Anatomy and Physiology I

Cardiovascular System

Structural Anatomy of Heart

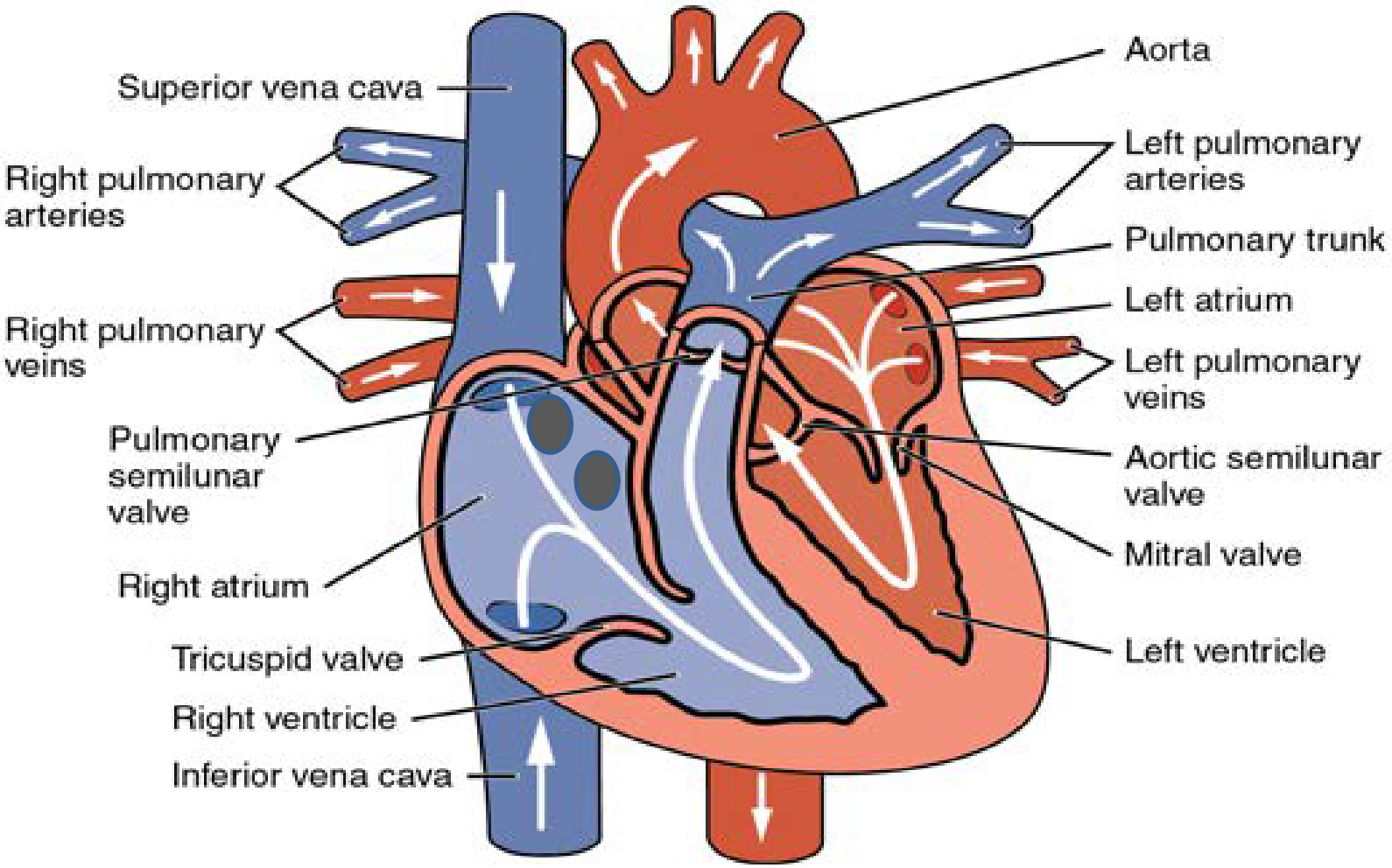
Functional Anatomy of Heart

Vascular Anatomy of Importance to Anesthesia

Objectives

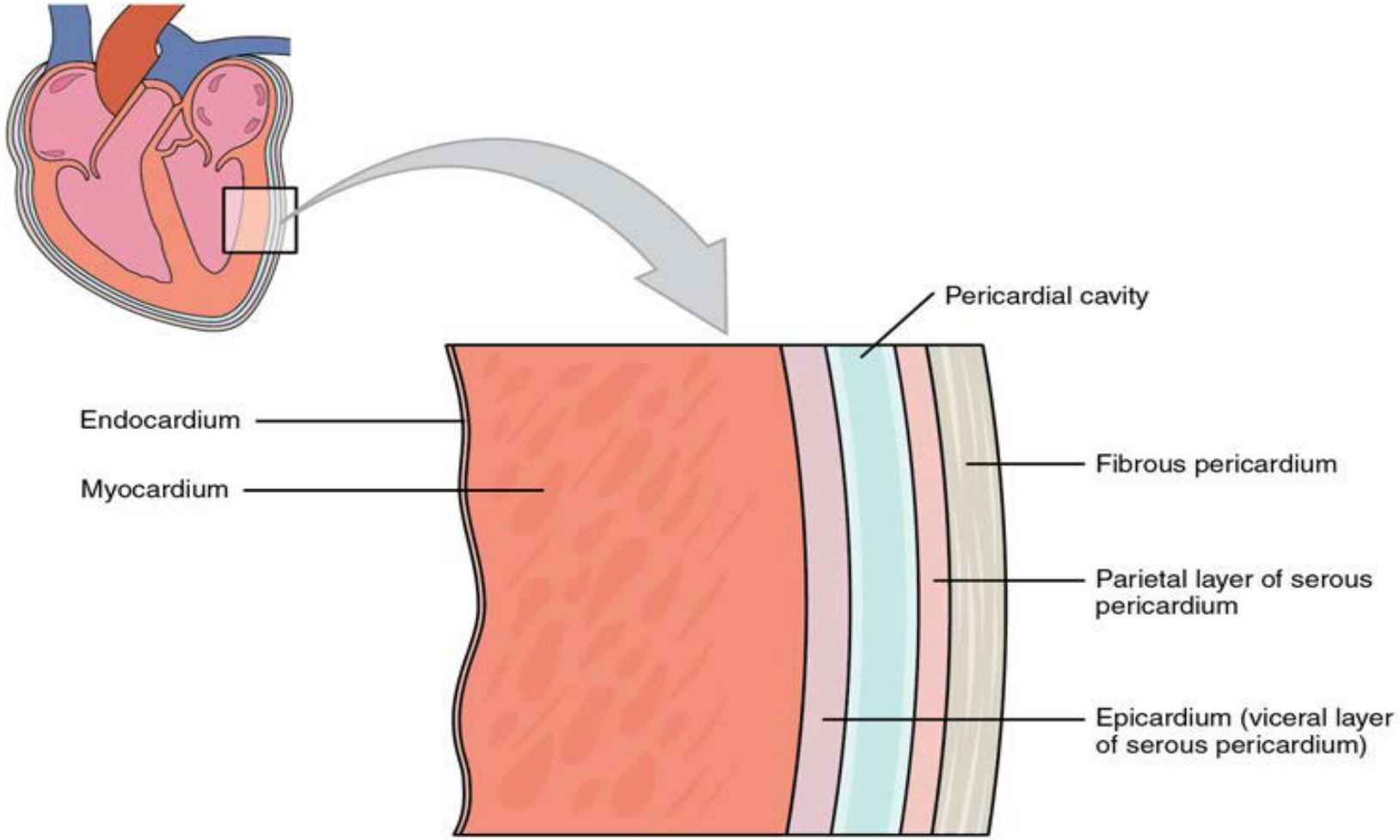
- Describe structural anatomy of the heart.
- Contrast the functional anatomy of the right and left heart.
- Identify the four cardiac valves.
- Outline the right and left coronary arteries.
- Summarize the major vessels of the neck, upper and lower extremities of importance to anesthesia

Heart Anatomy



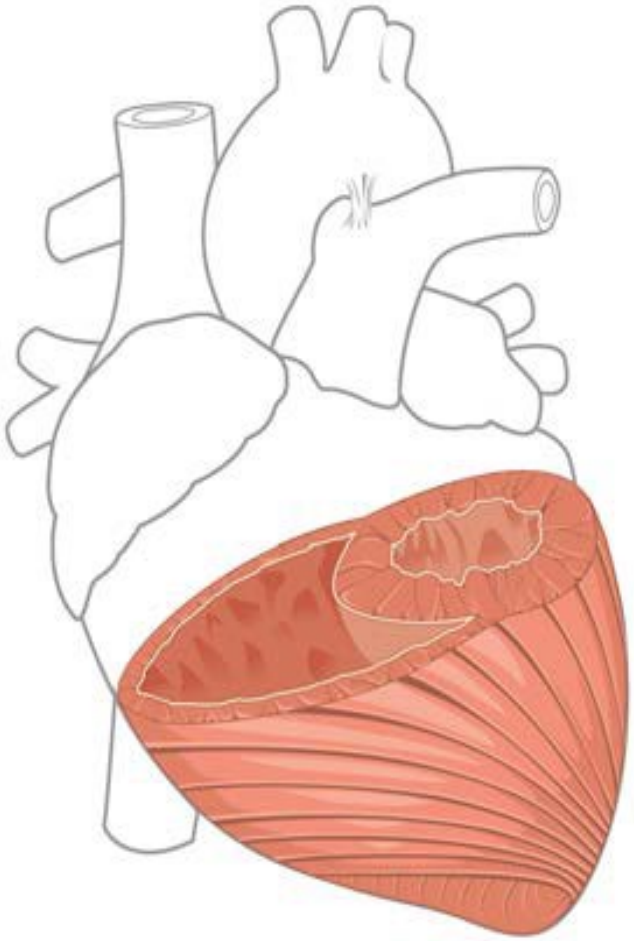
Betts. 2013. Anatomy and Physiology. Pg. 828

