

Cardiovascular System
Heart Failure
Pulmonary Heart Disease
Pulmonary Hypertension

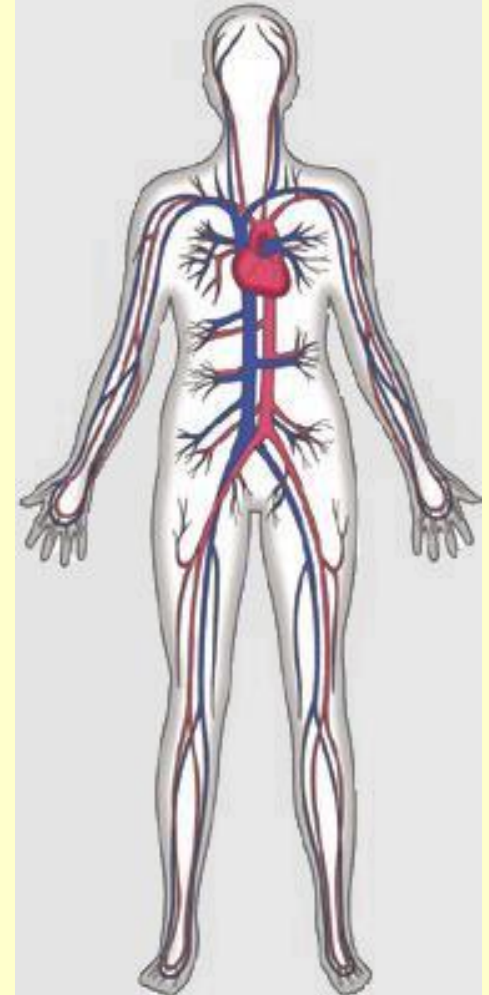
lecture from Physiology and Pathophysiology II

14. 3. 2023

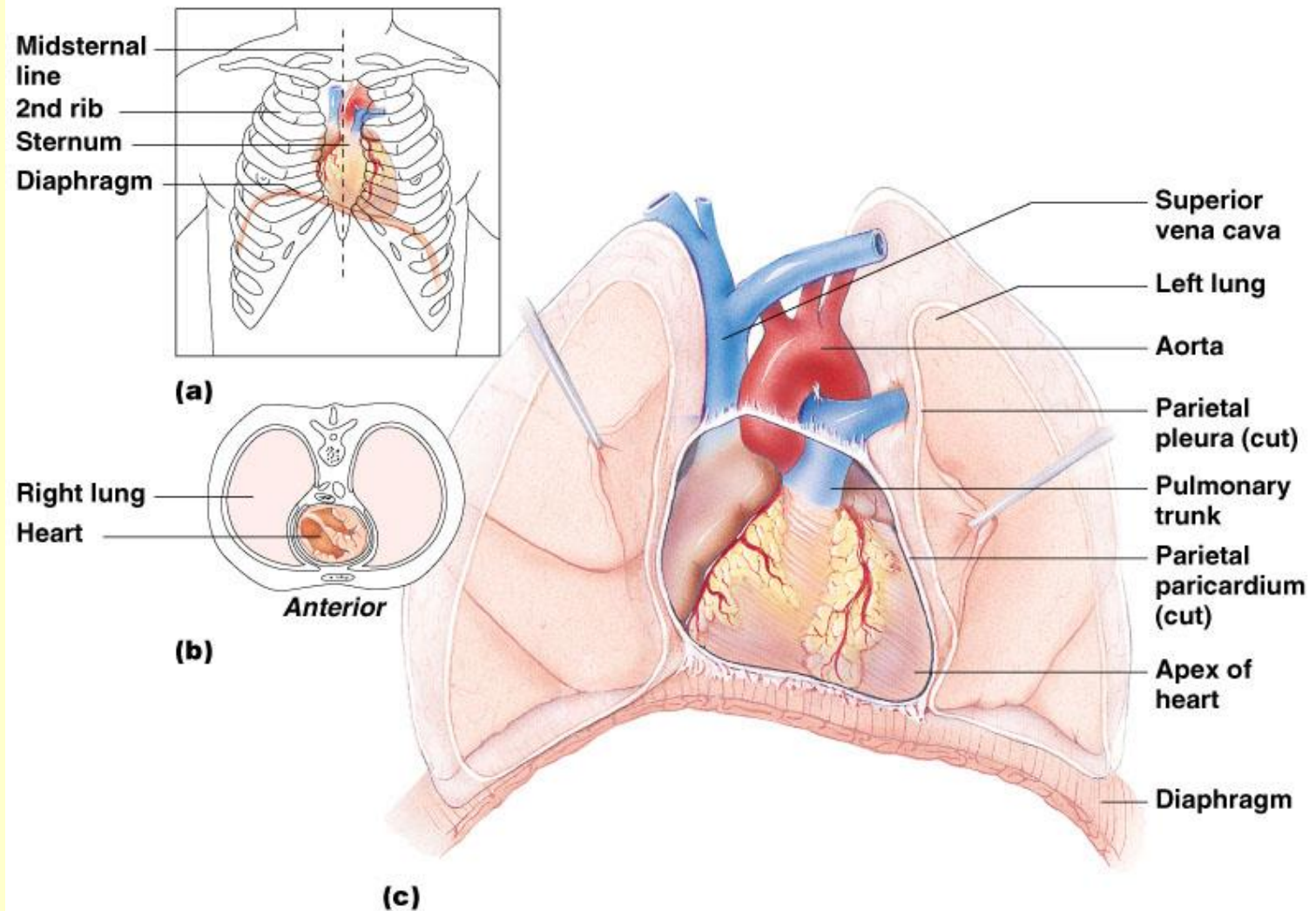
M. Chalupová

Cardiovascular System

- closed system of the heart and blood vessels
 - heart pumps blood
 - blood vessels allow blood to circulate to all parts of the body
- function is to deliver oxygen and nutrients and to remove carbon dioxide and other waste products



