Coronary Collateral Circulation

The branches of the coronary arteries are generally considered to be

Functional End arteries!!!!!

arteries that supply regions of the myocardium
lacking sufficient anastomoses
from other large branches to maintain viability of the tissue should **occlusion** occur

However

Some Anastomoses do exist

Which artery is larger?

- **The calibre of coronary arteries**, both main stems and larger branches, based on measurements of arterial casts or angiograms, ranges between 1.5 and 5.5 mm for the coronary arteries at their origins.
- **The left exceed the right in 60%** of hearts, **the right being larger in 17%**, and both vessels being approximately equal in 23%.
- The diameters of the coronary arteries may **increase up to the 30th year**

BLOOD SUPPLY OF THE HEART

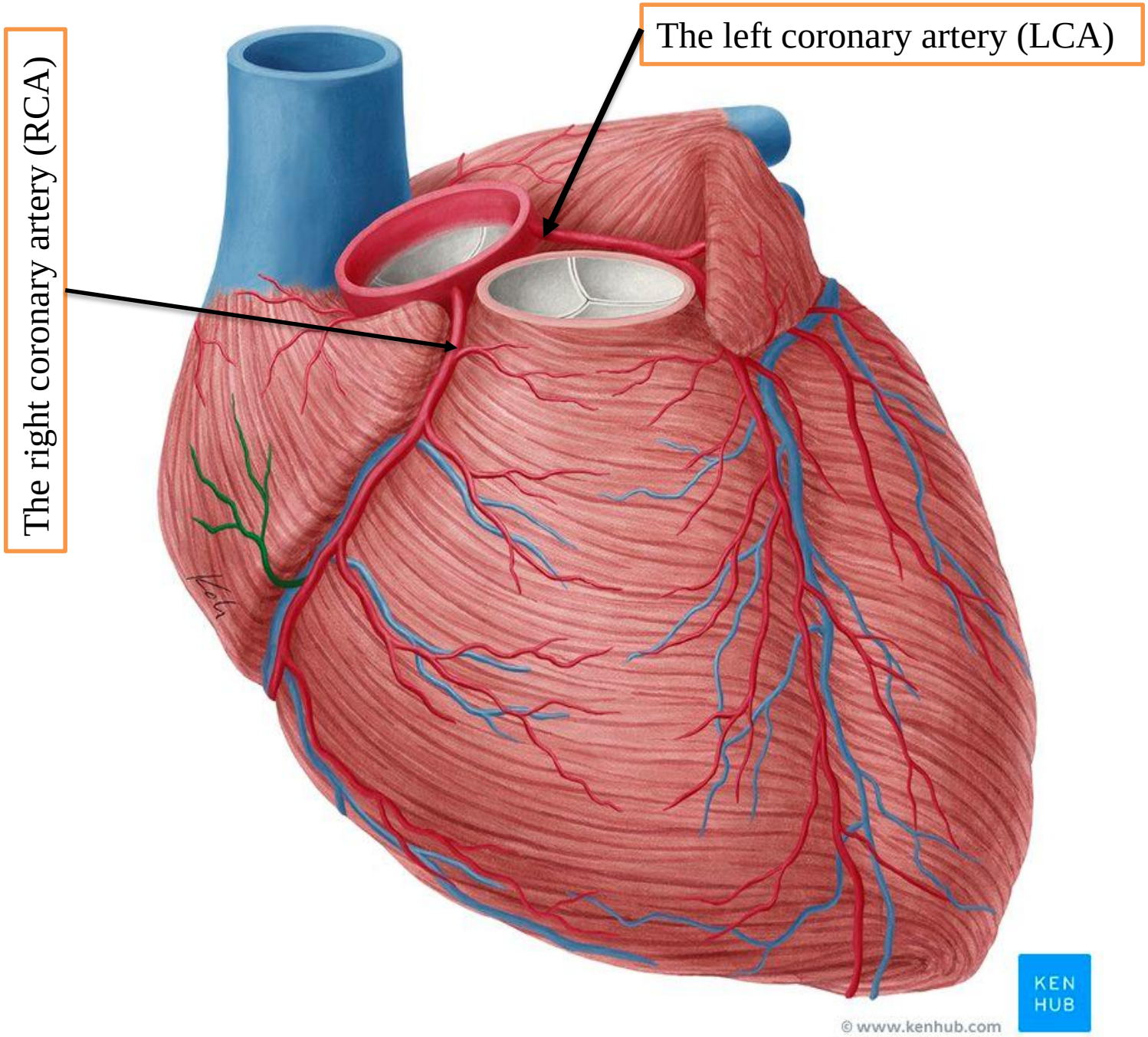
from two coronary arteries

The two arteries, as indicated by their name, form an oblique inverted crown, in which an anastomotic circle in the atrioventricular groove is connected by marginal and interventricular (descending) loops intersecting at the cardiac apex

The left coronary artery (LCA)

The right coronary artery (RCA)

The endocardium and some subendocardial tissue located immediately external to the endocardium receive oxygen and nutrients by diffusion or microvasculature directly ***from the chambers of the heart***

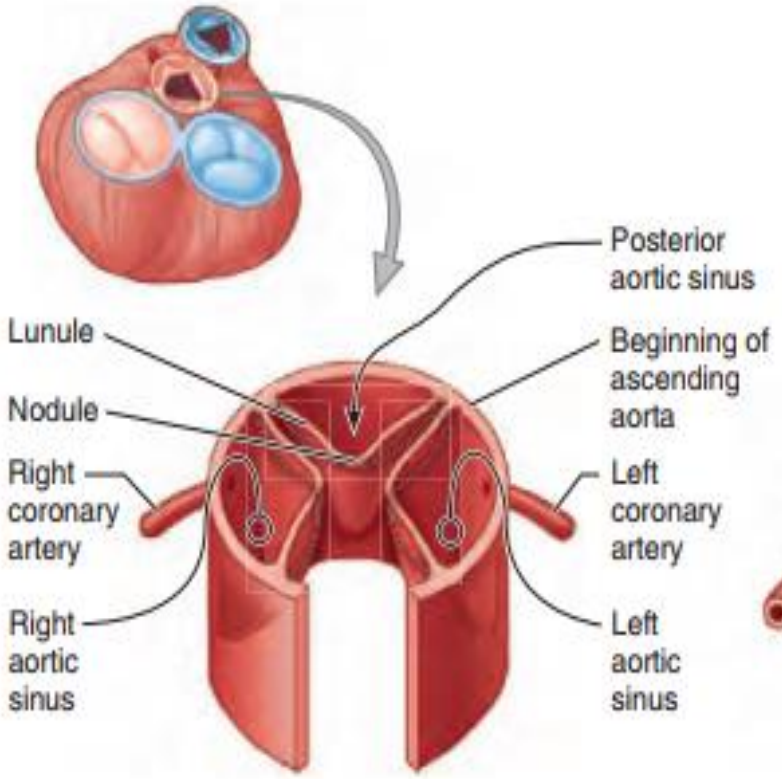

The left coronary artery (LCA)
The right coronary artery (RCA)
© www.kenhub.com
KEN HUB

The aortic valve

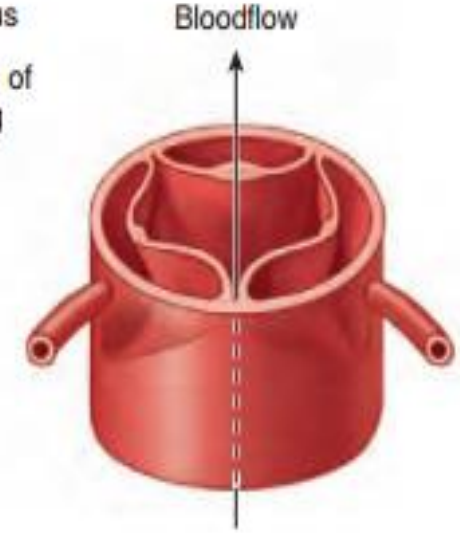
consists of three semilunar cusps

Posterior (non-coronary) cusp
Right
Left

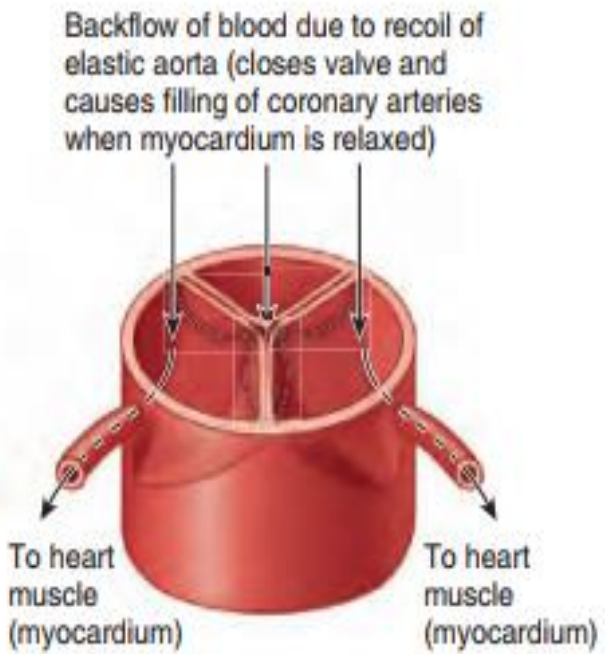
Just superior to right and left cusps in the Sinus of **Valsalva** are the openings of the right and left coronary arteries, respectively



(A) Anterior view of aortic valve



(B) Valve open

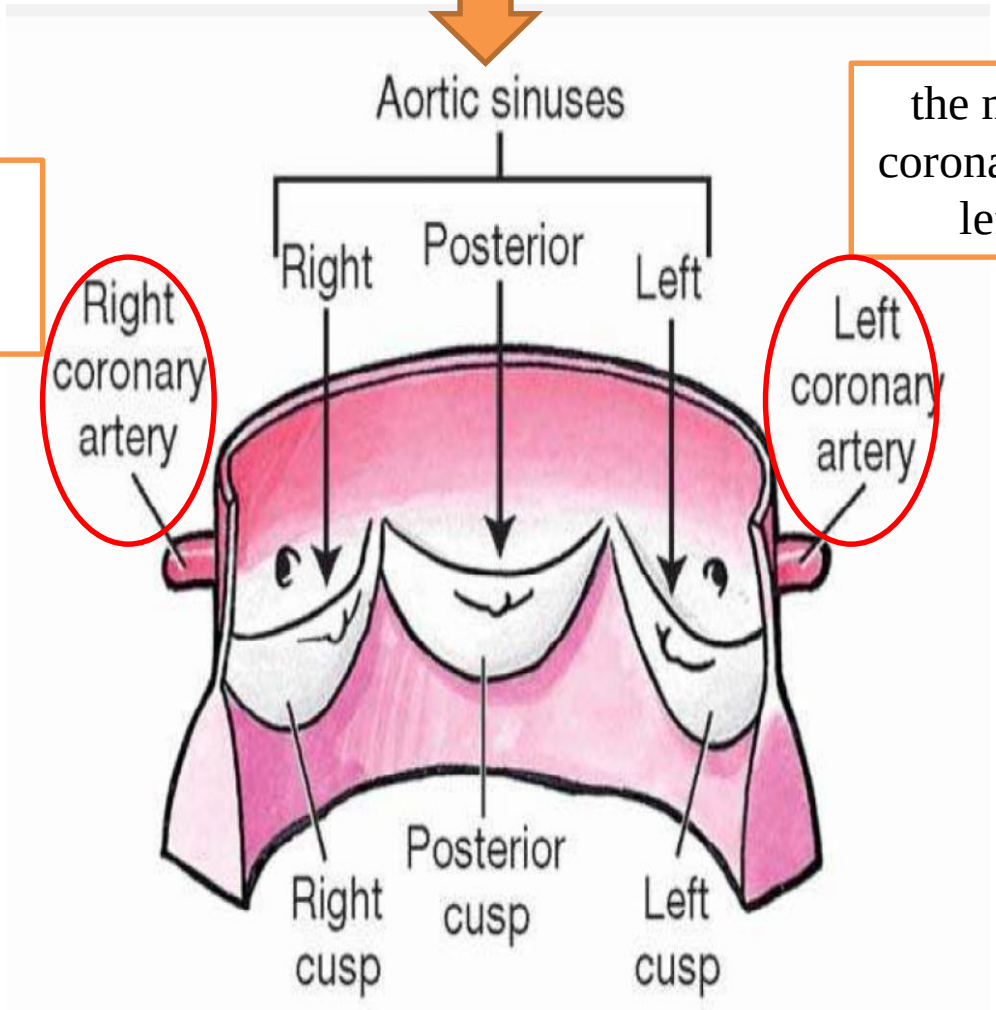


(C) Valve closed

no artery arises from the posterior aortic **(noncoronary) sinus**

The mouth of the right coronary artery is in the right aortic sinus;

the mouth of the left coronary artery is in the left aortic sinus



THE LEFT CORONARY ARTERY (LCA)

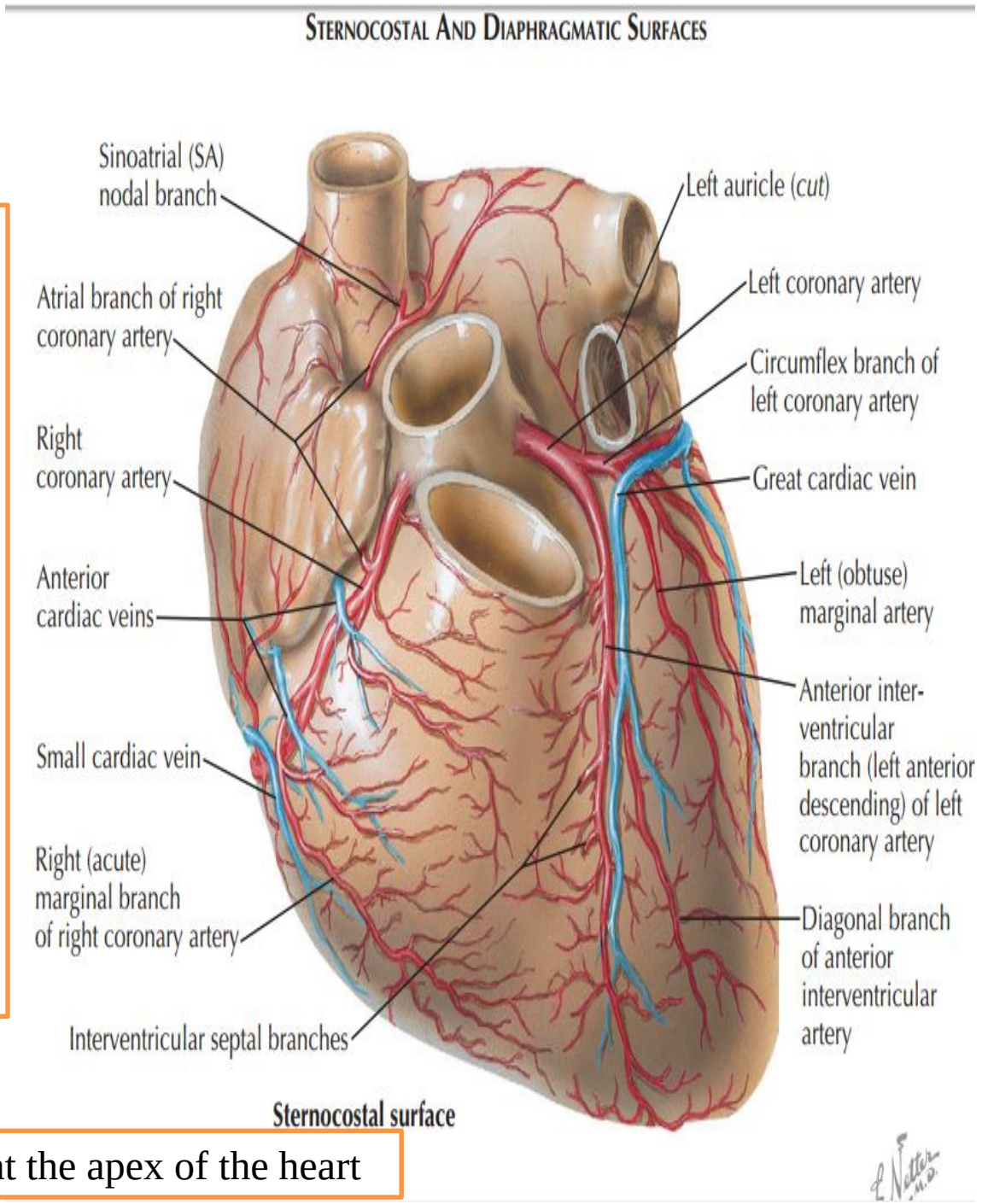
The left coronary artery (LCA) originates from
The left sinus of Valsalva
(the left aortic sinus) of the ascending aorta passes
between **the left auricle** and **the left side of the pulmonary trunk**