The Pericardium

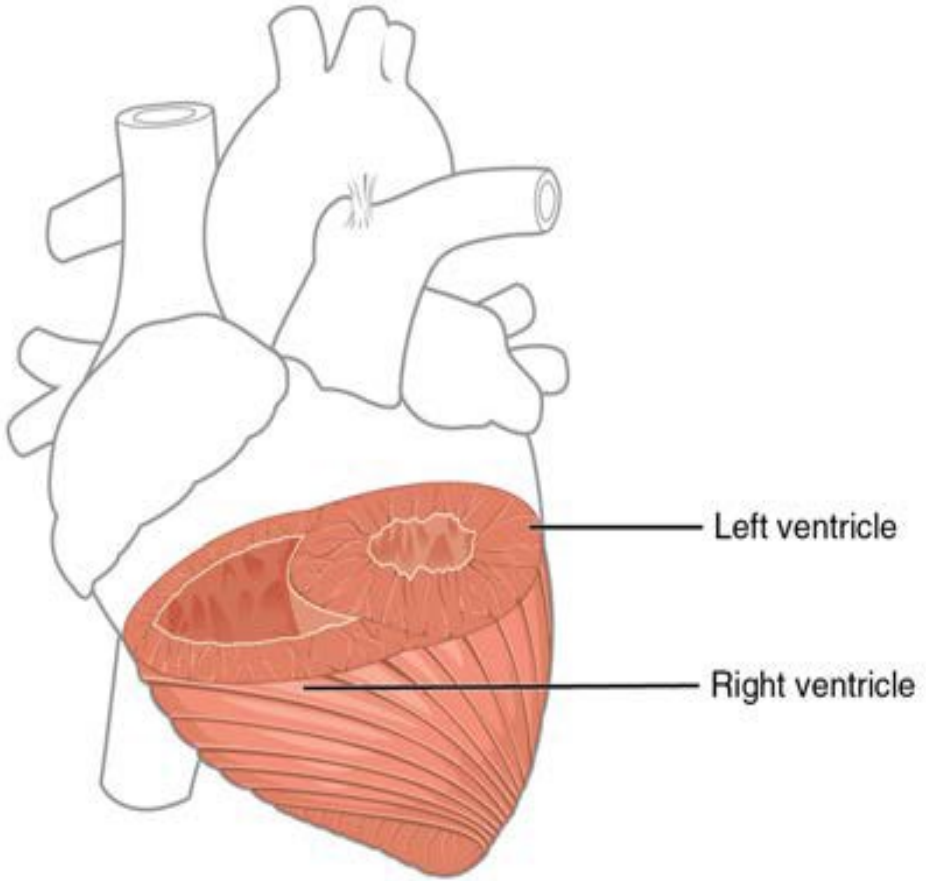


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Cardiac Layers



Relaxed

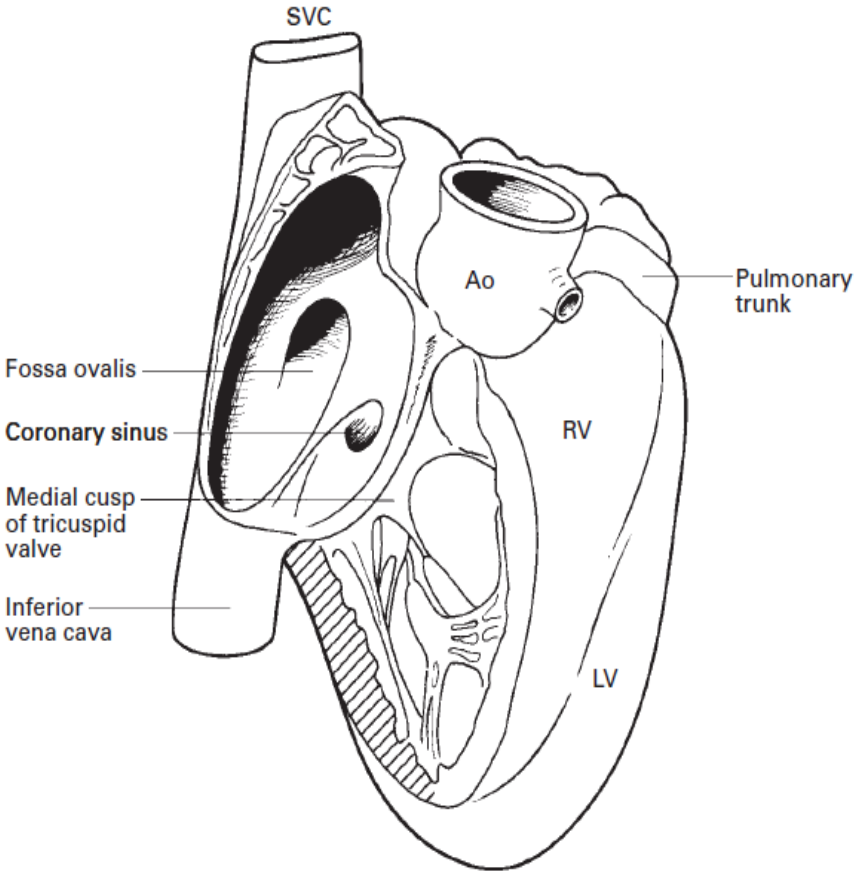


Contracted

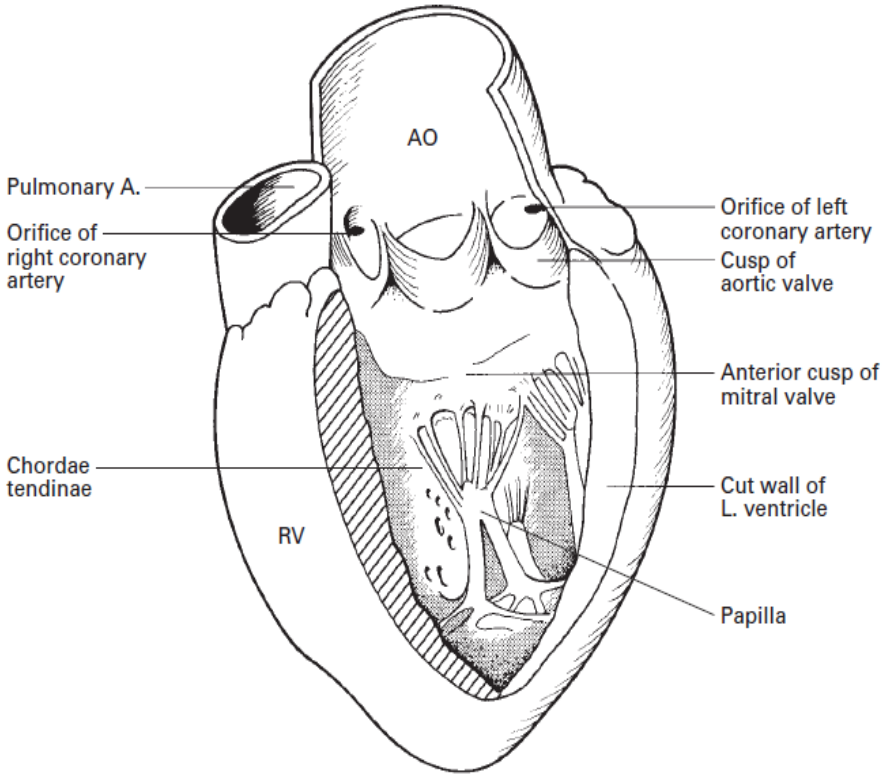
Betts.2013. Anatomy and Physiology. Pg.. 831

The Valves: Interior View

Right Ventricle

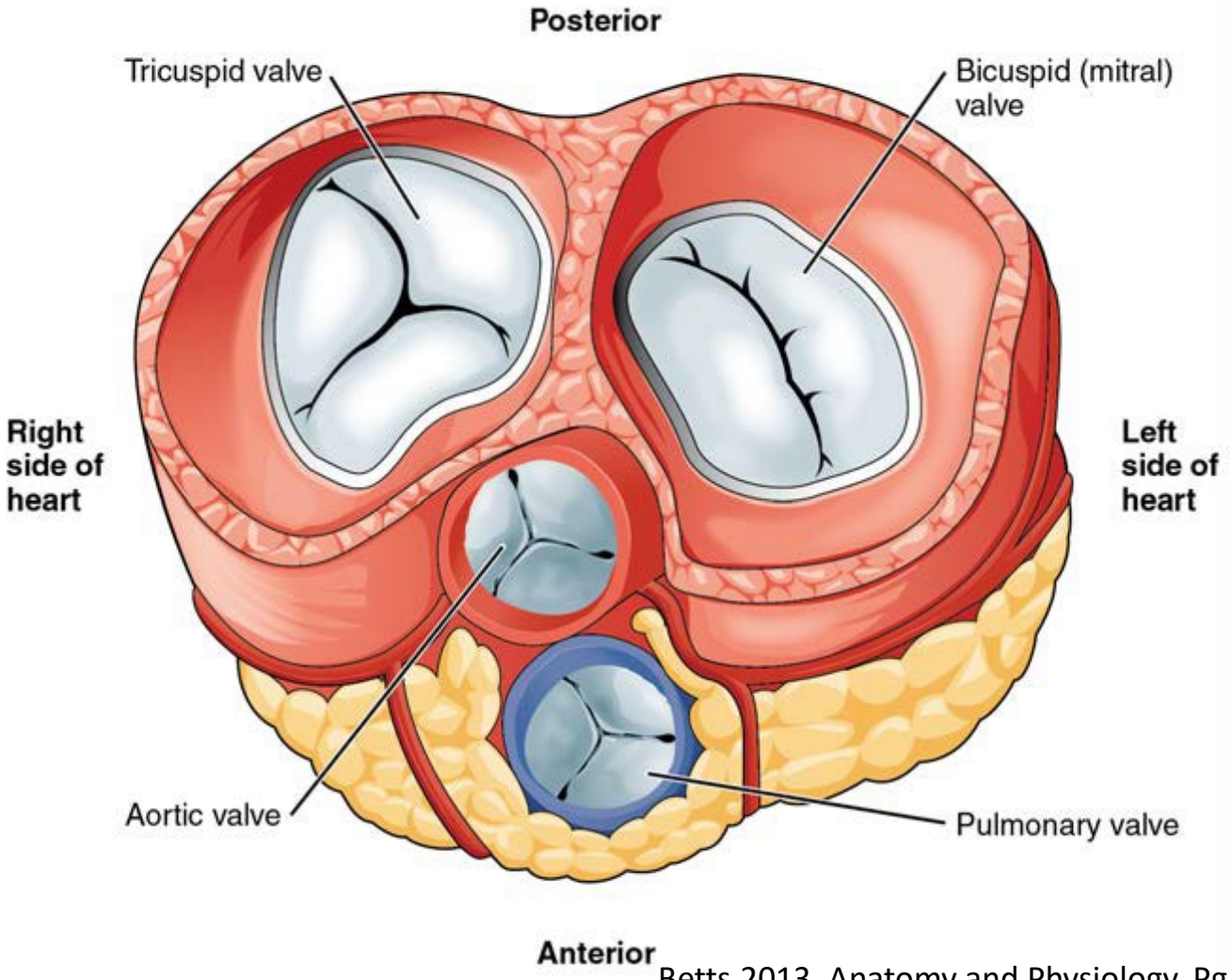


Left Ventricle



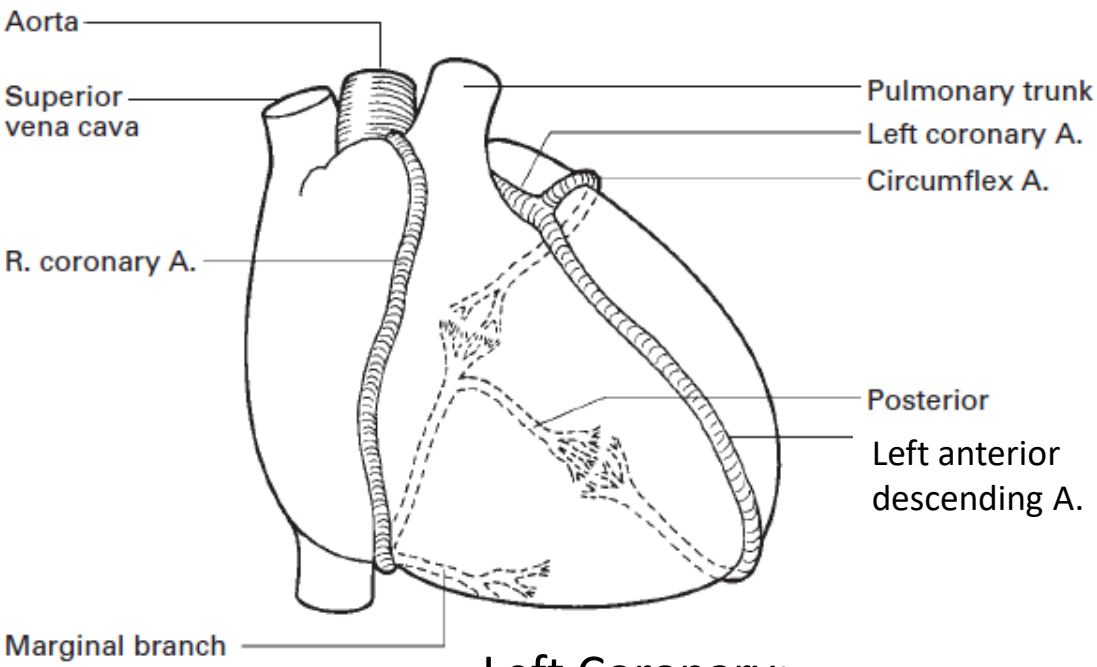
Ellis. Anatomy for Anaesthetists. 8th Edition. Pg.. 77-78

The Valves: Superior View



Betts.2013. Anatomy and Physiology. Pg.. 837

Coronary Arteries



Right Coronary:

- Right atrium
- Part of the left atrium
- Right ventricle
- Posterior interventricular septum
- Sino-atrial node (in 60%)
- Atrioventricular node (in 80%)

