HEART FAILURE
etiology, pathogenesis, types.

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The heart
Right and Left Ventricles

Conductive system of the heart
Heart physiology

• **Essential functions of the heart**
  To cover metabolic needs of body tissue (oxygen, substrates) by adequate blood supply

• **Essential conditions for fulfilling these functions**
  Normal structure and functions of the heart
  Adequate filling of the heart by blood
End diastolic pressure and volume = beginning of isovolumetric contraction.

Isovolumetric relaxation

P = 80 mm Hg, aortic valve opens

P = 110, V = 40, ventricular pressure falls below aortic

Factors Affecting Cardiac Output

Cardiac Output = Heart Rate × Stroke Volume

Preload Afterload Contractility
Preload
Pressure stretching the ventricle of the heart, after passive filling of the ventricle and subsequent atrial contraction, increasing end-diastolic volume

preload = increased diastolic sarcomere length leading to increased tension in muscle before its contraction

- venous return to the heart is important → end-diastolic volume is influenced
- stretching of the sarcomere maximises the number of actin-myosin bridges responsible for development of force
- optimal sarcomere length ~ 2.2 μm

Afterload
It is expressed as tension which must be developed in the wall of ventricles during systole to open the semilunar valves and eject blood to aorta/pulmonary artery

Laplace law:

\[
\text{intraventricular pressure} \times \text{radius of ventricle} = \frac{\text{wall tension}}{2 \times \text{ventricular wall thickness}}
\]

↑ afterload: due to - elevation of arterial resistance
  - ↑ ventricular size
  - myocardial hypertrophy

↓ afterload: due to - ↓ arterial resistance
  - myocardial hypotrophy
  - ↓ ventricular size
Cardiac dysfunctions

Normal heart

Diastolic dysfunction

Systolic dysfunction

Characteristic features of diastolic dysfunction (diastolic failure)

- ventricular cavity size is normal or small
- myocardial contractility is normal or hyperdynamic
- ejection fraction is normal (>50%) or supranormal
- ventricle is usually hypertrophied
- ventricle is filling slowly in early diastole (during the period of passive filling)
- end-diastolic ventricular pressure is increased
Characteristic features of systolic dysfunction (systolic failure)

- ventricular dilatation
- reducing ventricular contractility (either generalized or localized)
- diminished ejection fraction (i.e., that fraction of end-diastolic blood volume ejected from the ventricle during each systolic contraction – less than 45%)
- in failing hearts, the LV end-diastolic volume (or pressure) may increase as the stroke volume (or CO) decreases

Adaptive mechanisms of the heart to increased load

- Frank - Starling mechanism
- Ventricular hypertrophy
  - increased mass of contractile elements → increased strength of contraction
- Increased sympathetic adrenergic activity
  - increased HR, increased contractility
- Increased activity of R–A–A system
Heart failure

Definition

The pathophysiological process in which the heart as a pump is unable to meet the metabolic requirements of the tissue for oxygen and substrates despite the venous return to heart is either normal or increased.

Where every river flows ...

Heart failure is a complex clinical syndrome that can result from any structural or functional cardiac disorder that impair the ventricle to fill with or eject blood.
Terminology

- **Myocardial failure** = abnormalities reside in the *myocardium* and lead to inability of myocardium to fulfill its function

- **Circulatory failure** = any abnormality of the circulation responsible for the inadequacy in body tissue perfusion, e.g. decreased blood volume, changes of vascular tone, heart function disorders

- **Congestive heart failure** = clinical syndrome which is developed due to accumulation of the blood in front of the left or right parts of the heart

Epidemiology

- **Prevalence**
  - Affects nearly 5 million Americans currently, >500,000 new cases diagnosed each year

- **Cost**
  - Annual direct cost in >10 billion dollars

- **Incidence increased with age**
  - Effects 1-2% of patient from 50-59-years-old and 10% of patient over the age of 75

