

The Heart 4

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

BLOOD SUPPLY OF THE HEART

from two coronary arteries.

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*

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**

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

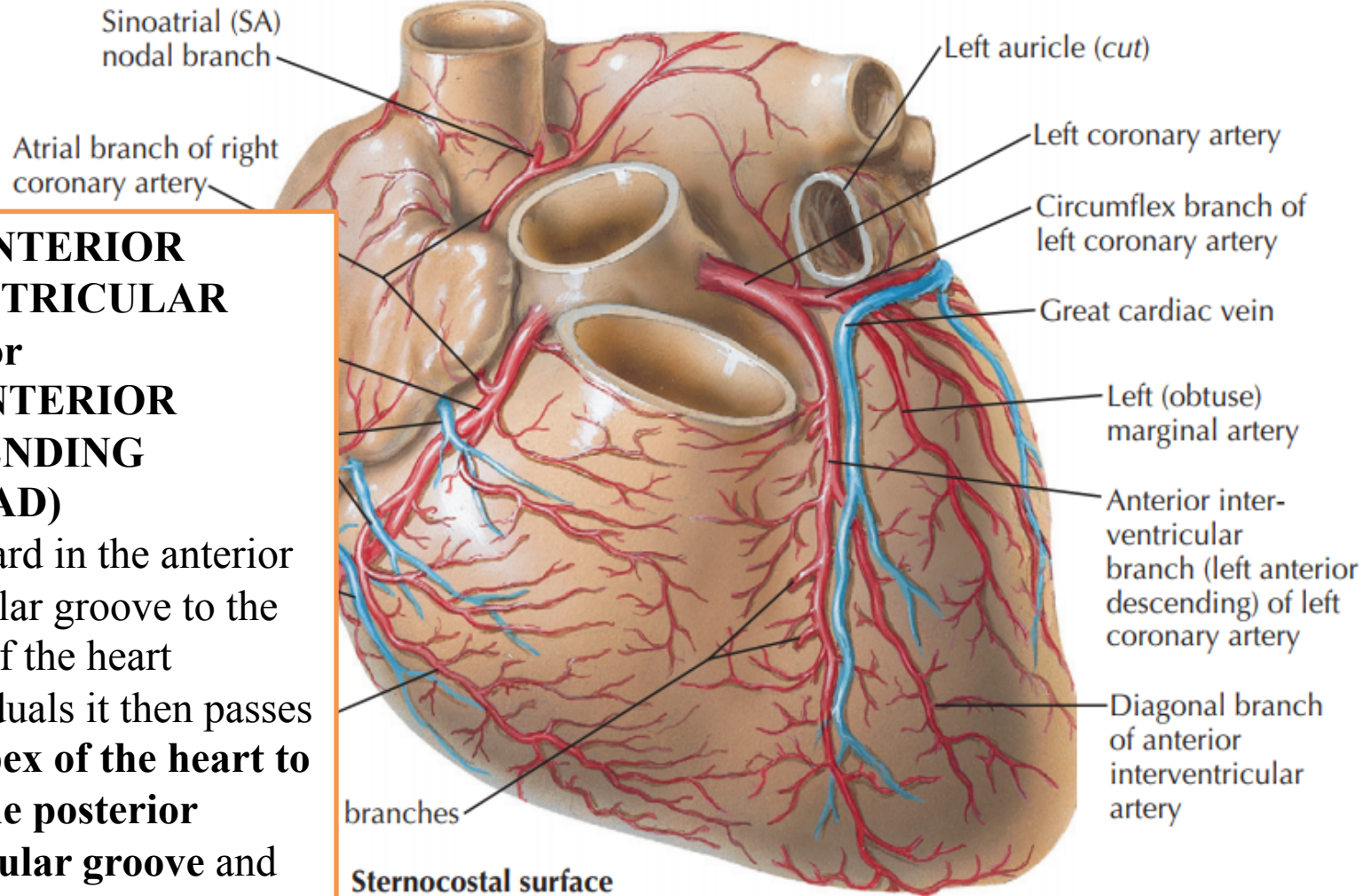
left diagonal artery, may arise directly from the trunk of the left coronary artery

The LCA usually has a short (0.5-2 cm) common stem that

travels a short course between the left auricle and ventricle, and divides into 2 branches: **anterior interventricular or left anterior descending (LAD) artery** and **circumflex artery**.

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

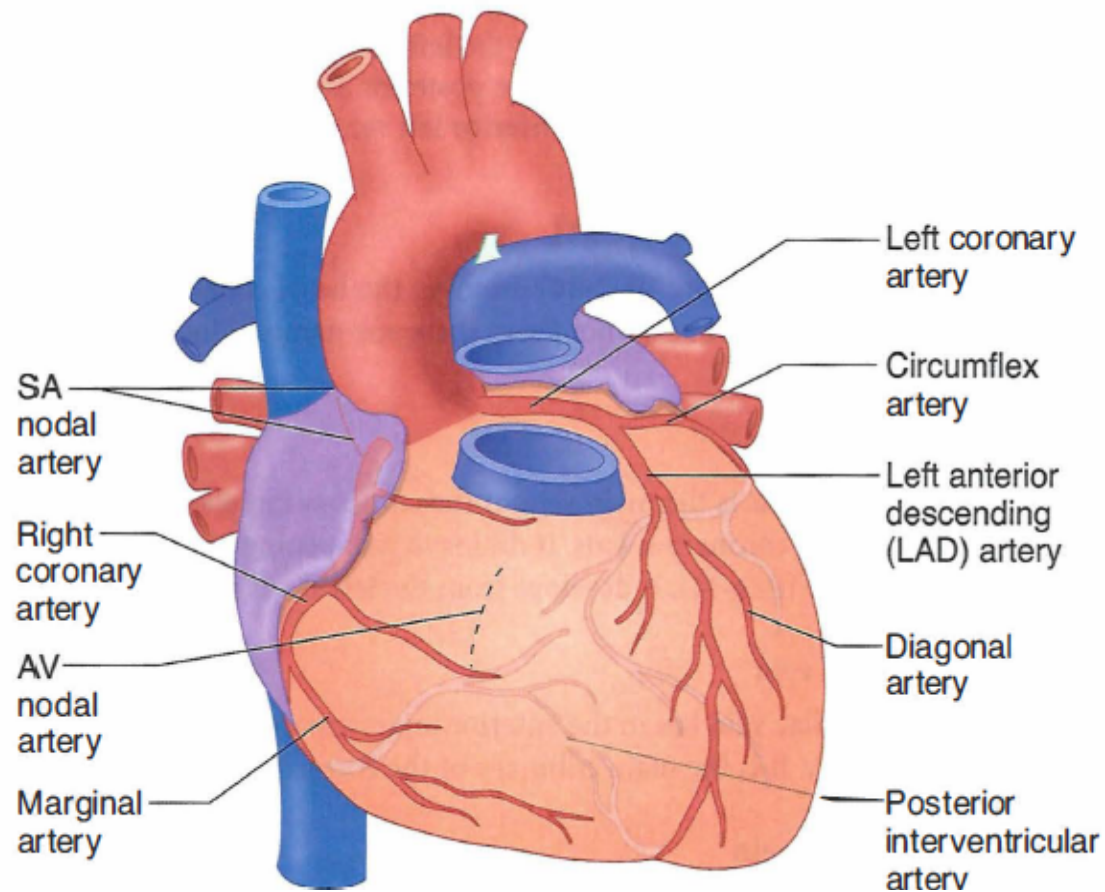
- Runs downward in the anterior interventricular groove to the apex of the heart
- In most individuals it then passes **around the apex of the heart to enter the posterior interventricular groove and anastomoses with the terminal branches of the right coronary artery.**
- **In one third** of individuals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

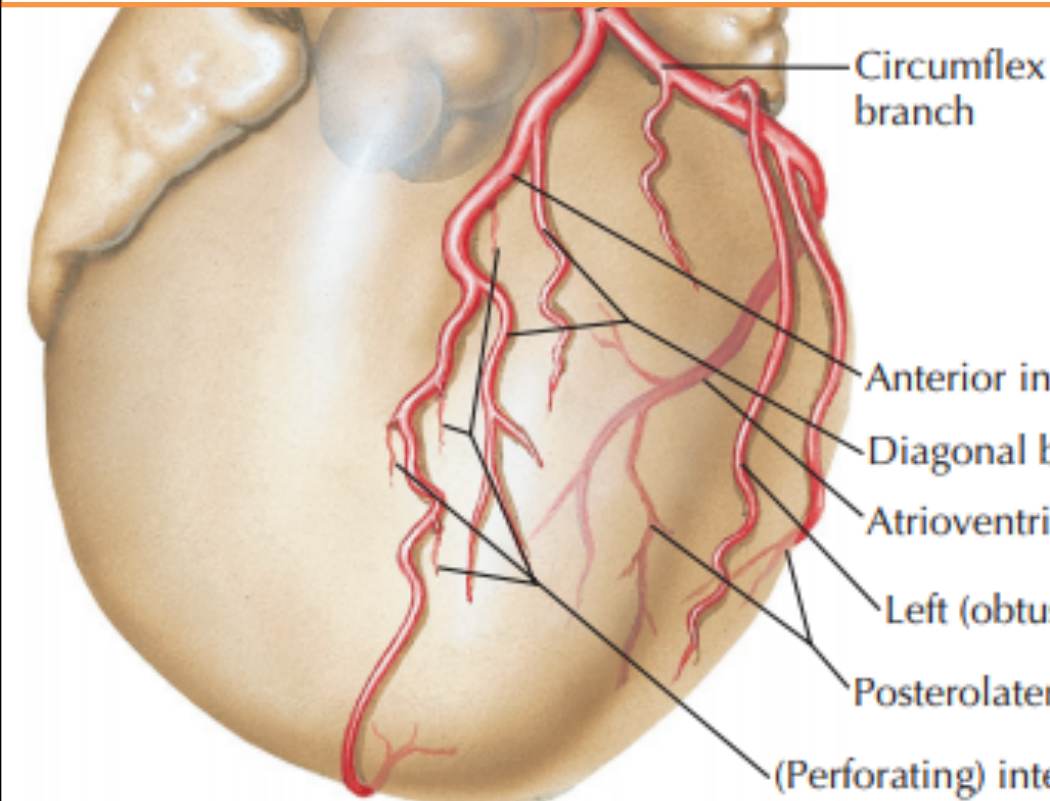
- is the same size as the anteriorinterventricular artery
- It winds around the left margin of the heart in the *atrioventricular groove*.
- **A left marginal artery** is a large branch that supplies the left margin of the left ventricle down to the apex.
- **Anterior ventricular and posterior ventricular**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

