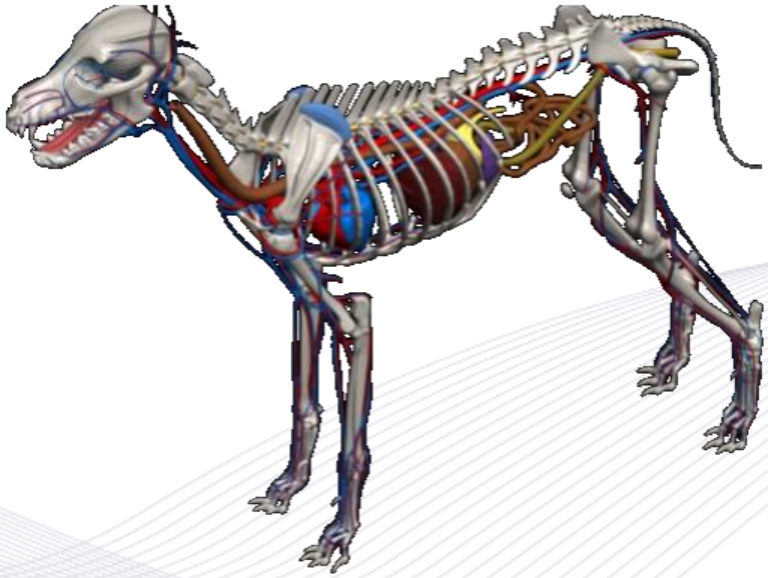
Veterinary Bioscience 1: Cardiovascular System

THE UNIVERSITY OF MELBOURNE

Lecture 2:

The heart within the thorax



Simon Bailey
bais@unimelb.edu.au

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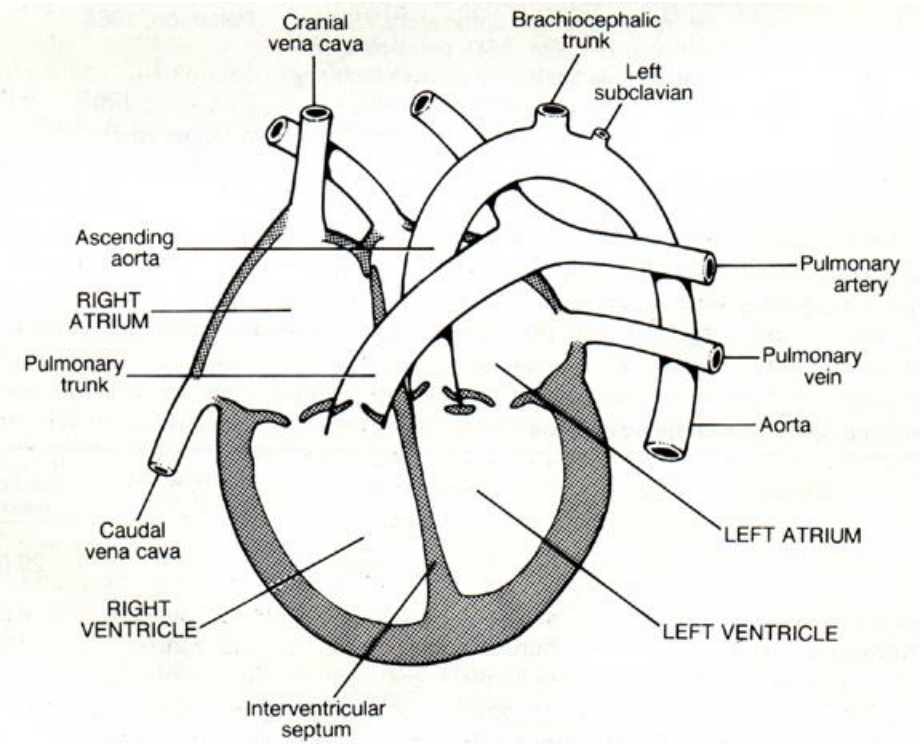
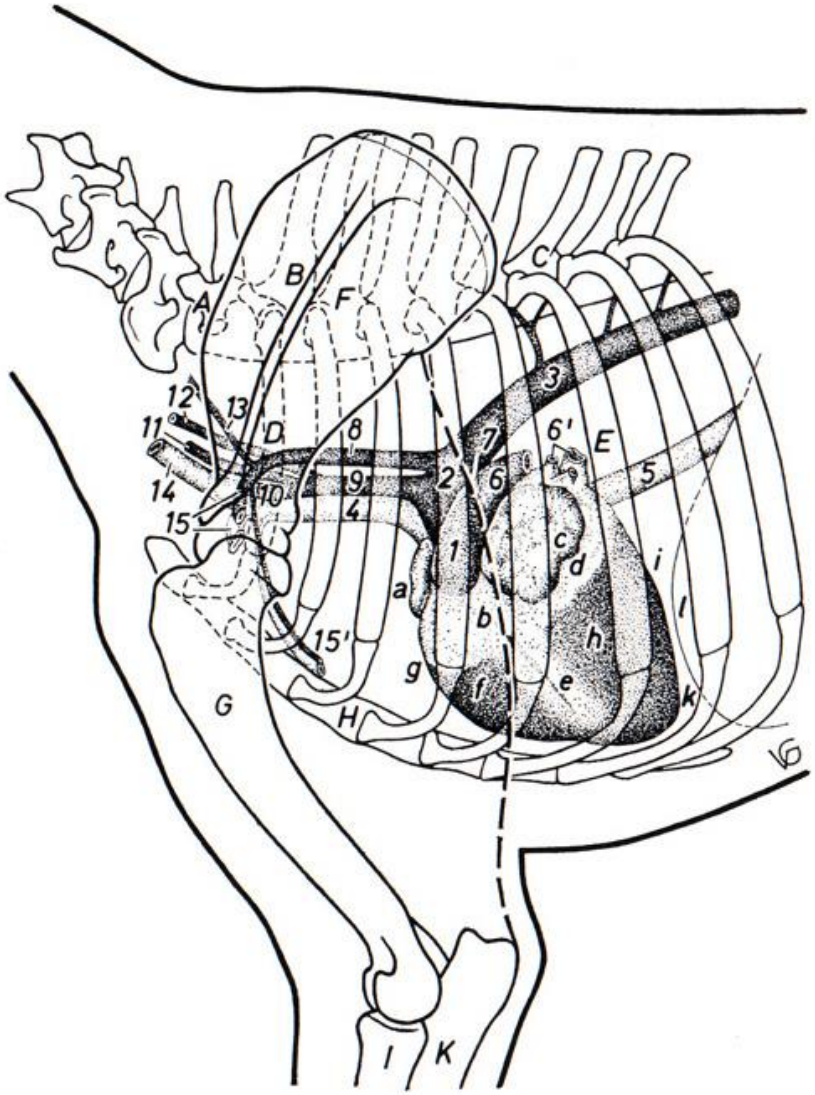
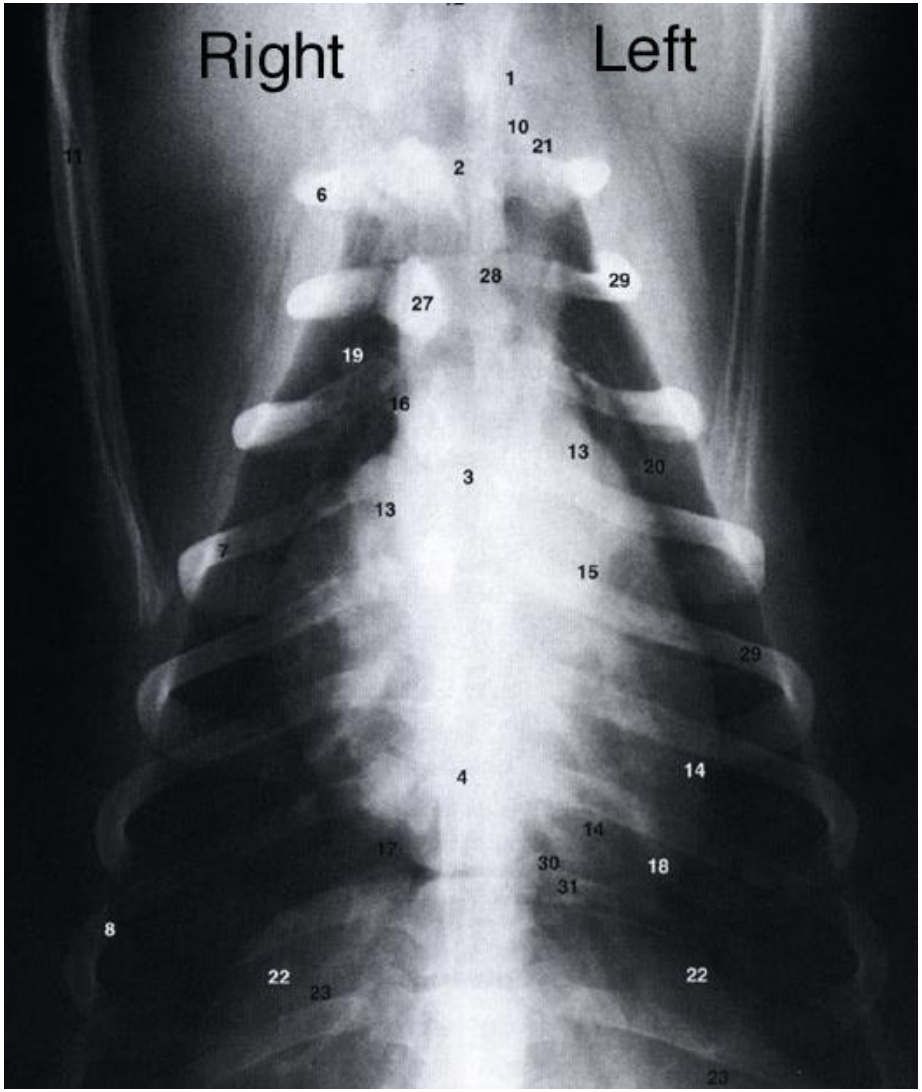
The heart – an efficient pump