Heart

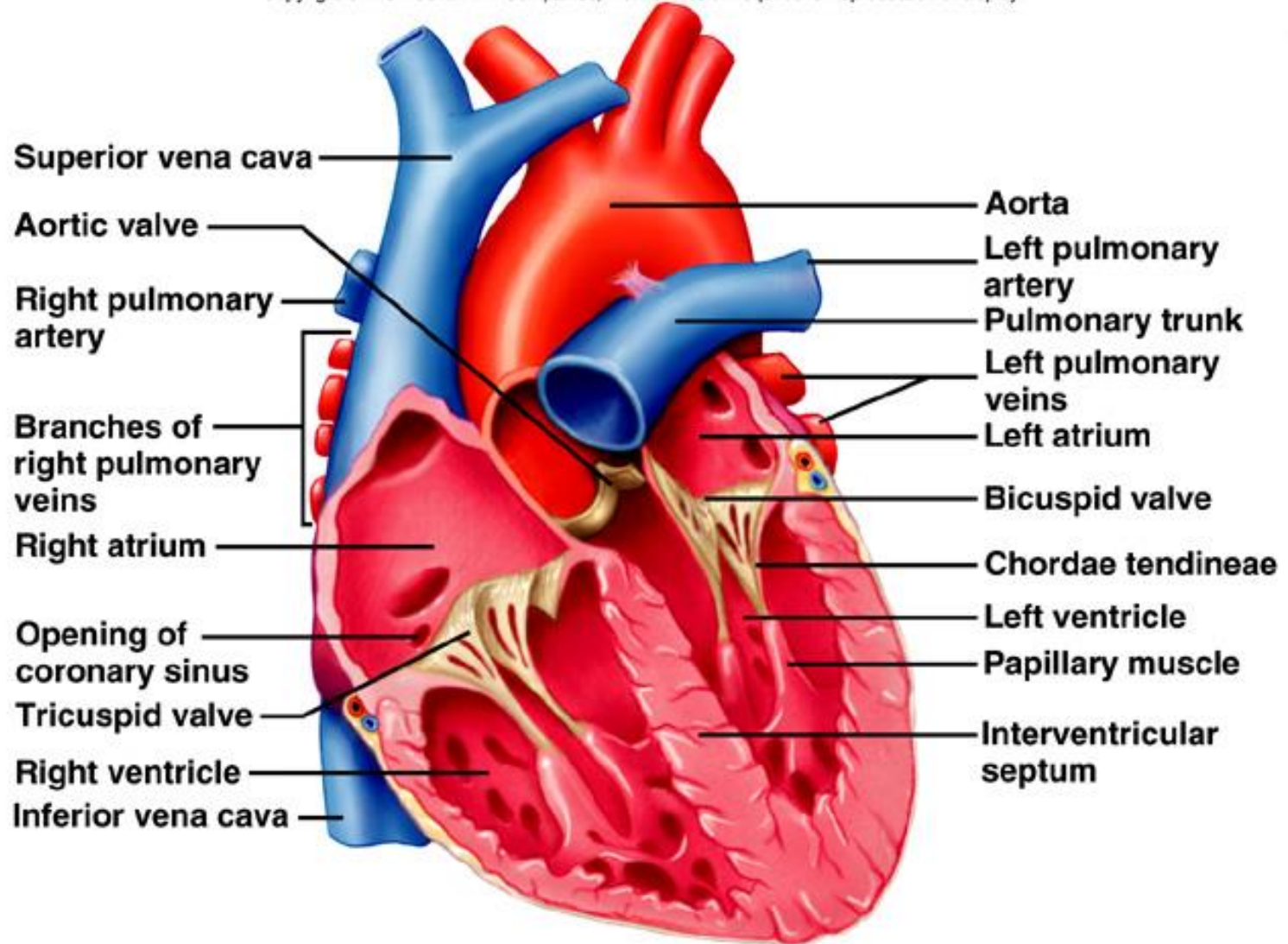


Heart Valves

- allow blood to flow in only one direction
- **atrioventricular valves** – between atria and ventricles
 - bicuspid valve (left)
 - tricuspid valve (right)
- **semilunar valves** between ventricle and artery
 - pulmonary semilunar valve
 - aortic semilunar valve

