What Causes Heart Failure

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HFSN

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Dropsy

Valve regurgitation or stenosis

HFPEF

Cor pulmonale

LVSD - HFREF

CCF – congestive cardiac failure

Pulmonary hypertension

LVF

HFPEF

Right heart failure

Dropsy

Pulmonary hypertension

Arrhythmias

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Definitions

- **Syndrome (complex)**
  - collection of problems (either structural or functional) resulting in typical signs and symptoms

  - **symptoms:** breathlessness, orthopnoea, oedema, cough, fatigue

  - **signs:** lung crackles, raised JVP, water retention in legs/abdomen/lungs, heart sounds

- **Reduced cardiac output**

- **Many causes**
  - Diseased heart muscle: weak muscle, stiff muscle
  - High pressures (damaged structures (valves), systemic or pulmonary hypertension)
  - Speed (fast or slow)

- **Many combinations**
  - Often more than one, often inter-related
The Heart is a pump designed for one way flow only

- Two ways in
- Two ways out
- 4 chambers and 4 valves

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Normal function (left)

The cardiac cycle – starting point at the mid relaxation (diastole) left side

1. when the pressure is high enough the mitral valve opens and the ventricle fill freely

2. the atria contract and fills the ventricle a further 25%

3 & 4. the ventricle contracts, mitral valve shuts, aortic valve opens and blood is sent up the aorta

5. aortic valve shuts as the ventricle relaxes and blood continues to return constantly to the heart and fills the atrium raising the pressure again
Cardiac output explained

$\text{Cardiac output} \ = \ \text{volume ejected} \times \text{pulse rate (ml/min)}$

Ejection fraction

$= \frac{\text{volume squeezed out}}{\text{full volume}} \times 100\%$

55-70% = normal

Cardiac output = volume ejected \times pulse rate (ml/min)
Types of heart failure

1. Due to a weak left ventricle 31%¹
2. Due to aortic valve stenosis 10%²
3. Due to mitral valve regurgitation 12%²
4. Due to a stiff left ventricle 34%¹

5. Due to pulmonary hypertension 21%¹
6. Due to tricuspid valve regurgitation 18%²
7. Due to a weak right ventricle 13-31%³

Not an exclusive list (AR, MS)
1. A Weak Heart (left ventricle)

- Imagine in this case a full plastic water bottle in your hand and squeeze gently
  - Less water will be squeezed out (reduced ejection fraction), reduced Cardiac Output (CO)
- Causes of a weakened heart are mainly coronary artery disease and dilated cardiomyopathies
  - myocardial infarctions, angina, cardiomyopathies

LVSD - Left ventricular systolic dysfunction

HFREF - Heart failure with a reduced ejection fraction

CCF - Congestive cardiac failure

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Myocardial infarction

Patrick J. Lynch, medical illustrator; C. Carl Jaffe, MD, cardiologist.

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Remodelling

1. Baseline
2. AMI
3. Compensatory hypertrophy
4. Infarct expansion
5. Progressive dilatation

Coronary occlusion

Time:
- Hours
- Days
- Weeks
- Months
- Years

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Dilated Cardiomyopathies
‘cardiac muscle disease’

- Often inherited 25-35%
- Toxin induced e.g. alcohol, anthracycline chemotherapy, cocaine and its ‘cutting’ agents, cobalt
- Thyroid disease, Chagas disease (in South America)
- Peripartum (pregnancy)
- Idiopathic and viral (myocarditis)
- Uncontrolled fast heart rate