- Double pump - right and left sides "in series" for separate circulations



Position of the heart





Position of the heart

- Lies in the mediastinum

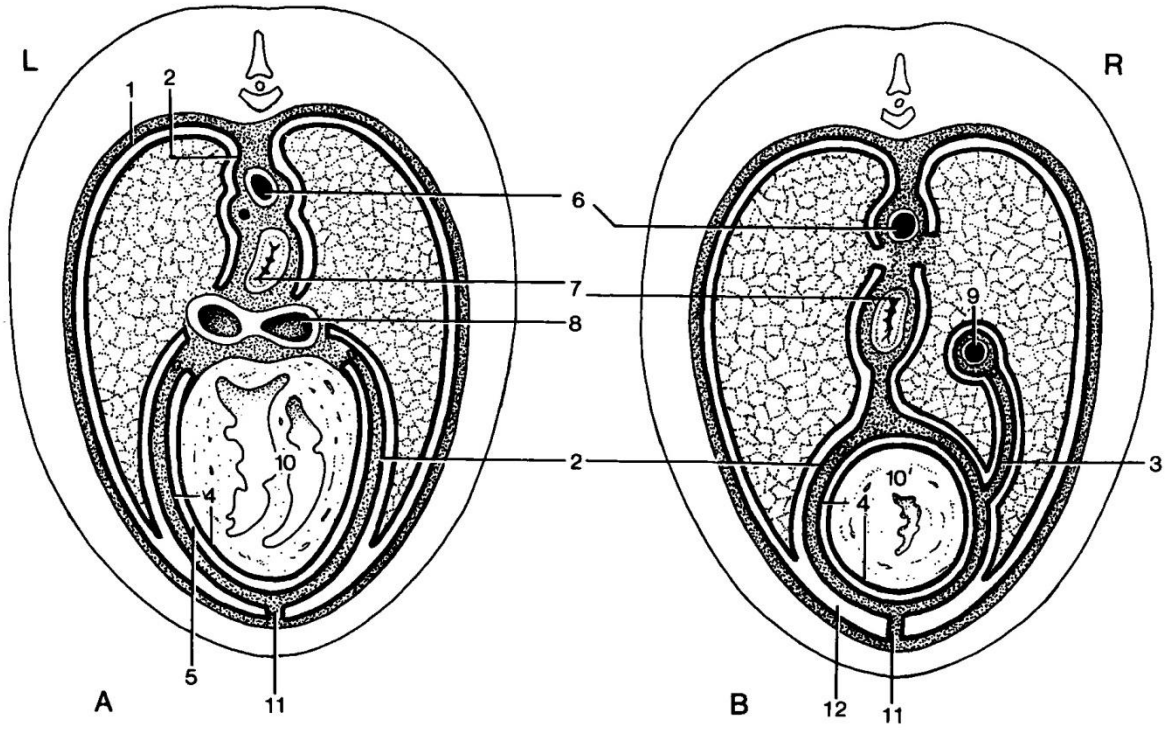
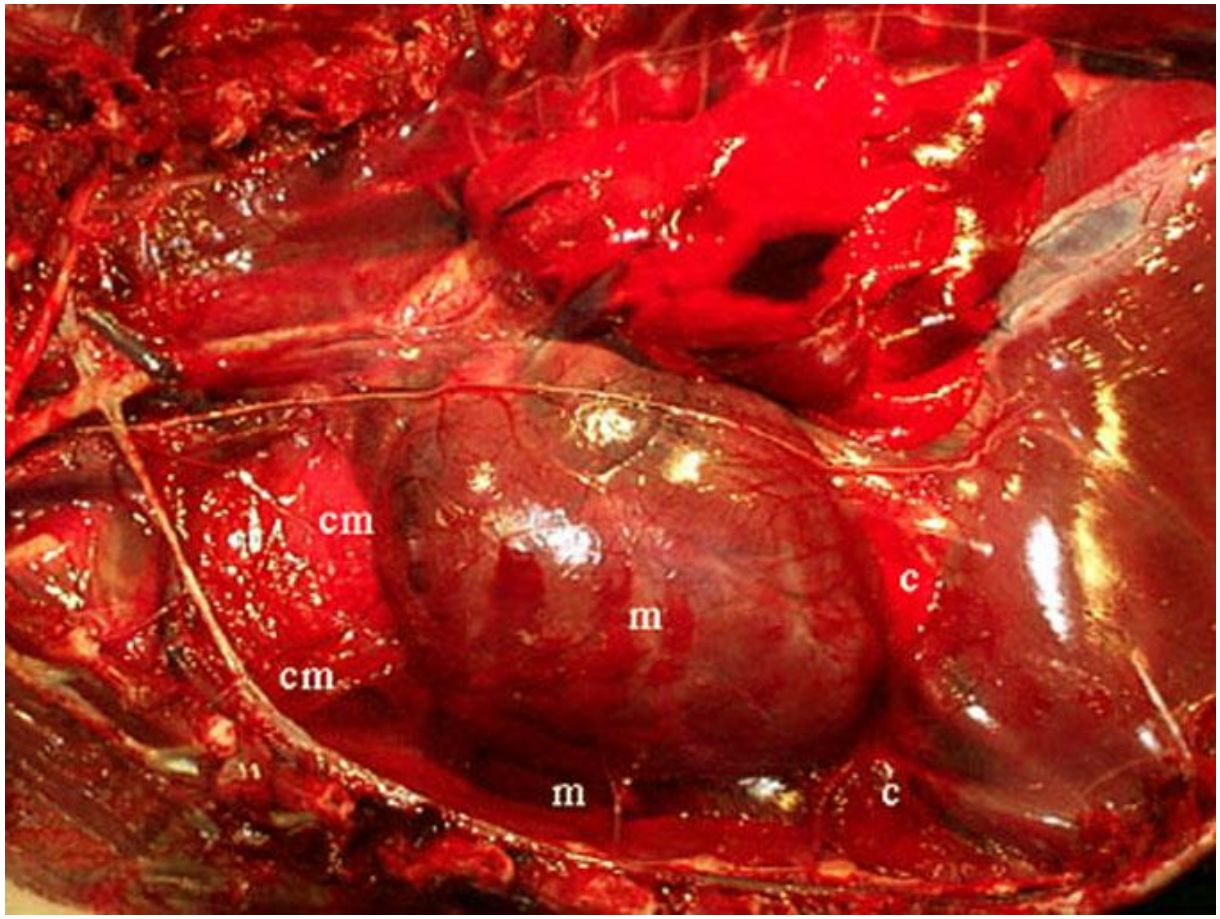


FIGURE 4–17. Schematic transverse sections of the thorax at the level of the heart (*A*) and at the transition of heart to caudal mediastinum (*B*).

1. Costal pleura; 2, mediastinal pleura; 3, plica venae cavae; 4, parietal and visceral pericardium; 5, pericardial space; 7. aorta; 7, esophagus; 8, tracheal bifurcation; 9, caudal vena cava; 10, heart; 10′, apex of heart; 11, sternopericardial ligament; 12, costomediastinal recess.

Dyce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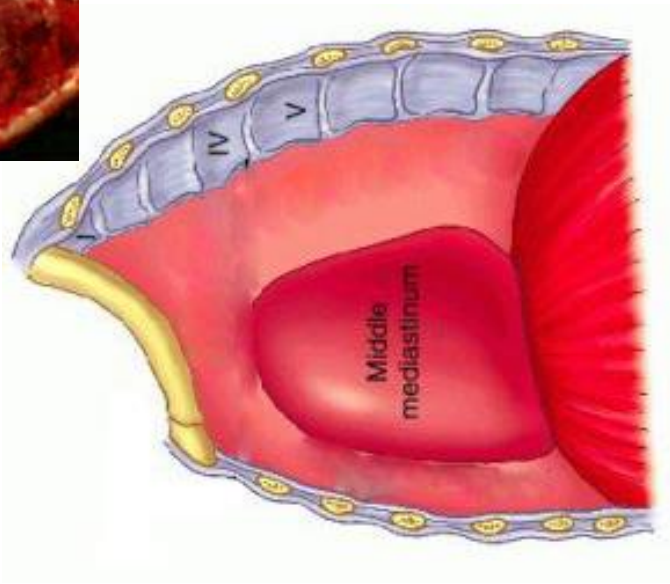
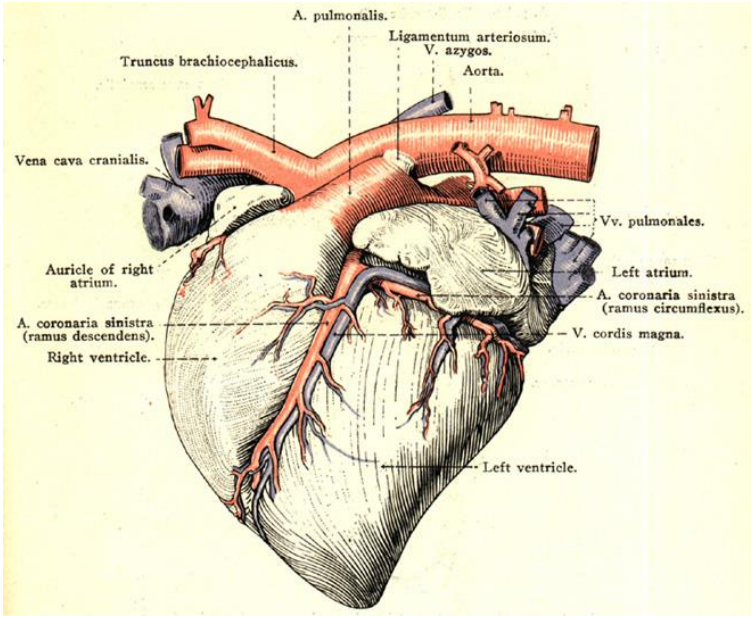

IV
V
Middle mediastinum

Size of the heart

- ~ 0.6% of total body weight
- Post natal ↑ in heart mass - mainly achieved by hypertrophy
- Comparative aspects: cone shaped in horses and ruminants, more globular in small animals - see addendum in notes (p33).