RADIOGRAPHIC VIEWS

Coronary artery: left anterior oblique view



Left coronary angiogram



Circumflex branch

Anterior interventricular branch (left anterior descending)

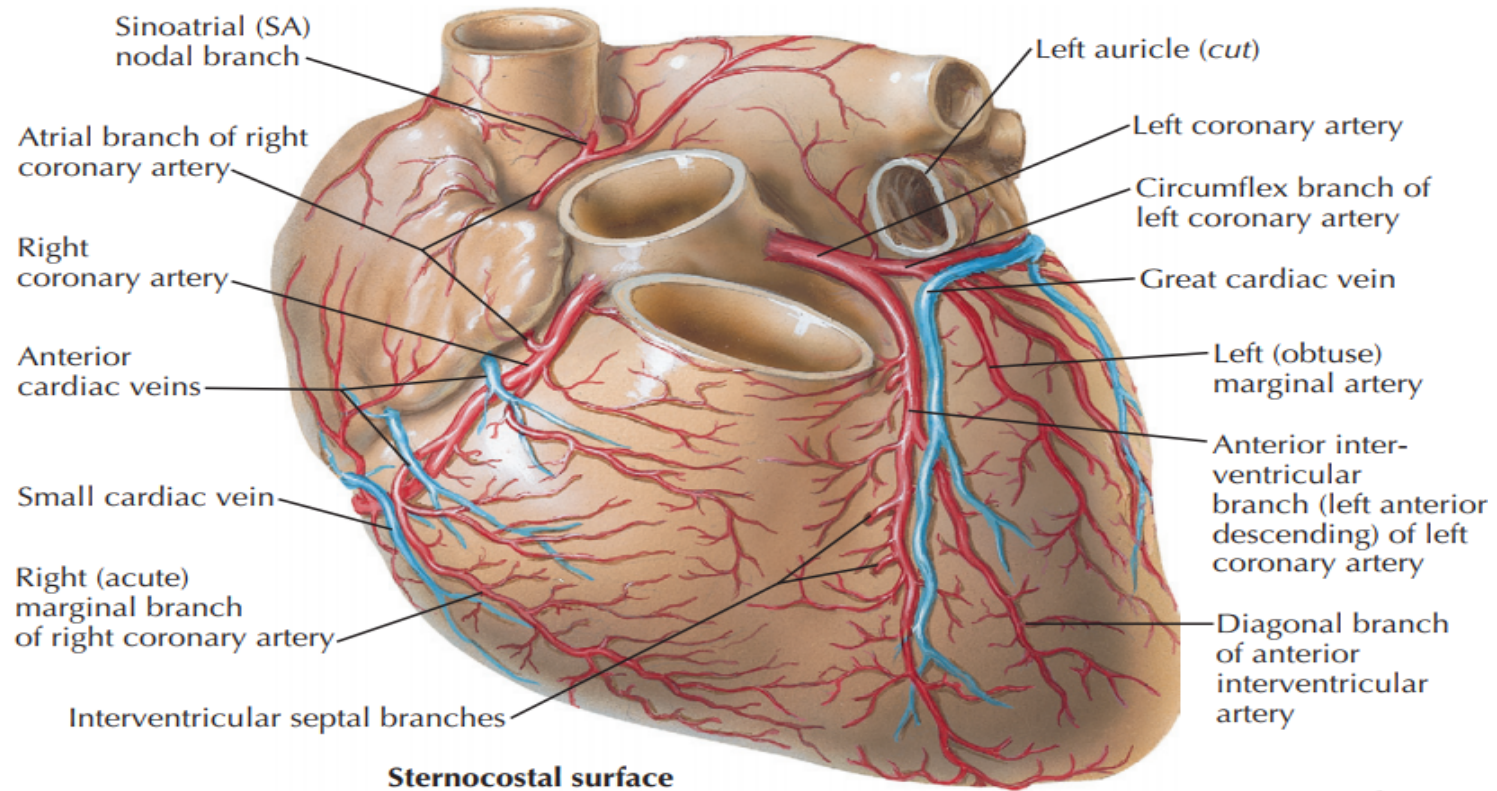
Diagonal branches of anterior interventricular branch

Atrioventricular branch of circumflex branch

Left (obtuse) marginal branch

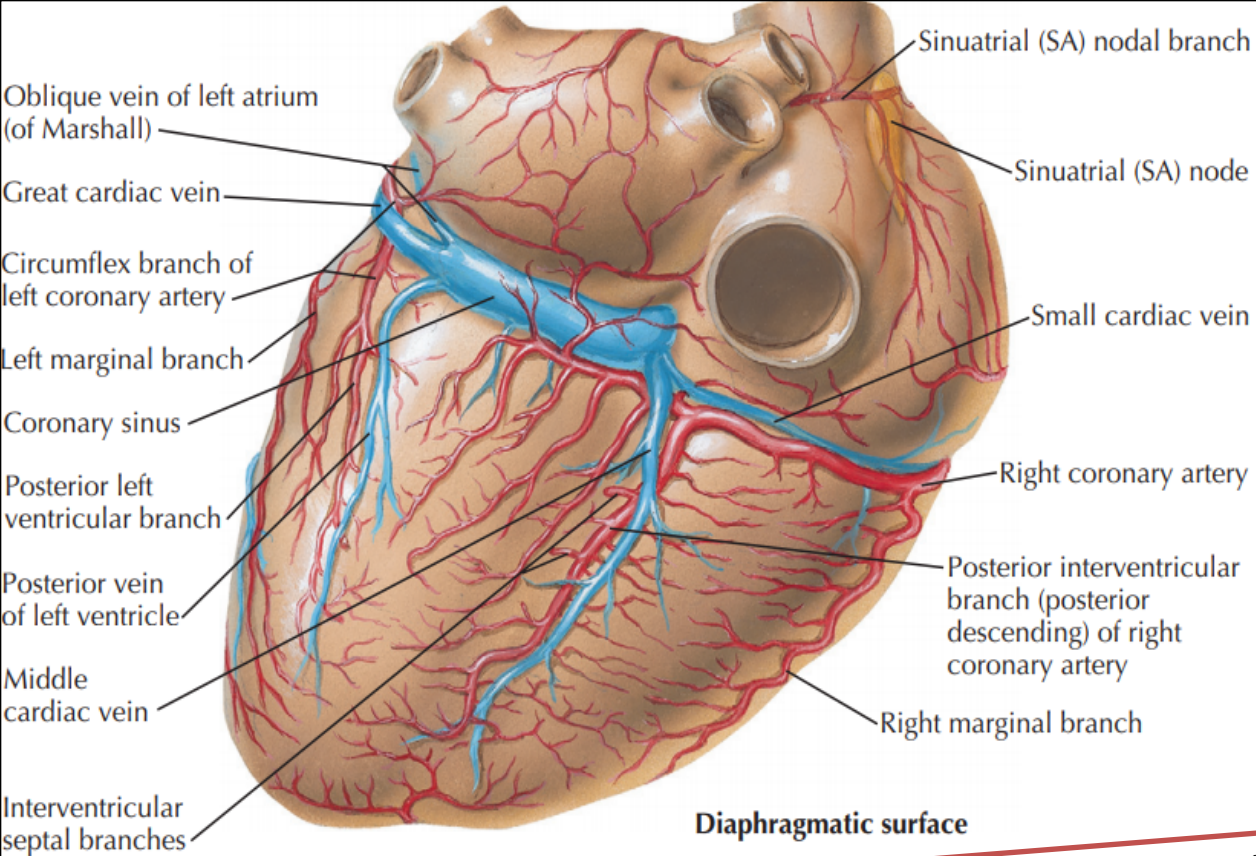
Posterolateral branches

(Perforating) interventricular septal branches



L. Netter M.D.

The **circumflex artery** courses around the left border of the heart in the coronary sulcus and supplies (1) the **left border of the heart** via the **marginal branch** and (2) ends on the posterior aspect of the left ventricle and supplies the **posterior-inferior** left ventricular wall.



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.

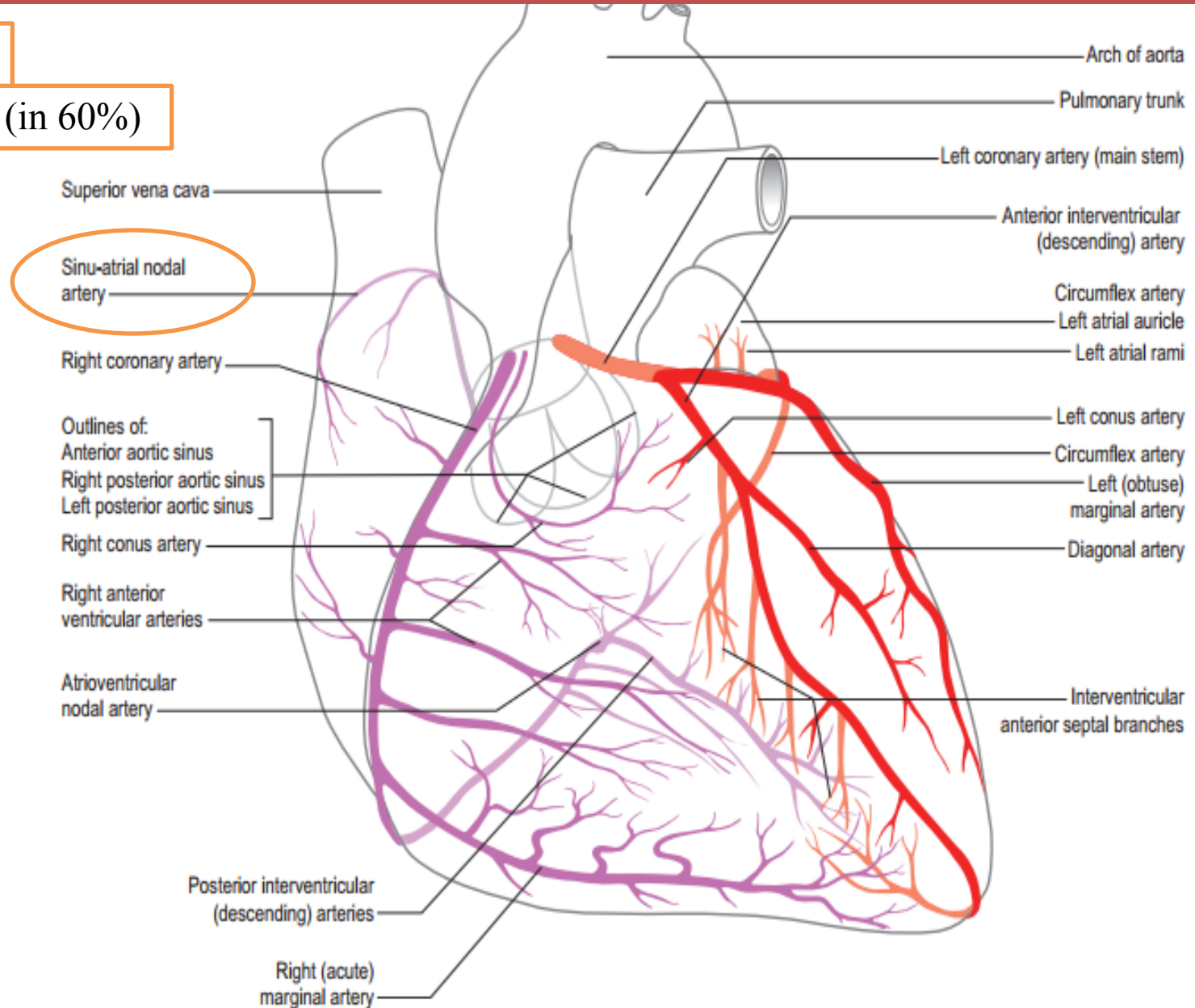
The LBB also receives small branches.