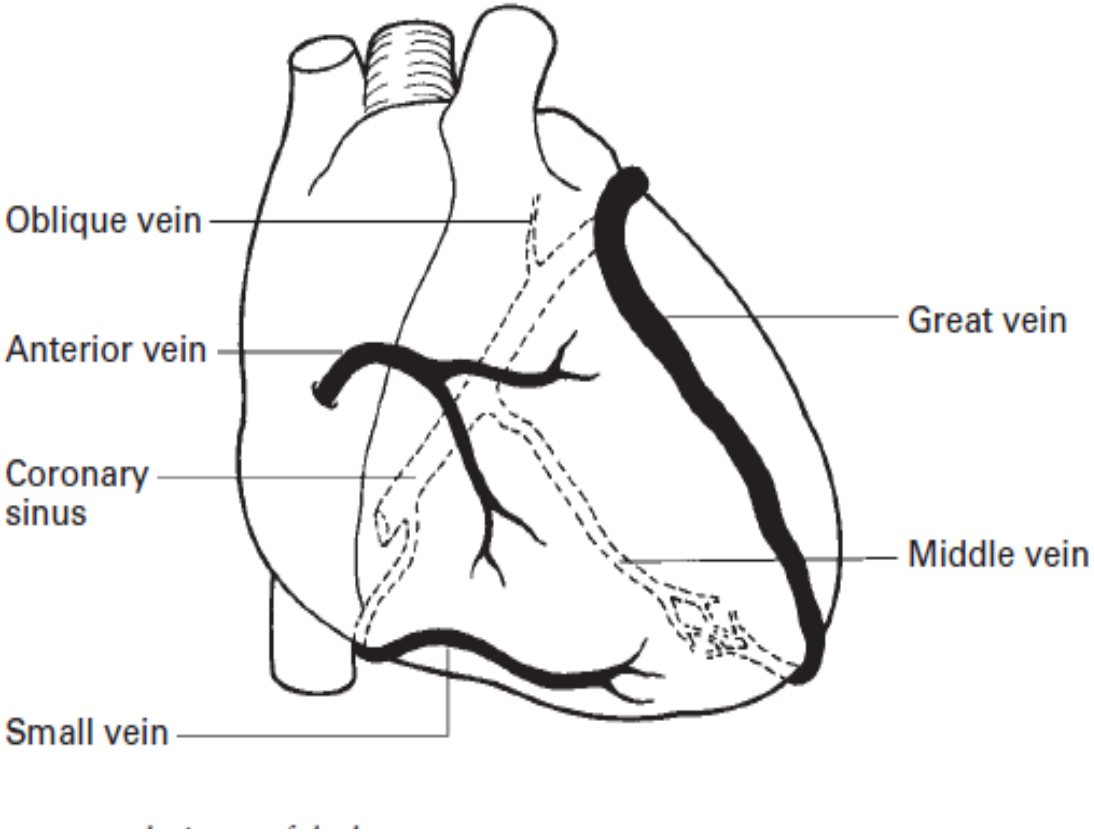
Left Coronary:

- Left atrium
- Left ventricle
- Anterior interventricular septum
- Sino-atrial node (in 40%)
- Atrioventricular node (in 20%)

Ellis. Anatomy for Anaesthetists. 8th Edition. Pg..80

Coronary Veins

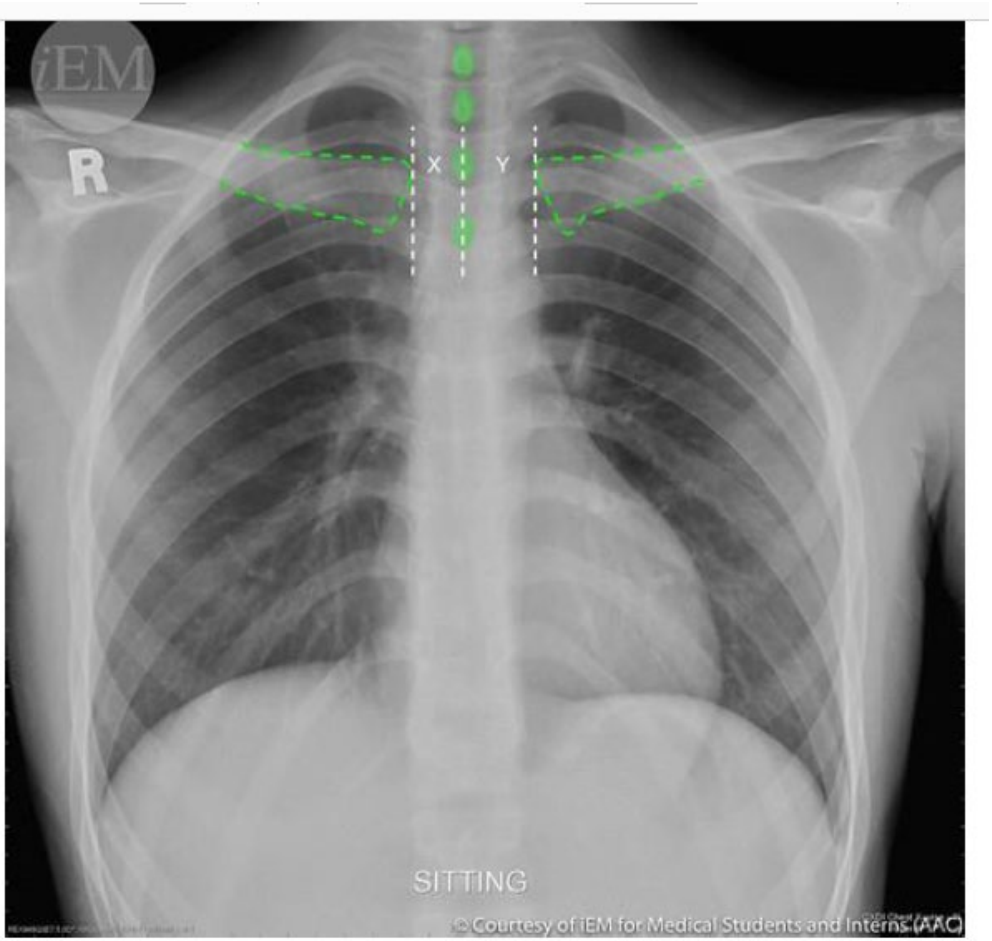
- Anterior Cardiac
  - Anterior heart
- Coronary Sinus
  - Posterior heart and septum

