Heart failure

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Circulatory failure
Heart

Insufficient oxygen and nutrient supply to the tissues, and cells
+ insufficient removal of the metabolic endproducts

causes:

 cardiac
  1. decreased venous return
  2. increased vascular capacity
  3. decreased oxyhemoglobin

extracardiac
Heart failure:
the heart is unable to pump sufficient blood, provided the venous return is normal

**mechanical**
1. pressure overload
   AS, hypertension
2. volume overload
   valvular regurg., shunts
3. insufficient filling
   mitral or tricuspid stenosis
4. Pericardial disease

**myocardial**
1. ischaemic heart disease
   diffuse or segmental
2. myocardial disease
Classifications of impaired ventricular function

1. Forward failure vs backward failure
2. Left heart failure vs right heart failure
3. Systolic vs diastolic dysfunction
4. Acute vs chronic
5. Low output vs high output
“Backward” failure

James Hope 1832
1. ventricular volume and pressure
2. atrial volume and pressure behind the failing ventricle
3. atrial contraction
4. venous pressure
5. capillary pressure
6. transudation into the interstitial tissue
7. extracellular fluid volume
“Forward failure”

Sir James Mackenzie 1913

decreased cardiac output:

- kidneys → sodium retention (RAS activation)
- liver → dysfunction
- muscular → weakness, fatigue
- brain → confusion
„left” or „right” heart failure

This is implicitly „backward failure”
congestion behind the originally failing ventricle

left ventricle ➔ pulmonary congestion, pulm edema
right ventricle ➔ liver and peripheral congestion oedema etc
Acute heart failure

The sudden development of the syndrome
no time for compensatory mechanisms to activate

massive myocardial infarction
heart block with very slow ventricular rate < 35/min
tachyarrhythmia with very rapid rate > 180/min
rupture of a valve
occlusion of a large segment of pulmonary artery

sudden reduction of cardiac output
stroke volume

symp

catechol → vasoconstr

prostaglandin dilate

bradykinin dilate

vasopressin constr

aldosterone constr

PRA

AII

constrictor > dilatator
Low-output vs high-output failure

1. Low output is the typical: most of the heart diseases impaired peripheral circulation, cold, pale or cyanotic extremities
2. High output: cardiac output is high before the development of failure
   anaemia, hyperthyroidism
   AV shunts, Paget’s disease, Beriberi (B1 vit defic)
   gravidity
   hot, hyperemic extremities
Compensatory mechanisms

Extracardiac
- preload↑
- afterload
- volume↑
- decomp
- vasoconstr

Cardiac
- RAS↑
- symp, ADH
- RBF↓↑
- GFR↓↑
- sodium retention
- cardiac output↓

natriuresis
- cardiac dilat
- vasodilat

ANP

sodium retention
<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical</td>
<td>More specific</td>
</tr>
<tr>
<td>Breathlessness</td>
<td>Elevated jugular venous pressure</td>
</tr>
<tr>
<td>Orthopnoea</td>
<td>Hepatojugular reflux</td>
</tr>
<tr>
<td>Paroxysmal nocturnal dyspnoea</td>
<td>Third heart sound (gallop rhythm)</td>
</tr>
<tr>
<td>Reduced exercise tolerance</td>
<td>Laterally displaced apical impulse</td>
</tr>
<tr>
<td>Fatigue, tiredness, increased time to recover after exercise</td>
<td>Cardiac murmur</td>
</tr>
<tr>
<td>Ankle swelling</td>
<td></td>
</tr>
</tbody>
</table>
## Table 1  Diagnosis of heart failure

<table>
<thead>
<tr>
<th>HF-REF requires three conditions to be satisfied:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Symptoms typical of HF</td>
</tr>
<tr>
<td>2. Signs typical of HF&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>3. Reduced LVEF</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>HF-PEF requires four conditions to be satisfied:</th>
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<tr>
<td>1. Symptoms typical of HF</td>
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<tr>
<td>2. Signs typical of HF&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>3. Normal or only mildly reduced LVEF and LV not dilated</td>
</tr>
<tr>
<td>4. Relevant structural heart disease (LV hypertrophy/LA enlargement) and/or diastolic dysfunction (see Section 4.1.2)</td>
</tr>
</tbody>
</table>

HF = heart failure; HF-PEF = heart failure with ‘preserved’ ejection fraction; HF-REF = heart failure and a reduced ejection fraction; LA = left atrial; LV = left ventricular; LVEF = left ventricular ejection fraction.

