CONGESTIVE
HEART FAILURE

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CONGESTIVE HEART FAILURE

- Superior vena cava
- Pulmonary artery:
  - Systolic: 15–30
  - Diastolic: 5–15
  - Mean: 10–20
- Right atrium: 0–5
- Right ventricle:
  - Systolic: 15–30
  - End-diastolic: 0–5
- Inferior vena cava

Aorta:
- Systolic: 90–140
- Diastolic: 60–90
- Mean: 70–105

Left atrium: 4–12

Left ventricle:
- Systolic: 90–140
- End-diastolic: 4–12
DEFINITION
Congestive Heart Failure is a clinical syndrome in which the heart is unable to pump sufficient blood to meet the metabolic requirements of the body, or can do so only at an elevated filling pressure.
EPIDEMIOLOGY
• HF is a burgeoning problem worldwide, with more than 20 million people affected.
• The overall prevalence of HF in the adult population in developed countries is 2%.
• HF prevalence follows an exponential pattern, rising with age, and affects 6–10% of people over age 65.
• Although the relative incidence of HF is lower in women than in men, women constitute at least one-half the cases of HF because of their longer life expectancy.
• Although HF once was thought to arise primarily in the setting of a depressed left ventricular (LV) ejection fraction (EF), epidemiologic studies have shown that approximately one-half of patients who develop HF have a normal or preserved EF (EF 40–50%).
• Accordingly, HF patients are now broadly categorized into one of two groups: (1) HF with a depressed EF (commonly referred to as systolic failure) or (2) HF with a preserved EF (commonly referred to as diastolic failure).
Heart failure

Low-output versus High-output

Low-output: metabolic demands are normal but heart is unable to meet them

High-output: metabolic demands are increased and the heart is unable to meet them

Left-sided, Right-sided and Biventricular

Left-sided: when blood is not adequately pumped from the left ventricle

Right-sided: when blood is not pumped adequately from right ventricle

Biventricular (Left + Right)
• However, both the above classifications are outdated and not used clinically. They are used only academically for better understanding.
• The classification currently used clinically is that of systolic-failure versus diastolic-failure which was explained in epidemiology.
• Apart from this, it is also classified as acute / chronic failure.
ETIOLOGY

• Heart failure can result from any disorder that affects the ability of the heart to contract (systolic function) and/or relax (diastolic dysfunction)
• Common causes are given in the table below
<table>
<thead>
<tr>
<th>Systolic dysfunction (decreased contractility)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reduction in muscle mass (e.g., myocardial infarction)</td>
</tr>
<tr>
<td>• Dilated cardiomyopathies</td>
</tr>
<tr>
<td>• Ventricular hypertrophy</td>
</tr>
<tr>
<td>i. Pressure overload (e.g., systemic/pulmonary hypertension, aortic/pulmonic valve stenosis)</td>
</tr>
<tr>
<td>ii. Volume overload (e.g., valvular regurgitation, shunts, high-output states)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diastolic dysfunction (restriction in ventricular filling)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Increased ventricular stiffness</td>
</tr>
<tr>
<td>i. Ventricular hypertrophy (as above)</td>
</tr>
<tr>
<td>ii. Infiltrative myocardial diseases (e.g., amyloidosis, sarcoidosis, endomyocardial fibrosis)</td>
</tr>
<tr>
<td>iii. Myocardial ischemia and infarction</td>
</tr>
<tr>
<td>• Mitral or tricuspid valve stenosis</td>
</tr>
<tr>
<td>• Pericardial disease (e.g., pericarditis, pericardial tamponade)</td>
</tr>
</tbody>
</table>
PATHOPHYSIOLOGY

Normal Cardiac Performance

• To understand the pathophysiologic processes in heart failure, a basic understanding of normal cardiac function is necessary.
• Cardiac output (CO) is defined as the volume of blood ejected per unit time (L/min) and is the product of heart rate (HR) and stroke volume (SV): CO = HR × SV
• Heart rate is controlled by the autonomic nervous system.
• Stroke volume, or the volume of blood ejected during systole, depends on preload, afterload, and contractility.
• Thus, cardiac performance is dependent on four factors (this is the basis of Starling’s law):
1. Preload – volume and pressure of blood in ventricle at the end of diastole
2. Afterload – volume and pressure of blood in ventricle during systole
3. Contractility
4. Heart rate
Compensatory mechanisms
• Heart failure is a progressive disorder initiated by an event that impairs the ability of the heart to contract and/or relax.
• The index event may have an acute onset, as with myocardial infarction, or the onset may be slow, as with long-standing hypertension.
• Regardless of the index event, the decrease in the heart’s pumping capacity results in the heart having to rely on compensatory responses to maintain an adequate cardiac output.
• The compensatory mechanisms include:
1. Tachycardia and increased contractility through Sympathetic stimulation
2. Increased preload due to decreased sodium and water retention because of activation of RAAS, which is activated by decreased renal perfusion
3. Vasoconstriction and increased afterload- vasoconstriction occurs due to a number of neurohormones like NE, angiotensin 2, endothelin-1 and vasopressin. Vasoconstriction increases peripheral vascular resistance and hence further decreases cardiac output
4. Ventricular hypertrophy and remodelling
<table>
<thead>
<tr>
<th>Compensatory Response</th>
<th>Beneficial Effects of Compensation</th>
<th>Detrimental Effects of Compensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased preload (through Na⁺ and water retention)</td>
<td>Optimize stroke volume via Frank-Starling mechanism</td>
<td>Pulmonary and systemic congestion and edema formation</td>
</tr>
<tr>
<td>Vasoconstriction</td>
<td>Maintain BP in face of reduced CO</td>
<td>Increased MVO₂</td>
</tr>
<tr>
<td>Tachycardia and increased contractility (because of SNS activation)</td>
<td>Shunt blood from nonessential organs to brain and heart</td>
<td>Increased MVO₂</td>
</tr>
<tr>
<td>Ventricular hypertrophy and remodeling</td>
<td>Helps maintain CO</td>
<td>Increased afterload decreases stroke volume and further activates the compensatory responses</td>
</tr>
<tr>
<td></td>
<td>Helps maintain CO</td>
<td>Increased MVO₂</td>
</tr>
<tr>
<td></td>
<td>Reduces myocardial wall stress</td>
<td>Shortened diastolic filling time</td>
</tr>
<tr>
<td></td>
<td>Decreases MVO₂</td>
<td>β₁-receptor downregulation, decreased receptor sensitivity</td>
</tr>
</tbody>
</table>

BP, blood pressure; CO, cardiac output; MVO₂, myocardial oxygen demand; SNS, sympathetic nervous system.
18.13 Factors that may precipitate or aggravate heart failure in patients with pre-existing heart disease