Heart

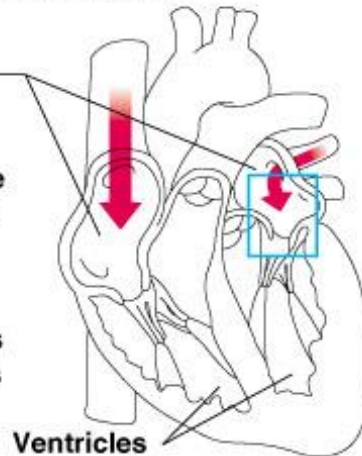
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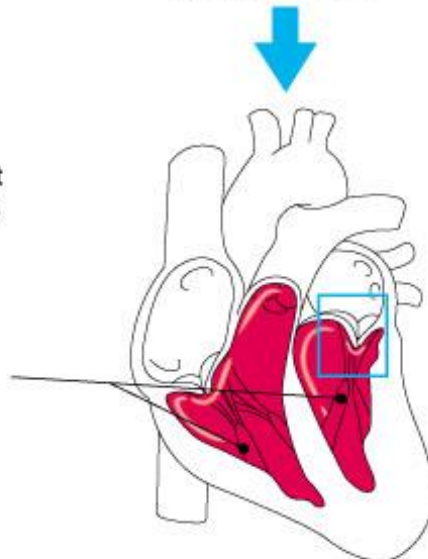
Heart Valves Operations

Operation of the AV valves

- ① Blood returning to the heart fills atria, putting pressure against atrioventricular valves; the atrioventricular valves are forced open
- ② As the ventricles fill, atrioventricular valve flaps hang limply into ventricles
- ③ Atria contract, forcing additional blood into ventricles



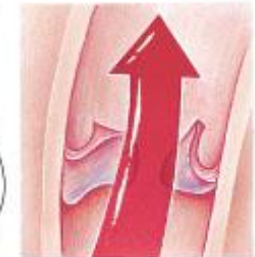
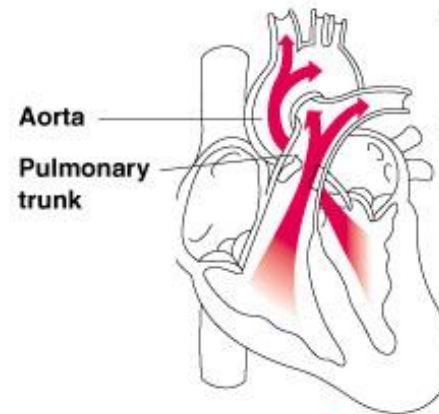
- ① Ventricles contract, forcing blood against atrioventricular valve cusps
- ② Atrioventricular valves close
- ③ Chordae tendineae tighten, preventing valve flaps from everting into atria



(a)

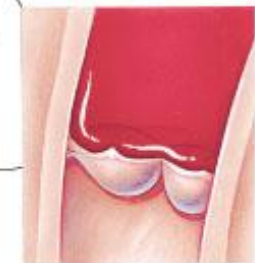
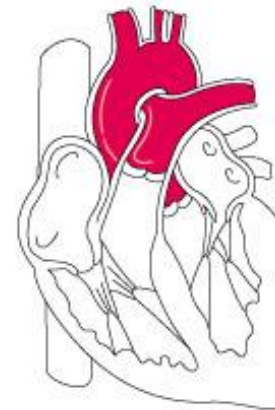
Operation of the semilunar valves

As ventricles contract and intraventricular pressure rises, blood is pushed up against semilunar valves, forcing them open



Semilunar valve open

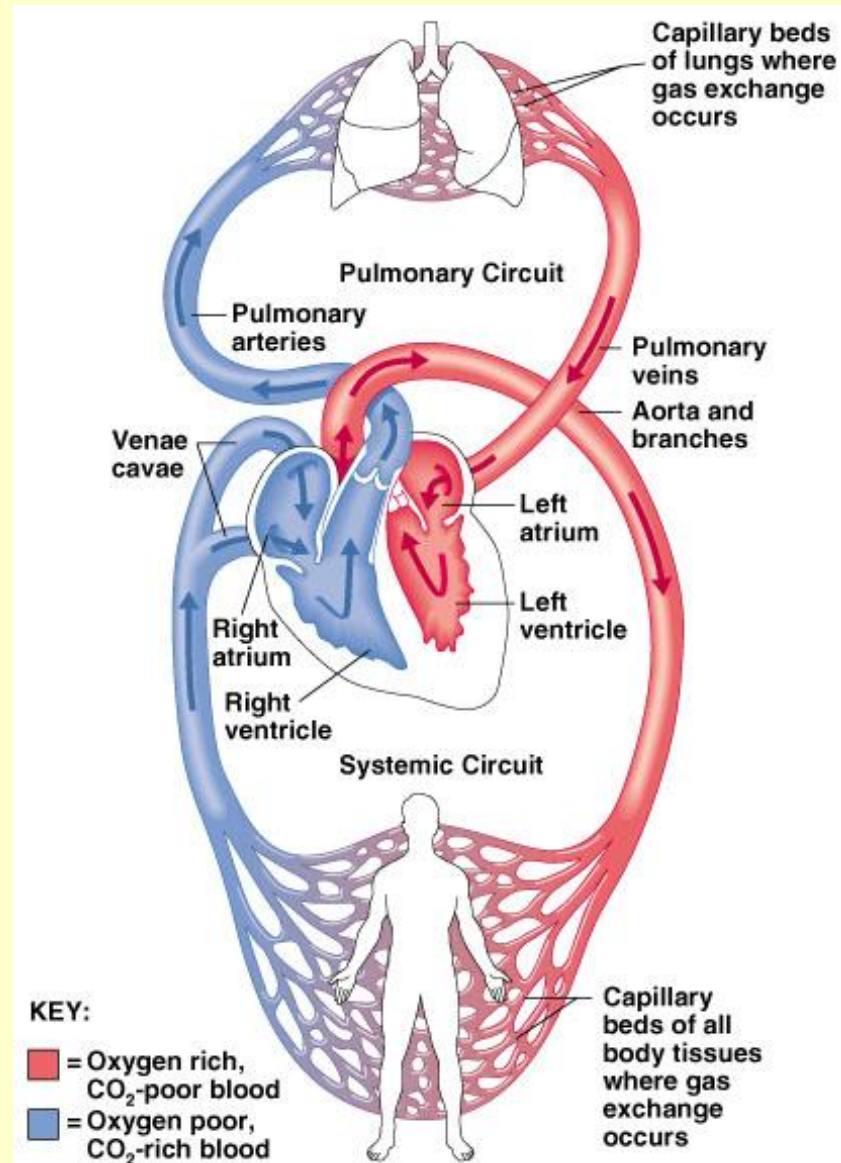
As ventricles relax, and intraventricular pressure falls, blood flows back from arteries, filling the cusps of semilunar valves and forcing them to close