The LCA usually has a short (0.5-2 cm) common stem that travels a short course between the left aurcle and ventricle, and divides into 2 branches: **anterior interventricular or left anterior descending (LAD) artery** and **circumflex artery.**

left diagonal artery, may arise directly from the trunk of the left coronary artery

1-THE ANTERIOR INTERVENTRICULAR or LEFT ANTERIOR DESCENDING (LAD)

- Runs downward in the anterior interventricular groove to the apex of the heart
- In most individuals it then passes **around the apex of the heart to enter the posterior interventricular groove** and **anastomoses with the terminal branches of the right coronary artery.**

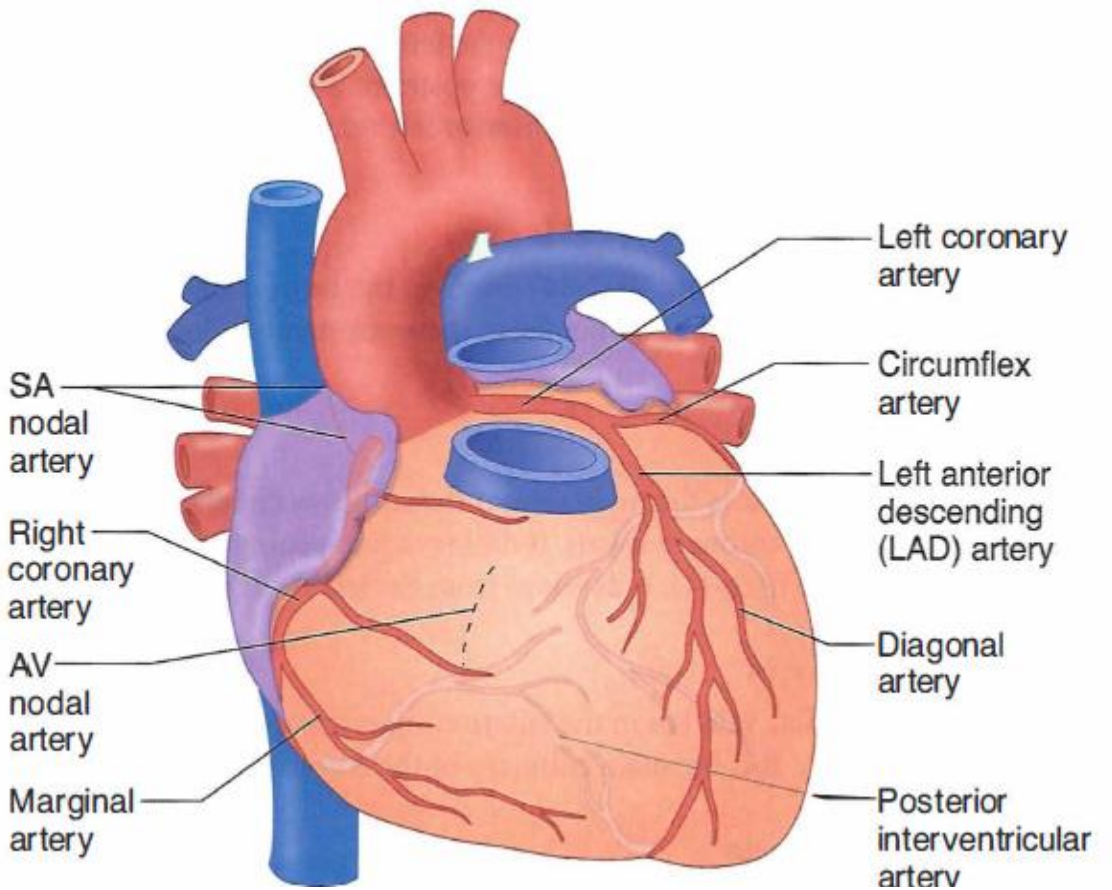


In one third of individuals it ends at the apex of the heart

- **The anterior interventricular branch LEFT ANTERIOR DESCENDING (LAD)**

Clinical Correlate

In myocardial infarction, the left anterior descending artery is obstructed in 50% of cases, the right coronary in 30%, and the circumflex artery in 20% of cases.

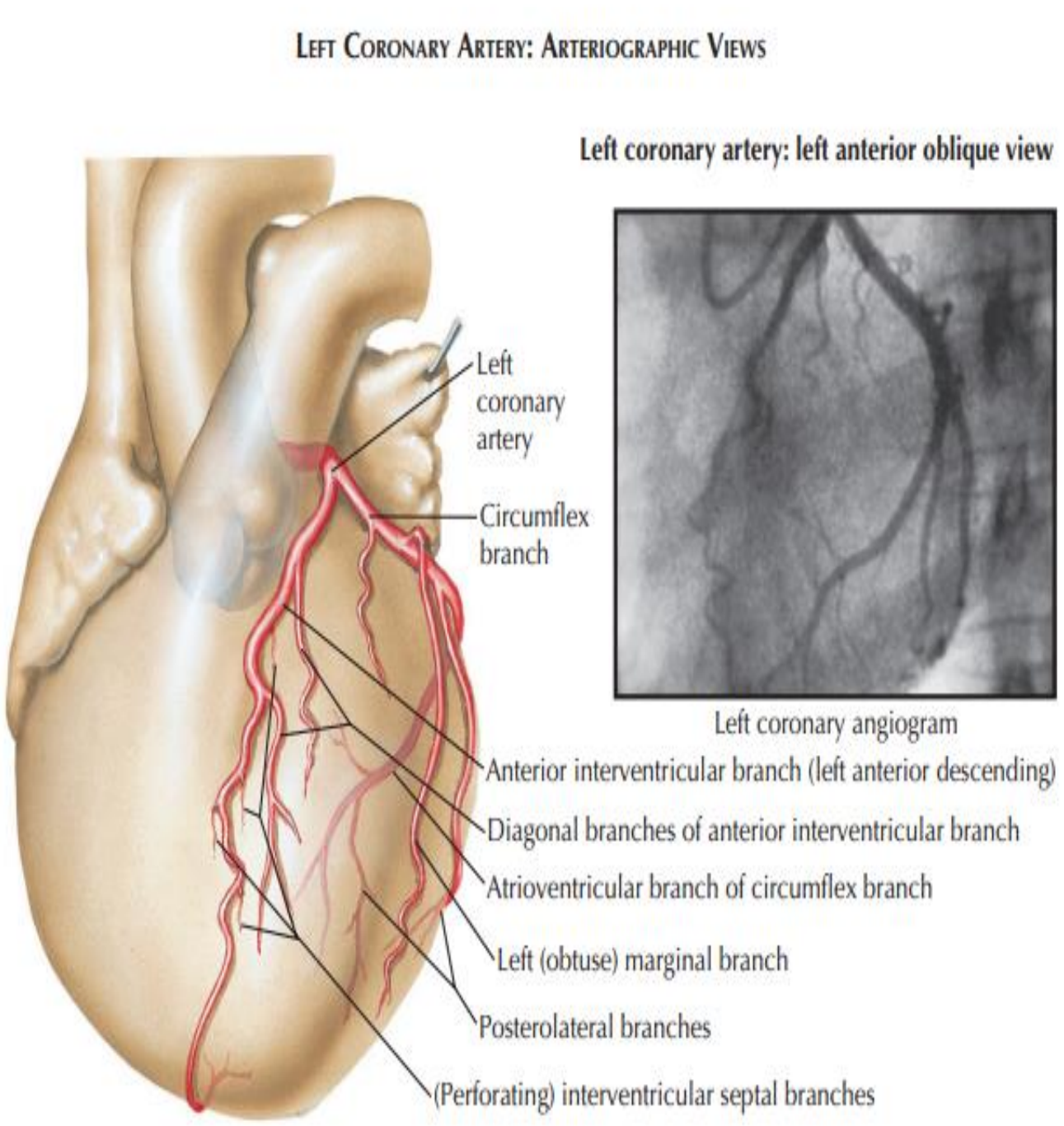


Supplies

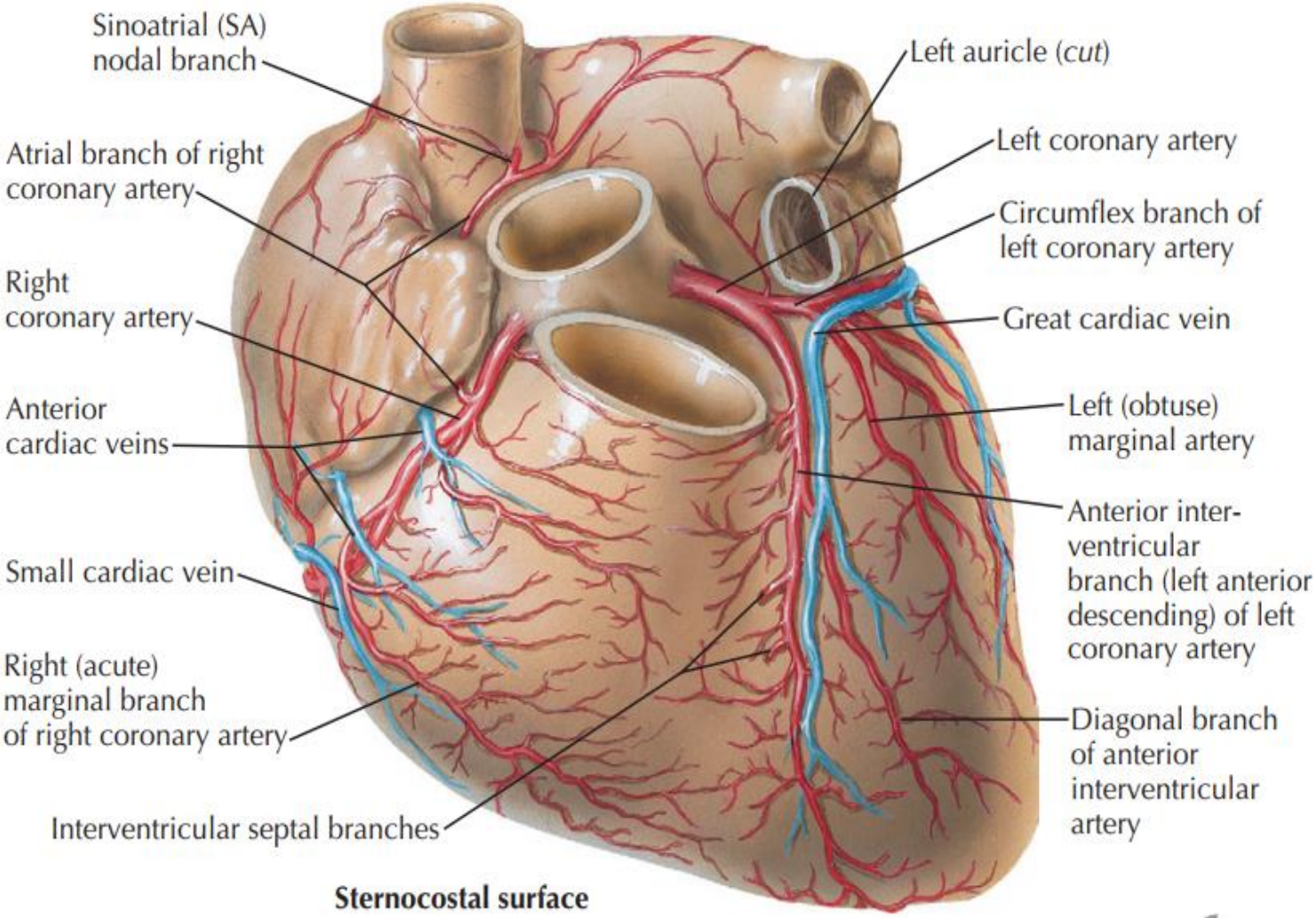
(1) anterior left ventricle wall, (2) anterior two-thirds of the interventricular septum, (3) bundle of His, and (4) apex. The LAD is the most common site of coronary occlusion.

2-THE CIRCUMFLEX ARTERY

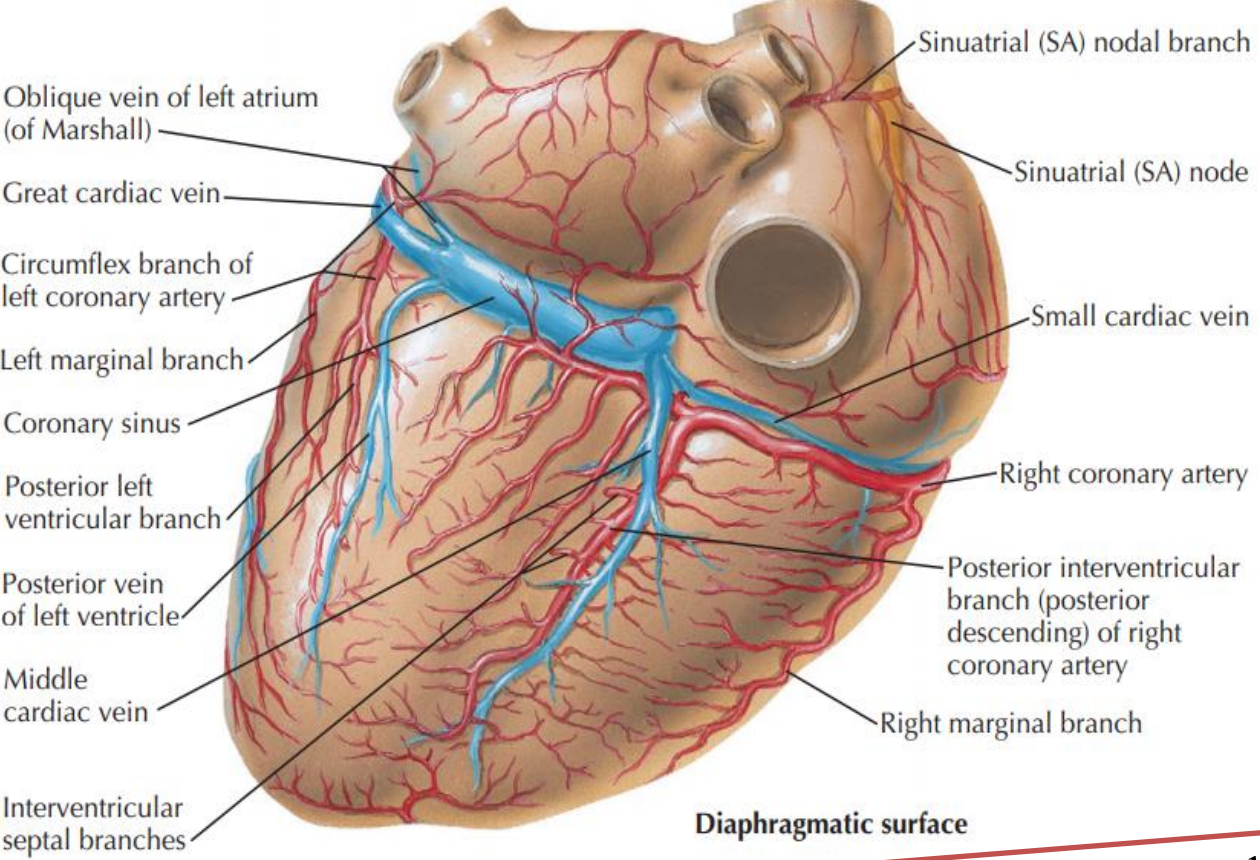
- It is the same size as the anterior interventricular artery
- It winds around the left margin of the heart in the *atrioventricular groove.*
- **A left marginal artery** is a large branch that supplies the left margin of the left ventricle down to the apex.
- **Anterior ventricular and posterior ventricular** branches supply the left ventricle.
- **Atrial branches supply the left atrium**



Sternocostal And Diaphragmatic Surfaces



Sternocostal surface



Summary of the Overall Arterial Supply to the Heart from the LCA

The left coronary artery supplies:
most of the left ventricle,
a small area of the right ventricle to the right of the interventricular groove,
the anterior two thirds of the ventricular septum
, most of the left atrium,
the RBB
and the LBB

The right coronary artery (RCA) arises from **The right anterior sinus of Valsalva** of the aorta and runs along the right AV sulcus, embedded in fat.