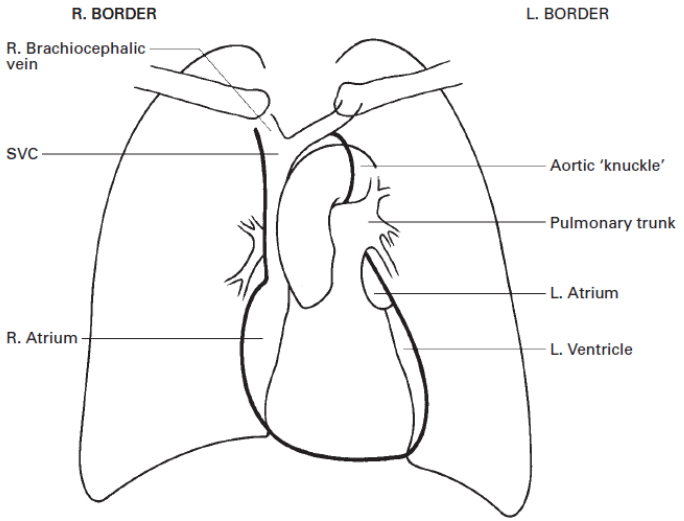


Ellis. Anatomy for Anaesthetists. 8th Edition. Pg..81

Cardiac Silhouette: Anterior

https://iem-student.org/how-to-read-chest-x-rays/

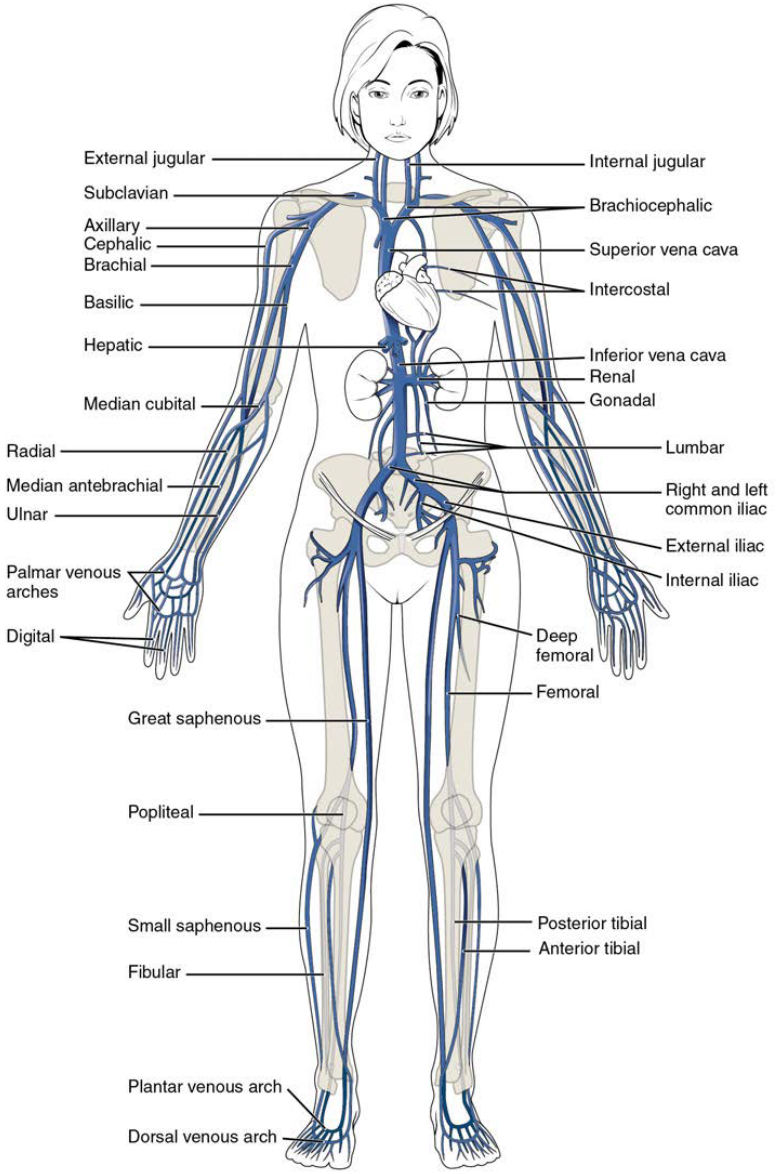




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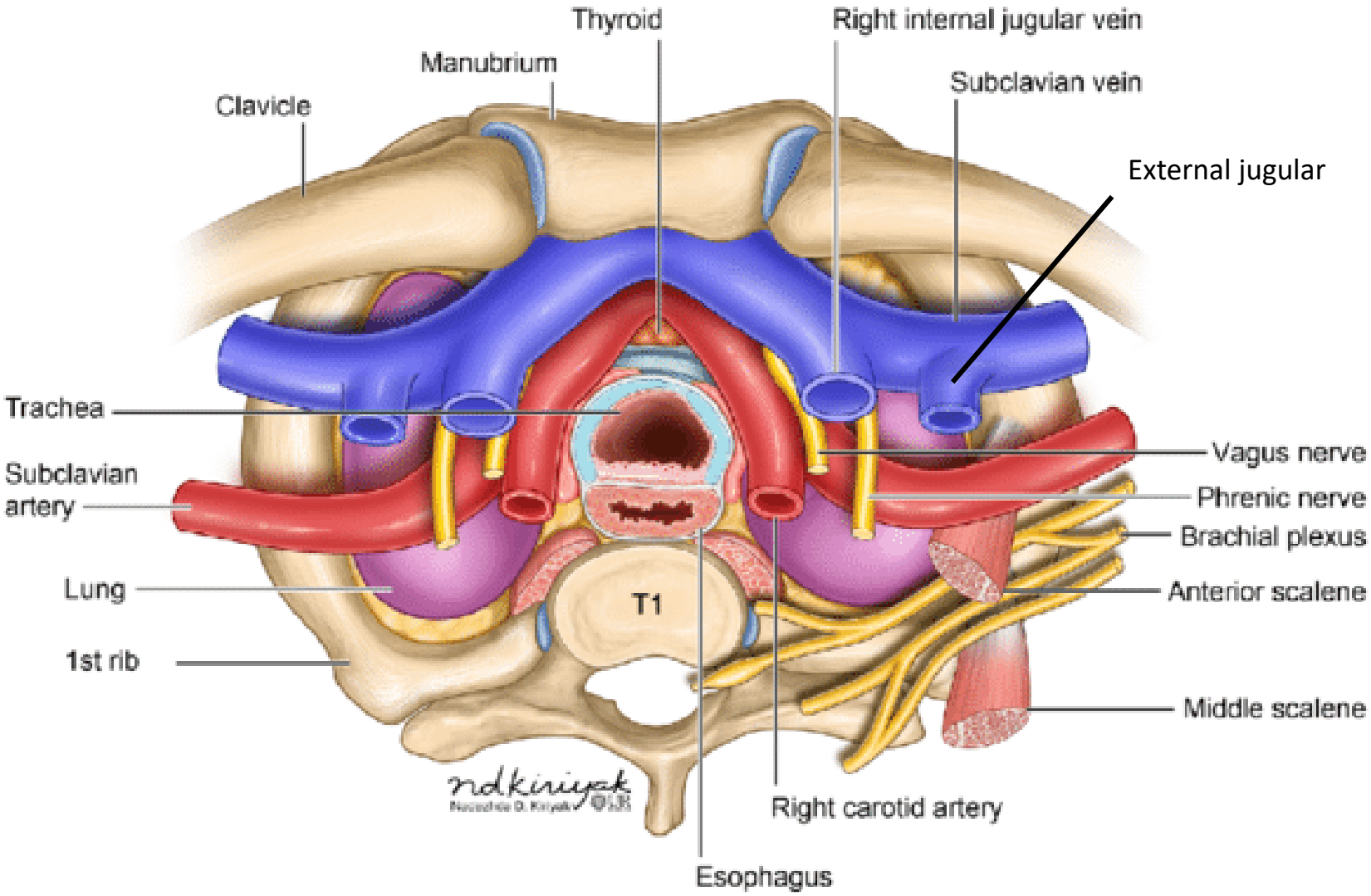
Vascular Anatomy

- Neck
  - Internal jugular
  - External jugular
  - Subclavian vein
- Upper extremities
  - Antecubital fossa
  - Radial artery
- Lower extremities
  - Femoral artery and vein
  - Saphenous vein
  - Dorsal venous arch
  - Dorsalis pedis artery