- Myocardial ischaemia or infarction
- Intercurrent illness, e.g. infection
- Arrhythmia, e.g. atrial fibrillation
- Inappropriate reduction of therapy
- Administration of a drug with negative inotropic properties (e.g. β-blocker) or fluid-retaining properties (e.g. non-steroidal anti-inflammatory drugs (NSAIDs), corticosteroids)
- Pulmonary embolism
- Conditions associated with increased metabolic demand, e.g. pregnancy, thyrotoxicosis, anaemia
- I.v. fluid overload, e.g. post-operative i.v. infusion
CLINICAL PRESENTATION
General

- Patient presentation may range from asymptomatic to cardiogenic shock
- The clinical picture depends on the nature of the underlying heart disease, the type of heart failure that it has evoked, and the neurohumoral changes that have developed
Symptoms

- Dyspnea, particularly on exertion
- Orthopnea
- Paroxysmal nocturnal dyspnea
- Exercise intolerance
- Tachypnea
- Cough
- Fatigue
- Nocturia
- Hemoptysis
- Abdominal pain
- Anorexia
- Nausea
- Bloating
- Poor appetite, early satiety
- Ascites
- Mental status changes
Signs

- Pulmonary rales
- Pulmonary edema
- S3 gallop
- Cool extremities
- Pleural effusion
- Cheyne-Stokes respiration
- Tachycardia
- Narrow pulse pressure
- Cardiomegaly
- Peripheral edema
- Jugular venous distension
- Hepatojugular reflux
- Hepatomegaly
INVESTIGATIONS

Blood tests

- Blood gas analysis – to assess respiratory gas exchange
- Serum creatinine and urea – to assess renal function
- Serum alanine- and aspartate-aminotransferase plus other liver function tests – increased due to hepatic congestion
- Complete blood count (CBC) – to investigate possibility of anaemia and if heart failure is due to it
- Thyroid function tests to investigate possibility of thyrotoxicosis
- Brain natriuretic peptide (BNP) – elevated in heart failure ( >100 pg/mL) and is a marker of risk; it is useful in the investigation of patients with breathlessness or peripheral oedema.
- Neopterin levels increase and are biomarkers of cardiovascular remodelling
Electrocardiogram
• A routine 12-lead ECG is recommended. The major importance of the ECG is to assess cardiac rhythm and determine the presence of LV hypertrophy or a prior MI (presence or absence of Q waves) as well as to determine QRS width to ascertain whether the patient may benefit from resynchronization therapy (see below). A normal ECG virtually excludes LV systolic dysfunction.
Echocardiogram

• Non-invasive cardiac imaging is essential for the diagnosis, evaluation, and management of HF. The most useful test is the two-dimensional (2-D) echocardiogram/Doppler, which can provide a semiquantitative assessment of LV size and function as well as the presence or absence of valvular and/or regional wall motion abnormalities (indicative of a prior MI).
• Echocardiogram assesses left ventricle size, valve function, pericardial effusion, wall motion abnormalities, and ejection fraction
• Although the history, physical examination, and laboratory tests can provide important clues to the underlying cause of heart failure, the echocardiogram is the single most useful test in the evaluation of a patient with heart failure
Echocardiography is very useful and should be considered in all patients with heart failure in order to:
* determine the aetiology
* detect hitherto unsuspected valvular heart disease, such as occult mitral stenosis, and other conditions that may be amenable to specific remedies
* identify patients who will benefit from long-term therapy with drugs, such as ACE inhibitors (see below).
Chest radiography

- A chest x-ray provides useful information about cardiac size and shape, as well as the state of the pulmonary vasculature (for edema), and may identify non-cardiac causes of the patient's symptoms.
Fig. 18.25 Radiological features of heart failure. A Chest X-ray of a patient with pulmonary oedema. B Enlargement of lung base showing septal or ‘Kerley B’ lines (arrow).
TREATMENT

Goals of therapy

• Relieve or reduce symptoms
• Delay progression of the disease
• Decrease hospitalization
• Mainly decrease preload and afterload

Although these goals are still important, identification of risk factors for heart failure development and recognition of its progressive nature have led to increased emphasis on preventing the development of this disorder.
• With this in mind, the American College of Cardiology/American Heart Association (ACC/AHA) guidelines for the evaluation and management of chronic heart failure use a staging system that recognizes not only the evolution and progression of the disorder, but also emphasizes risk factor modification and preventive treatment strategies.
The New York Heart Association (NYHA) system is primarily intended to classify symptomatic heart failure according to the clinician’s subjective evaluation and does not recognize preventive measures or the progression of the disorder.
**Stage A**
Patients at high risk for developing heart failure

**Stage B**
Patients with structural heart disease but no HF signs or symptoms

**Stage C**
Patients with structural heart disease and current or previous symptoms

**Stage D**
Refactory HF requiring specialized interventions

**Common Examples**
- Hypertension, coronary artery or other atherosclerotic vascular disease, diabetes, obesity, metabolic syndrome
- Previous MI, left ventricular hypertrophy, left ventricular systolic dysfunction
- Left ventricular systolic dysfunction and symptoms such as dyspnea, fatigue, and reduced exercise tolerance
- Patients with treatment refractory symptoms at rest despite maximal medical therapy (e.g., patients requiring recurrent hospitalization or who cannot be discharged without mechanical assist devices or inotropic therapy)

**FIGURE 16-5.** ACC/AHA heart failure staging system. (HF, heart failure; MI, myocardial infarction.) (Adapted with permission from Circulation 2005;112:154–234.)
# New York Heart Association Functional Classification

## Functional class

I. Patients with cardiac disease but without limitations of physical activity. Ordinary physical activity does not cause undue fatigue, dyspnea, or palpitation.

II. Patients with cardiac disease that results in slight limitations of physical activity. Ordinary physical activity results in fatigue, palpitation, dyspnea, or angina.

III. Patients with cardiac disease that results in marked limitation of physical activity. Although patients are comfortable at rest, less-than-ordinary activity will lead to symptoms.

IV. Patients with cardiac disease that results in an inability to carry on physical activity without discomfort. Symptoms of congestive heart failure are present even at rest. With any physical activity, increased discomfort is experienced.
Non-pharmacologic therapy

<table>
<thead>
<tr>
<th>18.15 General measures for the management of heart failure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Education</strong></td>
</tr>
<tr>
<td>• Explanation of nature of disease, treatment and self-help strategies</td>
</tr>
<tr>
<td><strong>Diet</strong></td>
</tr>
<tr>
<td>• Good general nutrition and weight reduction for the obese</td>
</tr>
<tr>
<td>• Avoidance of high-salt foods and added salt, especially for patients with severe congestive heart failure</td>
</tr>
<tr>
<td><strong>Alcohol</strong></td>
</tr>
<tr>
<td>• Moderation or elimination of alcohol consumption. Alcohol-induced cardiomyopathy requires abstinence</td>
</tr>
<tr>
<td><strong>Smoking</strong></td>
</tr>
<tr>
<td>• Cessation</td>
</tr>
<tr>
<td><strong>Exercise</strong></td>
</tr>
<tr>
<td>• Regular moderate aerobic exercise within limits of symptoms</td>
</tr>
<tr>
<td><strong>Vaccination</strong></td>
</tr>
<tr>
<td>• Influenza and pneumococcal vaccination should be considered</td>
</tr>
</tbody>
</table>
Pharmacologic therapy