<sup>a</sup> Signs may not be present in the early stages of HF (especially in HF-PEF) and in patients treated with diuretics (see Section 3.6).
ACC Heart Failure Guidelines
Slide Deck

Based on the ACC/AHA 2005 Guideline Update for the Diagnosis and Management of Chronic Heart Failure in the Adult

January 2006
Definition of Heart Failure

HF is a complex clinical syndrome that can result from any structural or functional cardiac disorder that impairs the ability of the ventricle to fill with or eject blood.
Because not all patients have volume overload at the time of initial or subsequent evaluation, the term “heart failure” is preferred over the older term “congestive heart failure.”
Causes of HF in Western World

For a substantial proportion of patients, causes are:

1. Coronary artery disease
2. Hypertension
3. Dilated cardiomyopathy
### NYHA Classification of HF

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class I</strong></td>
<td><em>No limitation:</em> Ordinary physical activity does not cause undue fatigue, dyspnea, or palpitation.</td>
</tr>
<tr>
<td><strong>Class II</strong></td>
<td><em>Slight limitation of physical activity:</em> Such patients are comfortable at rest. Ordinary physical activity results in fatigue, palpitation, dyspnea, or angina.</td>
</tr>
<tr>
<td><strong>Class III</strong></td>
<td><em>Marked limitation of physical activity:</em> Although patients are comfortable at rest, less than ordinary activity will lead to symptoms.</td>
</tr>
<tr>
<td><strong>Class IV</strong></td>
<td><em>Inability to carry on any physical activity without discomfort:</em> Symptoms of congestive failure are present even at rest. With any physical activity, increased discomfort is experienced.</td>
</tr>
</tbody>
</table>
Stages of Heart Failure

At Risk for Heart Failure:

STAGE A

STAGE B

Heart Failure:

STAGE C

STAGE D
Stage A

Patients at High Risk for Developing Heart Failure
Stage B

Patients with Asymptomatic LV Dysfunction
Stage C

Patients with Past or Current Symptoms of Heart Failure
Stage D

Patients with Refractory End-Stage HF
Options for end-of-life care should be discussed with the patient and family when severe symptoms in patients with refractory end-stage HF persist despite application of all recommended therapies.
<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Patients at high risk of developing HF because of the presence of conditions that are strongly associated with the development of HF. Such patients have no identified structural or functional abnormalities of the pericardium, myocardium, or cardiac valves and have never shown signs or symptoms of HF.</td>
<td>Systemic hypertension; coronary artery disease; diabetes mellitus; history of cardiotoxic drug therapy or alcohol abuse; personal history of rheumatic fever; family history of cardiomyopathy.</td>
</tr>
<tr>
<td>B</td>
<td>Patients who have developed structural heart disease that is strongly associated with the development of HF but who have never shown signs or symptoms of HF.</td>
<td>Left ventricular hypertrophy or fibrosis; left ventricular dilatation or hypocontractility; asymptomatic valvular heart disease; previous myocardial infarction.</td>
</tr>
<tr>
<td>C</td>
<td>Patients who have current or prior symptoms of HF associated with underlying structural heart disease.</td>
<td>Dyspnea or fatigue due to left ventricular systolic dysfunction; asymptomatic patients who are undergoing treatment for prior symptoms of HF.</td>
</tr>
<tr>
<td>D</td>
<td>Patients with advanced structural heart disease and marked symptoms of HF at rest despite maximal medical therapy and who require specialized interventions.</td>
<td>Patients who are frequently hospitalized for HF or cannot be safely discharged from the hospital; patients in the hospital awaiting heart transplantation; patients at home receiving continuous intravenous support for symptom relief or being supported with a mechanical circulatory assist device; patients in a hospice setting for the management of HF.</td>
</tr>
</tbody>
</table>

HF indicates heart failure.
### Table 6  Classification of heart failure by structural abnormality (ACC/AHA), or by symptoms relating to functional capacity (NYHA)

