전공의 연수강좌, 여수

Normal Cardiac Anatomy

Hong Ju Shin, M.D.

Cardiovascular Surgery

Yonsei University College of Medicine

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SEVERANCE

1885 Chejungwon
Cardiovascular Hospital

Anatomy

- Shape
- Function

Shape

hankyung.com

http://c.hani.co.kr/story/2117126

Shape

http://etv.sbs.co.kr

http://m.segye.com/content/html/2013/04/15/20130415004212.html

Shape

http://www.coowool.com/bbs/star-a/575050461741056O

http://www.newspim.com/view.jsp?newsId=20130603000990

Function

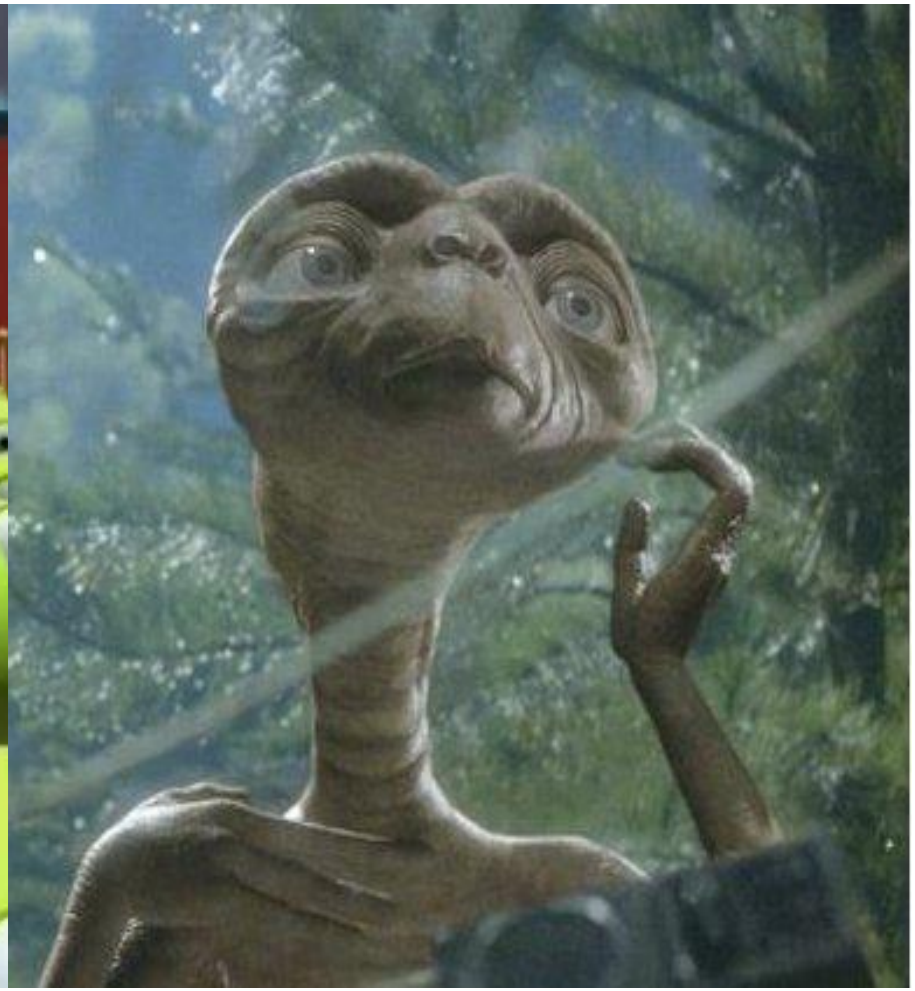
http://coolbusan.tistory.com/1796

http://starin.edaily.co.kr/news/NewsRead.edy?SCD=EA21&newsid

Function

http://article.joins.com/news/article/article.asp?ctg=14&Total_ID=8775545

http://blog.daum.net/bhjun/5508307



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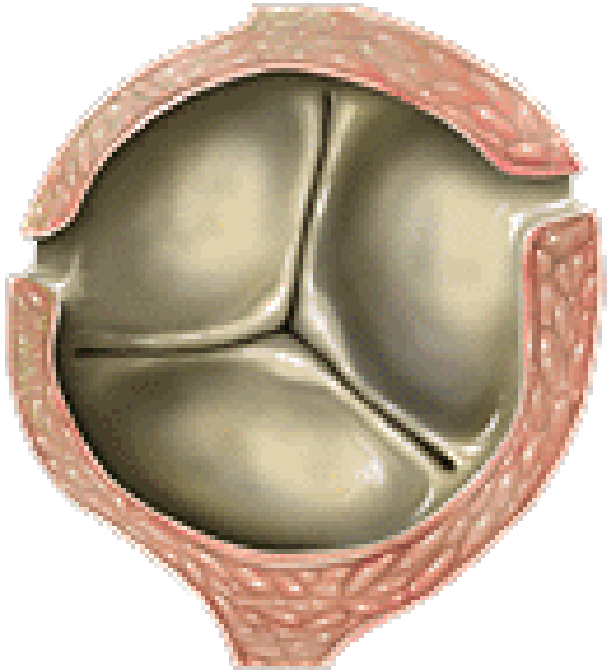
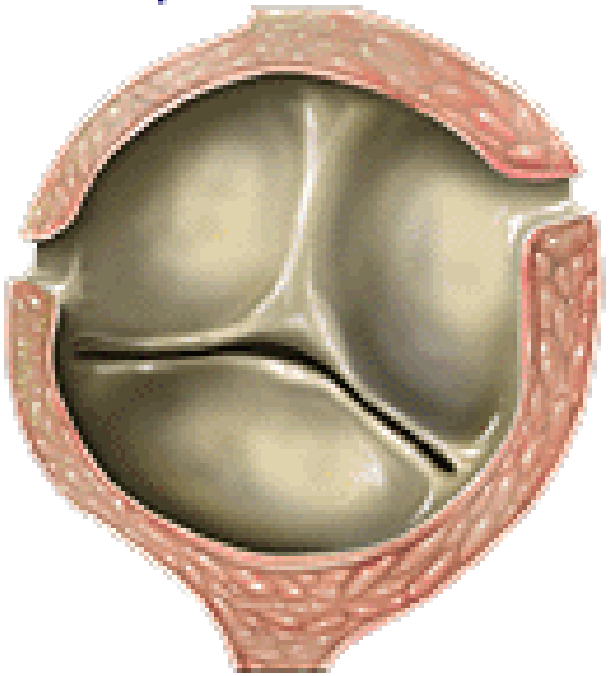
kirinyaga.tistory.com

Normal Aortic Valve

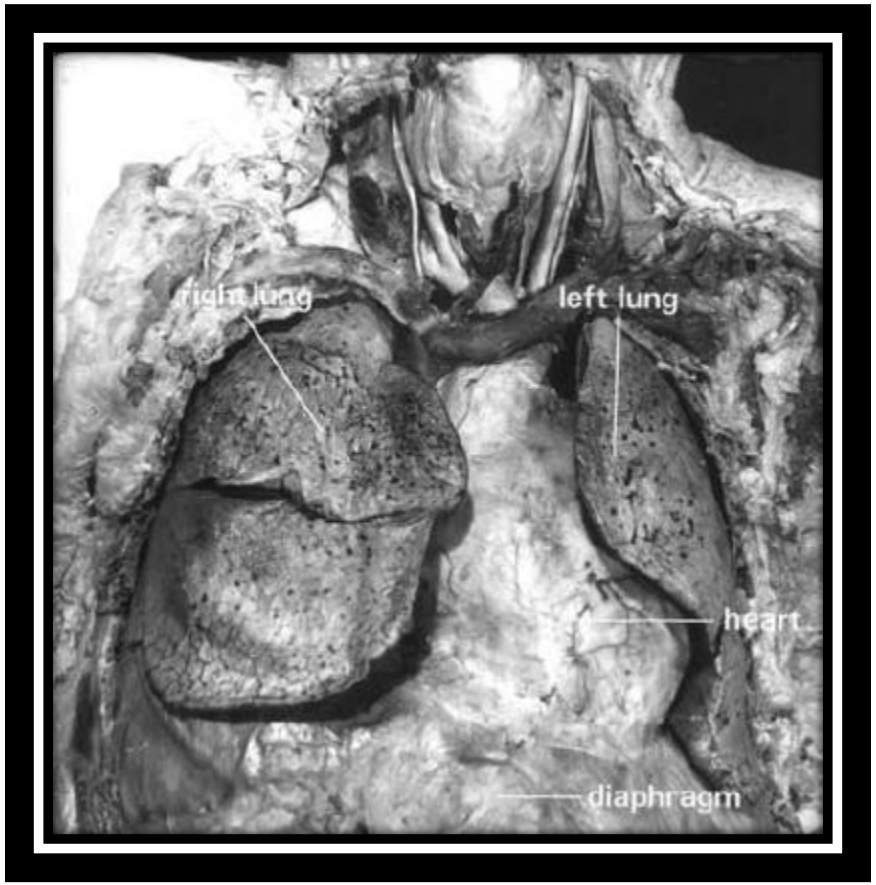


Bicuspid Aortic Valve

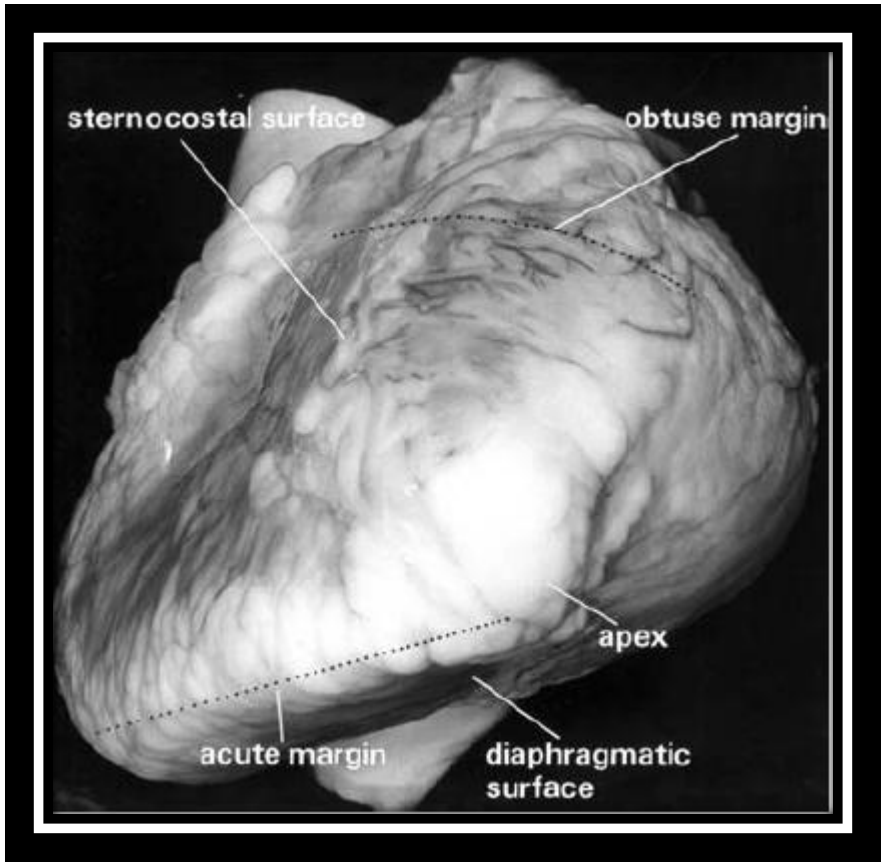


bav-genetic.org

CARDIAC SHAPE AND POSITION



- It possesses a base, which lies in an oblique plane behind the sternum and angles as it descends to the right, and an apex, which extends outward into the left hemithorax

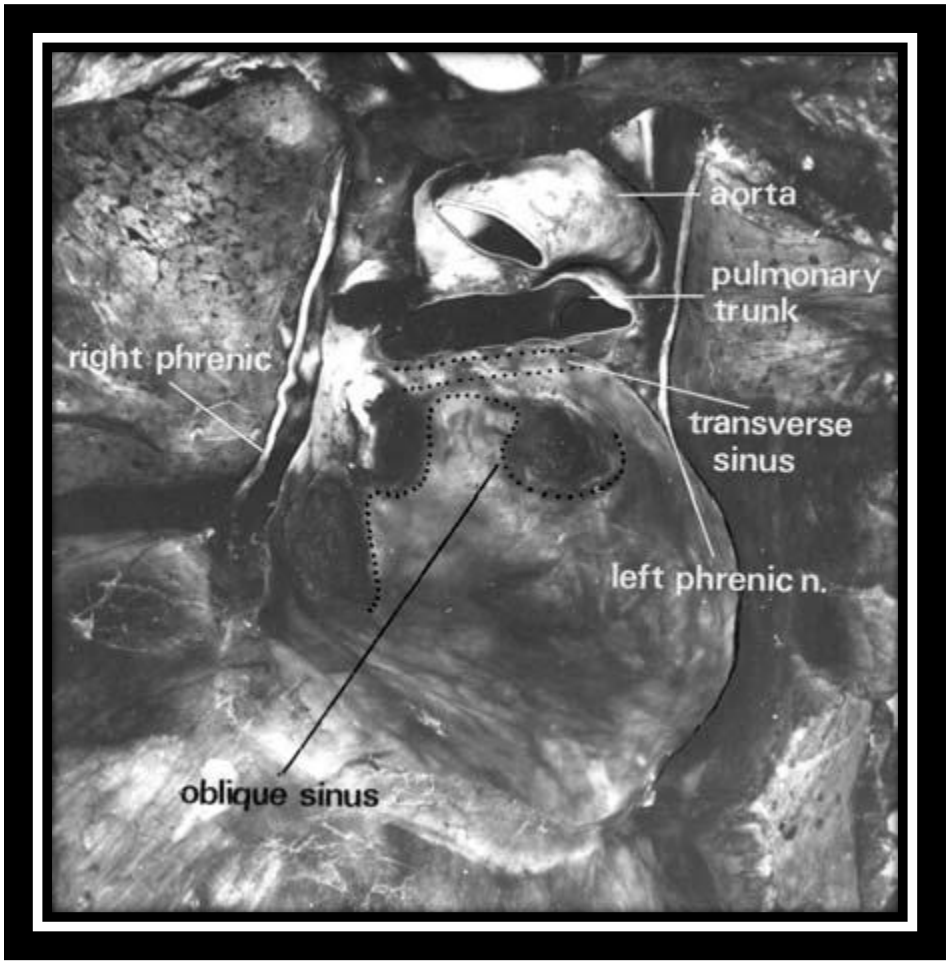


- The pyramidal shape of the heart is best appreciated by viewing it from the apex along its long axis

PERICARDIAL CAVITY

- The serous pericardium - double-layered membrane
- The inner layer of the serous pericardium is fused to the surface of the heart, forming the epicardium, or visceral pericardium

PERICARDIAL CAVITY



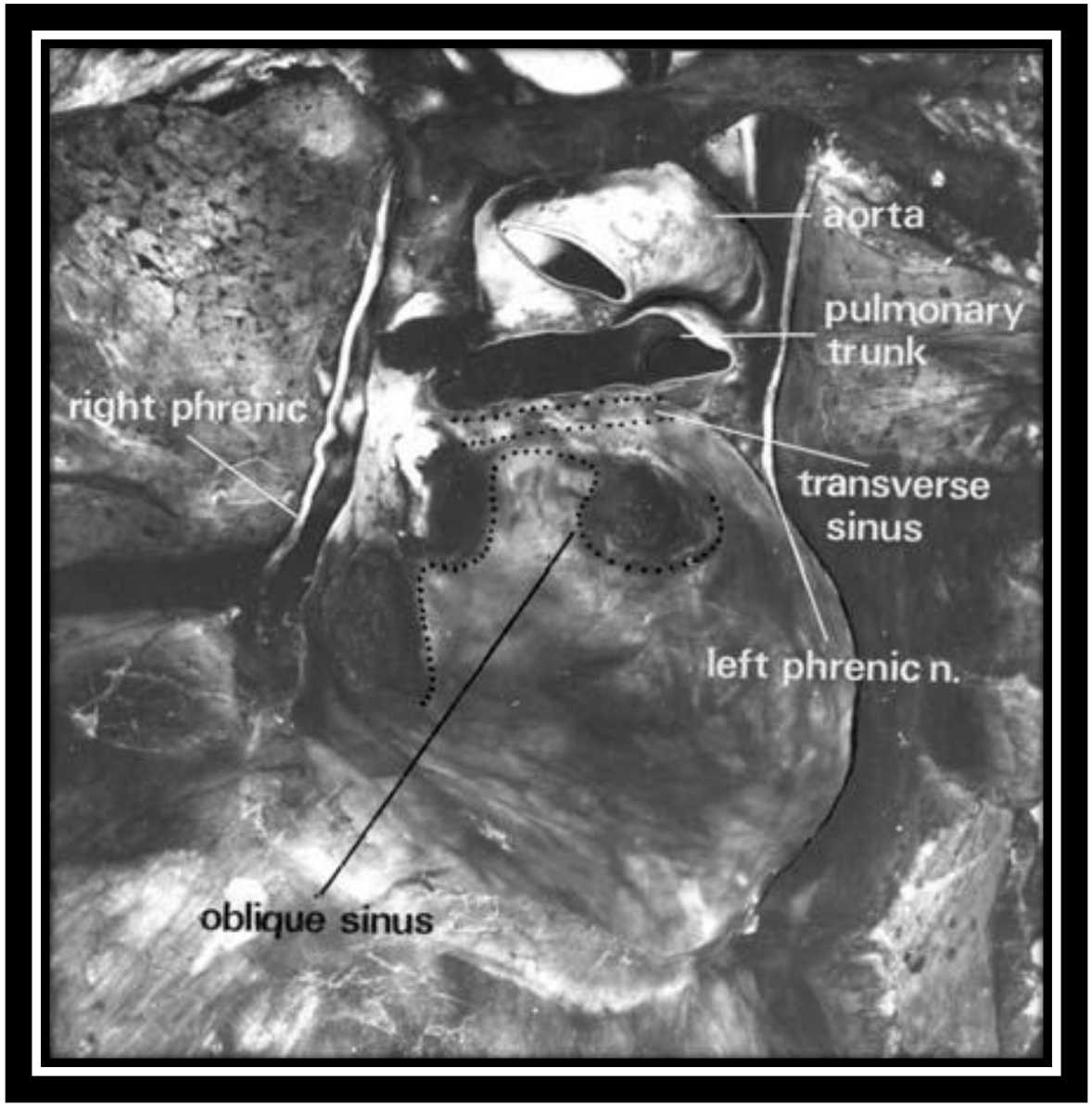
- The oblique sinus, is a cul-de-sac behind the LA
- It is limited to the right by the IVC and RPVs and to the left by the LPVs
- Its right wall is a fold of tissue extending from the RPV around the IVC.
- If it is necessary to encircle the IVC within the fibrous pericardium during surgery, this fold must be divided

Oblique sinus and Transverse sinus

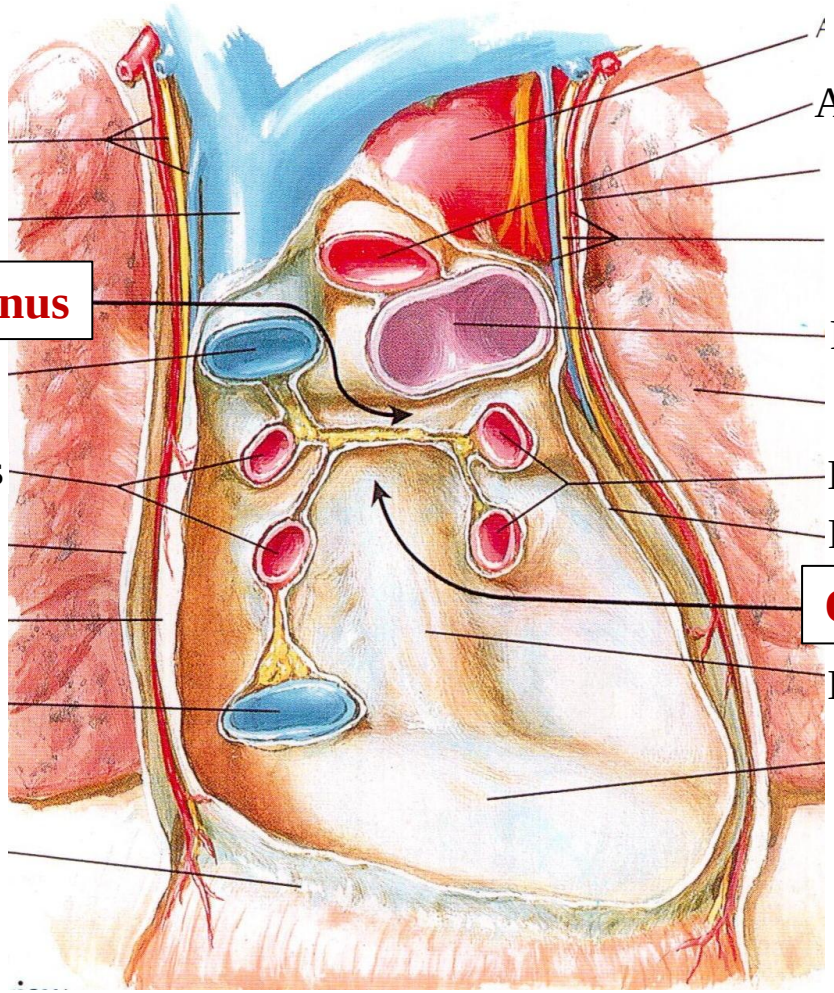
- The reflection between the RPVs and LPVs forms the roof of the sinus, and separates the oblique and the transverse sinuses, the small bare area of the left atrium being between the sinuses

- To the left of the roof, between the LPA and the subjacent PV, is **the fold of serous pericardium known as the ligament of the left superior vena cava (SVC),** or Marshall's ligament

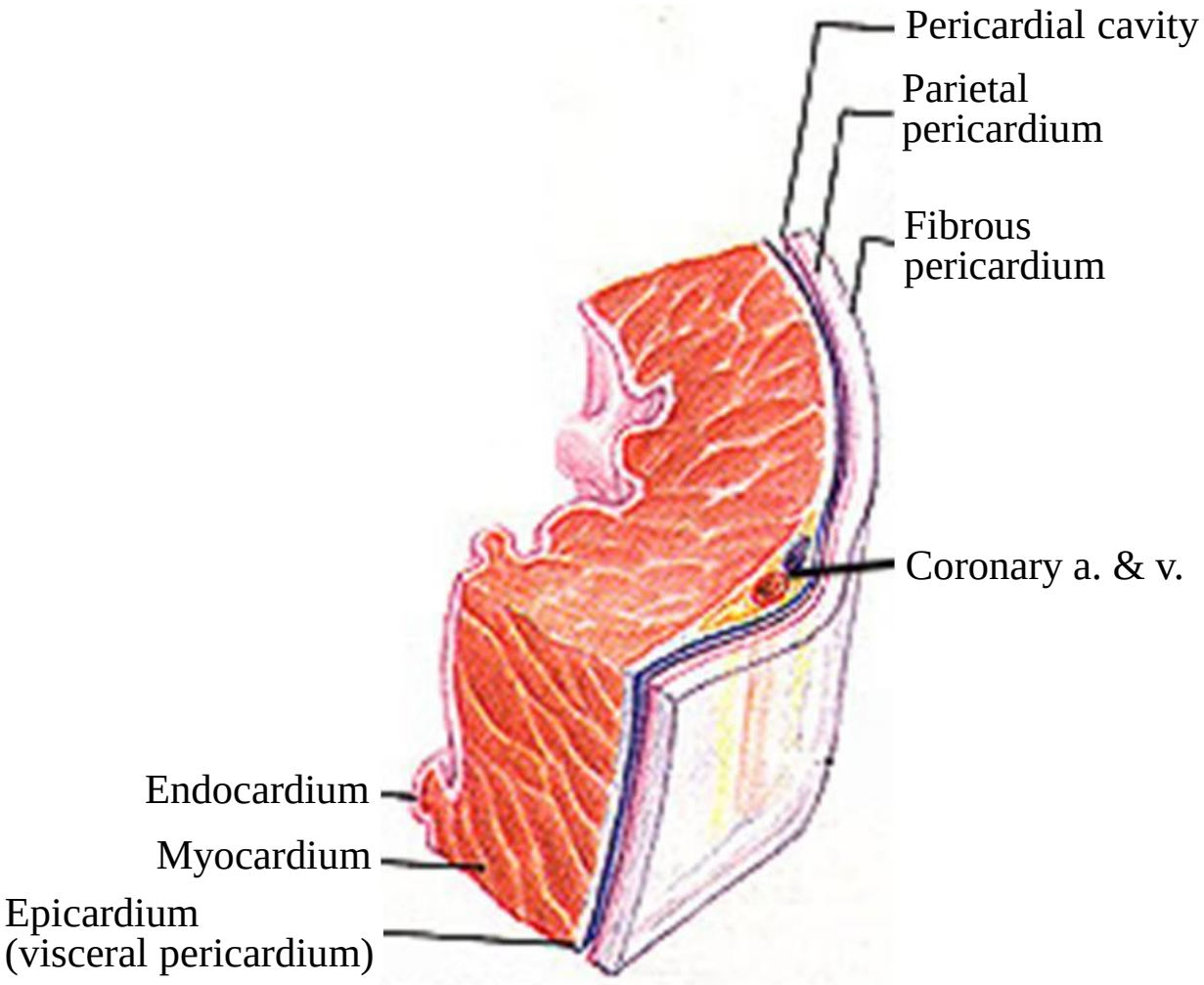
- The transverse sinus is an extensive recess between the layer of serous pericardium surrounding the anterior aspect of the atrial chambers and the cuff of pericardium that encloses the aorta and the pulmonary trunk.
- This sinus lines the important inner curvature of the heart, marking the site of the ventriculo-infundibular fold.
- Although a probe can be passed through the sinus to encircle the aorta, such a probe would also encircle the pulmonary trunk


aorta
pulmonary trunk
right phrenic
transverse sinus
left phrenic n.
oblique sinus

Pericardium



Pericardium



RELATIONSHIPS OF THE HEART

- The thymus is situated

  between the hilar regions above the heart
- Prominent at birth, and continues to grow until puberty, but regresses thereafter
- Two important nerves descend through the mediastinum posterior to the thymus and in relation to the hilar regions, viz. the vagus (10th cranial) and phrenic nerves

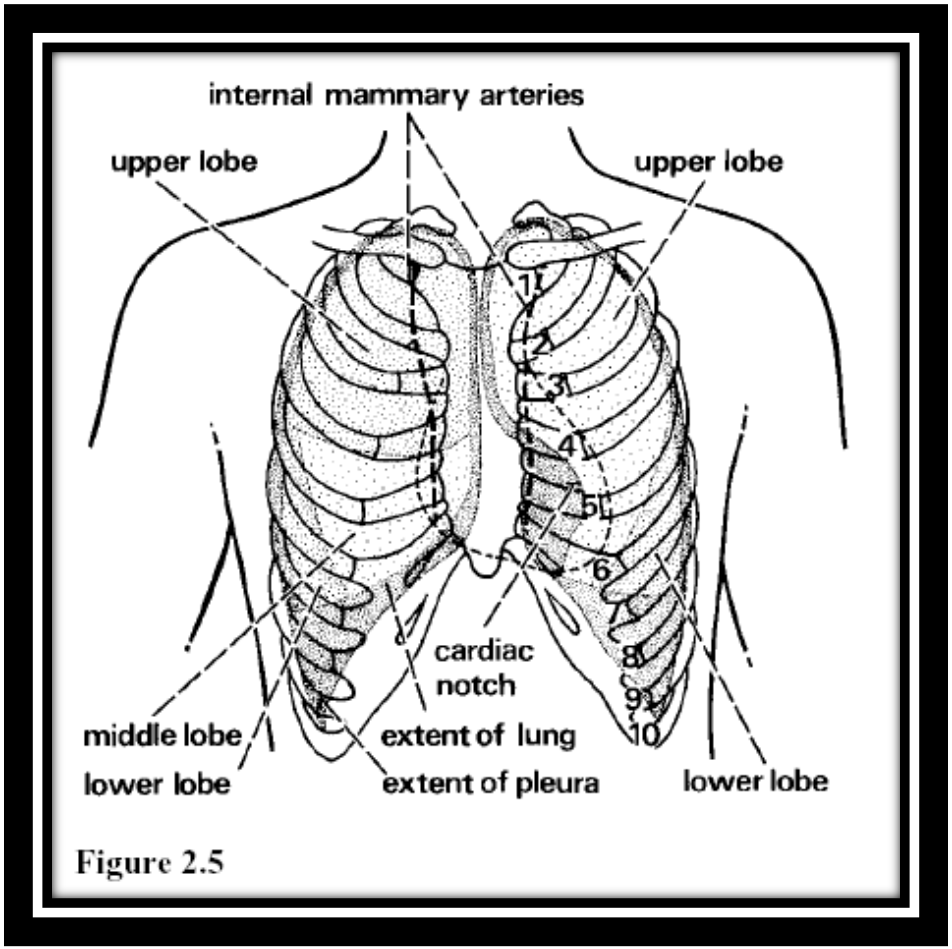
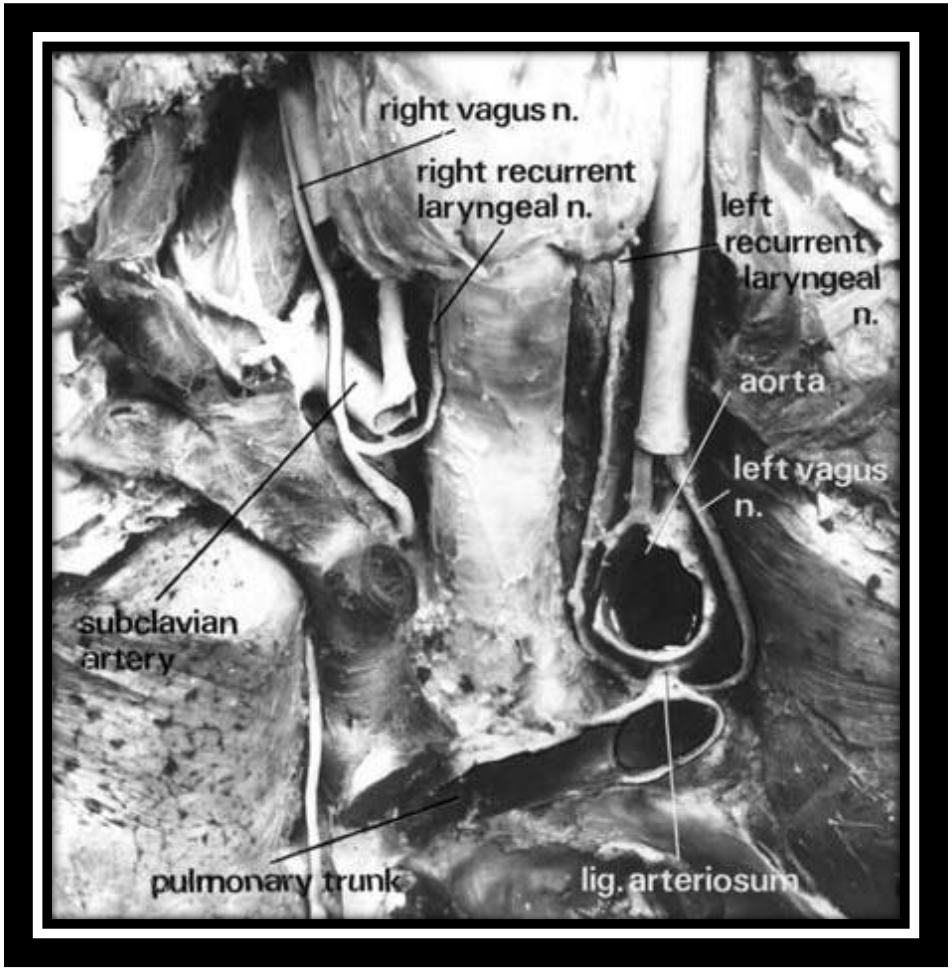
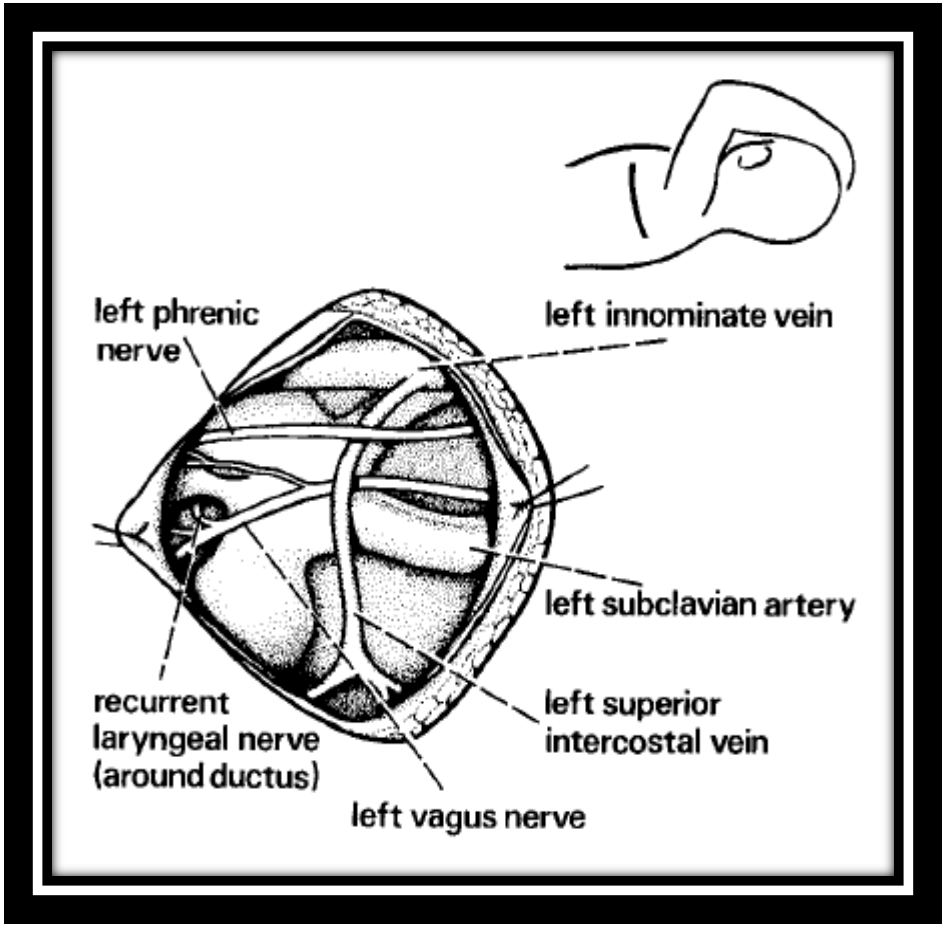