Management of Heart Failure

Stage A: High risk with no symptoms
- Control risk factors
  - Treat HTN, DM, HLD, CAD
- Eliminate alcohol
- Smoking cessation
- Regular exercise
- ACEI* or ARB
  - All measures under stage A

Stage B: Structural heart disease, no symptoms
- LVH, LVEF <40
- No signs and symptoms of HF
- ACEI* or ARB and BB titrated to target/maximum tolerated doses

Stage C: Structural heart disease, previous or current symptoms
- Volume overload
  - Diuretics
- Salt and H₂O restriction
- Consider (aldosterone blockers, hydralazine/nitrate, digoxin)**
  - In selected patients ICD and for cardiac synchronization
- ACEI*/BB titrated to target/maximum tolerated doses
- No symptom improvement

Stage D: Refractory symptoms requiring special intervention
- Refractory HF
- Cardiac transplant
- Permanent/destination mechanical circulatory support

* If ACEI induces cough, switch to ARB
** Consider aldosterone blocker as next agent unless est CrCl <30 mL/minute and serum potassium >5.0 mEq/L

FIGURE 19-5 Stages in the development of heart failure and recommended therapy by stage. ACEI, angiotensin-converting enzyme inhibitors; ARB, angiotensin receptor blockers; BB, β-blockers; CAD, coronary artery disease; CrCl, creatinine clearance; DM, diabetes mellitus; EF, ejection fraction; HLD, hyperlipidemia; HTN, hypertension; ICD, implantable cardioverter-defibrillator; LVH, left ventricular hypertrophy.
Heart Failure

- The most common reason for hospitalization in adults >65 years old.
Heart Failure- (progression)

Mild

Control With

Drugs
Diet
Fluid
Restriction

CDHF (Pulmonary Edema)

Cardiogenic shock
Cardiomyopathy

Severe End Stage
Irreversible

Needs new ventricle

Emergency - Upright, O2, morphine, etc

VAD
IABP
Heart Transplant
Definition-Heart Failure (HF)
Key Concepts

• CO = SV x HR-becomes insufficient to meet metabolic needs of body

• SV- determined by preload, afterload and myocardial contractility

• EF< 40% (need to understand)

• *Classifications HF
  – Systolic failure- dec. contractility
  – Diastolic failure- dec. filling
  – Mixed
• **Keys to understanding HF**

• All organs (liver, lungs, legs, etc.) return blood to heart
• When heart begins to fail/ weaken > unable to pump blood forward-fluid backs up > Inc. pressure within all organs.
  • Organ response
  • LUNGS: congested > “stiffer”, inc effort to breathe; fluid starts to escape into alveoli; fluid interferes with O2 exchange, aggravates shortness of breath.

![Diagram showing blood flow and pressure changes in heart failure.](image)

• Shortness of breath during exertion, may be early symptoms > progresses > later require extra pillows at night to breathe > experience "P.N.D." or paroxysmal nocturnal dyspnea.
• Pulmonary edema
• Legs, ankles, feet- blood from feet and legs > back-up of fluid and pressure in these areas, heart unable to pump blood as promptly as received > inc. fluid within feet and legs causes fluid to "seep" out of blood vessels; inc. weight
Heart Failure (ADHF) Pneumonic

U  Upright Position
N  Nitrates
L  Lasix
O  Oxygen
A  ACE, ARBs, Amiodorone
D  Dig, Dobutamine
M  Morphine Sulfate
E  Extremities Down
Heart Failure

Etiology and Pathophysiology

• **Systolic failure**- *most common cause*
  – Hallmark finding: Dec. in *left ventricular ejection fraction* (EF)
  • Due to
    – Impaired contractile function (e.g., MI)
    – Increased afterload (e.g., hypertension)
    – **Cardiomyopathy**
    – Mechanical abnormalities (e.g., valve disease)
Heart Failure

Etiology and Pathophysiology

- **Diastolic failure**
  - Impaired ability of ventricles to relax and fill during diastole > dec. stroke volume and CO
  - Diagnosis based on presence of pulmonary congestion, pulmonary hypertension, ventricular hypertrophy
  - *normal ejection fraction (EF)*- *Know why!*
Heart Failure

Etiology and Pathophysiology

- **Mixed systolic and diastolic failure**
  - Seen in disease states such as dilated cardiomyopathy (DCM)
  - Poor EFs (<35%)
  - High pulmonary pressures

- **Biventricular failure** (both ventricles may be dilated and have poor filling and emptying capacity)
Factors effecting heart pump effectiveness

**Preload**

- Volume of blood in ventricles at *end diastole*
- Depends on venous return
- Depends on compliance

**Afterload**

- Force needed to eject blood into circulation
- Arterial B/P, pulmonary artery pressure
- Valvular disease increases afterload
Cardiomegaly/ventricular remodeling occurs as heart overworked by changes in size, shape, and function of heart after injury to left ventricle. Injury due to acute myocardial infarction or due to causes that inc. pressure or volume overload as in Heart failure.
Heart Failure
(AKA-congestive heart failure)

• *Pathophysiology*

• **A.** Cardiac compensatory mechanisms
  – 1. tachycardia
  – 2. ventricular dilation - Starling’s law
  – 3. myocardial hypertrophy
    • Hypoxia leads to dec. contractility
Pathophysiology-Summary

- B. Homeostatic Compensatory mechanisms
- Sympathetic Nervous System- *(beta blockers block this)*
  - 1. Vascular system- norepinephrine- vasoconstriction (What effect on *afterload*?)
  - 2. Kidneys
    - A. Dec. CO and B/P > renin angiotensin release. (ACE)
    - B. Aldosterone release > Na and H2O retention
  - 3. Liver- stores venous volume (ascites, +HJR, Hepatomegaly- can store 10 L. check enzymes

Counter-regulatory-

- Inc. Na > release of ADH (diuretics)
- Release of atrial natriuretic factor > Na and H2O excretion, *prevents severe cardiac decompensation*
- What is **BNP**? What drug is **synthetic form BNP**?
Heart Failure

Etiology and Pathophysiology

- **Compensatory mechanisms** - activated to maintain adequate CO
  - Neurohormonal responses: *Endothelin* - stimulated by ADH, catecholamines, and angiotensin II
    - Arterial vasoconstriction
    - Inc. in cardiac contractility
    - Hypertrophy
**Heart Failure**

*Etiology and Pathophysiology*

- **Counter regulatory processes**
  - Natriuretic peptides: atrial natriuretic peptide (ANP) and b-type natriuretic peptide (BNP)- *also dx test for HF*

- Released in response to inc. in atrial volume and ventricular pressure
- Promote venous and arterial vasodilation, **reduce preload and afterload**
- Prolonged HF > *depletion of these factors*
Heart Failure

Etiology and Pathophysiology

• Counter regulatory processes
  – Natriuretic peptides- *endothelin and aldosterone antagonists*
    • Enhance diuresis
    • Block effects of the RAAS
  – Natriuretic peptides- *inhibit development of cardiac hypertrophy*; may have antiinflammatory effects
Pathophysiology -

**Structural Changes with HF**

- Dec. contractility
- Inc. preload (volume)
- Inc. afterload (resistance)
- **Ventricular remodeling** *(ACE inhibitors can prevent this)*
  - Ventricular hypertrophy
  - Ventricular dilation
FLUID OVERLOAD > Acute Decompensated Heart Failure (ADHF)/Pulmonary Edema

> Medical Emergency
Heart Failure

*Classification Systems*

- New York Heart Association Functional Classification of HF
  - Classes I to IV
- ACC/AHA Stages of HF (newer)
  - Stages A to D
### NYHA Functional Classification of Heart Disease

**Class I**  
No limitation of physical activity. Ordinary physical activity does not cause fatigue, dyspnea, palpitations, or anginal pain.

