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B.Pharm – SEMESTER I

BP104T

Human Anatomy, Physiology and Pathophysiology I

UNIT V

Cardiovascular System

Heart Anatomy • Circulation • Conduction System • ECG • Hypertension • IHD

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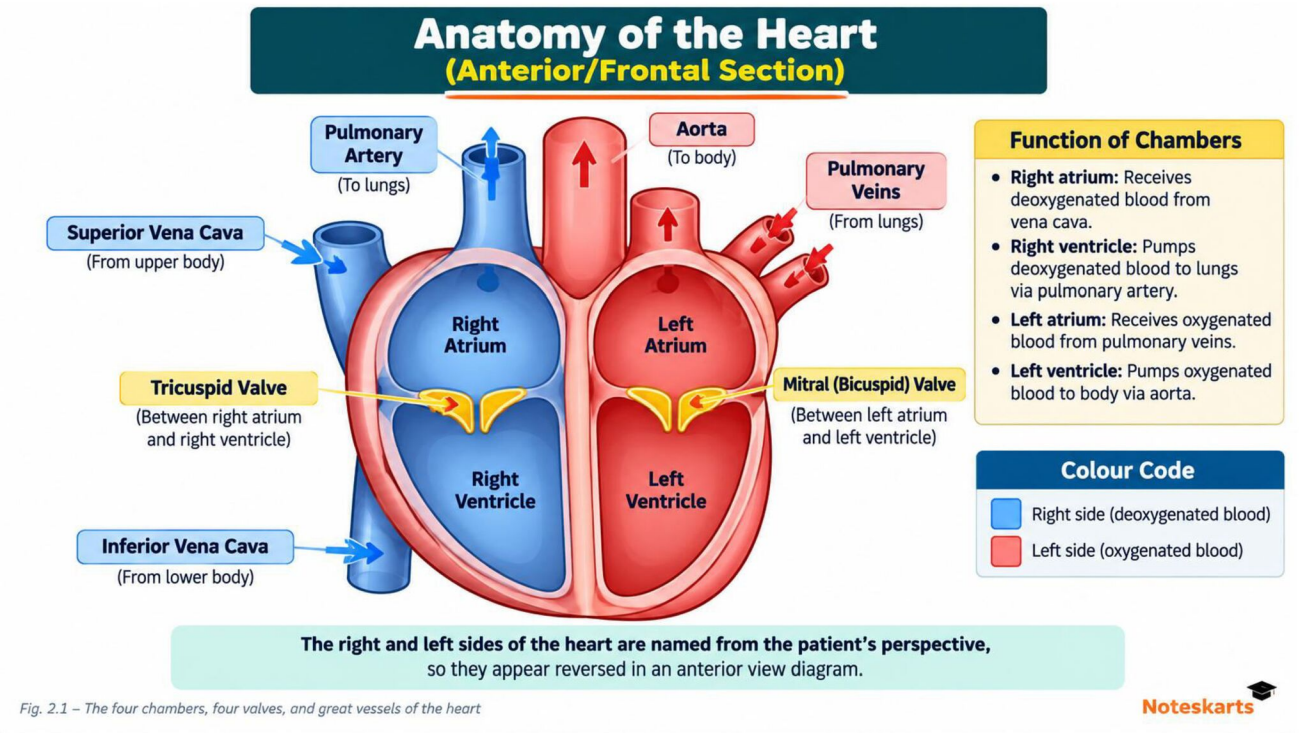

Fig. 1 – Anatomy of the heart

Heart Anatomy, Circulation & Vessels

The **heart is a muscular organ that pumps blood throughout the body**. It has four chambers and four main valves that keep blood flowing in the correct direction. The right side sends deoxygenated blood to the lungs, while the left side sends oxygenated blood to the body.