Figure 2.5

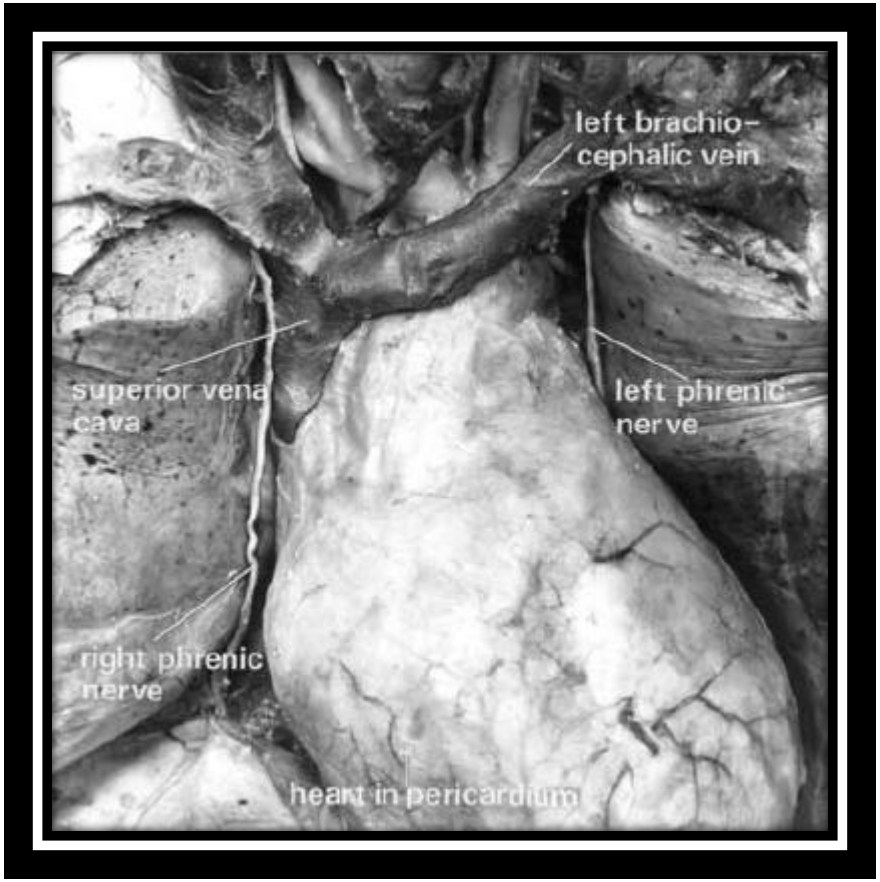
- The right pleural cavity overlies the right side of the heart almost to the midline
- The left pleural cavity, in contrast, extends away from the midline in the cardiac notch, leaving a bare area of the pericardium that projects directly onto the underside of the thoracic cage



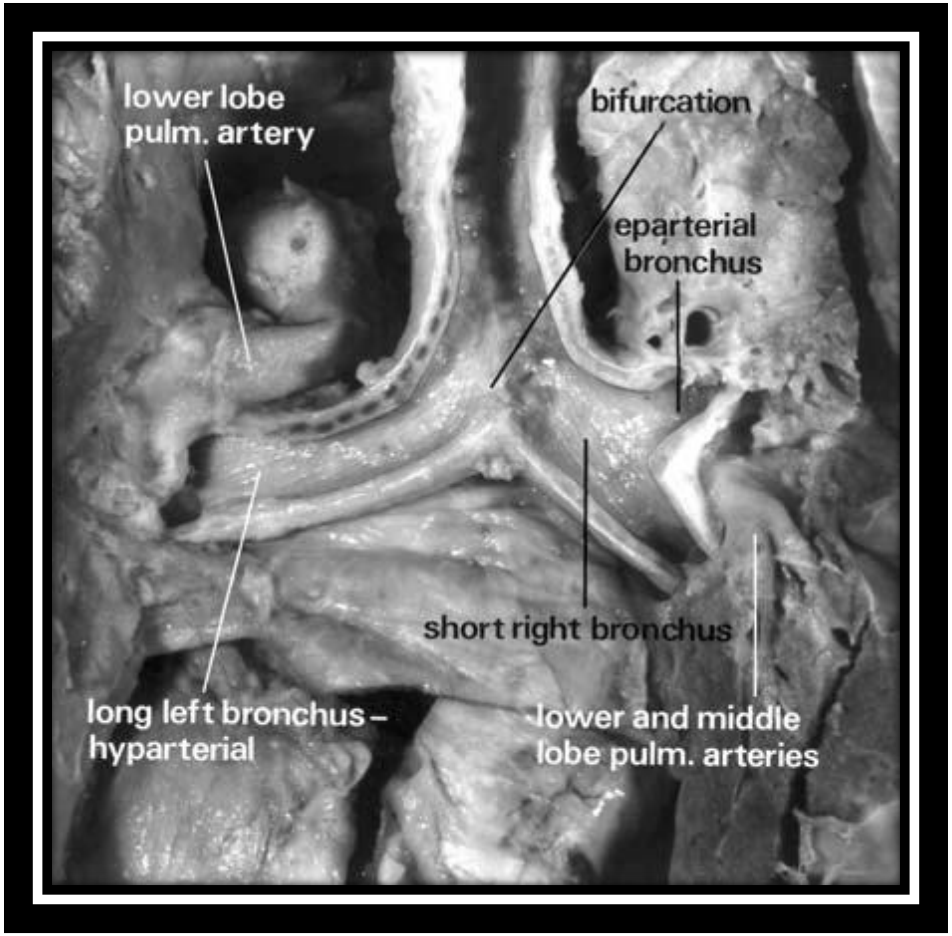
- On the right side, the vagus nerve gives off its recurrent laryngeal branch high up, with the recurrent nerve



- On the left side, the phrenic and vagus nerves extend forward across the aortic arch, and the superior intercostal vein is insinuated between them



- They are in potential danger of surgical trauma during the removal of part of the pericardium to harvest a patch, and during dissection around the SVC, especially at reoperations



- The artery to the right upper lobe ascends to run into the lobe alongside and beneath this bronchus, which is therefore an eparterial bronchus, since it is above the artery
- In contrast, the first branch of the left main bronchus is a hyparterial bronchus, since it runs underneath the branch of the PA

The posterior view of bronchial anatomy

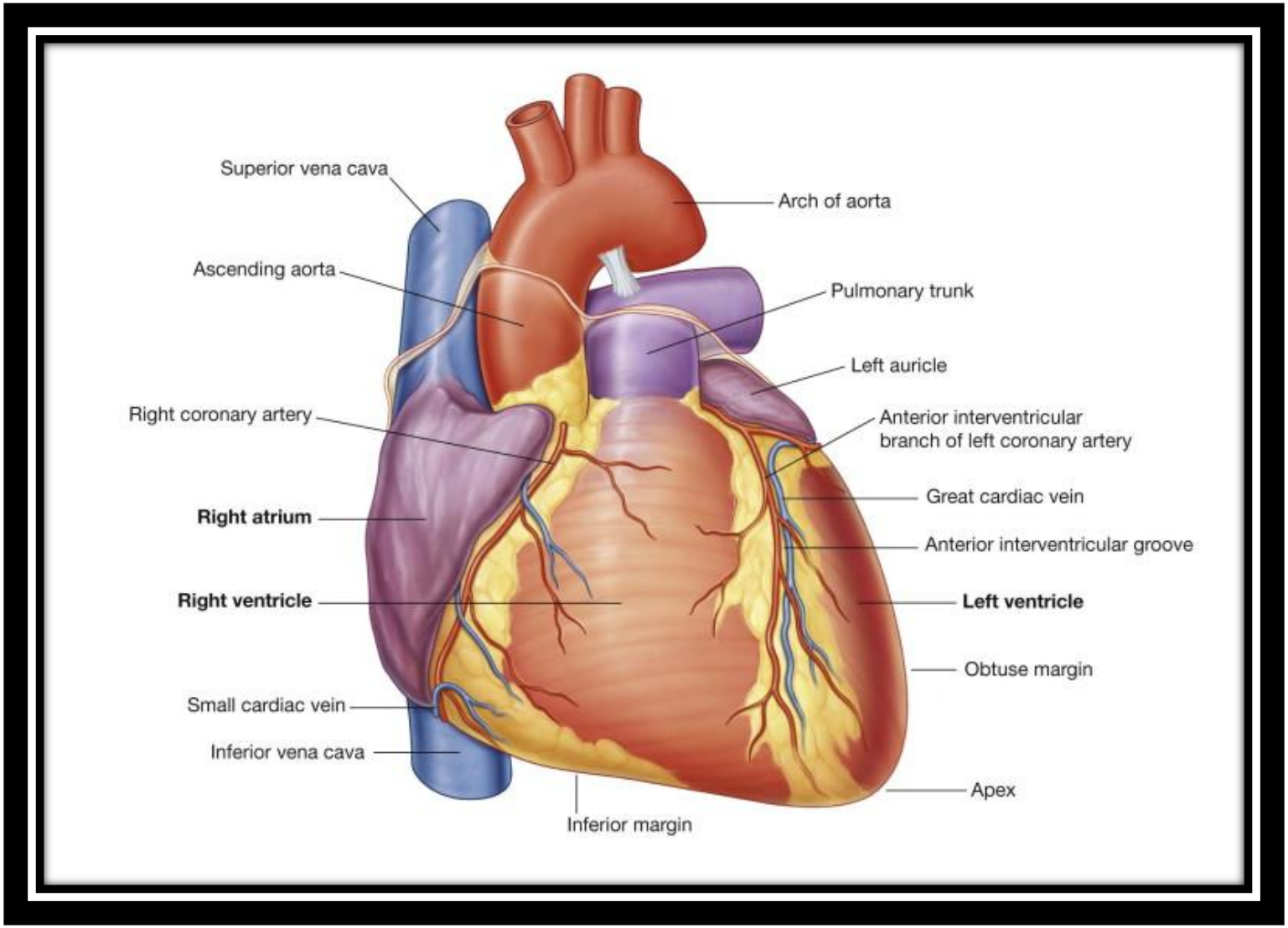
- The esophagus

Descending into the thoracic cavity with the trachea, it continues beyond the tracheal bifurcation and runs directly behind the left atrium, leaving thethoracic cavity through the right crux of the diaphragm

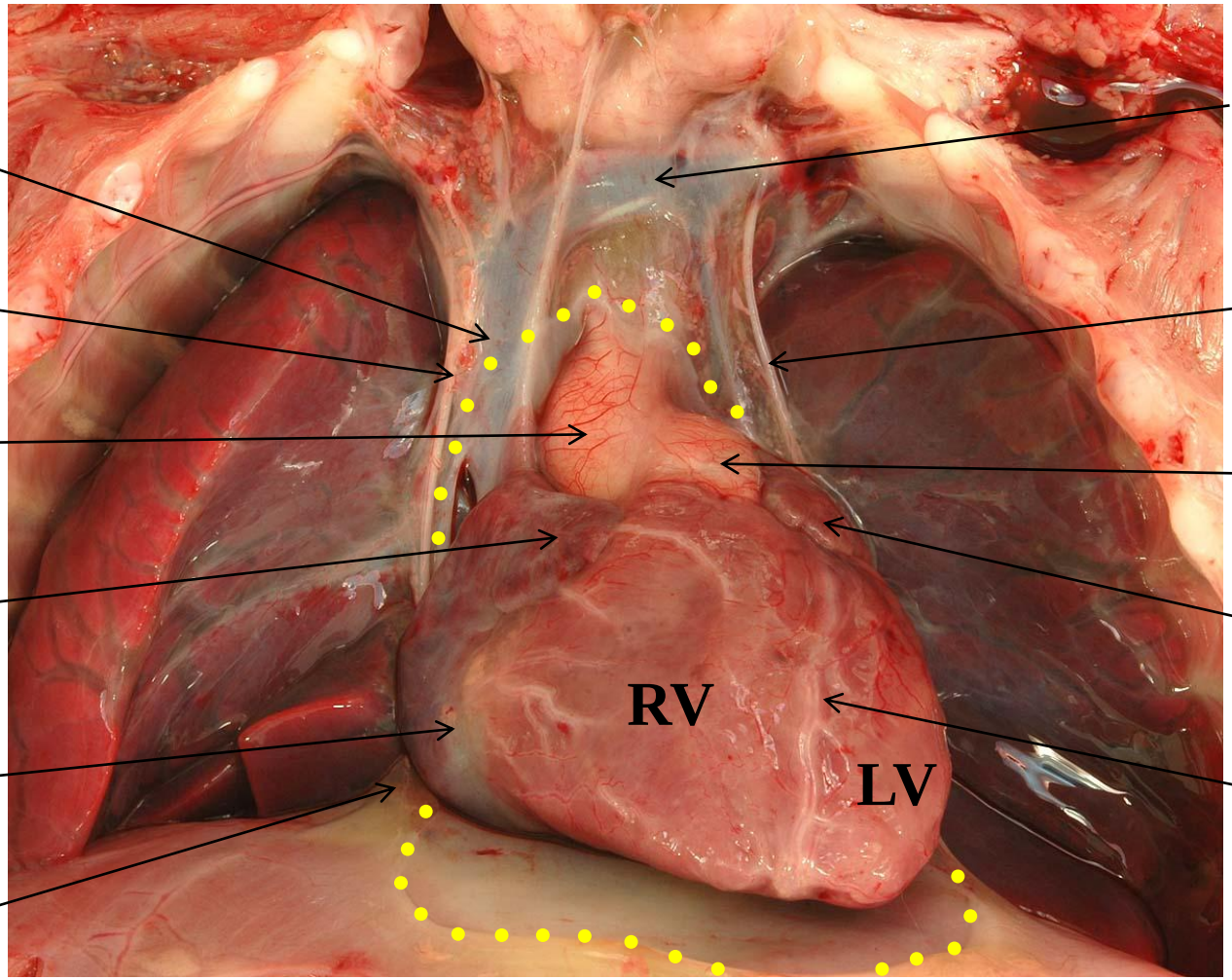
ANATOMY OF CARDIAC CHAMBERS

- Because of the orientation of the cardiac long axis, the ventricles are more or less to the left of their corresponding atrial chambers
- RA and RV are relatively anterior to their left counterparts
- Because of the anterior position of the chambers of the right heart, the aorta and its valve have a central position in the heart, being wedged between the atrio-ventricular valves and posterior to the infundibulum of the RV
- The aortic valve is, therefore, related to all four cardiac chambers