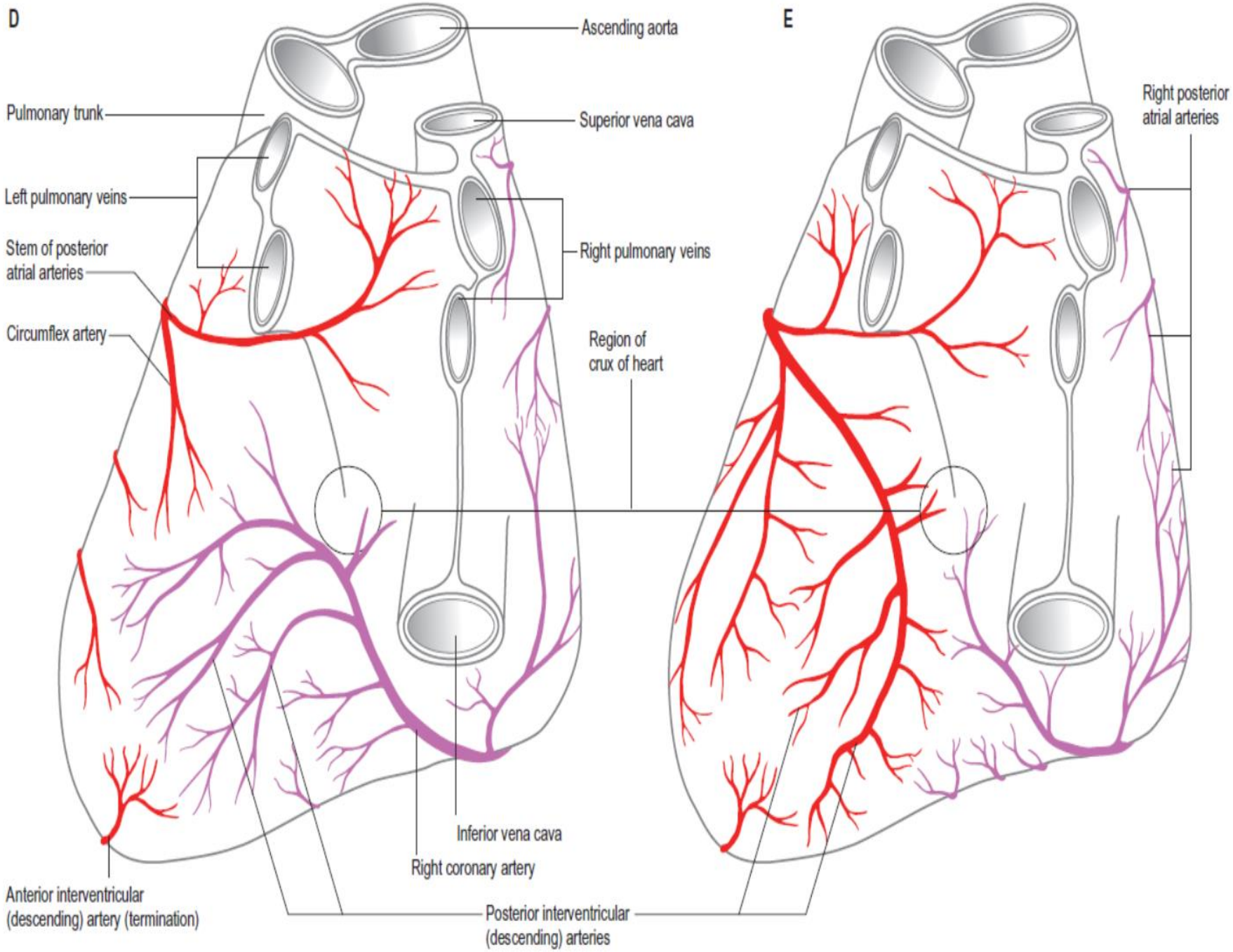
The branches of the right coronary include the following:

- **Sinoatrial (SA) nodal artery:** One of the first branches of the right coronary, it encircles the base of the superior vena cava to supply the **SA node**.
- **Atrioventricular (AV) nodal artery:** It arises from the distal end of the right coronary artery as it forms the posterior interventricular artery and penetrates the interatrial septum to supply the **AV node**.
- **Posterior interventricular artery:** It is the terminal distribution of the right coronary artery and courses in the posterior interventricular sulcus to supply parts of the right and left ventricles and, importantly, **the posterior third** of the interventricular septum.

Summary of the Overall Arterial Supply to the Heart from the RCA

in Most Individuals The right coronary artery supplies **all of the right ventricle (except for the small area to the right of the anterior interventricular groove)**, the variable part of the diaphragmatic surface of the left ventricle, the posteroinferior third of the ventricular septum, the right atrium and part of the left atrium, and the sinuatrial node and the atrioventricular node and bundle.

The LBB also receives small branches.

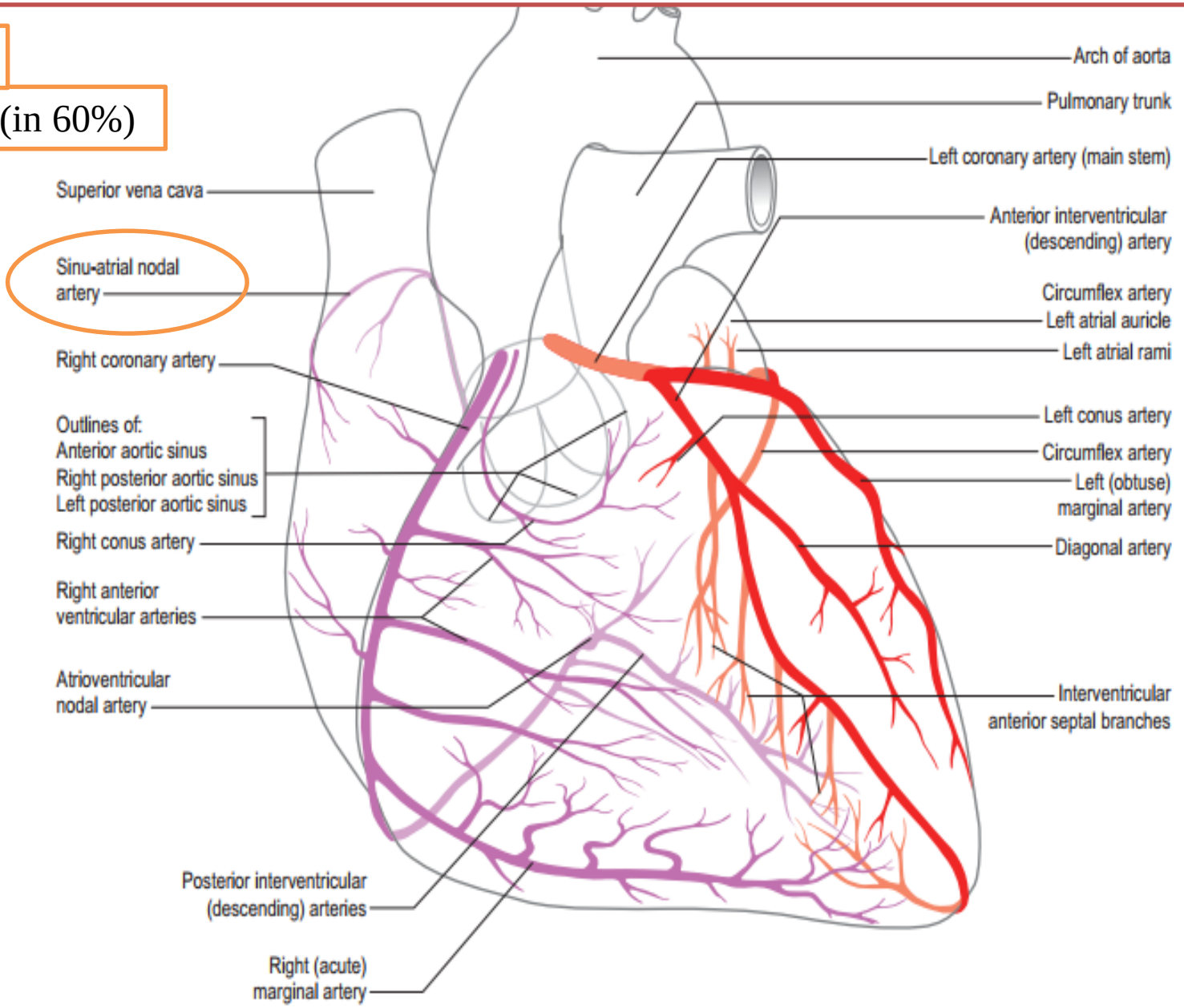

D
Ascending aorta
Pulmonary trunk
Superior vena cava
Left pulmonary veins
Right pulmonary veins
Stem of posterior atrial arteries
Circumflex artery
Region of crux of heart
Inferior vena cava
Right coronary artery
Anterior interventricular (descending) artery (termination)
Posterior interventricular (descending) arteries
E
Right posterior atrial arteries

Arterial Supply to the Conducting System

1-The sinuatrial node is usually supplied by the right but sometimes by the left coronary artery.

From the

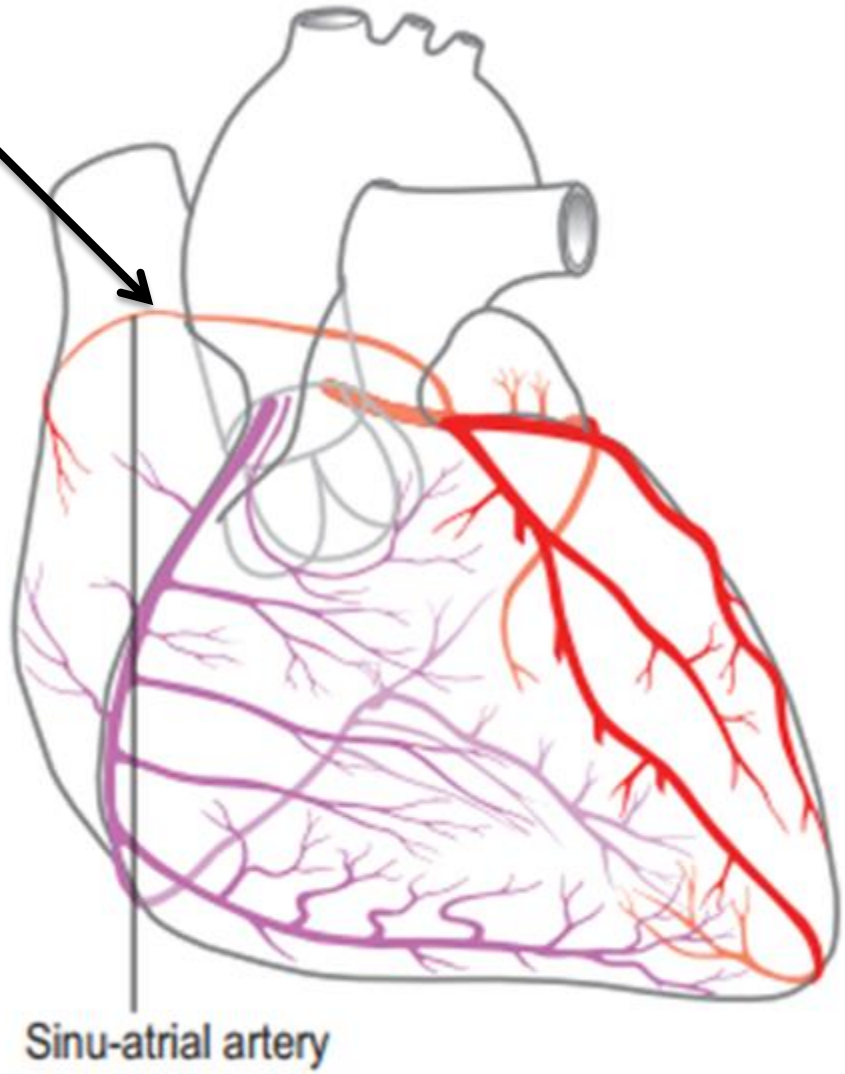
RCA near its origin (in 60%)



from

Circumflex branch of LCA
(in 40%)

A common variation in the origin of the sinoatrial nodal artery.



2-The **atrioventricular node** and the **atrioventricular bundle** are supplied by **THE RIGHT CORONARY ARTERY**

3-The **RBB** of the atrioventricular bundle is supplied by **the left coronary artery**

4-the **LBB** is supplied by **the right and left coronary arteries**

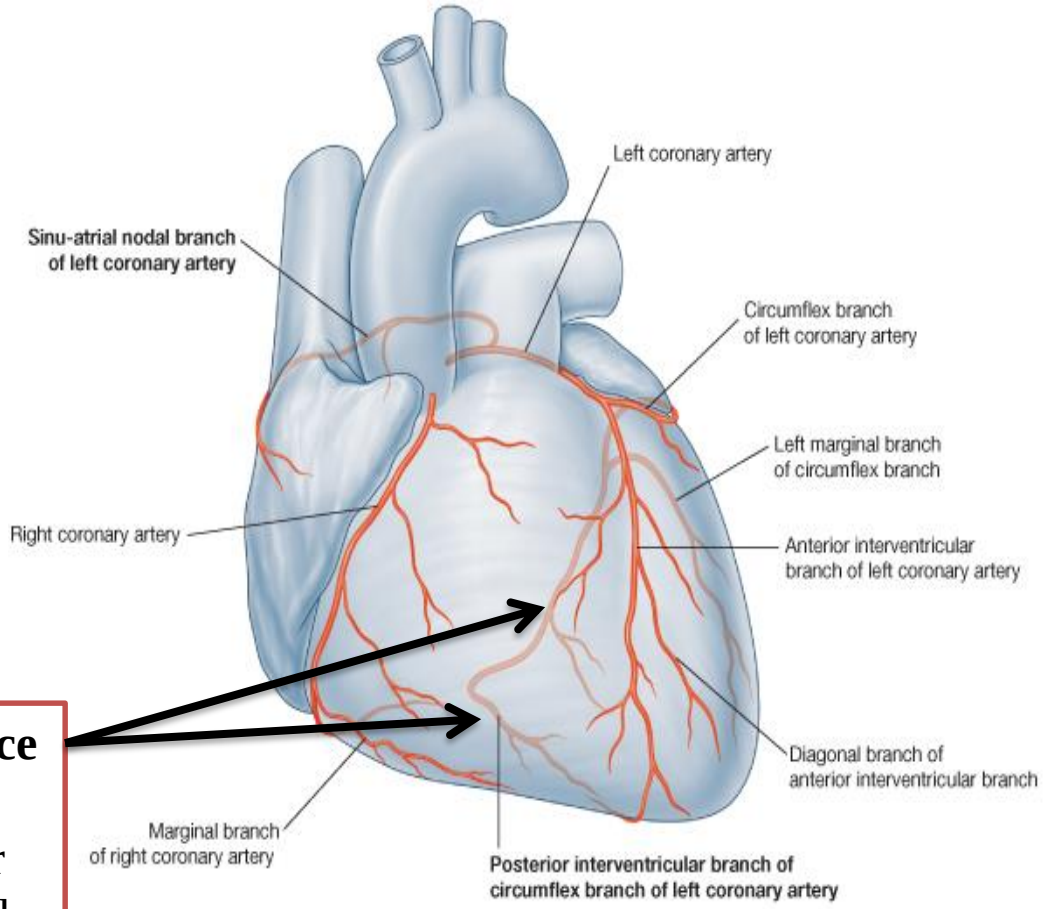
Variations in the Coronary Arteries

The most common variations affect the blood supply to the diaphragmatic surface of both ventricles

the origin, size, and distribution of the **Posterior Interventricular Artery Can be** *variable*

In right dominance, the posterior interventricular artery is a large branch of the right coronary artery. Right dominance is present in most individuals (90%).

In left dominance the posterior interventricular artery is a branch of the circumflex branch of the left coronary artery (10%).



The term 'dominant' is used to refer to the coronary artery giving off the posterior interventricular (descending) branch

In the so-called **'balanced' pattern**, branches of both arteries run in or near the posterior interventricular groove

The term ‘dominant
Is misleading

because the left artery almost always supplies a greater volume of tissue than the right.

.

intra- and inter-coronary anastomoses in vessels
up to 100–200 μm in calibre.

Read only

The most frequent sites of extramural anastomoses **are:**
The apex
The anterior aspect of the right ventricle
The posterior aspect of the left ventricle
Interatrial and interventricular grooves
Between the sinoatrial nodal and other atrial vessels

The functional value of such anastomoses must vary, but they appear to become more effective in ***slowly progressive pathological conditions***.

Extracardiac anastomoses
May connect **various coronary branches** with other thoracic vessels
via the pericardial arteries and **arterial vasa vasora of vessels**
which link the heart ***with the systemic and pulmonary circulations.***

The effectiveness of these connections as collateral routes in coronary occlusion is unpredictable

Coronary arteriovenous anastomoses and numerous connections between the coronary circulation and cardiac cavities, producing so-called ‘myocardial sinusoids’ and ‘arterioluminal’ vessels, have been reported; their importance in coronary disease is uncertain

Venous Drainage of the Heart

The major cardiac veins draining the heart course in the sulci and accompany the arteries but do not carry the same names. The major veins are the following:

- **Coronary sinus**

  The coronary sinus is the main vein of the coronary circulation; it lies in the posterior coronary sulcus. It drains to an opening in the right atrium It develops from the **left sinus venosus**.

- **Great cardiac vein**

  The great cardiac vein lies in the anterior interventricular sulcus with the LAD artery. It is the main tributary of the coronary sinus.

