STRUCTURES AND LAYERS OF THE HEART

Medical Editor: May Perez

OUTLINE

FYI: ABBREVIATIONS

- RV: Right Ventricle
- LV: Left Ventricle
- RA: Right Atrium
- LA: Left Atrium
- SA: Sino-Atrial
- AV: Atrio-ventricular

I) OVERVIEW

- The heart weights approximately **200-300 grams**

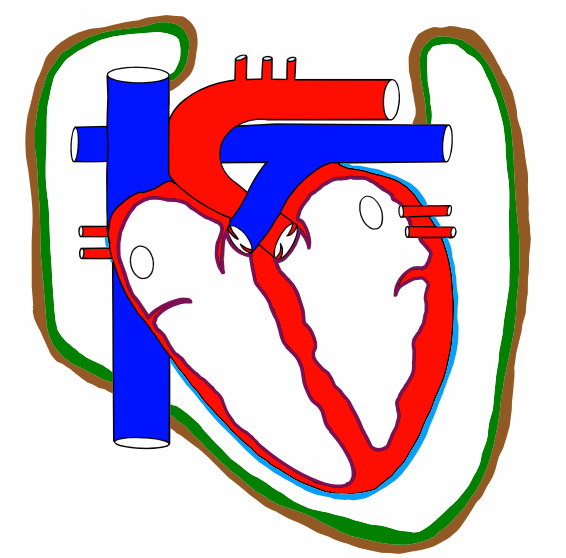


Figure 1.1. Overview of Heart Structure

(A) ORIENTATION

- Shifted ⅔ to the left of the midsternal line
- Base of the heart
  - Superior Surface
  - Points towards right shoulder
- Apex of the heart
  - Inferior surface
  - points to left hip

(B) LOCATION

- **Middle mediastinum** in a pericardial covering in the thoracic cavity
  - Anterior to heart
    - Sternum and costal cartilage Peric
  - Posterior to heart
    - Vertebral column from (T5-T8)
    - Esophagus
    - Carina of trachea and primary bronchi
  - Lateral to heart
    - Lungs

II) LAYERS OF THE HEART

- From the inner layer to the outer layer of the heart

(1) Endocardium

(i) Endothelium:

- **Simple Squamous epithelial** tissue with **areolar** connective tissue

(ii) Function:

- Keeps blood in heart antithrombotic
  - Prevents clotting
  - Releases PGI2 and Nitric oxide which inhibits platelet activation and aggregation
- Act as a barrier between blood and tissue.
  - Makes tight junctions which controls movement between cells.
- Continues as Endothelium in blood vessels
- Lines the outer layer of the valves in the heart

(2) Myocardium

(i) Cardiac muscle tissues:

- Contractile Cardiac Muscle
- Non-Contractile Cardiac Muscle
  - SA node
    - Nodal, auto-rhythmic cells, that can generate AP and set sinus rhythm
  - AV node
  - Bundle of His
  - Bundle branches (right and left)
  - Purkinje fibers

(ii) Functions:

- Non-Contractile cardiac muscle
  - generates and conducts action potentials
- Contractile cardiac muscle
  - contracts as a unit to pump blood through and out of the heart
- Secrete **atrial natriuretic peptide (ANP)** and **Brain natriuretic peptide (BNP)** when stretched
  - ANP and BNP→ ↑Na+ and H_2O excretion → dilates blood vessels this combination leads to→ ↓ blood volume and decrease stretch of myocardium

(3) Visceral layer of serous pericardium

- Also called **epicardium**
- Mesothelium: simple squamous with loose areolar connective tissue
- **Secretes pericardial serous fluid** into the cavity to lubricate tissue layers.

(4) Pericardial cavity

- Contains serous fluid
  - Usually has no blood under normal physiologic conditions
- Prevents friction from two serous layers rubbing against each other

- Clinical Correlate: *Pericarditis*
  - Less fluid → More friction → Severe stabbing pain

(5) Parietal layer of serous pericardium

- Continuous with the epicardium
- Mesothelium: **simple squamous** + **loose areolar** connective tissue
- **Secretes pericardial serous fluid** into the cavity to lubricate tissue layers.