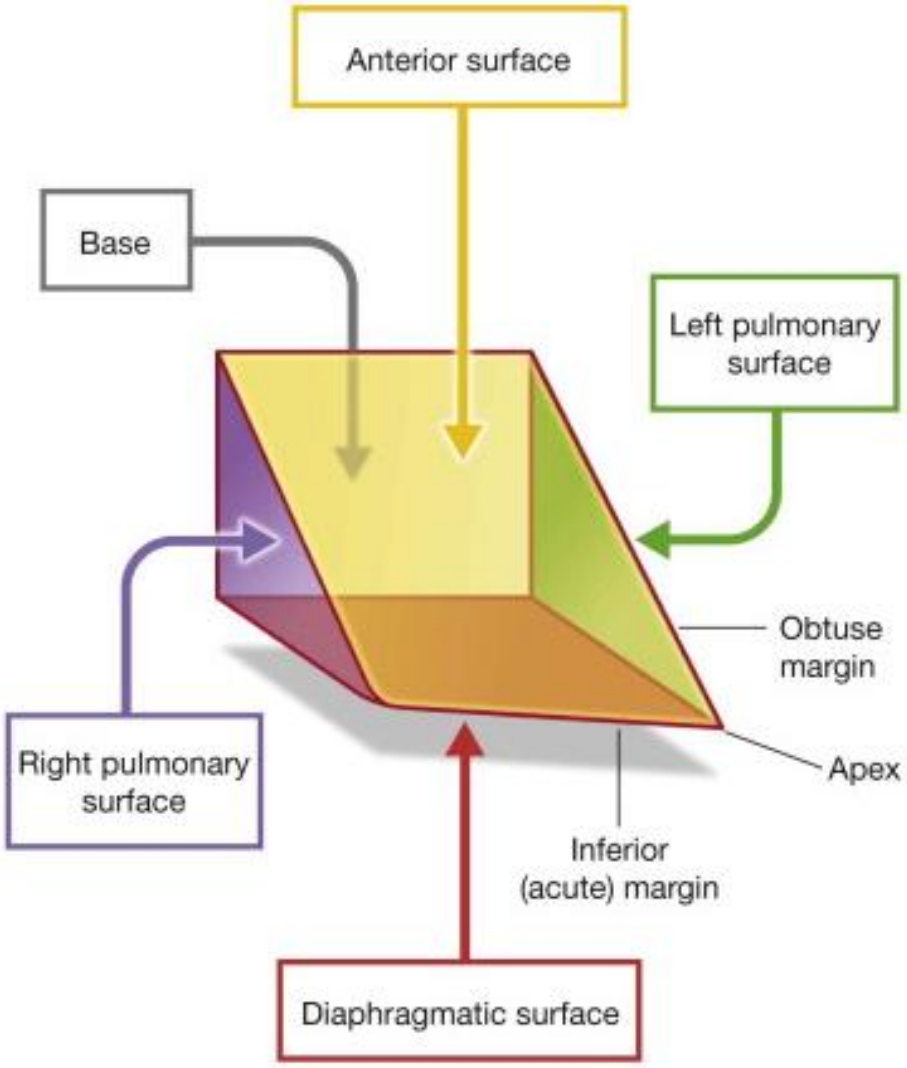
Anterior Surface



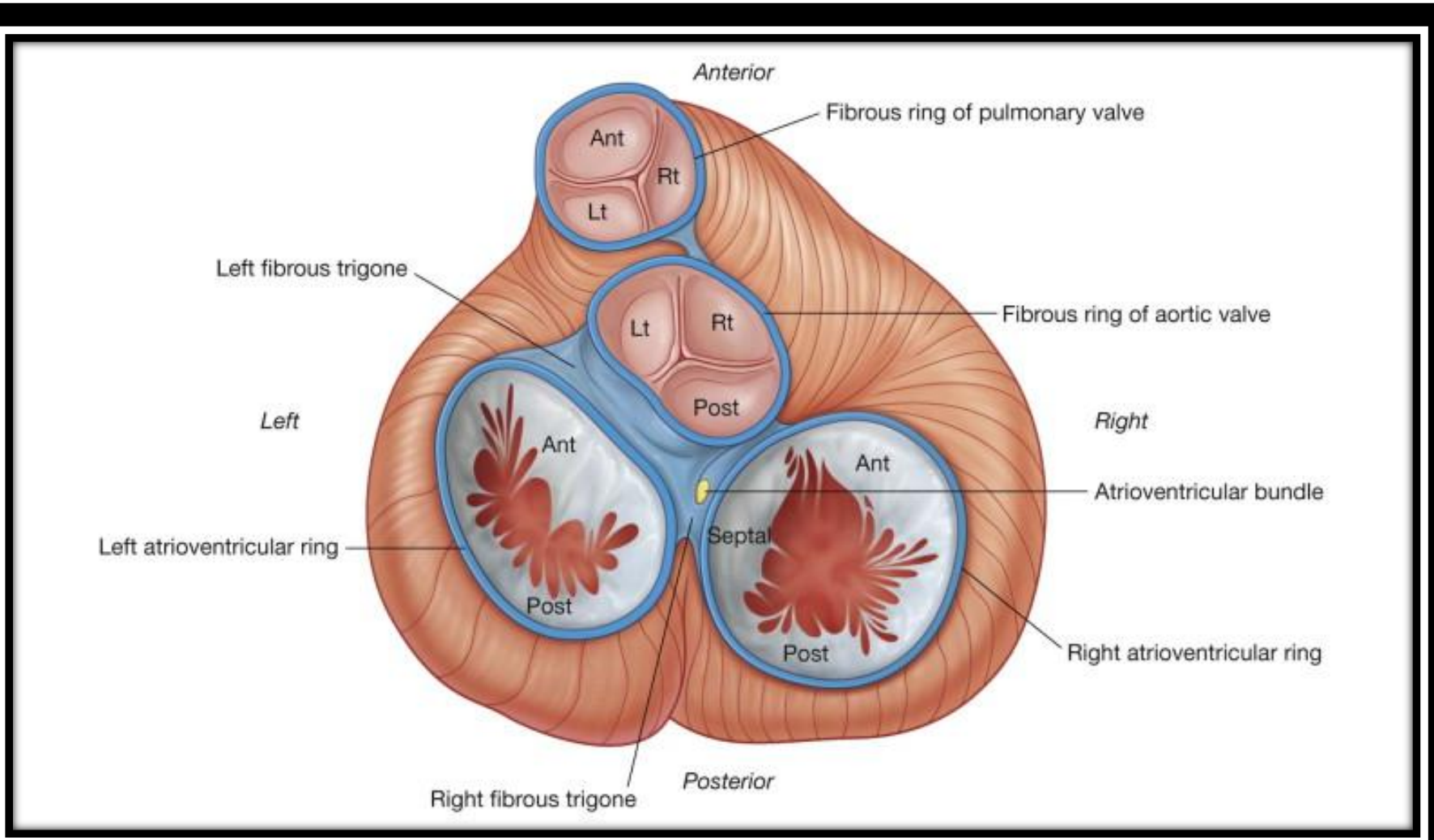
Heart In Situ



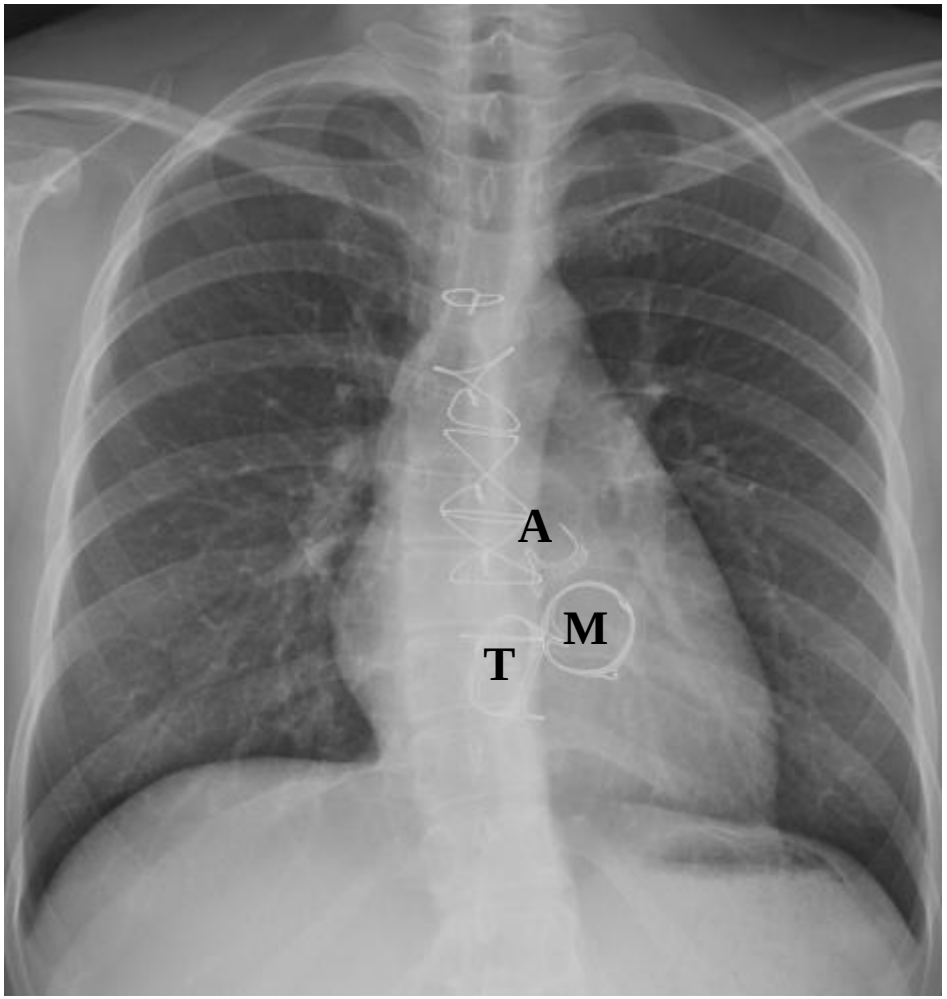
Heart Orientation

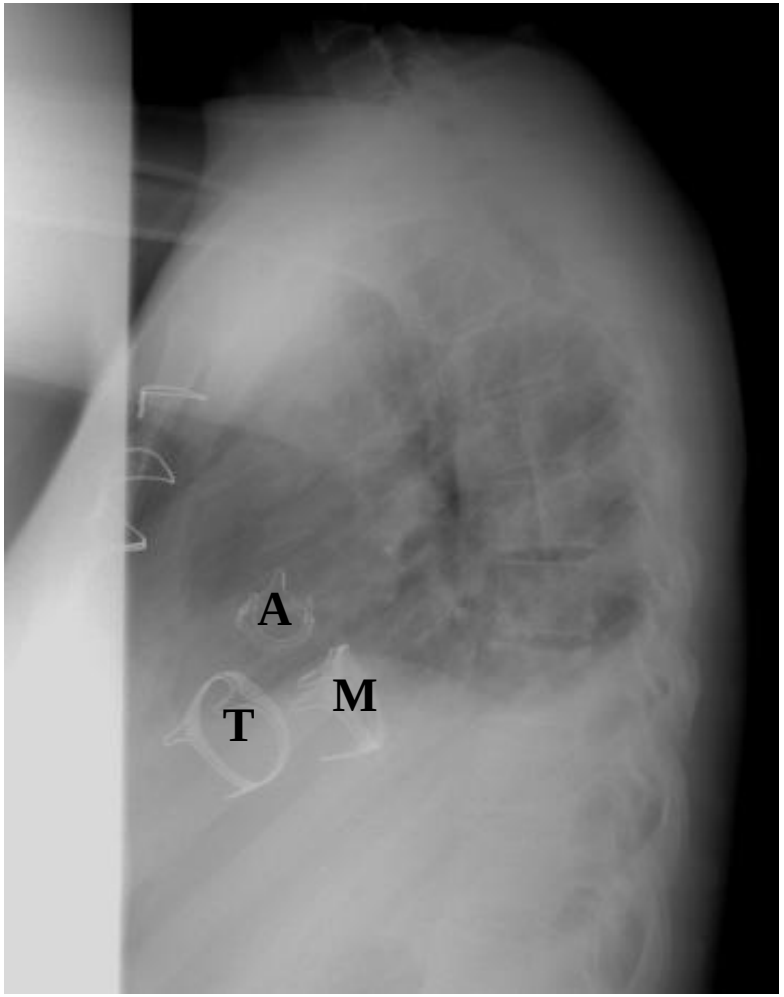


Heart Valves

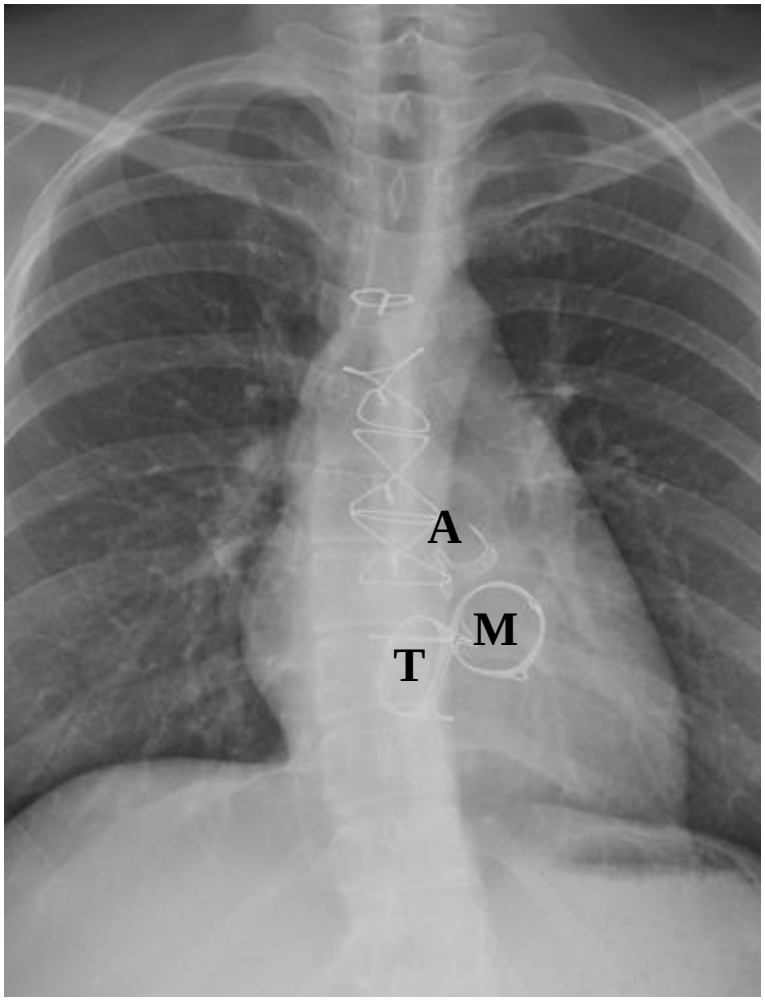


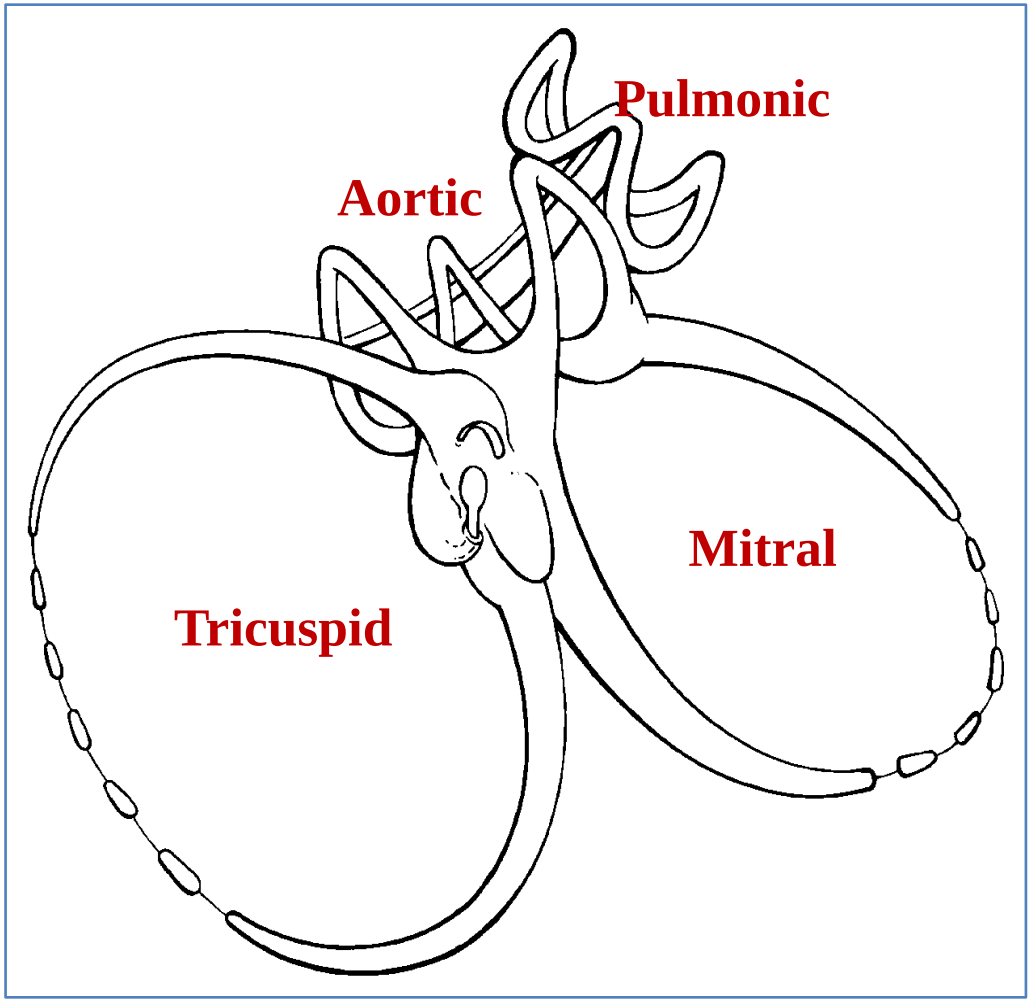
s/p Triple Valve Replacement



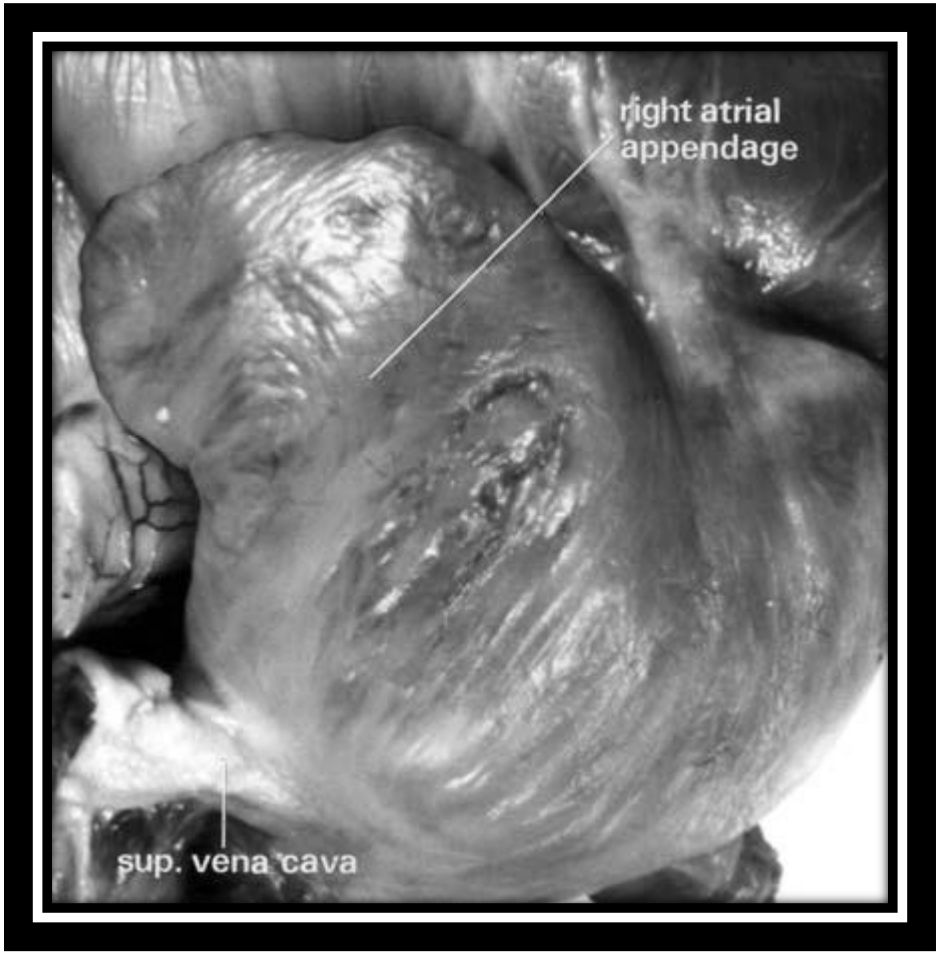


Fibrous Skeleton



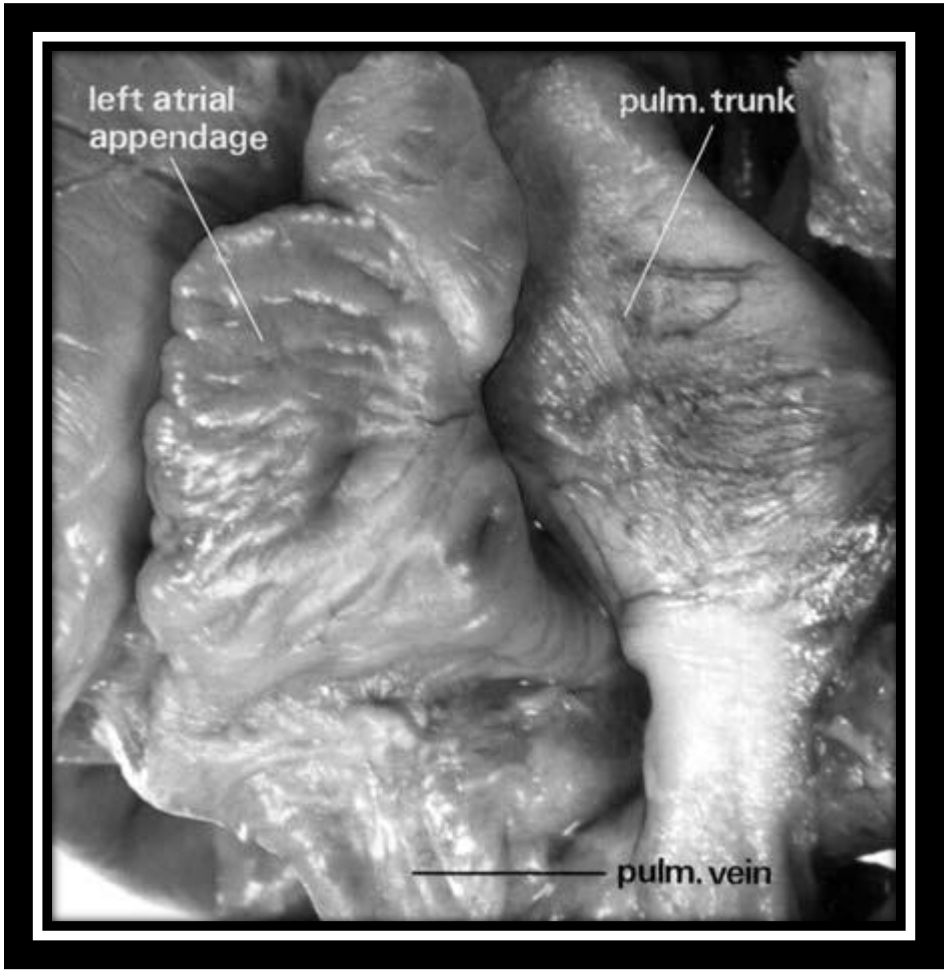


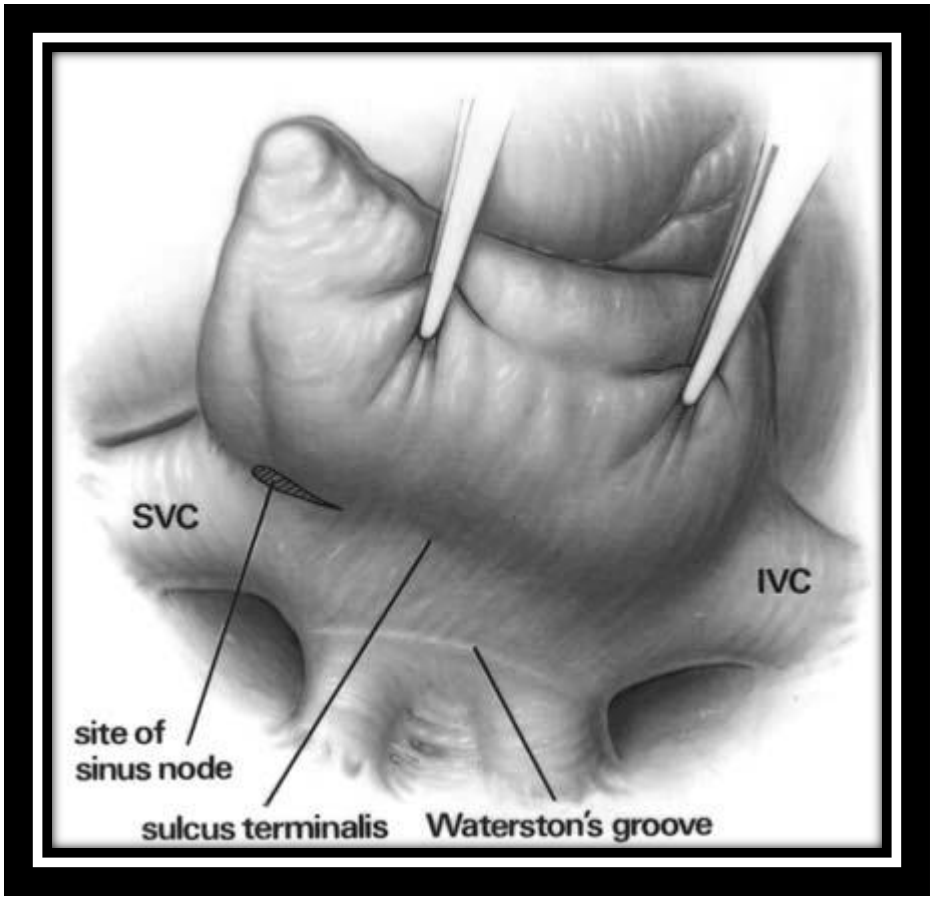
The Right Atrium



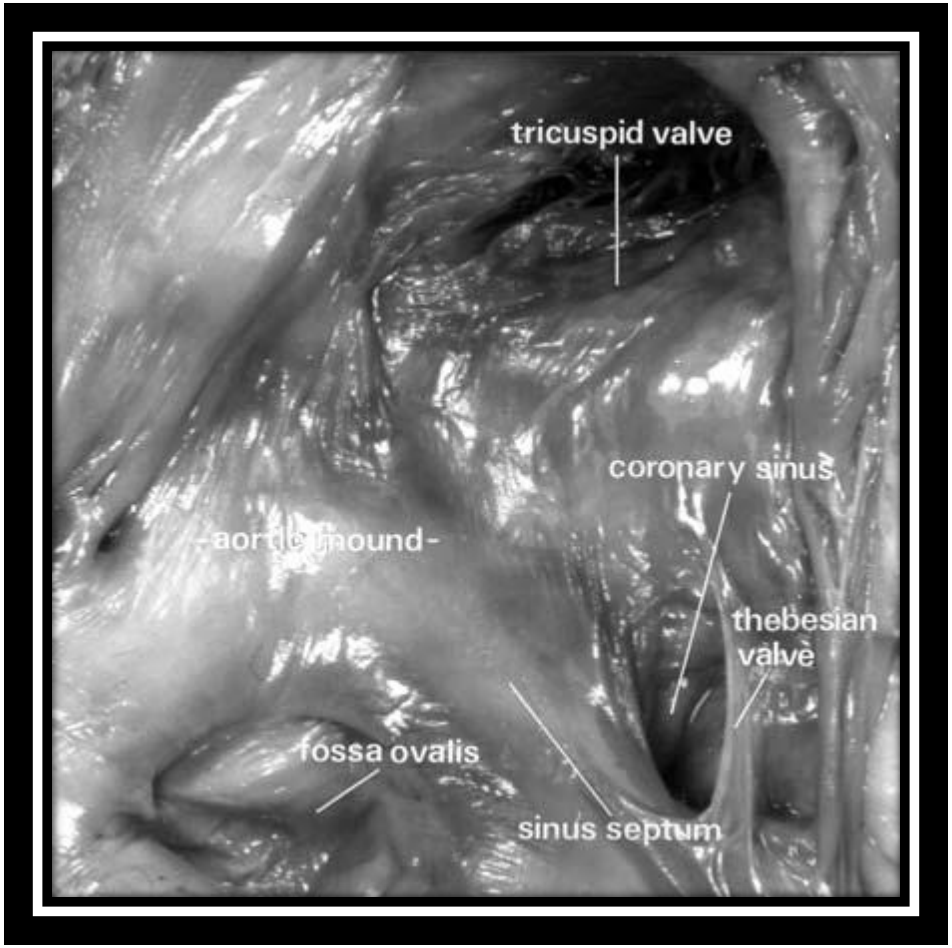
- It extends forward in a pouchlike manner to clasp the right side of the aorta
- When viewed externally in surgical orientation, the appendage is triangular but blunt

Left Atrial Appendage

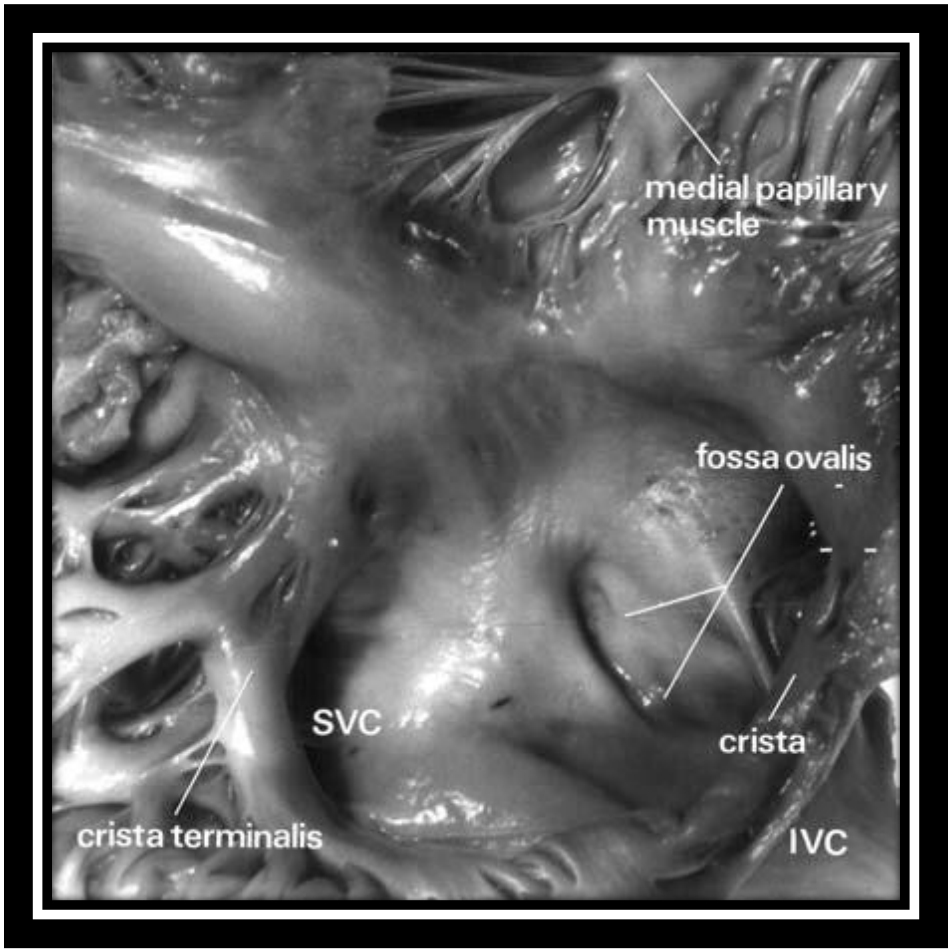




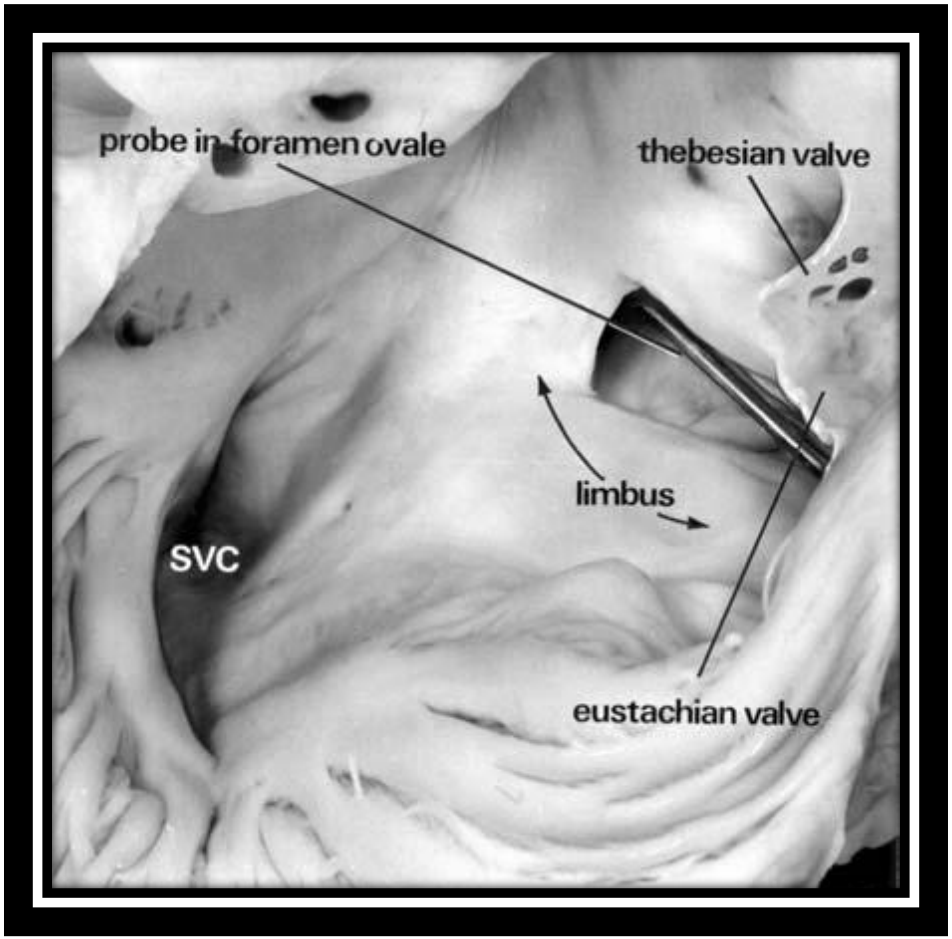
- Sinus node as seen by the surgeon
- A second groove is between the SVC and the PVs and continues toward the IVC, separating it from the LA
- It marks the site of the interatrial fold, and is known as Waterston's groove



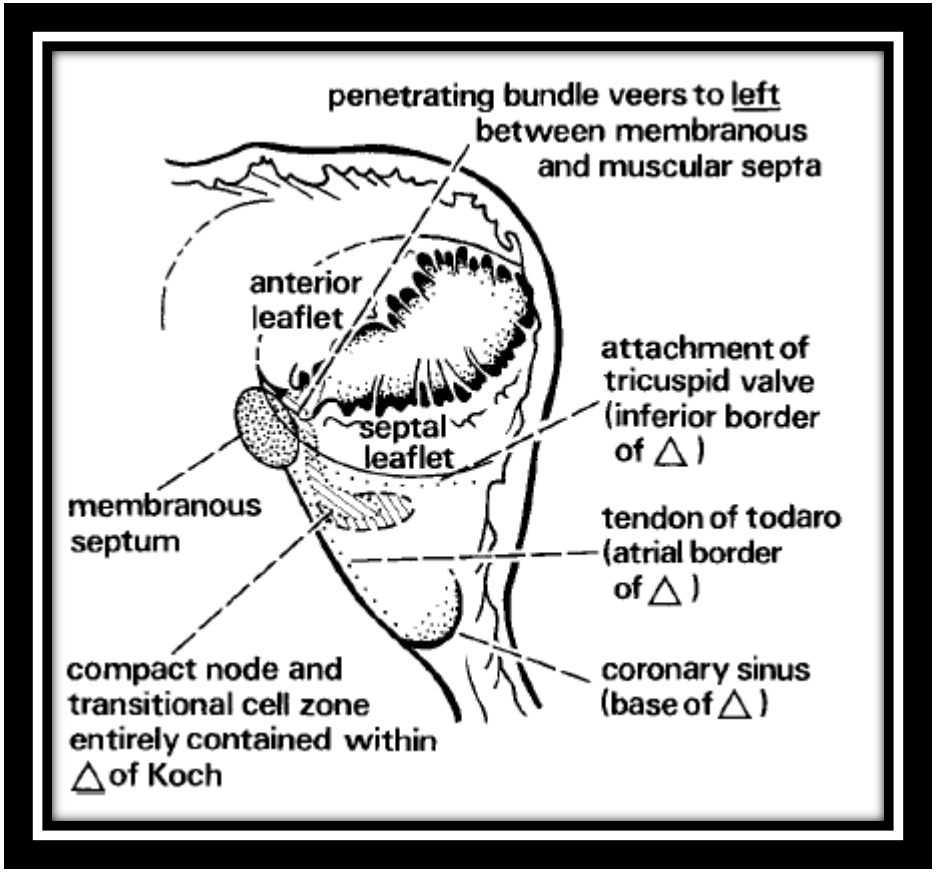
- When the RA is opened, a muscular prominence is seen in its floor; this prominence overlies the root of the aorta and the central fibrous body



- The crista terminalis springs from within the atrial appendage
- It extends onto the septal surface to become continuous with the superior rim of the fossa ovalis

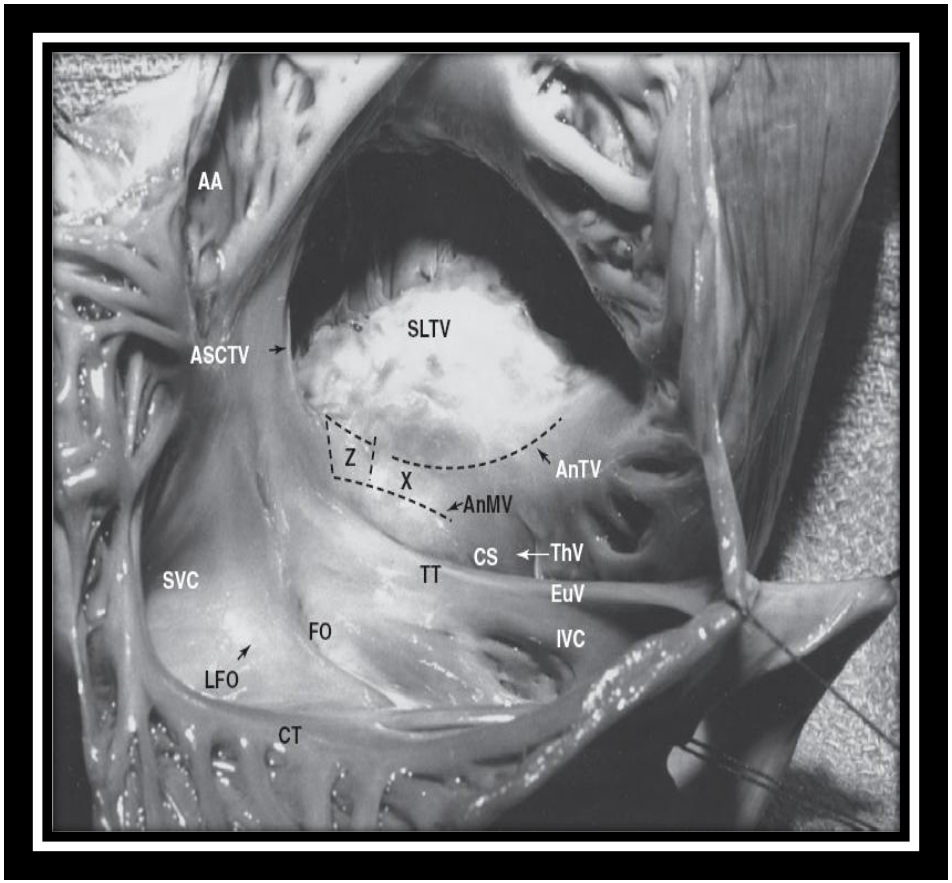


- Fibrous membranes are attached to the crista terminalis at the entrance of the IVC (the valve of the IVC, or Eustachian valve)
- above the entrance of the coronary sinus (the valve of the coronary sinus, or Thebesian valve)



- Tendon of Todaro

  can easily be brought into prominence by placing tension on the Eustachian valve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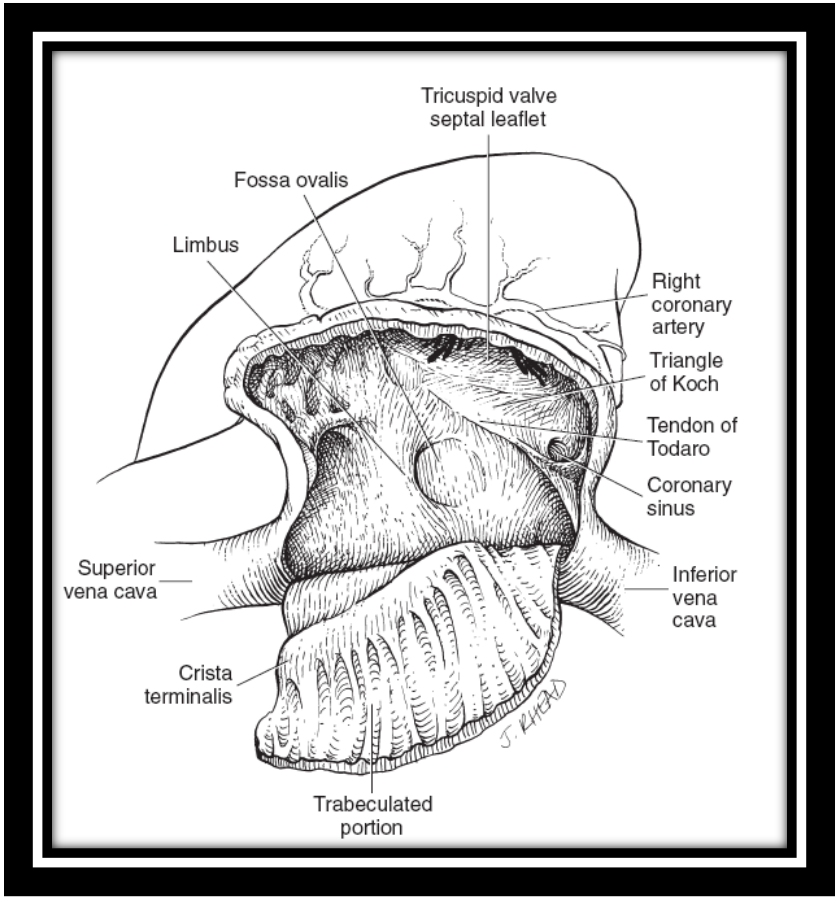
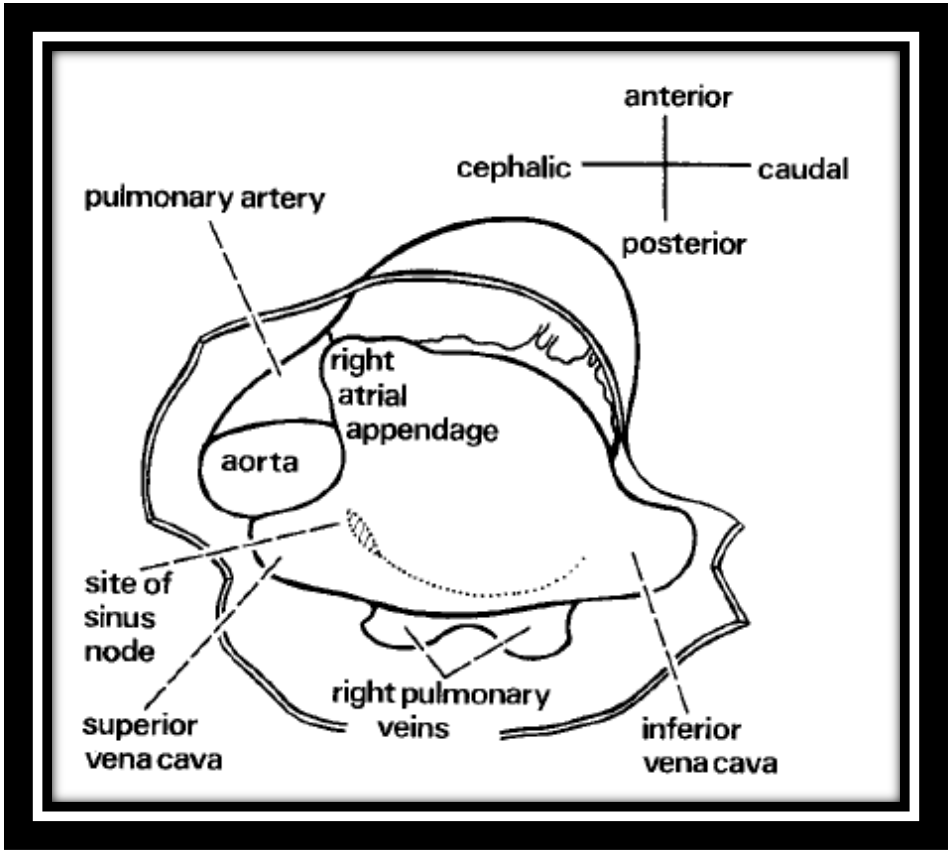