Semilunar valve closed

(b)

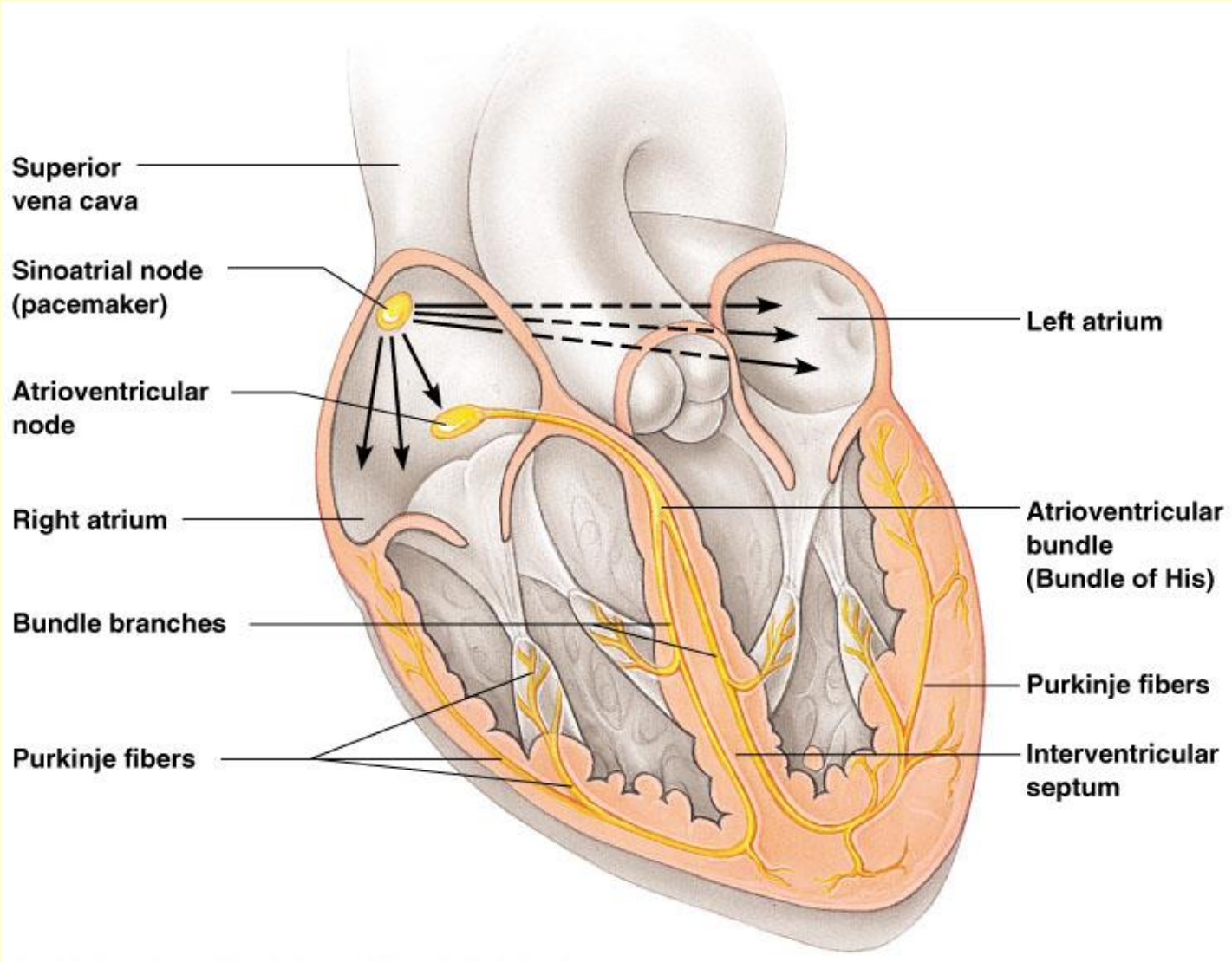
Blood Circulation



Conduction System of the Heart

- specialized muscular tissue sets the pace
- **sinoatrial node** (right atrium)
 - pacemaker
- **atrioventricular node** (junction of r&l atria and ventricles)
- Atrioventricular bundle (Bundle of His)
- Bundle branches (right and left)
- Purkinje fibers