- **4 chambers:**
  - **Right atrium** → receives deoxygenated blood.
  - **Right ventricle** → pumps blood to the lungs through the **pulmonary artery**.
  - **Left atrium** → receives oxygenated blood from the lungs.
  - **Left ventricle** → pumps oxygenated blood to the body through the **aorta**.
- **Blood flow:**
  Right Atrium → Right Ventricle → Pulmonary Artery → Lungs → Left Atrium → Left Ventricle → Aorta → Body
- **4 valves:**
  - **Tricuspid valve** – between right atrium and right ventricle.
  - **Pulmonary valve** – between right ventricle and pulmonary artery.
  - **Mitral/Bicuspid valve** – between left atrium and left ventricle.
  - **Aortic valve** – between left ventricle and aorta.
- **Heart sounds:**
  - **"Lub"** → closure of the AV valves (tricuspid and mitral).
  - **"Dub"** → closure of the semilunar valves (pulmonary and aortic).
- **Heart wall layers:**
  - **Pericardium** – protective sac around the heart.
  - **Myocardium** – muscular layer that contracts and pumps blood.
  - **Endocardium** – smooth inner lining of the heart.

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- **Coronary arteries:**
  - **LAD, LCx and RCA** supply oxygen-rich blood to the heart muscle.
  - They arise from the **base of the aorta**.
- .

Heart Valves

The **heart valves prevent the backflow of blood** and ensure that blood moves in one direction. The heart has two main circuits: **pulmonary circulation**, which carries blood between the heart and lungs, and **systemic circulation**, which carries blood between the heart and the rest of the body.

- **Tricuspid valve:** Located between the **right atrium (RA)** and **right ventricle (RV)**.
- **Pulmonary semilunar valve:** Located between the **right ventricle** and **pulmonary artery**.
- **Mitral/Bicuspid valve:** Located between the **left atrium (LA)** and **left ventricle (LV)**.
- **Aortic semilunar valve:** Located between the **left ventricle** and **aorta**.
- **Main function of all valves:** Prevent **backflow of blood**.