- **Middle cardiac vein**

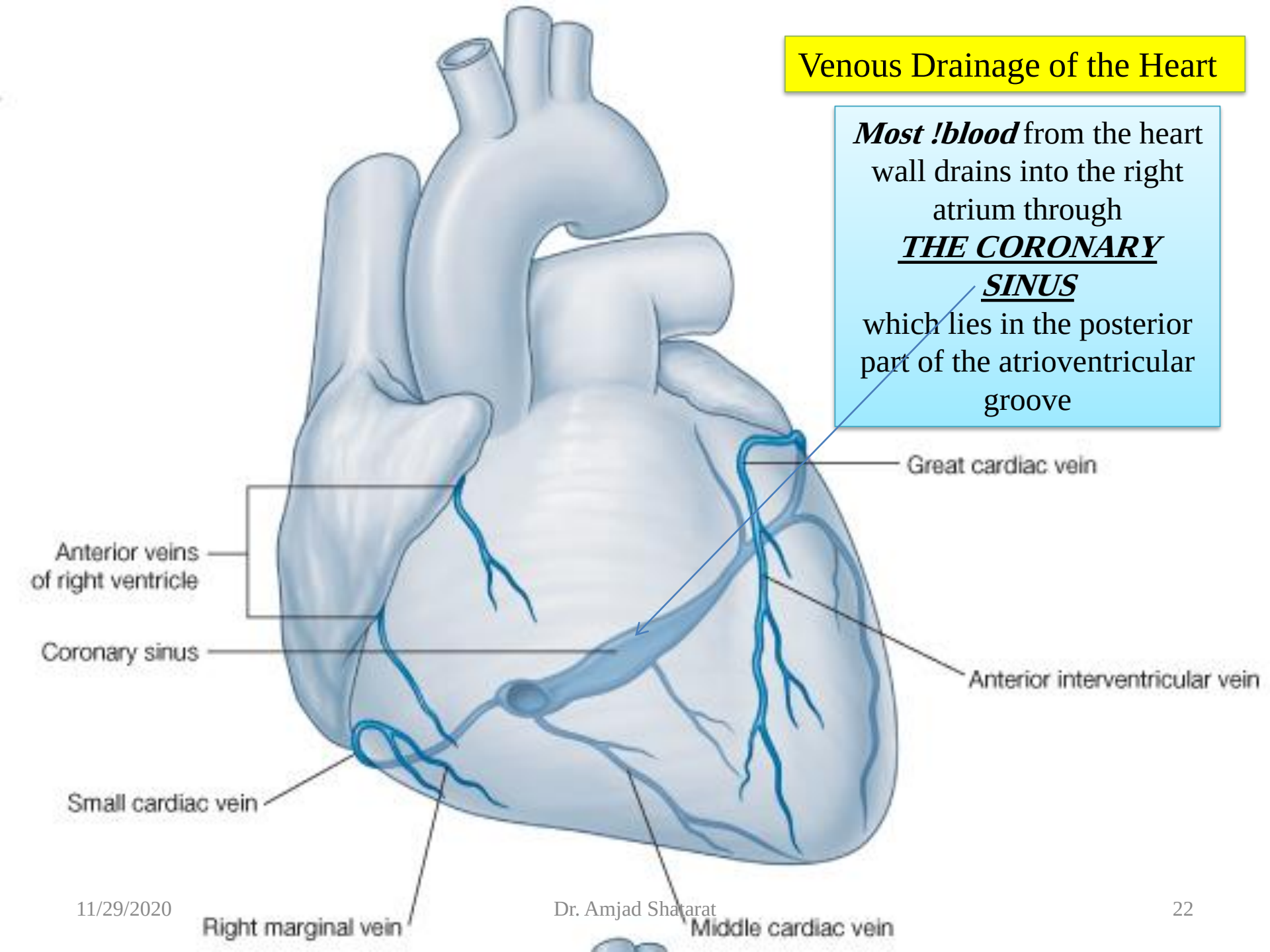
  The middle cardiac vein lies in the posterior interventricular sulcus with the posterior interventricular artery. It joins the coronary sinus.

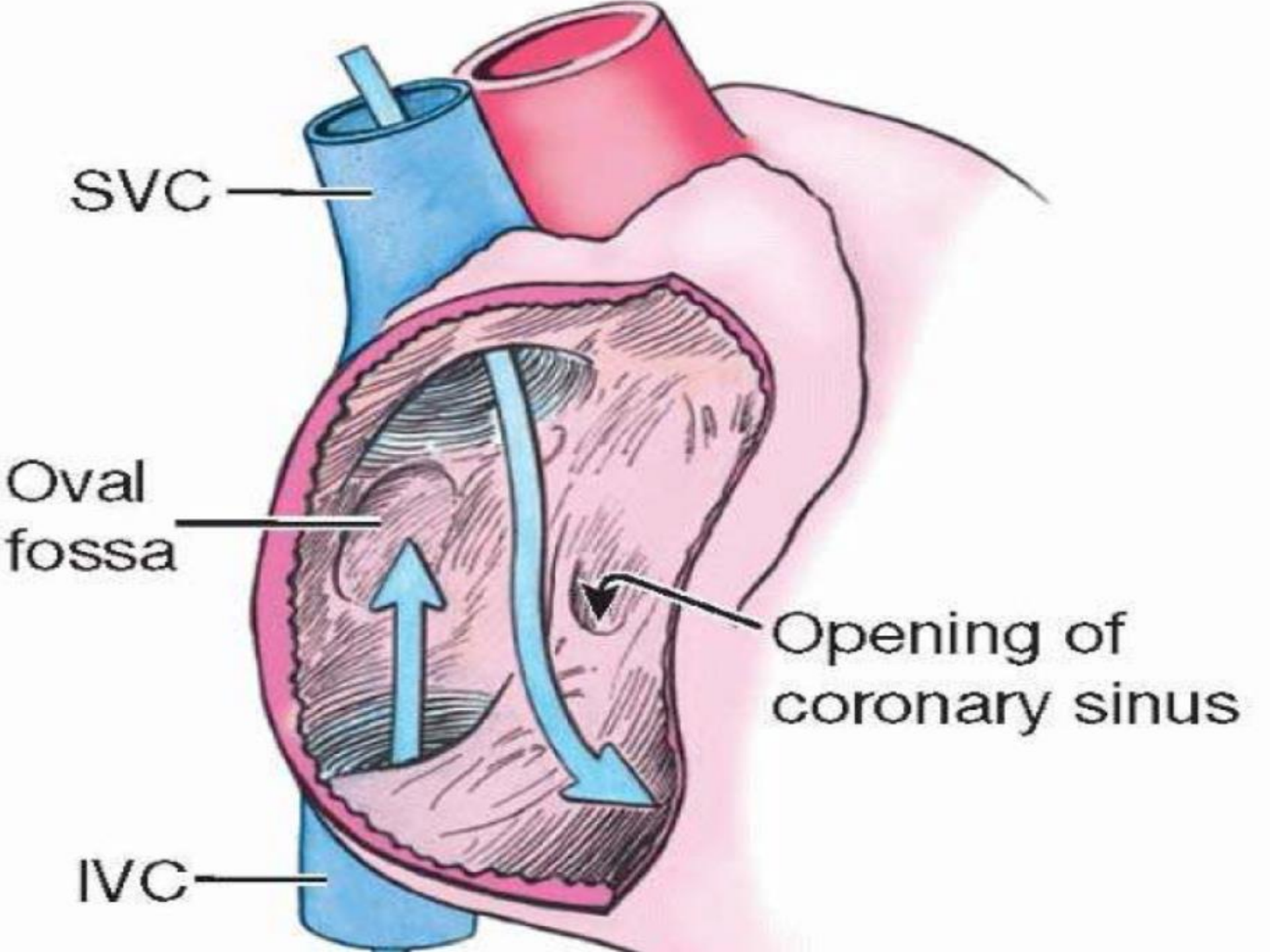
- **Venae cordis minimae (thebesian veins) and anterior cardiac veins**

  The venae cordis minimae and anterior cardiac veins open directly to the chambers of the heart.

Venous Drainage of the Heart

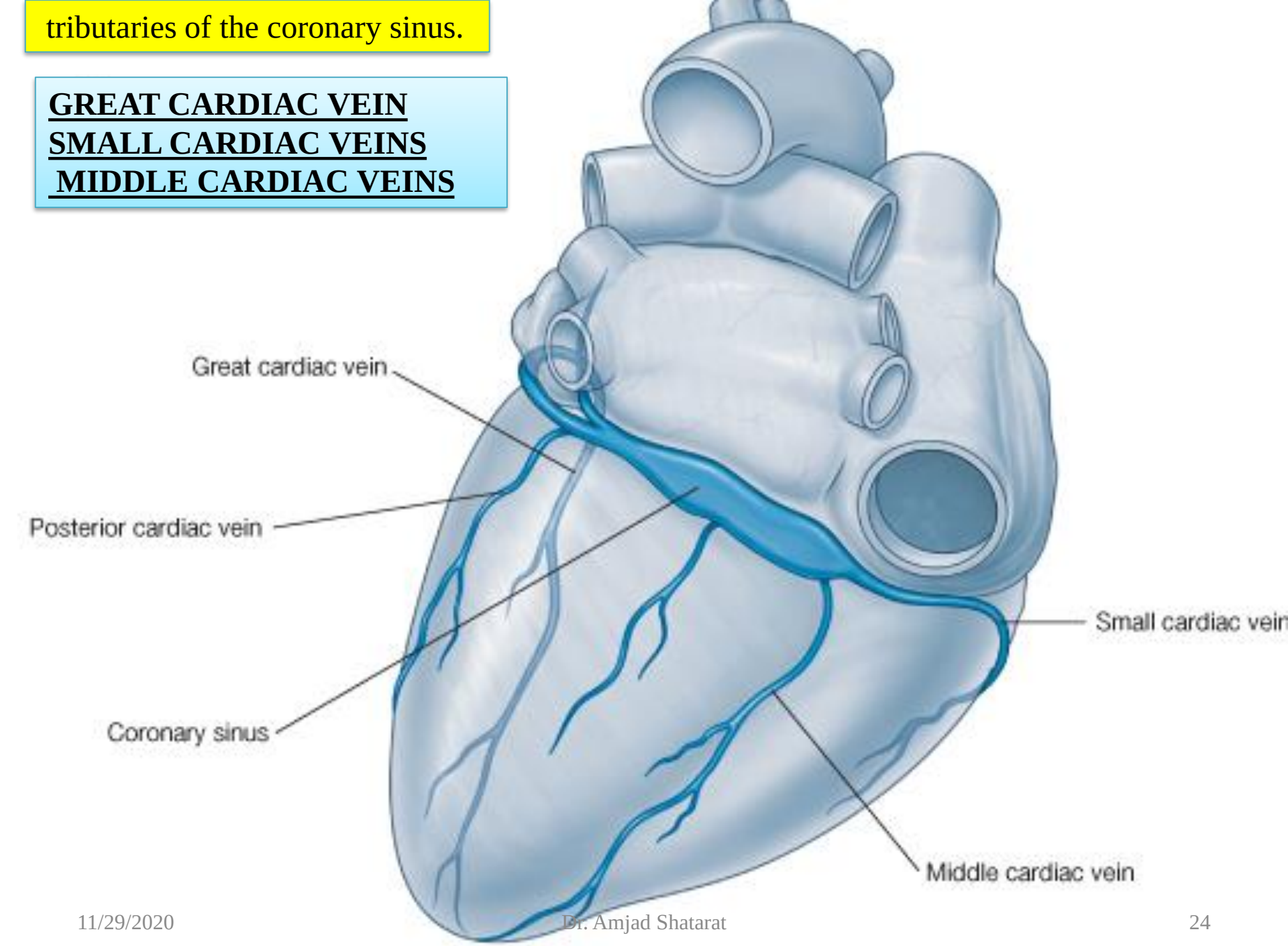
Most !blood from the heart wall drains into the right atrium through ***THE CORONARY SINUS*** which lies in the posterior part of the atrioventricular groove

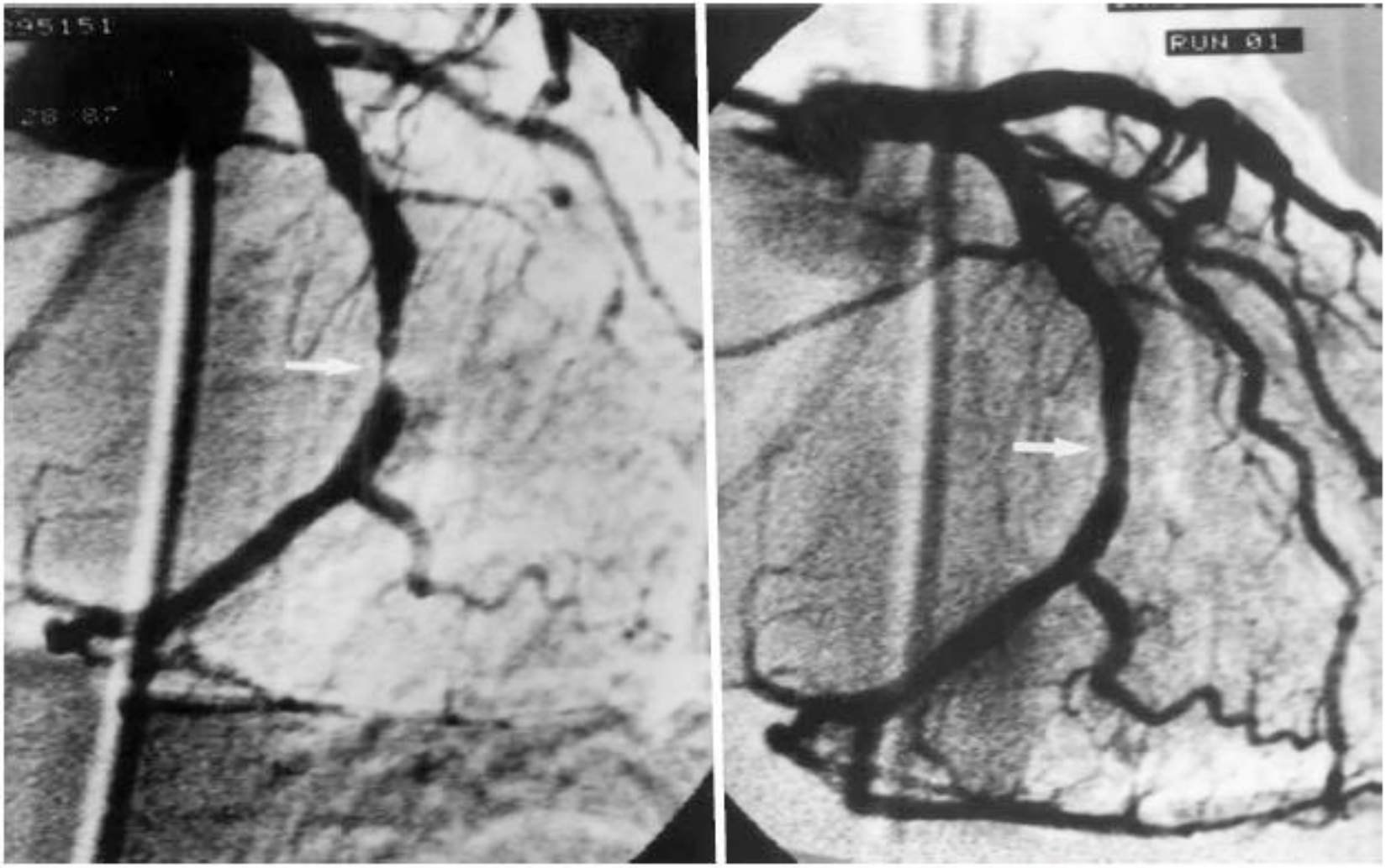



SVC
Oval
fossa
Opening of
coronary sinus
IVC

tributaries of the coronary sinus.