Betts.2013. Anatomy and Physiology. Pg.. 944

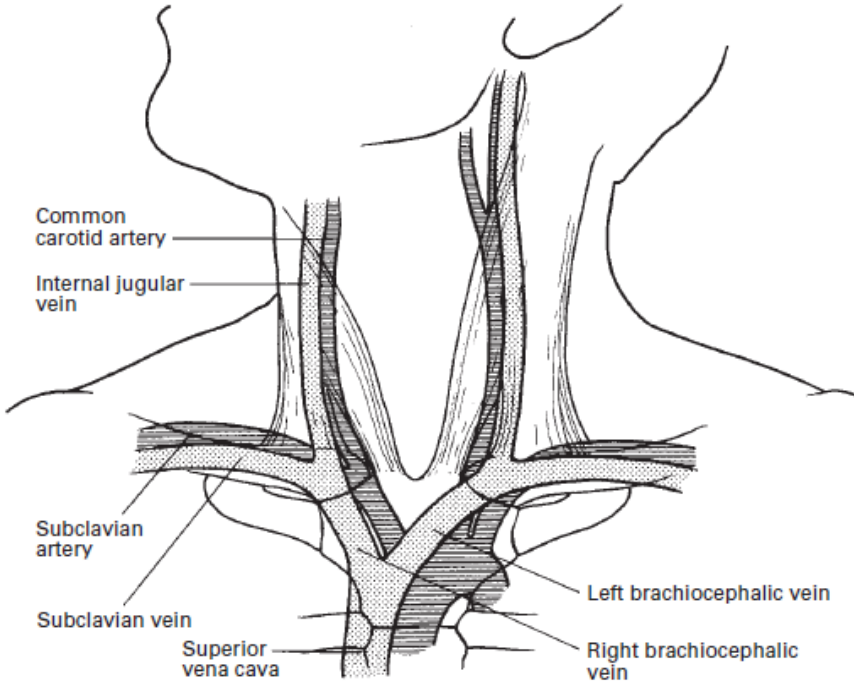
Thoracic Inlet

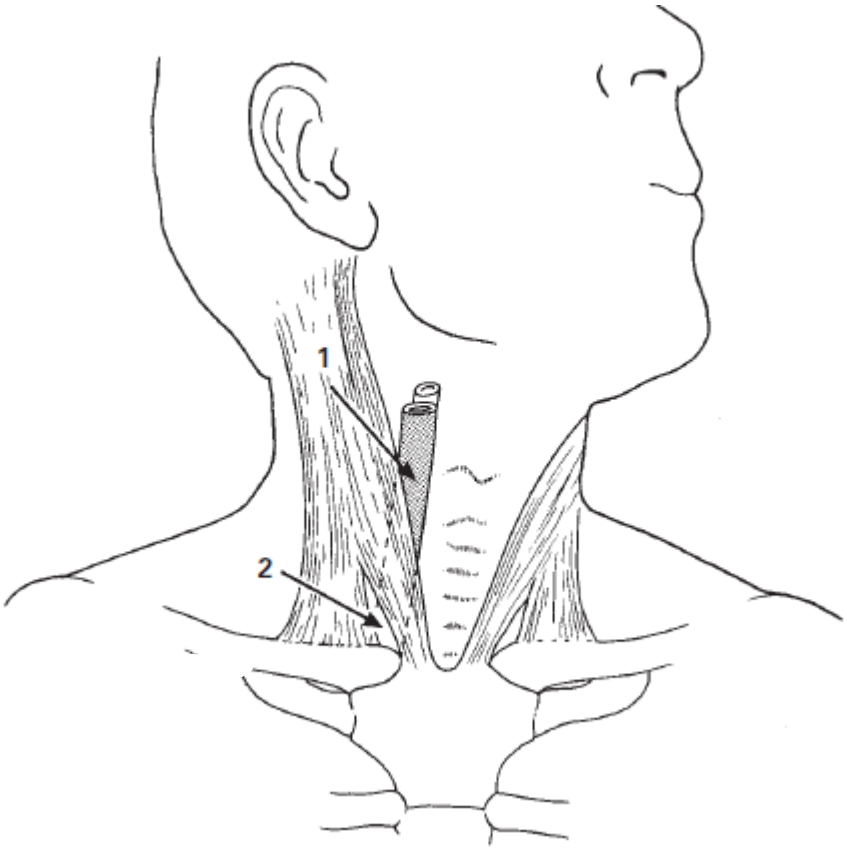


https://www.researchgate.net/fig1_337751428

Internal Jugular Vein

Anatomy

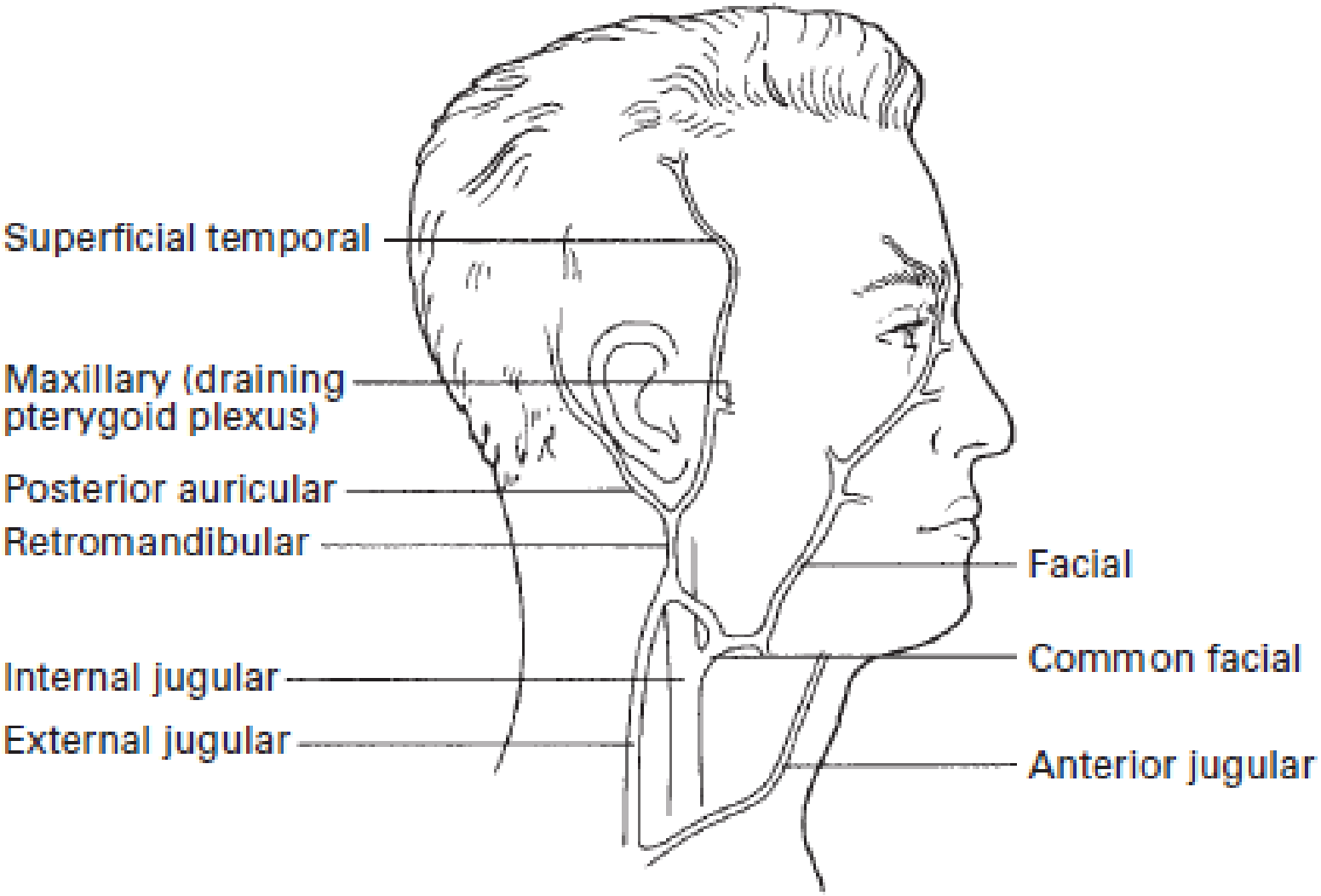




Cannulation

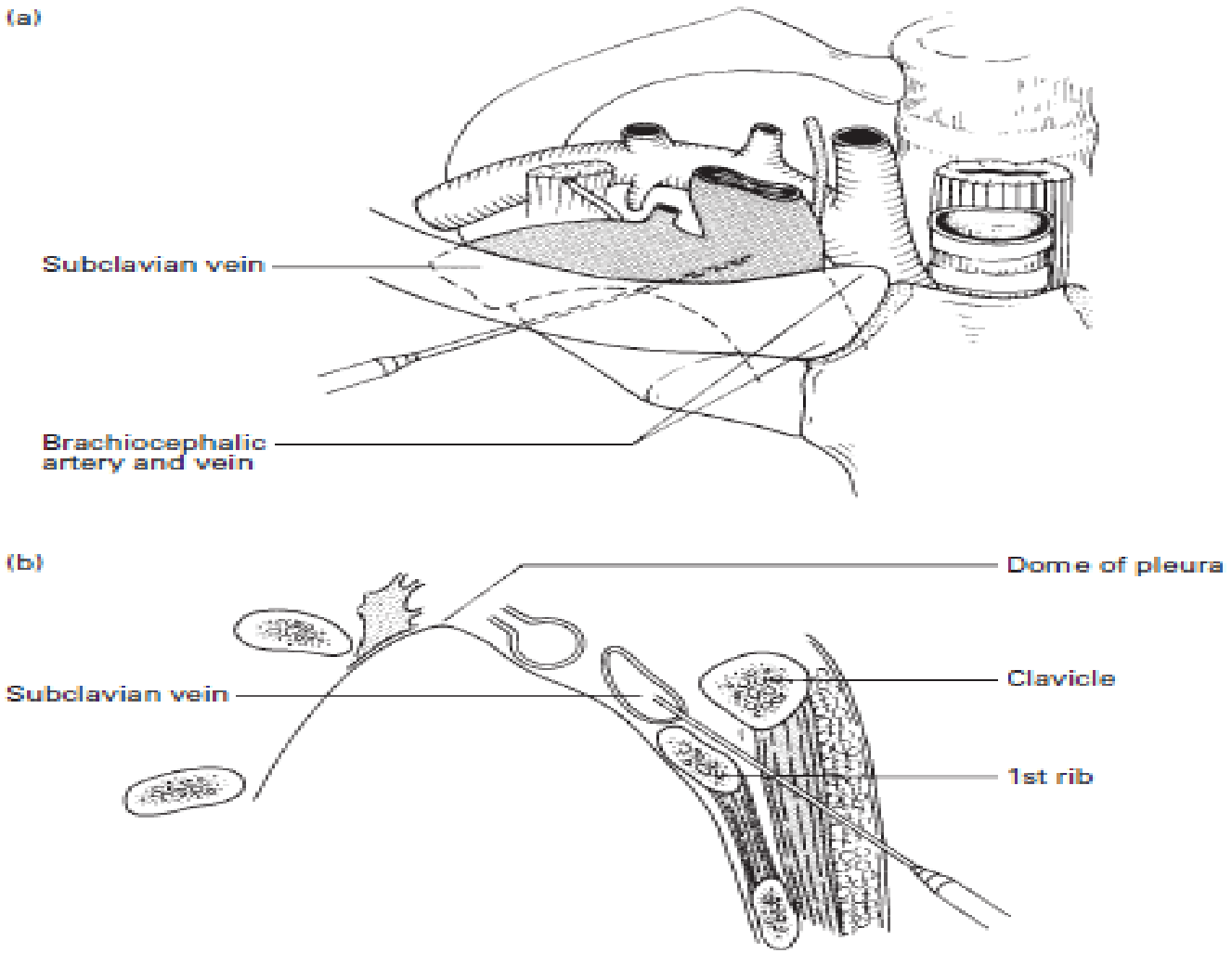
Ellis. Anatomy for Anaesthetists. 8th Edition. Pg.. 331 and 334

External Jugular



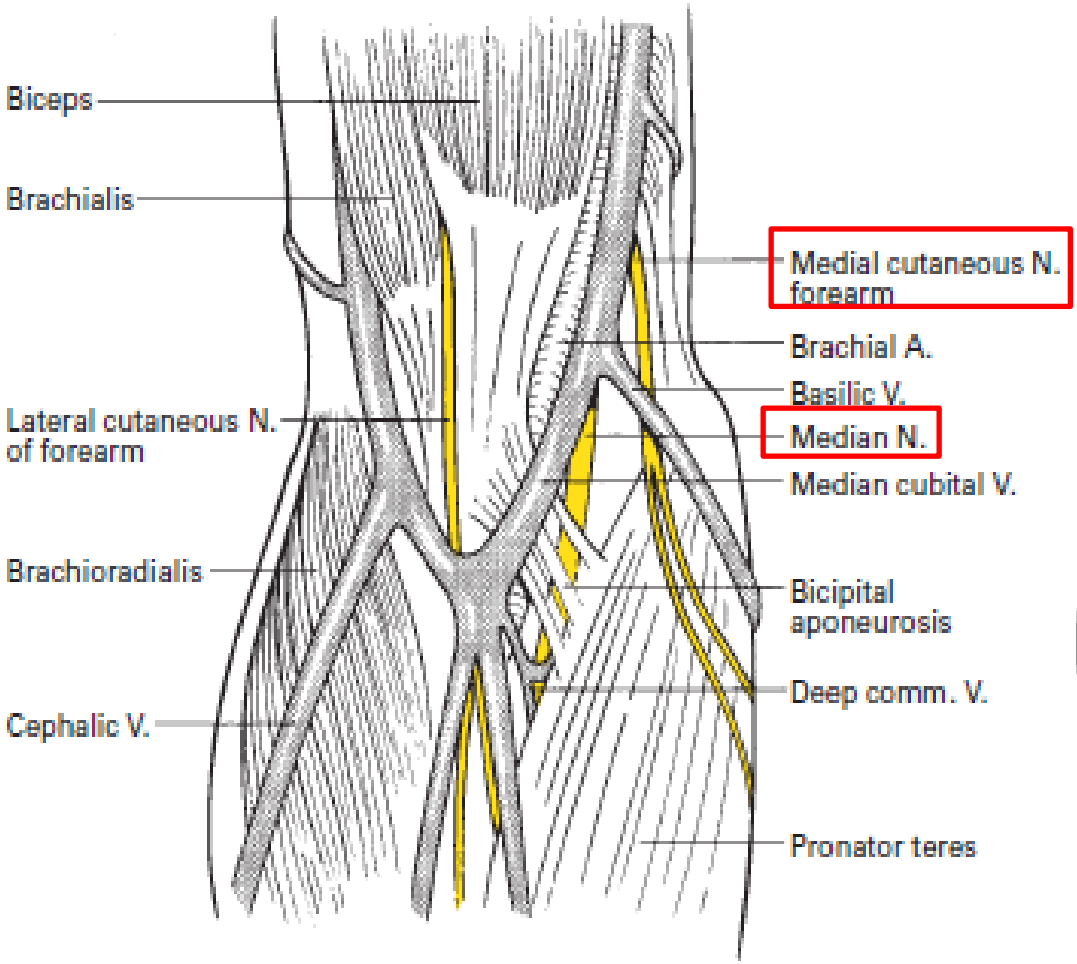
Ellis. Anatomy for Anaesthetists. 8th Edition. Pg.. 332