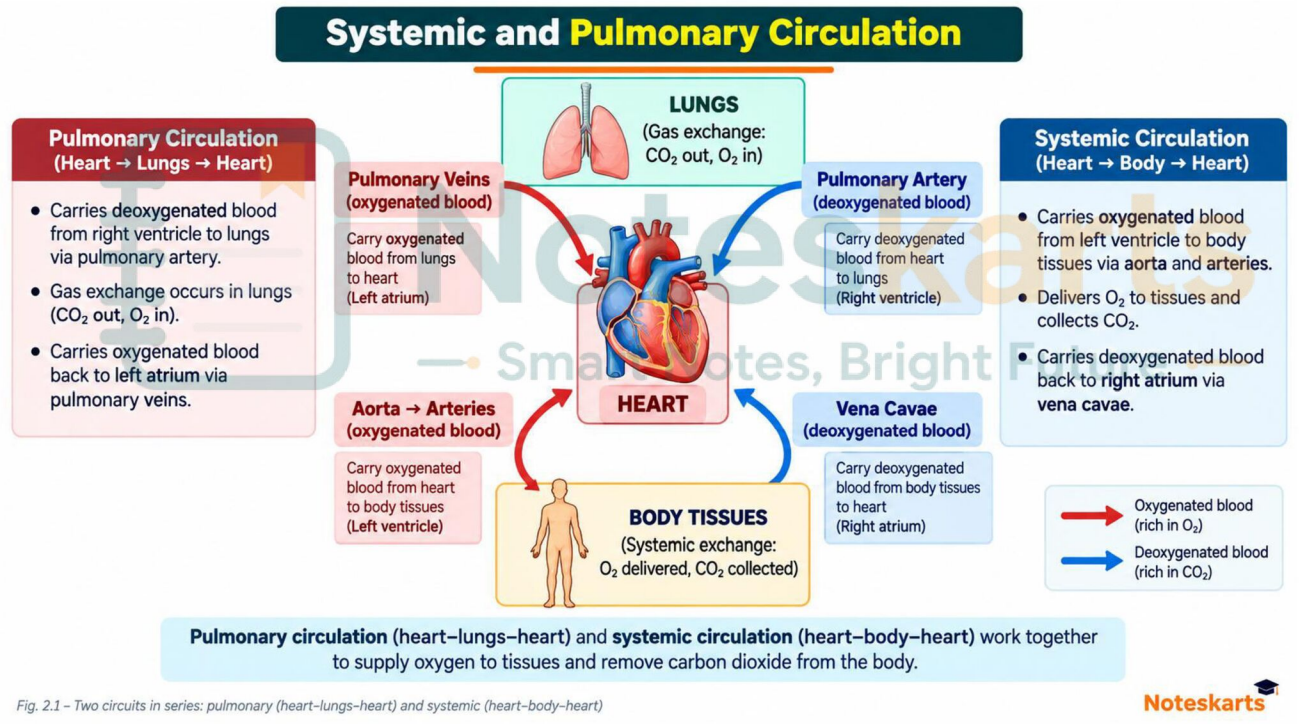

Fig. 2 – Systemic and pulmonary circulation

Pulmonary Circulation

Right ventricle → Pulmonary artery → Lungs → Pulmonary veins → Left atrium

- Blood goes to the **lungs for gas exchange**.
- CO_2 is removed and O_2 is taken up.

Systemic Circulation

Left ventricle → Aorta → Body tissues → Venae cavae → Right atrium

- Oxygenated blood is delivered to the **body tissues**.

- Deoxygenated blood returns to the **right atrium**.

Types of Blood Vessels

- **Arteries**
  - Carry blood **away from the heart**.
  - Have **thick, muscular walls**.
  - Carry blood under **high pressure**.
- **Veins**
  - Carry blood **towards the heart**.
  - Have **thinner walls** and **valves**.
  - Carry blood under **lower pressure**.
- **Capillaries**
  - Have a **single layer of endothelial cells**.
  - Connect arteries and veins.
  - Main site for **exchange of oxygen, nutrients, CO_2 and wastes**.

Cardiac Cycle Recap

The **cardiac cycle** is the sequence of events that occurs during one heartbeat. It includes contraction and relaxation of the atria and ventricles, allowing blood to fill the heart and then be pumped out.

- **Atrial systole** → Atria contract and push blood into ventricles.
- **Isovolumetric ventricular contraction** → Ventricles start contracting; all valves are closed.
- **Ventricular ejection** → Ventricles contract and pump blood into the arteries.
- **Isovolumetric relaxation** → Ventricles relax; all valves are closed.
- **Ventricular filling** → Blood flows from atria into ventricles.
- **"Lub"** → AV valves close.
- **"Dub"** → Semilunar valves close.

