MEDI2101 Week 11

MACQUARIE University
SYDNEY·AUSTRALIA

Diseases of the Heart: Heart Failure

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Image from heartfailure.com.au

Learning outcomes

LO11.1 Define heart failure

LO11.2 Describe types of heart failure

LO11.3 Understand common causes and symptoms of heart failure

LO11.4 Describe the pathophysiology of heart failure

LO11.5 Understand the impact of heart failure on exercise capacity

LO11.6 Identify and describe the diagnostic tests and treatments for heart failure

What ISNT'T heart failure?

Heart failure is not:

- Heart has stopped working altogether
- Heart attack
- Cardiac arrest

Heart attack
Triggered by blocked coronary artery preventing adequate oxygen supply to part of the heart, leading to heart muscle damage
Cardiac arrest
Triggered by arrhythmia (e.g. ventricular fibrillation) leading to heart being unable to pump blood

What IS heart failure? (LO11.1)

Heart failure (HF)

Heart fails to pump blood effectively around the body to meet its metabolic demands

- Can affect either side or both sides of the heart
- Can be that the heart isn't able to pump out enough blood (systolic dysfunction), or fill with enough blood (diastolic dysfunction), or both

Types of heart failure (LO11.2)

- Acute and chronic
- Right-sided, left-sided, or both
- Left-sided heart failure can be further categorised based on left ventricular ejection fraction (LVEF):

Ejection Fraction (EF)

Ratio of stroke volume (SV) to left ventricular end diastolic blood volume (LVEDV), expressed as a percentage

$$EF = \frac{SV}{LVEDV} \times 100\%$$

Types of heart failure (LO11.2)

- Classification of HF based on LVEF:

HFrEF	HF with **reduced** EF (LVEF ≤ 40%)
HFimpEF	HF with **improved** EF (previous LVEF ≤ 40%, follow-up measurement of LVEF > 40%)
HFmrEF	HF with **mildly** reduced EF (LVEF = 41% - 49%)
HRpEF	HF with **preserved** EF (LVEF ≥ 50%)

Severity of heart failure

New York Heart Association (NYHA) Functional Classification

Class I	No limitation of ordinary physical activity
Class II	Slight limitation of ordinary physical activity; No symptoms at rest
Class III	Marked limitation of ordinary physical activity; No symptoms at rest
Class IV	Symptoms at rest; worsens with physical activity

National Heart Foundation (2018), National Heart Foundation of Australia and Cardiac Society of Australia and New Zealand: Guidelines for the Prevention, Detection, and Management of Heart Failure in Australia 2018

Common causes of heart failure (LO11.3)

Ischaemic heart disease (coronary artery disease)	Leads to damaged heart muscle
Myocardial infarction	Leads to damaged heart muscle
Hypertension	Leads to left ventricular hypertrophy (enlargement of the left ventricle)
Cardiomyopathy	Leads to stiffening, thickening or enlargement of left ventricle
Valvular disease	Leads to regurgitation of blood

All of these conditions would lead to a decrease in cardiac output. Why?

Symptoms of heart failure (LO11.3)

Fatigue

Swollen feet or ankles (oedema)

Breathlessness / Shortness of breath (dyspnoea)

Breathlessness whilst laying flat (orthopnoea)