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

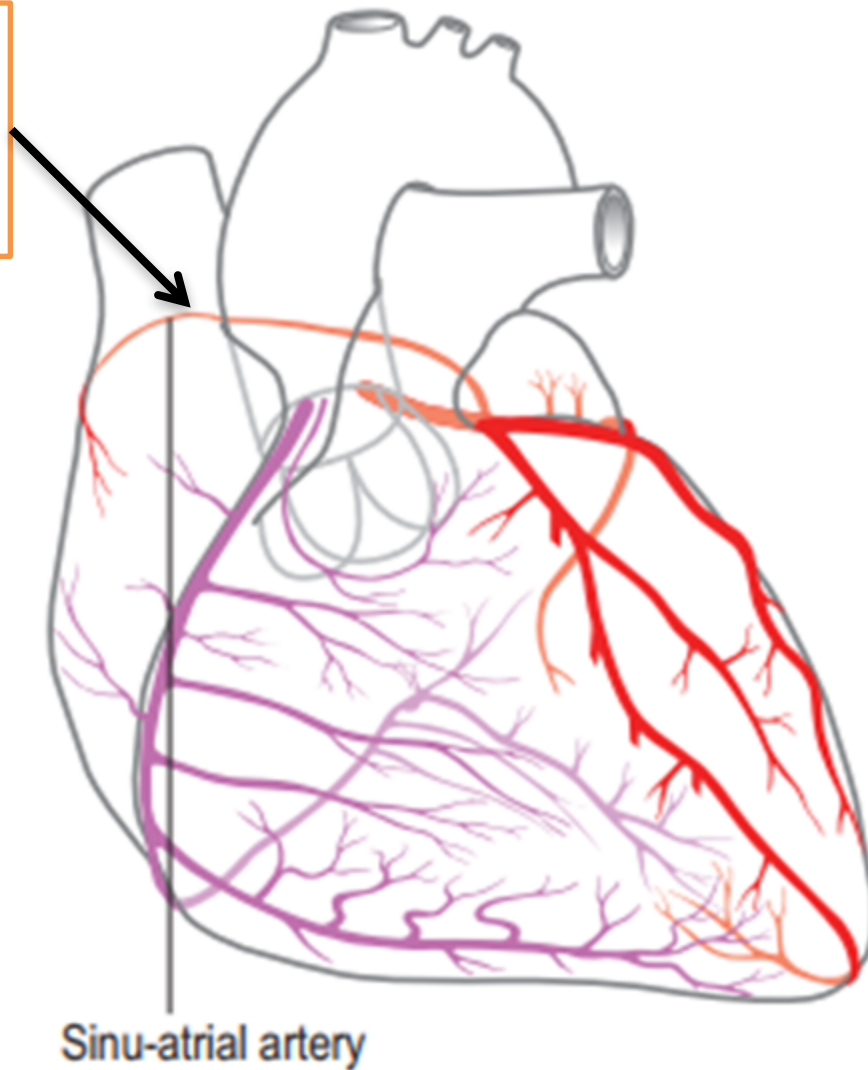
RCA near its origin (in 60%)



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

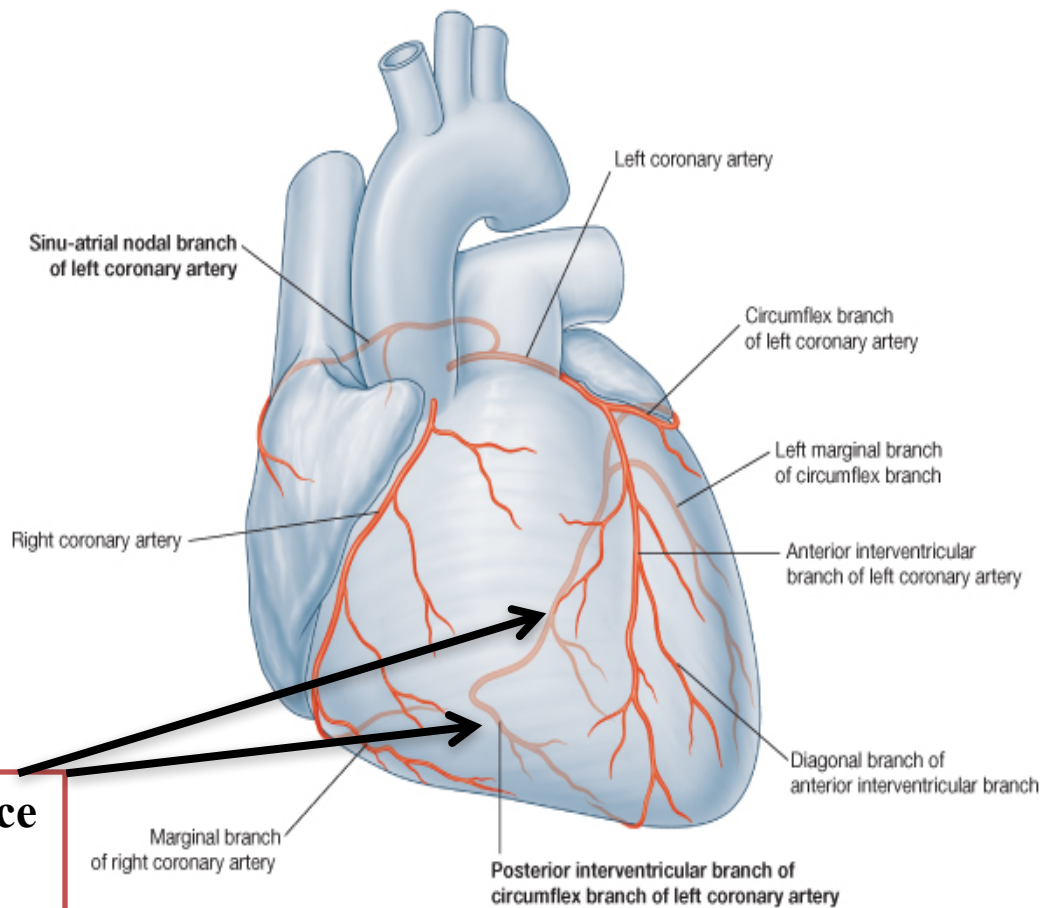
Variations in the Coronary Arteries

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%).



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

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

Read only

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**

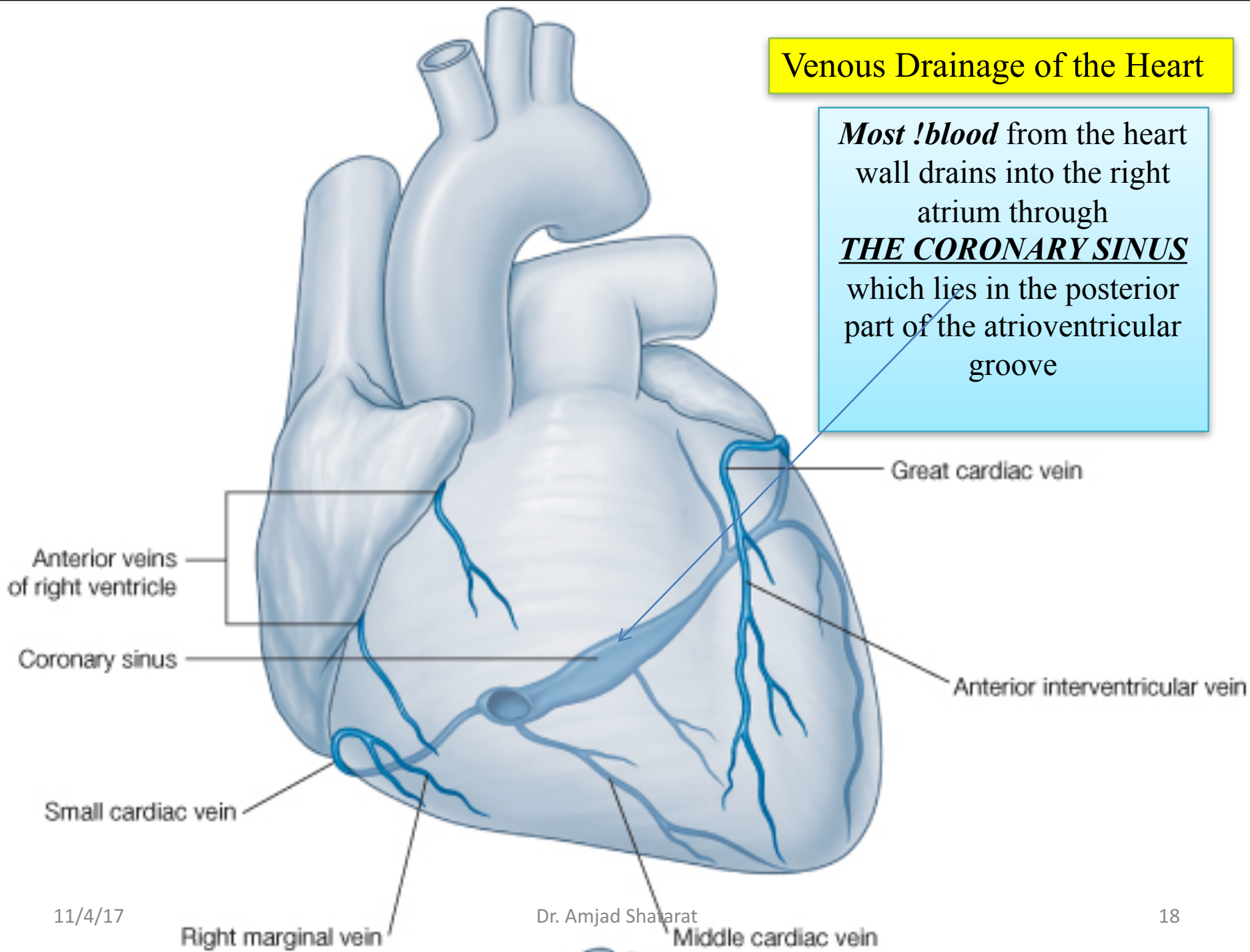
The middle cardiac vein lies in the posterior interventricular sulcus with the posterior interventricular artery. It joins the coronary sinus.