2. Conduction System, Cardiac Cycle & ECG

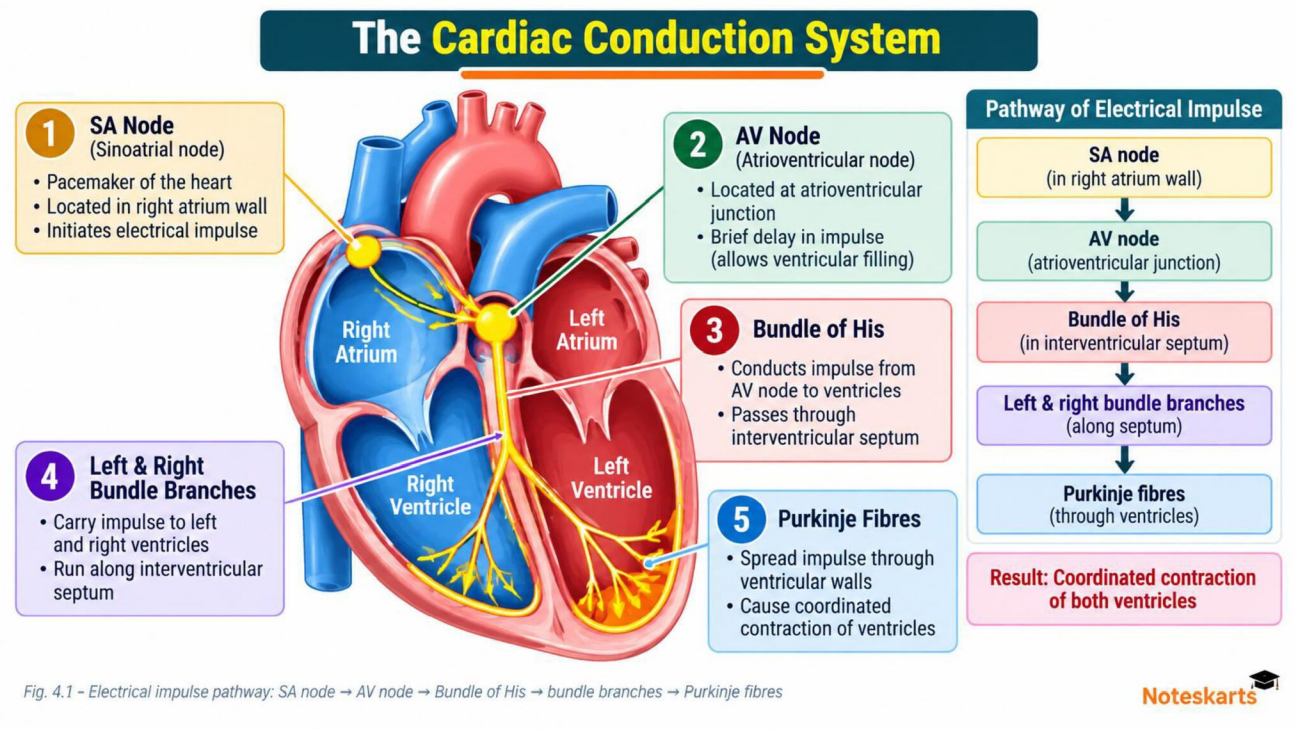

Fig. 3 – Cardiac conduction system

The **cardiac conduction system** produces and carries electrical impulses that control the heartbeat. The **SA node** starts the impulse, while the **AV node** briefly delays it before it reaches the ventricles.

- **Impulse pathway:**
  SA Node → AV Node → Bundle of His → Bundle Branches → Purkinje Fibres → Ventricular contraction
- **SA Node:** Natural pacemaker; normally **60–100 beats/min**.
- **AV Node:** Delays the impulse, allowing the ventricles to fill with blood.

Autonomic Control

- **Sympathetic:** Increases **heart rate, contractility and AV conduction**.
- **Parasympathetic (Vagus):** Decreases **heart rate and AV conduction**.

Cardiac Output

- **Cardiac Output = Heart Rate × Stroke Volume**
- Resting cardiac output is about **5 L/min**.
- **Stroke volume** depends mainly on:
  - **Preload** – amount of blood filling the ventricle.
  - **Contractility** – strength of ventricular contraction.
  - **Afterload** – resistance against which the heart pumps.