Subclavian Vein

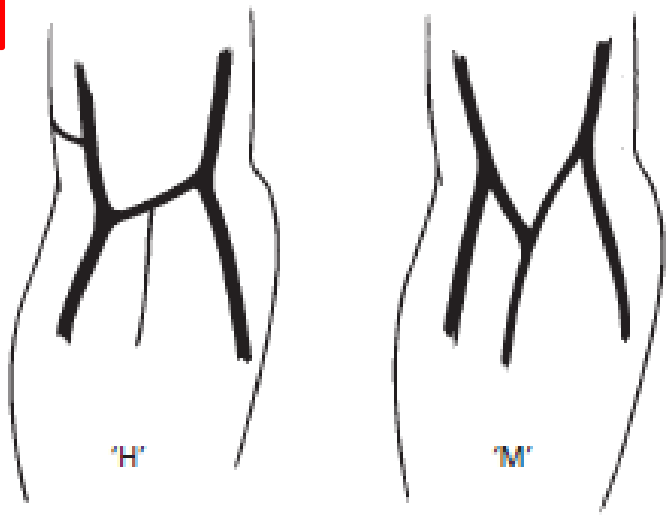


Ellis. Anatomy for Anaesthetists. 8th Edition. Pg.. 335

Antecubital Fossa

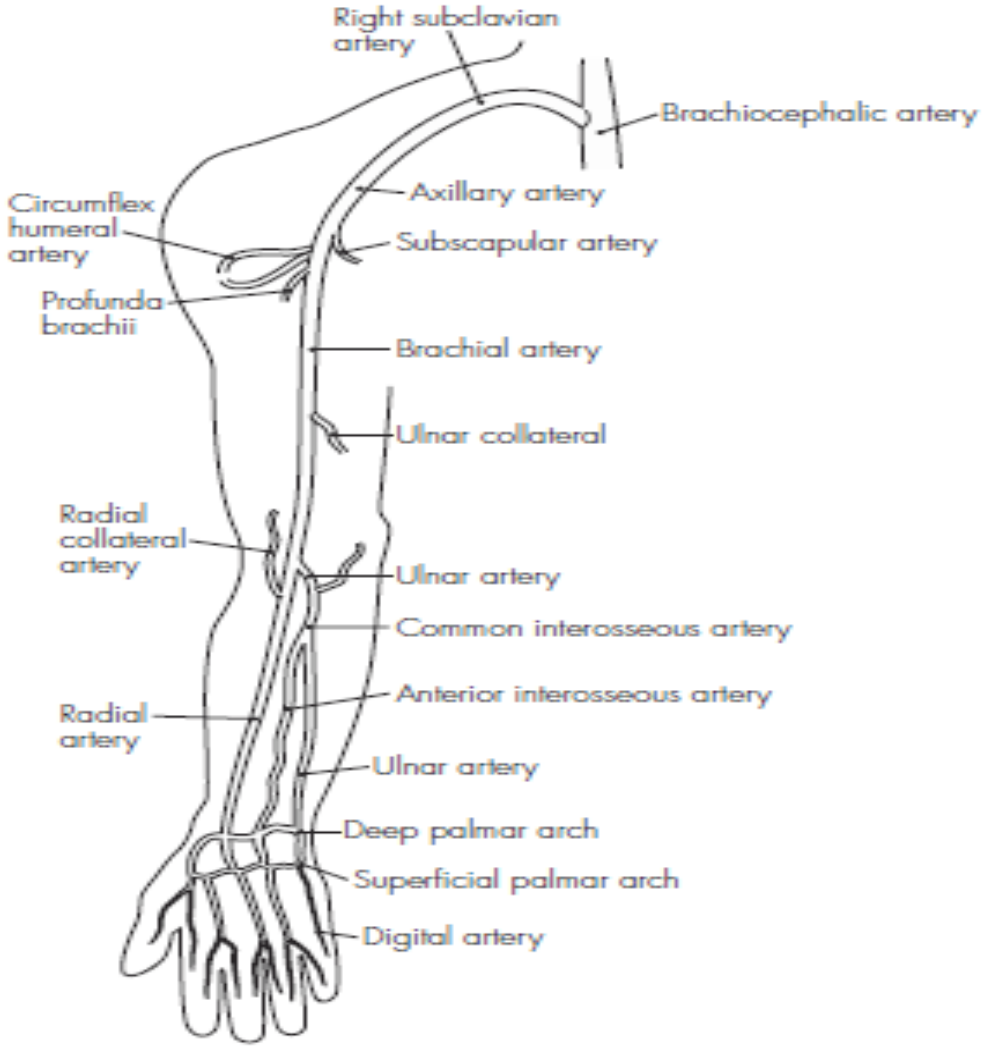


Median Cubital Vein variations



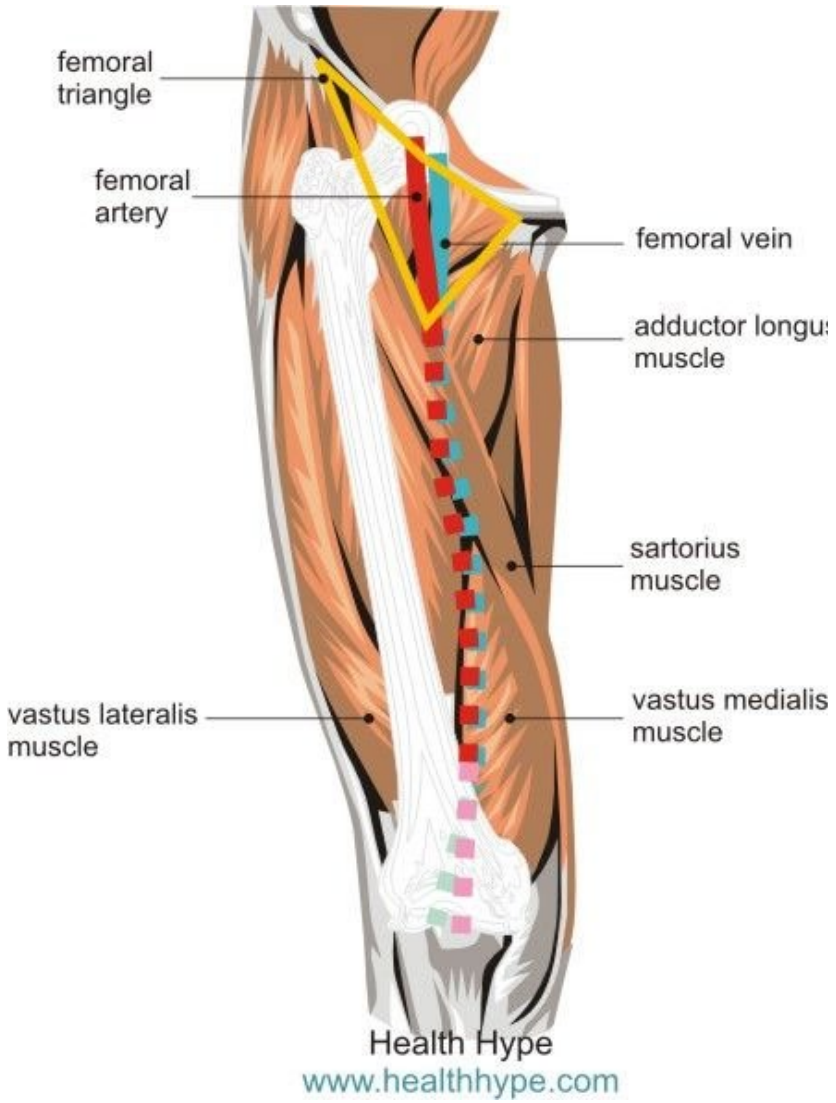
Ellis. Anatomy for Anaesthetists. 8th Edition. Pg.. 325 and 327

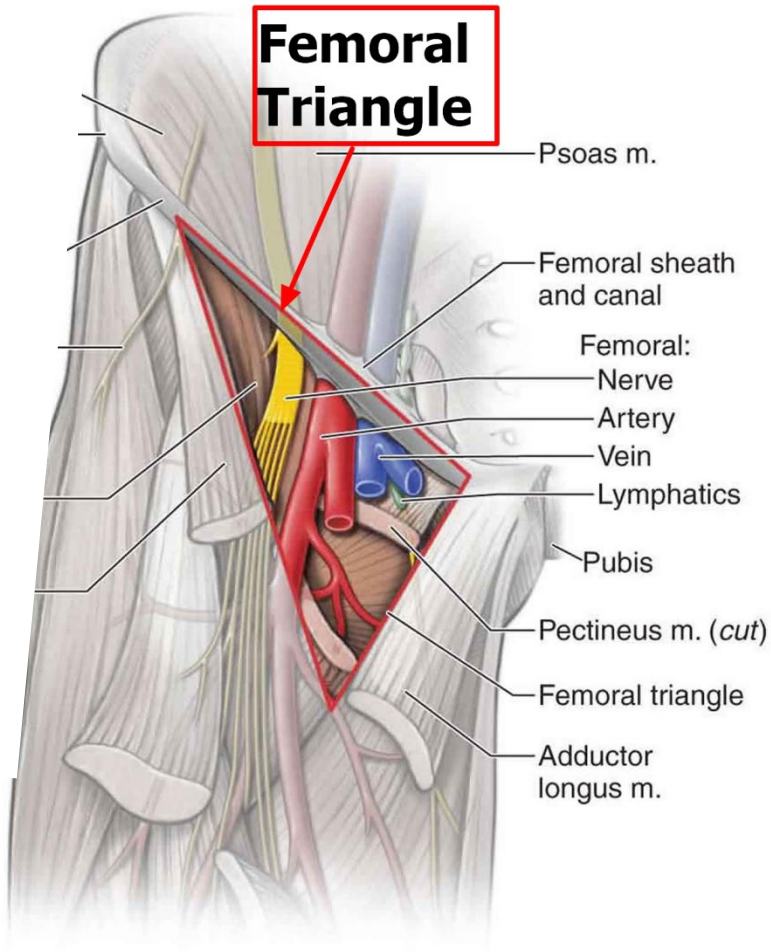
Radial Artery



Erdmann, A. 2001. Concise Anatomy for Anaesthesia. Pg.. 33

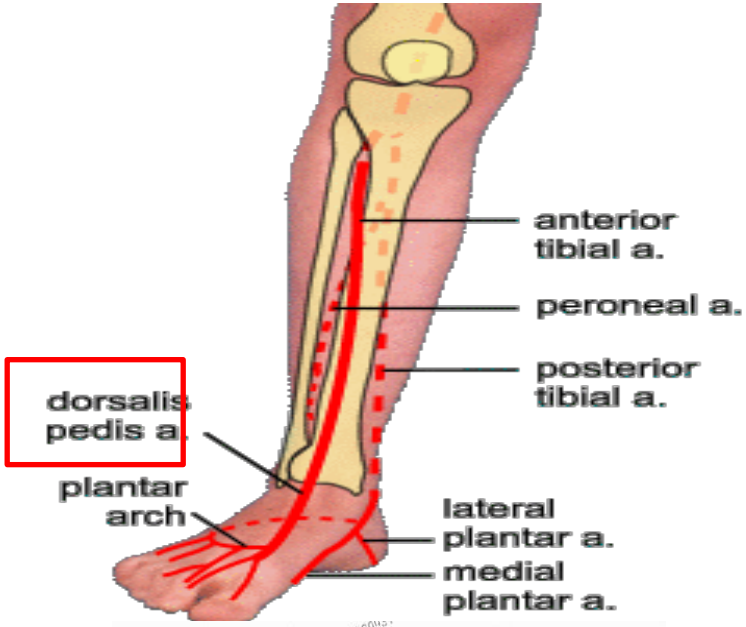
Femoral

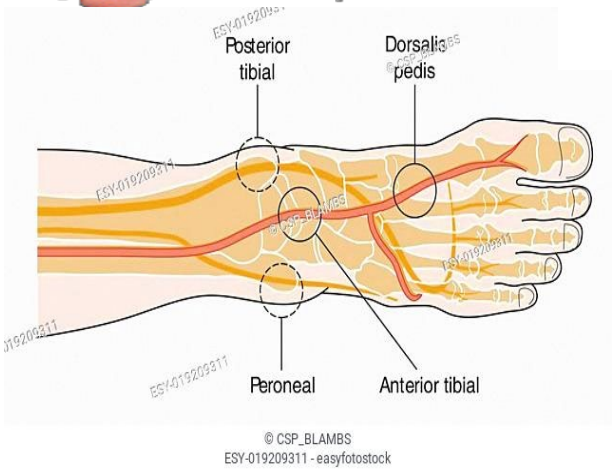


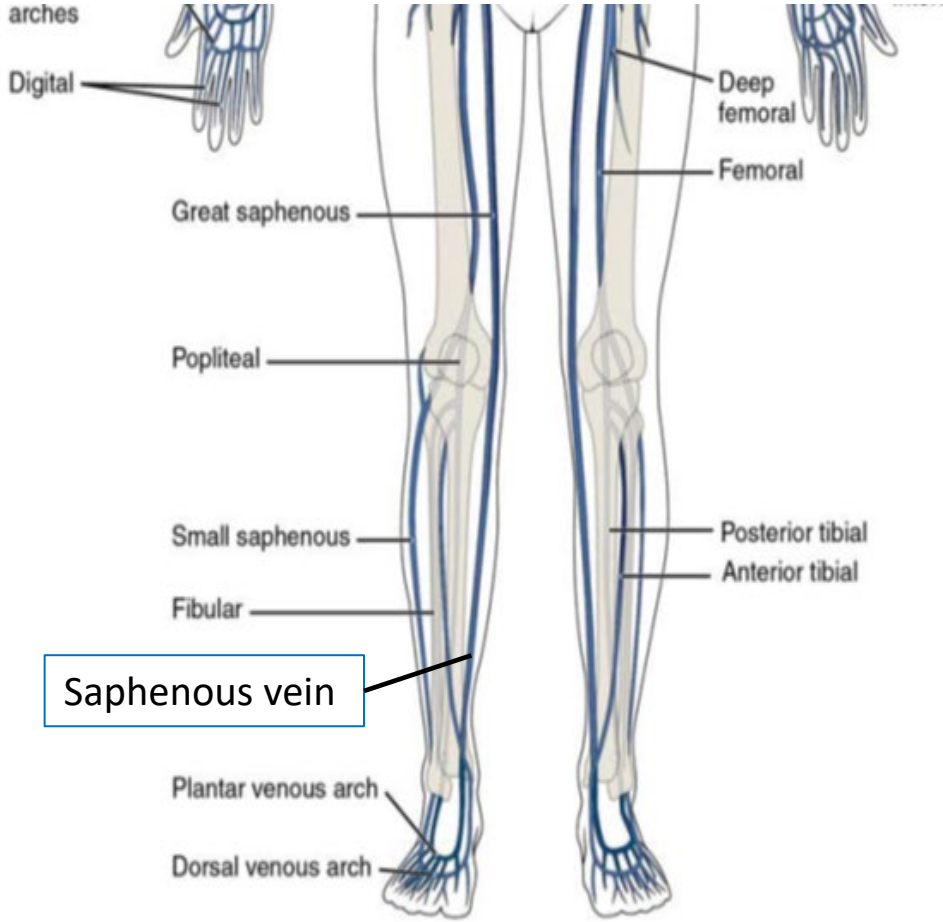


www.blogspot.com

Artery and Veins Below the Knee







Betts.2013. Anatomy and Physiology. Pg.. 944

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Summary Questions - Anatomy

Anatomy and Physiology I

Cardiovascular System

Preload, afterload, contractility

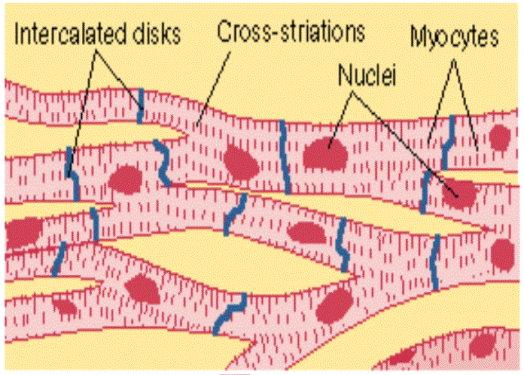
Homeostatic regulation of blood pressure