- **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.

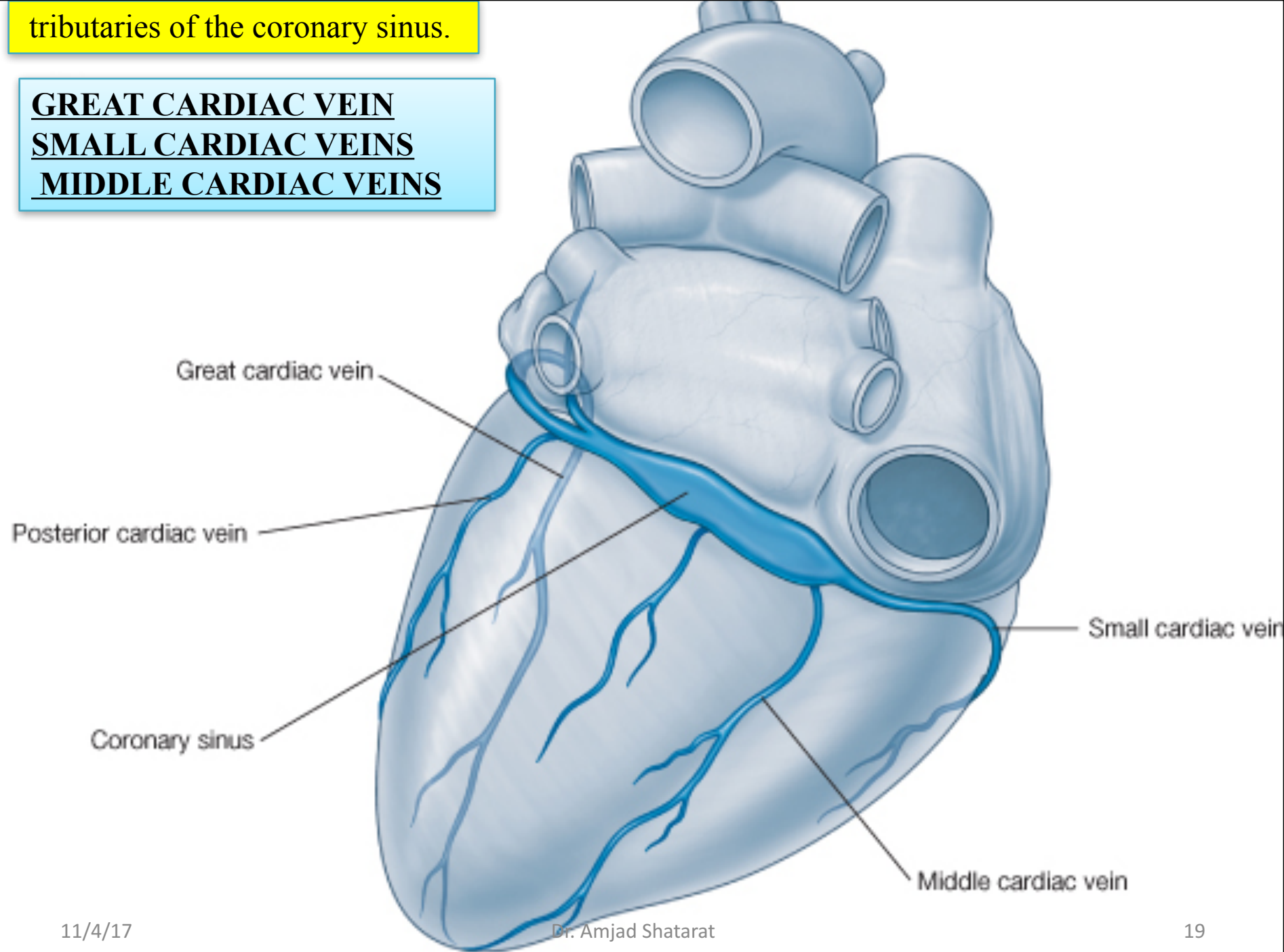
Venous Drainage of the Heart

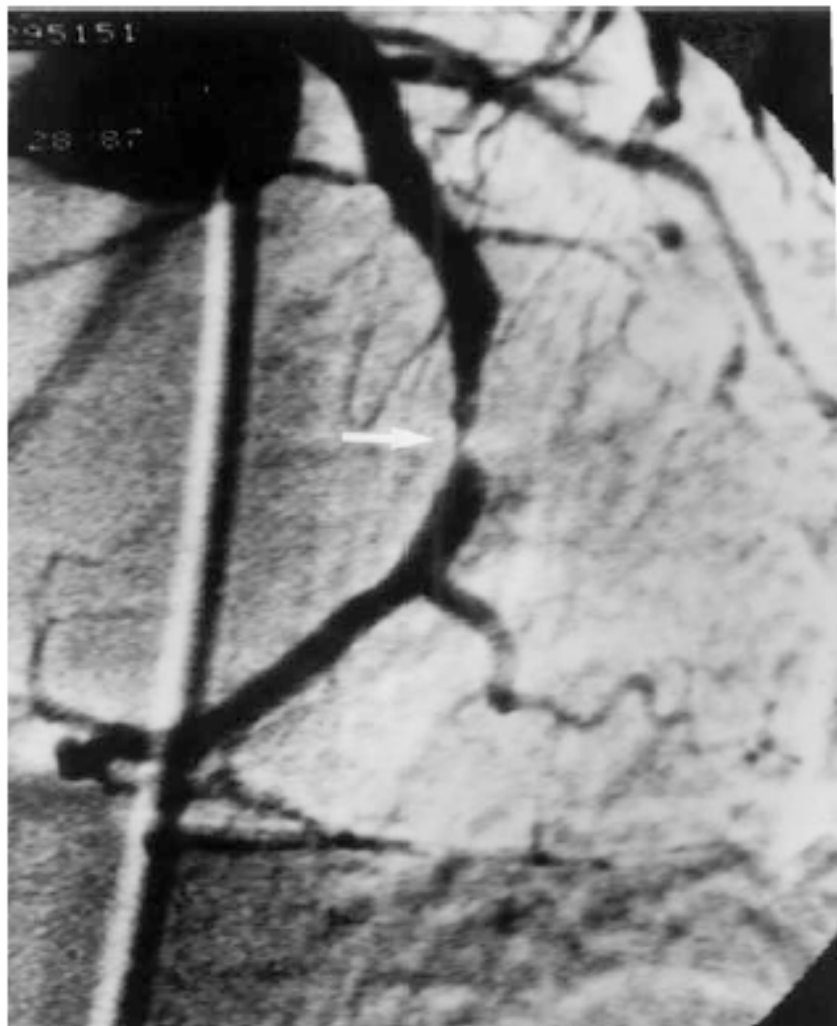
Most !blood from the heart wall drains into the right atrium through **THE CORONARY SINUS** which lies in the posterior part of the atrioventricular groove



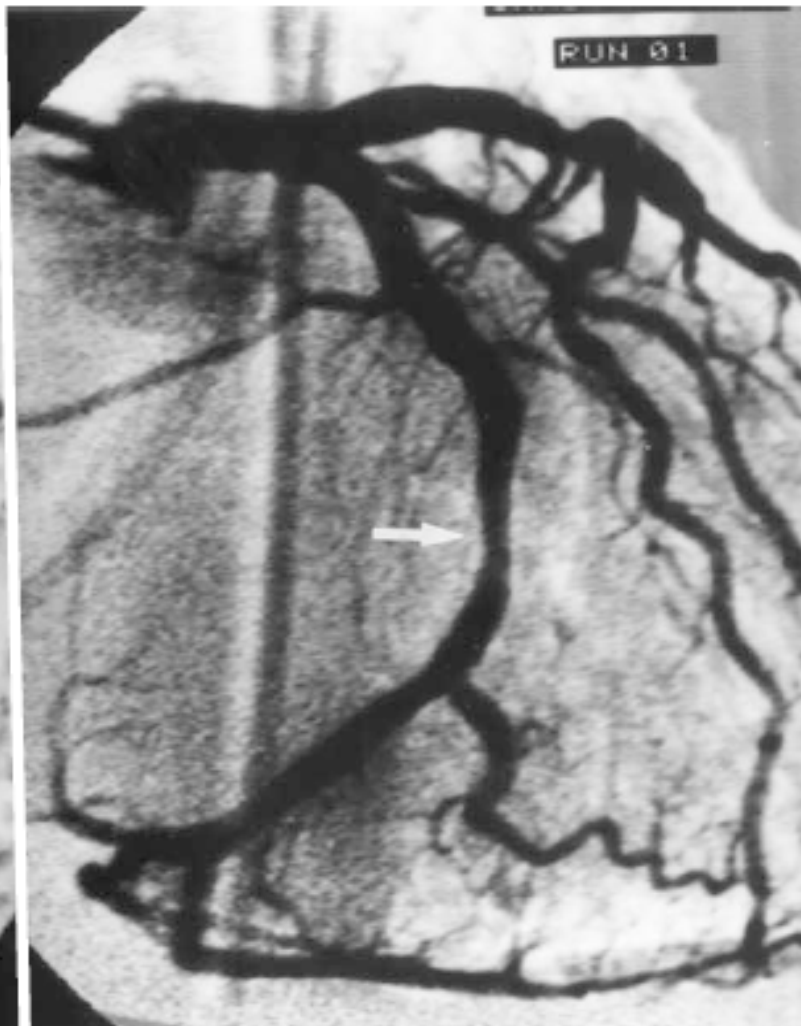
tributaries of the coronary sinus.