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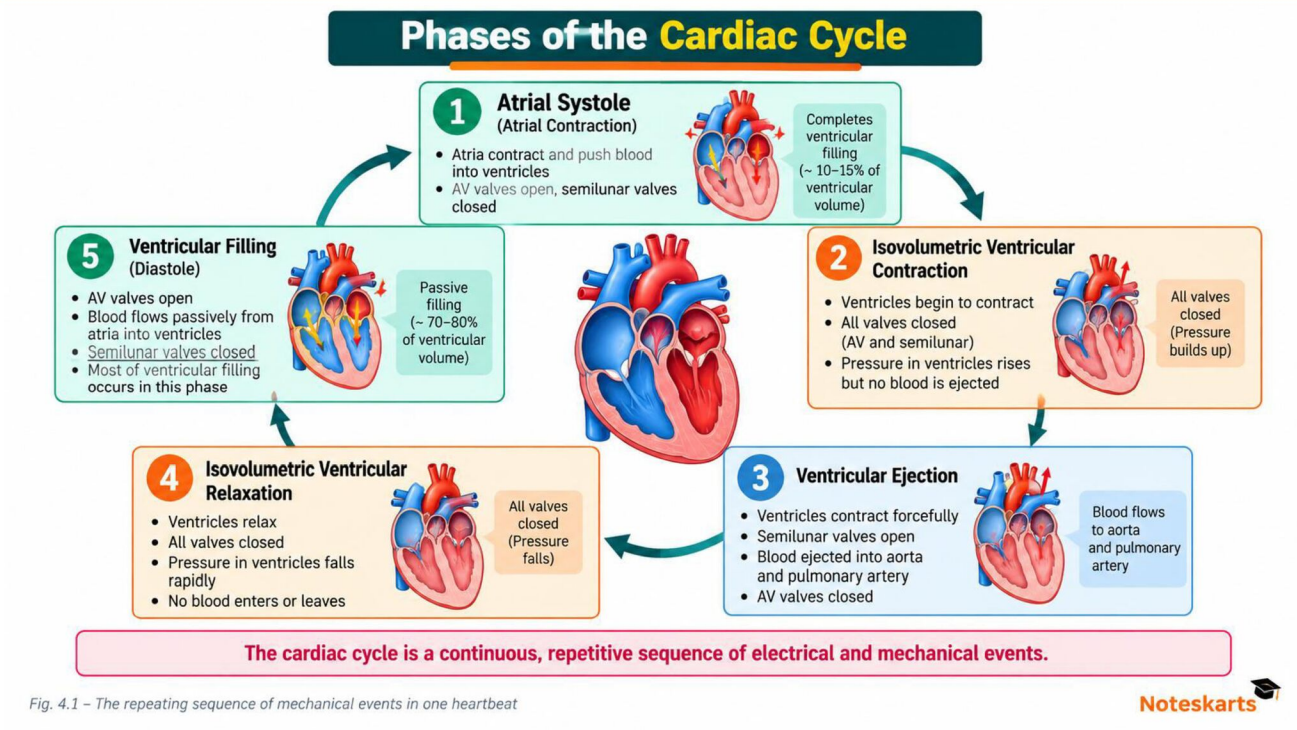

Fig. 4 – Phases of the cardiac cycle

- Cardiac cycle: Atrial systole → Isovolumetric ventricular contraction → Ventricular ejection → Isovolumetric relaxation → Ventricular filling.