- **Frequency**
  - It is the most common inpatient diagnosis in the US for patients over 65 years of age
  - Visits to their family practitioner on average 2-3 times per year

- **Gender**
  - Men > women in those between 40 and 75 years of age
  - The sexes are equal over 75 years of age
Higher mortality than cancer

Five year Survival of Patients admitted to Hospital in Scotland 1991

The Progressive Development of Cardiovascular Disease
Causes of heart failure

A. MECHANICAL ABNORMALITIES

1. Increased pressure load
   - central (aortic stenosis, aortic coarctation...)
   - peripheral (systemic hypertension)

2. Increased volume load
   - valvular regurgitation
   - hypervolemia

3. Obstruction to ventricular filling
   - valvular stenosis
   - pericardial restriction

B. MYOCARDIAL DAMAGE

1. Primary
   a) cardiomyopathy
   b) myocarditis
   c) toxicity (e.g. alcohol)
   d) metabolic abnormalities (e.g. hyperthyroidism)

2. Secondary
   a) oxygen deprivation (e.g. coronary heart disease)
   b) inflammation (e.g. increased metabolic demands)
   c) chronic obstructive lung disease
C. ALTERED CARDIAC RHYTHM

1. ventricular flutter and fibrilation

2. extreme tachycardias

3. extreme bradycardias

Precipitating factors

- infection, especially pulmonary infection, fever
- physical, environmental, or emotional stress
- increased sodium load
- arrhythmia,
- pulmonary emboli
- pregnancy and delivery
- anemia, bleeding, excessive transfusion
Pathophysiology of heart failure

Preload
Afterload
Vaso-Constriction
Na+ retention

Cardiac Output
A & NA
Blood Pressure

NEURO-ENDOCRINE ACTIVATION
Renin/Angiotensin
Sympathetic sys.
ANP / BNP
Heart failure subgroups

- Systolic Heart Failure
  - Heart failure with reduced ejection fraction

- Diastolic Heart Failure
  - Heart failure with preserved ejection fraction

Systolic vs. Diastolic

- Diastolic dysfunction
  - EF normal or increased
  - Hypertension
  - Due to chronic replacement fibrosis & ischemia-induced decrease in distensibility
- Systolic dysfunction
  - EF < 40%
  - Usually from coronary disease
  - Due to ischemia-induced decrease in contractility
- Most common is a combination of both
Subtypes of Systolic Heart Failure

- **High output**
  - Severe anemia
  - AV malformations
  - Hyperthyroidism

- **Low cardiac output**

- **Right Heart Failure**
  - Peripheral edema

- **Left Heart Failure**
  - Pulmonary congestion

- **Biventricular Failure**
  - Systemic and pulmonary congestion

Acute Left Heart Failure

- **Causes:**
  - extensive acute myocardial infarction;
  - acute myocarditis;
  - malignant or accelerated hypertension;
  - mitral stenosis;
  - severe cardiac arrhythmias;
  - rapid and excessive volume injection
Intra-aortic balloon (IAB) pulsation

**Diastole**
- IAB inflation
  - Increase coronary perfusion
  - Enhance pulsatile coronary arterial flow

**Systole**
- IAB deflation
  - Decrease cardiac work
  - Decrease myocardial VO₂
  - Increase cardiac output

**Definition of diastolic heart failure**

It is pathophysiological process characterized by symptoms and signs of congestive heart failure, which is caused by increased filling resistance of ventricles and increased intraventricular diastolic pressure.

**Primary diastolic heart failure**
- No signs and symptoms of systolic dysfunction is present
- 1 up to 40% of patients suffering from heart failure!

**Secondary diastolic heart failure**
- Diastolic dysfunction is the consequence of primary systolic dysfunction
Pathophysiology of diastolic heart failure

- **systolic heart failure** = failure of ejection function of the heart

- **diastolic heart failure** = failure of filling the ventricles, resistance to filling of ventricles

**Diastolic failure is a widely recognized clinical entity**

But, which of the cardiac cycle is real diastole?