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).

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

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

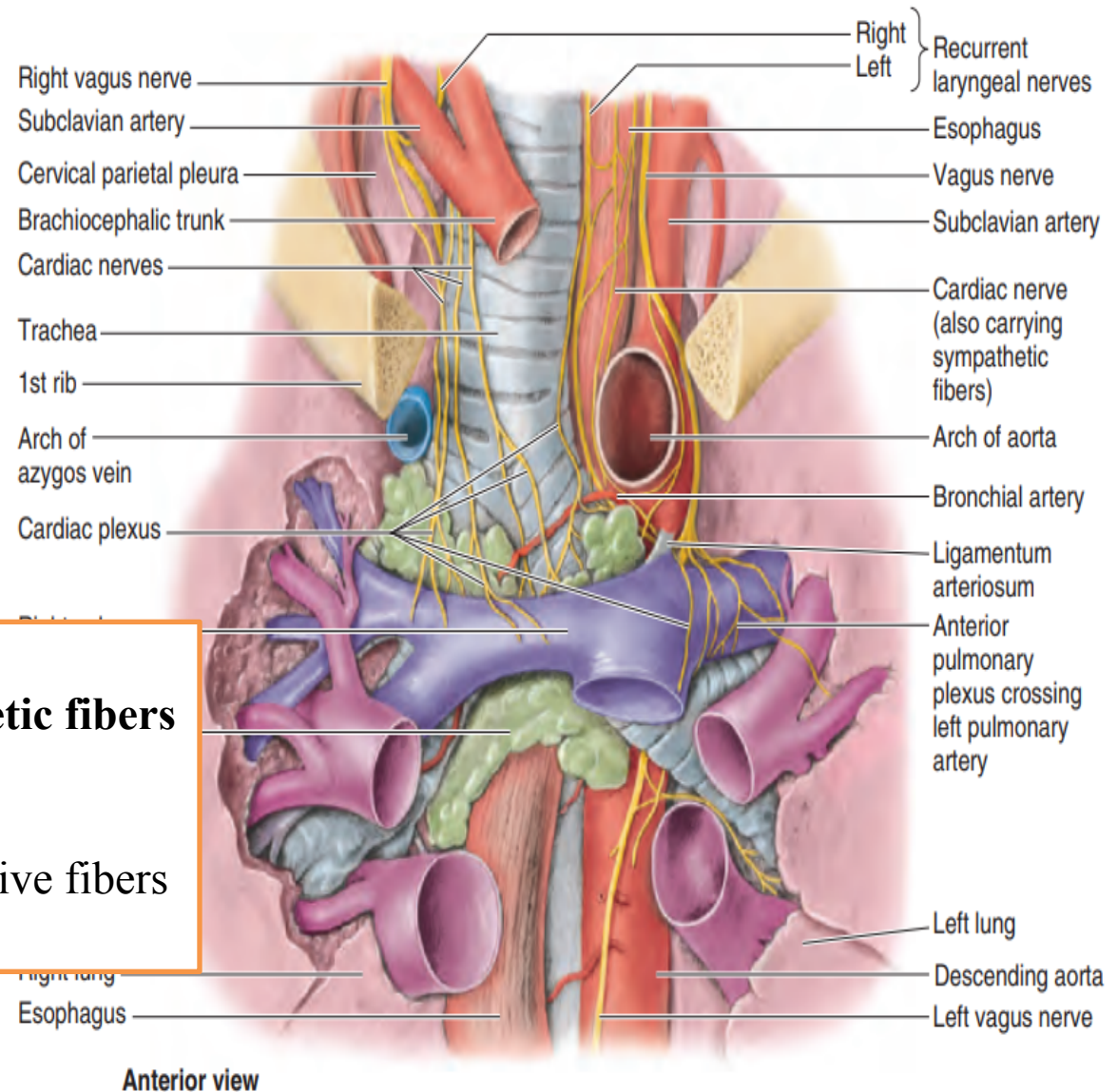
ECG, electrocardiographic; LAD, left anterior descending (interventricular); RCA, right coronary artery.

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



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** and in relation to the **terminations of parasympathetic fibers on the coronary arteries**.

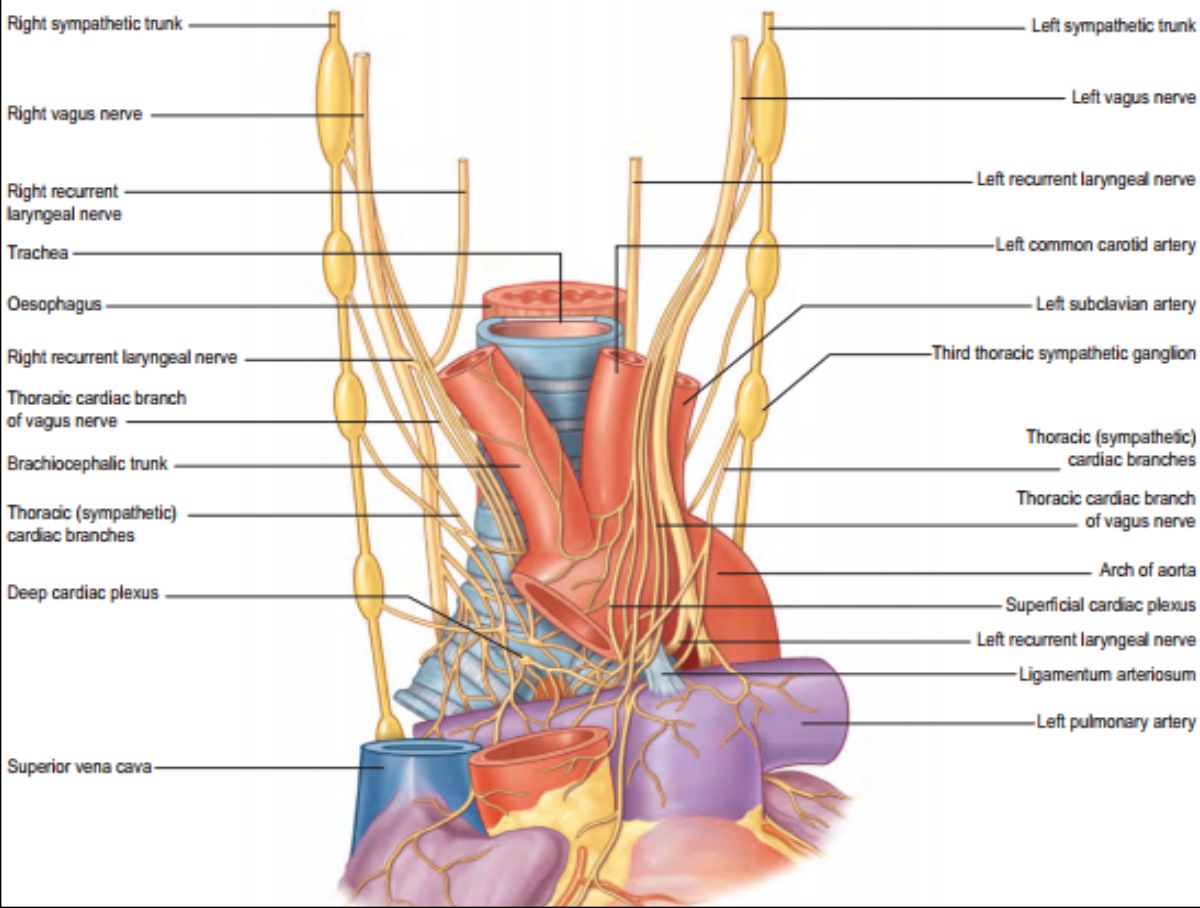


Sympathetic stimulation

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**



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 stimulates the sensory nerve endings in the myocardium.



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 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**

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.***

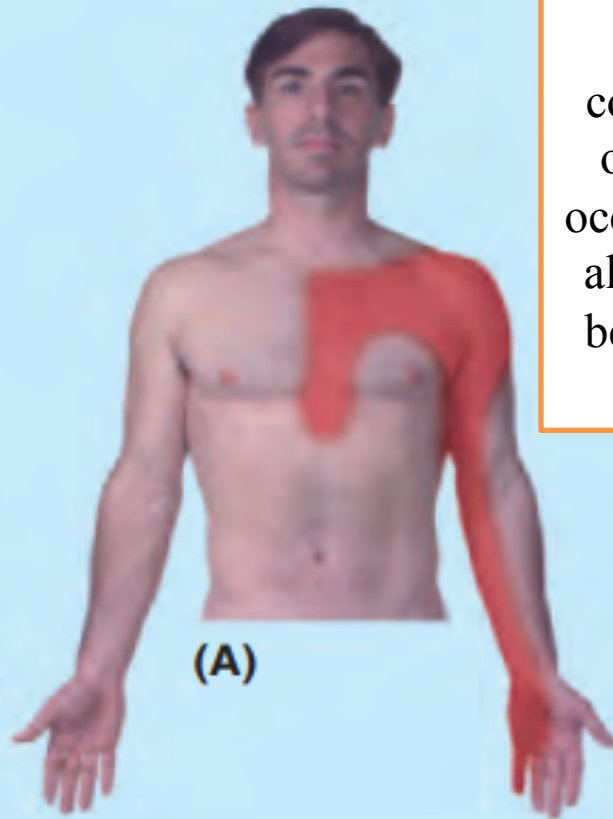
???