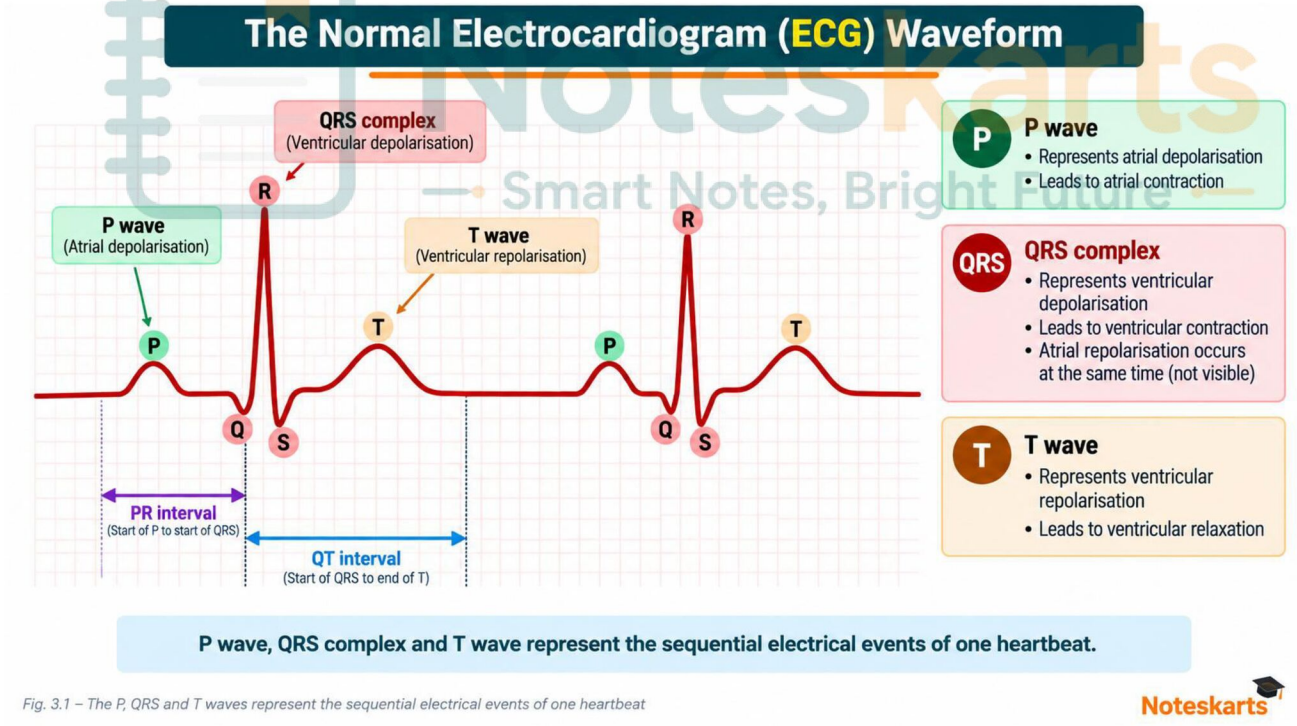

Fig. 5 – The normal ECG waveform

- P wave = atrial depolarisation. QRS complex = ventricular depolarisation. T wave = ventricular repolarisation. PR interval = AV nodal delay. QT interval = total ventricular activity.

Arterial Pulse

- Palpable pressure wave from each ventricular ejection. Common sites: radial (wrist), carotid (neck), femoral (groin), dorsalis pedis (foot). Assessed for rate, rhythm, volume, symmetry.