**Class II**  
Slight limitation of physical activity. No symptoms at rest. Ordinary physical activity results in fatigue, dyspnea, palpitations, or anginal pain.

**Class III**  
Marked limitation of physical activity. Usually comfortable at rest. Ordinary physical activity causes fatigue, dyspnea, palpitations, or anginal pain.

**Class IV**  
Inability to carry on any physical activity without discomfort. Symptoms of cardiac insufficiency or of angina may be present even at rest. If any physical activity is undertaken, discomfort is increased.

### ACC/AHA Stages of Heart Failure

**Stage A**  
Patients at high risk of developing left ventricular dysfunction because of the presence of conditions that are strongly associated with the development of HF.

**Stage B**  
Patients who developed structural heart disease that is strongly associated with the development of HF but who have never shown signs of HF.

**Stage C**  
Patients who have current or prior symptoms of HF associated with underlying structural heart disease.

**Stage D**  
Patients with advanced structural heart disease and marked symptoms of HF at rest despite maximal medical therapy and who require specialized interventions.

*ACC/AHA, American College of Cardiology/American Heart Association; HF, heart failure; NYHA, New York Heart Association.*

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ACC/AHA Stages

**Stage A**
- High risk for developing CHF
- No structural disorder of heart

**Stage B**
- Structural disorder of heart
- Never developed symptoms of CHF

**Stage C**
- Past or current symptoms of CHF
- Symptoms associated with underlying heart disease

**Stage D**
- End-stage disease
- Requires specialized treatment strategies

NY ASSN Funct Class

**Class I**
- No limitation of physical activity
- Ordinary activity does not cause fatigue, palpitations, dyspnea, or angina

**Class II**
- Slight limitation of physical activity
- Comfortable at rest
- Ordinary activity results in fatigue, palpitations, dyspnea, or angina

**Class III**
- Marked limitation of physical activity
- Comfortable at rest
- Less than ordinary activity results in fatigue, palpitations, dyspnea, or angina

**Class IV**
- Inability to carry on any physical activity without discomfort
- Symptoms present even at rest
- Symptoms exacerbated by any activity

**Class IIIa**
- No dyspnea at rest

**Class IIIb**
- Recent dyspnea at rest

**Treatment Options**
| Stage A | At high risk for developing heart failure. Includes people with:  
|         | Hypertension  
|         | Diabetes mellitus  
|         | CAD (including heart attack)  
|         | History of cardiotoxic drug therapy  
|         | History of alcohol abuse  
|         | History of rheumatic fever  
|         | Family history of CMP  
|         | Exercise regularly  
|         | Quit smoking  
|         | Treat hypertension  
|         | Treat lipid disorders  
|         | Discourage alcohol or illicit drug use  
|         | If previous heart attack/current diabetes mellitus or HTN, use ACE-I  |
| Stage B | Those diagnosed with “systolic” heart failure - have *never* had symptoms of heart failure (usually by finding an ejection fraction of less than 40% on echocardiogram  
|         | Care measures in Stage A +  
|         | Should be on ACE-I  
|         | Add beta-blockers  
|         | Surgical consultation for coronary artery revascularization and valve repair/replacement (as appropriate  
| Stage C | Patients with known heart failure with *current or prior* symptoms.  
|         | Symptoms include: SOB, fatigue  
|         | Reduced exercise intolerance  
|         | All care measures from Stage A apply, ACE-I and beta-blockers should be used + Diuretics, Digoxin,  
|         | Dietary sodium restriction  
|         | Weight monitoring, Fluid restriction  
|         | Withdrawal drugs that worsen condition  
|         | Maybe Spironolactone therapy  
| Stage D | Presence of advanced symptoms, *after* assuring optimized medical care  
|         | All therapies - Stages A, B and C + evaluation for: Cardiac transplantation, VADs, surgical options, research therapies, Continuous intravenous inotropic infusions/ End-of-life care  |
Heart Failure
Etiology and Pathophysiology

- Primary risk factors
  - Coronary artery disease (CAD)
  - Advancing age
- Contributing risk factors
  - Hypertension
  - Diabetes
  - Tobacco use
  - Obesity
  - High serum cholesterol
  - African American descent
  - Valvular heart disease
  - Hypervolemia
CHF-due to

− 1. Impaired cardiac function
  • Coronary heart disease
  • Cardiomyopathies
  • Rheumatic fever
  • Endocarditis

− 2. Increased cardiac workload
  • Hypertension
  • Valvular disorders
  • Anemias
  • Congenital heart defects

− 3. Acute non-cardiac conditions
  • Volume overload
  • Hyperthyroid, Fever, infection
Classifications- (how to describe)

• Systolic versus diastolic
  – Systolic- loss of contractility get dec. CO
  – Diastolic- decreased filling or preload

• Left-sided versus right –sided
  – Left- lungs
  – Right-peripheral

• High output- hypermetabolic state

• Acute versus chronic
  – Acute- MI
  – Chronic-cardiomyopathy
Symptoms

- Shortness of breath
- Swelling of feet & legs
- Chronic lack of energy
- Difficulty sleeping at night due to breathing problems
- Swollen or tender abdomen with loss of appetite
- Cough with frothy sputum
- Increased urination at night
- Confusion and/or impaired memory
Left Ventricular Failure

- Signs and symptoms
  - dyspnea
  - orthopnea PND
  - Cheyne Stokes
  - fatigue
  - Anxiety
  - rales

- NOTE L FOR LEFT AND L FOR LUNGS
- Why does this occur??
Heart Failure

Clinical Manifestations

- Acute decompensated heart failure (ADHF)
  - > Pulmonary edema, often life-threatening
  - Early
    - Increase in the respiratory rate
    - Decrease in PaO$_2$
  - Later
    - Tachypnea
    - Respiratory acidemia
Heart Failure

Clinical Manifestations

• Acute decompensated heart failure (ADHF)

• Physical findings
  • Orthopnea
  • Dyspnea, tachypnea
  • Use of accessory muscles
  • Cyanosis
  • Cool and clammy skin

• Physical findings
  • *Cough with frothy, blood-tinged sputum—why???
  > (see next slide)
  • Breath sounds: Crackles, wheezes, rhonchi
  • Tachycardia
  • Hypotension or hypertension
ADHF/Pulmonary Edema (advanced L side HF)

- When PA WEDGE pressure is approx 30mmHg
  - Signs and symptoms
    - 1. wheezing
    - 2. pallor, cyanosis
    - 3. Inc. HR and BP
    - 4. s3 gallop
    - 5. rales, copious pink, frothy sputum

The Auscultation Assistant - Rubs and Gallops
Right Heart Failure

• Signs and Symptoms
  – fatigue, weakness, lethargy
  – wt. gain, inc. abd. girth, anorexia, RUQ pain
  – elevated neck veins
  – Hepatomegaly +HJR
  – may not see signs of LVF
What does this show?
What is present in this extremity, common to right sided HF?
Can You Have RVF Without LVF?