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

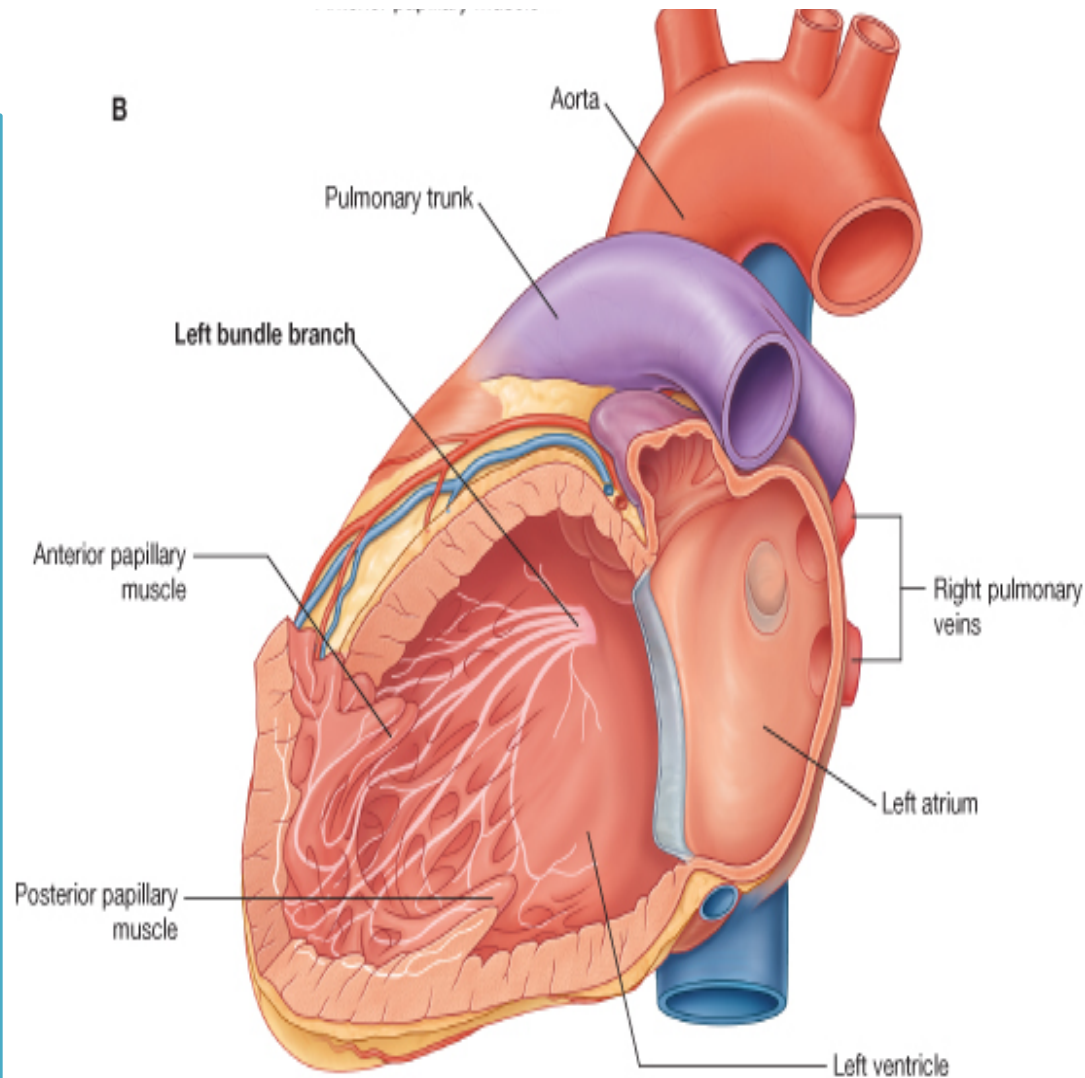


THE CONDUCTING SYSTEM OF **THE HEART**

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

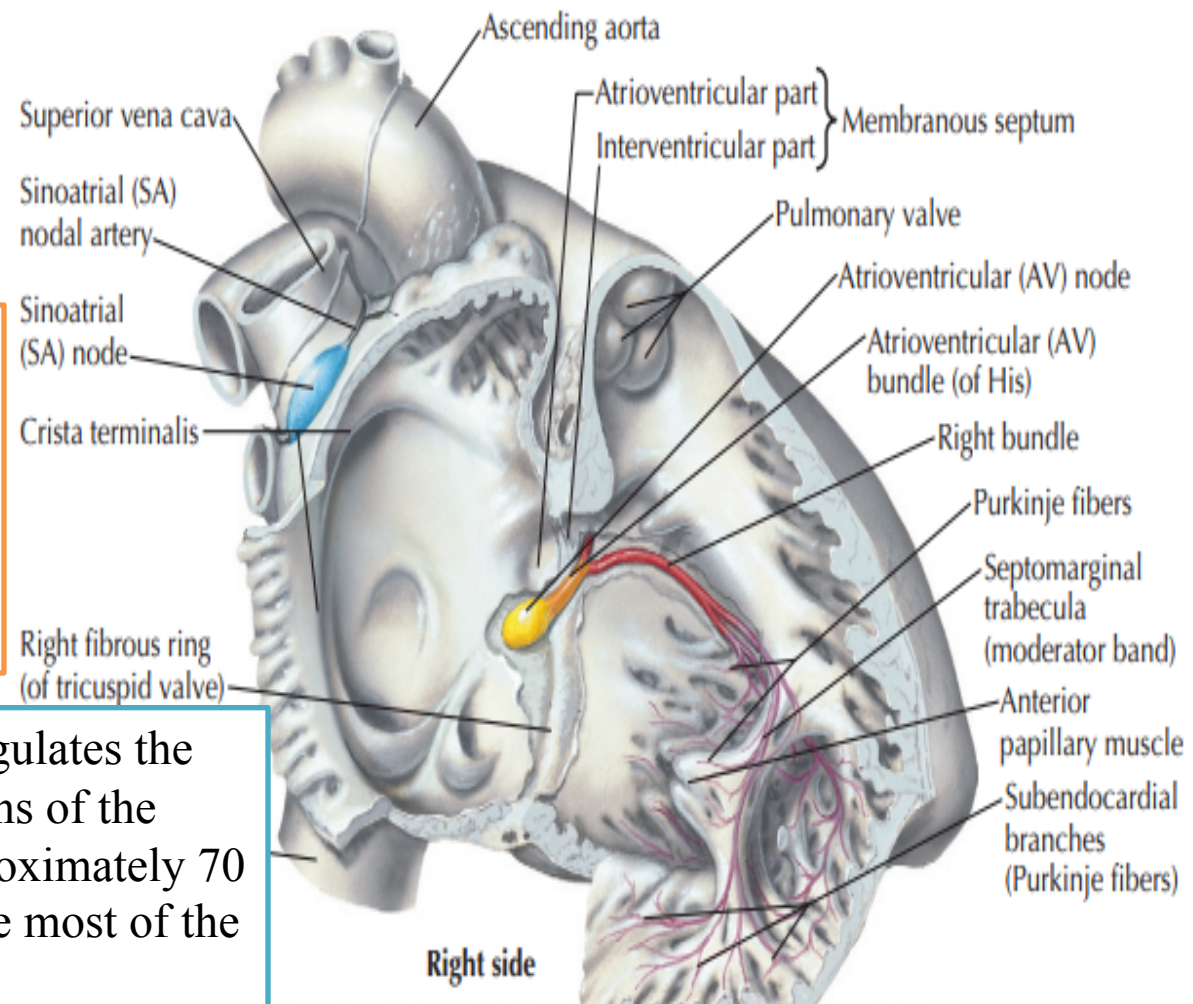


The sinu-atrial (SA) node

- 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 heart giving off an impulse approximately 70 times per minute in most people most of the time

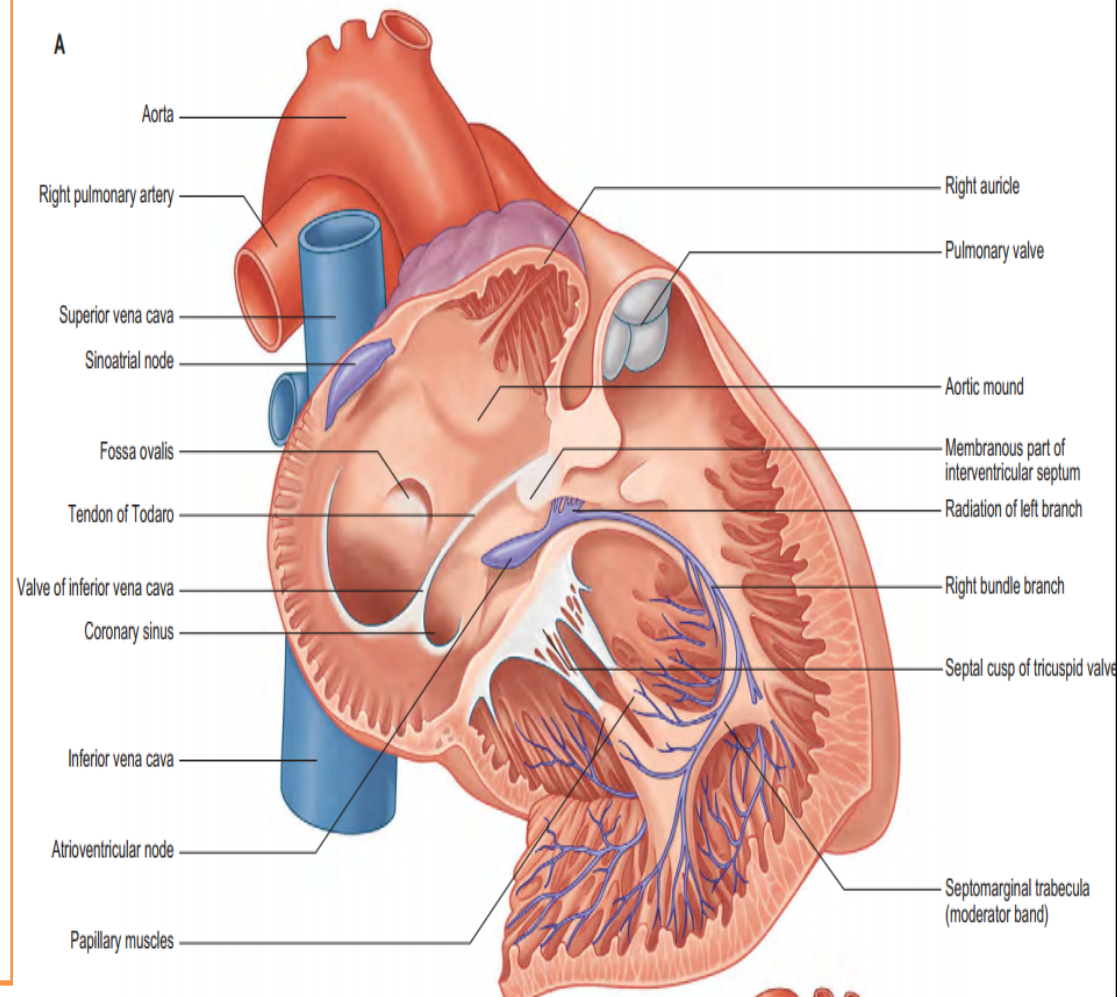


The contraction signal from the SA node spreads myogenically (through the musculature) of both atria