Shape of the heart

- Slightly flattened cone
  - Base - low dome, formed by left and right atria
  - Great veins/arteries - enter/emerge from the base
  - Apex - tapered portion of cone, formed by left ventricle



Pericardium:

- Serous sac enclosing the heart
- Inner wall -
  - Single layer of flattened mesothelium
  - Visceral pericardium
- Outer wall - two layers
  - 1. Inner parietal pericardium
  - 2. Outer fibrous pericardium
- Pericardial cavity
  - Occupied by thin film of serous fluid - lubricant

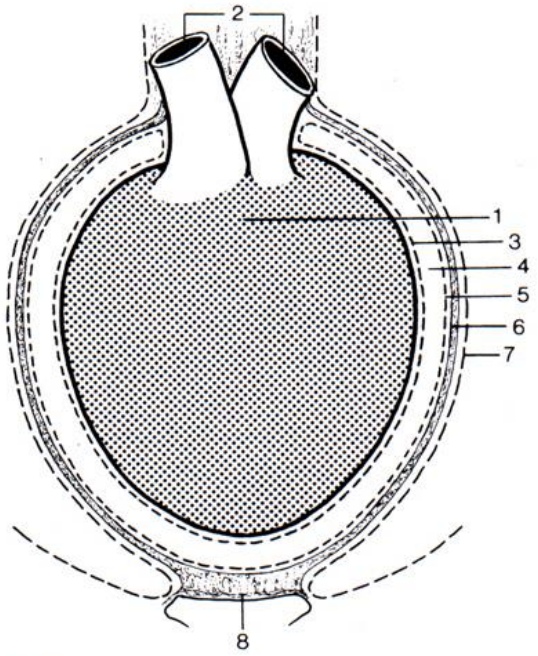


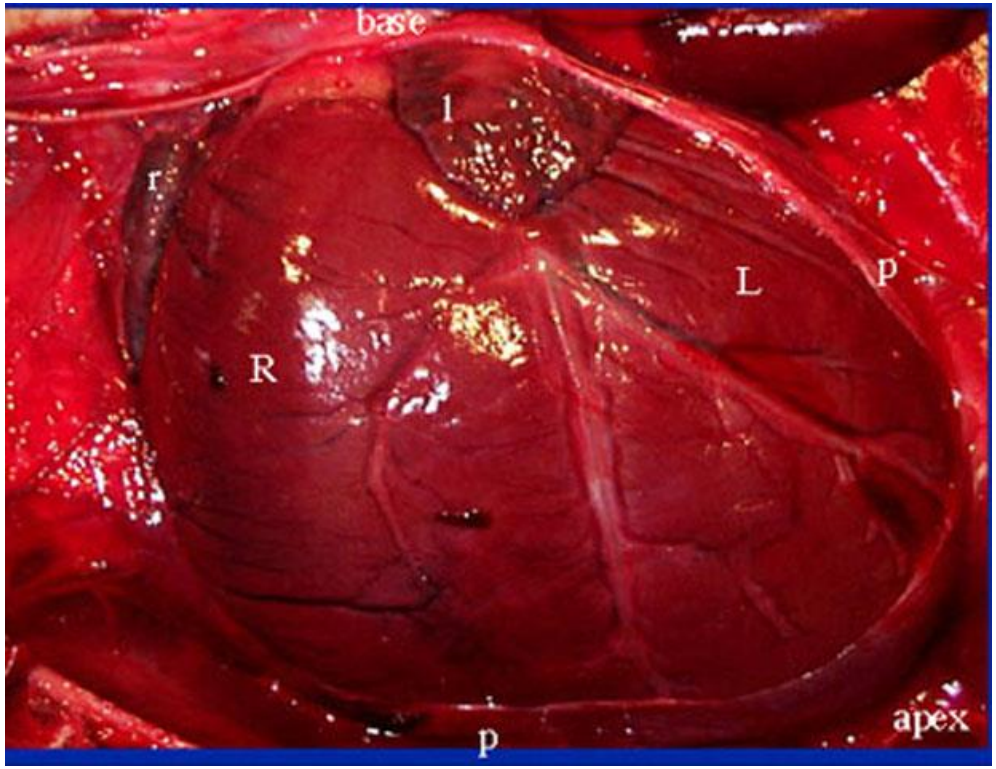
Figure 7–5. Schematic illustration of the pericardium.

1, Heart; 2, great vessels; 3, visceral pericardium (epicardium); 4, pericardial cavity (exaggerated in size); 5, parietal pericardium; 6, connective tissue layer of the parietal pericardium; 7, mediastinal pleura; 8, sternopericardial ligament.

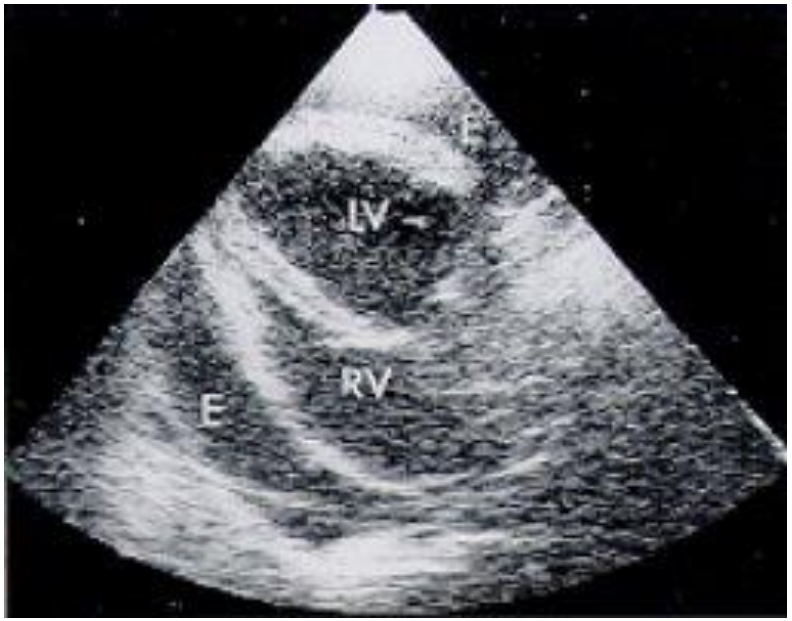
Dyce, Sack and Wensing. 2002. Textbook of Veterinary Anatomy.

Functions of the pericardium

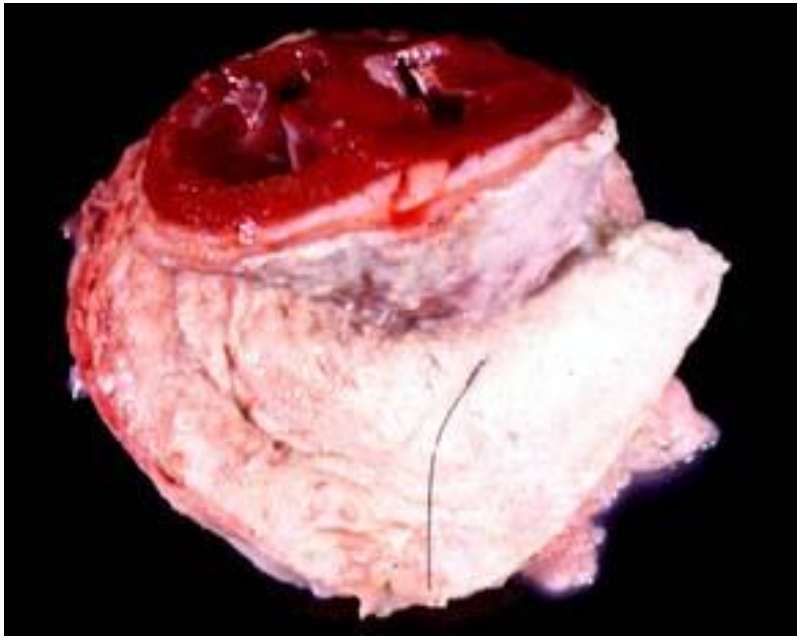
- Protective
- Help maintain position
- Minimise friction during cardiac cycle
- Prevent over-distension of the heart?



Pericardial effusion (horse)



Pericarditis (cow)



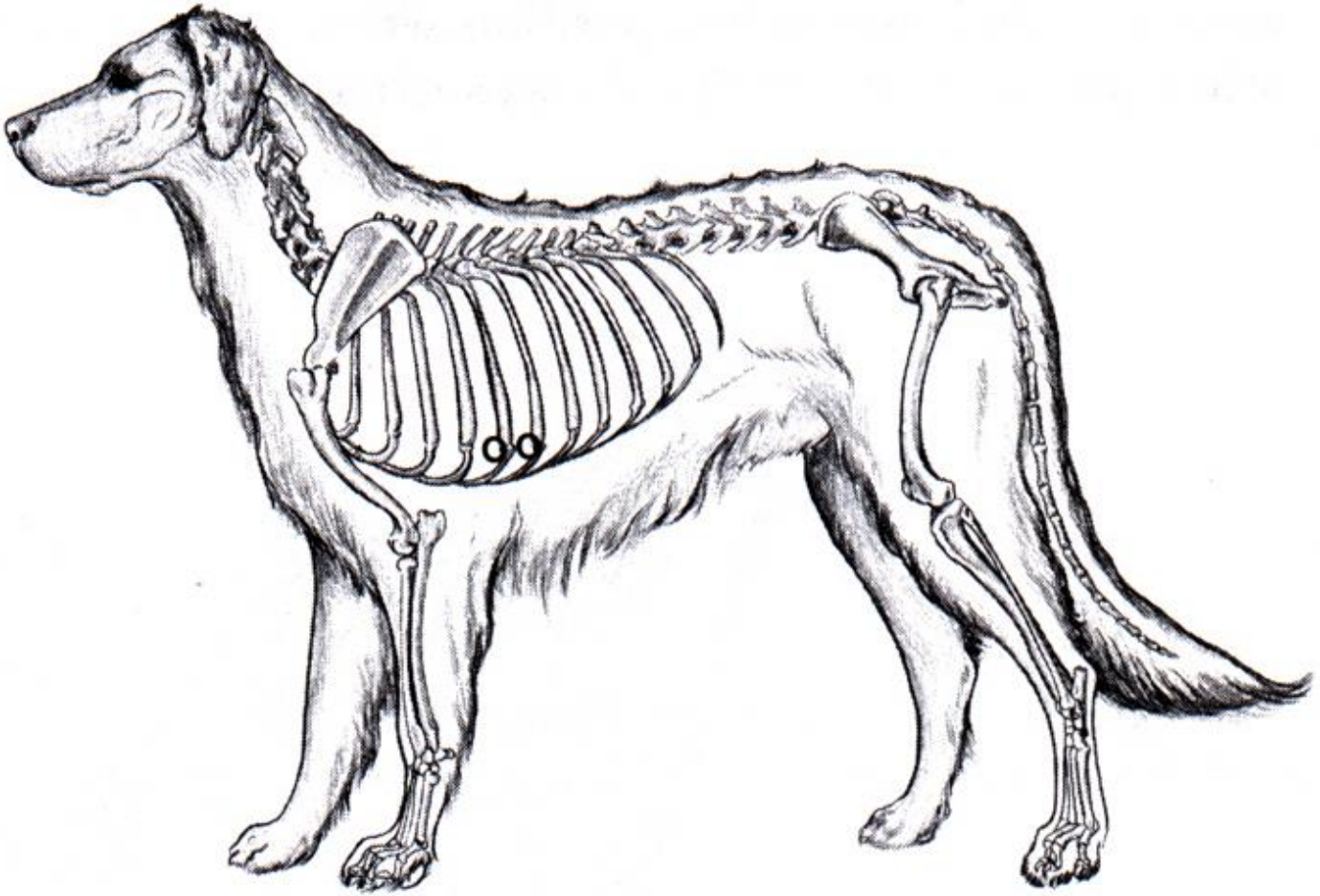


Figure 22-2 Sites for performing pericardiocentesis.