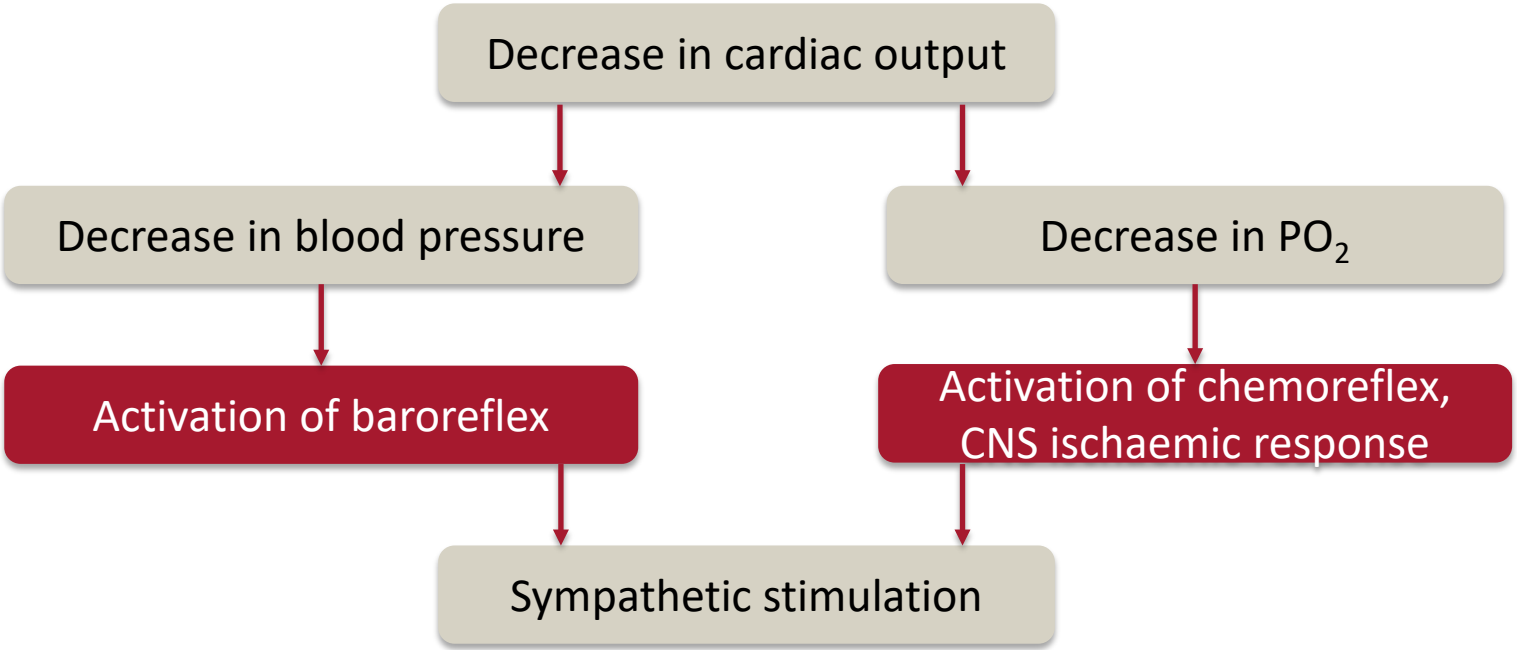
Persistent coughing

Images from heartfailure.com.au

Pathophysiology of heart failure (LO11.4)

Initial compensatory response to onset of heart failure

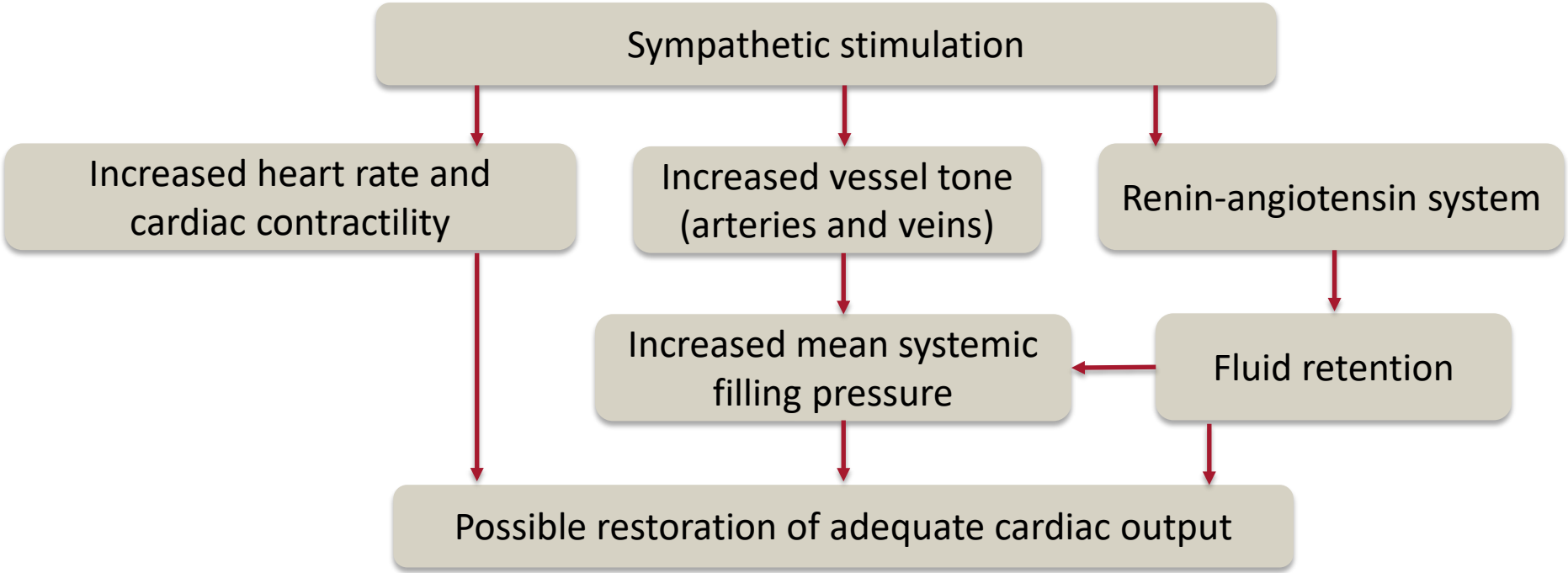
The body's compensatory response to a drop in cardiac output:



Pathophysiology of heart failure

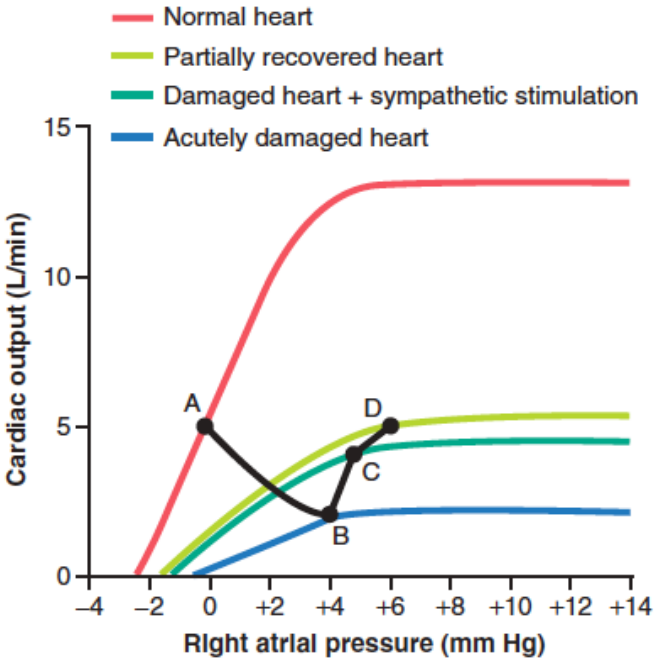
Initial compensatory response to onset of heart failure

The body's compensatory response to a drop in cardiac output (cont'd)



Pathophysiology of heart failure

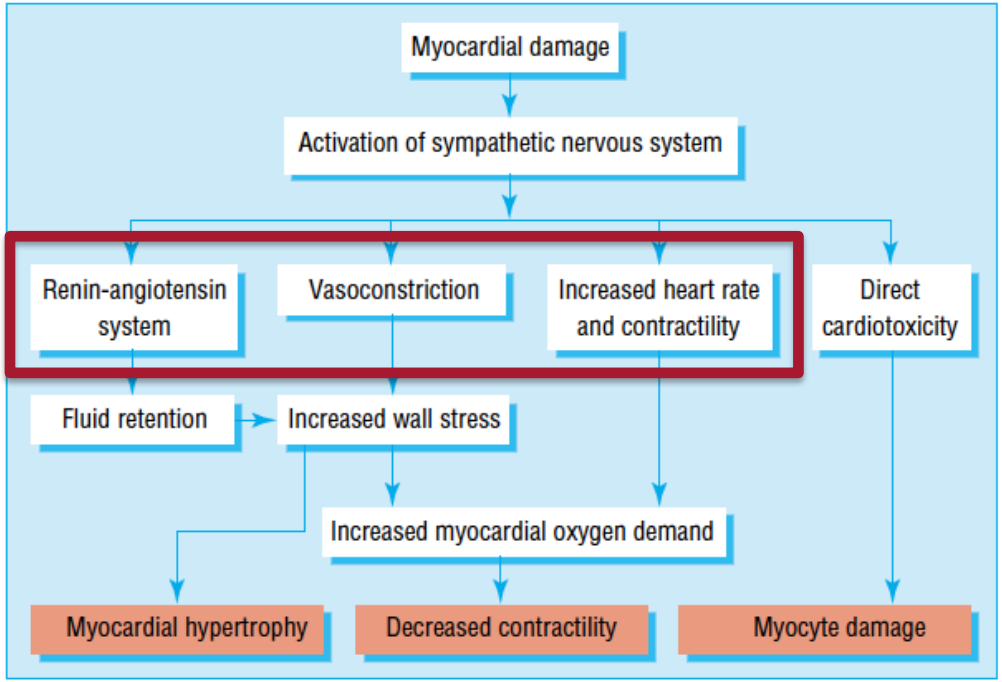
Progressive changes of CO due to compensatory response to onset of heart failure



Guyton and Hall Textbook of Medical Physiology p. 272

Pathophysiology of heart failure

Effects of prolonged compensatory response to heart failure: sympathetic activation



Jackson G *et al. (2000)* BMJ 320;167-170.