<table>
<thead>
<tr>
<th>ACC/AHA stages of heart failure</th>
<th>NYHA functional classification</th>
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<tr>
<td><strong>Stage of heart failure based on structure and damage to heart muscle</strong></td>
<td><strong>Severity based on symptoms and physical activity</strong></td>
</tr>
<tr>
<td>Stage A  At high risk for developing heart failure. No identified structural or functional abnormality; no signs or symptoms.</td>
<td>Class I  No limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, or dyspnoea.</td>
</tr>
<tr>
<td>Stage B  Developed structural heart disease that is strongly associated with the development of heart failure, but without signs or symptoms.</td>
<td>Class II  Slight limitation of physical activity. Comfortable at rest, but ordinary physical activity results in fatigue, palpitation, or dyspnoea.</td>
</tr>
<tr>
<td>Stage C  Symptomatic heart failure associated with underlying structural heart disease.</td>
<td>Class III  Marked limitation of physical activity. Comfortable at rest, but less than ordinary activity results in fatigue, palpitation, or dyspnoea.</td>
</tr>
<tr>
<td>Stage D  Advanced structural heart disease and marked symptoms of heart failure at rest despite maximal medical therapy.</td>
<td>Class IV  Unable to carry on any physical activity without discomfort. Symptoms at rest. If any physical activity is undertaken, discomfort is increased.</td>
</tr>
</tbody>
</table>

Stages of Heart Failure

COMPLEMENT, DO NOT REPLACE NYHA CLASSES

- NYHA Classes - shift back/forth in individual patient (in response to Rx and/or progression of disease)

- Stages - progress in one direction due to cardiac remodeling
Differential Diagnosis in Patient with HF and Normal LVEF with Symptoms

- Incorrect diagnosis of HF
- Inaccurate measurement of LVEF
- Primary valvular disease
- Restrictive (infiltrative) cardiomyopathies
- Amyloidosis, sarcoidosis, hemochromatosis
- Pericardial constriction
- Episodic or reversible LV systolic dysfunction
- Severe hypertension, myocardial ischemia

- HF associated with high metabolic demand (high-output states)
- Anemia, thyrotoxicosis, arteriovenous fistulae
- Chronic pulmonary disease with right HF
- Pulmonary hypertension associated with pulmonary vascular disorders
- Atrial myxoma
- Diastolic dysfunction of uncertain origin
- Obesity
NT-proBNP and BNP: Synthesis and secretion

Stretched cardiac myocyte

pre-proBNP (134 amino acids)

proBNP (108 amino acids)

signal peptide (26 amino acids)

NT-proBNP (1-76)

BNP 32 (physiologically active form)

blood

ESC Guidelines for the Diagnosis and Treatment of CHF - 2005
Natriuretic Peptides

Plasma concentrations of certain natriuretic peptides or their precursors, especially BNP and NT-proBNP, are helpful in the diagnosis of heart failure.

- A *low-normal* concentration in an untreated patient makes heart failure unlikely as the cause of symptoms.
- BNP and NT-proBNP have considerable prognostic potential, although evaluation of their role in treatment monitoring remains to be determined.
BNP - echo
dyspnea

EKG, RTG, BNP

<100

HF unlikely

100-500

echo: LVD ↓
COPD
PE

>500 pg/ml

HF 95% echo

Maisel Rev CV Med 2003;4:S3-12
Systolic vs diastolic heart failure

Implicit in the physiological definition the defect to pump adequate volume of blood is a **systolic heart failure**

the abnormality may be caused by a defect of ventricular filling i.e. **diastolic heart failure**

slowed or incomplete ventricular relaxation

possible causes:

- acute or chronic ischaemia
- concentrical hypertrophy
- restrictive cardiomyopathy

most clinical manifestations are combined
Diastolic dysfunction

- Fibrosis
- Cellular dysarray
- Hypertrophy
- Asynchrony
- Abnormal loading
- Ischemia
- Abnormal Ca++ flux

- Passive chamber stiffness
- Relaxation
- Diastolic pressure
Diastolic heart failure became a central issue of cardiology.

Diastolic heart failure is heart failure with **preserved systolic function** or normal ejection fraction (HFNEF) $\text{EF} > 50\%$
Figure 2. Left Ventricular Pressure–Volume Loops in Systolic and Diastolic Dysfunction.