External features of the heart

- Base - thin-walled atria
- Coronary groove:
  - Demarcates atria from ventricles
  - Contains the main coronary vessels - often concealed by fat

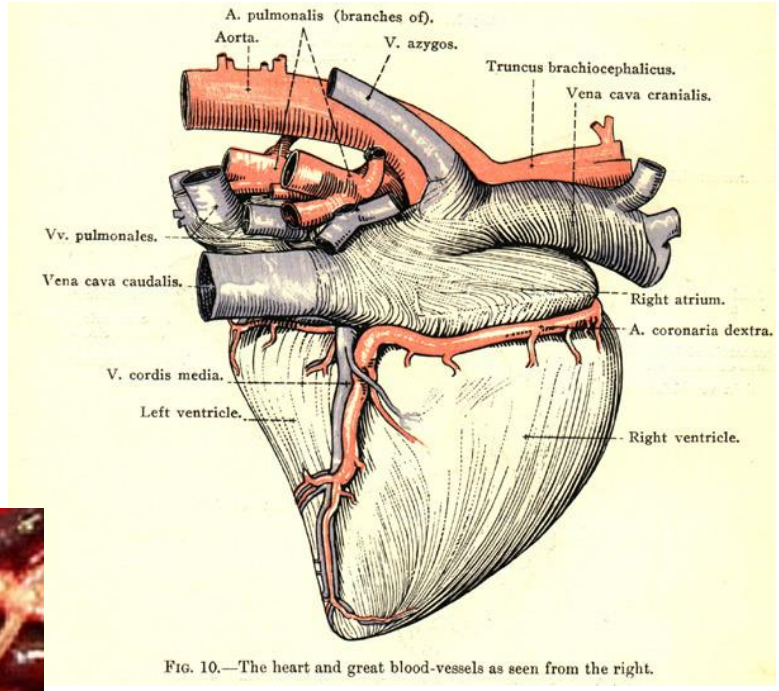
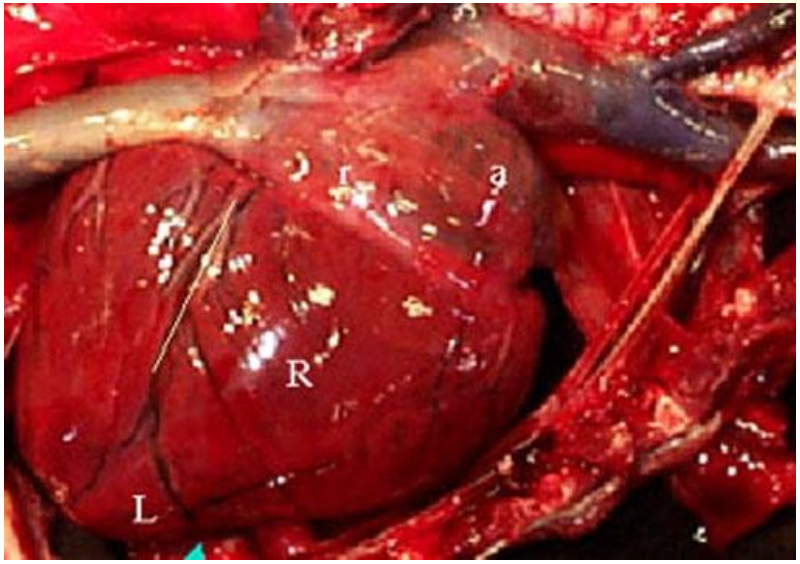
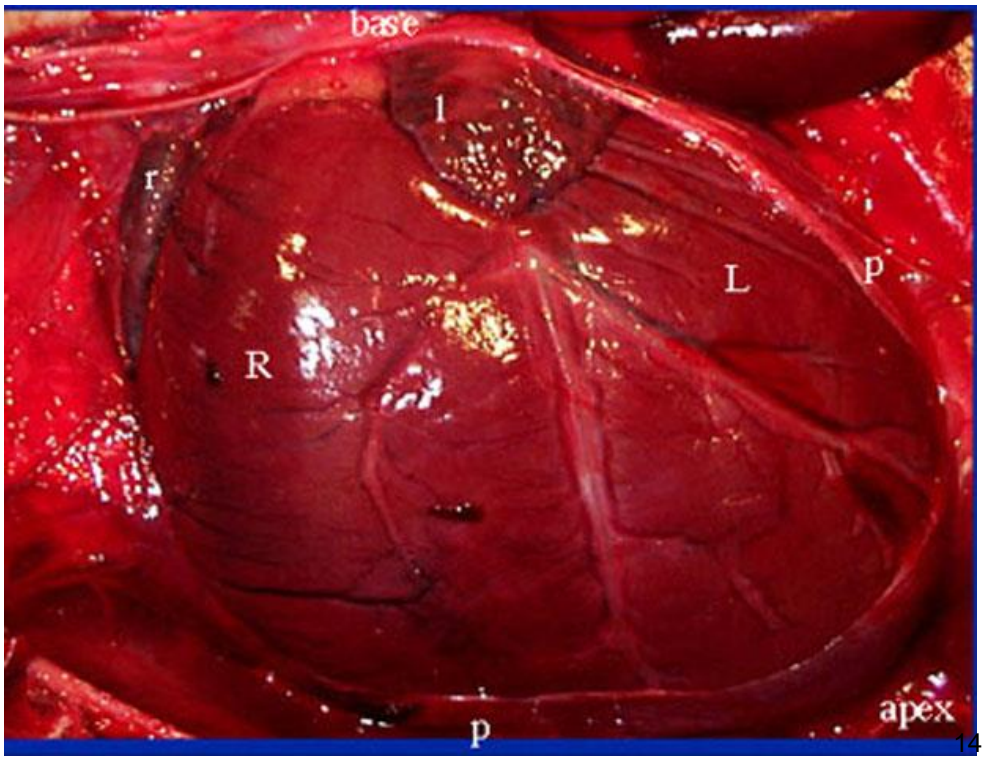


FIG. 10.—The heart and great blood-vessels as seen from the right.



External features of the heart

- Atrium has a ‘free appendage’ - the auricle
- Right and left auricles curve around the origin of the pulmonary trunk
- Right auricle – most cranial part of the heart



External features of the heart

- Thicker walled right and left ventricles form a firm cone
- Position of the interventricular septum is marked by:
  - Left interventricular groove
  - Right interventricular groove
  - Apex - tip of the cone - part of left ventricle

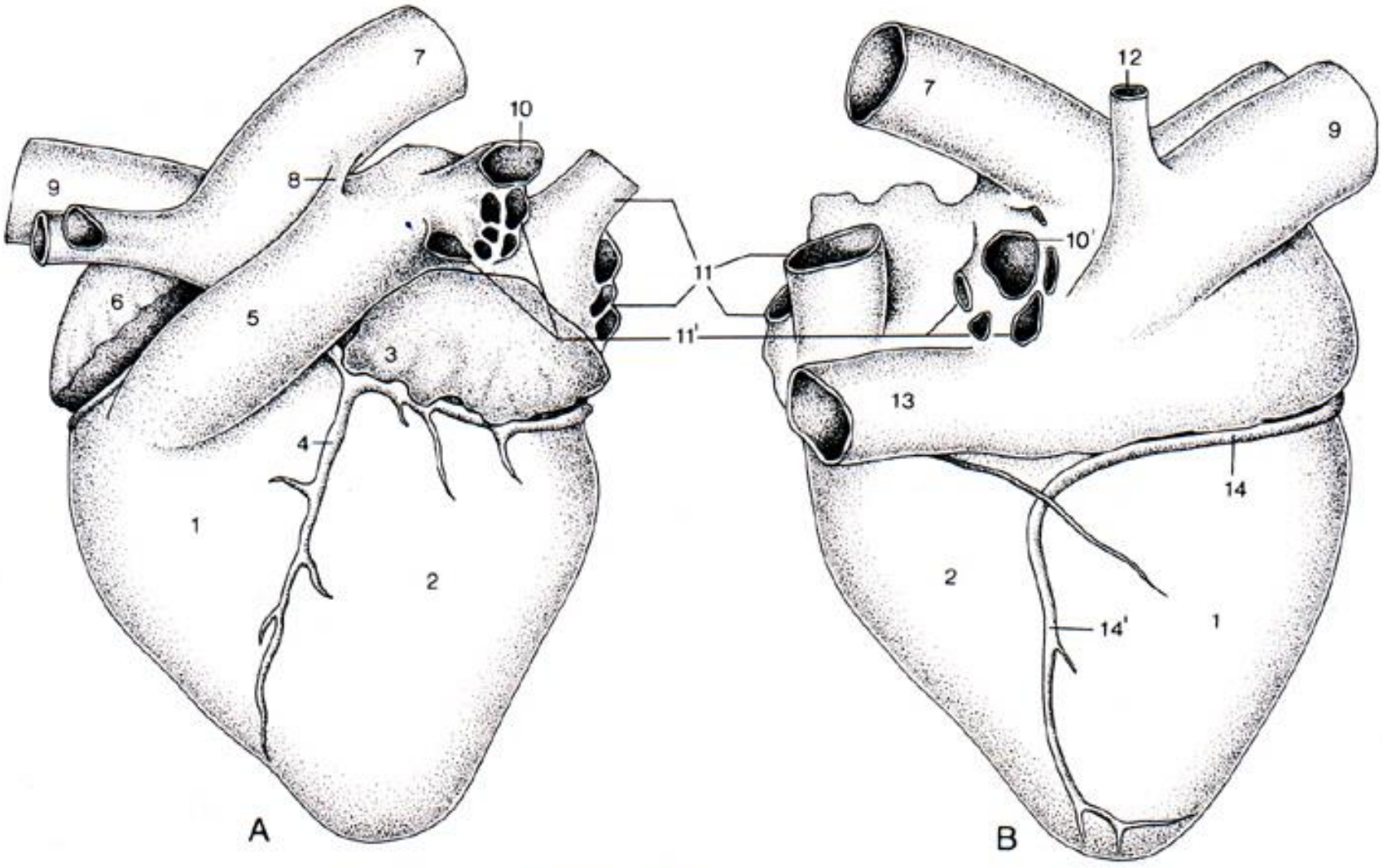


Figure 7–7. Left (*A*) and right (*B*) views of the equine heart.