Tricuspid valve septal leaflet
Fossa ovalis
Limbus
Right coronary artery
Triangle of Koch
Tendon of Todaro
Coronary sinus
Superior vena cava
Inferior vena cava
Crista terminalis
Trabeculated portion

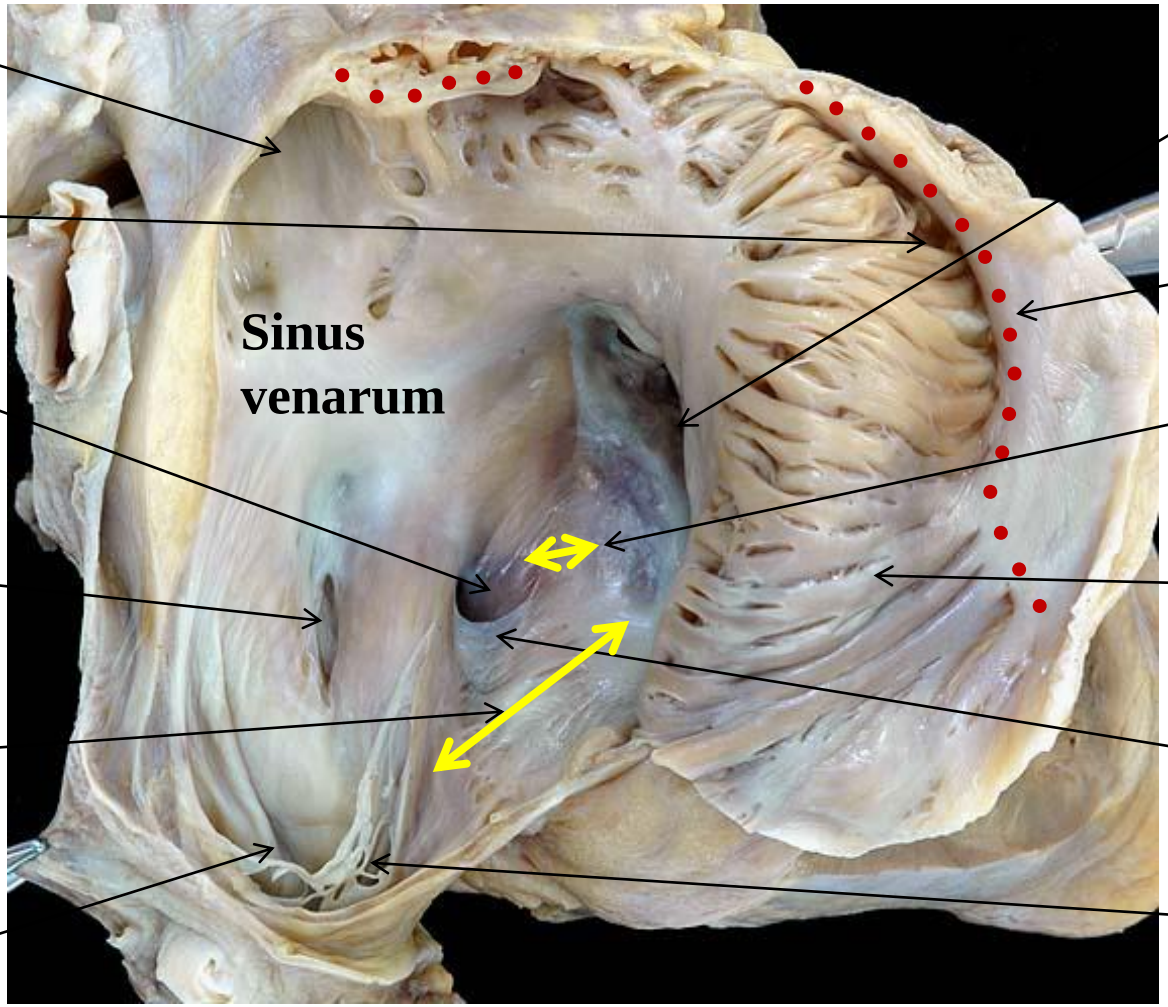


- The sinus node is a small spindle-shaped structure that lies directly subepicardially in the sulcus terminalis
- In about 90% of people, the node is entirely lateral to the junction of the SVC with the RA,

  but in the remaining 10%

  In a horseshoe manner

Right Atrium

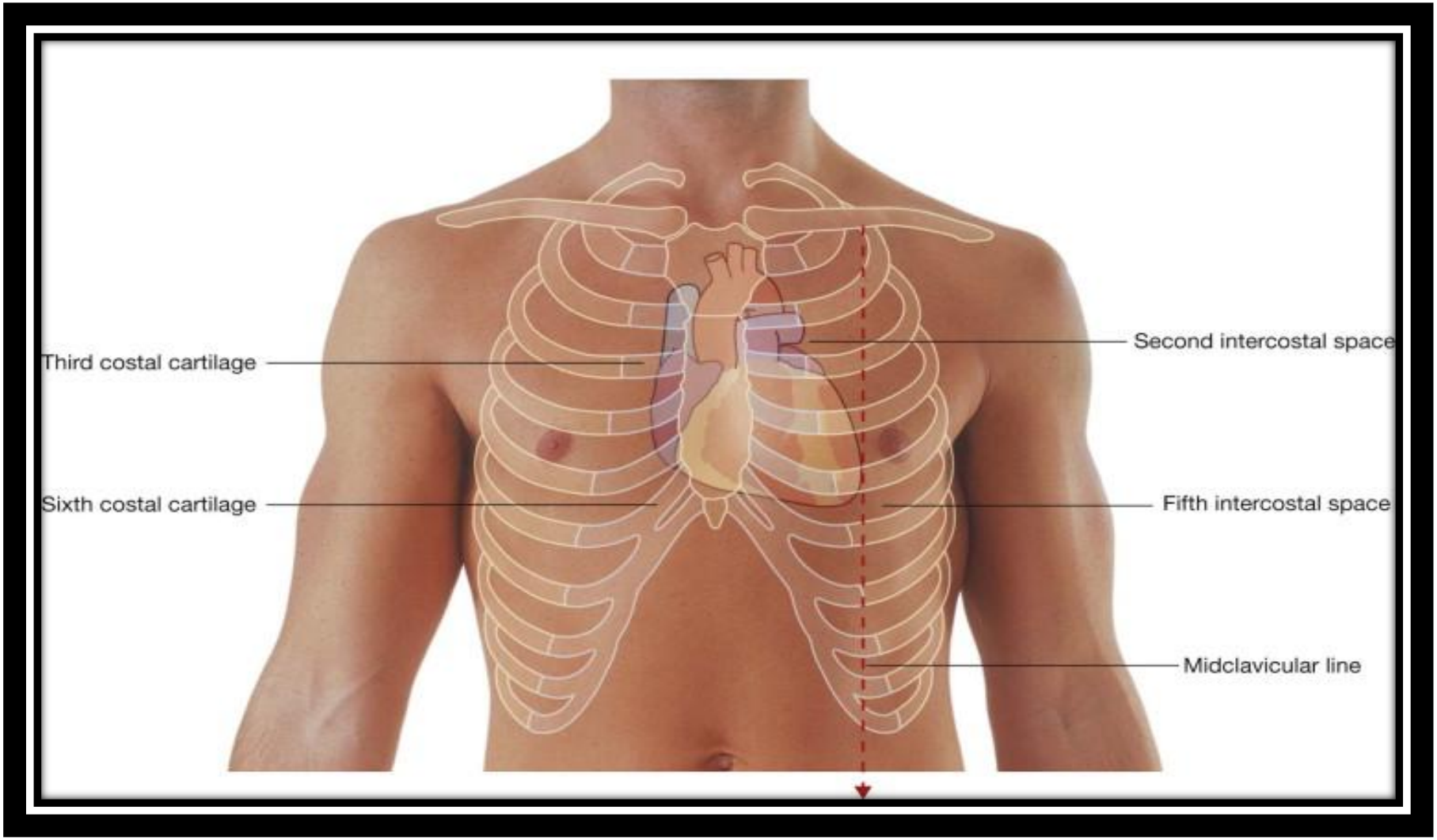


The Left Atrium

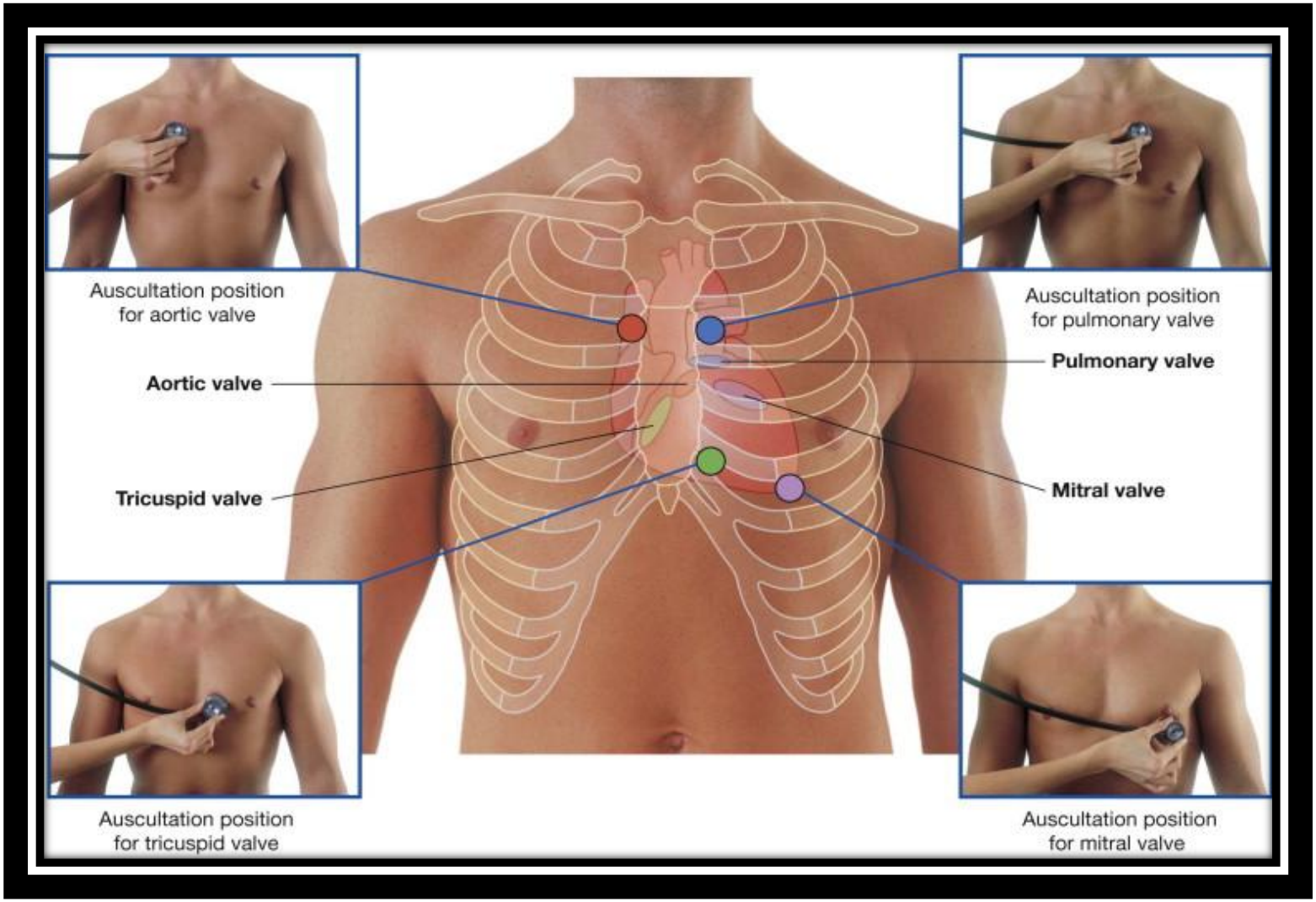
- Shape

  being hooked and usually constricted at several points along its extensive but narrow length
- The appendage extends around the left border of the pulmonary trunk, and is the only part of the LA to appear on the cardiac silhouette

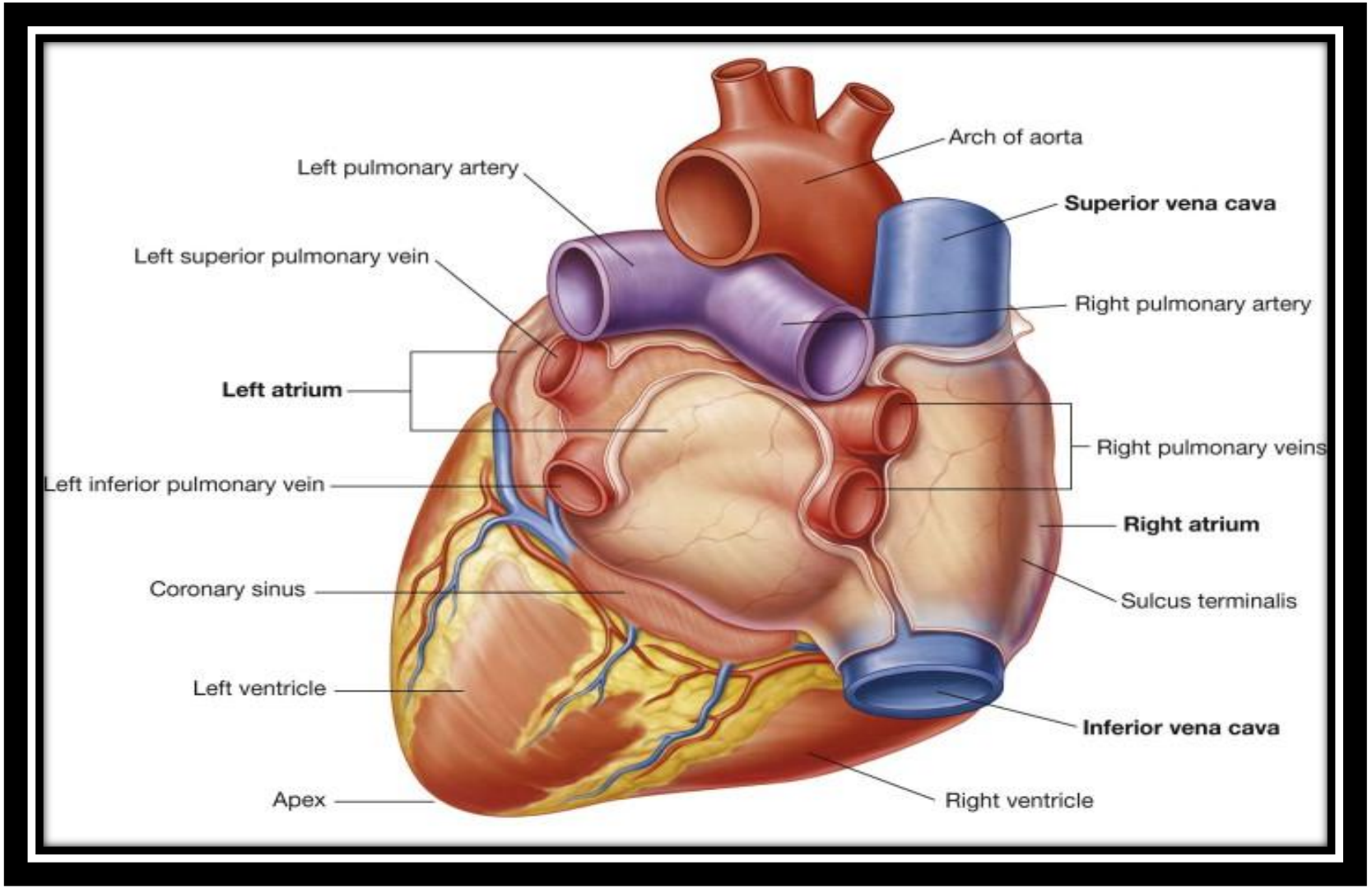
Surface Projection



Auscultation



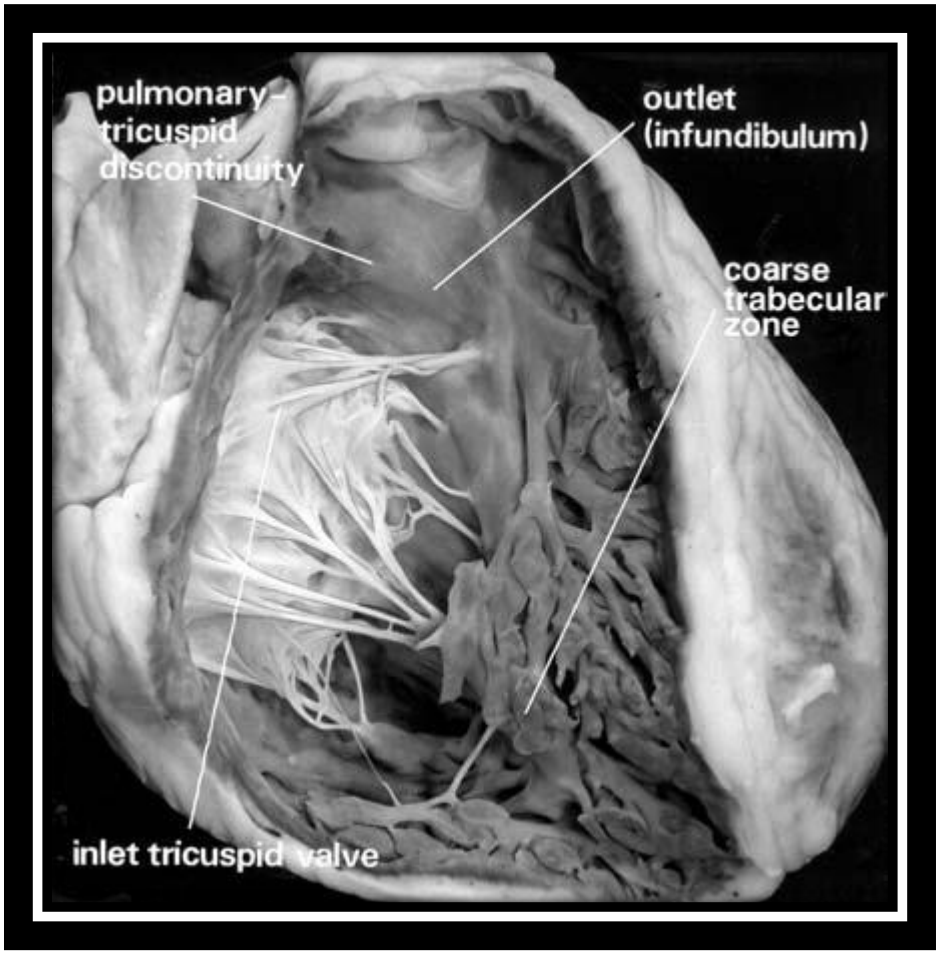
Posterior Surface



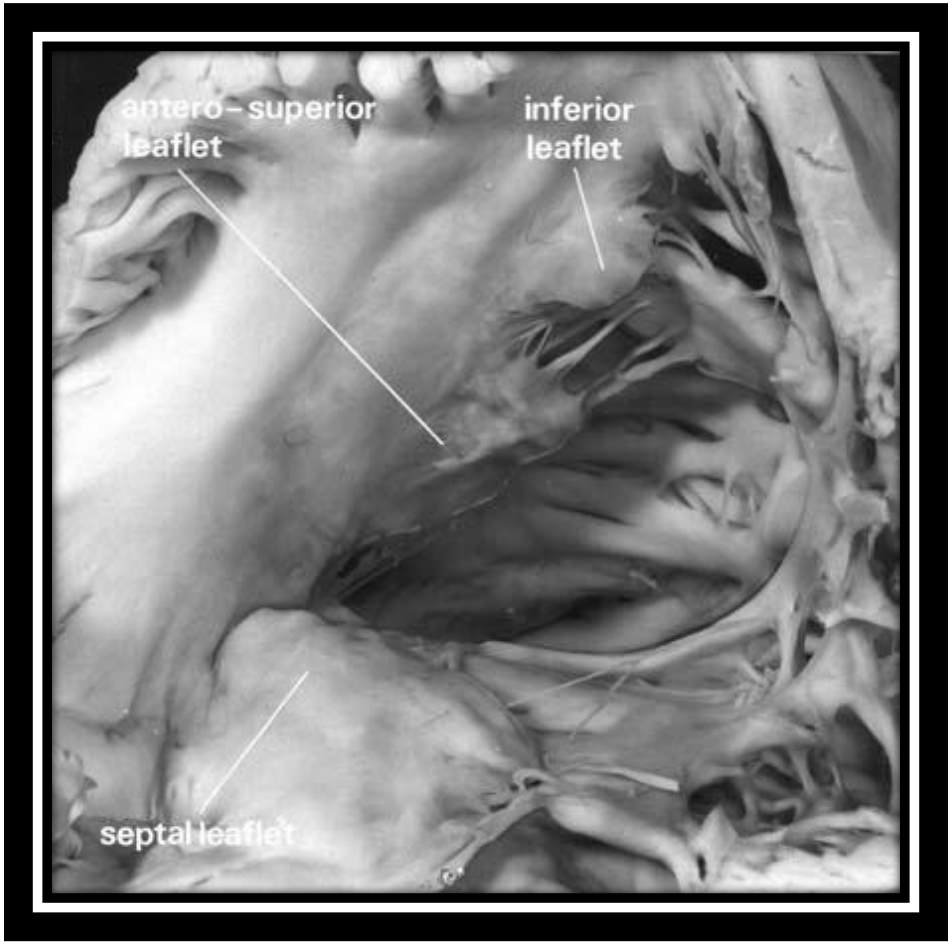
The Ventricles

- Each ventricle is composed of an inlet portion, which contains an atrio-ventricular valve, and is limited by the attachments of its tension apparatus
- The leaflets do not meet at their free edges; rather, they close at about one-third of the distance from the free edge to the attached margin

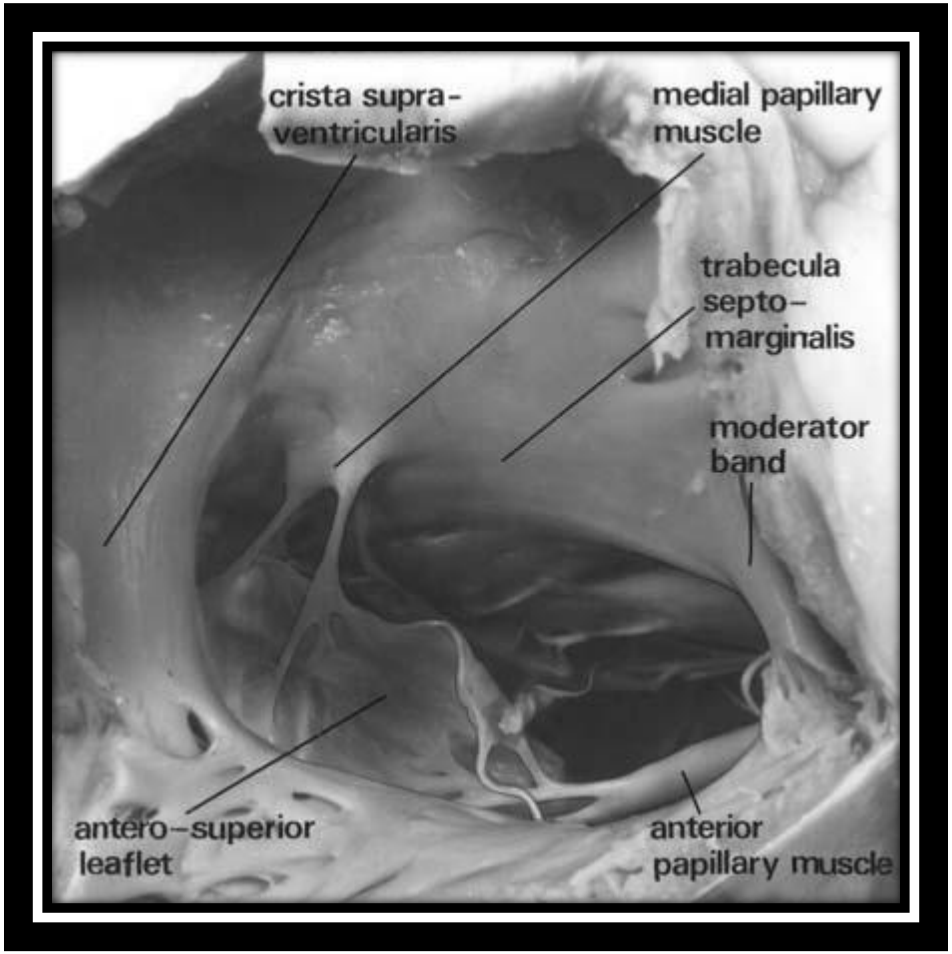
The Morphologically Right Ventricle



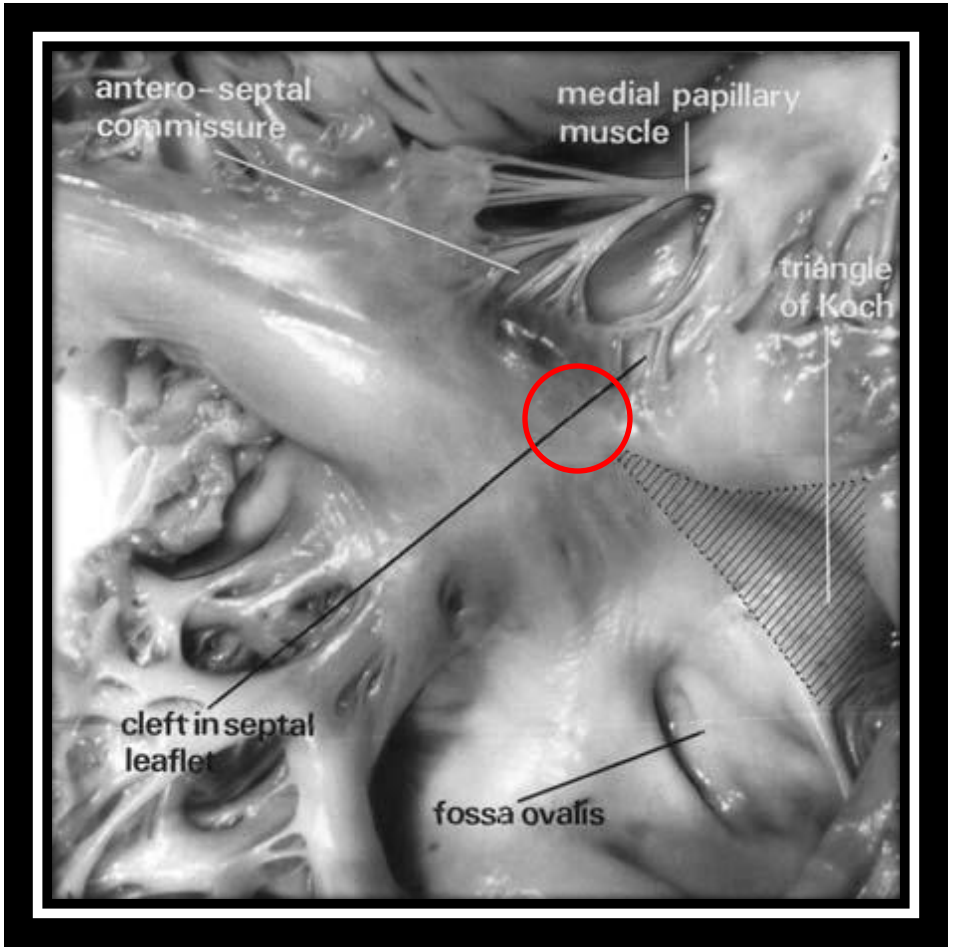
- The apical trabecular zone has coarse trabeculations
- The atrio-ventricular and arterial valves are separated by a prominent muscular shelf in the ventricular roof, the supraventricular crest (crista supraventricularis)



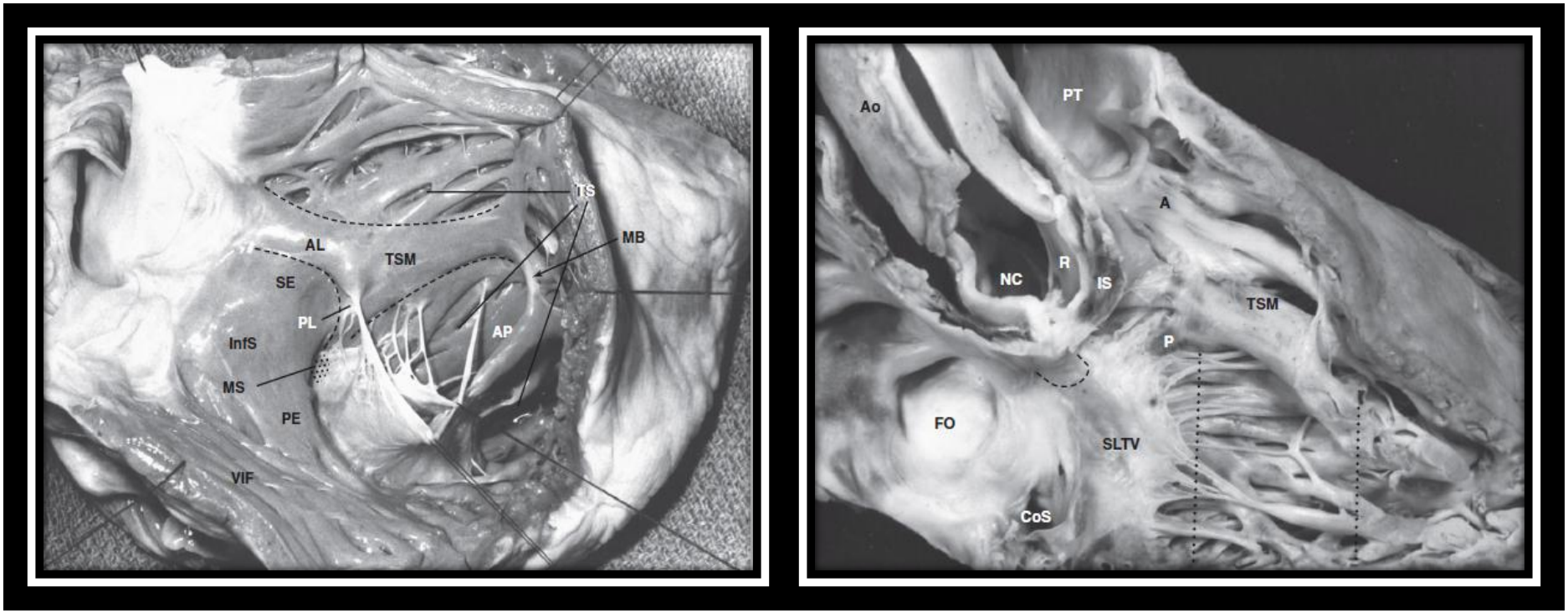
- The three leaflets of the tricuspid valve
- Septal
- Anterosuperior
- Inferior (Posterior)



- The anteroseptal zone of apposition is supported by the almost constant, but small, medial papillary muscle, known also as the muscle of Lancisi, which springs from the inferoposterior limb of the trabecula septomarginalis



