notable for tachypnea, cyanosis, and tachycardia. Patients may be sitting upright, they may demonstrate air hunger, and they may become agitated and confused. Patients usually appear anxious and diaphoretic.
- Hypertension is often present, because of the hyperadrenergic state. Hypotension indicates severe LV systolic dysfunction and the possibility of cardiogenic shock.
- **Auscultation** of the lungs usually reveals bubbling crepitation, but rhonchi or wheezes may also be present.

Investigations:

monitoring of blood oxygen and co2 content, chest x ray shows prominent pulmonary vessels (may show butter fly appearance), effusion, kerley B lines. ECG to exclude arrhythmias or on going myocardial infarction.

Lines of treatment of pulmonary edema

Treatment in hospitalized patients includes all CHF treatments and:

- ✓ **Oxygen therapy**
- ✓ **Diuretics:** like furosemide IV (important line of treatment)
- ✓ **Nitroglyceric IV** is for patients who are not hypotensive. It provides excellent and reliable preload reduction.
- ✓ **IV ACE inhibitors.**
- ✓ **Sodium nitroprusside:** is a potent, direct smooth muscle–relaxing agent that primarily reduces afterload but can mildly reduce preload. It improves cardiac output but can precipitously decrease blood pressure.
- ✓ **Inotropic drugs IV:** dobutamine, milrinone in case of severe hypotension temporary use of vasopressors such as dopamine, norepinephrine
- ✓ **Ultrafiltration.**
- ✓ **Intubation/ventilation** if the above measures failed.