External features of the heart

- Left lateral surface of the heart
  - Left atrium and left ventricle
  - Right ventricle and right auricle extend around the cranial border

- Right lateral surface of the heart
  - Right atrium and right ventricle
  - Left ventricle and left atrium extend around the caudal border

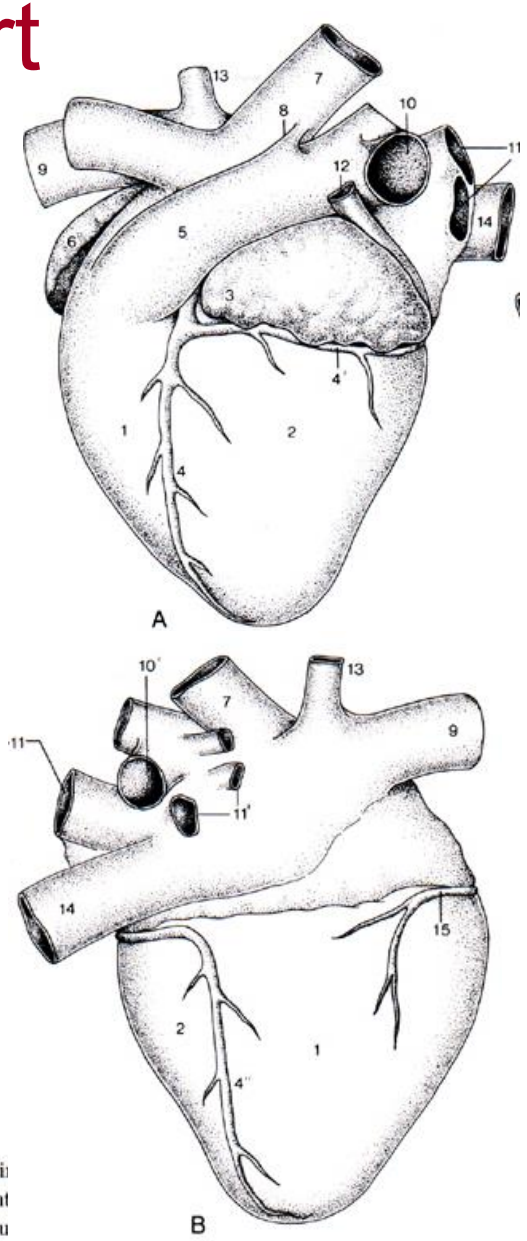


Figure 7–9. Left (*A*) and right (*B*) views of the bovine heart.

1, Right ventricle; 2, left ventricle; 3, left auricle; 4, paraconal interventricular branch of left coronary artery; 4′, ci branch of left coronary artery; 4″, subsinuosal interventricular branch of left coronary artery; 5, pulmonary trunk; 6, right 7, aorta; 8, ligamentum arteriosum; 9, cranial vena cava; 10, 10′, left and right pulmonary arteries; 11, 11′, left and right pu veins; 12, left azygous vein; 13, right azygous vein; 14, caudal vena cava; 15, right coronary artery.

External features of the heart

- Right ventricle lies as much cranially as to the right of the left ventricle
- Cranial border of right ventricle is convex
- Caudal border of left ventricle
  - Carnivores - slightly convex
  - Horse - almost straight
  - Ruminants - slightly concave

Internal features of the heart

- Right atrium
  - Four main openings
    - Cranial vena cava
    - Caudal vena cava
    - Coronary sinus
    - Right atrio-ventricular opening
  - Other variable openings
    - Small coronary veins
    - Azygous vein (in some species)

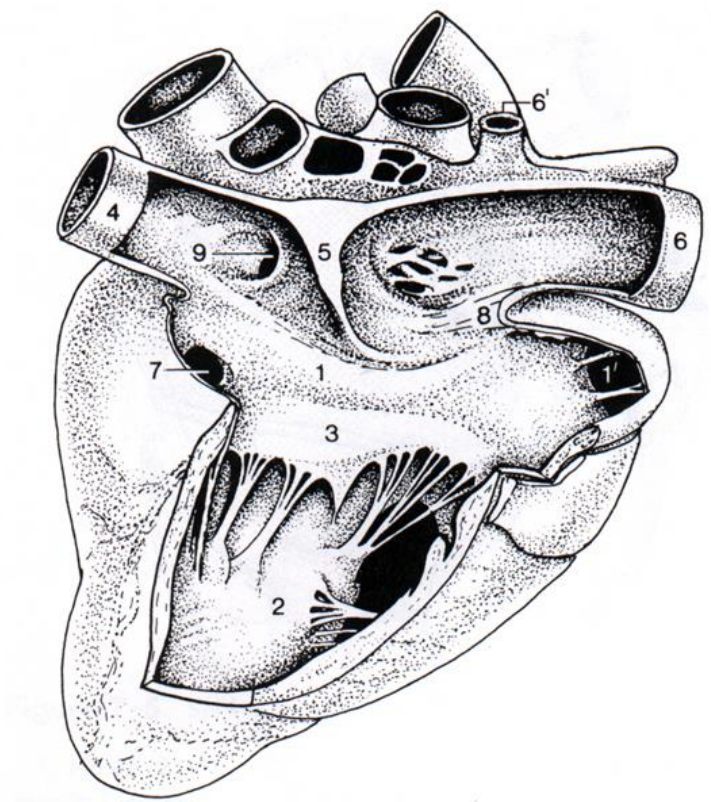
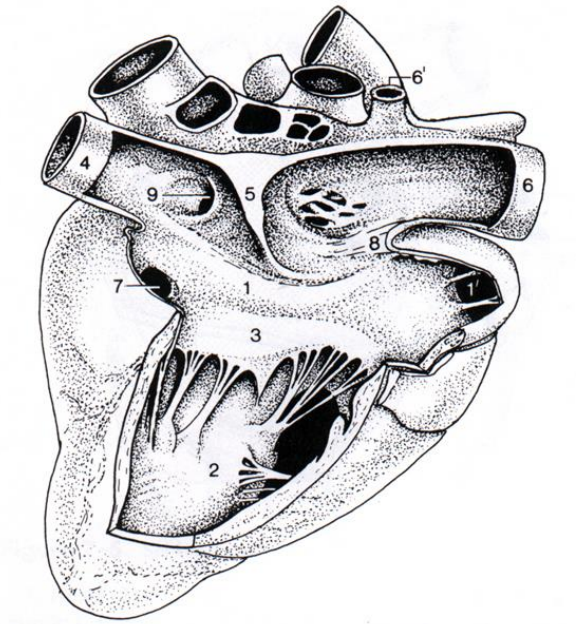


Figure 7–8. Overview of the interior of the right atrium and right ventricle of the equine heart.

Internal features of the heart

- Right atrium - surface is smooth
- Right auricle - surface is interlaced with pectinate muscles

- Vestiges of the fetal circulation
  - Fossa ovalis
  - Intervenous tubercle



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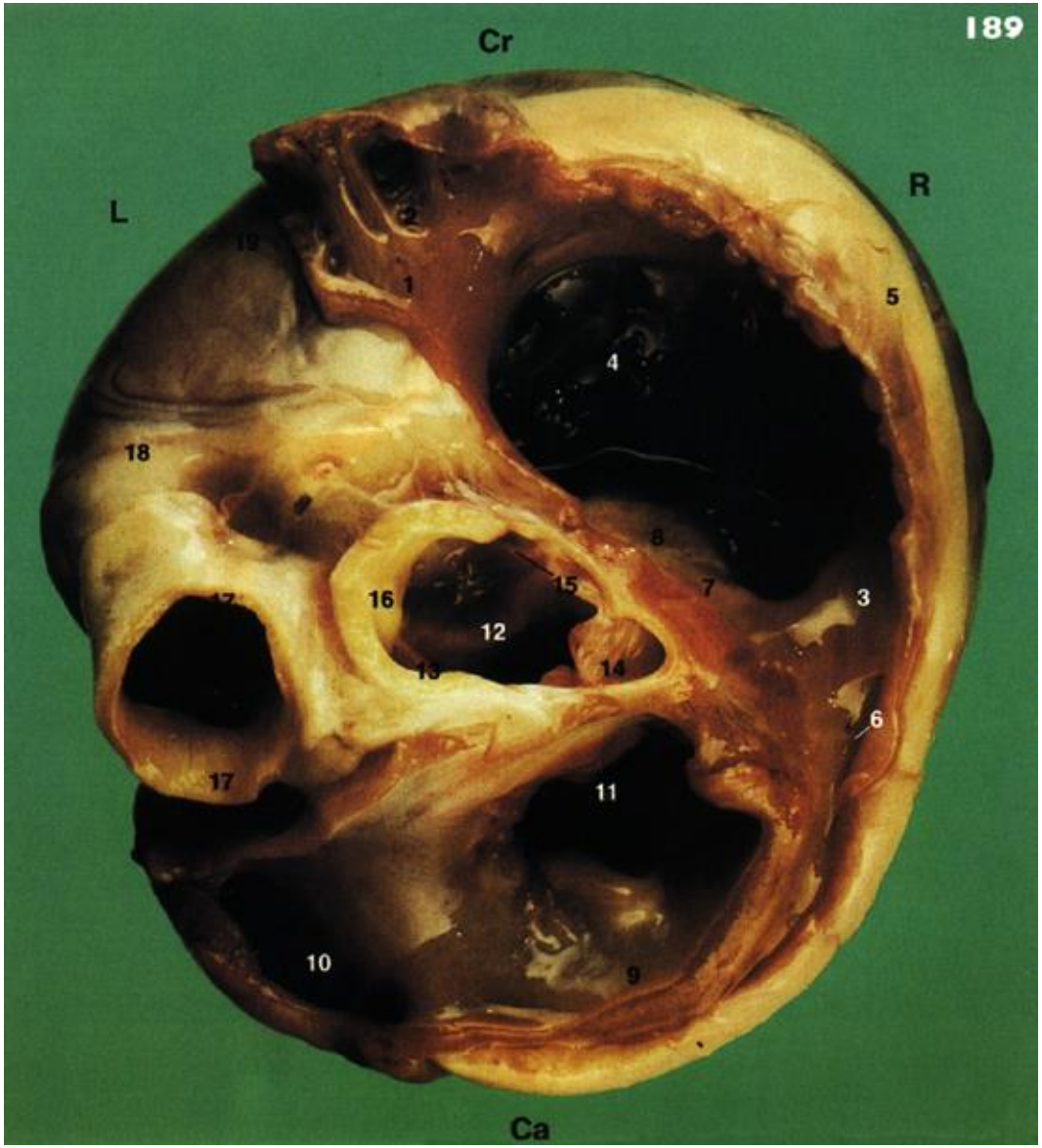
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Internal features of the heart