3. Blood Pressure & Cardiovascular Pathophysiology

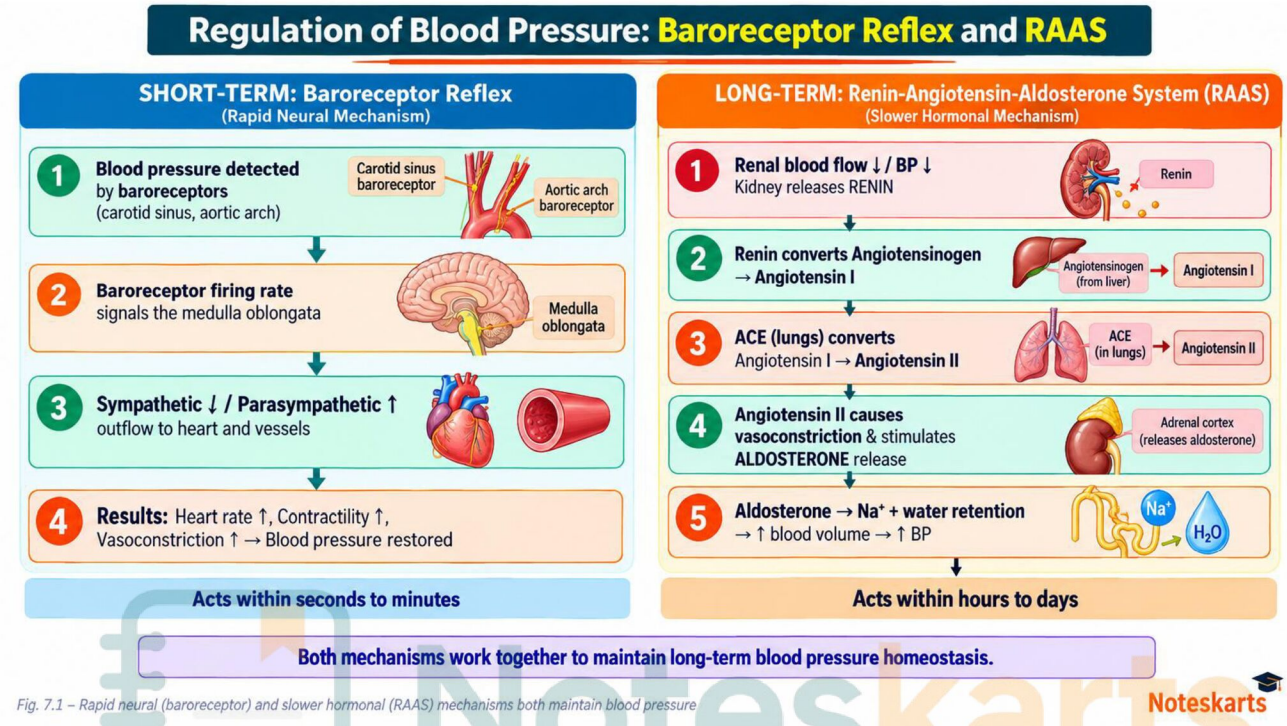

Fig. 6 – Regulation of blood pressure

Blood pressure depends mainly on cardiac output and peripheral resistance. The body regulates BP through short-term nervous mechanisms and long-term hormonal mechanisms.

- **BP = Cardiac Output × Peripheral Resistance**
- **Short-term regulation – Baroreceptor Reflex:**
  - Baroreceptors are present in the **carotid sinus and aortic arch**.
  - Signals reach the **medulla**, which adjusts sympathetic and parasympathetic activity.
  - Acts within **seconds**.
- **Long-term regulation – RAAS:**
  - ↓ Renal blood flow → **Renin** release
  - Renin → **Angiotensin I**
  - ACE converts Angiotensin I → **Angiotensin II**

- Angiotensin II causes **vasoconstriction** and ↑ **aldosterone**.
- Aldosterone → **Na^+ and water retention** → ↑ blood volume → ↑ BP.

Hypertension

Hypertension is persistently high blood pressure, commonly defined as **≥140/90 mmHg**.

- **Primary hypertension:** No single identifiable cause; most common.
- **Secondary hypertension:** Caused by conditions such as **renal or endocrine disease**.
- **Mechanisms:** ↑ Sympathetic activity, **RAAS overactivity**, and impaired sodium excretion.
- Often has **no symptoms** and is called the **"silent killer."**
- Long-term effects: **LVH, stroke, CKD and atherosclerosis**.

Cardiac Arrhythmias

Arrhythmias are abnormal heart rhythms caused by problems with impulse formation or conduction.

- **Bradyarrhythmias:** Slow heart rate, e.g., **heart block**.
- **Supraventricular tachyarrhythmias:** Rapid rhythms arising above the ventricles, e.g., **atrial fibrillation (AF)**.
- **Ventricular arrhythmias: VT/VF**, which can be life-threatening.

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Congestive Heart Failure

Heart failure occurs when the heart cannot pump enough blood to meet the body's needs.

- **Compensation:** Sympathetic activation, RAAS activation and cardiac remodelling.
- Over time, these mechanisms can **worsen heart failure**.
- **Left-sided failure:** Pulmonary congestion → **dyspnoea, orthopnoea**.
- **Right-sided failure:** Systemic congestion → **oedema, raised JVP, hepatomegaly**.