GREAT CARDIAC VEIN
SMALL CARDIAC VEINS
MIDDLE CARDIAC VEINS

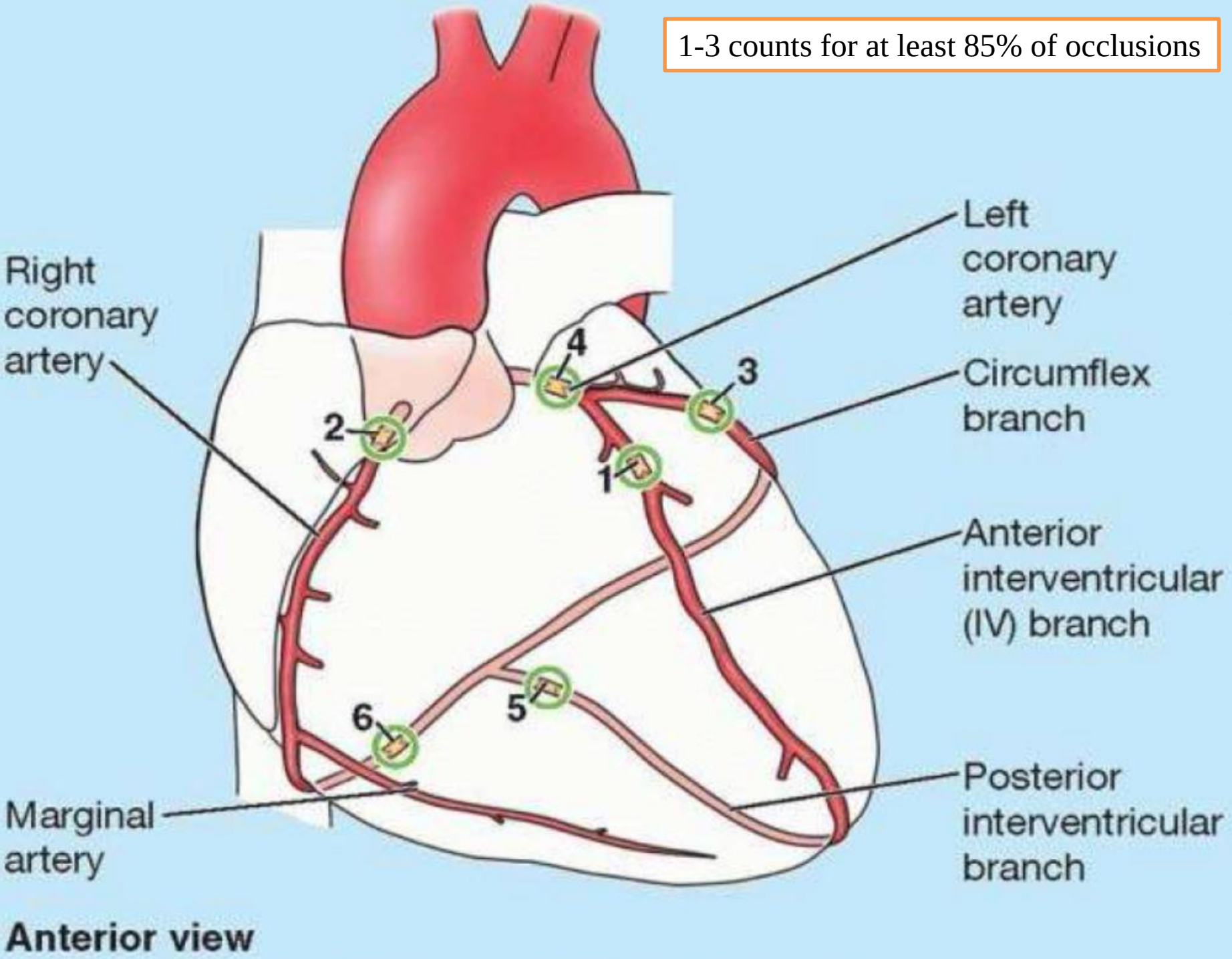


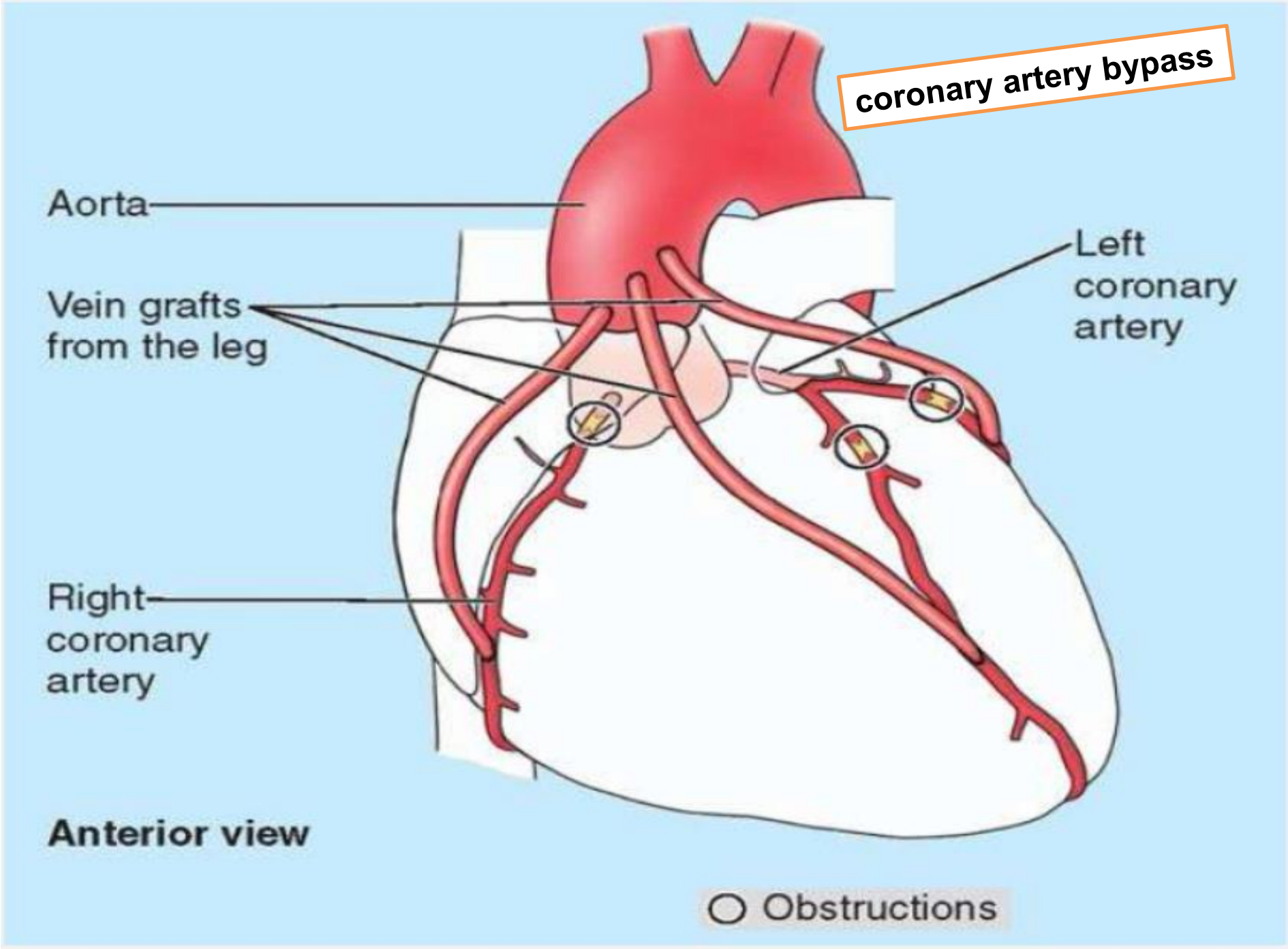


A B

CD Figure 4-1 Coronary angiograms. **A.** An area of extreme narrowing of the circumflex branch of the left coronary artery (white arrow). **B.** The same artery after percutaneous transluminal coronary angioplasty. Inflation of the luminal balloon has dramatically improved the area of stenosis (white arrow).

1-3 counts for at least 85% of occlusions




coronary artery bypass
Aorta
Vein grafts from the leg
Left coronary artery
Right coronary artery
Anterior view
Obstructions

Read only and you will not enjoy?!!!!

CD Table 4-1 Coronary Artery Lesions, Infarct Location, and ECG Signature

Coronary Artery	Infarct Location	ECG Signature
Proximal LAD	Large anterior wall	ST elevation: I, L, V1–V6
More distal LAD	Anteroapical	ST elevation: V2–V4
	Inferior wall if wraparound LAD	ST elevation: II, III, F
Distal LAD	Anteroseptal	ST elevation: V1–V3
Early obtuse, marginal	High lateral wall	ST elevation: I, L, V4–V6
More distal marginal branch, circumflex	Small lateral wall	ST elevation: I, L, or V4–V6, or no abnormality
Circumflex	Posterolateral	ST elevation: V4–V6; ST depression: V1–V2
Distal RCA	Small inferior wall	ST elevation: II, III, F; ST depression: I, L
Proximal RCA	Large inferior wall and posterior wall	ST elevation: II, III, F; ST depression: I, L, V1–V3
	Some lateral wall	ST elevation: V5–V6
RCA	Right ventricular	ST elevation: V2R–V4R; some ST elevation: V1, or ST depression: V2–V3
	Usually inferior	ST elevation: II, III, F

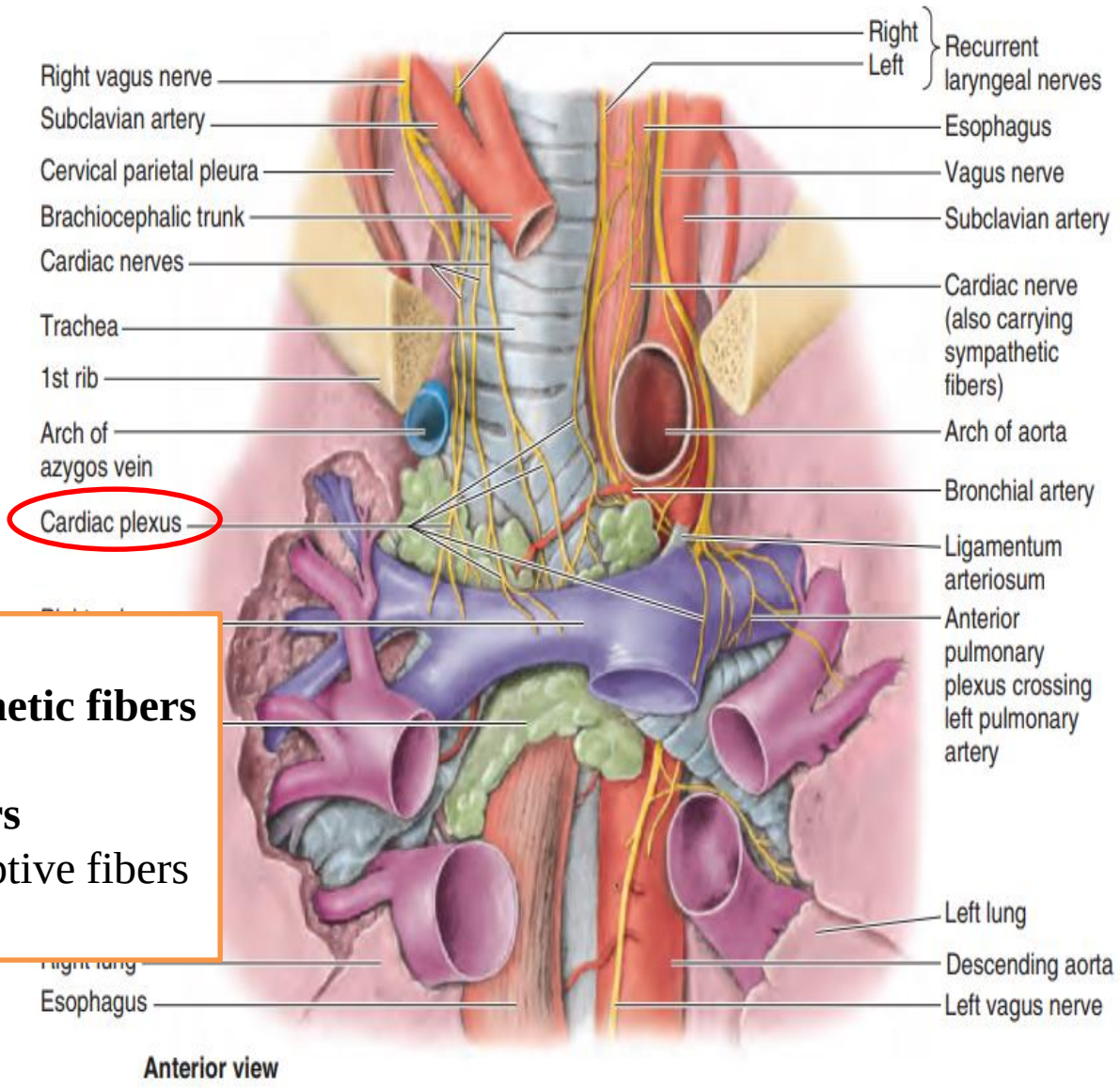
ECG, electrocardiographic; LAD, left anterior descending (interventricular); RCA, right coronary artery.

Innervation of the Heart

The heart is supplied by autonomic nerve fibers from **The cardiac plexus** which is often quite artificially divided into superficial and deep portions

The cardiac plexus Leis on the anterior surface of the **bifurcation of the trachea**

It is formed of both **sympathetic and parasympathetic fibers** as well as **visceral afferent fibers** conveying reflexive and nociceptive fibers from the heart



Anterior view

The sympathetic supply is from

Presynaptic Fibers, with cell bodies in the intermediolateral cell columns (IMLs) of the superior five or six thoracic segments of the spinal cord

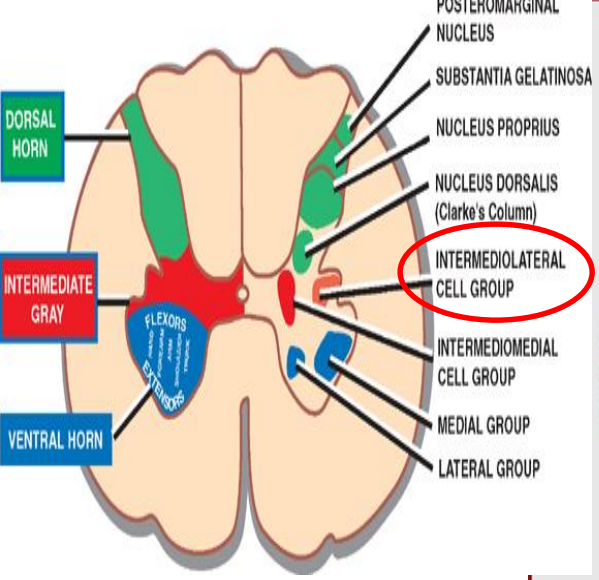
Postsynaptic Sympathetic Fibers, with cell bodies in the cervical and superior thoracic paravertebral ganglia **of the sympathetic trunks**.
The postsynaptic fibers traverse cardio pulmonary splanchnic nerves and the cardiac plexus to end **in the SA and AV nodes**

Sympathetic stimulation

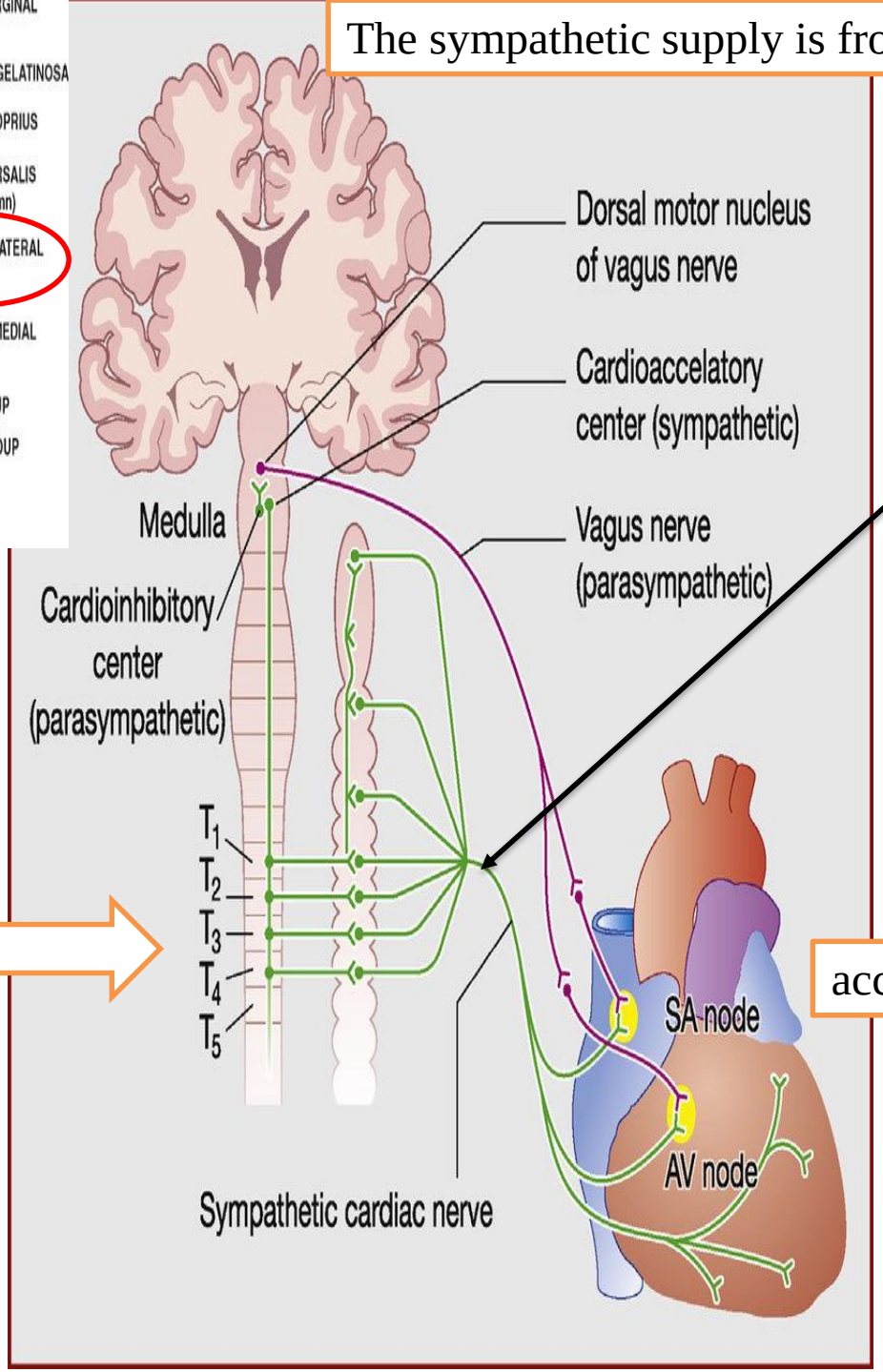
Adrenergic stimulation of the SA node and conducting tissue