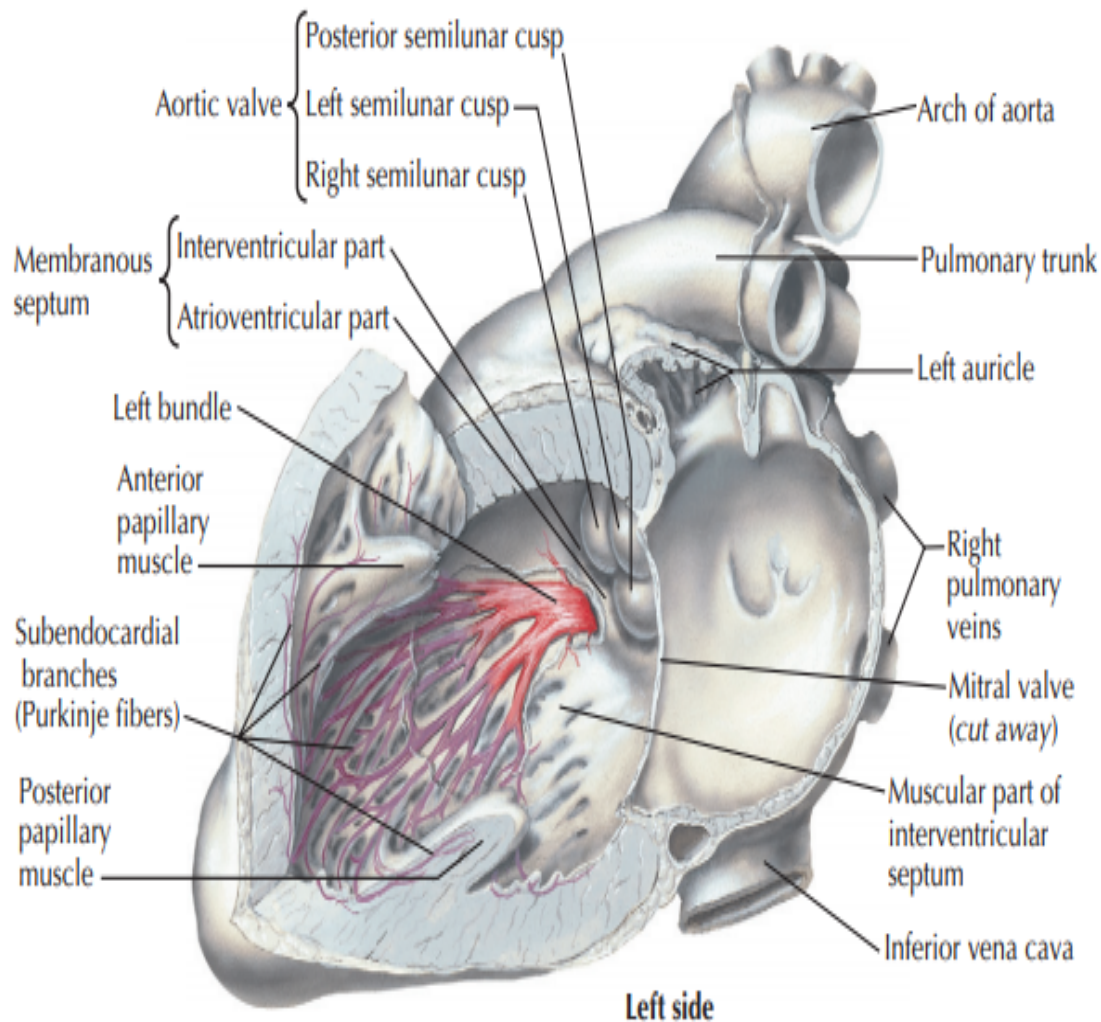
- The SA node is stimulated by the sympathetic division of the autonomic nervous system to accelerate the heart rate and is inhibited by the parasympathetic division to return to or approach its basal rate.

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)



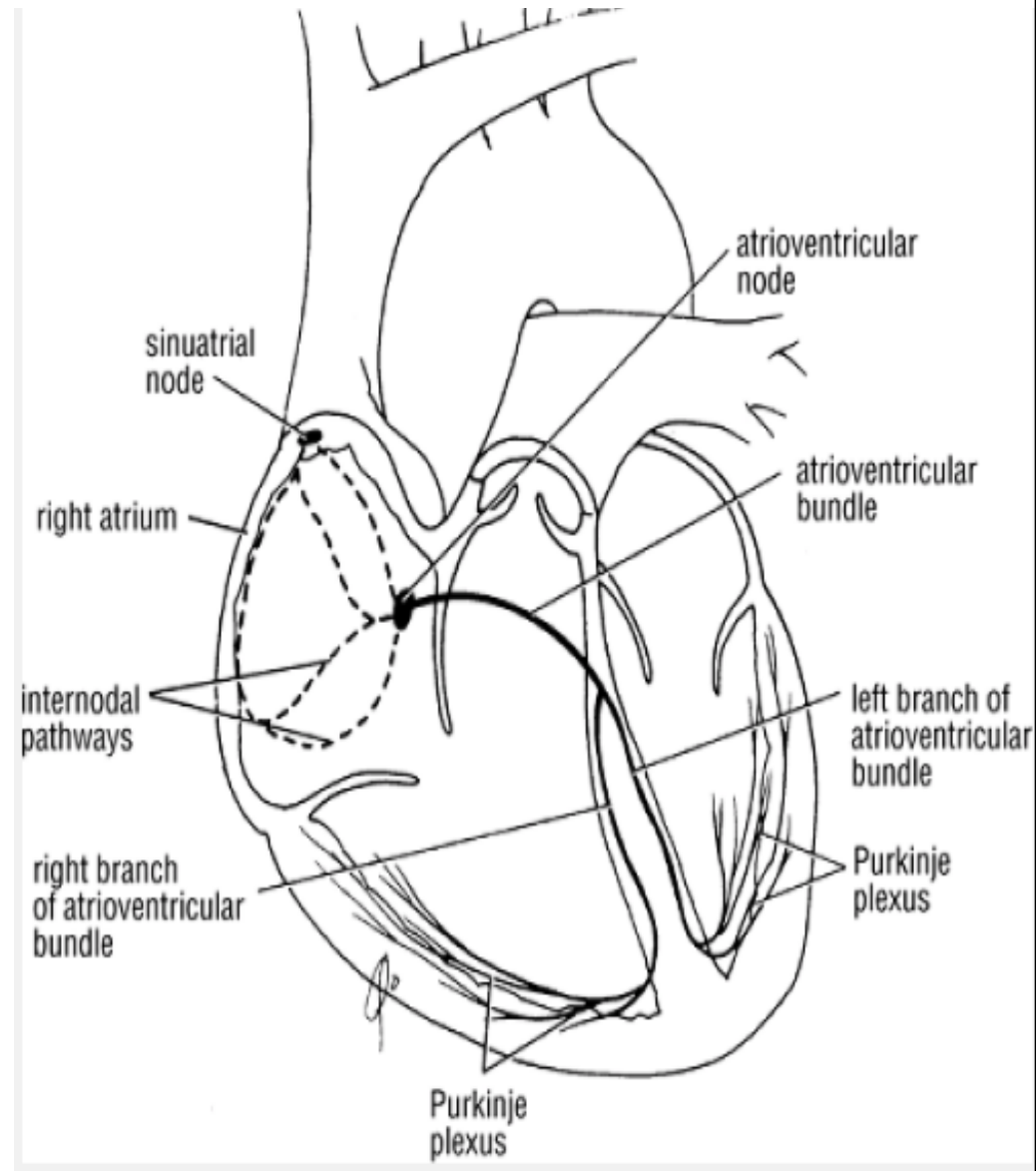
- ❖ Sympathetic stimulation speeds up conduction, and parasympathetic stimulation slows it down.
- ❖ The AV bundle, **the only bridge between the atrial and ventricular myocardium**, passes from the AV node through the fibrous skeleton of the heart and along the membranous part of the IVS