- A cleft extending to the area of the membranous septum is frequently seen in the septal leaflet
- The area around both the cleft and the zone of apposition should be avoided at all costs because it is the location of the AV conduction tissues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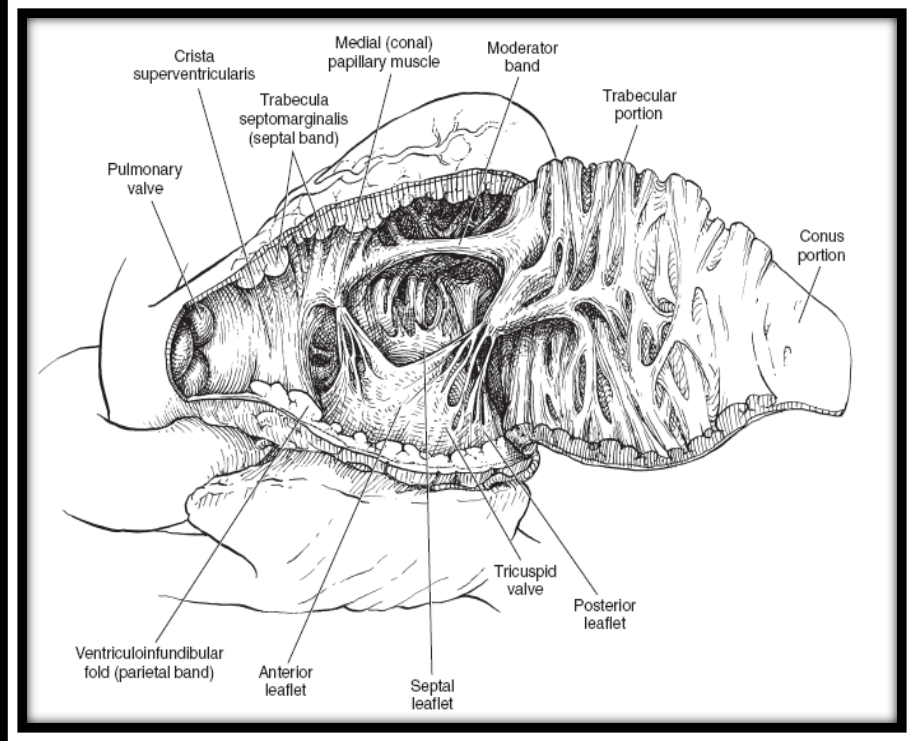
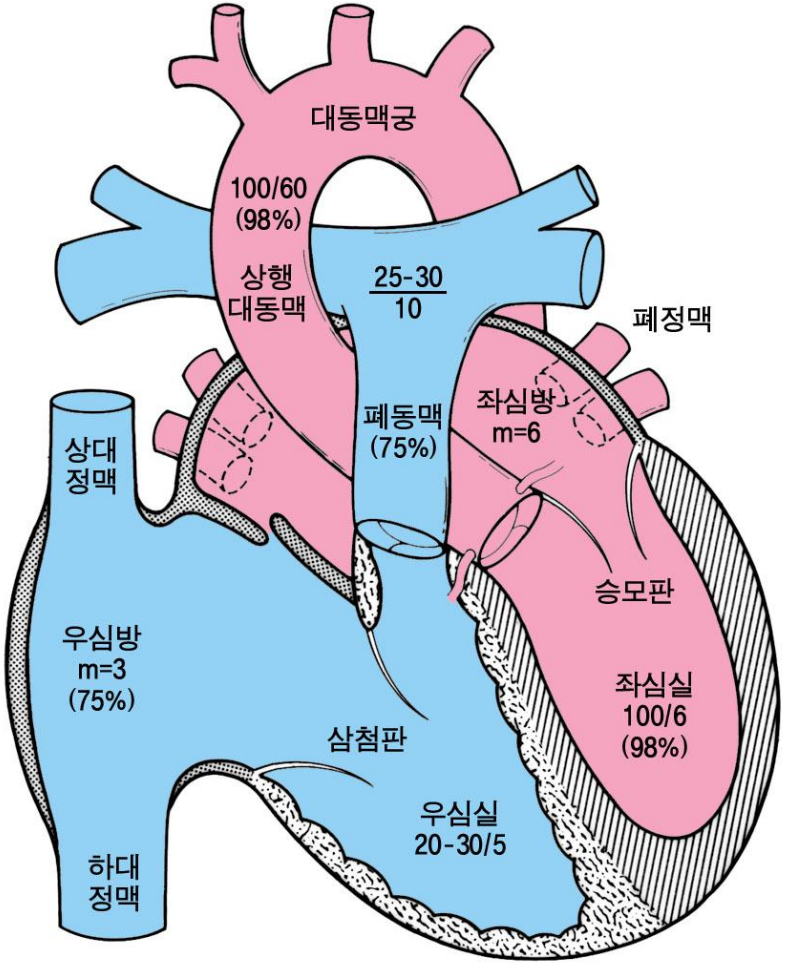
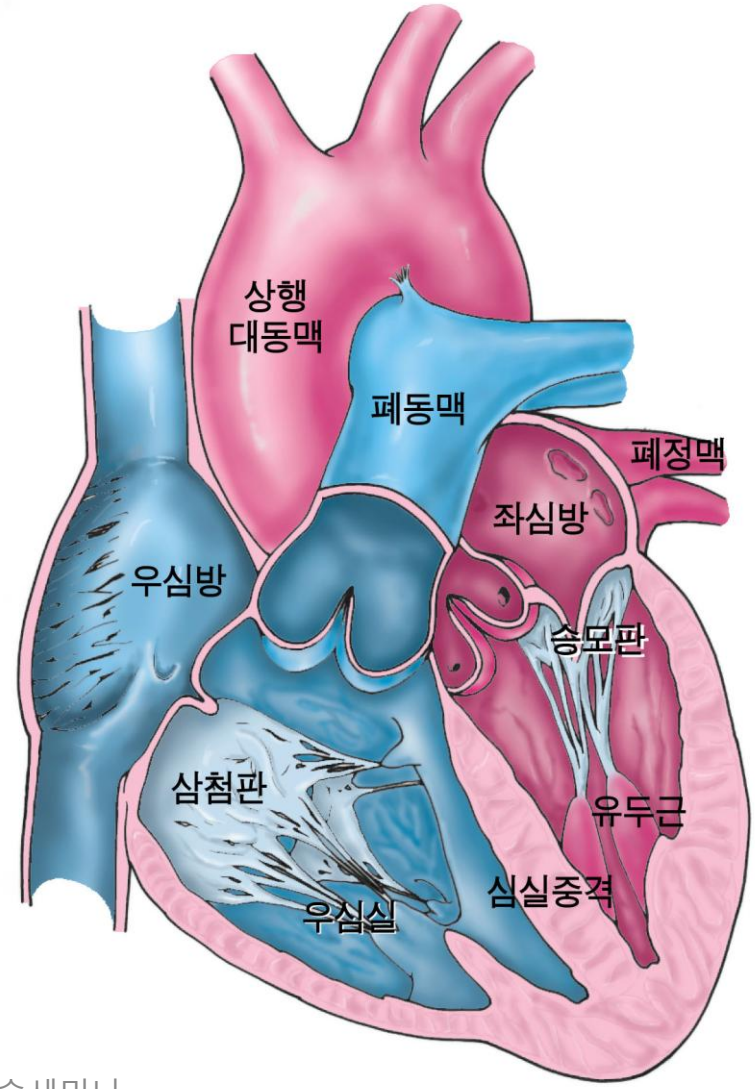

Crista
superventricularis
Medial (conal)
papillary muscle
Moderator
band
Trabecula
septomarginalis
(septal band)
Trabecular
portion
Pulmonary
valve
Conus
portion
Tricuspid
valve
Posterior
leaflet
Ventriculoinfundibular
fold (parietal band)
Anterior
leaflet
Septal
leaflet

우심실과 좌심실의 형태학적 특징





우심실(right ventricle, RV)의 특징

1) **벽의 근육이 좌심실에 비해 많이 얇다.** 좌심실에 비해서 약 1/3~1/4정도로 얇다. 거의 대부분의 선천성 심장병에서는 우심실에 과대하게 부과되는 용적이나 압력부담 때문에 우심실 근육이 두꺼워진다

2) **벽의 근육이 울퉁불퉁하다 (Trabeculation)**

3) 모양은 앞뒤로 눌리고 양옆으로 퍼진 모양으로 흉골의 바로 아래에 위치하며 **둥근 모양의 좌심실 위에 얹혀있는 모양이다**

4) **입구가 삼첨판과 연결되어있다 (Apical displacement)**

좌심실(left ventricle, LV)의 특징

1) 벽의 근육이 우심실에 비해 훨씬 두껍다

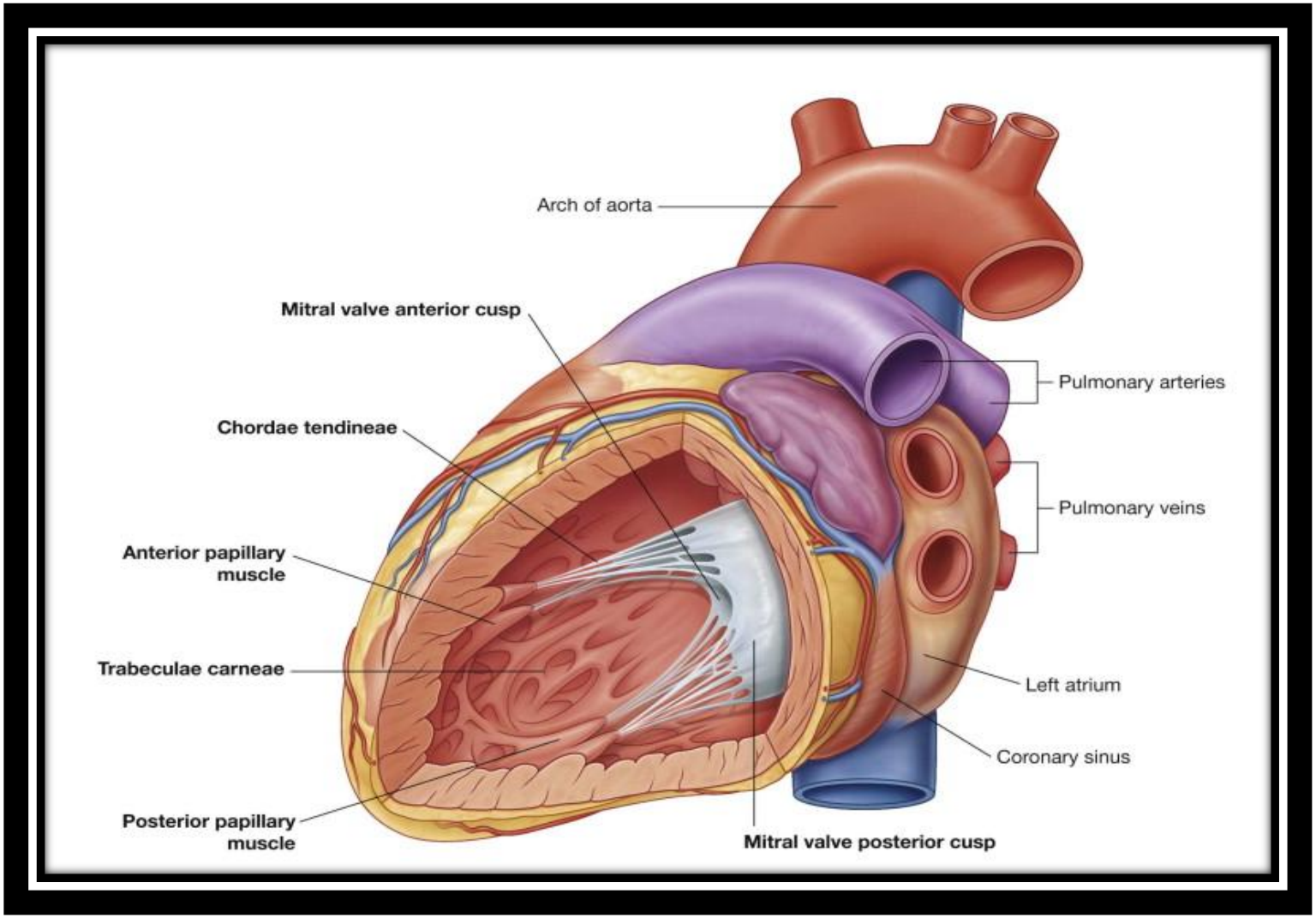
2) 벽의 근육 표면이 비교적 매끈하다

3) 좌심실은 아래쪽이 뾰족한 딸기모양으로써 두꺼운 벽의 근육과 함께 높은 압력을 내는 펌프로써 아주 효과적인 모양을 하고 있다.

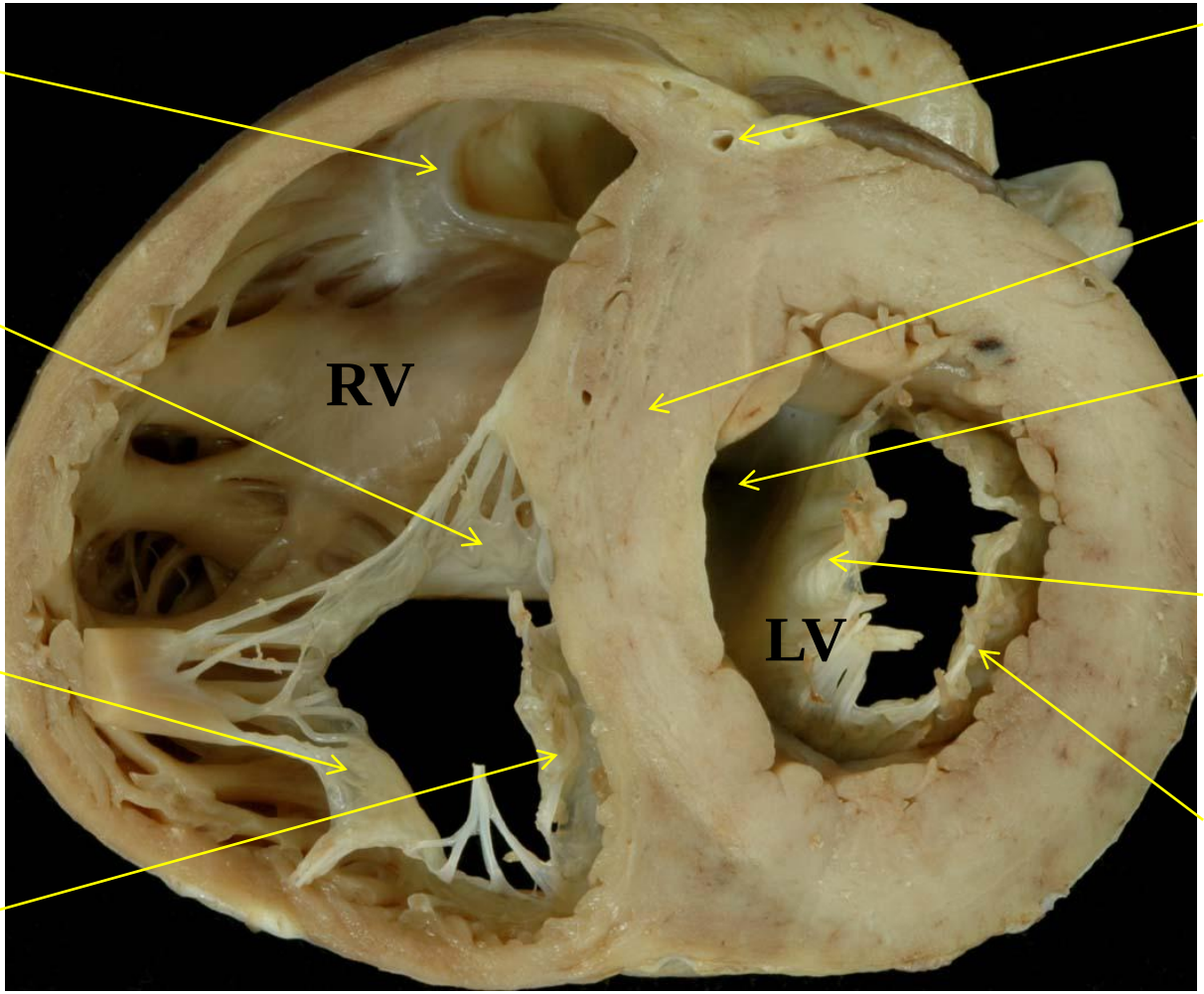
4) 입구가 승모판과 연결되어 있다

5) 유두근이 2개 뚜렷이 보인다

Internal view of LV



Short Axis View of the Ventricles



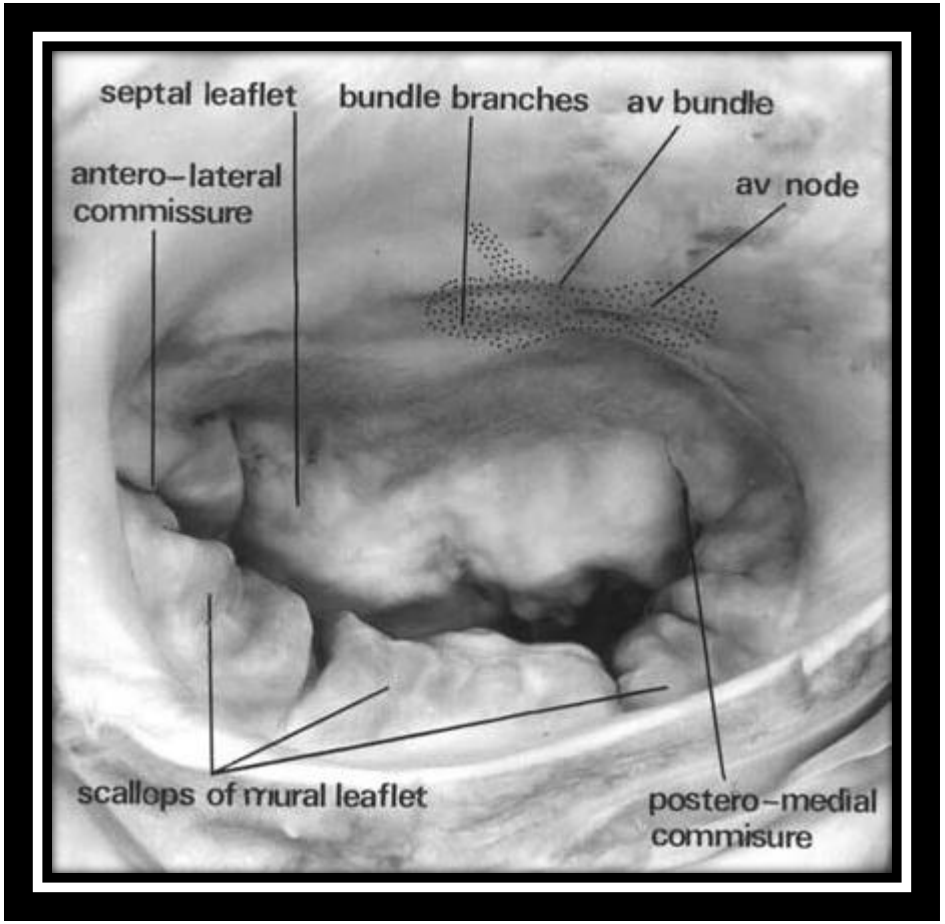
The Morphologically Left Ventricle

- The apical trabecular zone of the LV

  fine trabeculations

- The leaflets of its atrio-ventricular and arterial valves are in fibrous continuity

- The septal surface is smooth

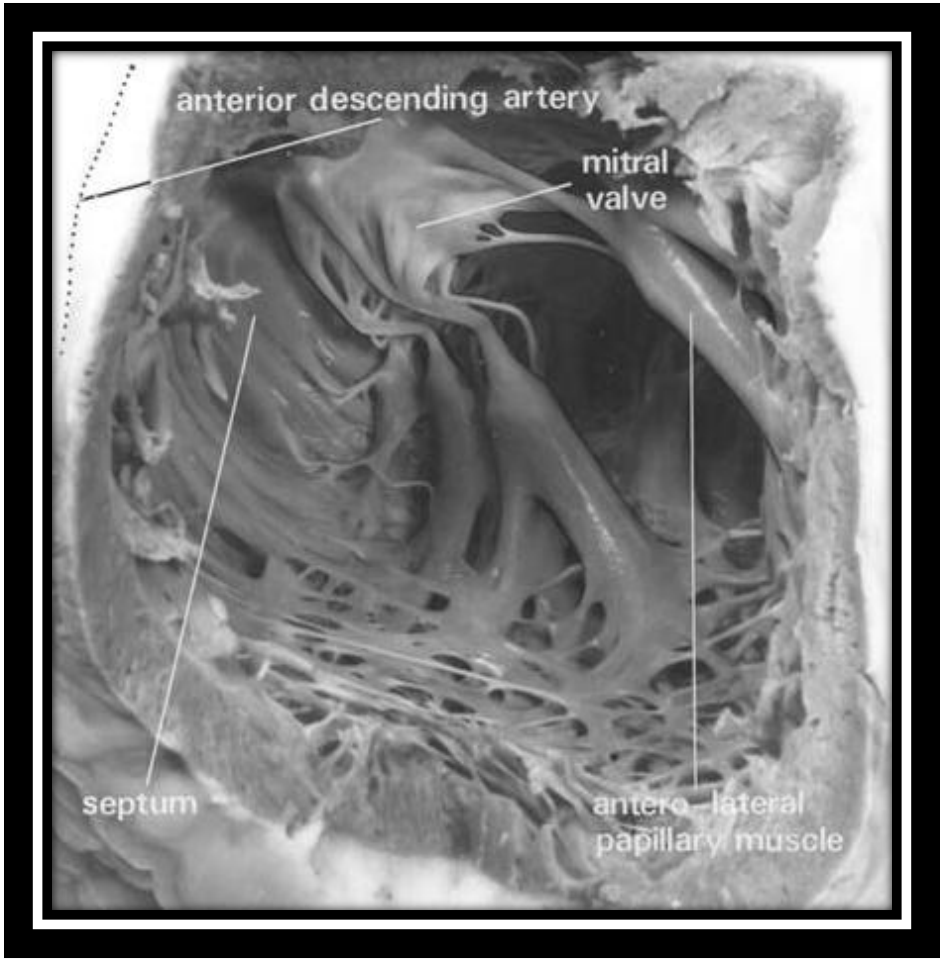


- The aortic leaflet (Ant.)

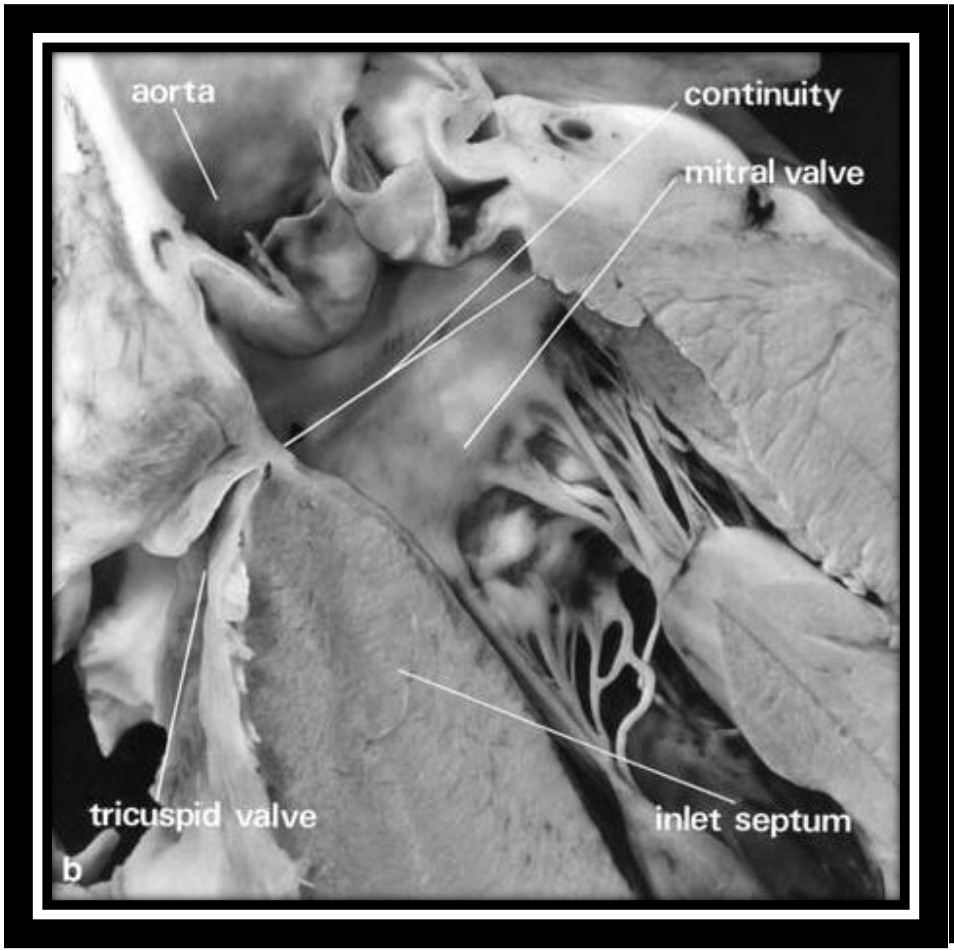
  In fibrous continuity with the leaflets of the AV

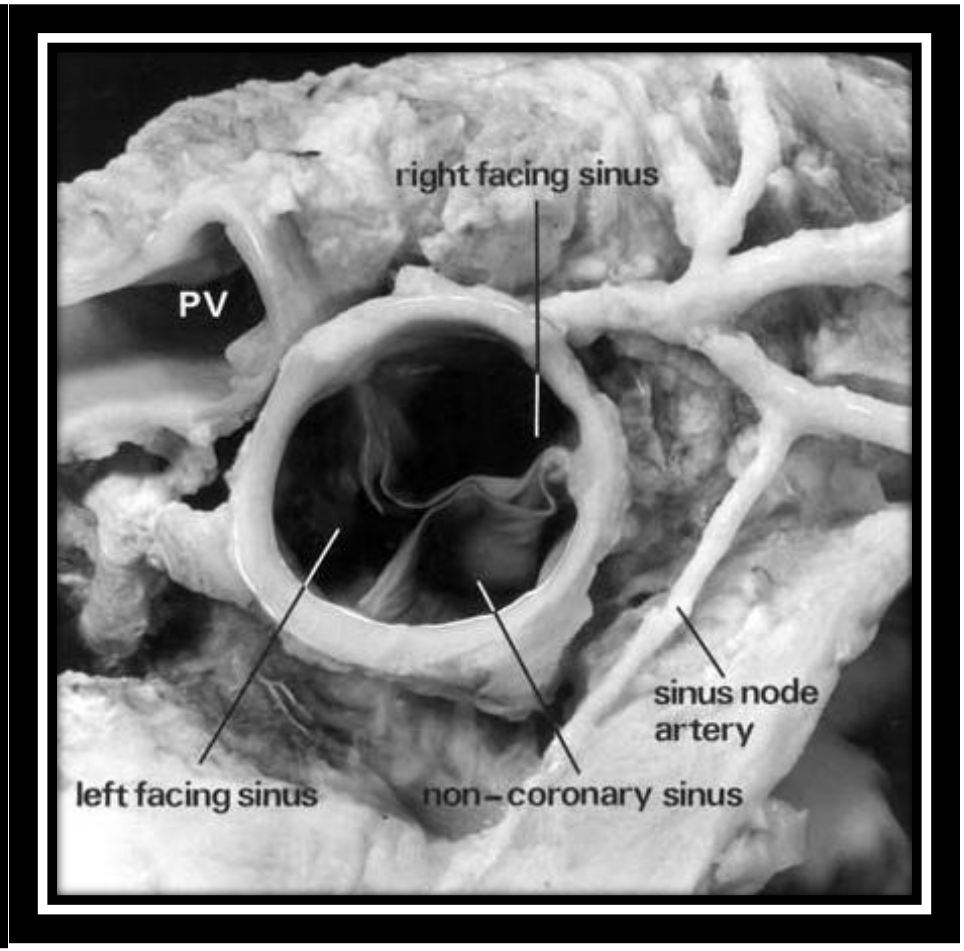
- The mural leaflet (Post.)