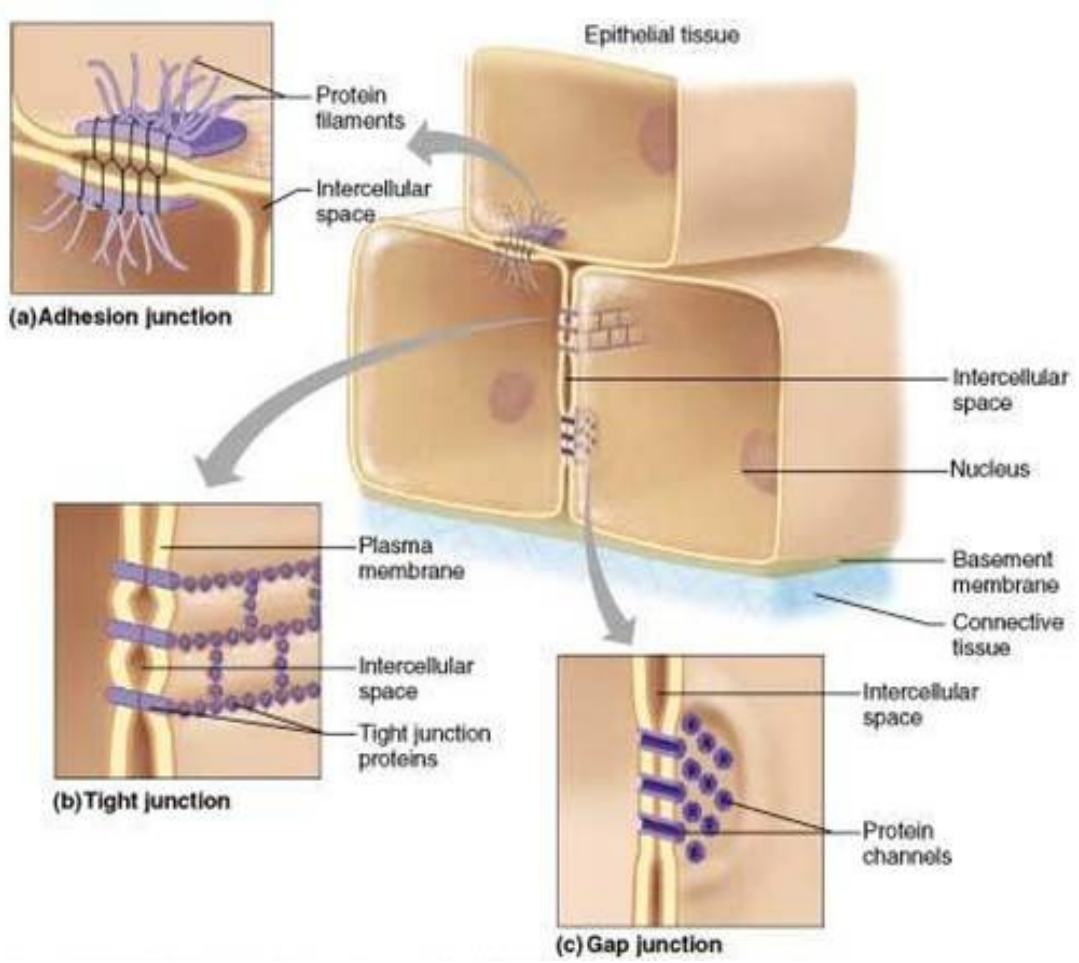
Objectives

- Contrast the two cell types of the heart.
- Describe the cardiac cycle.
- Summarize the major components of cardiac output.
- Explain how the body maintains a normal blood pressure at rest, with movement and with dehydration.

Cardiac Muscle Anatomy

- Contraction Cells



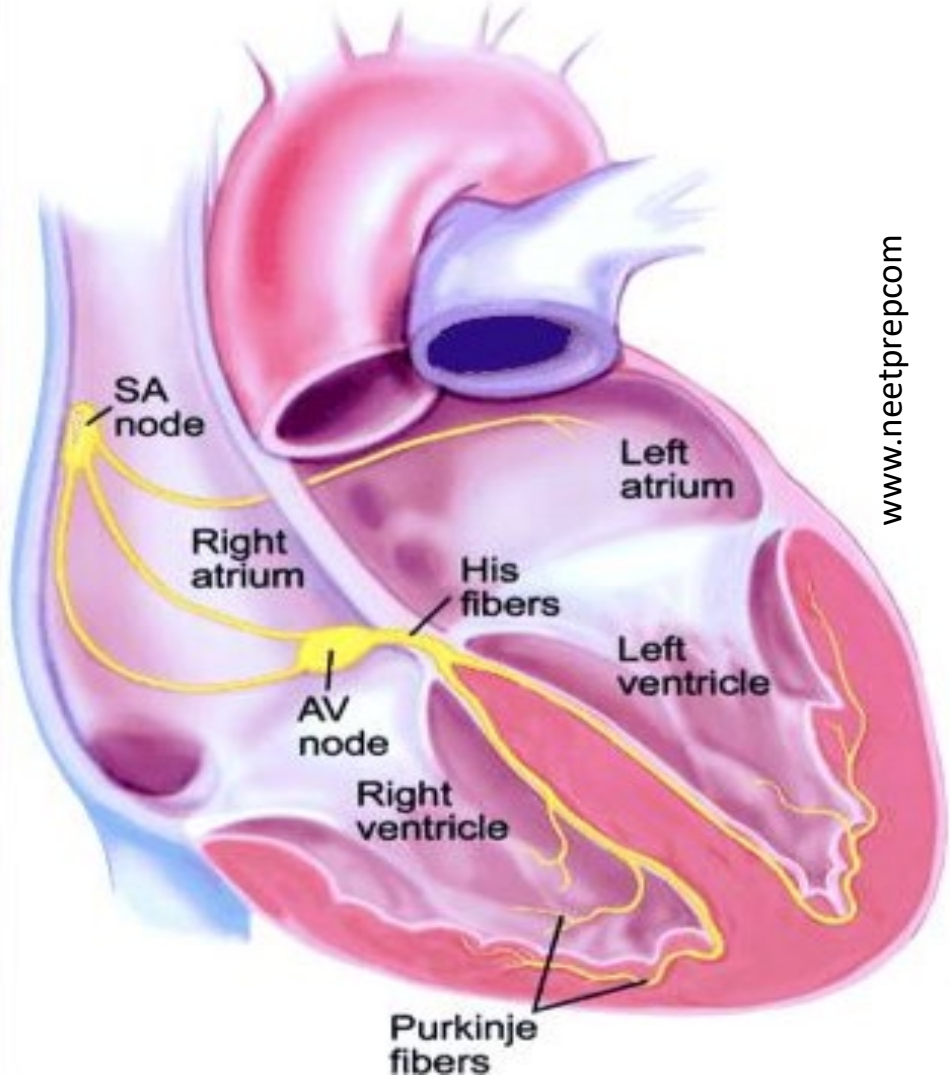


www.medicalpicturesinfo.com biophoria.byethost24.com

Cardiac Conduction Anatomy

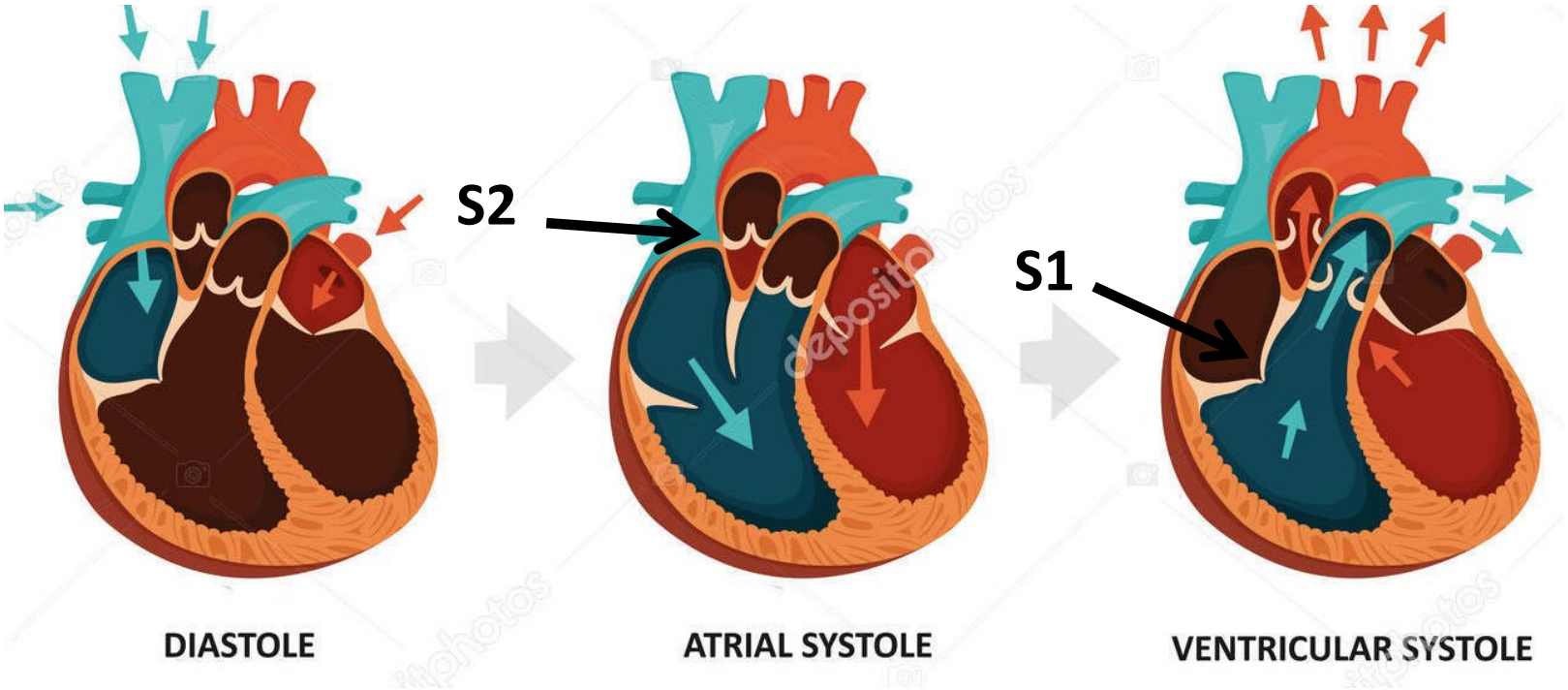
- Conduction Cells
  - Fastest to spontaneously generate action potential to spread conduction

SA → Atria → AV → L / R Ventricles



Cardiac Cycle

- Blood flows according to a pressure gradient
- Systole: heart chamber contracts
- Diastole: heart chamber relaxes



www.depositphotos.com

Cardiac Output

- The amount of blood pumped by each ventricle in one minute.
  - Proportional to the size of the heart, gender, age and level of fitness
- Normal adult values
  - Heart rate: 60-100 beats per minute
  - 50-100 ml blood per beat
  - Cardiac output 4-8 L per minute (per ventricle)

Components of Cardiac Output

- **Heart Rate** **X** **Stroke Volume**
  - Pacemaker
  - Age
  - Neural input
  - Preload
  - Afterload
  - Contractility

- Blood viscosity
- Internal environmental factors

Cardiac Output: Heart Rate

Chronotropy is impacted by

- Pacemaker: how fast the heart beats/minute
  - SA node is the heart's normal pacer
  - Rates vary: 60-80 in the average adult

- Age: heart rate decreases with age
  - Maximum expected heart rate = 220 – age

Example, 40 year old , max HR = 220 – 40 = 180 beats per minute

- Neural input: autonomic nervous system input

Cardiac Output: Heart Rate

Neural input on the heart

- Afferent : cranial nerves IX and X → medulla
  - Sensory receptors in carotid sinus, aortic arch, vena cava, atria, pulmonary arteries



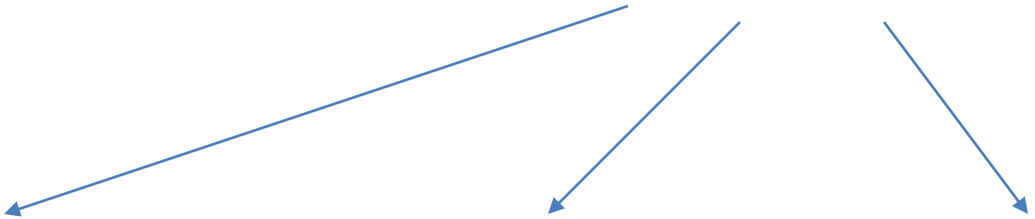
- Cardiovascular centers in the medulla oblongata



- Efferent: medulla → heart
  - Sympathetic nervous system: accelerator/↑ HR
    - **β_1 receptor** stimulus to increased cardiac output
  - Parasympathetic nervous system: brake/↓ HR
    - **Muscarinic receptor** stimulus to decrease cardiac output