In systolic dysfunction, left ventricular contractility is depressed, and the end-systolic pressure–volume line is displaced downward and to the right (Panel A, black arrow); as a result, there is a diminished capacity to eject blood into the high-pressure aorta. In diastolic dysfunction, the diastolic pressure–volume line is displaced upward and to the left (Panel C, black arrow); there is diminished capacity to fill at low left-atrial pressures. In systolic dysfunction, the ejection fraction is depressed, and the end-diastolic pressure is normal (Panel A, open arrow); in diastolic dysfunction, the ejection fraction is normal and the end-diastolic pressure is elevated (Panel C, open arrow).
Systole and diastole

“So that the coming together, depends on the going apart, the systole depends on the diastole; the flow depends on the ebb.”

DH Lawrence
Symptoms of heart failure

1. dyspnea
2. fatigue and weakness
   - hypoperfusion of the skeletal musculature
   - hyponatremia caused by diuretics
3. nocturia
   - redistribution of cardiac output at night: ↑RBF
4. liver distension
   - epigastrial dyscomfort
General mechanisms of dyspnoe:
left atrial pressure $\uparrow$

- pulmonary capillary pressure $\uparrow$
- interstitial fluid volume in the lungs $\uparrow$
  - elasticity of the lung $\downarrow$
- increased work of breathing
- low cardiac output $\to$ impaired perfusion of the respiratory muscles $\to$ fatigue $\to$ sensation of dyspnoe
Physical signs of heart failure 1

• visible dyspnoe
• gray color of the face
• cold extremities and acrocyanosis
• decreased pulse pressure
• extension of the veins (jugular)
• palpable liver
• symmetrical edema (pitting)
  ankle-sacral-generalized
• ascites
• hydrothorax
• rales „moist” at the end of inspiration
Physical signs of heart failure 2

tachycardia
pulsus alternans  

auscultation of the heart
S3 gallop
accentuated P2
syst murmur- tricusp regurg

heart cachexia
Pulsus alternans

this is just an interesting possibility
Framingham criteria for congestive heart failure

Major criteria:

- paroxysmal nocturnal dyspnea or orthopnea
- neck vein distension
- rales
- cardiomegaly
- acute pulmonary edema
- S3 gallop
- increased venous pressure > 16cm H2O
- circulation time > 25 sec
- hepatojugular reflux
Framingham criteria for congestive heart failure

**Minor criteria:**
- ankle edema
- night cough
- dyspnea on exertion
- hepatomegaly
- pleural effusion
- vital capacity \( \downarrow \) 1/3 from maximum
- tachycardia > 120/min

**Minor or major criterion:**
- weight loss > 4.5 kg in 5 days in response to treatment
The main causes of heart failure

**Ischaemic heart disease**
- myocardial infarction
- necrosis
- remodeling

**Systemic hypertension**
- LV hypertrophy

**Valvular heart disease**
- pressure load, AS
- volume load AI

**Cardiomyopathies**
- obstructive
- dilatative
- restrictive
Algorithm of diagnostic approach to HF

Suspicion of HF

- EKG, RTG, BNP if available

  abnormal

  echocardiography

  abnormal

  Cause, type, severity?

  therapy

  norm

Dg. rejected

additional Workup, eg. coronaryography
Epidemiology of heart failure

~ 4 million pts in the USA
yearly incidence > 400,000
hospitalization 1,000,000
most prevalent cause of death > 300,000
Hospital mortality 30-50% / year
in the mixed population

5 years survival after
diagnosis only 25% in men and
38% in women

yearly cost 22 billion $
Annual incidence of heart failure per 1000 population in Framingham
Prevalence of heart failure

![Bar chart showing CHF prevalence per 1000 persons by age and gender.](chart.png)
Prevalence of HF

Overall 2.5% in the community

Senni, Circ 1998; 98:2282

USA CHS 8,8
Finland Helsinki 8,2
England Poole 7,5
Sveden Västeras 6,7
Den. Copen. 6,4
Spain Asturias 4,9
Portugal EPICA 4,2
USA Olmsted 2,2
Nether. Rotter. 2,1

proportion with preserved LV systolic function

Overall 2.5% in the community

Senni, Circ 1998; 98:2282
ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2012

The Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association (HFA) of the ESC

Authors/Task Force Members: John J.V. McMurray (Chairperson) (UK)*, Stamatis Adamopoulos (Greece), Stefan D. Anker (Germany), Angelo Auricchio...