Atherosclerosis

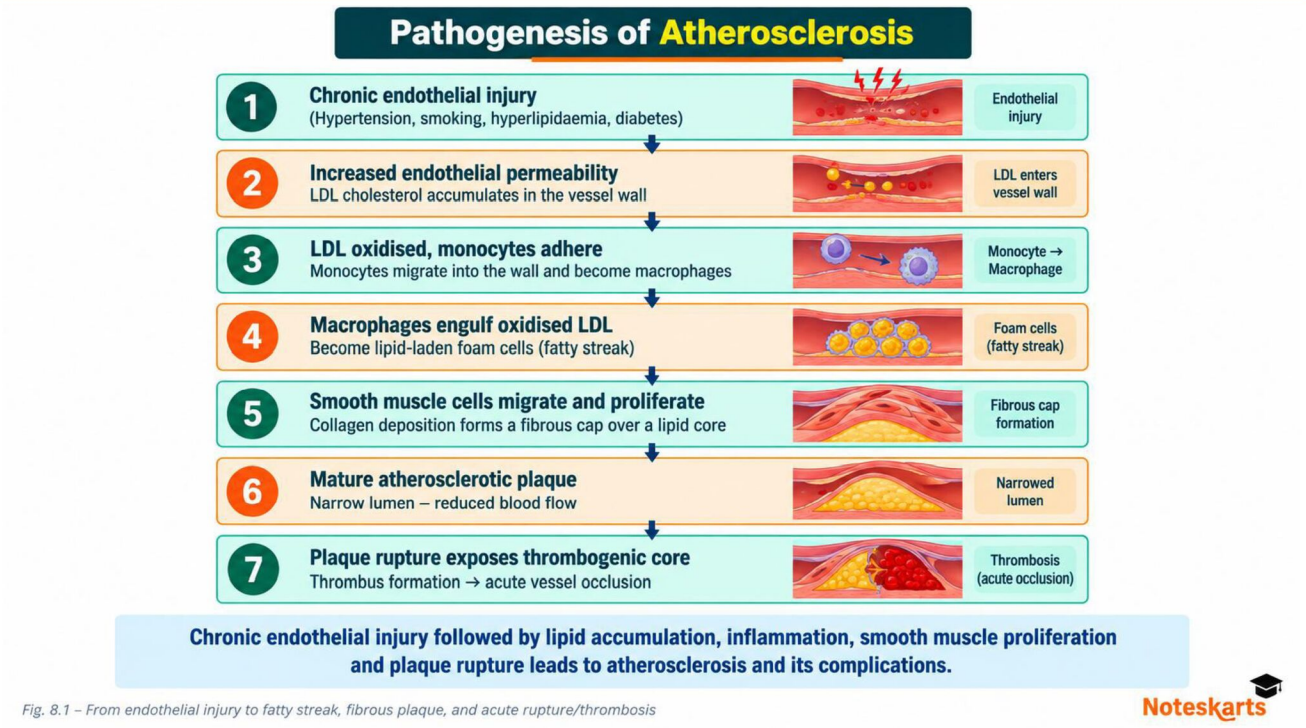

Fig. 7 – Pathogenesis of atherosclerosis

Atherosclerosis is the buildup of fatty plaques inside arteries.

- **Endothelial injury** → LDL accumulation and oxidation
- **Macrophages** → form foam cells
- Foam cells → **fatty streak**
- Fatty streak → **fibrous plaque**
- Plaque rupture → **thrombosis** → possible vessel blockage

Coronary Artery Disease: Angina & MI

Angina

Angina is temporary, reversible heart muscle ischaemia.

- **Stable:** Occurs during exertion; relieved by rest.
- **Unstable:** May occur at rest; **medical emergency**.
- **Prinzmetal:** Caused by **coronary artery spasm**.

Myocardial Infarction (MI)

MI occurs when prolonged coronary artery blockage causes **irreversible heart muscle necrosis**.

- Usually caused by a **thrombus over a ruptured plaque**.
- **STEMI:** Usually complete occlusion → **ST elevation** and extensive myocardial injury.

- **NSTEMI:** Usually partial occlusion → **subendocardial injury**.
- **Diagnosis:** Mainly by elevated **cardiac troponin**.
- **Treatment:** Urgent **reperfusion**; traditional **MONA** measures may be used when appropriate.

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