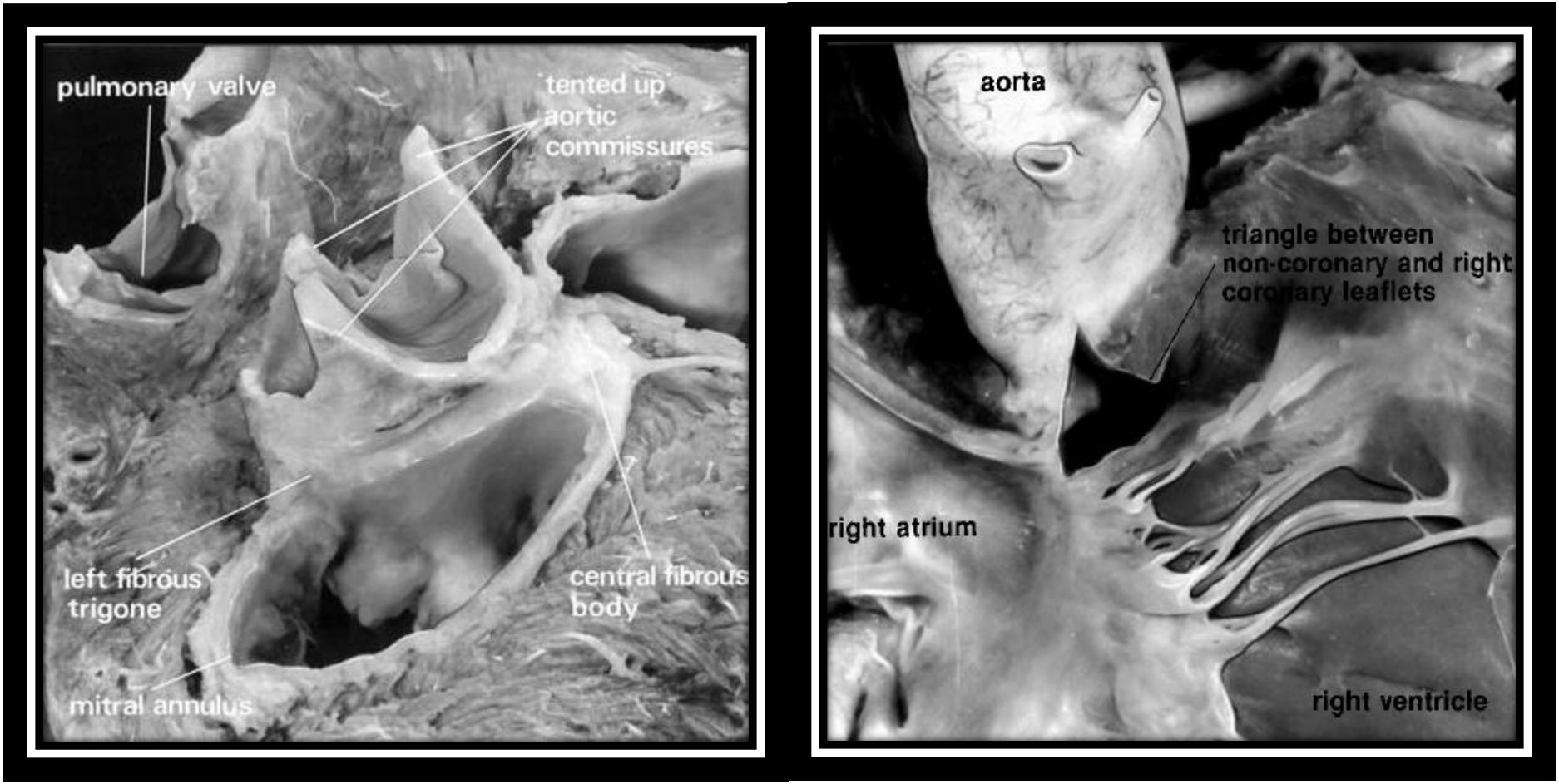
  attachment of the valve laterally may be closely related to the left coronary artery


anterior descending artery
mitral valve
septum
antero-lateral papillary muscle


aorta
outlet septum
membran-ous septum
ventriculo-infundibular fold
a


aorta
continuity
mitral valve
tricuspid valve
inlet septum
b


right facing sinus
PV
sinus node artery
left facing sinus
non-coronary sinus


pulmonary valve
tented up aortic commissures
left fibrous trigone
central fibrous body
mitral annulus
aorta
triangle between non-coronary and right coronary leaflets
right atrium
right ventricle

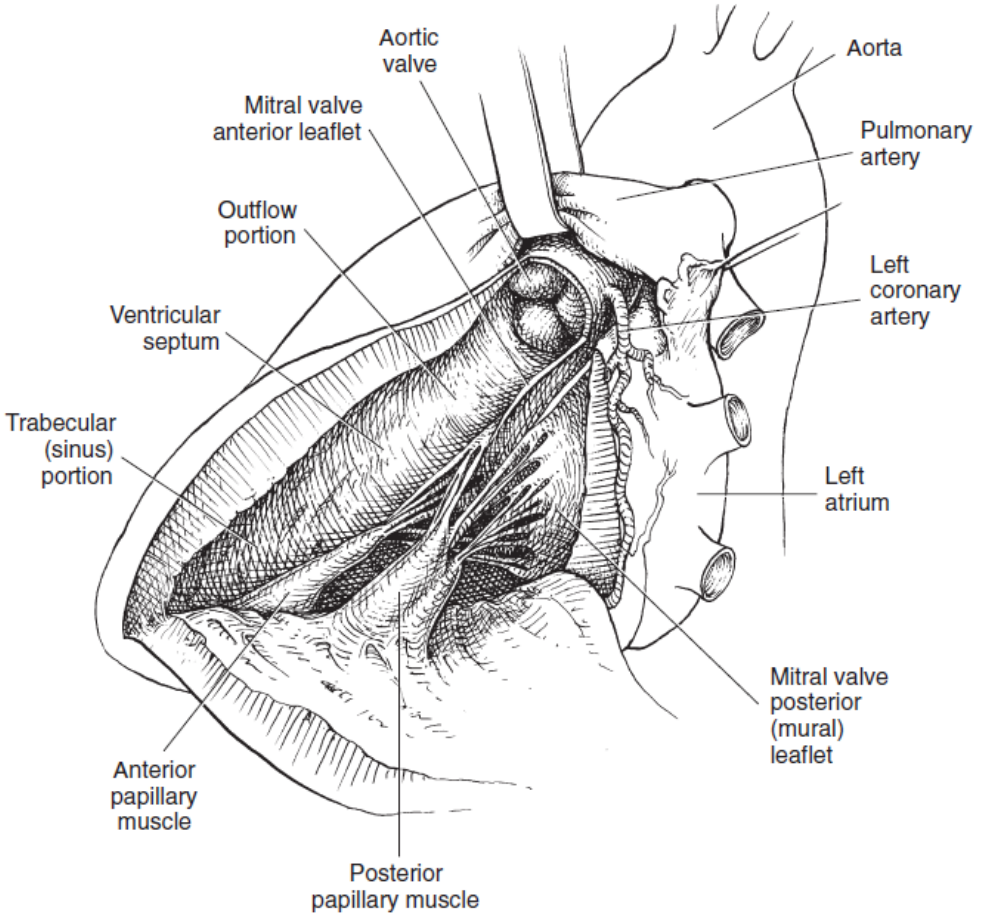
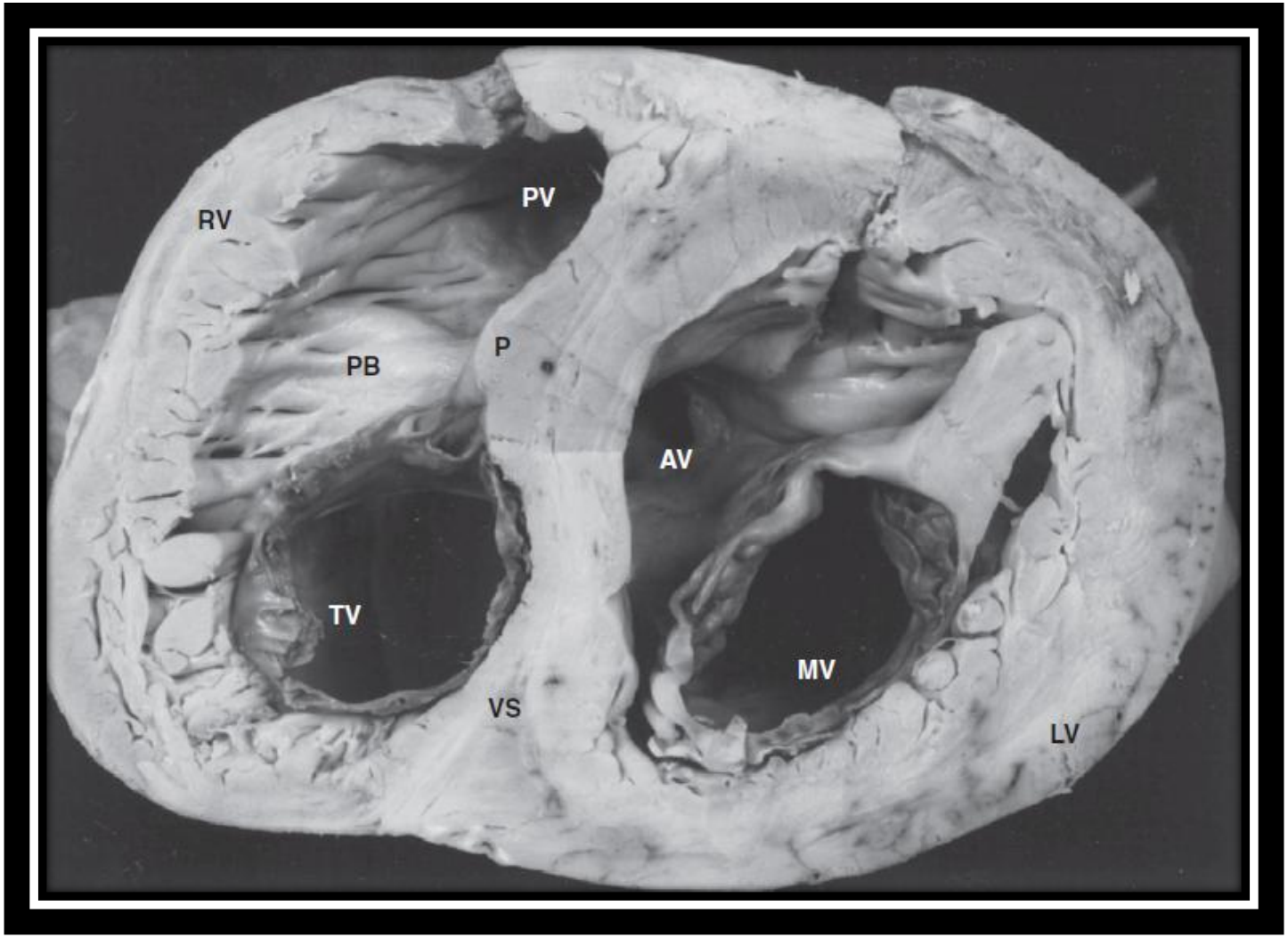
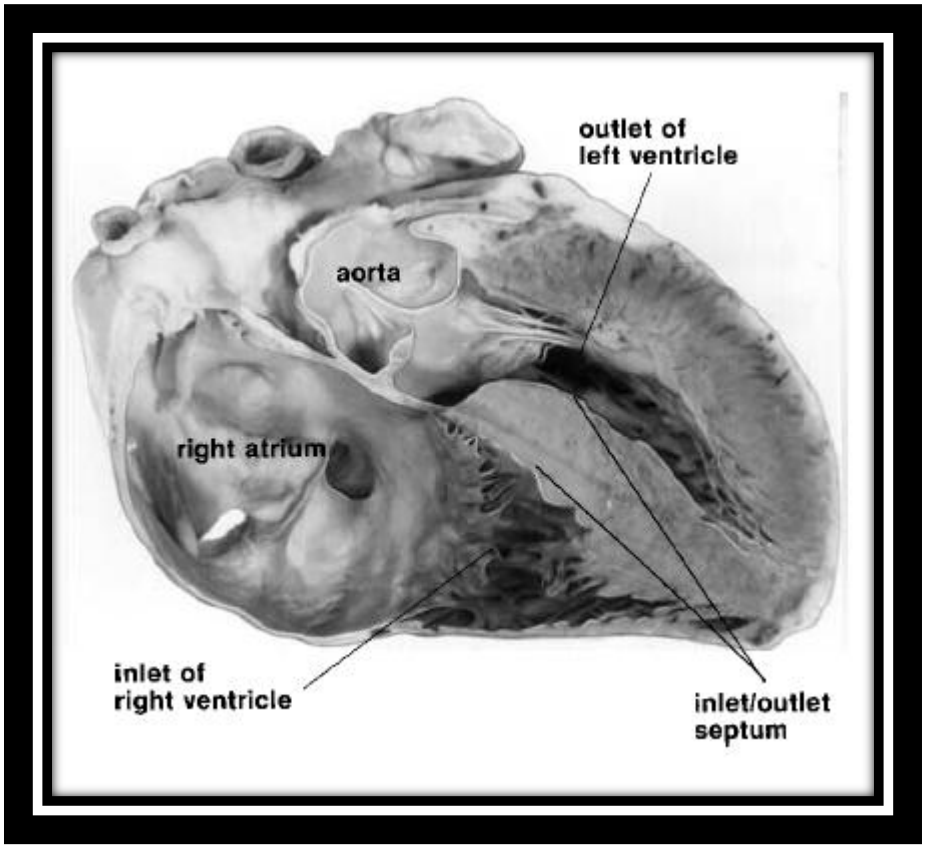


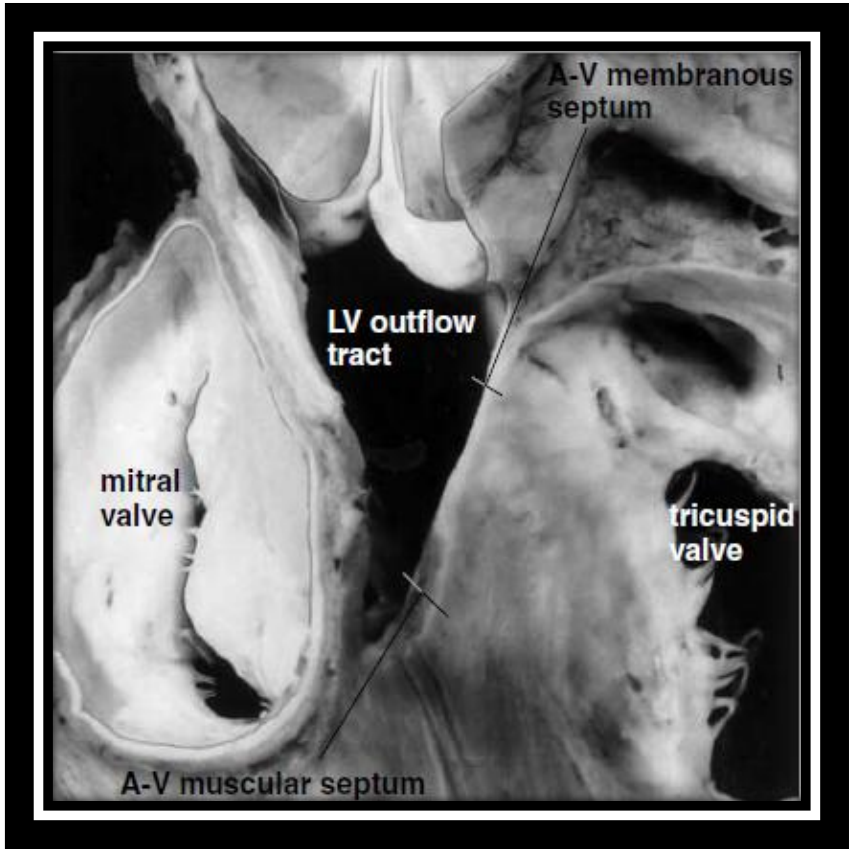
Figure 1-14 Interior of left ventricle, lateral view. Trabecular and outflow portions of ventricular septum are demonstrated. Inflow portion is beneath and behind mitral valve. Anterior leaflet of mitral valve is in fibrous continuity with aortic valve. Passageway below aortic valve, bounded by outflow portion of ventricular septum and anterior leaflet of mitral valve, is called the *left ventricular outflow tract*. Mitral valve is supported by two papillary muscles, anterior and posterior, arising from free wall of left ventricle.

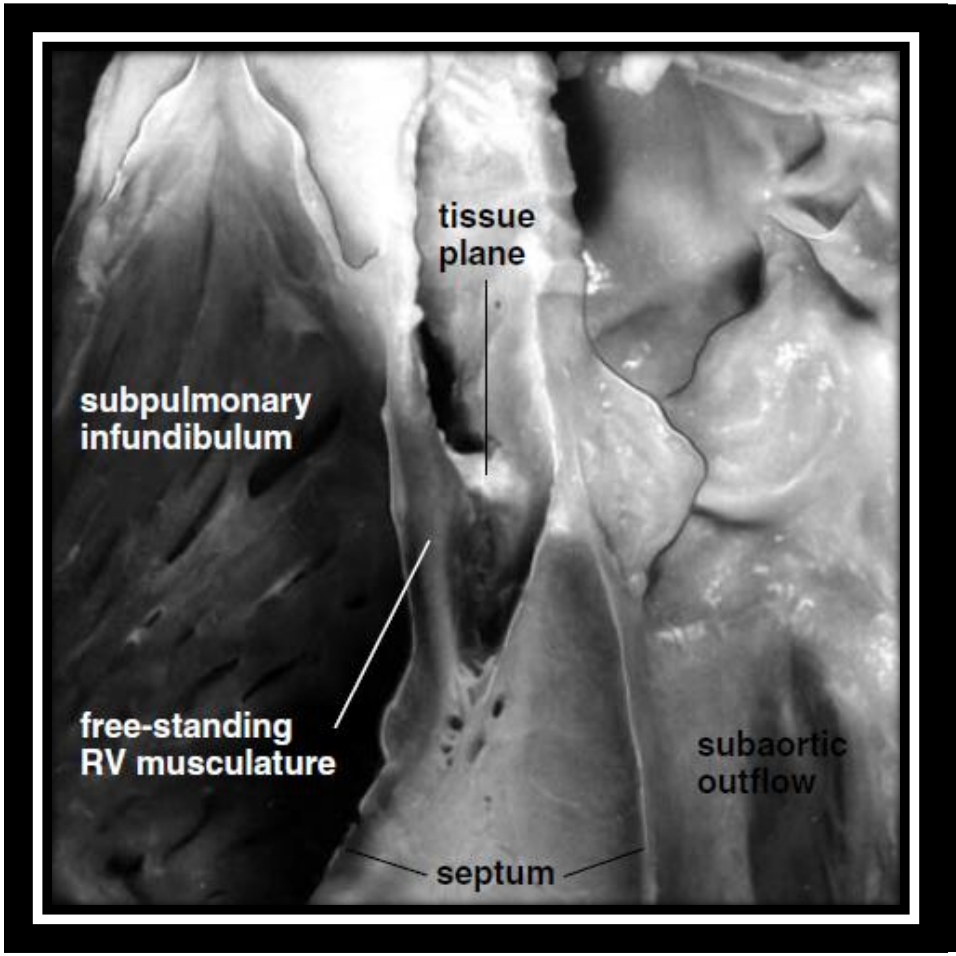

RV
PV
P
PB
AV
TV
MV
VS
LV

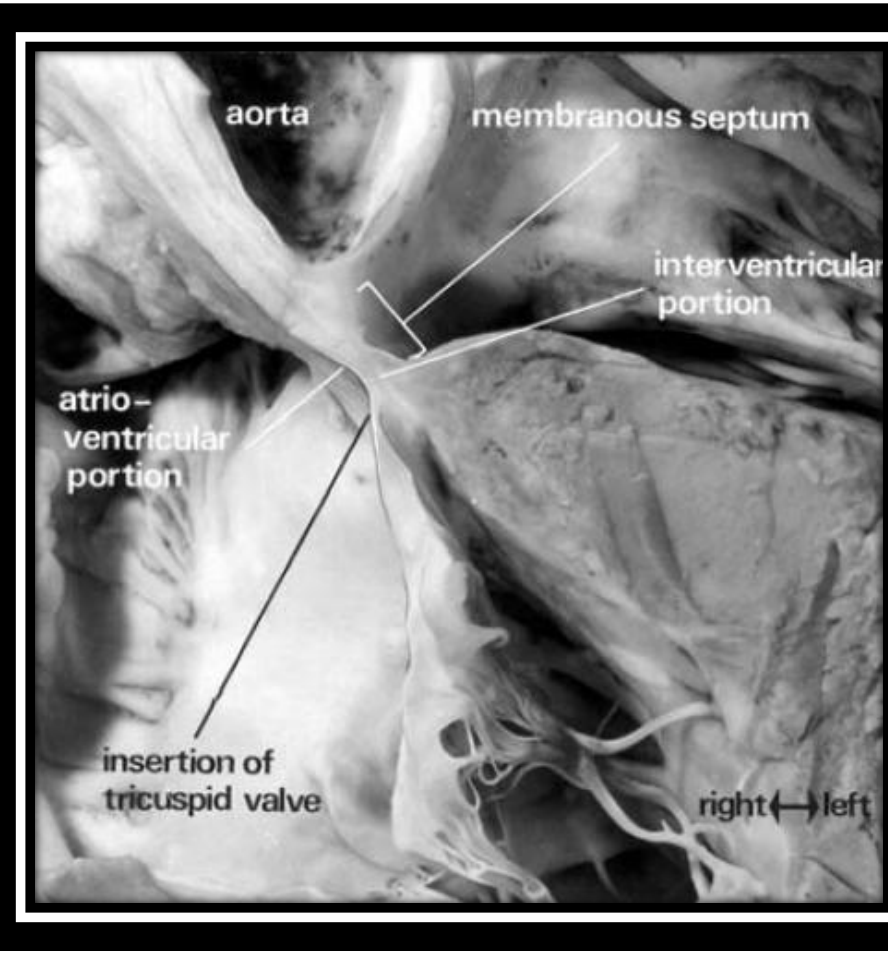
The Ventricular Septum

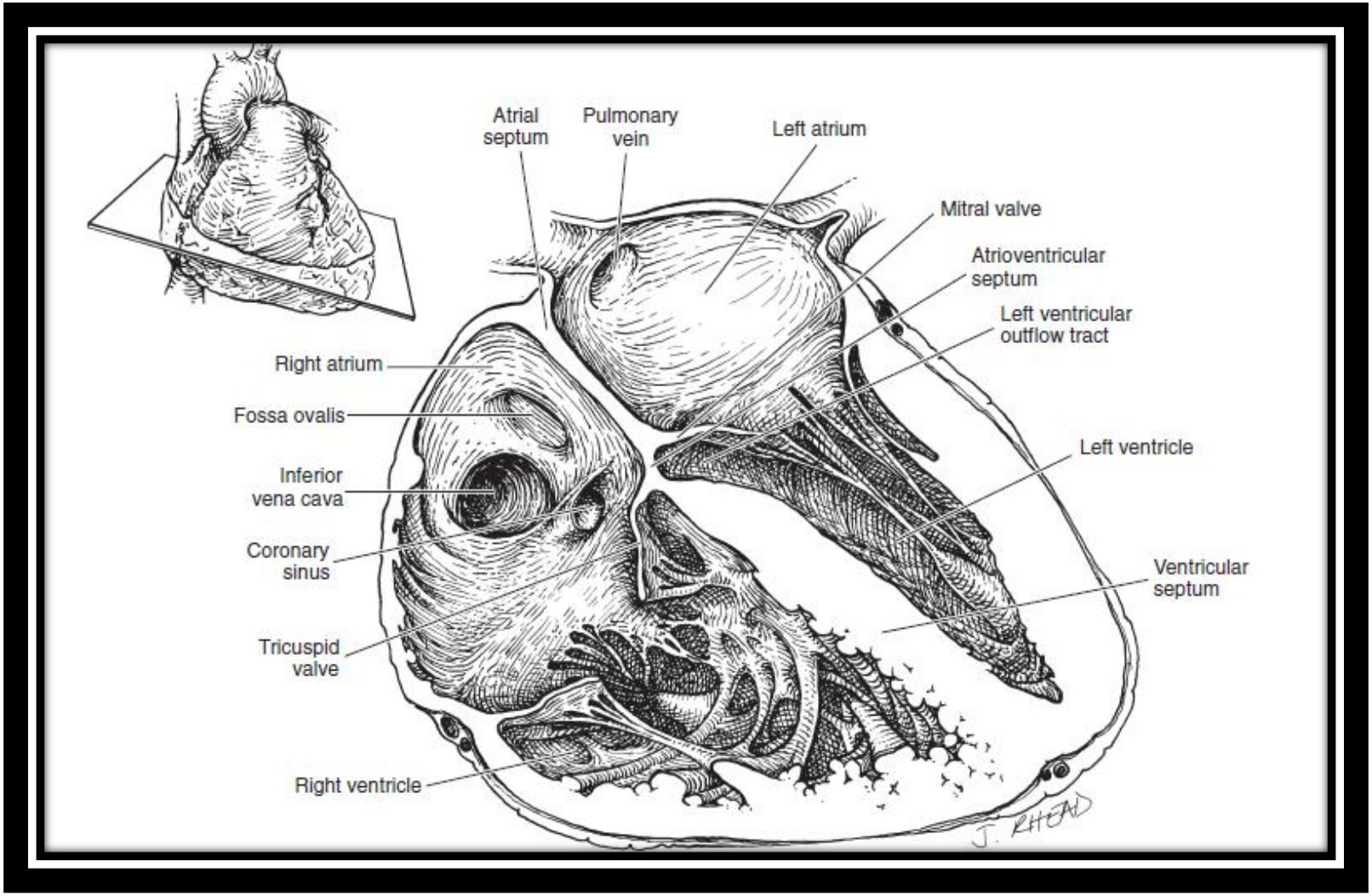
- It is most accurate to recognize the septum as having an extensive muscular part and a very small fibrous or membranous component
- Most of this membranous component is itself positioned in an atrio-ventricular location because it is crossed on its right-sided aspect by the attachment of the septal leaflet of the tricuspid valve


outlet of
left ventricle
aorta
right atrium
inlet of
right ventricle
inlet/outlet
septum


A-V membranous
septum
LV outflow
tract
mitral
valve
tricuspid
valve
A-V muscular septum


tissue
plane
subpulmonary
infundibulum
free-standing
RV musculature
subaortic
outflow
septum

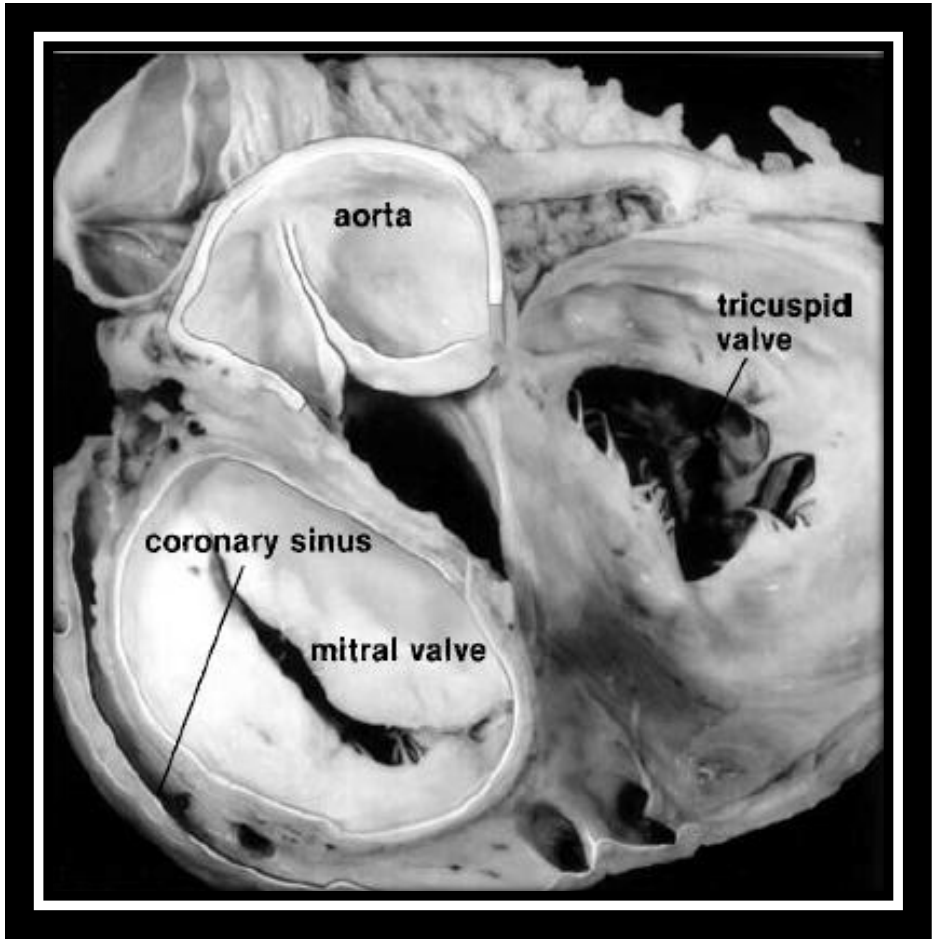

aorta
membranous septum
interventricular
portion
atrio-
ventricular
portion
insertion of
tricuspid valve
right ⟷ left


Atrial septum
Pulmonary vein
Left atrium
Mitral valve
Atrioventricular septum
Left ventricular outflow tract
Right atrium
Fossa ovalis
Left ventricle
Inferior vena cava
Coronary sinus
Ventricular septum
Tricuspid valve
Right ventricle
J. RHEAD

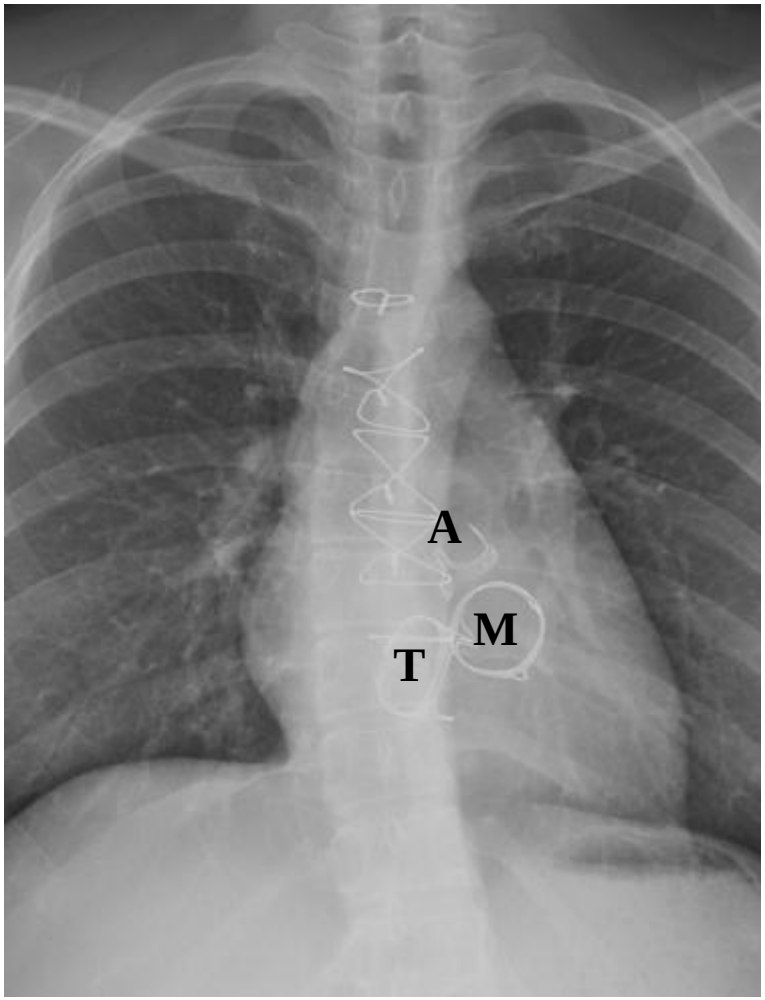
THE ATRIO-VENTRICULAR JUNCTIONS

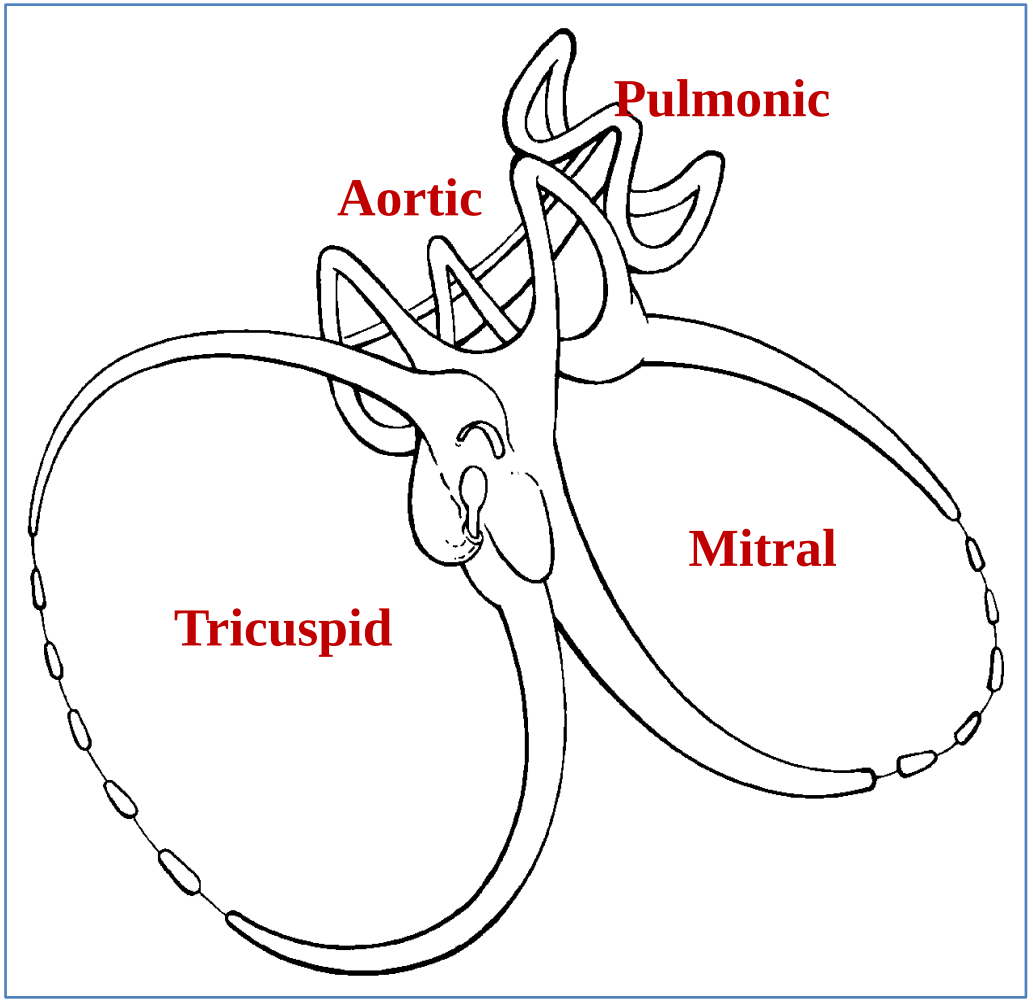
- The most vulnerable and complicated regions because they contain the origins of the leaflets of the atrio-ventricular valves, the atrio-ventricular conduction system and the major branches of the coronary arteries
- The attachments of the leaflets of the aortic, mitral and tricuspid valves form the fibrous skeleton of the heart