- Right ventricle
  - Lumen - crescent-shaped
  - Opening - guarded by the tricuspid valve
    - Three thin flap-like cusps
    - Free edge of cusp - restrained by chordae tendineae
    - Chordae tendineae arise from papillary muscles

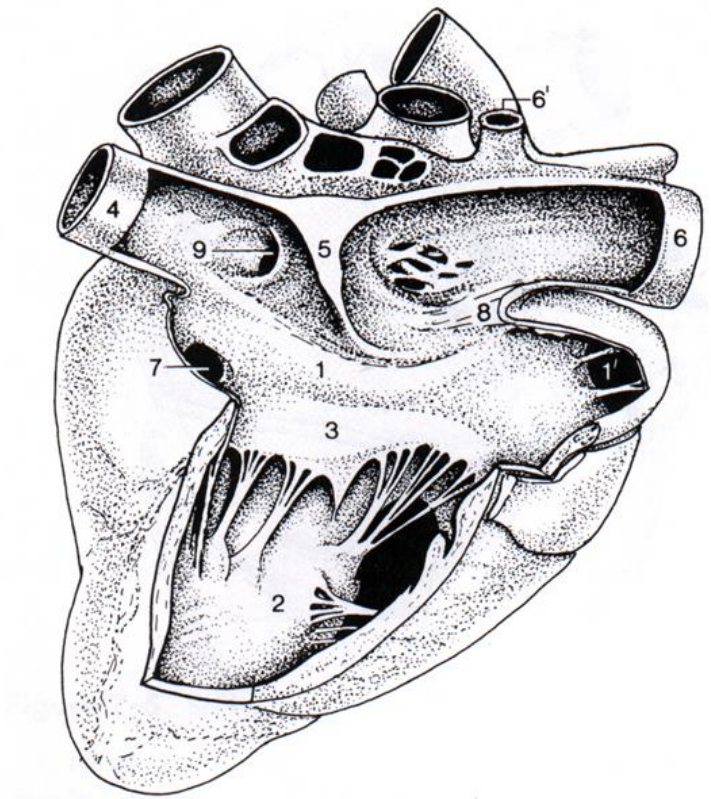


Figure 7–8. Overview of the interior of the right atrium and right ventricle of the equine heart.

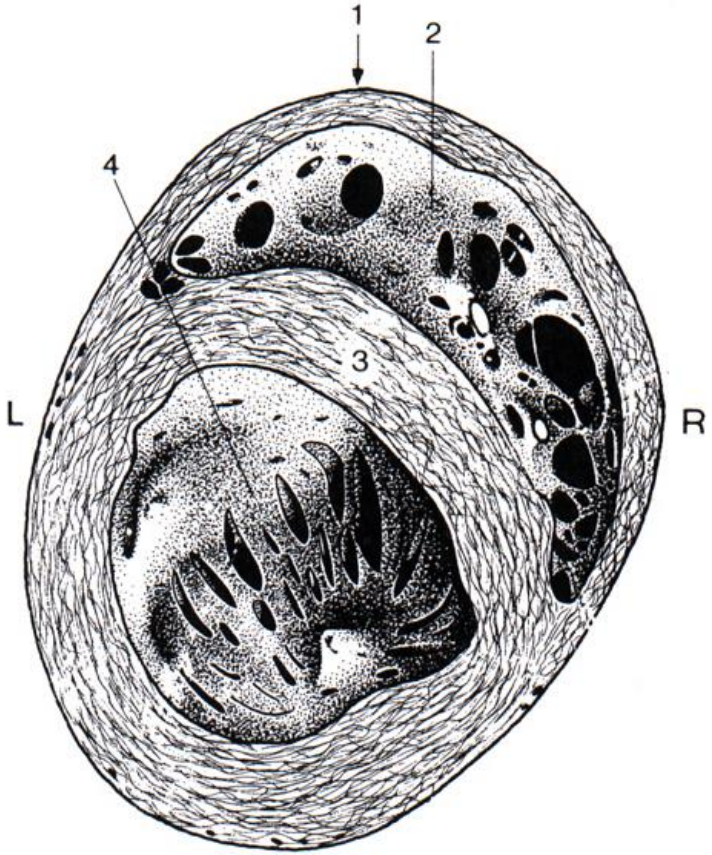


Figure 7–10. Transverse section through the ventricles.

Under normal circumstances, the interventricular septum, which divides the ventricles, contracts as part of the LV.

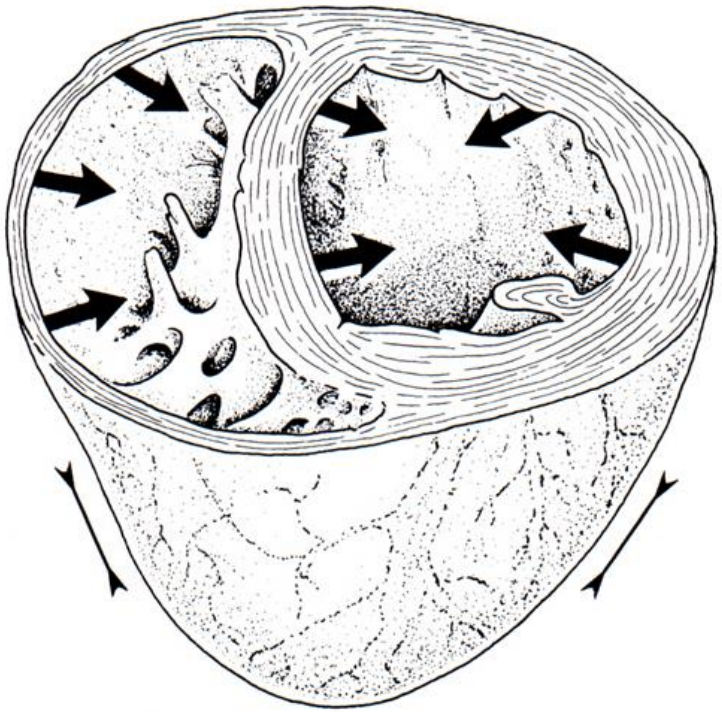


Figure 7–19. Schematic drawing of the mode of contraction of the left and right ventricles. The wall of the left ventricle contracts radially, while the right ventricular lumen is squeezed in a "bellows" action.

Internal features of the heart

- Right Ventricular cavity
  - Crossed by the right septomarginal trabeculae
  - Irregular surface - presence of trabeculae carneae
  - Three papillary muscles:
    - Two from septum
    - Large one from the outer wall

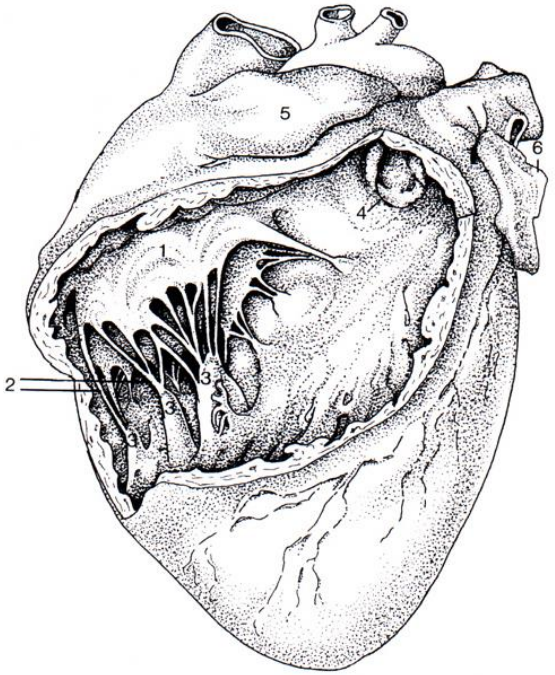


Figure 7–12. Cranioventral view of the interior of the right ventricle.

Internal features of the heart

- Right ventricular cavity -
  - Out-flow channel
    - Funnel-shaped ‘conus arteriosus’
    - Directs blood into the pulmonary trunk
    - Smooth walls
  - Root of the pulmonary trunk - increased in diameter

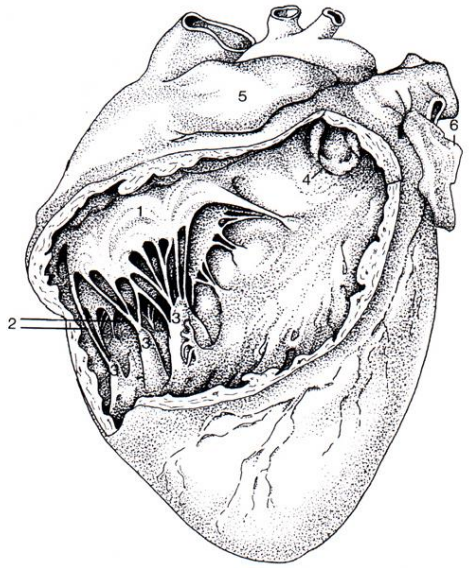


Figure 7–12. Cranioventral view of the interior of the right ventricle.

Internal features of the heart

- Pulmonary valve
  - 3 semi-lunar valvules - pockets
  - 3 bulges in the wall of the pulmonary trunk - sinuses of the pulmonary trunk
  - The pulmonary valve leaflets are much thinner structures than the aortic valve leaflets.