Pathophysiology of heart failure

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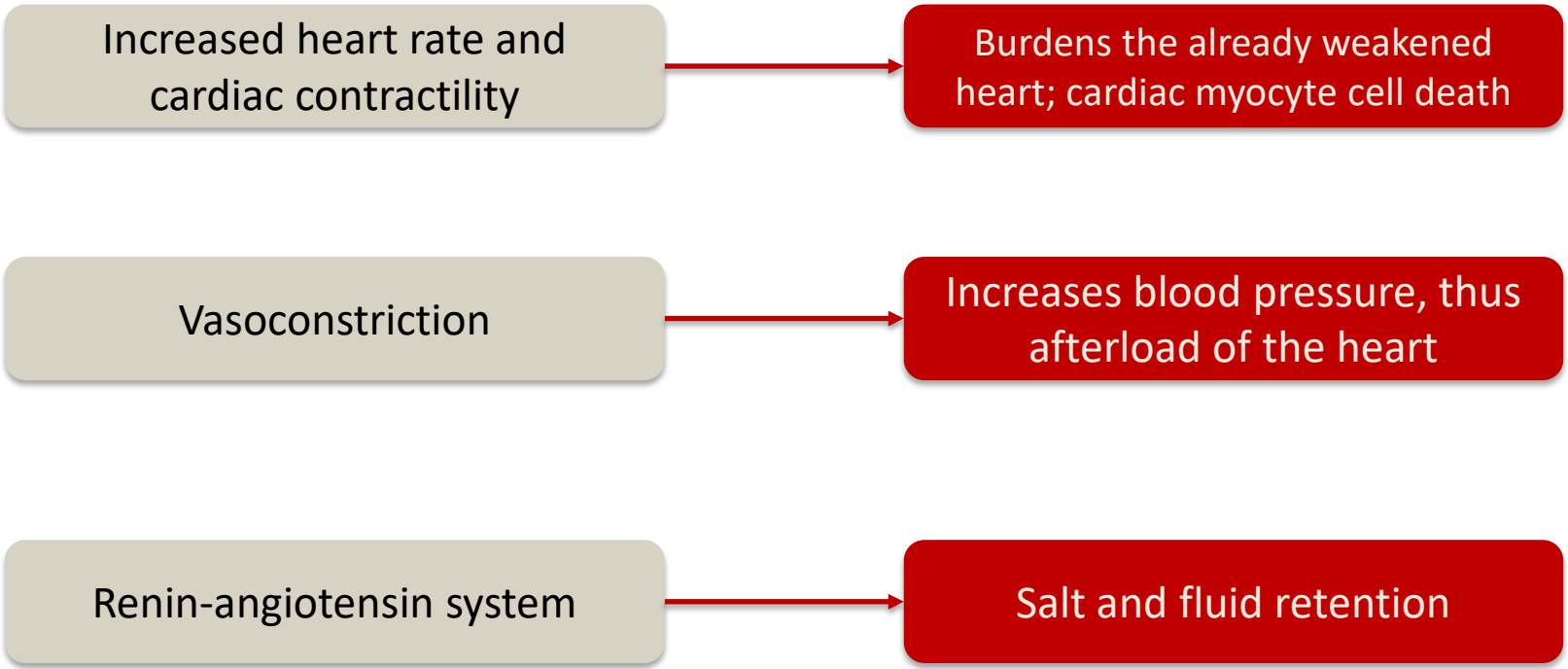
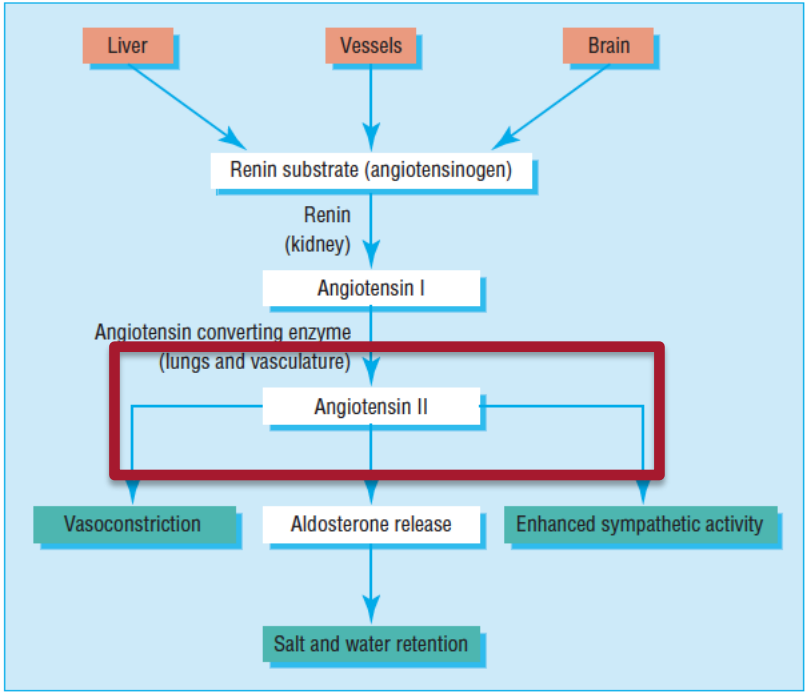