(6) Fibrous pericardium

- Tissue:
  - Dense fibrous irregular connective tissue
- Function:
  - Anchors heart to surrounding structures
  - Prevents heart from overfilling with blood because it's not a distensible or "stretchy" tissue
  - Protects the heart because of tough tissue

III) CHAMBERS OF THE HEART

(A) ATRIAL CHAMBERS

- **Interatrial Septum**
  - Separates the LA and RA

(1) Right Atrium (RA)

- Received deoxygenated blood from three vessels:
  - **Superior Vena Cava**
    - Brings blood from structures above the diaphragm (i.e., The head and neck and arms)
  - **Inferior Vena Cava**
    - Brings blood from structures below the diaphragm (i.e., The abdomen and the liver)
  - **Coronary Sinus**
    - Brings blood from coronary circulation
- Pushes deoxygenated blood into RV
  - → **drives blood into the pulmonary circulation**
- Contains **Fossa Ovalis**
  - Scar tissue
  - Remnant of the *Foramen Ovale*
    - Hole between the RA and the LA in the embryo that closes up at birth
      - Lets blood move from RA to LA in the fetus
        - Prevents blood from moving from RA → RV → Pulmonary Trunk → Pulmonary Circulation
      - Function arises from the fact that lungs of the fetus aren't functioning in the embryo
        - Hence, no need to send blood to the pulmonary circulation

(2) Left Atrium (LA)

- Receives oxygenated blood from 4 **pulmonary veins**
  - Two left pulmonary veins from the left lung
  - Two right pulmonary veins from the right lung
- Pushes oxygenated blood into LV
  - →**This drives blood into the systemic circulation**

(B) AURICLES

(1) Left Auricle or Left atrial appendage

- Increases space and volume of right atrium
- Clinically Relevance
  - Thrombi very commonly forms in atrial fibrillation

(2) Right Auricle or Right atrial appendage

- Increases space and volume of right atrium
- Clinical Relevance
  - Thrombi formation happens but not as common as in the left auricle during atrial fibrillation

(C) VENTRICULAR CHAMBERS

- **Interventricular Septum**
  - Separates the RV and LV
  - Clinical Correlate: *Ventricular Septal Defect*
    - Most common type of heart defect
    - Causes mixing of blood in RV and LV

(1) Right Ventricle (RV)

- Receives deoxygenated blood from RA
- Pushes deoxygenated blood into pulmonary circulation via the Pulmonary trunk

(2) Left Ventricle (LV)

- Receives oxygenated blood from LA
- Pushes oxygenated blood into systemic circulation via the ascending aorta.

IV) VALVES OF THE HEART

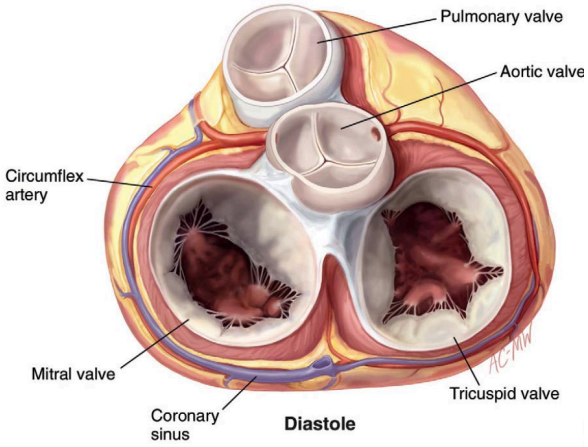


Figure 1.2. Anatomy of the heart valves [American Association of thoracic surgery]

(A) OVERVIEW

(1) Valve Structure

- Four annulus rings of fibrous tissue
  - **Leaflets tissue** hang from these annulus rings
    - Endothelial layer
    - Zona Spongiosa
    - Zona Fibrosa
    - Zona Ventricularis/Atrialis
- **Chordae tendineae**
  - Anchors the leaflets to papillary muscles
  - **Collagen** cords of connective tissue
  - Attached to the **cusps** of the valves
  - Keeps valve tight to prevent them from ballooning back into the atrium and causing blood backflow
- **Papillary muscles**
  - Projections of the myocardium
  - Anchors the chordae tendineae
  - If ischemic, muscles weaken → unable to contract → valve flaps loosen → valve regurgitation
- Surround the orifice between atria and ventricles and ventricles and pulmonary trunk and Aorta

(2) Valves Function:

- Ensures a one-way flow
- Prevent backflow
- Valves are anchored to cardiac skeleton
- As electrical insulator between atria and ventricles
  - Blocks electrical signals from atria to ventricles
  - Ensures all electrical signals go through AV node

(B) ATRIOVENTRICULAR VALVES

- Between atria and ventricles
- Prevents backflow of blood from ventricles into atria

(1) Tricuspid Valve

- Right atrial-ventricular valve
- Between RA and RV
- Contains Three leaflets

(2) Bicuspid or Mitral Valve

- Between LA and LV
- Contains Two leaflets

(C) SEMILUNAR VALVES

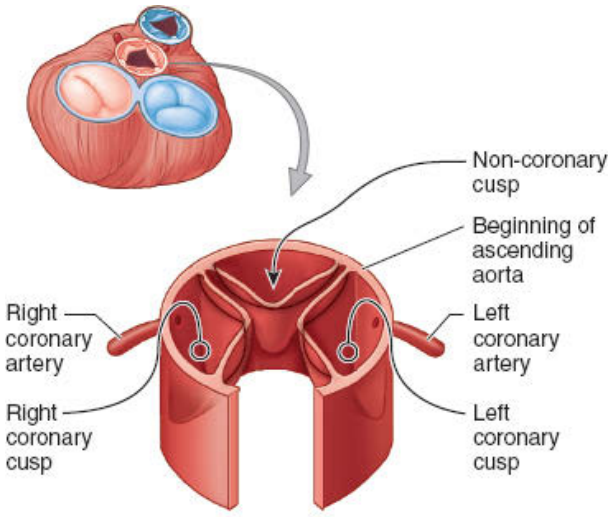
- These valves have three crescent shaped cusps
- Between ventricles and pulmonary trunk and aorta
  - Pulmonary trunk splits into the left and right pulmonary arteries
  - Aorta
    - Ascending aorta
    - Aortic arch
      - Three vessels
        - Brachiocephalic artery
          - Splits into right subclavian and right common carotid artery
        - Left common carotid artery
        - Left subclavian artery
    - Descending aorta

(1) Pulmonary Semilunar valve

- Between RV and Pulmonary trunk

(2) Aortic Semilunar Valve

- Between LV and Ascending Aorta
- two coronary arteries
  - arise from the aorta just beyond the semilunar valves;
  - during diastole, the increased aortic pressure above the valve's forces blood into the coronary arteries and thence into the musculature of the heart [Britannica]



Anterior view of aortic valve

Figure 1.3 Relation between the aortic valve cusps and the coronary arteries [The Ohio State University]

V) APPENDIX

Table 1. Layers of the Heart

Layer	FUNCTIONS	TISSUE	OTHER DETAILS
Endocardium	● Keeps blood in heart antithrombotic ● Act as a barrier between blood and tissue. ● Continues as Endothelium in blood vessels ● Lines the outer layer of the valves in the heart	Endothelium: Simple Squamous epithelial tissue with areolar connective tissue	
Myocardium	● Non-Contractile cardiac muscle generates and conducts action potentials ● Contractile cardiac muscle contracts as a unit to pump blood through and out of the heart	Myocardium Tissue	
Visceral layer of serous pericardium	Secretes pericardial serous fluid into the cavity to lubricate tissue layers.	Mesothelium: simple squamous with loose areolar connective tissue	Also known as Epicardium
Pericardial cavity	Prevents friction from two serous layers rubbing against each other		Contains serous fluid
Parietal layer of serous pericardium	Secretes pericardial serous fluid into the cavity to lubricate tissue layers.	Mesothelium: simple squamous + loose areolar connective tissue	Continuous with the epicardium
Fibrous pericardium	● Anchors heart to surrounding structures ● Prevents heart from overfilling with blood Protects the heart because of tough tissue	Dense fibrous irregular connective tissue	