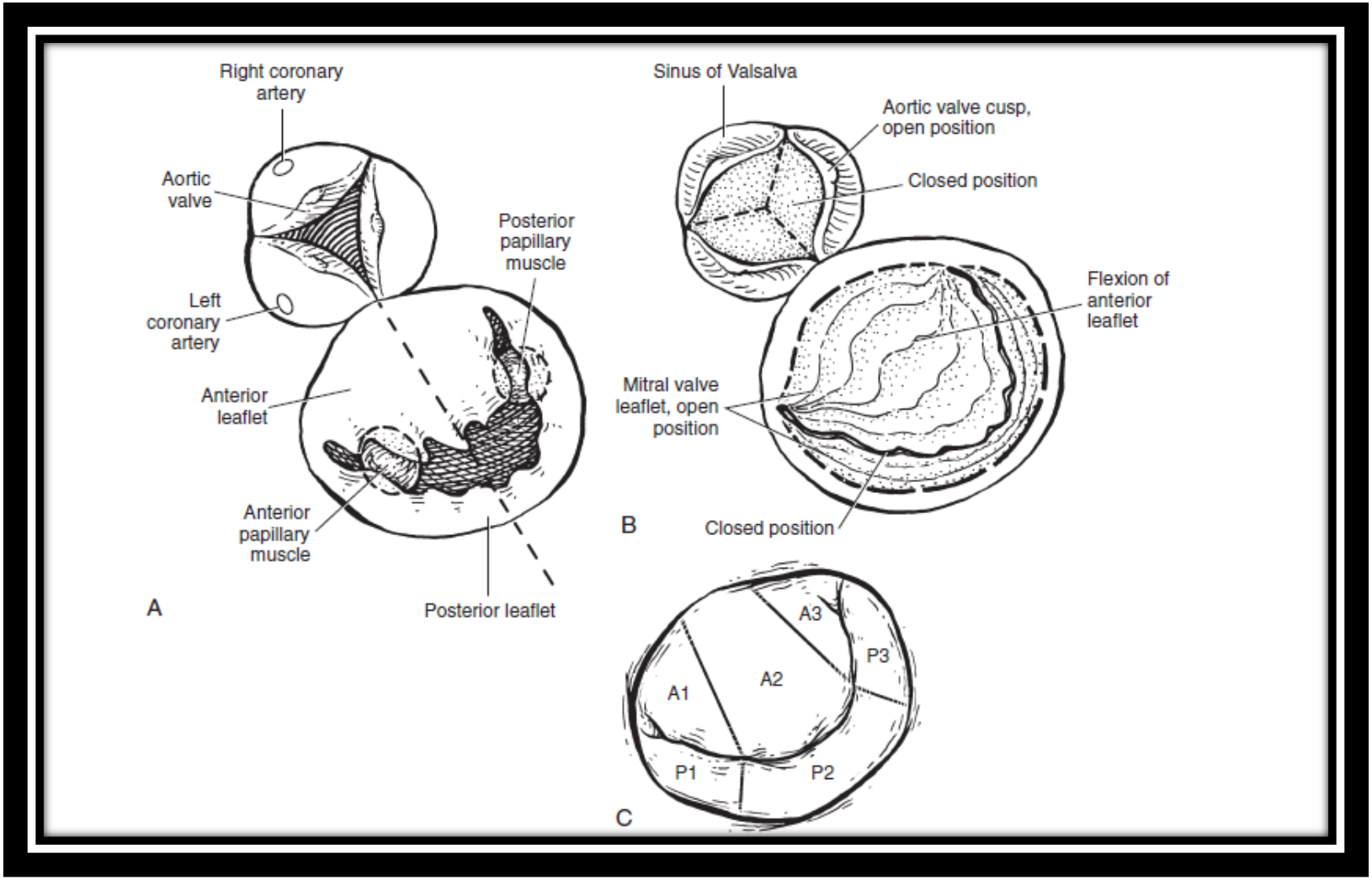
THE CARDIAC SKELETON



Fibrous Skeleton






Right coronary artery
Aortic valve
Posterior papillary muscle
Left coronary artery
Anterior leaflet
Anterior papillary muscle
Posterior leaflet
A
Sinus of Valsalva
Aortic valve cusp, open position
Closed position
Flexion of anterior leaflet
Mitral valve leaflet, open position
Closed position
B
A3
P3
A2
A1
P1
P2
C

THE AV CONDUCTION SYSTEM AND BUNDLE BRANCHES

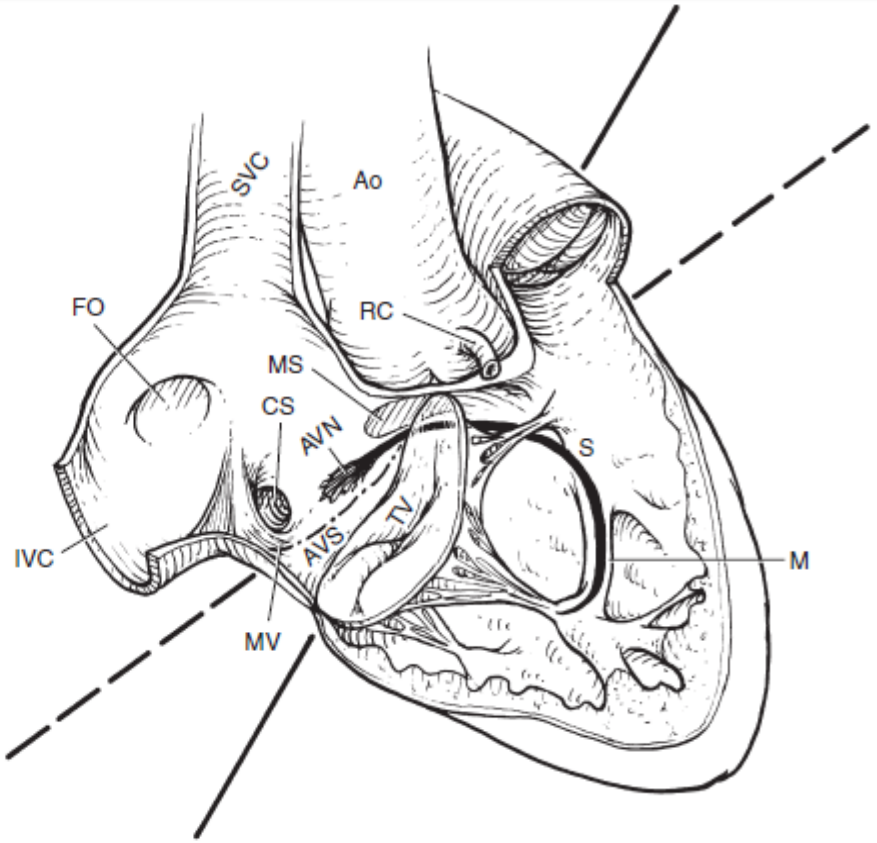
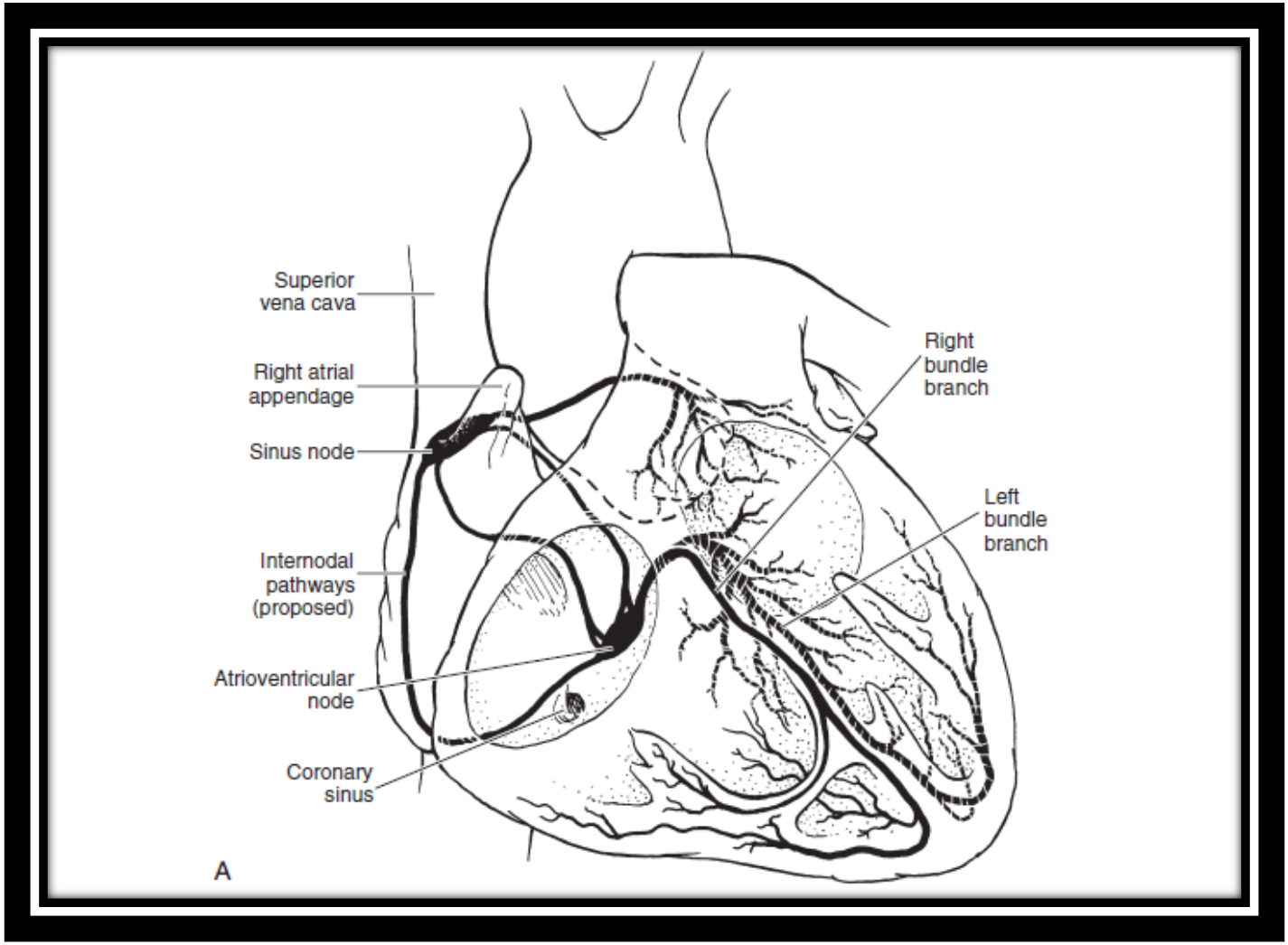
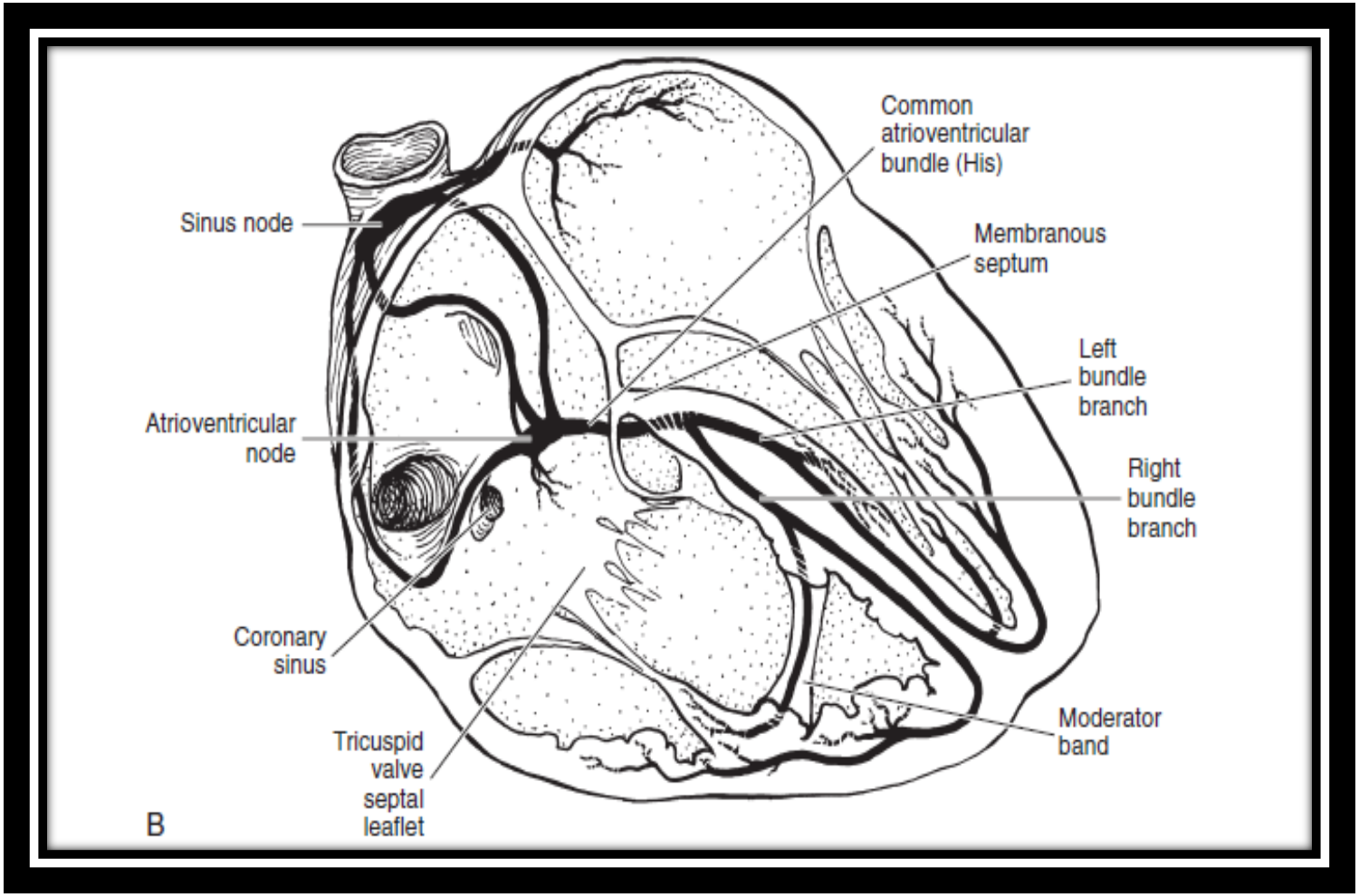


Figure 1-18 Diagram of right heart, aortic root, and conduction tissue at approximately 65-degree right anterior oblique projection. Plane of mitral valve attachment *(dashed line)* corresponds to atrial edge of muscular atrioventricular septum and inferior edge of membranous septum, but differs from plane of tricuspid valve *(solid line)*. Muscular portion of atrioventricular septum is frequently smaller than depicted. Key: *Ao,* Ascending aorta; *AVN,* atrioventricular node extending into bundle of His and right bundle branch; *AVS,* muscular atrioventricular septum; *CS,* coronary sinus; *FO,* fossa ovalis; *IVC,* inferior vena cava; *M,* moderator band; *MS,* membranous septum, crossed by attachment of tricuspid valve; *MV,* mitral valve anulus; *RC,* right coronary artery; *S,* portion of trabecula septomarginalis (septal band); *SVC,* superior vena cava; *TV,* tricuspid valve. (Modified from McAlpine.[M3])


Superior vena cava
Right atrial appendage
Sinus node
Internodal pathways (proposed)
Atrioventricular node
Coronary sinus
Right bundle branch
Left bundle branch
A


Common
atrioventricular
bundle (His)
Sinus node
Membranous
septum
Left
bundle
branch
Atrioventricular
node
Right
bundle
branch
Coronary
sinus
Moderator
band
Tricuspid
valve
septal
leaflet
B

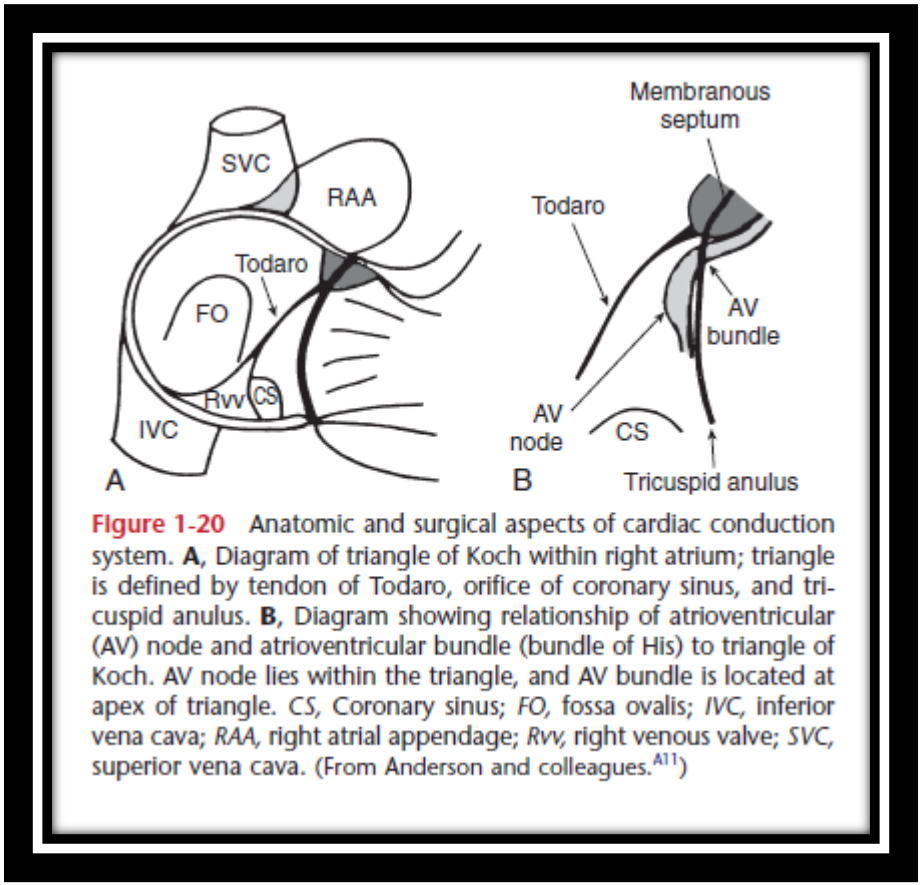
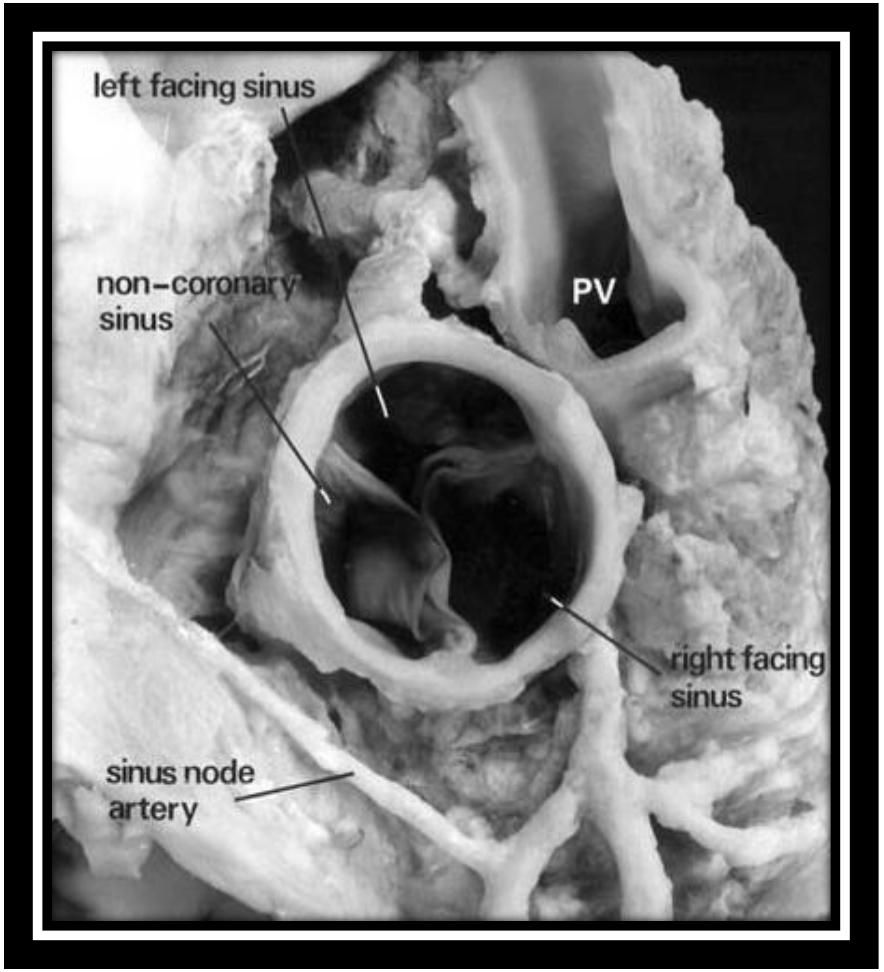
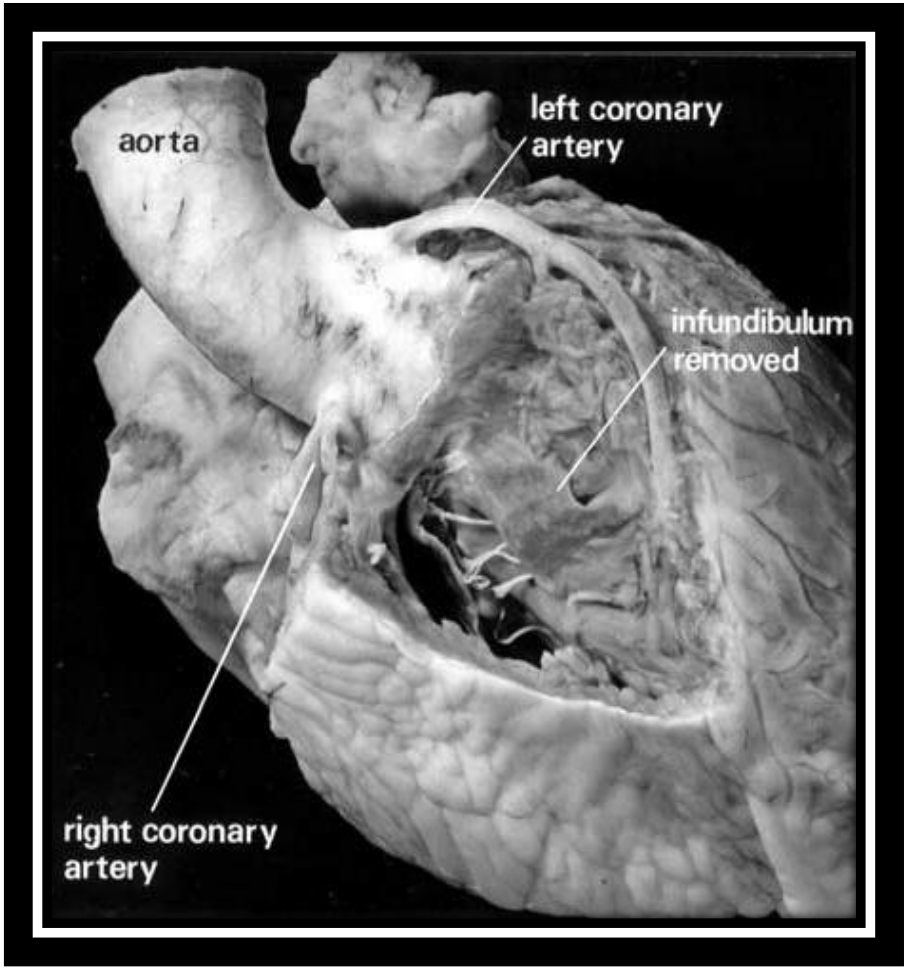
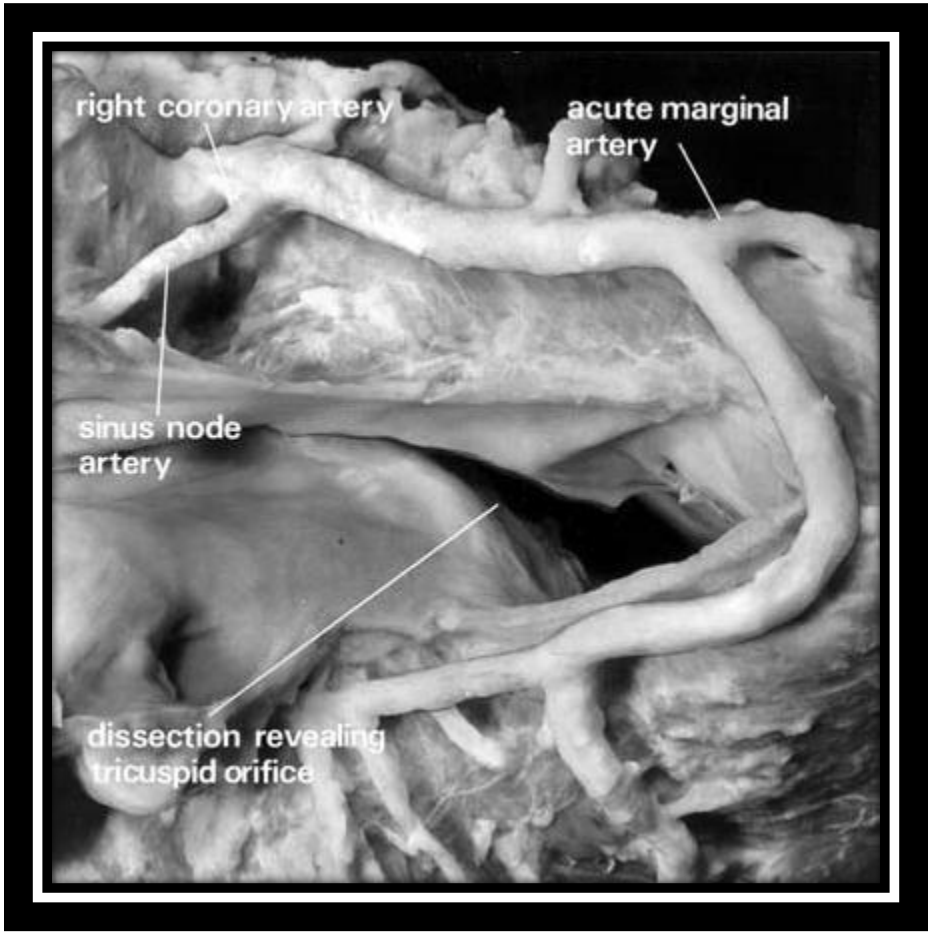


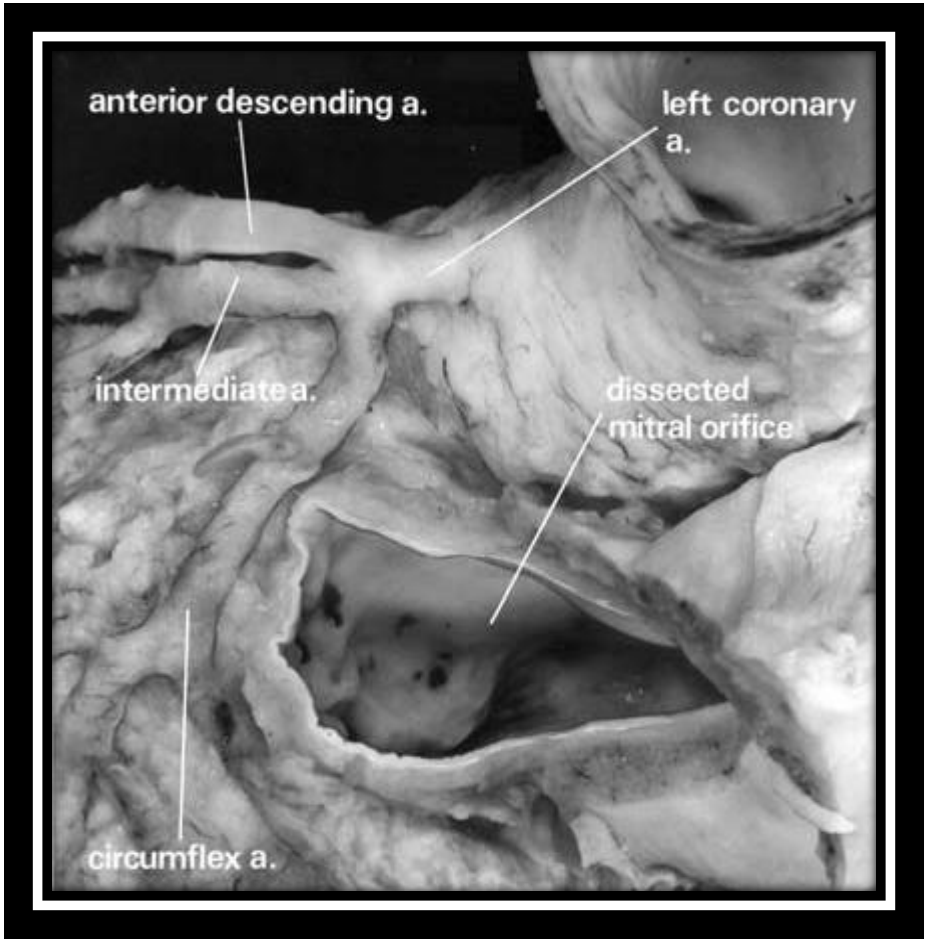
Figure 1-20 Anatomic and surgical aspects of cardiac conduction system. **A**, Diagram of triangle of Koch within right atrium; triangle is defined by tendon of Todaro, orifice of coronary sinus, and tricuspid anulus. **B**, Diagram showing relationship of atrioventricular (AV) node and atrioventricular bundle (bundle of His) to triangle of Koch. AV node lies within the triangle, and AV bundle is located at apex of triangle. *CS*, Coronary sinus; *FO*, fossa ovalis; *IVC*, inferior vena cava; *RAA*, right atrial appendage; *Rvv*, right venous valve; *SVC*, superior vena cava. (From Anderson and colleagues.[A11])