- What is this called?

**COR PULMONALE**

Cor pulmonale, or right-sided heart failure, is an enlargement of the right ventricle due to high blood pressure in the lungs usually caused by chronic lung disease.
Heart Failure

Complications

- Pleural effusion
- Atrial fibrillation (most common dysrhythmia)
  - Loss of atrial contraction (kick) - reduce CO by 10% to 20%
  - Promotes thrombus/embolus formation inc. risk for stroke
  - Treatment may include cardioversion, antidysrhythmics, and/or anticoagulants
Heart Failure

Complications

• **High risk of fatal dysrhythmias** (e.g., sudden cardiac death, ventricular tachycardia) with HF and an EF <35%

  – HF lead to severe hepatomegaly, especially with RV failure
    • Fibrosis and cirrhosis - develop over time
  – Renal insufficiency or failure
Heart Failure

Diagnostic Studies

• Primary goal - determine underlying cause
  – History and physical examination (dyspnea)
  – Chest x-ray
  – ECG
  – Lab studies (e.g., cardiac enzymes, BNP- (beta natriuretic peptide- normal value less than 100) electrolytes
  – EF
Heart Failure

**Diagnostic Studies**

- Primary goal - determine underlying cause
  - Hemodynamic assessment-Hemodynamic Monitoring-CVP- (right side) and Swan Ganz (left and right side)
  - Echocardiogram-TEE best
  - Stress testing- exercise or medicine
  - Cardiac catheterization- determine heart pressures (inc.PAW)
  - Ejection fraction (EF)
Nursing Assessment

- Vital signs
- PA readings
- Urine output
- What else!!
Decreased cardiac output

- Plan frequent rest periods
- Monitor VS and O2 sat at rest and during activity
- Take apical pulse
- Review lab results and hemodynamic monitoring results
- Fluid restriction - keep accurate I and O
- Elevate legs when sitting
- Teach relaxation and ROM exercises
Knowledge deficit

- Low Na diet
- Fluid restriction
- Daily weight
- When to call Dr.
- Medications
• Improve cardiac function
  – For patients who do not respond to conventional pharmacotherapy - (e.g.- O2, even intubate, high Fowler’s, diuretics, vasodilators, morphine sulfate)
  
• Inotropic therapy
  – Digitalis
    β-Adrenergic agonists (e.g., dopamine)
  – Phosphodiesterase inhibitors (e.g., milrinone)
  – Caution – re- calcium channel blockers- dec. contractility- only amilodopine (Norvasc) approved even in mild heart failure)

• Hemodynamic monitoring
Chronic HF

Collaborative Management

• O2 (non-rebreather if emergency); morphine, diuretics, etc-dec preload, afterload

• Physical and emotional rest

• Nonpharmacologic therapies
  – Cardiac resynchronization therapy (CRT) or biventricular pacing
  – Cardiac transplantation
CRT - Cardiac Resynchronization Therapy

**HOW IT WORKS:**

Standard implanted pacemakers - equipped with two wires (or "leads") conduct pacing signals to specific regions of heart (usually at positions A and C).

Biventricular pacing devices have added a third lead (to position B) that is designed to conduct signals directly into the left ventricle. Combination of all three lead > synchronized pumping of ventricles, inc. efficiency of each beat and pumping more blood on the whole.
Chronic HF - Collaborative Management

Drug therapy

- **Diuretics**
  - Thiazide
  - Loop
  - Spironolactone

- **Vasodilators**
  - ACE inhibitors - pril or ril *first line heart failure*
  - Angiotensin II receptor blockers
  - Nitrates
  - β-Adrenergic blockers - al or ol
  - **Nesiritide** - Natrecor (BNP)
• Drug therapy (cont’d)
  – *Positive inotropic agents*
    • Digitalis
    • Calcium sensitizers- *(Levosimendan)* new under research; cardioprotective, inc. cardiac contractility
  – *BiDil* (combination drug containing isosorbide dinitrate and hydralazine) approved only for the treatment of HF in African Americans
Chronic HF
Collaborative Management

• Nutritional therapy
  – Diet/weight reduction recommendations - individualized and culturally sensitive
  – Dietary Approaches to Stop Hypertension (DASH) diet recommended
  – Sodium - usually restricted to 2.5 g per day
  – Potassium encouraged unless on K sparing diuretics (Aldactone)
Chronic HF
Collaborative Management

• Nutritional therapy
  – Fluid restriction may or may not be required
  – **Daily weights** important
    • Same time, same clothing each day
  – *Weight gain* of 3 lb (1.4 kg) over 2 days or a 3-to 5-lb (2.3 kg) gain over a week-report to health care provider
Intraaortic Balloon Pump (IABP)

- Provides temporary circulatory assistance
  - ↓ Afterload
  - Augments aortic diastolic pressure
- Outcomes
  - Improved coronary blood flow
  - Improved perfusion of vital organs
Intraaortic balloon pump

Balloon increases blood flow to the heart and relieves some of the workload by inflating when the heart relaxes and deflating just before the heart contracts.

This perspective shows the aorta as it extends down behind the heart.
10 Commandments of Heart Failure Treatment

1. Maintain patient on 2- to 3-g sodium diet. Follow daily weight. Monitor standing blood pressures in the office, as these patients are prone to orthostasis. Determine target/ideal weight, which is not the dry weight. In order to prevent worsening azotemia, some patients will need to have some edema. Achieving target weight should mean no orthopnea or paroxysmal nocturnal dyspnea. Consider home health teaching.

2. Avoid all nonsteroidal anti-inflammatory drugs because they block the effect of ACE inhibitors and diuretics. The only proven safe calcium channel blocker in heart failure is amlodipine (Lotrel /Norvasc).

3. Use ACE inhibitors in all heart failure patients unless they have an absolute contraindication or intolerance. Use doses proven to improve survival and back off if they are orthostatic. In those patients who cannot take an ACE inhibitor, use an angiotensin receptor blocker like irbesartan (Avapro).

4. Use loop diuretics (like furosemide [Lasix]) in most NYHA class II through IV patients in dosages adequate to relieve pulmonary congestive symptoms. Double the dosage (instead of giving twice daily) if there is no response or if the serum creatinine level is > 2.0 mg per dL (180 µmol per L).