Conduction System of the Heart

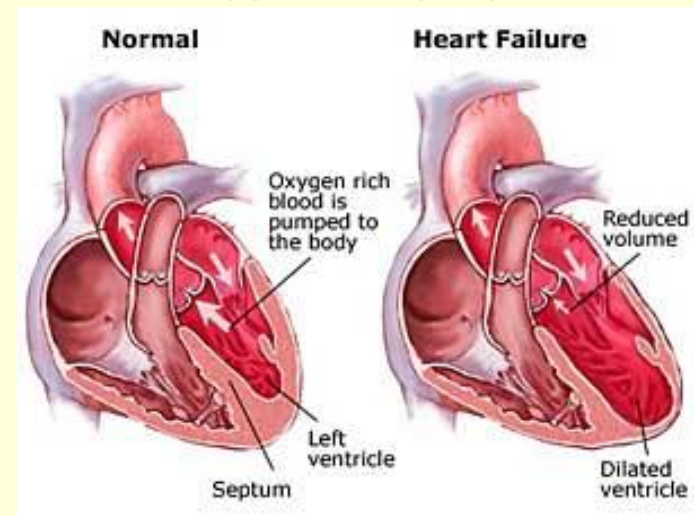


Heart Failure

- results from any structural or functional abnormality that impairs the ability of the ventricle to eject blood (**Systolic Heart Failure**) or to fill with blood (**Diastolic Heart Failure**)
- caused by:
 - coronary artery disease
 - heart attack
 - high blood pressure
 - infections
 - heart valve abnormalities
 - hyperthyroidism

Heart Failure

- heart failure can involve the left or right side of the heart or both (the left side is rather affected first)
- usually a chronic disease
- the heart tries to compensate for the loss in pumping function by:
 - developing more muscle mass (**ventricular hypertrophy**)
 - enlarging
 - pumping faster (**tachycardia**)



Heart Failure

LEFT HEART FAILURE

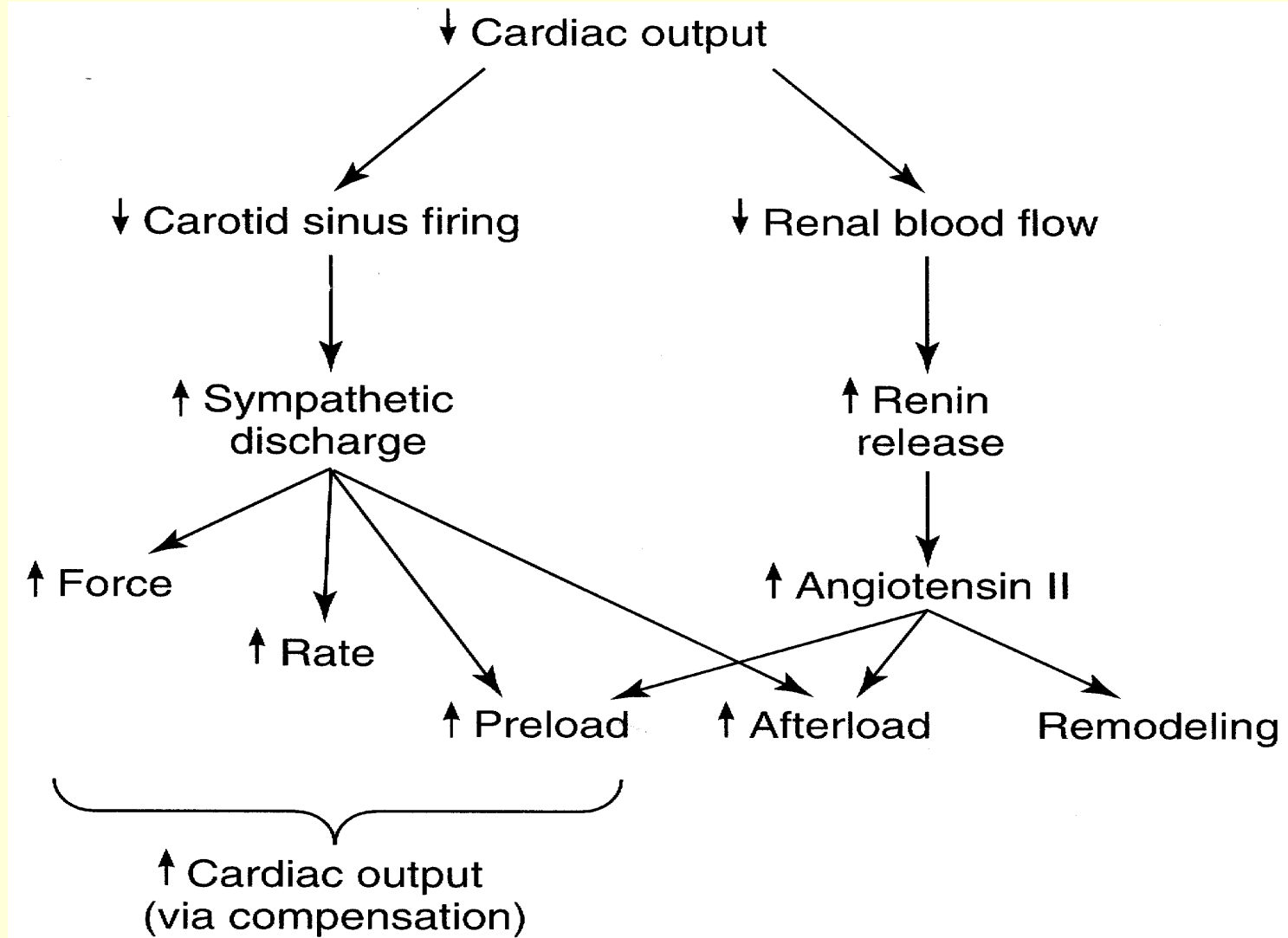
- involves the left ventricle of the heart
 - **Systolic failure**
 - the heart loses its ability to contract or pump blood into the circulation
 - **Diastolic failure**
 - the heart loses its ability to relax because it becomes stiff
 - it cannot be filled properly between each beat