- Hereditary
  - Secondary to other cardiovascular disease: ischemia, hypertension, valvular disease, tachycardia induced
  - Infectious: viral, rickettsial, bacterial, fungal, metazoal, protozoal
  - Probable infectious: Whipple disease, Lyme disease
- Congenital or acquired causes: hypothyroidism, hyperthyroidism, diabetes mellitus, electrolyte imbalance (e.g., potassium, phosphate, magnesium), pheochromocytoma
- Rheumatologic/connective tissue disorders: scleroderma, rheumatoid arthritis, systemic lupus erythematosus
- Nutritional: thiamine deficiency (beriberi), protein deficiency, starvation, carnitine deficiency
- Toxic: drugs (e.g., antineoplastic/anthracycline agents, vascular endothelial growth factor [VEGF] inhibitors), poisons, foods, anesthetic gases, heavy metals, alcohol
- Collagen vascular disease:
  - Infiltrative: hemochromatosis, amyloidosis, glycogen storage disease
  - Granulomatous (sarcoidosis, giant cell myocarditis)
- Physical agents: extreme temperatures, ionizing radiation, electric shock, nonpenetrating thoracic injury
- Neurologic, muscular diseases: muscular dystrophy, myotonic, spinal muscular atrophy, Duchenne dystrophy, fascioscapulohumeral (Landouzy-Dejerine dystrophy), Friedreich disease, myotonic dystrophy
- Primary cardiac tumor (myxoma)
- Senile
- Peripartum
- Stress induced cardiomyopathy (Takotsubo cardiomypathy)
DCM

Normal

Dilated cardiomyopathy

Aorta

Right atrium

Left atrium

Right ventricle

Left ventricle

Enlarged right atrium

Enlarged right ventricle

Enlarged left atrium

Thinned wall

Enlarged left ventricle
2. Valve abnormalities

- There are 4 heart valves: Mitral, aortic, tricuspid and pulmonic
- Aortic stenosis (AS) - 2% over 65, 3% over 75 and 4% over 85**
- Mitral regurgitation (MR) - 2% of the total population* 10% over 75
- TR - 70% of the population (mainly trace to mild) F>M, in 70 yo+ 1.5% men and 5.6% women***
Valve malfunctions

- **Stenosis** = tight or narrowed, elevating pressure needed to open the valve e.g. Aortic stenosis
- **Regurgitation** = leaky, elevating backward pressure through the valve e.g. mitral regurgitation
2. Aortic stenosis (AS)

- Due to the tightness of the only outflow from the ventricle, pressure rises in the ventricle causing hypertrophy but eventual failure
- BUT pressure is lower in the aorta
- Pressure gradient

Reduced output

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3. Mitral Regurgitation (MR)

- Looking at the cardiac cycle MR affects ventricular systole
- Blood not only ejects up the aorta but also back to the atria

- Visualise the effect as squeezing the full water bottle which has a big hole near the top
- Less output where it’s wanted!

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4. HFpEF Heart Failure with Preserved Ejection Fraction

- ‘A stiff heart’ or diastolic impairment in 80-90%
- Hypertension, DM, obesity, AF, OSA, older people…

- High blood pressure
  - bigger myocytes to compensate
  - less flexibility/springiness
  - less blood fills the LV
  - less is ejected
  - It’s a filling problem

- Imagine filling the water bottle only half full and squeeze normally - Less comes out
HFrEF v HFpEF

100ml EDV
50% EF=50ml SV

50ml EDV
50% EF=25ml SV

Same EF but reduced cardiac output

i.e for a HR of 72
3600ml/min versus 1800ml/min
5. Pulmonary hypertension

- Many causes
  - 1. primary pulmonary hypertension PAH
  - 2. due to heart disease
  - 3. due to lung disease
  - 4. due to pulmonary emboli

- Pressure in pulmonary artery above 25 mmHg will dilate the RV in time.
- This high pressure is reflected into the atrium and venous system (the veins in the kidneys being very important to us)
- This is why these patients are so often hard to diurese
Heart rhythms

- To allow good filling and contraction heart rate is best between 50-100 resting.
- Tachycardia common in atrial fibrillation (AF) can lead to decompensation.
  - And can lead to cardiomyopathy.
- A bradycardia on top of a weak heart or leaky valve can also decompensate.
Summary

- HFrEF: HF due to a reduced ejection fraction = LVSD
- AS: aortic stenosis
- MR: mitral regurgitation
- HFpEF: HF due to preserved ejection fraction
- PH: pulmonary hypertension
- TR: tricuspid regurgitation
- Rhythm

- Usually a mixture of the above
- Benefit from expert input for acute and long term management planning
- Refer to HFSNs via GP or Hospital Consultant

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