- ❖ increases the rate of depolarization of the pacemaker cells while increasing atrioventricular conduction

causes **increased heart rate**
impulse conduction
force of contraction



The sympathetic supply is from

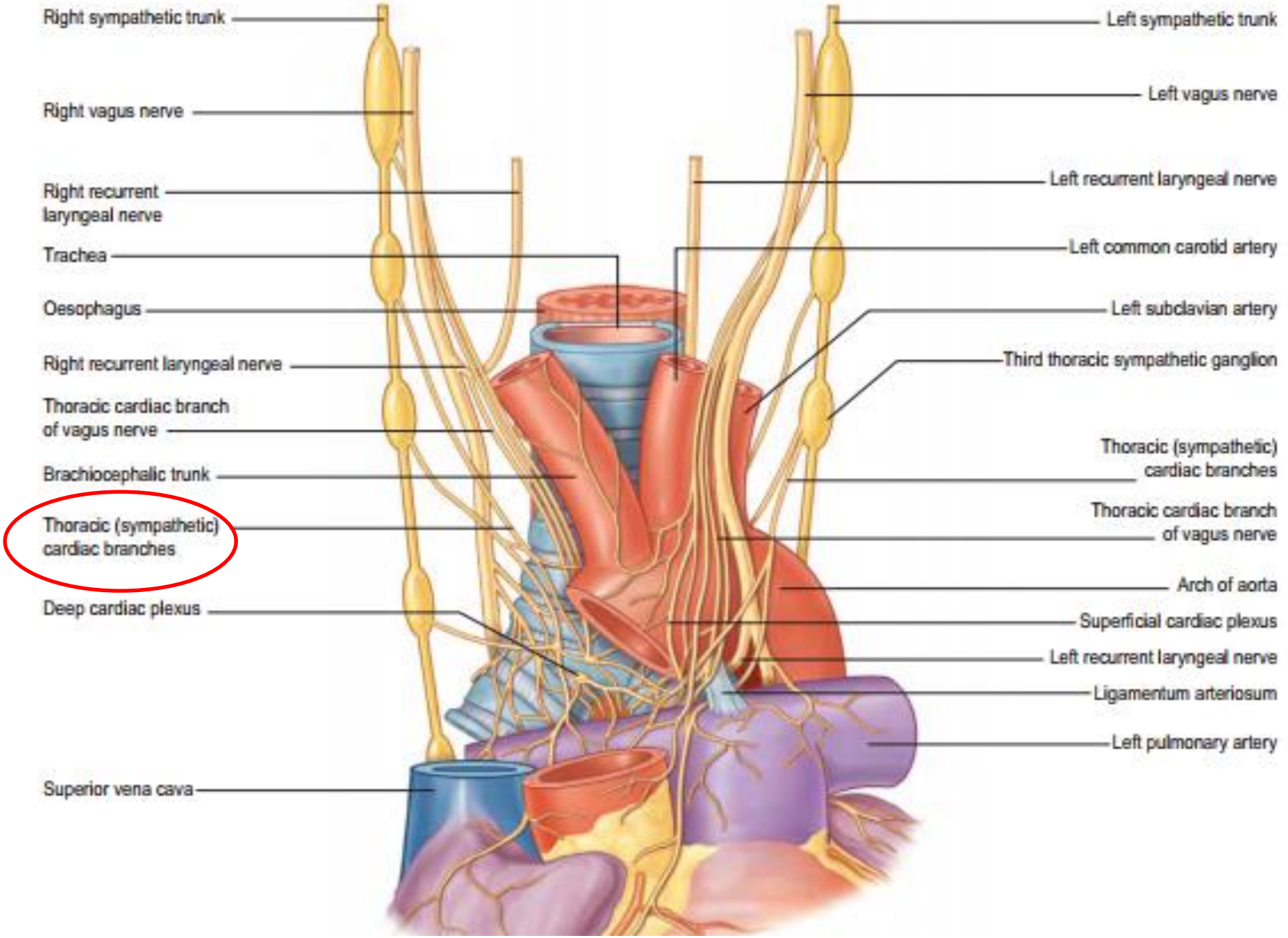


Presynaptic Fibers, with cell bodies in the intermediolateral cell columns (IMLs) of the superior five or six thoracic segments of the spinal cord They join the sympathetic trunk Where they synapse

The postsynaptic fibers traverse cardio pulmonary splanchnic nerves and the cardiac plexus to end **in the SA and AV nodes**

accelerates the heart rate

And constrict blood vessels in the body! What about the coronary arteries? would they also be constricted!!!???


Right sympathetic trunk
Right vagus nerve
Right recurrent laryngeal nerve
Trachea
Oesophagus
Right recurrent laryngeal nerve
Thoracic cardiac branch of vagus nerve
Brachiocephalic trunk
Thoracic (sympathetic) cardiac branches
Deep cardiac plexus
Superior vena cava
Left sympathetic trunk
Left vagus nerve
Left recurrent laryngeal nerve
Left common carotid artery
Left subclavian artery
Third thoracic sympathetic ganglion
Thoracic (sympathetic) cardiac branches
Thoracic cardiac branch of vagus nerve
Arch of aorta
Superficial cardiac plexus
Left recurrent laryngeal nerve
Ligamentum arteriosum
Left pulmonary artery

At the same time

Increased blood flow through the coronary vessels!!!!!!!!!

to support the **increased activity**

Most adrenergic receptors on coronary blood vessels **are β_2-receptors,** which, when activated, **cause relaxation** (or perhaps inhibition) of vascular smooth muscle and, therefore, dilation of the arteries (Wilson-Pauwels et al., 1997).
This supplies more oxygen and nutrients to the myocardium during periods of increased activity.

The parasympathetic supply

- is from presynaptic fibers of ***the vagus nerves***

- Postsynaptic parasympathetic cell bodies (intrinsic ganglia) are located in

  - The atrial wall
  - Interatrial septum near the SA and AV node
  - Along the coronary arteries

- Parasympathetic stimulation ***slows***
  - ***The heart rate***
  - ***reduces the force of the contraction***
  - ***constricts the coronary arteries***
- Postsynaptic parasympathetic fibers release

ACETYLCHOLINE

which binds with **muscarinic receptors** to slow the rates of depolarization of the pacemaker cells and atrioventricular conduction and decrease atrial contractility.

Cardiac Pain

The nature of the pain varies considerably, from a severe crushing pain to nothing more than a **mild discomfort**

Pain originating in the heart stimulate the sensory nerve endings in the myocardium.

The afferent nerve fibers ascend to the central nervous system through ***the cardiac branches of the sympathetic trunk*** and enter the spinal cord through the posterior roots of

the upper four thoracic nerves

Cardiac referred pain is **a phenomenon** whereby noxious stimuli originating in the heart are perceived by a person as pain arising from a superficial part of the body—the skin on the left upper limb

The pain is not felt in the heart,

but is referred to the skin areas supplied by the upper four thoracic nerves

The skin areas supplied by the upper four intercostal nerves and by the intercostobrachial nerve (T2) are therefore affected.

The intercostobrachial nerve communicates with the medial cutaneous nerve of the arm ***and is distributed to skin on the medial side of the upper part of the arm***

A certain amount of spread of nervous information must occur within the central nervous system, for the pain is sometimes ***felt in the neck and the jaw.***

????

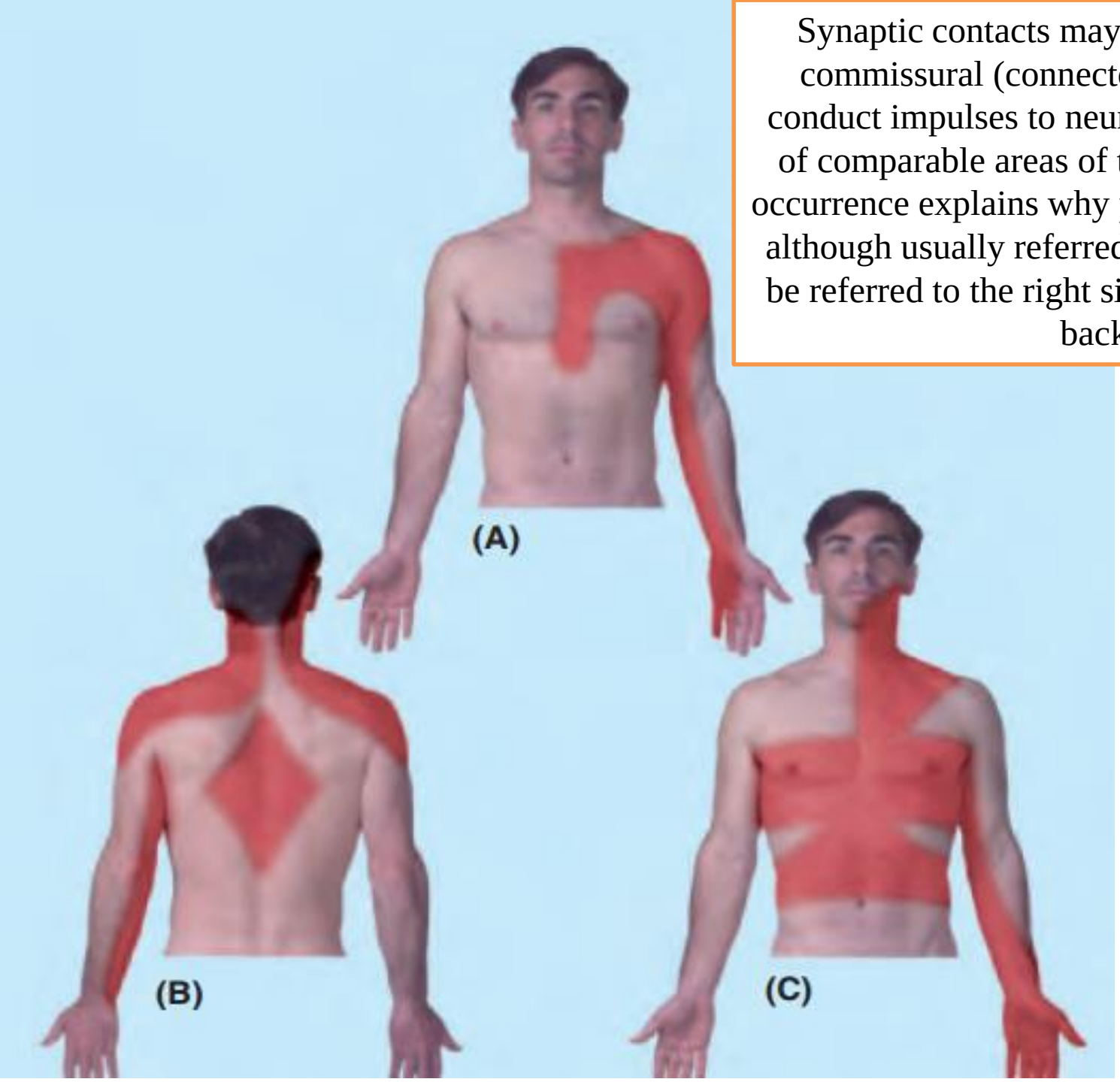
Myocardial infarction involving
the inferior wall or diaphragmatic surface of the heart often gives rise to discomfort

in the epigastrium.

One must assume that the afferent pain fibers from the heart ascend in the sympathetic nerves and enter the spinal cord in the posterior roots of
the ***seventh, eighth, and ninth thoracic spinal*** nerves
and give rise to referred pain in the **T7, T8, and T9** thoracic

dermatomes in the epigastrium

Synaptic contacts may also be made with commissural (connector) neurons, which conduct impulses to neurons on the right side of comparable areas of the spinal cord. This occurrence explains why pain of cardiac origin, although usually referred to the left side, may be referred to the right side, both sides, or the back

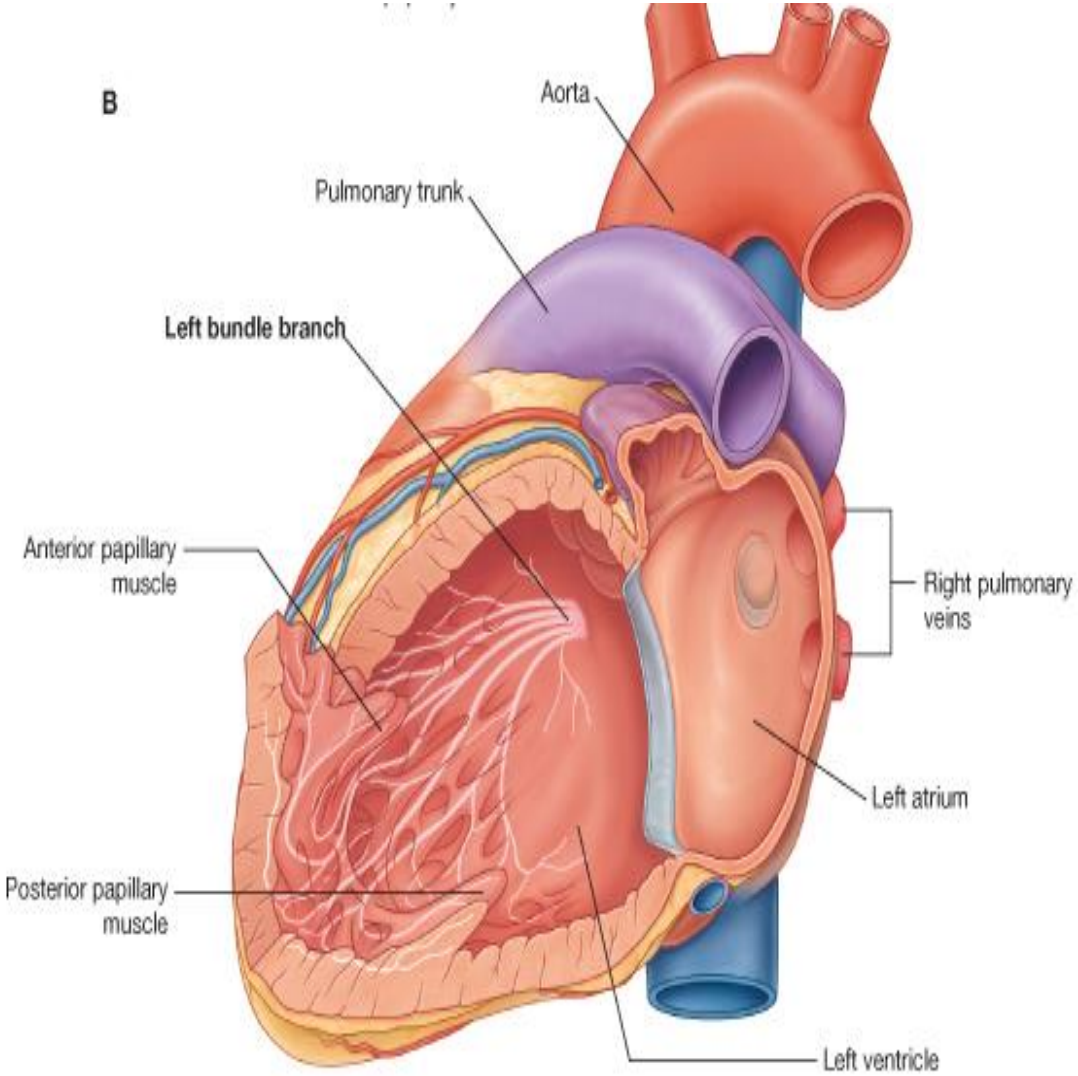


THE CONDUCTING SYSTEM OF THE HEART

THE CONDUCTING SYSTEM OF THE HEART

consists of specialized cardiac muscle present in

- **THE SINUATRIAL NODE**
- **THE ATRIOVENTRICULAR NODE**
- **THE ATRIOVENTRICULAR BUNDLE**
- **RIGHT AND LEFT TERMINAL BRANCHES**
- **THE SUBENDOCARDIAL PLEXUS OF PURKINJE FIBERS**