Heart Failure

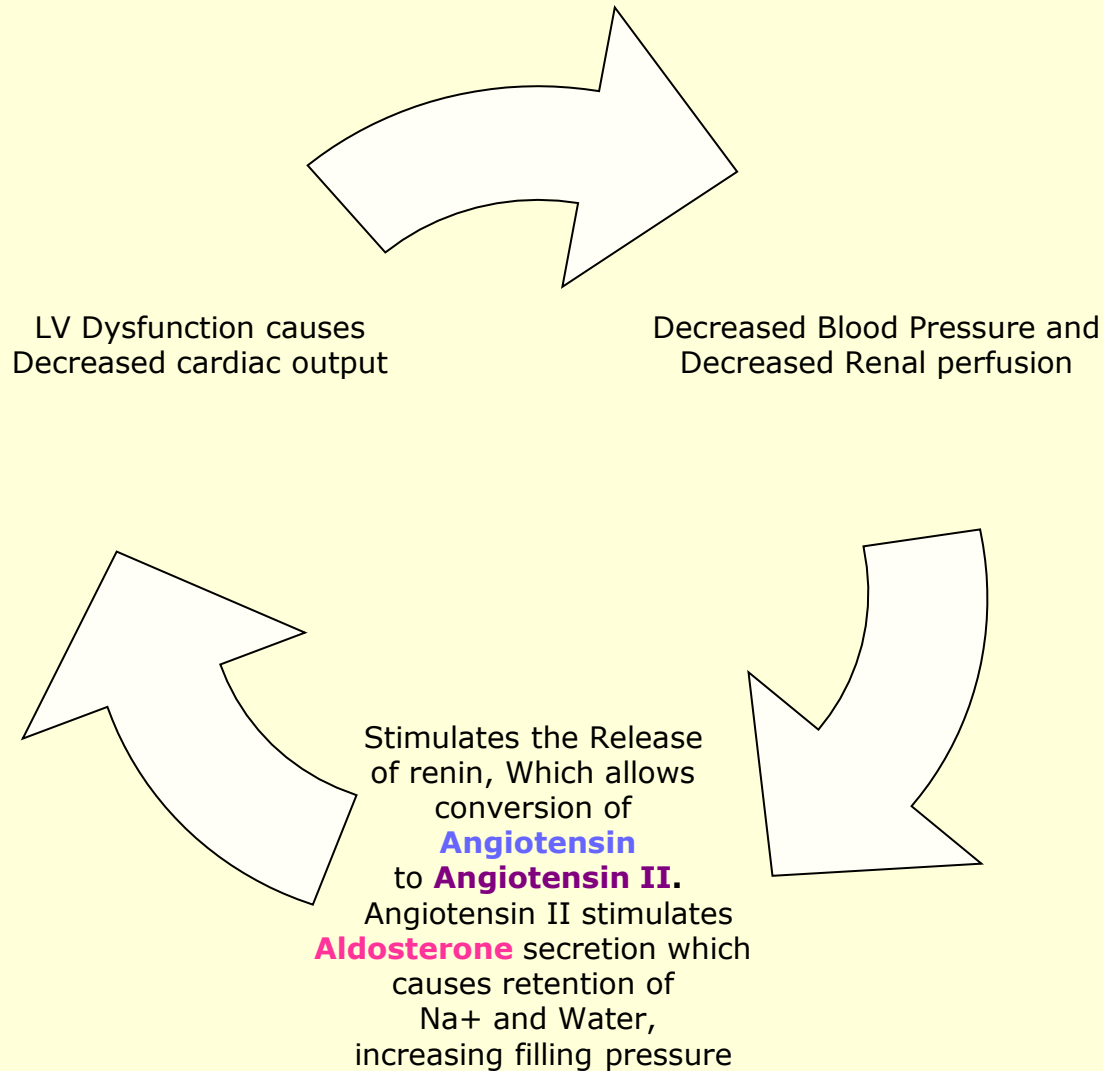
RIGHT HEART FAILURE

- usually occurs as a result of left heart failure
- the right ventricle pumps blood to the lungs for oxygen
- occasionally **isolated right heart failure** can occur due to lung disease or pulmonary embolism