5. For patients who respond poorly to large dosages of loop diuretics, consider adding 5 to 10 mg of metolazone (Zaroxolyn) one hour before the dose of furosemide once or twice a week as tolerated.
The 10 Commandments of Heart Failure Treatment

6. Consider adding 25 mg spironolactone in most class III or IV patients. Do not start if the serum creatinine level is > 2.5 mg per dL (220 µmol per L).

7. Use metoprolol (Lopressor), carvedilol (Coreg) or bisoprolol (Zebeta) (beta blockers) in all class II and III heart failure patients unless there is a contraindication. Start with low doses and work up. Do not start if the patient is decompensated.

8. Use digoxin in most symptomatic heart failure patients.

9. Encourage a graded exercise program.

10. Consider a cardiology consultation in patients who fail to improve.

ACE = angiotensin-converting enzyme.
Medical Treatment-Drug Therapy (typical)

- Cardiac Glycoside-Digoxin
- Positive inotropes-dobutamine, Primacor. Natrecor
- Antihypertensives- WHY
- ACE inhibitors- stops remodeling (pril or ril)
  - Catopril, enalapril, cozar, lisinopril
- Preload reduction *MSO4- important,
  - Vasodilators-nitrates
  - Diuretics-lasix, HCTZ, (Aldactone and Inspra)
  - Beta blockers- dec. effects of SNS (Coreg)
  - *Caution with CALCIUM CHANNEL BLOCKERS- dec cardiac contractility
Meds!

**Angiotensin-converting enzyme inhibitors**, such as captopril and enalapril, block conversion of angiotensin I to angiotensin II, a vasoconstrictor that can raise BP. These drugs alleviate heart failure symptoms by causing vasodilation and decreasing myocardial workload.

**Beta-adrenergic blockers**, such as bisoprolol, metoprolol, and carvedilol, reduce heart rate, peripheral vasoconstriction, and myocardial ischemia.

**Diuretics** prompt kidneys to excrete sodium, chloride, and water, reducing fluid volume. Loop diuretics such as furosemide, bumetanide, and torsemide are preferred first-line diuretics because of efficacy in patients with and without renal impairment. Low-dose spironolactone may be added to a patient's regimen if he has recent or recurrent symptoms at rest despite therapy with ACE inhibitors, beta-blockers, digoxin, and diuretics.

**Digoxin** increases the heart's ability to contract and improves heart failure symptoms and exercise tolerance in patients with mild to moderate heart failure.
Other drug options include nesiritide (Natrecor), a preparation of human BNP that mimics the action of endogenous BNP, causing diuresis and vasodilation, reducing BP, and improving cardiac output.

Intravenous (I.V.) positive inotropes such as dobutamine, dopamine, and milrinone, as well as vasodilators such as nitroglycerin or nitroprusside, are used for patients who continue to have heart failure symptoms despite oral medications. Although these drugs act in different ways, all are given to try to improve cardiac function and promote diuresis and clinical stability.
The nurse is caring for a hospitalized client with heart failure who is receiving captopril (Capoten) and spironolactone (aldactone). Which lab value will be most important to monitor?

- A. Sodium
- B. Blood urea nitrogen (BUN)
- C. Potassium
- D. Alkaline phosphatase (ALP)

C. Potassium
Heart (or cardiac) failure:
It is defined as the inefficiency of the heart to pump sufficient amount of oxygenated blood to the organs to meet the metabolic demands and to collect the blood from the organs.

Congestive heart failure (CHF):
It is complex clinical syndrome characterized by abnormalities of left ventricular function and neurohormonal regulation, which are accompanied by effort intolerance, fluid retention, and reduced longevity.
Based on amount of cardiac output

**Low-cardiac output failure**
- It is most common congestive heart failure.
- The metabolic demands of the body organs are normal within limits but the heart fails to pump sufficient amount of oxygenated blood to the organs of the body.
- The primary cause of LCOF is the *ventricular systolic dysfunction* and *ventricular diastolic dysfunction*.

- **Ventricular systolic dysfunction**
  - Myocardial infarction weakens the muscles of ventricles and make them inefficient to pump the required volume of blood.
  - Thus results in low cardiac output and low ejection fraction.

- **Ventricular diastolic dysfunction**
  - Hypertrophy is responsible for the stiffening of heart muscle
  - The stiffened muscle of the ventricles fails to relax during diastolic and thus cannot collect sufficient amount of blood.
  - This ultimately results in low cardiac output.
High cardiac output failure

- It occurs very rarely.
- Hyperthyroidism, anaemia & arteriovenous shunt, enhances the metabolic demands of the body for myocardial oxygen, which cannot be met even by the increased pumping action of the heart.

<table>
<thead>
<tr>
<th>Low cardiac output failure</th>
<th>High cardiac output failure</th>
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</thead>
<tbody>
<tr>
<td>Most frequent</td>
<td>Very rarely</td>
</tr>
<tr>
<td>Metabolic demands of the body organs for oxygen are <strong>normal and within limits</strong></td>
<td>Metabolic demands of the body for oxygen is <strong>very high</strong></td>
</tr>
<tr>
<td>Myocardial fraction is prominent factor leading to the failure of systolic &amp; diastolic function of the ventricles, ultimately results in low cardiac output failure</td>
<td>Hyperthyroidism, anaemia, arteriovenous shunt causes high cardiac output failure.</td>
</tr>
</tbody>
</table>
**Right side cardiac failure**

- The failure of right ventricle to pump the entire blood present in it during systole results in retention of some amount of blood after every systole.
- Thus blood is accumulated in right ventricle after few systoles.
- The left ventricle fails to accept the blood from peripheral organs and ultimately results in generalized systemic oedema or peripheral oedema.

<table>
<thead>
<tr>
<th>Left side cardiac failure</th>
<th>Right side cardiac failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the result of <strong>right side cardiac failure</strong></td>
<td>Is the result of <strong>left side cardiac failure</strong></td>
</tr>
<tr>
<td><strong>Inefficient pumping action</strong> of left ventricle is responsible for the accumulation of blood in the ventricles</td>
<td>Inefficient pumping action of right ventricle is responsible for the accumulation of blood in right ventricle</td>
</tr>
<tr>
<td>Left ventricle fails to accept/collection the blood from <strong>lungs due to back pressure</strong></td>
<td>Right ventricle fails to accept/collection the blood from <strong>peripheral organs</strong>.</td>
</tr>
<tr>
<td><strong>Pulmonary congestion/oedema</strong> is the final result</td>
<td><strong>Peripheral generalized oedema</strong> is the final result</td>
</tr>
</tbody>
</table>
Pathophysiology

- Normal filling capacity of left ventricle is about 130 ml, out of which about 70ml undergoes ejection, while the remaining volume persist in the ventricles.
- The volume of blood ejected from the left ventricle reduces to about 55ml in condition of left ventricular systolic dysfunctioning.
- Any factor that tends to increase the stress on the heart or lead to myocardial infraction results in left ventricular systolic dysfunction (LVSD).
- The eventual consequences is an impairment in the systolic contraction or diastolic relaxation or both.
- Impairment in the contracting ability of the heart results in systolic dysfunction, due to this ejection faction tends to get lowered.
- The diastolic function is concerned with the filling of the ventricles, such filling is governed by the venous return and adequate dilation of the ventricles.
- In case of diastolic dysfunction, the ventricles do not dilate properly resulting in relatively less filling.
- If the diastolic dysfunction persists for longer periods, it result in systolic dysfunction and remodelling of the ventricles.
Compensatory mechanisms of congestive heart failure

- To enhances the cardiac output, body compensates for the intrinsic cardiac effects in the following manner.