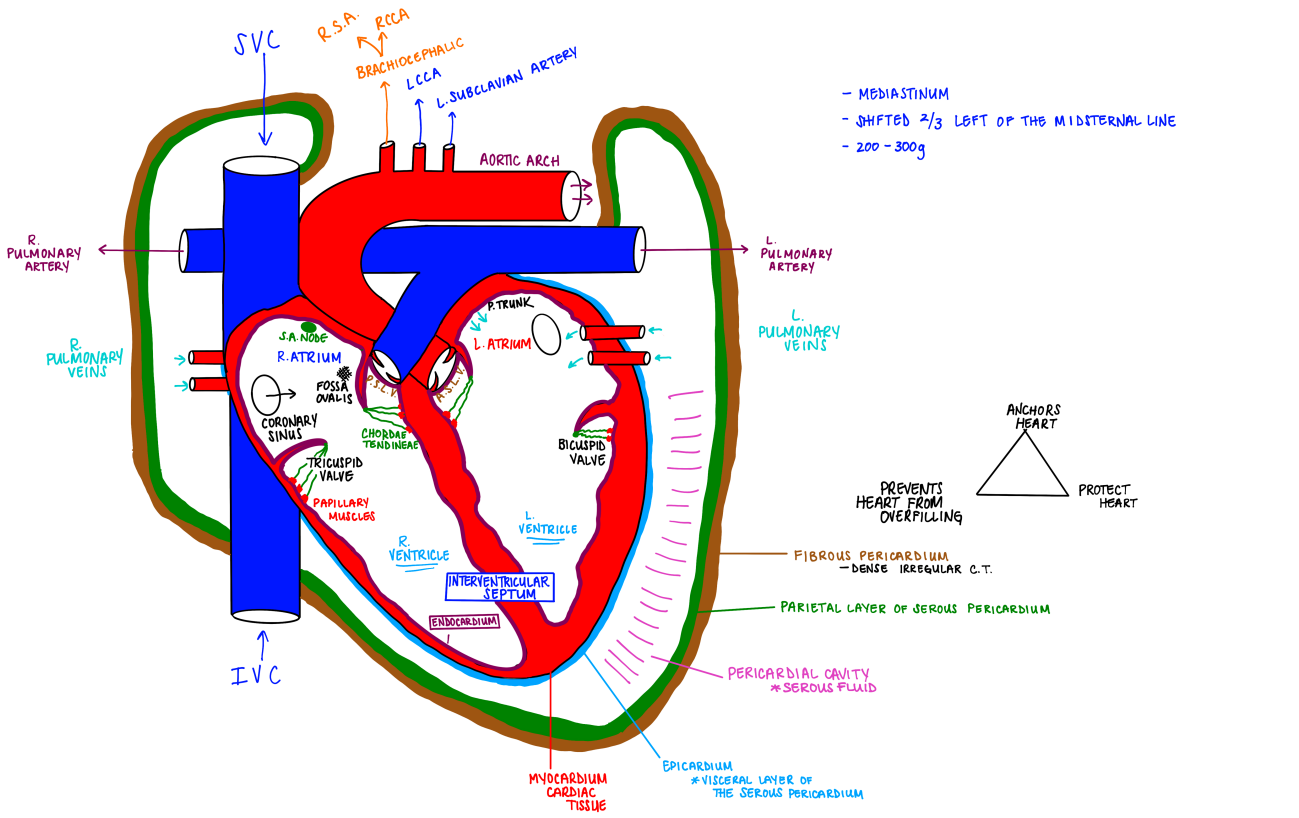


Figure 1.4. Heart with Labeled Structures and Layers

VI) REVIEW QUESTIONS

1) **Which of the following structures and functions are incorrectly paired?**
   a. SVC: Brings blood from structures above the diaphragm
   b. IVC: Brings blood from structures below the diaphragm
   c. Coronary Sinus: Brings blood from systemic circulation
   d. Foramen Ovale: Brings blood from RA to LA
2) **Which of the following is not a layer of the heart?**
   a. Epicardium
   b. Pericardial cavity
   c. Parietal layer of fibrous pericardium
   d. Myocardium

3) **Which is correct about the mitral valve?**
   a. Prevents backflow of blood from atria into ventricles
   b. It has two leaflets
   c. Brings blood for LV to LA
   d. Called the tricuspid valve

CHECK YOUR ANSWERS

VII) REFRENCES

- https://www.aats.org/aatsimis/SiteDownloads/ICS2017/Friday/1315_Coselli.pdf
- https://etd.ohiolink.edu/apexprod/rws_etd/send_file/send?accession=osu1574792274523727&disposition=inline
- https://www.britannica.com/science/coronary-circulation..