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**Pathophysiology of diastolic heart failure**

1. **structural disorders** → ↑ passive chamber stiffness
   - a) intramyocardial
     - e.g. myocardial fibrosis, amyloidosis, hypertrophy, myocardial ischemia...
   - b) extramyocardial – e.g. constrictive pericarditis

2. **functional disorders** → ↓ relaxation of chambers e.g. myocardial ischemia, advanced hypertrophy of ventricles, failing myocardium, asynchrony in heart functions
Symptoms and signs of heart failure

1. forward failure:
   - symptoms result from inability of the heart to pump enough blood to the periphery (from left heart), or to the lungs (from the right heart)
   
   a) forward failure of left heart:
      - muscle weakness, fatigue, dyspepsia, oliguria....
      - general mechanism: tissue hypoperfusion

   b) forward failure of right heart:
      - hypoperfusion of the lungs → disorders of gas exchange
      - decreased blood supply to the left heart

2. backward failure:
   - symptoms result from inability of the heart to accept the blood coming from periphery and from lungs

   a. backward failure of left heart:
      - increased pulmonary capillary pressure → dyspnoea and tachypnoea, pulmonary edema (cardiac asthma) → arterial hypoxemia and hypercapnia....

   b. backward failure of right heart:
      - increased pressure in systemic venous system → peripheral edemas, hepatomegaly, ascites → nocturnal diuresis....
### Laboratory Finding

- Venous pressure: elevated
- Chest roentgenogram: cardiothoracic ratio, pulmonary edema—Kerley’s lines, perivascular and subpleural edema (butterfly and pleural effusion)
- Invasive assessment of cardiac function: ventricular pressure, PCWP,
- Echo and radionuclide

### Functional Assessment

<table>
<thead>
<tr>
<th>Class I</th>
<th>Class III</th>
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<tbody>
<tr>
<td>No limitations of physical activity. No shortness of breath, fatigue, or heart palpitations with ordinary physical activity.</td>
<td>Symptoms with minimal exertion. SOB, fatigue, heart palpitations. Patients comfortable at rest.</td>
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<table>
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<tr>
<th>Class II</th>
<th>Class IV</th>
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<tbody>
<tr>
<td>Slight limitation of physical activity. SOB, fatigue, heart palpitations. Patient comfortable at rest.</td>
<td>Severe to complete limitation of activity. SOB, fatigue, heart palpitations, even at rest.</td>
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Effects of Heart Failure

Heart Failure
- Impaired myocardial contractility

Dyspnoea
- Physical deconditioning

Less efficient circulation & oxygen delivery

Skeletal muscle abnormalities & reduced skeletal muscle bulk

Early skeletal muscle fatigue

There is no single diagnostic test for HF because it is largely a clinical diagnosis that is based on a careful history and physical examination.

- ACC/AHA 2005 guideline
Complications

- Pulmonary embolism,
- Congestive hepatomegaly,
- Ascites,
- Hepatic sclerosis,
- Imbalance of electrolytes

Therapy

- To get rid of induction factors and complication
- Uses of inotropic agents: digitalis, dobutamine
- Uses of diuretics
- Uses of vasodilators
- Other treatment: sedative drug and oxygen supply
HF Th – Trial Evidence

- ACE inhibitors
- Vasodilators: Hydralazine/Nitrate
- Beta-Blockers
- Spironolactone
- Angiotensin Receptor Blockers
- Exercise Training

- Biventricular Pacing / Defibrillators
- Cardiac Transplantation

Artificial Pacemakers
Sinus node

AV node

Biventricular Pacing

BIVENTRICULAR PACING THERAPY


TREATMENT OBJECTIVES

Survival  
Morbidity
Exercise capacity
Quality of life
Neurohormonal changes
Progression of CHF
Symptoms
AbioCOR II

Thank you!