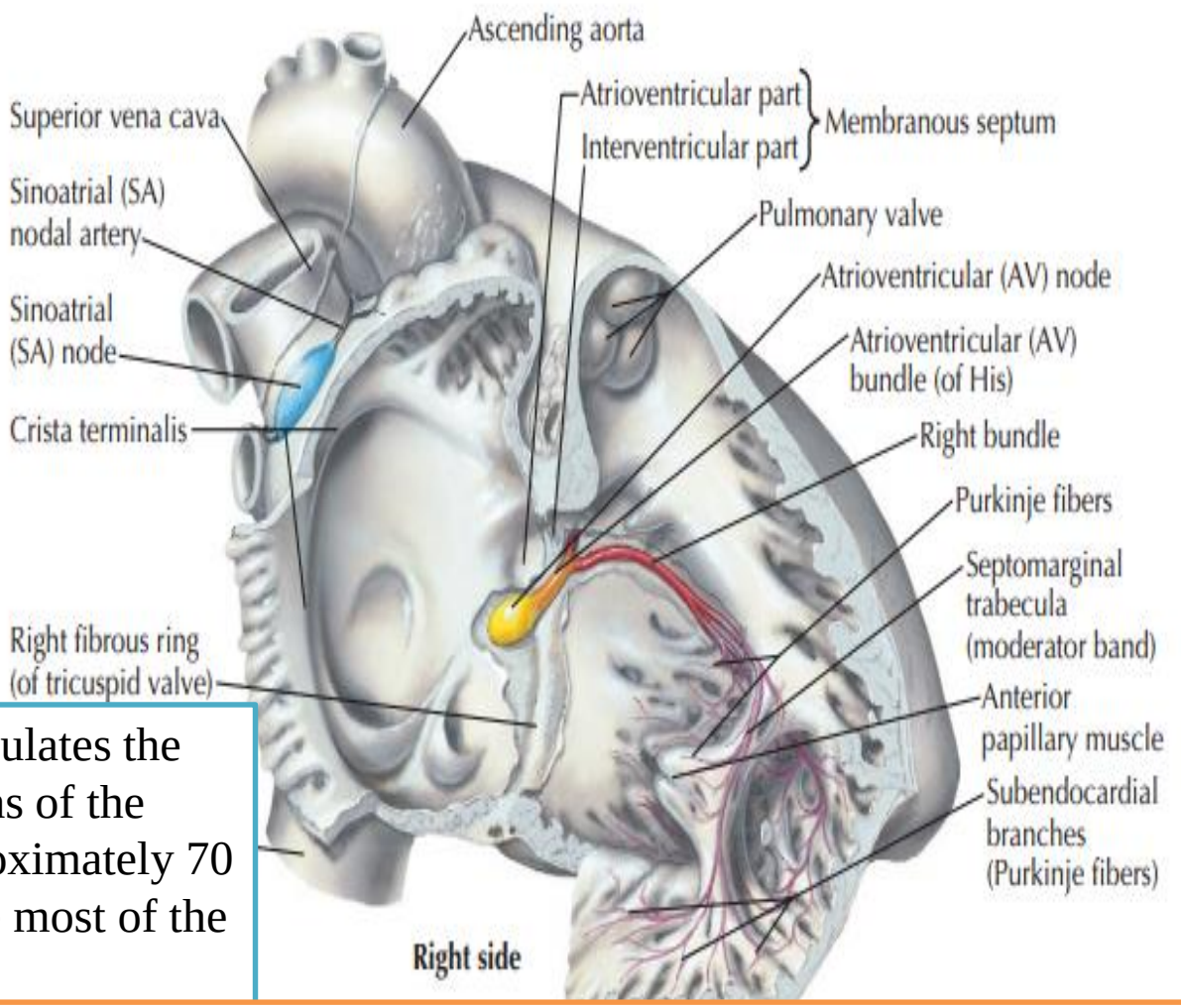


The sinu-atrial (SA) node

- is located anterolaterally just deep to the epicardium at the junction of the SVC and right atrium, near the superior end of the sulcus terminalis

- The SA node—a small collection of nodal tissue, specialized cardiac muscle fibers, and associated fibroelastic connective tissue—is the pacemaker of the heart

- The SA node initiates and regulates the impulses for the contractions of the heartgiving off an impulse approximately 70 times per minute in most people most of the time

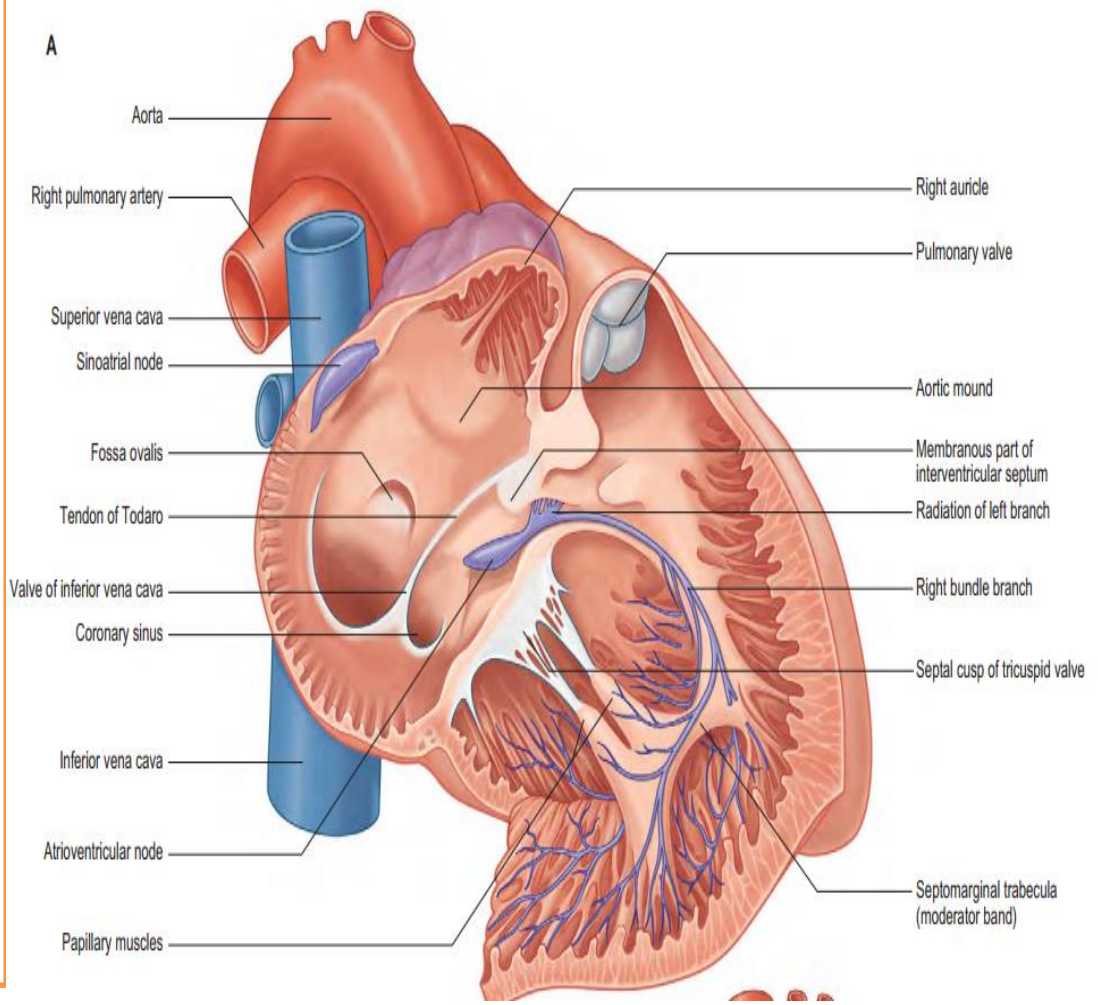


The contraction signal from the SA node spreads myogenically (through the musculature) of both atria

- The SA node is stimulated by the sympathetic division of the autonomic nervous system to accelerate the heart rate and is inhibited by the parasympathetic division to return to or approach its basal rate.

The atrioventricular (AV) node

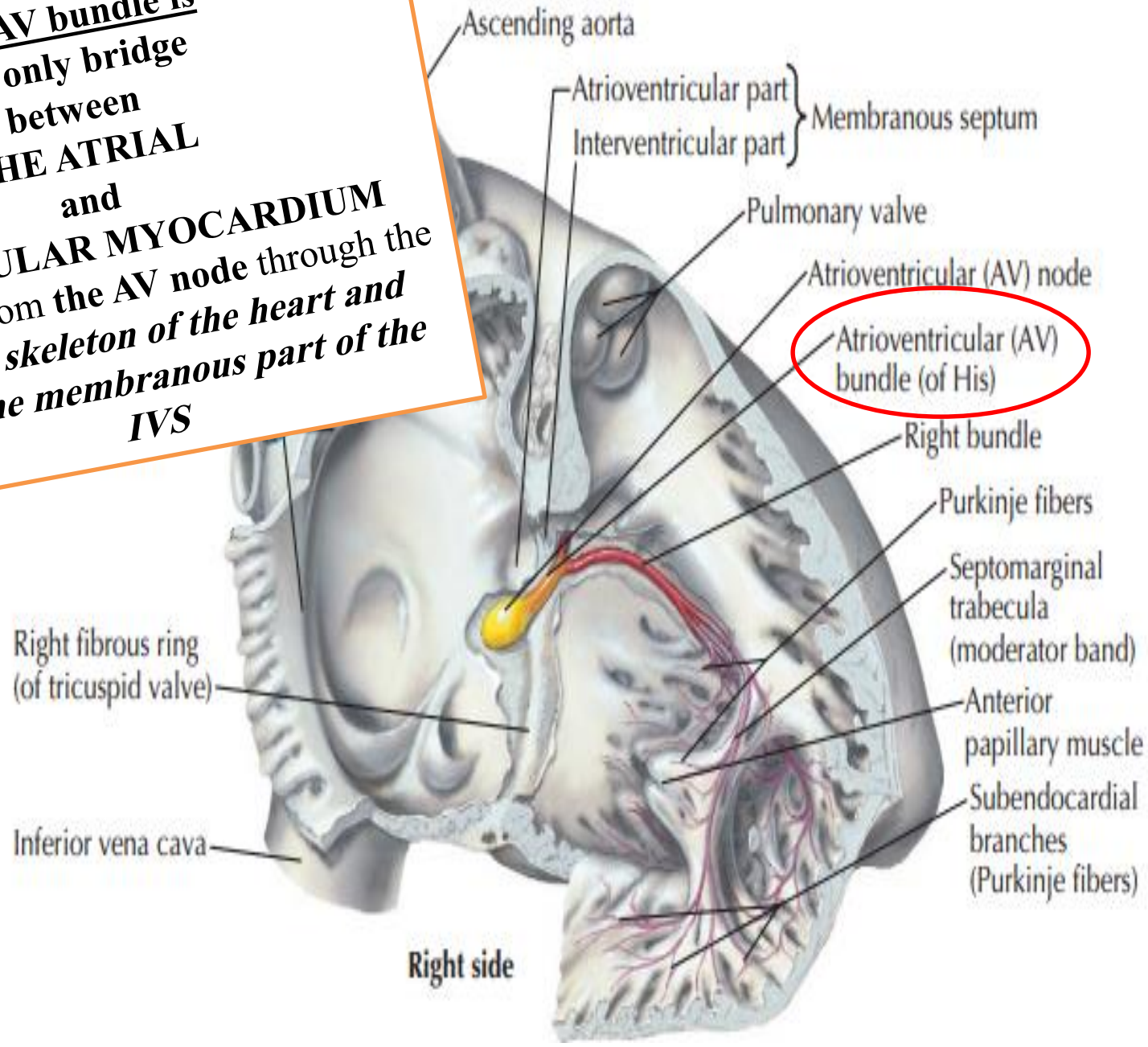
- is a smaller collection of nodal tissue than the SA node.
- The AV node is located in the **posteroinferior** region of the **interatrial septum near the opening of the coronary sinus**
- Its anatomical landmarks are the boundaries of the **triangle of Koch**
- The signal generated by the SA node passes through the walls of the right atrium, propagated by the cardiac muscle (**myogenic conduction**), which transmits the signal rapidly from the SA node to the AV node.
- The AV node then distributes the signal to the ventricles through the **AV bundle (of His)**

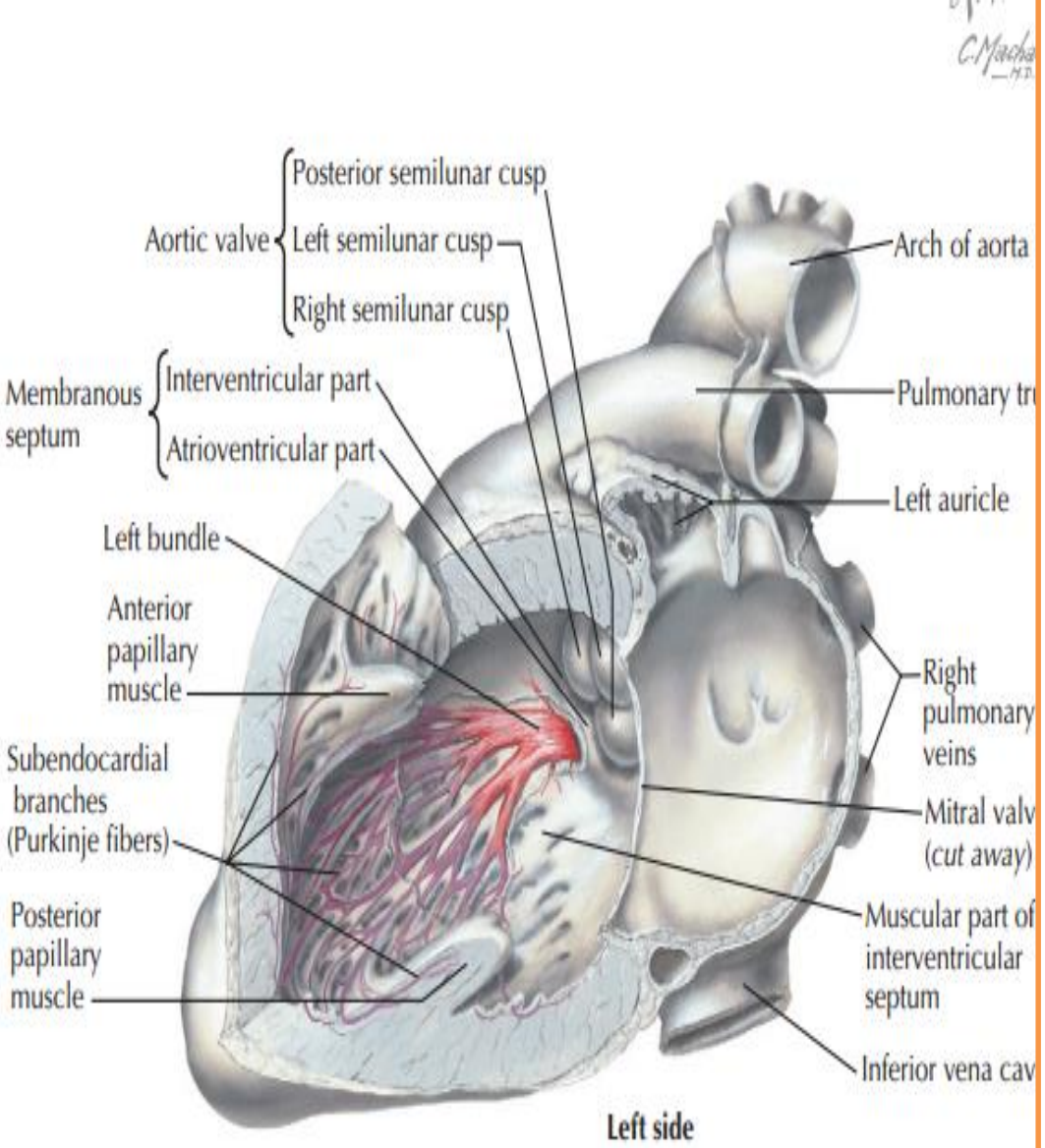


- Sympathetic stimulation speeds up conduction, and parasympathetic stimulation slows it down.