Pathophysiology of heart failure

Effects of prolonged compensatory response to heart failure: RAS activation



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Pathophysiology of heart failure

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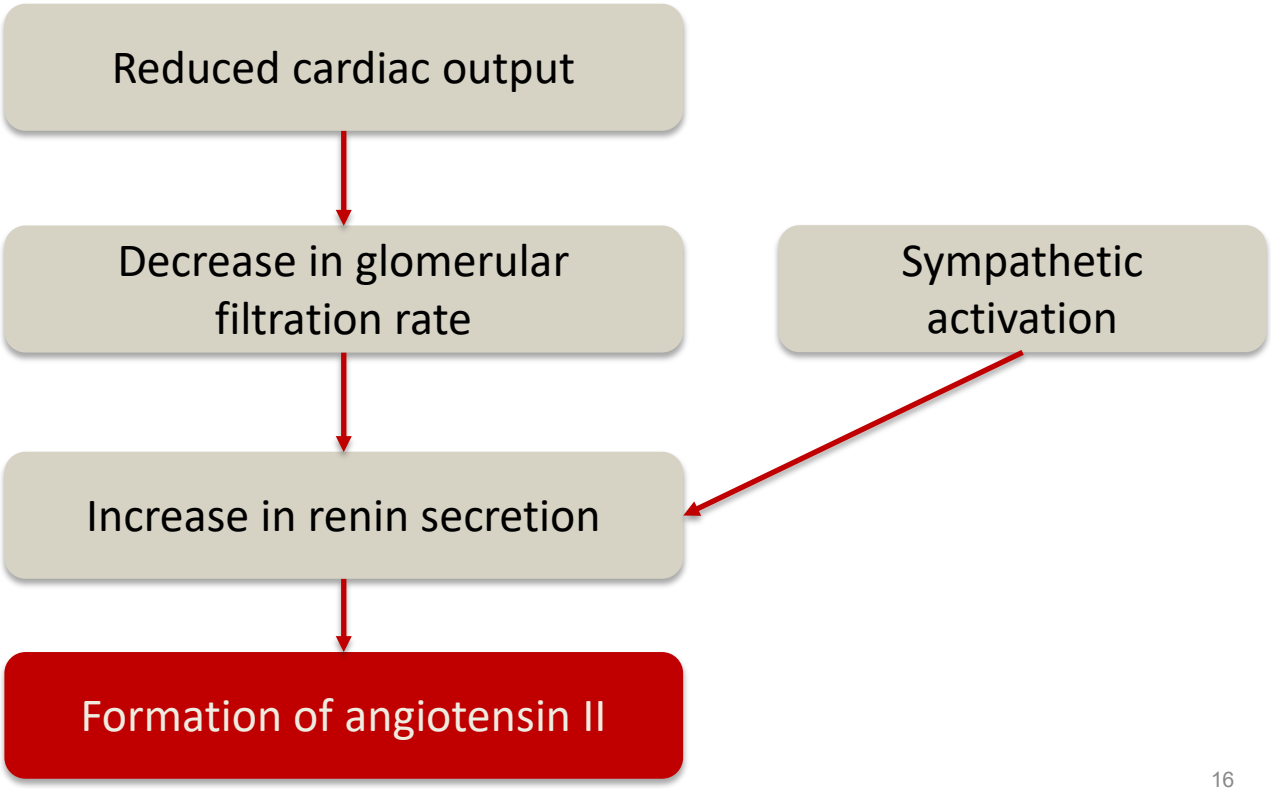