1. **Increased sympathetic discharge**
   - To compensate for the decreased B.P, **baroreceptors** located in the **arch of aorta** carotid sinuses and walls of the heart get stimulated and **causes activation of beta-adrenergic receptors** leading to an increase in rate and force of contraction of heart.
   - An increase in venous return (preload) is also seen due to the **activation of alpha-adrenergic receptors**.
   - Increased **rate and force of contraction** together with the increased **preload** results in an initial increase in the **cardiac output**.
   - Vasoconstriction of the arteries due to alpha stimulation also causes an increase in after load, leading to fall in ejection fraction.
   - As a result the cardiac output decreases.
• Fall in the cardiac output decreases the renal perfusion rate, as a result the RAA system gets activated.

• Angiotensin 2 causes vasoconstriction and an increase in the peripheral vascular resistance (PVR).

• While aldosterone leads to increased retention of sodium and water, thereby increasing the blood volume.

• PVR effects the after load during which the heart is unable to pump the extra blood volume.

• This leads to the development of back up pressure causing pulmonary congestion and peripheral oedema.
Clinical manifestations/signs and symptoms

• Fluid retention
• Pulmonary congestion
• Dyspnoea & orthopnoea

CVS MANIFESTATIONS
• Resting tachycardia
• Ventricular arrhythmias
• Enlargement of heart

RENAL MANIFESTATIONS
• Nocturia
• Oliguria

OTHER MANIFESTATIONS
• Reduced cardiac output lead to poor perfusion of skeletal muscle resulting in fatigue.
• Reduced perfusion to brain results in altered mental states & confusion.
• Reduced perfusion may also causes the patient to appear pale with cold and sweaty hands.
Non-drug Treatment/ Non-pharmacological Approach:

- Physical exercise
- Salt intake
- Fluid intake
- Alcohol consumption
- Liquorice
There are two distinct goals of drug therapy in CHF:

- **Relief of congestion/low cardiac output symptoms & restoration of cardiac performance:**
  - Inotropic drugs: digoxin, dobutamine, amrinone/milrinone.
  - Diuretics: furosemide, thiazides.
  - Vasodilators: ACE inhibitors/AT1 antagonist, hydralazine, nitrate.
  - BETA blocker: metoprolol, bisprolol, carvedilol

- **Arrest/reversal of disease progression & prolongation of survival**
  - ACE inhibitors/AT1 antagonist (ARBs).
  - Beta-blockers
  - Aldosterone antagonist-spironolactone..
Loop Diuretics

- **Furosemide, Bumetanide, Torsemid**
  - The Na+, K+, 2Cl- symporter, a carrier-mediated process.
  - It is the major reabsorptive mechanism in the thick ascending limb (TAL).
  - All four ions are transported by secondary active transport into the TAL epithelial cells, at their apical surface, using the energy derived from the Na+/K+-ATPase co-transporter, also a carrier-mediated mechanism.

**Mechanism of Action of Loop Diuretics:**

- Loop diuretics act on the Na-K-2Cl symporter in the thick ascending limb of the loop of Henle to inhibit sodium and chloride reabsorption. Because magnesium and calcium reabsorption in the thick ascending limb is dependent on sodium and chloride concentrations.
- Loop diuretics also inhibit their reabsorption. By disrupting the reabsorption of these ions, loop diuretics prevent the urine from becoming dilute and disrupt the generation of a hypertonic renal medulla. Without such a concentrated medulla, water has less of an osmotic driving force to leave the collecting duct system, ultimately resulting in increased urine production. This diuresis leaves less water to be reabsorbed into the blood, resulting in a decrease in blood volume.
- Loop diuretics cause vasodilation of the veins and of the kidney's blood vessels, mechanically causing a decrease in blood pressure. The collective effects of decreased blood volume and vasodilation decrease blood pressure.

**Adverse reaction:**
- pre-renal azotemia
- Hypokalemia
- Skin rash
- Ototoxicity
Potassium-Sparing Diuretics

- The K-sparing diuretics are weak diuretics alone.
- They are primarily used as adjuncts to thiazides and loop diuretics or for potassium and magnesium spacing. Instead of using thiazides alone for hypertension, triamterene is also used by combination.

- Amiloride can be used for magnesium deficiency because it increases renal reabsorption.
- If a patient who has hypomagnesemia, and you can't give them enough magnesium orally, because of laxative action, give amiloride.
- Also, amiloride is useful for patients taking lithium who have polyuria and complain of having to get up three or four times at night. At a dose of 5 mg bid, amiloride reduces urine volume by 30%.
- "Don't use any K-sparing diuretics with angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers [or] nonsteroidals.
- Be cautioned against using them when serum creatinine levels are above 2 mg/dL.

Specific side effects seen with K-sparing diuretics include

- Hyperchloremic acidosis;
- Hyperkalemia, especially if administered with an ACE inhibitor, angiotensin II receptor blocker or in patients with diabetes;
- Gynecomastia, impotence in men or irregular menstrual cycles in women (only with use of spironolactone);
- Folic acid deficiency (with chronic use of triamterene); or acute renal failure (with triamterene when used with indomethacin [Indocin]).
**K⁺ Sparing Agents**

- **Triamterene & amiloride**—acts on distal tubules to ↓ K secretion
- **Spironolactone** (Aldosterone antagonist)
  - It improves survival in CHF patients due to the effect on renin-angiotensin-aldosterone system with subsequent effect on myocardial remodeling and fibrosis.
- **Aldosterone inhibition** minimize potassium loss, prevent sodium and water retention, endothelial dysfunction and myocardial fibrosis.
• The **renin-angiotensin system (RAS)** or the **renin-angiotensin-aldosterone system (RAAS)** is a hormone system that **regulates blood pressure and water (fluid) balance**.

• When blood volume is low, **juxtaglomerular cells** in the kidneys secrete renin directly into circulation.

• Plasma renin then carries out the conversion of angiotensinogen released by the liver to angiotensin I.

• Angiotensin I is subsequently converted to angiotensin II by the enzyme angiotensin converting enzyme found in the lungs.

• Angiotensin II is a potent vaso-active peptide that causes blood vessels to constrict, resulting in increased blood pressure.

• Angiotensin II also stimulates the secretion of the hormone aldosterone from the adrenal cortex

• Aldosterone causes the tubules of the kidneys to increase the reabsorption of sodium and water into the blood. This increases the volume of fluid in the body, which also increases blood pressure.