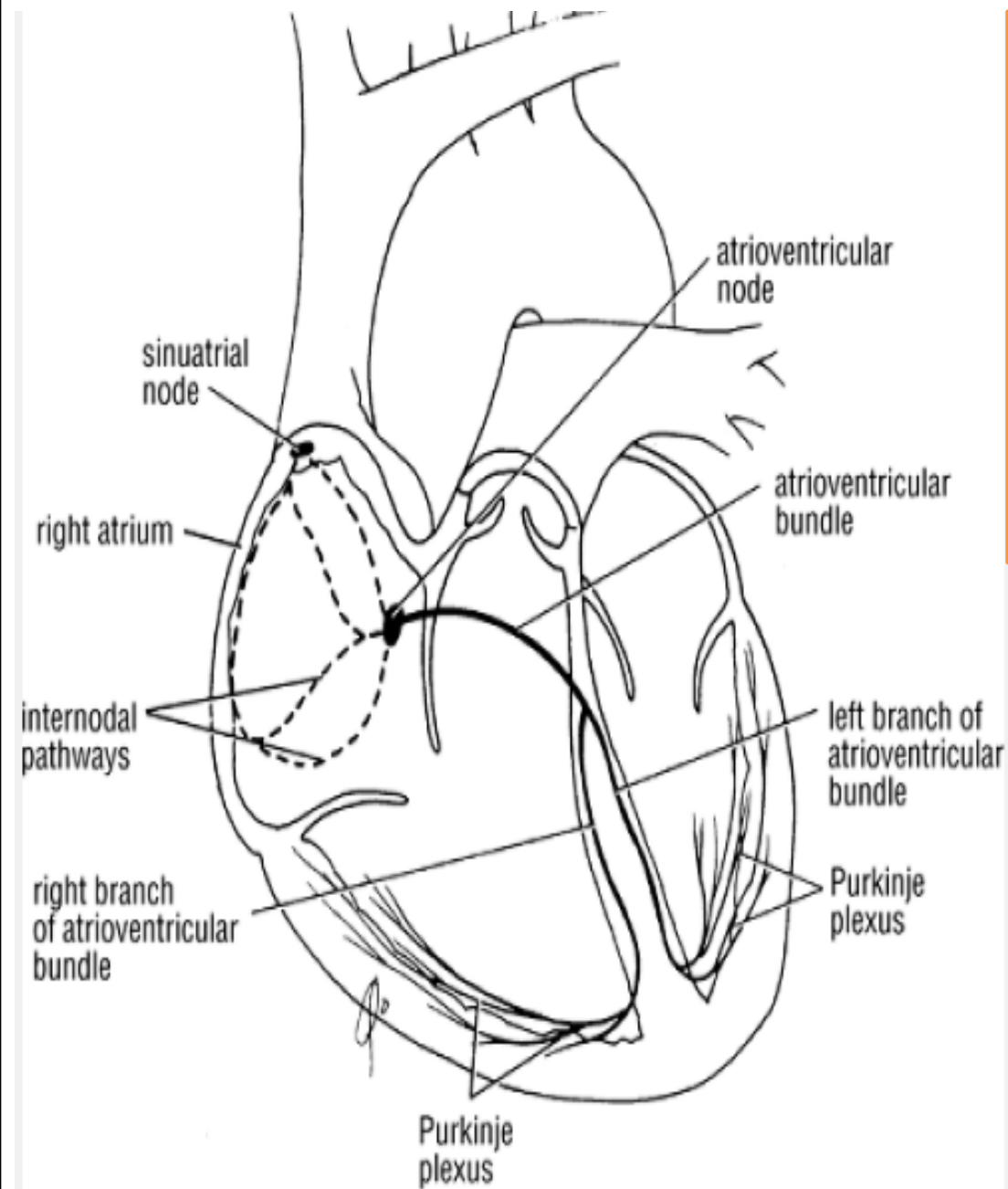


- At the junction of the **membranous and muscular parts** of the IVS, the AV bundle divides into right and left bundles
- These branches proceed on each side of the muscular IVS deep to the endocardium and then ramify into subendocardial branches (**Purkinje fibers**)
- which extend into the walls of 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.

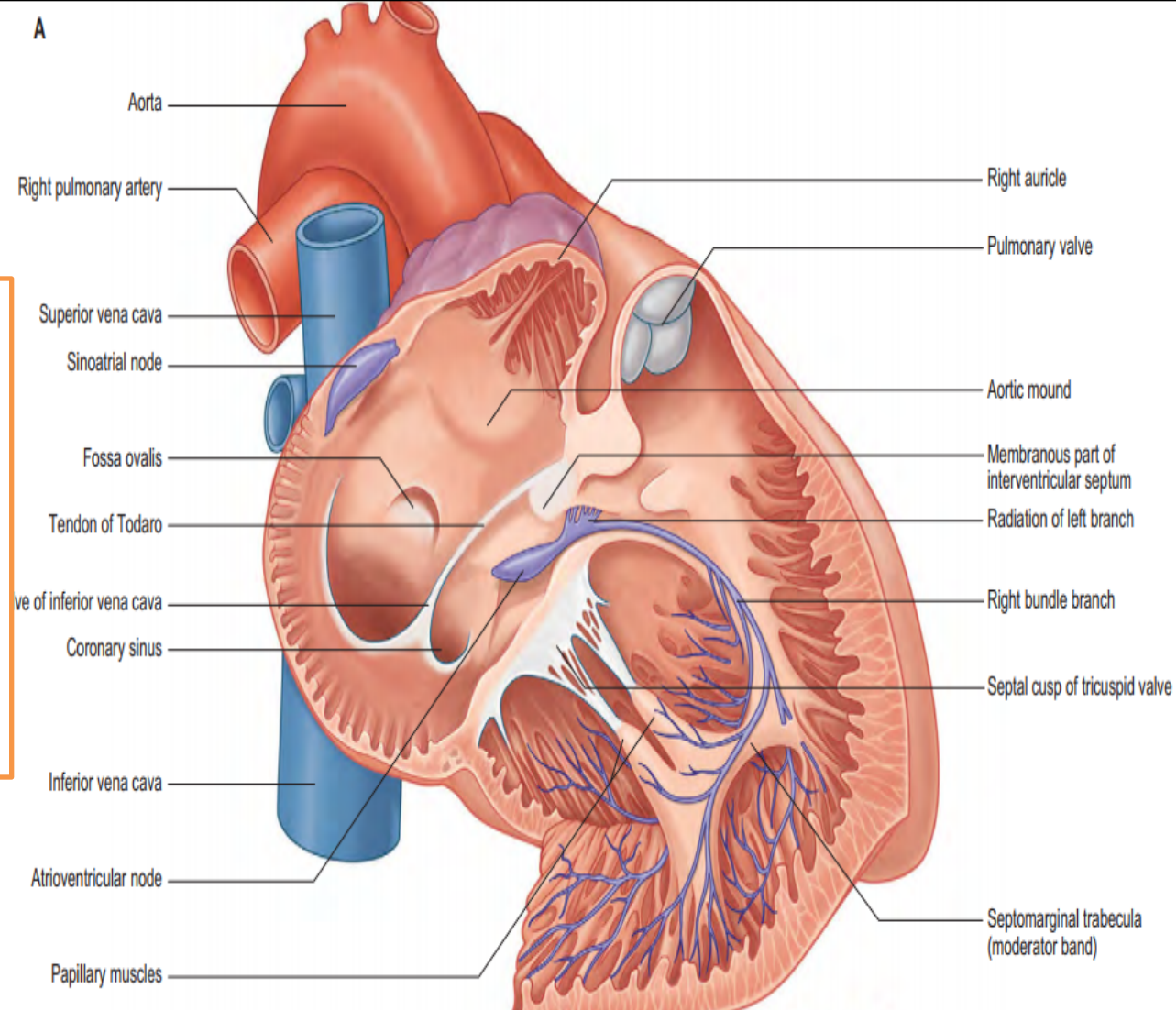
Destruction of the AV bundle would cut the only physiological link between the atrial and ventricular musculature, also producing a heart block as described above.





- 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.

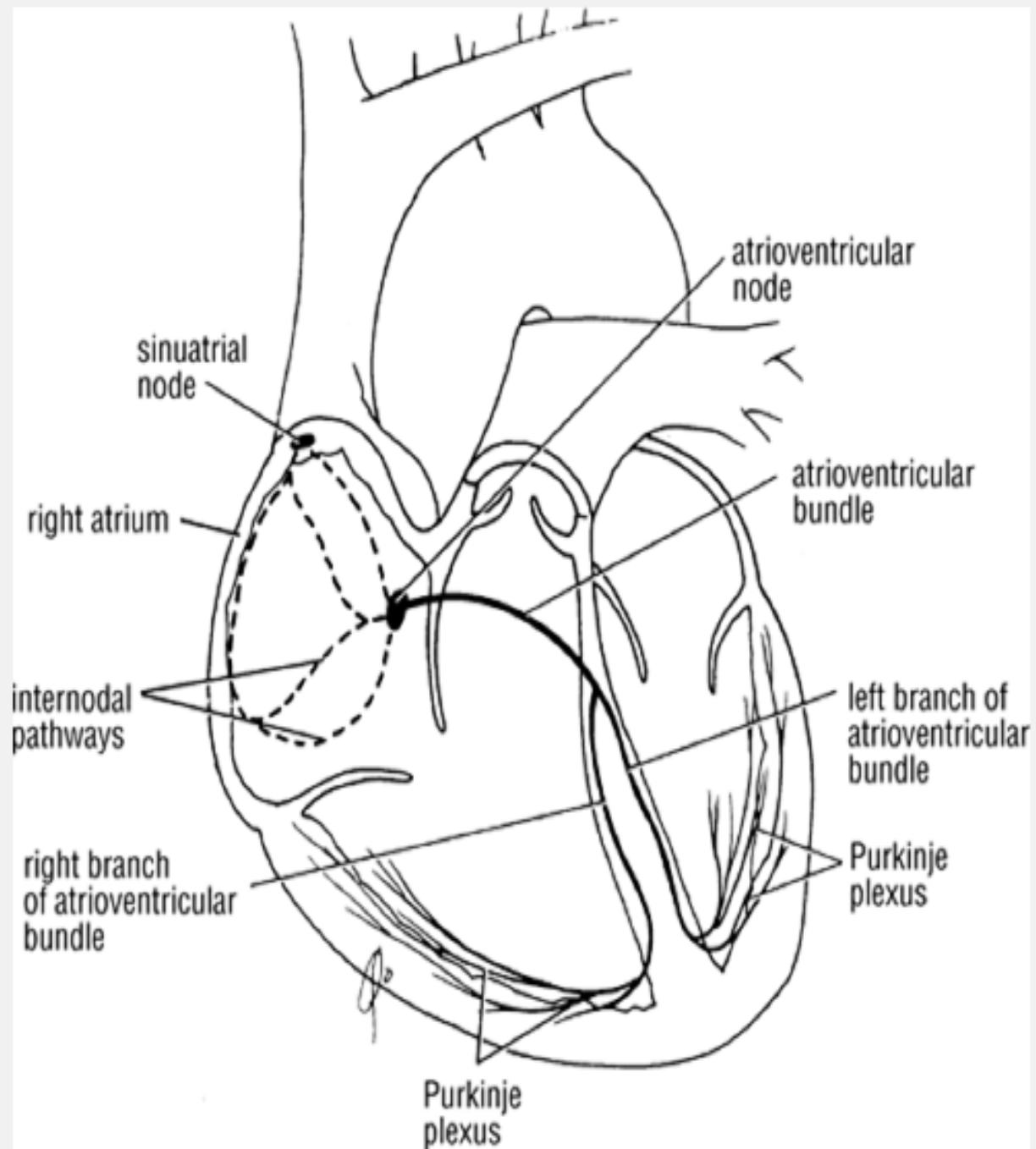
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Internodal Conduction Paths

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*