Pathophysiology of heart failure

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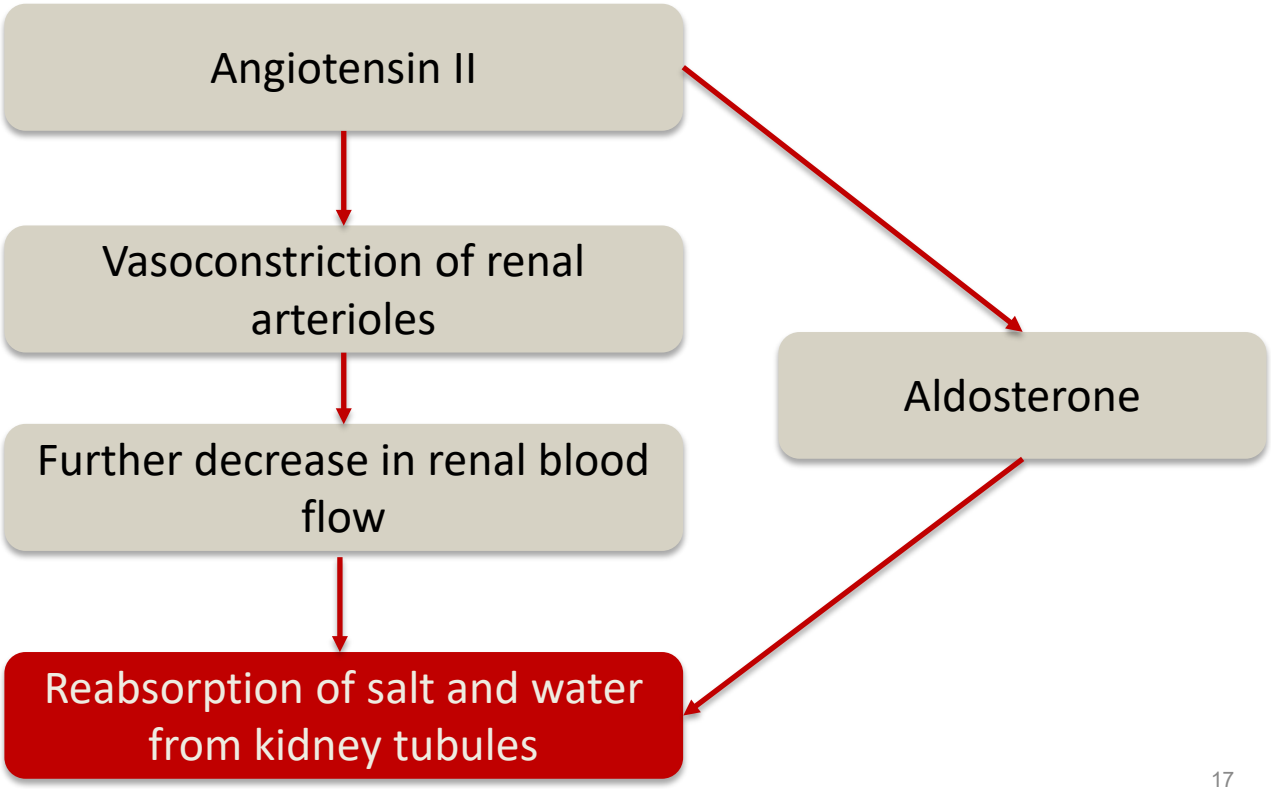


Pathophysiology of heart failure

Non-cardiac abnormalities in heart failure: pulmonary and peripheral oedema

Increased salt and water retention from kidneys

Increased blood volume

Increased venous return

Increased capillary pressure

Blood flow back into pulmonary circulation (pulmonary vascular congestion)