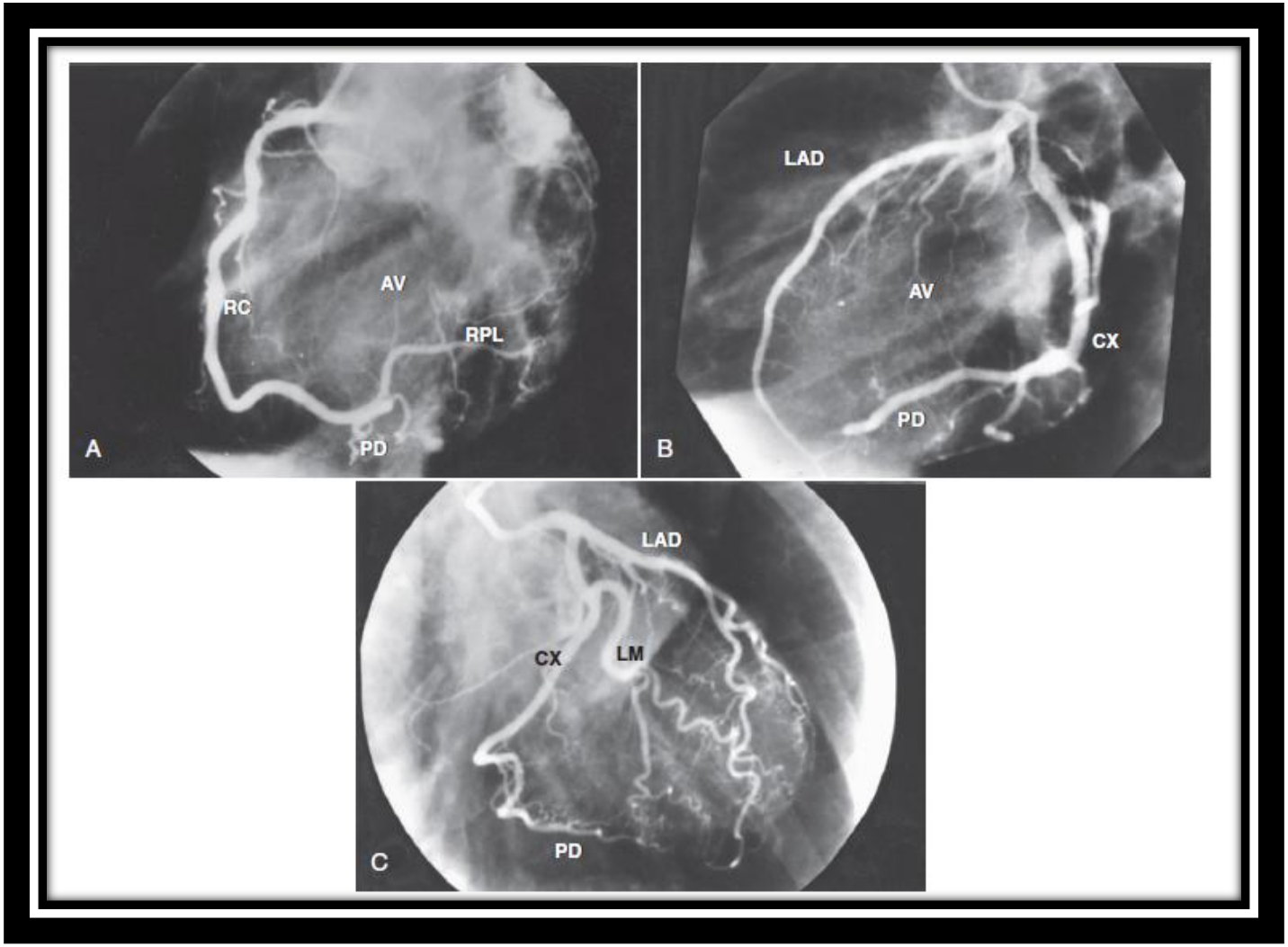
THE CORONARY CIRCULATION

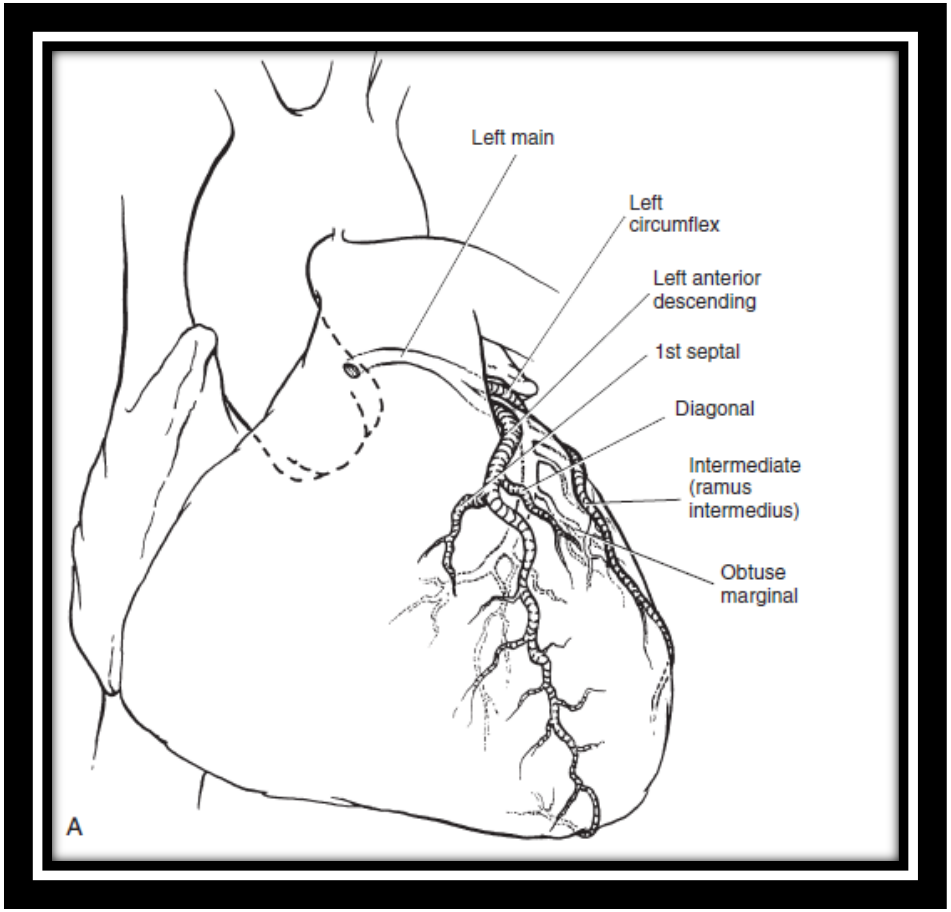


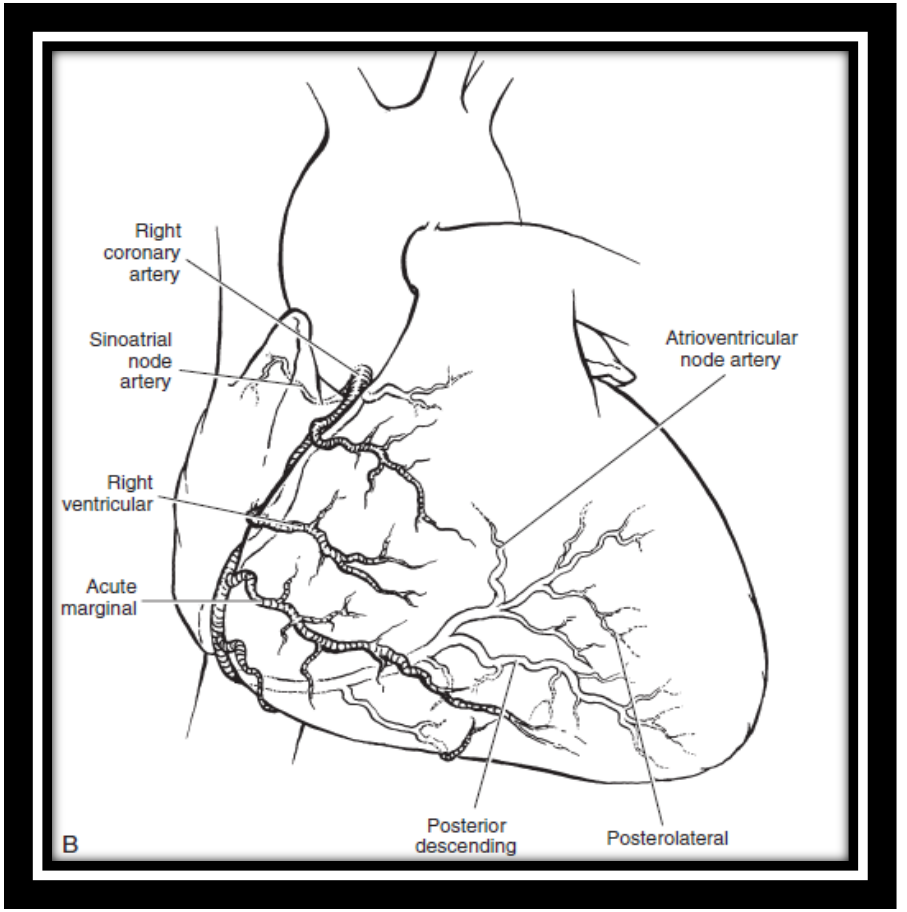



right coronary artery
acute marginal artery
sinus node artery
dissection revealing tricuspid orifice

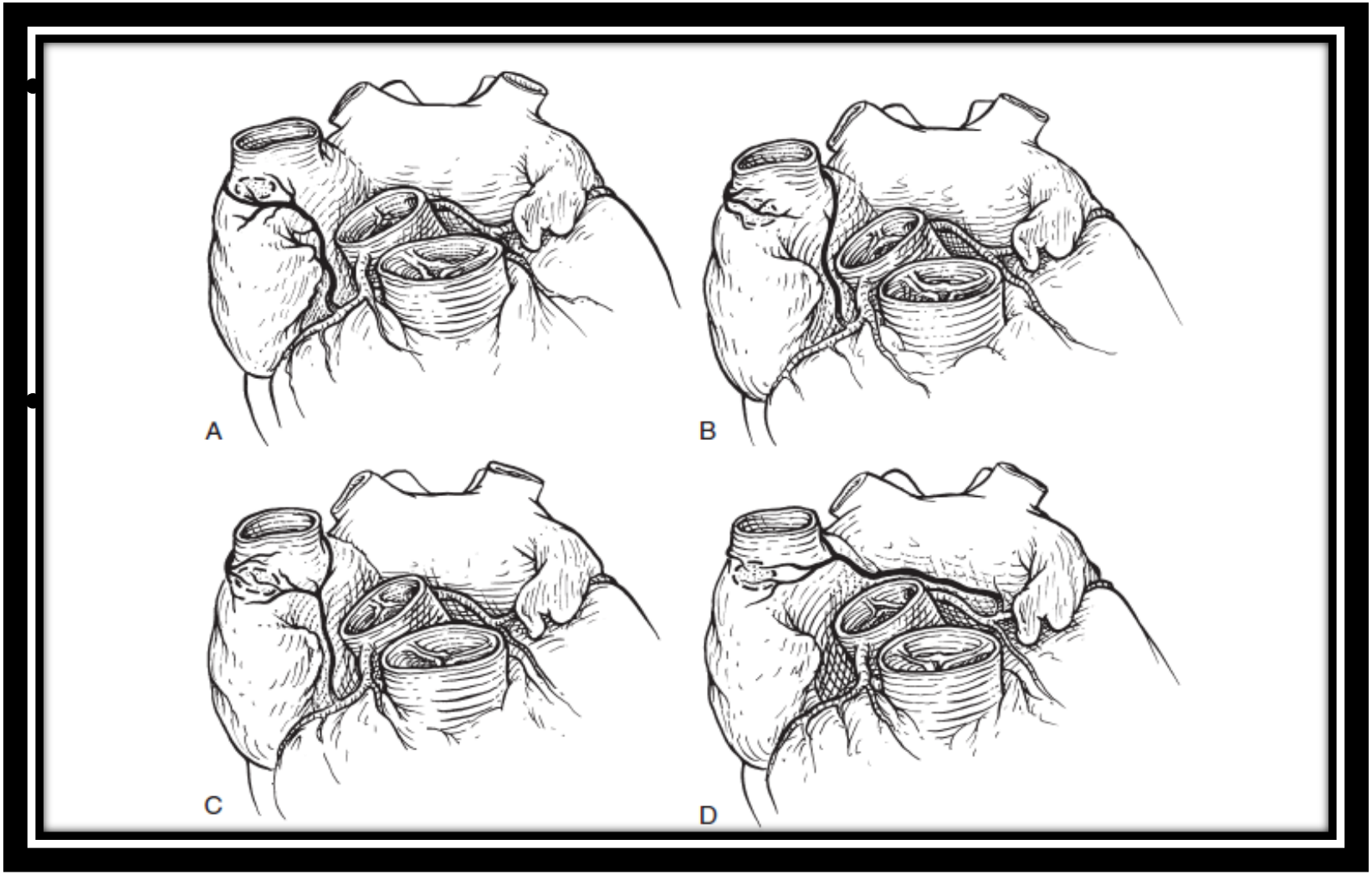

anterior descending a.
left coronary a.
intermediate a.
dissected mitral orifice
circumflex a.


A
RC
AV
RPL
PD
B
LAD
AV
CX
PD
C
LAD
CX
LM
PD


Left main
Left circumflex
Left anterior descending
1st septal
Diagonal
Intermediate (ramus intermedius)
Obtuse marginal
A


Right coronary artery
Sinoatrial node artery
Atrioventricular node artery
Right ventricular
Acute marginal
Posterior descending
Posterolateral
B

SA nodal artery



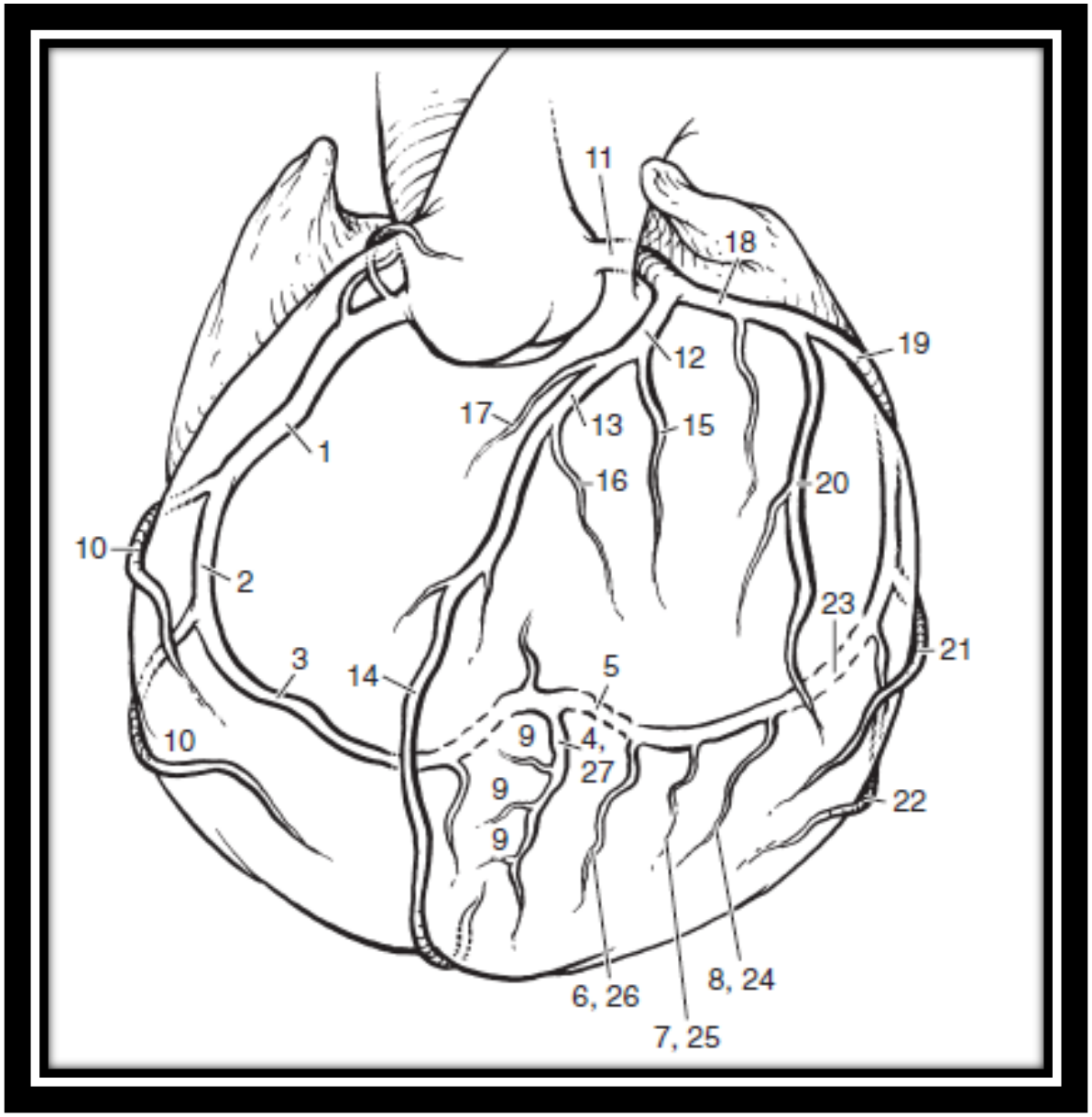
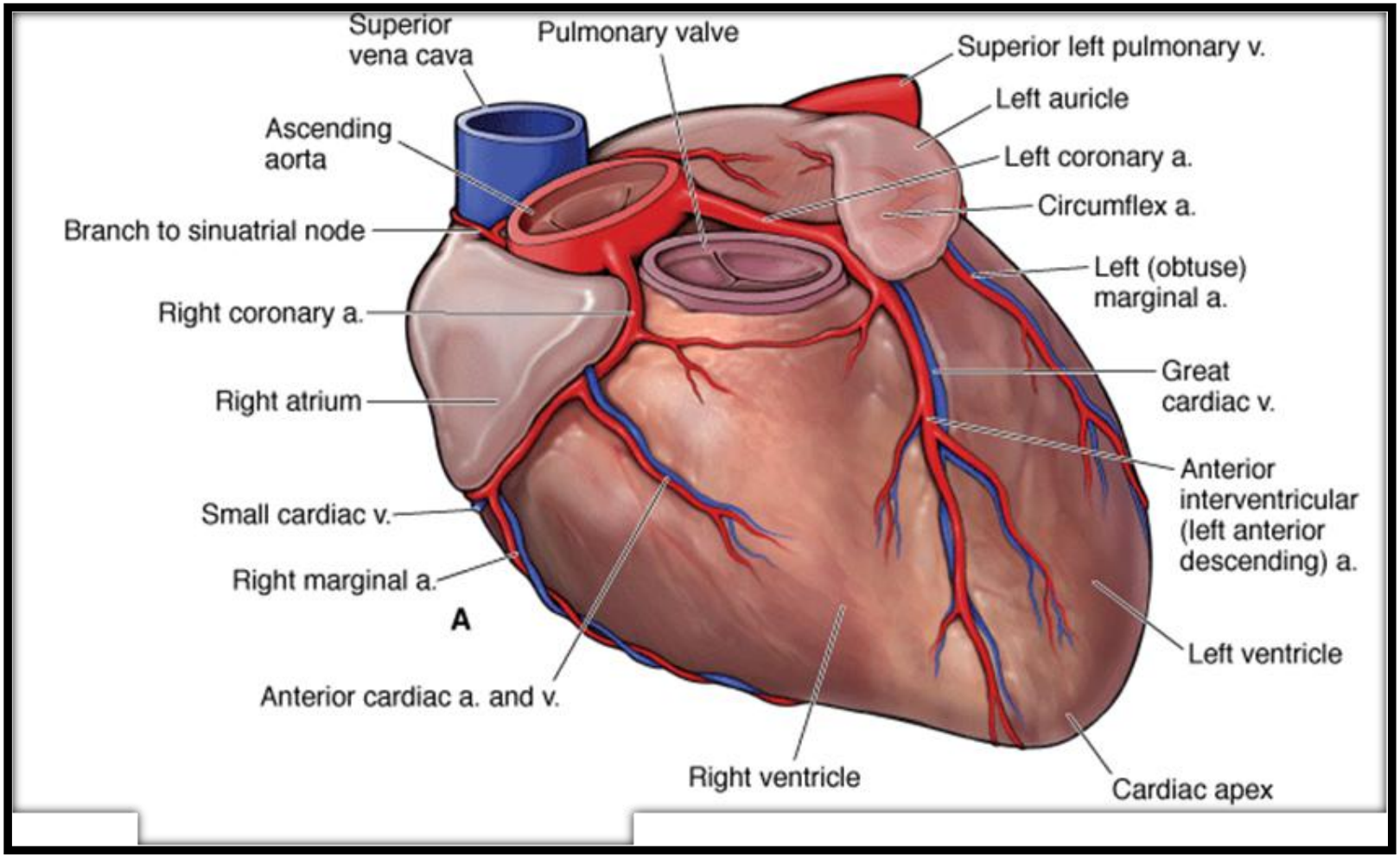
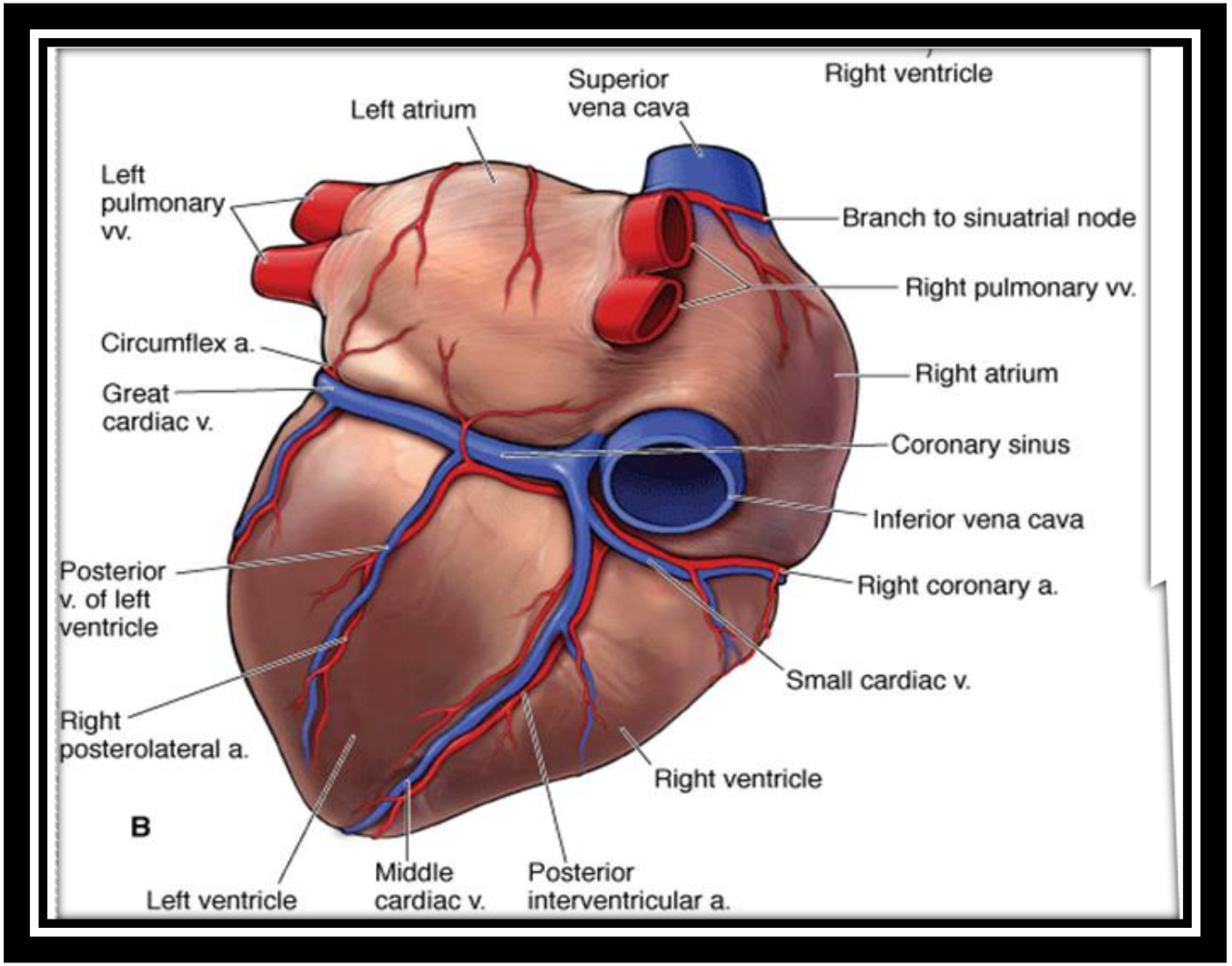

11
18
19
12
17
13
15
1
16
20
10
2
23
21
3
14
5
10
9
4,
27
9
22
9
6, 26
8, 24
7, 25

Figure 1-28 Diagram of anatomic segments of coronary arteries for use in locating lesions in individual patients. *1, 2, 3,* Proximal, mid-, and distal portions of right coronary artery. *4, 27,* Posterior descending coronary artery, which, as dotted segments proximal to it indicate, may arise from the right *(4)* or left *(27)* system. *5,* Right posterolateral segment, an extension of right coronary artery in association with right dominant systems. *6, 7, 8,* From it come several inferior surface (marginal) branches, called *right posterolateral arteries,* to the back of the left ventricle. Left dominant systems have a comparable left posterolateral segment leading to posterior descending artery. *9,* Inferior septal branches of posterior descending artery. *10,* Acute marginal branches of right coronary artery. *11,* Left main coronary artery. *12, 13, 14,* Proximal, mid-, and distal portions of left anterior descending coronary artery. *15, 16,* First and second diagonal branches. First diagonal may originate near bifurcation of left main coronary artery and was formerly called *ramus intermedius.* Additional diagonal branches may be present. *17,* First septal branch of left anterior descending artery. *18, 19,* Proximal and distal portions of left circumflex coronary artery. *20, 21, 22,* First, second, and third obtuse marginal branches of circumflex artery, the first usually being a large vessel. *23,* Extension of circumflex artery, called the *left AV artery,* present only in patients with a left dominant system. In such patients, this vessel gives off further inferior surface ("marginal") branches to the back of the left ventricle, called *left posterolateral arteries (24, 25, 26)* before terminating in left posterior descending coronary artery *(27).* (Modified from the National Heart, Lung, and Blood Institute Coronary Artery Surgery Study [CASS].[C2])

Coronary Circulation



Coronary Circulation



Lymphatic network

- The heart also possesses an extensive lymphatic network, divided into deep, middle and superficial plexuses
- All drain eventually into collecting channels

  that accompany the major arterial stems and finally into primary lymph nodes in the anterior mediastinum

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- 박인숙. 선천성 심장병. 2nd ed. Seoul: 고려의학, 2008
- Stark J, de Leval M, Tsang VT. Surgery for congenital heart defects. 3rd ed. Chichester: John Wiley & Son Ltd / England, 2006
- Kouchoukos N, Blackstnone E, Hanley F, Kirklin J. Kirklin / Barratt-Boyes. Cardiac Surgery. 4th ed. Elsevier/ USA, 2013

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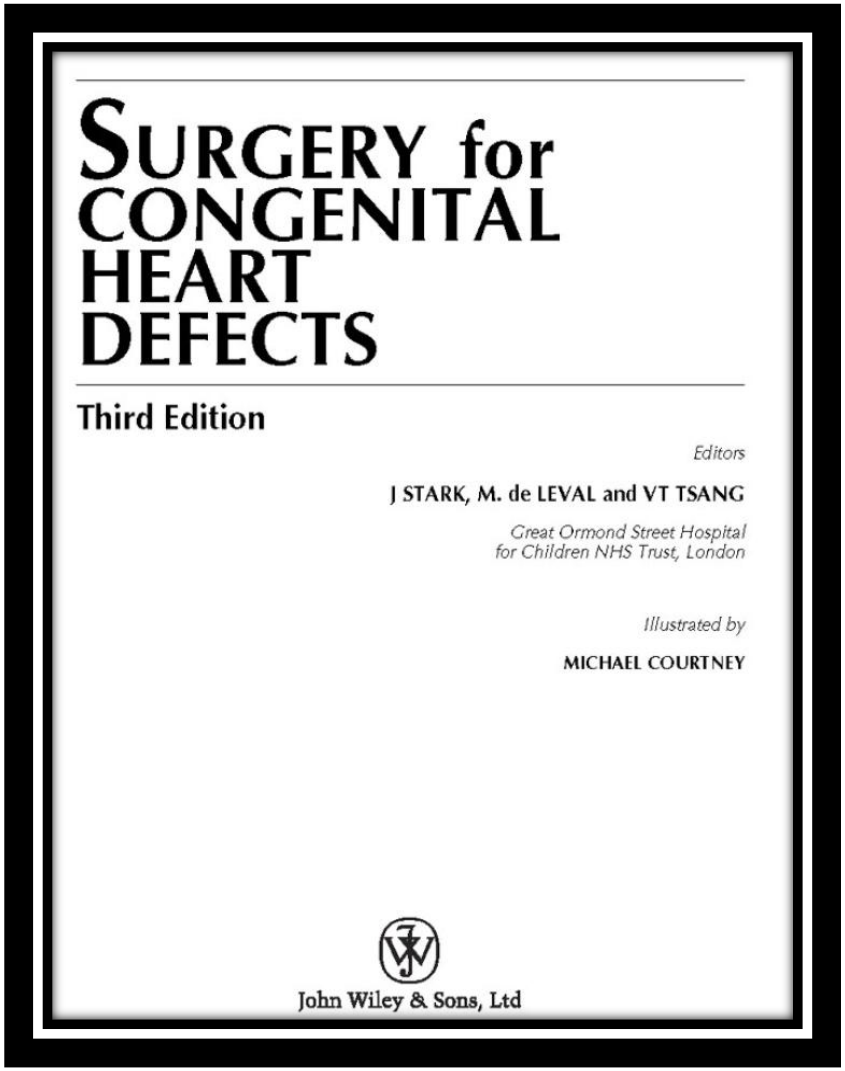
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Great Ormond Street Hospital for Children NHS Trust, London
Illustrated by
MICHAEL COURTNEY
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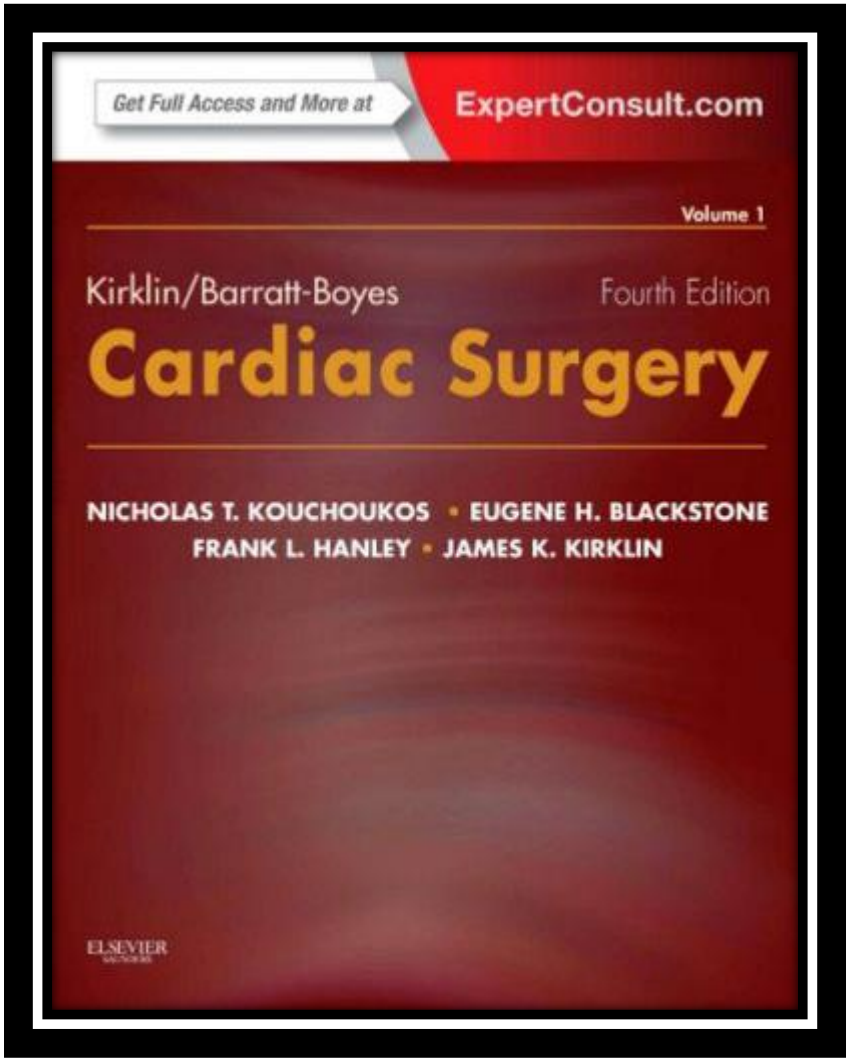
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