Heart Failure Pathophysiology



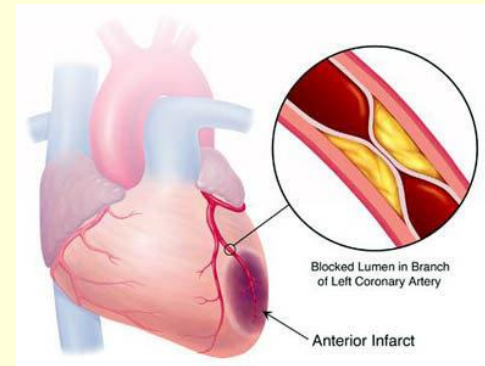
Heart Failure Vicious Cycle



Causes of Heart Failure

CORONARY ARTERY DISEASE

- cholesterol and fatty deposits build up in the heart's arteries
- less blood and oxygen reach the heart muscle
- this causes the heart to work harder and occasionally damages the heart muscle



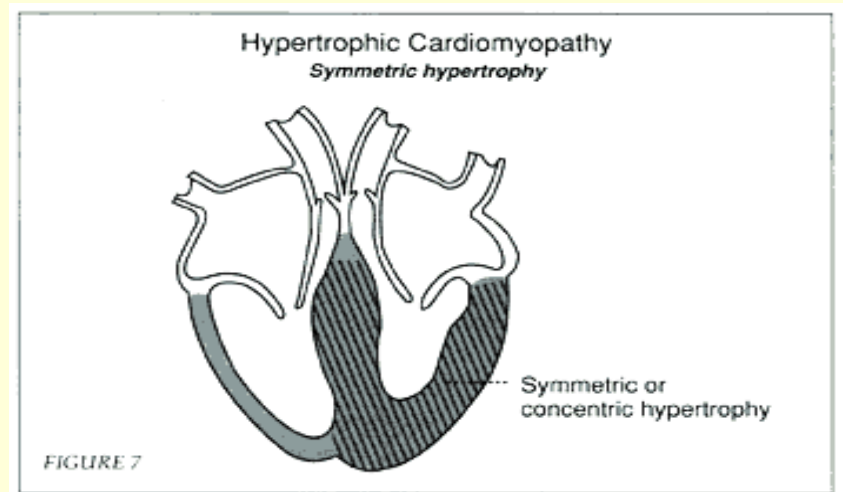
HEART ATTACK (MYOCARDIAL INFARCTION)

- coronary artery being blocked leading to cardiomyocyte necrosis
- remaining heart muscle must pump harder to keep up

Causes of Heart Failure

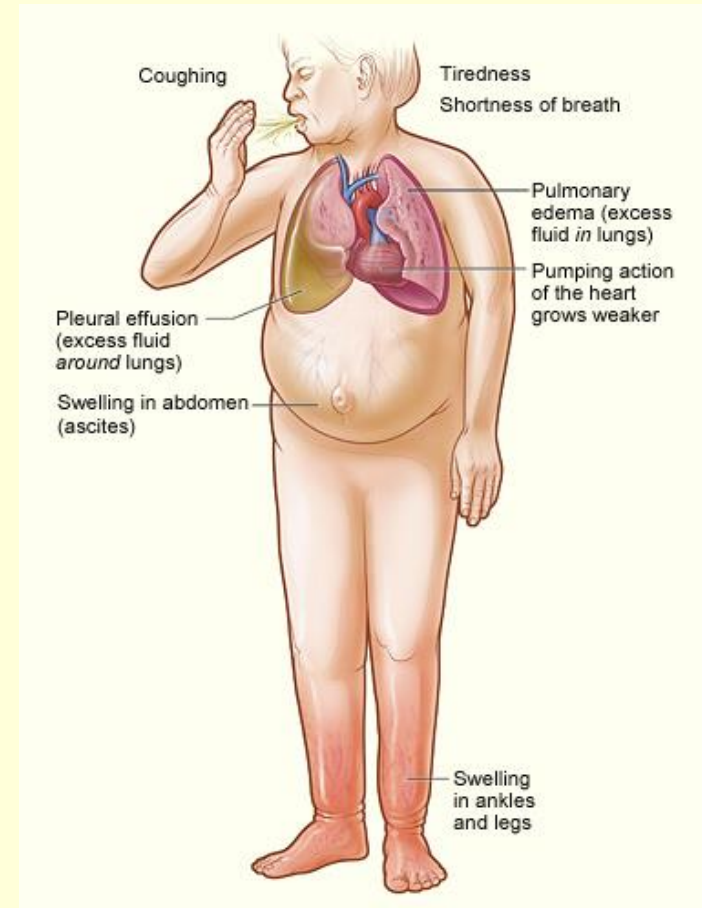
HIGH BLOOD PRESSURE (HYPERTENSION)

- uncontrolled high blood pressure doubles a person's risk of developing heart failure
- heart must pump harder to keep blood circulating
- chamber first thickens, then gets larger and weaker




Symptoms of Heart Failure

- shortness of breath (dyspnoea)
 - dyspnea on exertion or at rest
 - difficulty breathing when lying flat
 - waking up short of breath
- persistent cough or wheezing
- edemas
 - swelling in feet, ankles and legs
 - ascites
 - weight gain
- confusion, impaired thinking



Symptoms of Left Heart Failure

LEFT SIDED ♥ FAILURE

- Paroxysmal Nocturnal Dyspnea
 - Elevated Pulmonary Capillary Wedge Pressure
 - Pulmonary Congestion
 - Cough
 - Crackles
 - Wheezes
 - Blood-Tinged Sputum
 - Tachypnea
 - Restlessness
 - Confusion
 - Orthopnea
 - Tachycardia
 - Exertional Dyspnea
 - Fatigue
 - Cyanosis
- 
- A cartoon illustration of a man in a green brief, bent over in a hunched position, clutching his chest with both hands. He has a pained expression, with a wide-open mouth and a furrowed brow. Several blue teardrop-shaped droplets are floating around his head, suggesting distress or sweating. The man's back is covered in brown, textured patches, possibly representing congestion or fluid accumulation. The artist's signature 'C. MILLER' is visible at the bottom left of the illustration.