Increased pulmonary capillary pressure

Excess fluid pushed into lung interstitial spaces and alveoli

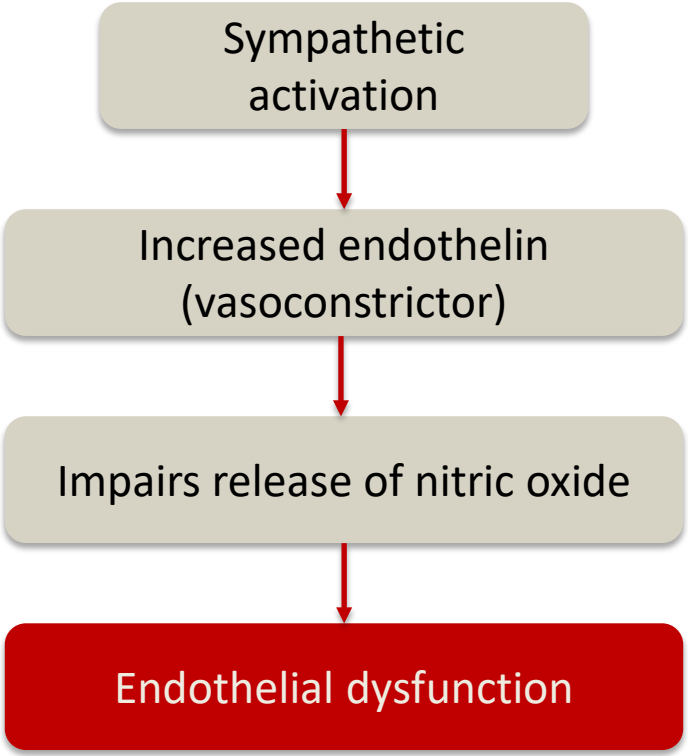
Excess fluid pushed out into interstitial fluid

Pulmonary oedema

Peripheral oedema

Pathophysiology of heart failure

Non-cardiac abnormalities in heart failure: vasculature



Pathophysiology of heart failure

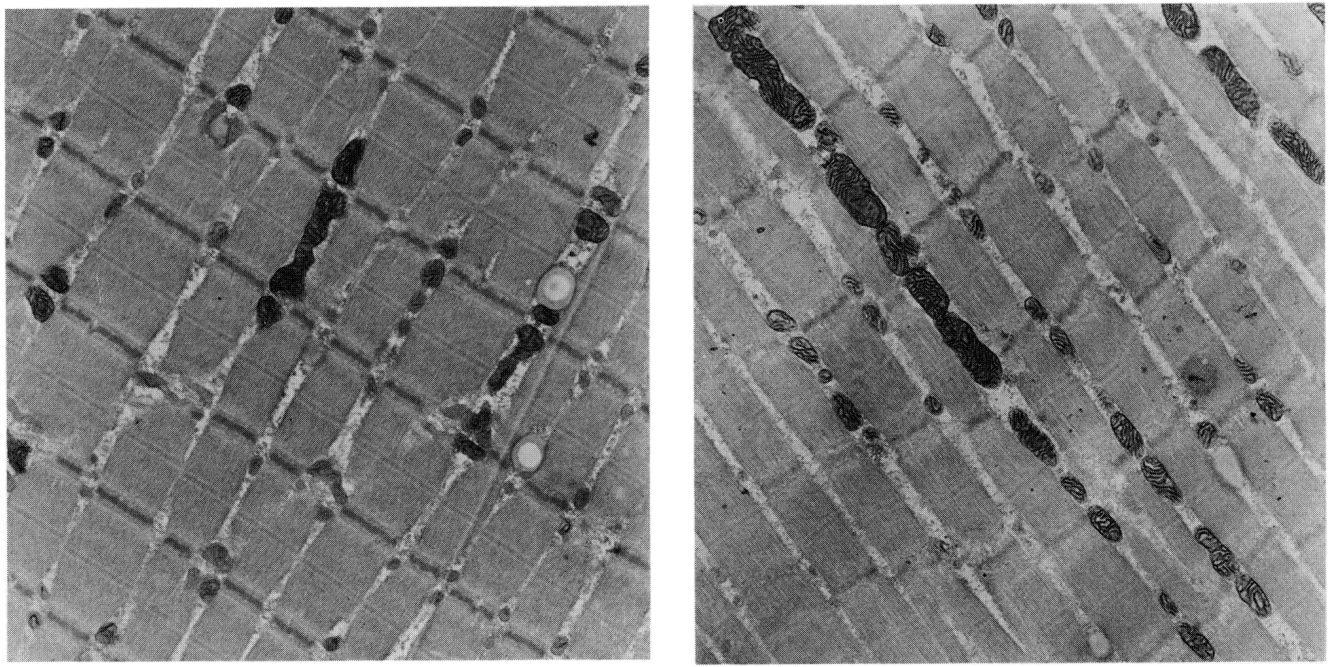
Non-cardiac abnormalities in heart failure: skeletal muscle

Effects of heart failure on skeletal muscle

- Skeletal muscle changes have been observed in heart failure patients, including reduction of muscle mass, as well as structural and functional abnormalities (muscle wastage)
- Metabolic function of skeletal muscle can also be affected

Pathophysiology of heart failure

Non-cardiac abnormalities in heart failure: skeletal muscle



Electron micrographs of mitochondria in a patient with severe heart failure (left) and in a normal subject (right). Black represents oxidative activity in the mitochondria. Drexler *et al* (1992) *Circulation* 85(5);1751-1759

Symptoms of heart failure

What leads to these symptoms?