<u>The AV bundle is</u>
the only bridge
between
THE ATRIAL
and
VENTRICULAR MYOCARDIUM

- It passes from **the AV node** through the ***fibrous skeleton of the heart and along the membranous part of the IVS***

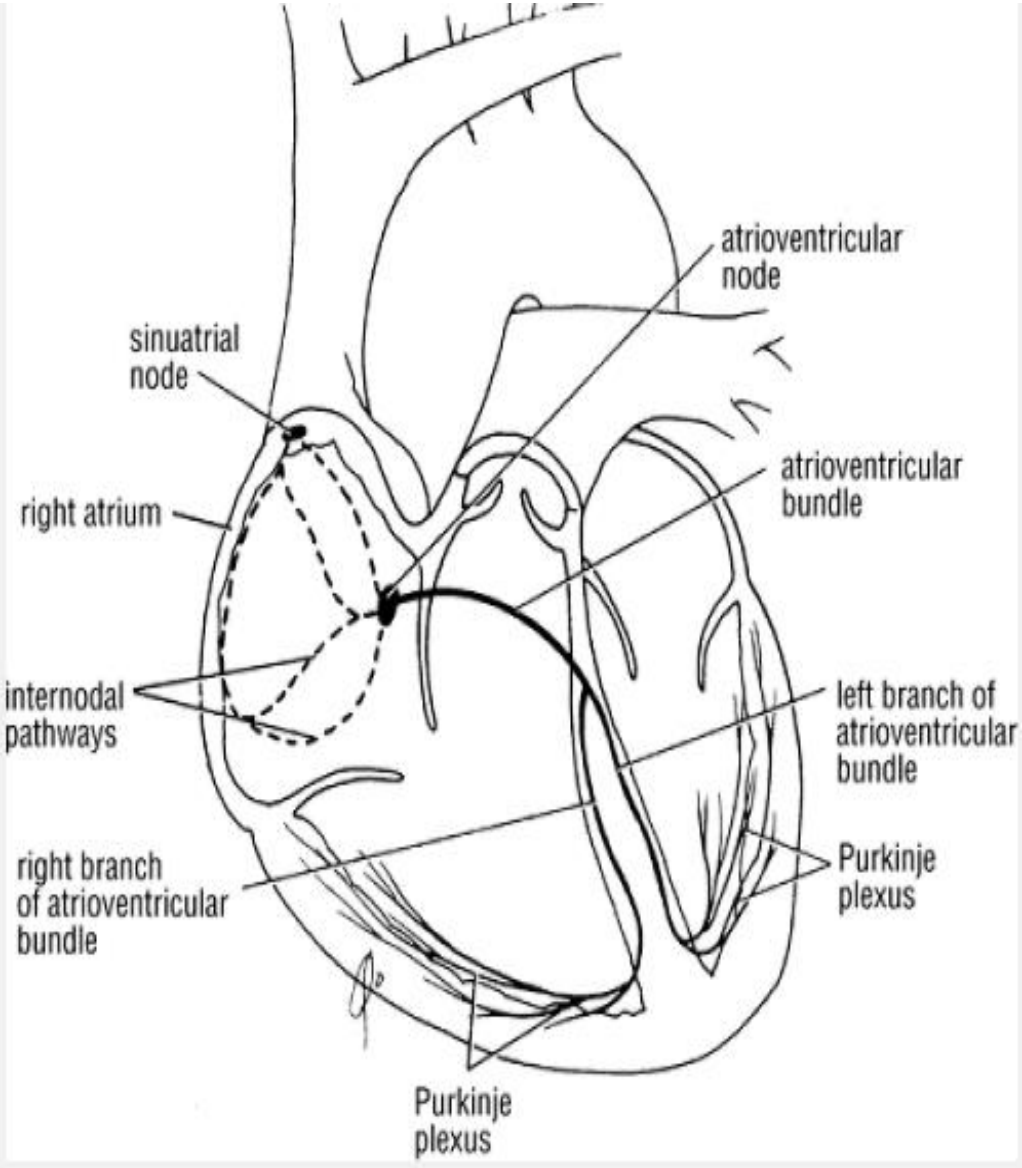


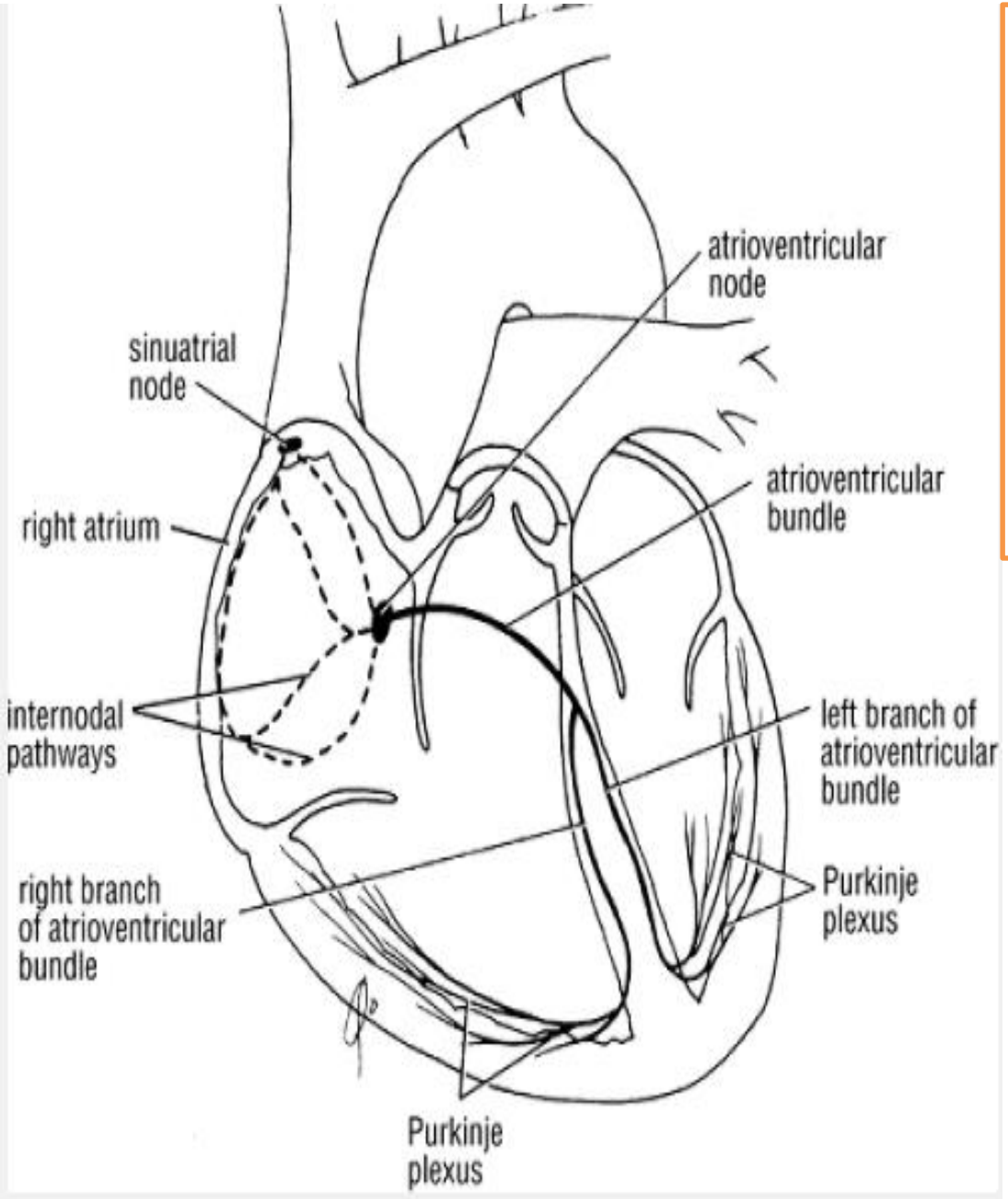


- At the junction of the **membranous and muscular parts** of the IVS, the AV bundle divides **<u>into right and left bundles</u>**
- These branches proceed on each side of the muscular IVS deep to the endocardium and then ramify into subendocardial branches **(Purkinje fibers)**
- which extend into the walls of the respective ventricles.
- The subendocardial branches **of the right bundle** stimulate the muscle of the IVS, the anterior papillary muscle through ***the septomarginal trabecula (moderator band),*** and the wall of the right ventricle.
- **The left bundle** divides near its origin into approximately six smaller tracts, which give rise to subendocardial branches that stimulate the IVS, the anterior and posterior papillary muscles, and the wall of the left ventricle.

With a VSD, the AV bundle usually **lies in the margin of the VSD. Obviously, this vital part of the conducting system must be preserved during surgical repair of the defect.**

Destruction of the AV bundle would cut the only physiological link between the atrial and ventricular musculature, also producing a heart block as described above.





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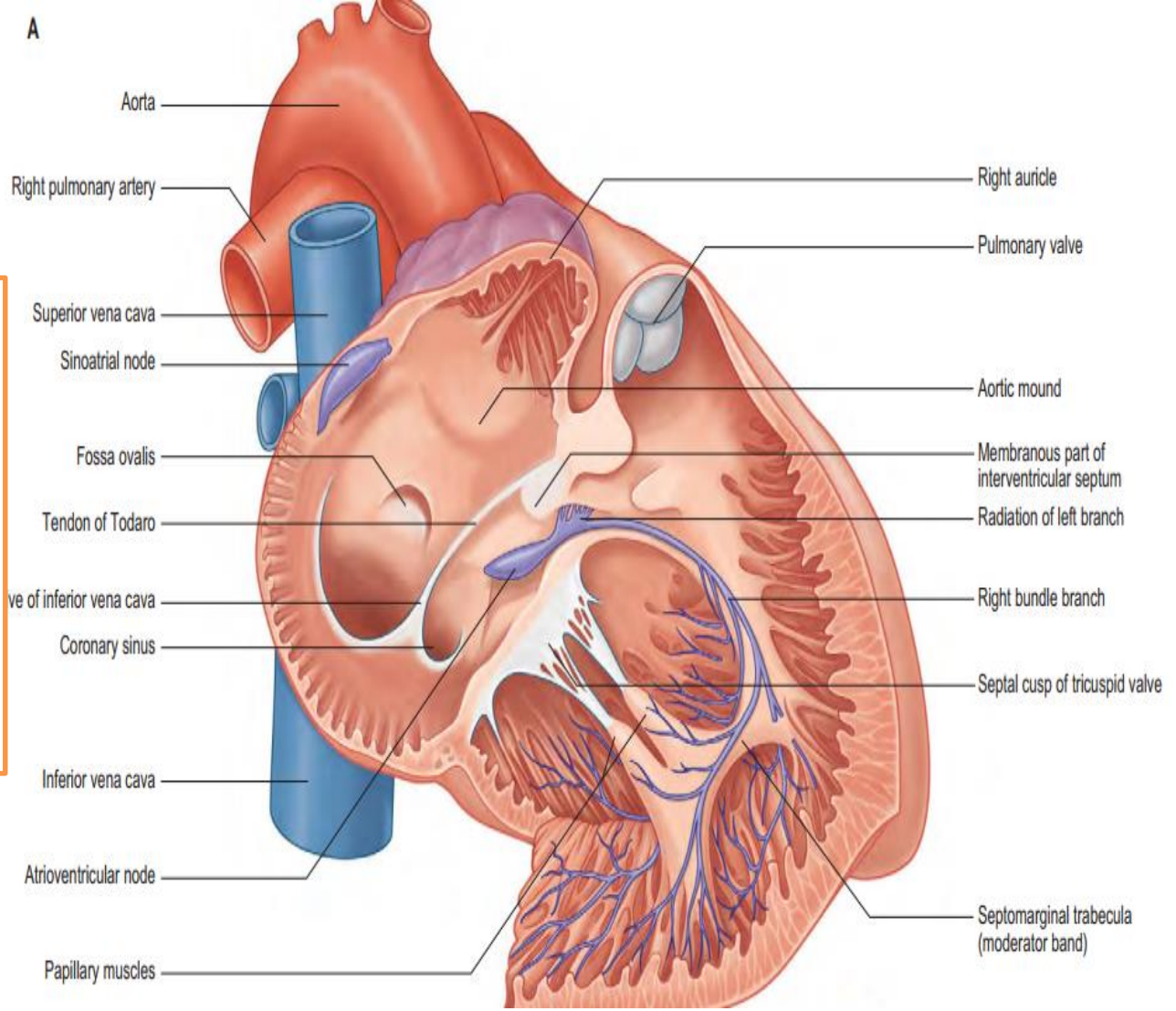
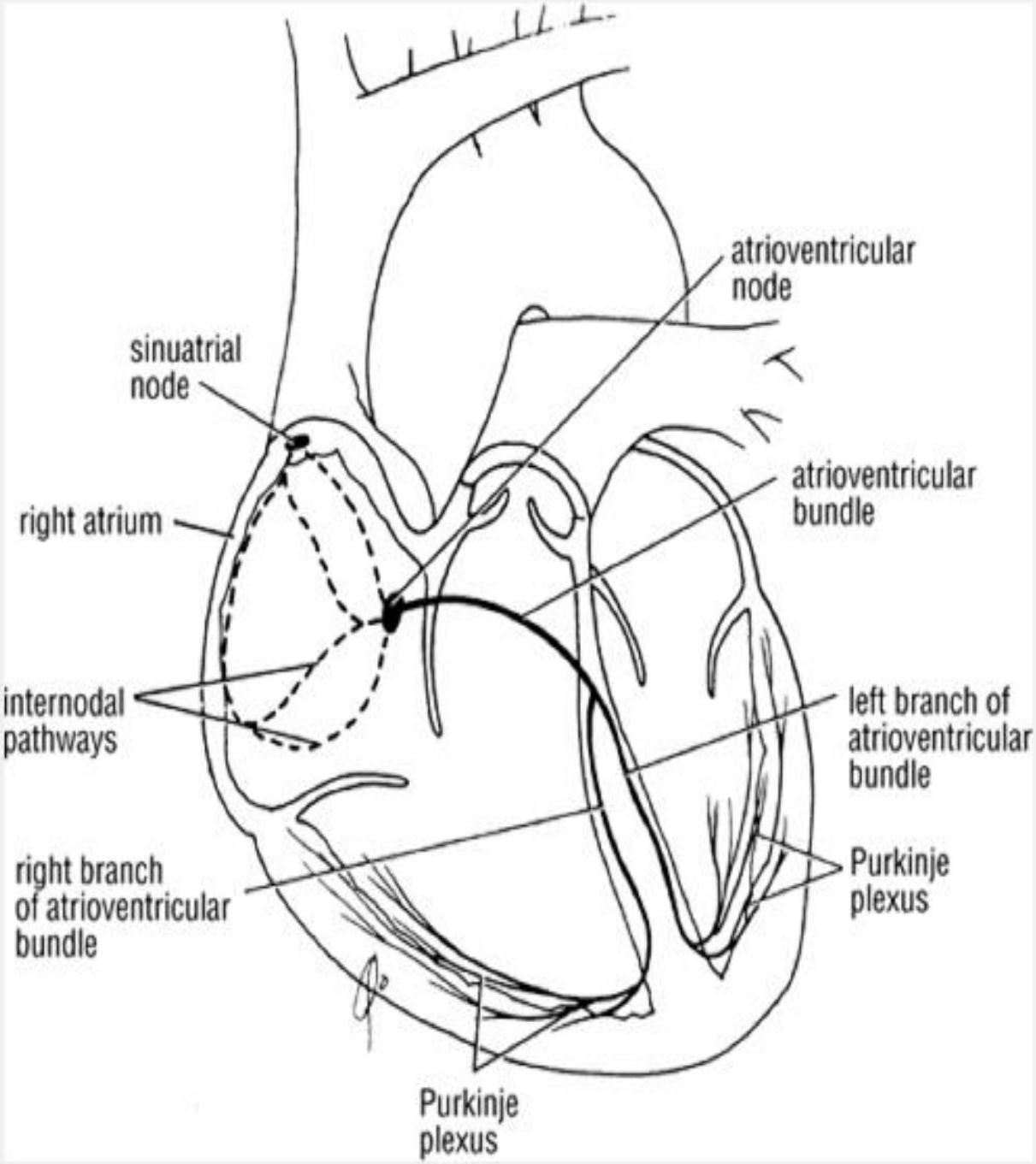


Internodal Conduction Paths

Impulses from the sinuatrial node have been shown to travel to the atrioventricular node more rapidly than they can travel by passing along **the ordinary myocardium.**

This phenomenon has been explained by the description of special pathways in the atrial wall which have a ***structure consisting of a mixture of Purkinje fibers and ordinary cardiac muscle cells.***



A-The anterior internodal pathway:
leaves ***the anterior end*** of the ***SA node*** and passes ***anterior to the superior vena caval opening***. It descends on the atrial septum and ends in the ***AV node.***

B- The middle internodal pathway
leaves ***the posterior end*** of the ***SA node*** and passes ***posterior to the superior vena caval opening***. It descends on the atrial septum to the ***AV node.***

C-The posterior internodal pathway:
leaves the ***posterior part*** of the ***SA node*** and descends through the **crista terminalis** and ***the valve of the inferior vena cava*** to the ***AV node***

Electrical System of the Heart