• If the renin-angiotensin-aldosterone system is too active, blood pressure will be too high.

• There are many drugs that interrupt different steps in this system to lower blood pressure. These drugs are one of the main ways to control high blood pressure (hypertension), heart failure, kidney failure, and harmful effects of diabetes.
Inhibitors of Renin- Angiotensin-Aldosterone System

- Angiotensin converting enzyme inhibitors
- Angiotensin receptors blockers
- Spironolactone (Aldosterone antagonist)
Angiotensin Converting Enzyme (ACE) Inhibitors

- Captopril, Lisinopril, Enalapril, Ramipril, Quinapril.

Mode of action:

- Angiotensin 1 → Angiotensin 2

- Hences, they inhibit the generation of angiotensin 2, a potent vasoconstrictor.
- They also inhibit the release of aldosterone & vasopressin, thereby inhibiting fluid and salt retention thus decreasing the preload.
- Elevate the levels of bradykinin, vasodilator thus enhancing renal & cardiac perfusion.
Angiotensin Receptor AT-1 blockers (ARB)

Losartan, candesartan, valsartan

- Angiotensin 2, a vasoconstrictor is concerned with ventricular remodelling and fluid retention.
- These drugs inhibit the binding of angiotensin 2 to its AT₁ receptor.
- Thus they preclude the above mentioned effects of angiotensin 2.
- These agents do not exert any action on bradykinin and thus do not produce cough.
- Has comparable effect to ACE I
- Can be used in certain conditions when ACE I are contraindicated

**Adverse drug reactions**

- Hypotension
- Impariment of renal functioning

**Dose**

- **Candesartan**
  - Initial: 4-8mg
  - Targeted dose - 32mg

- **Valsartan**
  - Initial: 40mg
  - Targeted dose - 160mg
Cardiac glycosides: Digoxin (DIGITALIS)

- It inhibits the Na⁺,K⁺-ATPase pump which:
  - Functions in the exchange of Na⁺ for K⁺ ions.
  - Such blockage results in intracellular accumulation of Na⁺ ions.
  - These ions are then exchanged with Ca²⁺ ions through Na⁺ - Ca²⁺ exchange carries.
  - These Ca²⁺ ions increase the contractility of the myocardium which is beneficial to the failing heart.

- Digoxin enhances the cholinergic activity which:
  - Reduces the HR and AV conduction.
  - Due to this, the time required for diastolic filling gets enhanced while the myocardial O₂ consumption is retarded.

- The sympathetic outflow comprising renin, aldosterone is also decreased by dioxin.
Drug reaction

- Bradycardia
- Nausea
- Vomiting
- Visual disturbances
- Non paroxysomal junctional tachycardia
- Supraventricular tachycardia
- Sexual dysfunction
- Neuralgic pain

USES:
- For tachyarrhythmias
- For ventricular arrhythmias
Dopamine

• Dopamine acts at a variety of receptors (dose dependant)
• Rapid elimination- can only be administered as a continuous infusion

Dobutamine

• Stimulates beta-adrenergic receptors and produces a positive inotropic response.

• Unlike the vasoconstriction seen with high doses of dopamine, dobutamine produces a mild vasodilatation
BIPYRIDINES
phosphodiesterase inhibitors

• Targets PDE -3 (found in cardiac and smooth muscle)
• Ex. Inamrinone, milrinone

alter the intracellular movements of calcium by influencing the sarcoplasmic reticulum

increasing inward calcium flux in the heart during the action potential

Inhibition of PDE3

the conversion of inactive protein kinase to active form

Protein kinases are responsible for phosphorylation of Ca channels

increased Ca entry into the cell

↑ Vascular Permeability leads to ↓ in intravascular fluid Volume

increase in contractility

Increase in cAMP

vasodilation
- Isosorbide dinitrate, isosorbide mononitrate, and hydralazine also used specially in patients who cannot tolerate ACE inhibitors.
Vasodilator (Hydralazine)

- It directly relaxes the arterioles & arteries reducing the peripheral vascular resistances & preload.
- It also help to reduce after load.

**Adverse drug reaction:**
- Nausea
- Palpitation
- Tachycardia
- Salt & water retention on prolong therapy.
Nitroglycerin is denitrated by glutathione S-transferase in smooth muscle.

Free nitrite ion is released, which is then converted to Nitric Oxide.

Activation of guanylyl cyclase enzyme.

Increase in cGMP.

Dephosphorylation of myosin light chain, preventing the interaction of myosin with actin (myosin light chain kinase essential for smooth muscle contraction).

Results in vasodilation.
NISIRITIDE (BNP)

- Brain (B-type) natriuretic peptide (BNP) is secreted constitutively by ventricular myocytes in response to stretch
- Niseritide = recombinant human BNP
- Naturally occurring atrial natriuretic peptide may vascular permeability may reduce intravascular volume

Main Side Effect:
- hypotension
Human BNP binds to the particulate guanylate cyclase receptor of vascular smooth muscle and endothelial

- intracellular concentrations (cGMP) ↑
- smooth muscle cell relaxation
- dilate veins and arteries
- systemic and pulmonary vascular resistances ↑
- Indirect ↑ in cardiac output and diuresis.
- Effective in HF because preload and afterload ↓
B-type natriuretic peptide (BNP) is a hormone produced by your heart. BNP is released in response to changes in pressure inside the heart. These changes can be related to heart failure and other cardiac problems. Levels go up when heart failure develops or gets worse, and levels go down when heart failure is stable. In most cases, BNP levels are higher in patients with heart failure than people who have normal heart function.
It’s measurement is a simple blood test to help diagnose or monitor heart failure.
Recombinant BNP (nesiritide) has been evaluated and approved for adjunctive therapy for acute CHF, although subsequent evidence of harm dramatically diminished its use for this indication.
An implantable cardioverter-defibrillator (ICD) is a specialized device designed to directly treat many dysrhythmias, and it is specifically designed to address ventricular tachyarrhythmias (V-tach) specially in patients with low ejection fraction post MI.
A permanent pacemaker is an implanted device that provides electrical stimuli, thereby causing cardiac contraction when intrinsic myocardial electrical activity is inappropriately slow or absent. All modern ICDs also function as pacemakers.
Renin-Angiotensin System Inhibition With Angiotensin-Converting Enzyme Inhibitor or Angiotensin Receptor Blocker or ARNI: The introduction of an angiotensin receptor–neprilysin inhibitor (ARNI) (valsartan/sacubitril) and a sinoatrial node modulator (ivabradine), complements established pharmacological and device-based therapies and represents a milestone in the evolution of care for patients with heart failure (HF). Accordingly, the writing committees of the “2016 ACC/AHA/HFSA Focused Update on New Pharmacological Therapy for Heart Failure” and the “2016 ESC Guideline on the Diagnosis and Treatment of Acute and Chronic Heart Failure” concurrently developed recommendations for the incorporation of these therapies into clinical practice.