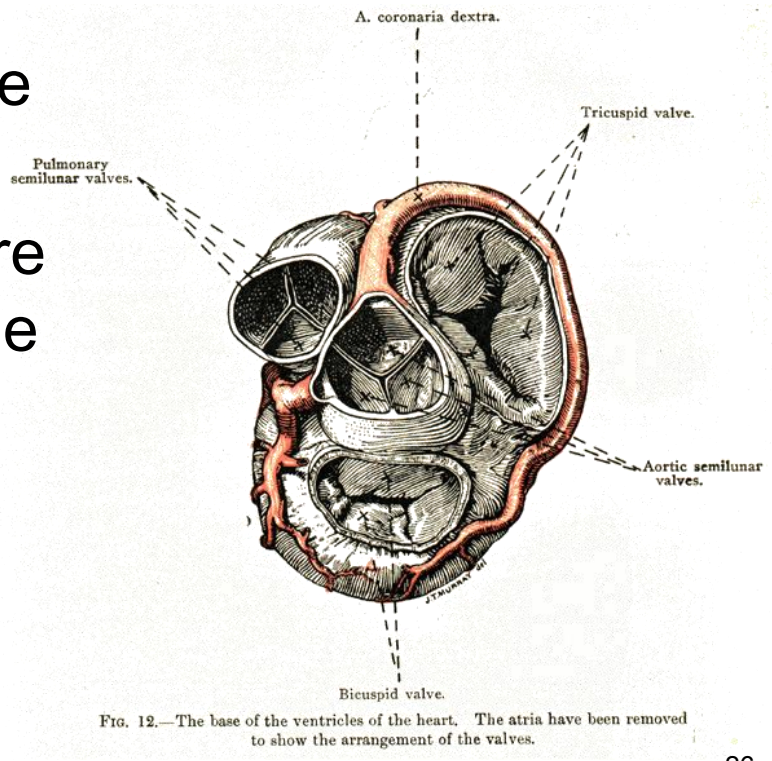


FIG. 12.—The base of the ventricles of the heart. The atria have been removed to show the arrangement of the valves.

Internal features of the heart

- Left atrium - openings:
  - Usually 6 pulmonary veins
    - 2 from the left
    - 4 from the right
  - Small coronary veins
  - Left A-V orifice into the left ventricle

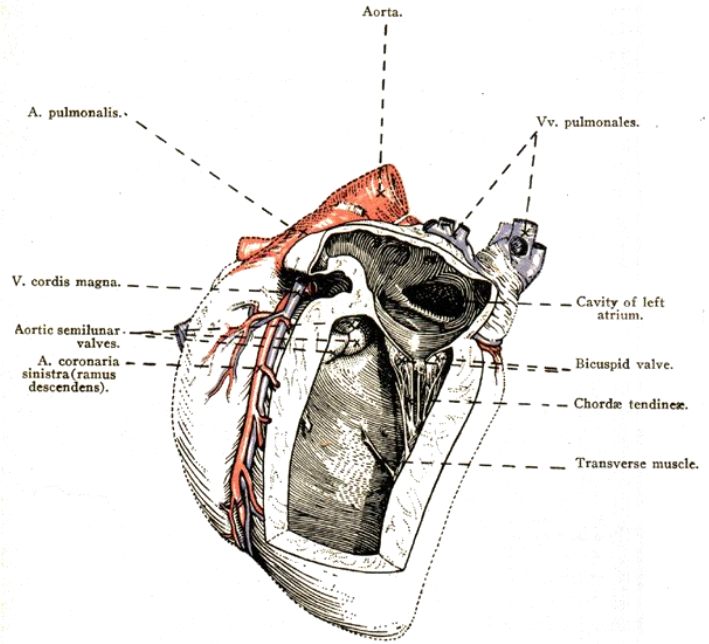


FIG. 14.—The heart viewed obliquely from the left and behind, with the interior of the left atrium and left ventricle exposed.

Internal features of the heart

- Left ventricle
  - Opening guarded by - mitral valve -
    - Has 2 cusps
  - Has 2 papillary muscles
    - Arise from the outer wall
  - Root of the aorta increased in diameter - aortic bulb

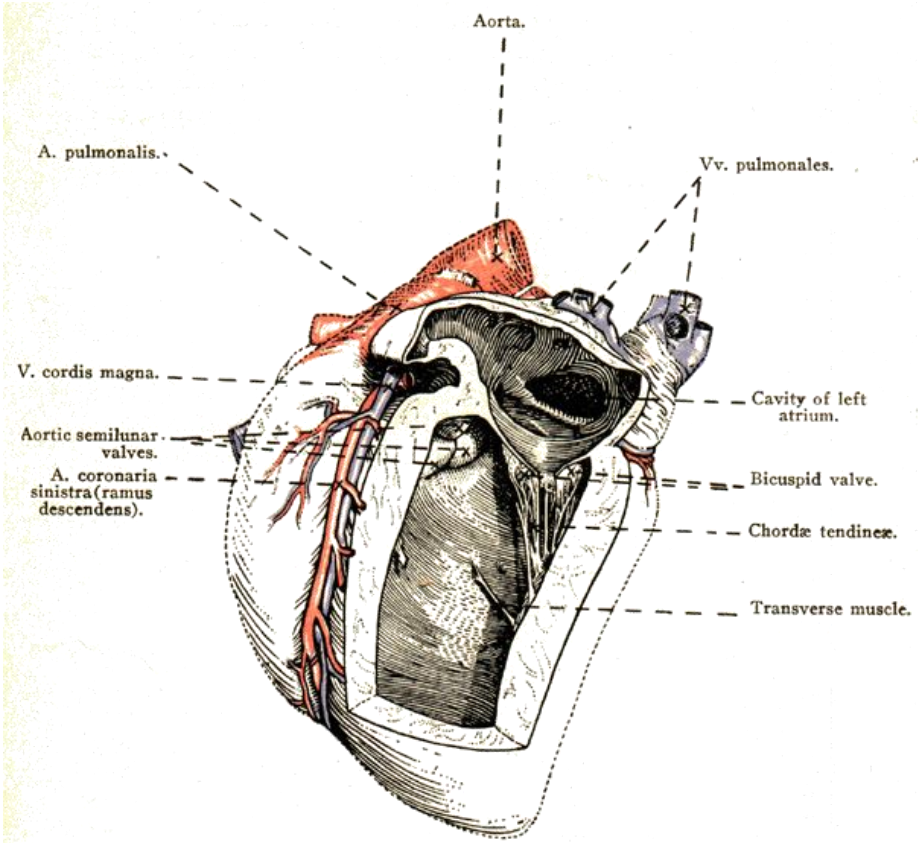
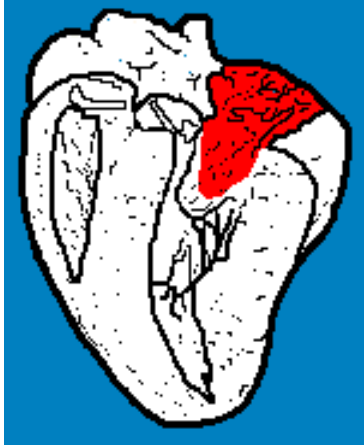
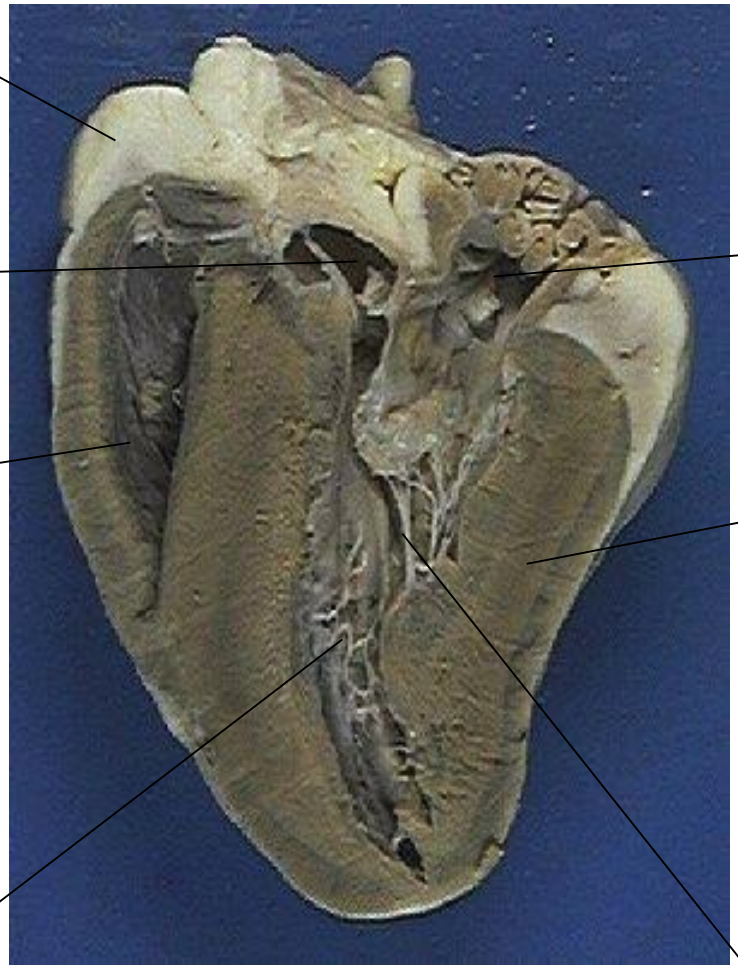


FIG. 14.—The heart viewed obliquely from the left and behind, with the interior of the left atrium and left ventricle exposed.

Sheep heart





adipose

Opening to aorta

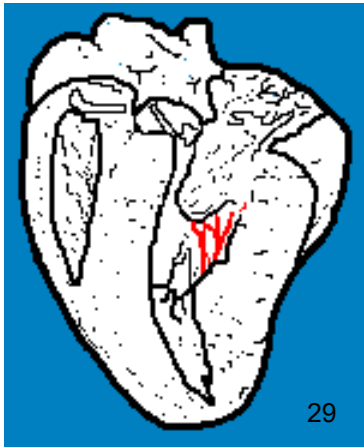
L atrium

R ventricle

L ventricular myocardium

Trabeculae carneae

Chordae tendineae



Internal features of the heart

- Interventricular septum - 2 components
  - Thick muscular portion
  - Thin membranous portion
    - Site of closure of the embryonic interventricular foramen

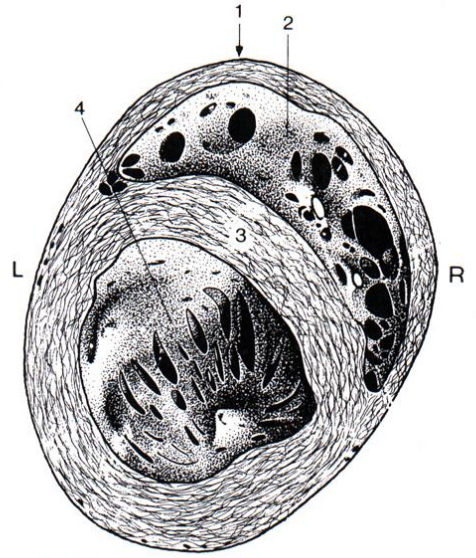


Figure 7–10. Transverse section through the ventricles.