Components of Cardiac Output

- Heart Rate X Stroke Volume



Preload

Volume of blood in the ventricle at the end of diastole

Afterload

Resistance, how hard the ventricle must contract to produce forward flow

Contractility

Strength of the heart muscle

Cardiac Output: Stroke Volume

Preload = Volume in ventricle at the end of diastole

- Low
  - Not enough fluid is returning to the heart (hypovolemia, rapid change to a vertical posture) and the **Frank-Starling Mechanism**
  - Short time for ventricle to fill with blood

- High
  - Too much fluid is returning to the heart (hypervolemia) and the **Frank- Starling Mechanism**
  - Heart is failing to pump out blood

Cardiac Output: Stroke Volume

Afterload = Resistance against which the heart has to pump to keep blood moving forward

– Low afterload (less resistance to forward flow)
  - Vasodilation (inhalational or spinal anesthesia, fever, systemic infection)
  - Blockade of neural input: the sympathetic nervous system **α_1 receptors** on the smooth muscle of the blood vessels

– High afterload (increased resistance to forward flow)
  - Vasoconstriction (idiopathic high blood pressure)
  - Stimulation of neural input: sympathetic nervous system **α_1 receptors** on the smooth muscle of the blood vessels

Cardiac Output: Stroke Volume

Contractility = Inotropy = **Strength** of the heart muscle

- Low
  - Parasympathetic nervous system stimulation of the **Muscarinic receptor** on the heart
  - Low ventricular compliance
  - Low preload: **Frank - Starling Mechanism**

- High
  - Sympathetic nervous system stimulation of the **β_1 receptor** on the heart
  - High ventricular compliance
  - High preload: **Frank - Starling Mechanism**

Stroke Volume Summary Slide

- If low
  - Preload
  - Afterload
  - Contractility
- Then _____ cardiac output
  - Low
  - High
  - Low
- If high
  - Preload
  - Afterload
  - Contractility
- Then ____ cardiac output
  - High (to a point)
  - Low
  - High (to a point)

Cardiac Output (CO)

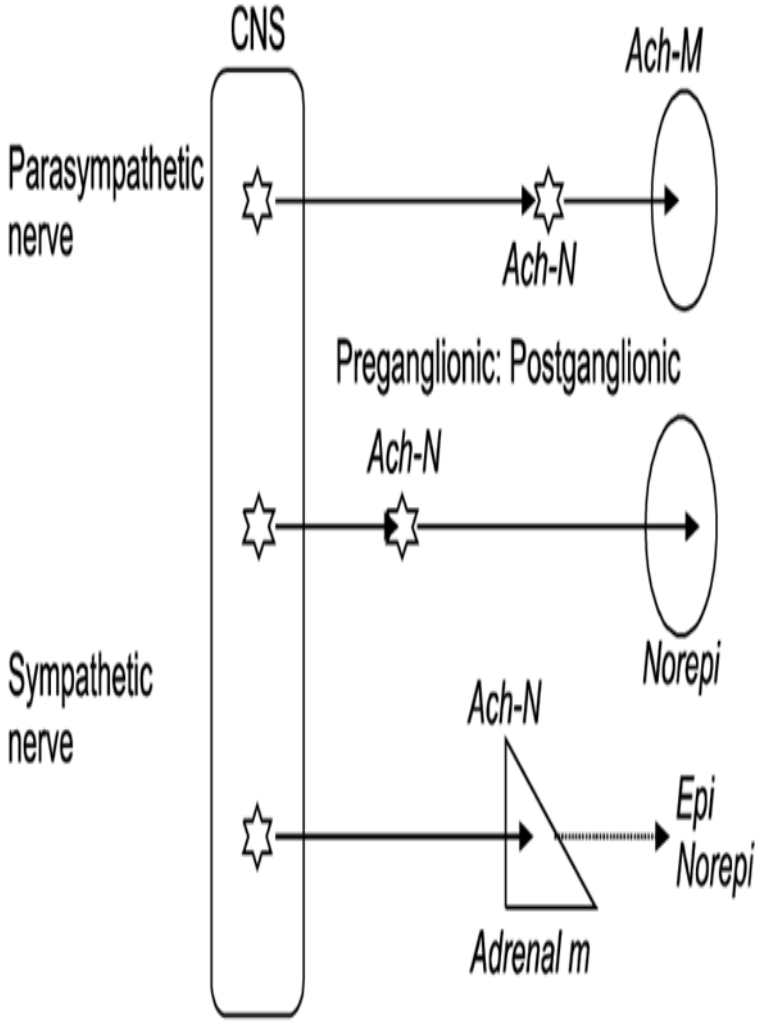
- Viscosity of blood
  - Ideal Hematocrit = 30-32 mg/dL
- Internal environmental factors
  - ↑ CO with an ↑ circulating concentrations of
    - Epinephrine -- Calcium -- Thyroid hormones
  - ↓ CO with an ↓ low circulating concentrations of
    - Potassium -- Sodium -- Oxygen
  - Body temperature: ↑ CO with fever

Blood Pressure

Cardiac Output X Peripheral Resistance

- Major arteries: elasticity
  - Systolic pressure – amount of pressure created by the ventricle to eject blood forward and the artery expands
  - Diastolic pressure – once artery receives blood/expands, it then recoils to keep moving blood forward.
- Arterioles: smooth muscle tubes
  - Poiseuille's law: small tube, high resistance to flow
  - Large tube, low resistance to flow

Examples of Maintaining Homeostasis

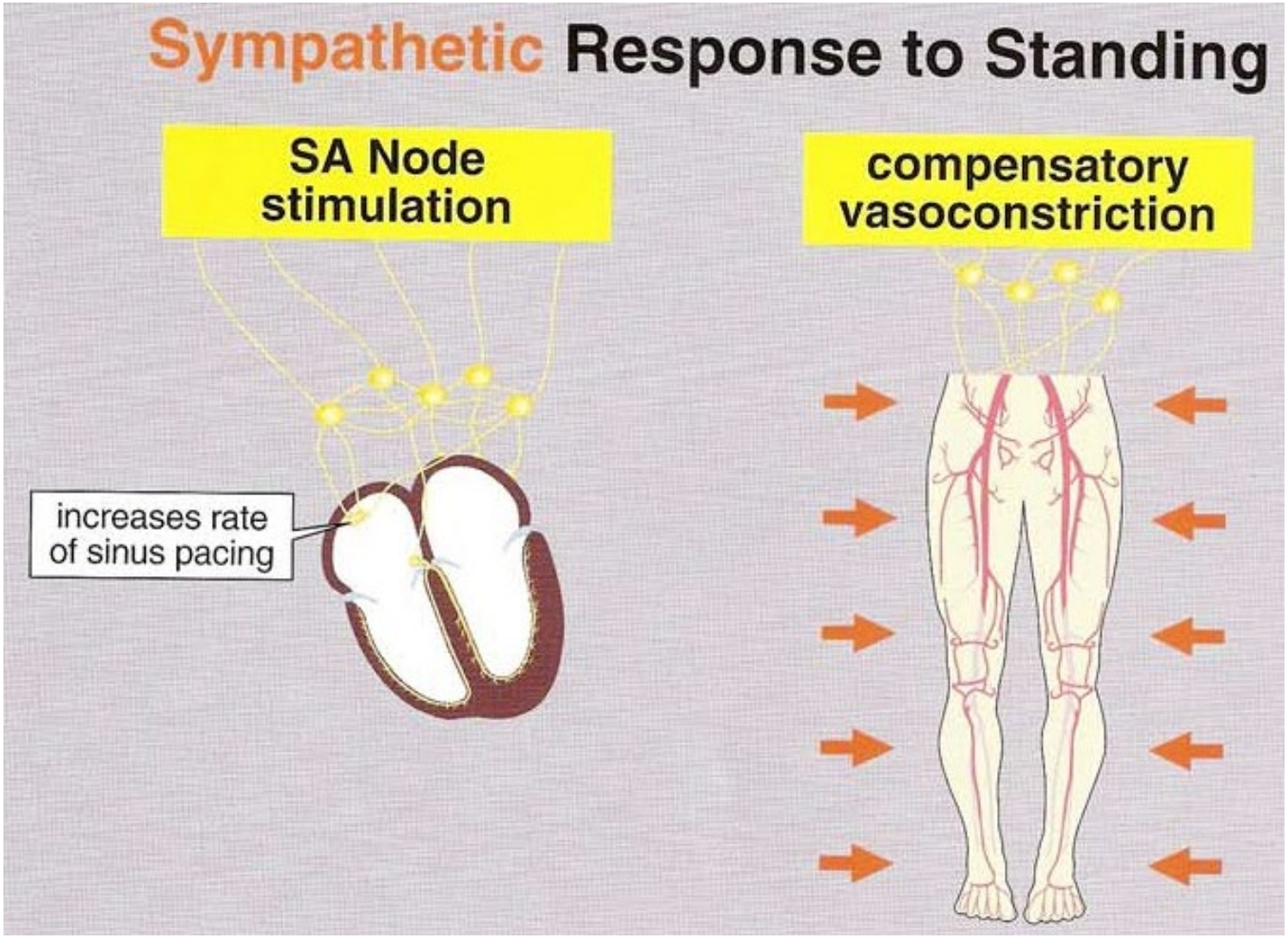


- Baroreceptors of carotid sinus and aortic arch
  - ↓ blood pressure sensed → ↑ HR
  - ↑ blood pressure sensed → ↓ HR
- Localized hypoxia
  - Low blood oxygen levels are sensed → ↑ HR to get flow to the tissues

Maintaining Basic Homeostasis

- Cardiovascular system at rest
  - Vascular tone set by sympathetic nervous system
  - Heart rate set by parasympathetic nervous system
- Cardiovascular system with posture change from sitting to standing
  - Drop in blood pressure is sensed causing sympathetic nervous system stimulation
    - β_1 receptor ↑ heart rate → ↑ cardiac output
    - α_1 receptor ↑ vasoconstriction → ↑ blood pressure

Blood Pressure and Posture Change



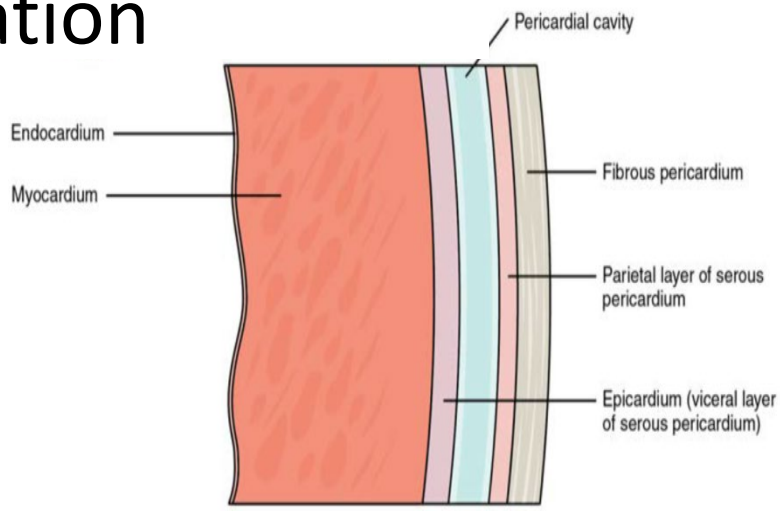
Dubin. Rapid Interpretation of EKG's. 6th Edition. P. 62

Advanced Homeostasis

- Cardiovascular system with exercise
  - Localized hypoxia in muscles is sensed → Sympathetic nervous system stimulation
    - **(β_1)** + norepinephrine ↑ heart rate
    - **(Muscarinic) +** acetylcholine → skeletal muscles blood vessels vasodilation
- Cardiovascular system with dehydration
  - Drop in blood pressure is sensed causing sympathetic nervous system stimulation →
    - ↑ cardiac output and blood pressure
  - Drop in preload → renal hormone activation →
    - ↑preload → ↑ cardiac output

Heart Specific Homeostasis

- Coronary artery autoregulation
  - Coronary arteries in the epicardium
  - Endocardial arteries are the most sensitive to ischemia



  - Blood flows into the coronary arteries only during ventricular diastole
  - Normal blood flow maintained between a **diastolic** blood pressure of 60-140mm Hg

Summary Questions