Symptoms of Right Heart Failure

RIGHT SIDED ♥ FAILURE

(Cor Pulmonale)

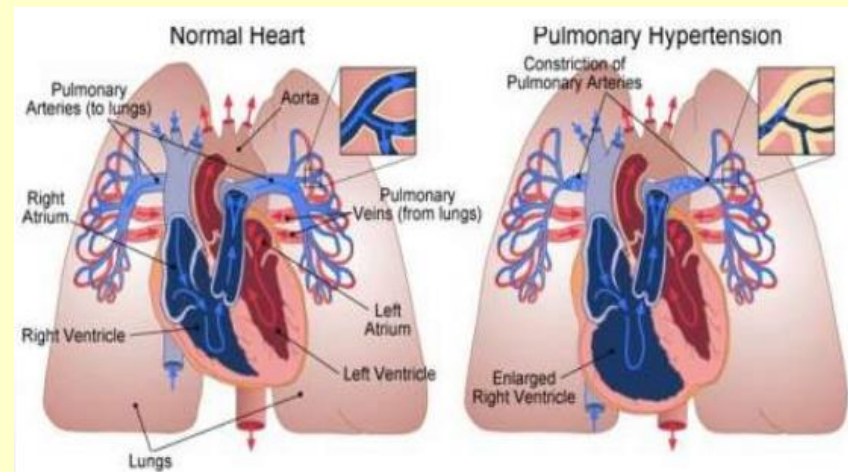
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- Fatigue
 - ↑ Peripheral Venous Pressure
 - Ascites
 - Enlarged Liver & Spleen
 - May be secondary to chronic pulmonary problems
 - Distended Jugular Veins
 - Anorexia & Complaints of GI Distress
 - Weight Gain
 - Dependent Edema

NYHA Heart Failure Classification

Class	% of patients	Symptoms
I	35 %	No symptoms or limitations in ordinary physical activity
II	35 %	Mild symptoms and slight limitation during ordinary activity
III	25 %	Marked limitation in activity even during minimal activity. Comfortable only at rest
IV	5 %	Severe limitation. Experiences symptoms even at rest

Pulmonary Heart Disease

- **pulmonary heart disease (cor pulmonale)**
- dilation/hypertrophy of right heart ventricle and heart failure due to increased vascular resistance or high blood pressure in the lungs
 - acute \Rightarrow dilation
 - chronic \Rightarrow hypertrophy

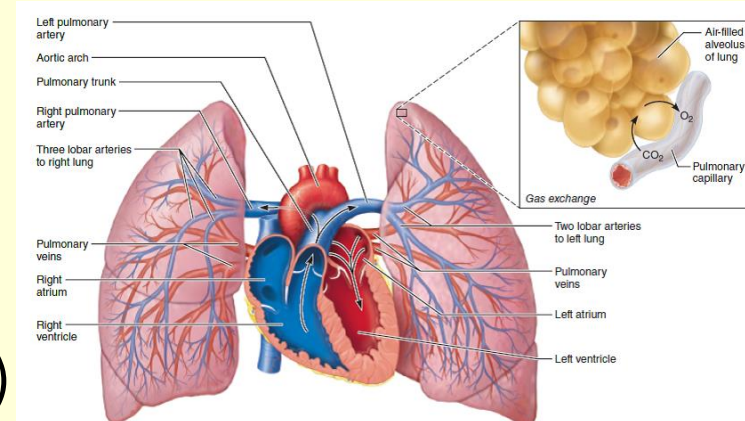


Pulmonary Heart Disease

- arises in the pulmonary circulation
- **symptoms**
 - dyspnoea, wheezing, liquid in the abdominal cavity (ascites), cyanosis, enlarged liver, edemas
- **causes**
 - pulmonary embolism, ARDS, COPD, primary pulmonary hypertension, interstitial lung diseases

Pulmonary Hypertension

- **mean pulmonary artery pressure** – 20–25 mmHg
 - determined by pulmonary vascular resistance, cardiac output and left arterial pressure
- **pulmonary hypertension** – over 25 mmHg
- **acute**
 - pulmonary embolism with **acute cor pulmonale** (right ventricle dilation) and acute right heart failure
- **chronic**
 - lung diseases
 - chronic thromboembolism
 - chronic altitude hypoxia
 - consequence is right ventricular hypertrophy (**chronic cor pulmonale**)



Pulmonary Hypertension

- **primary**

- idiopathic damage of small arteries
- bad prognosis

- **secondary**

- lung diseases
- hypoxia (high altitude)
- left heart failure, mitral valve disease
- thromboembolism