Fatigue

Swollen feet or ankles (oedema)

Breathlessness / Shortness of breath (dyspnoea)

Breathlessness whilst laying flat (orthopnoea)

Persistent coughing

Images from heartfailure.com.au

Effect of heart failure on exercise capacity (LO 11.5)

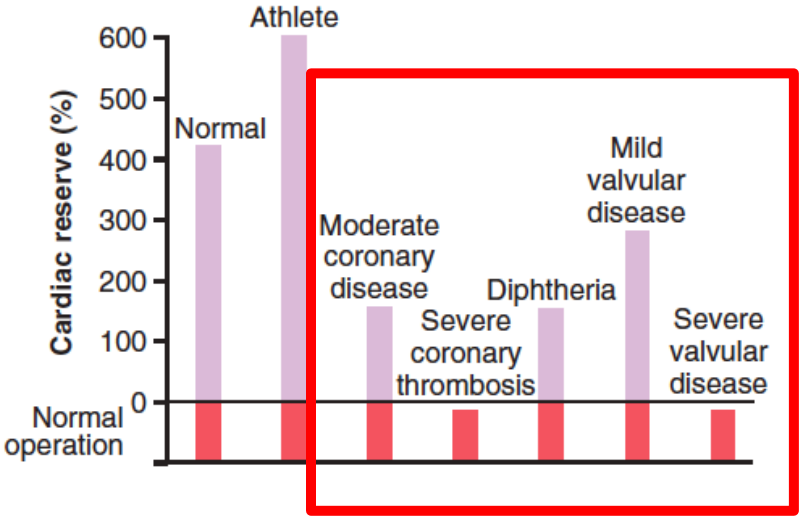
In heart failure patients, *cardiac reserve* is greatly reduced

Cardiac reserve

The maximum percentage cardiac output can increase above normal resting state

- In a normal, healthy individual, cardiac reserve can be up to 400%, and it is even higher in trained athletes
- This means during exercise, cardiac output can increase adequately to meet the increased metabolic demands
- In heart failure patients, low cardiac reserve means their exercise tolerance is reduced

Effect of heart failure on exercise capacity



Guyton and Hall Textbook of Medical Physiology *p. 278*

- When cardiac reserve is low, cardiac output cannot increase adequately, resulting in:
  - Immediate breathlessness
  - Extreme muscle fatigue
  - Excessive increase in heart rate and blood pressure

Diagnosing heart failure (LO11.6)

There is no single definitive test that can diagnose heart failure, but a combination of the below tests can help a clinician diagnose heart failure:

Test	Purpose
ECG	Arrhythmia, thickened ventricular wall, signs of previous or current heart attack
Chest X-ray	Enlargement of heart, fluid in lungs
Blood test	Presence of brain natriuretic peptide (also known as B-type natriuretic peptide)
Echocardiography	Structure of the heart, blood flow in the heart, ejection fraction
Stress test	Exercise test, often in combination with ECG and/or echocardiography

Treatment of heart failure (LO11.6)

Non-pharmacological treatment

Low salt diet

Quit smoking

Reduce alcohol intake

Exercise

Cardiac rehab program

Treatment of heart failure

Pharmacological treatment

Drug class	Mechanism
Angiotensin converting enzyme (ACE) inhibitors; angiotensin II receptor blockers (ARB); angiotensin receptor-neprilysin Inhibitor (ARNi)	First line therapy for renin-angiotensin system inhibition; prevents formation of angiotensin II, thus reduce effects of vasoconstriction, salt and water retention, release of aldosterone
Beta blockers	Reduces sympathetic activity
Mineralocorticoid receptor antagonists (MRAs) / aldosterone antagonist	Weak diuretic, reduces salt and water retention
Sodium-glucose cotransporter-2 inhibitors (SGLT2i)	Type 2 diabetes drug, reduces blood glucose levels; ???

Treatment of heart failure

Other treatment

Other treatments for heart failure patients may require:

- Implantable cardioverter defibrillator
  - reduces risk of sudden death and all-cause mortality in patients with NYHA class II-III HF
- Cardiac resynchronization therapy
  - Recommended for patients with prolonged QRS duration
- Left ventricular assist device
  - For advanced HF patients that require mechanical support

A little summary…