Heart wall structure

- Endocardium
  - Lines the lumen of the heart chambers
- Myocardium
  - Is the thick middle layer of the heart
  - Is composed of cardiac muscle
- Epicardium
  - External surface layer of the heart - also called the visceral pericardium

Internal features of the heart

- Aortic valve - 3 semi-lunar valvules
  - Left coronary artery opens from left aortic sinus
  - Right coronary artery opens from right aortic sinus
  - Valvules of the left A-V and aortic valves - thicker than in the right ventricle

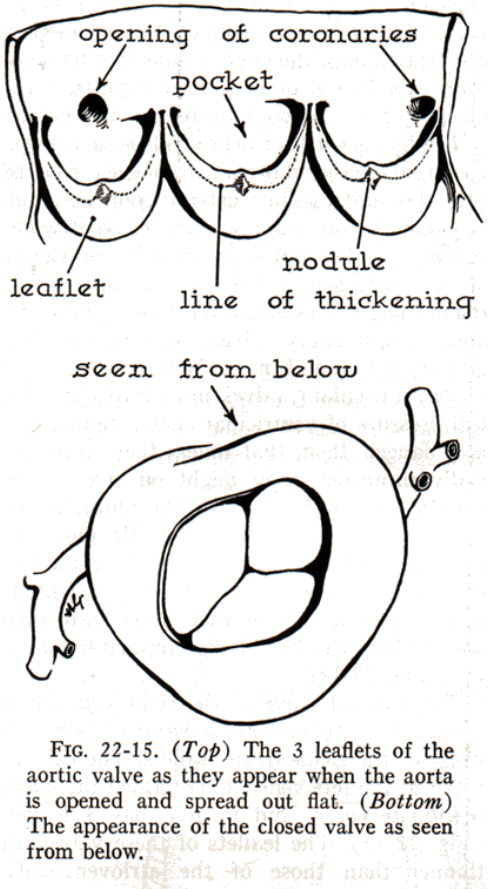


FIG. 22-15. (*Top*) The 3 leaflets of the aortic valve as they appear when the aorta is opened and spread out flat. (*Bottom*) The appearance of the closed valve as seen from below.

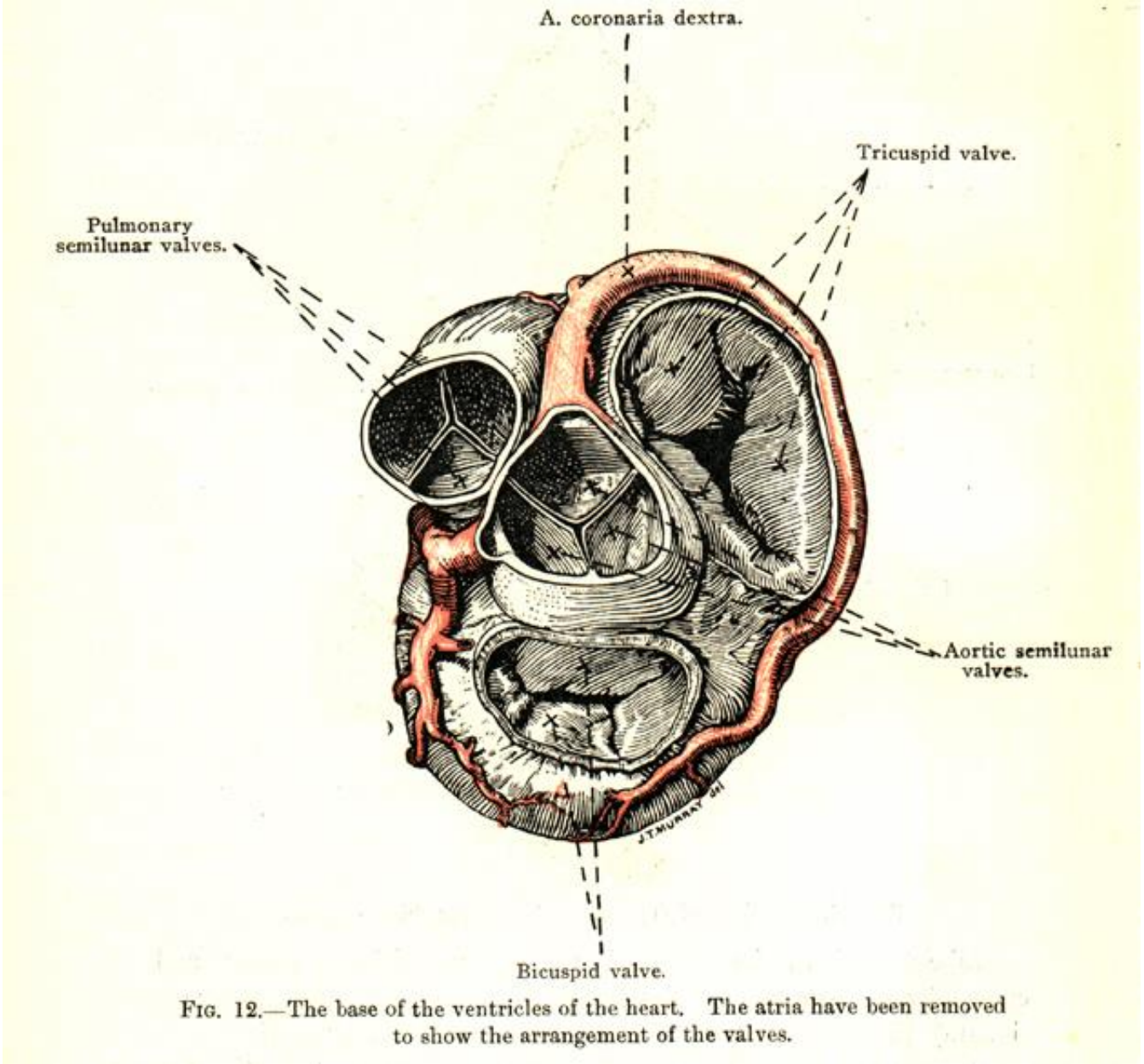
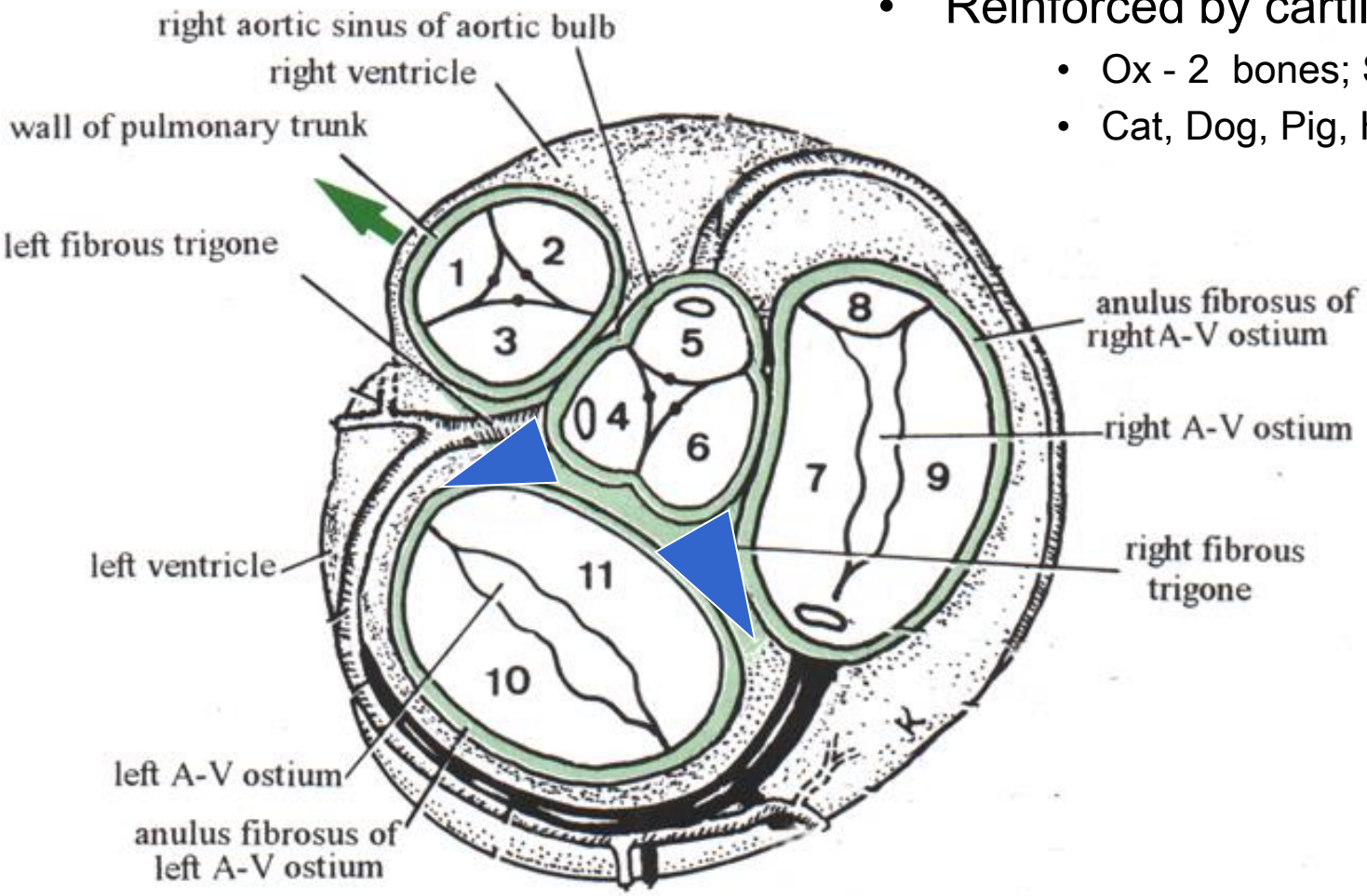


FIG. 12.—The base of the ventricles of the heart. The atria have been removed to show the arrangement of the valves.

The Cardiac Skeleton

- Plate - 2 triangular areas - trigones
- Reinforced by cartilage or bone:
  - Ox - 2 bones; Sheep - 1 bone ('os cordis')
  - Cat, Dog, Pig, Horse - cartilage



2-D cardiac skeleton after King 1999

Heart position in the chest

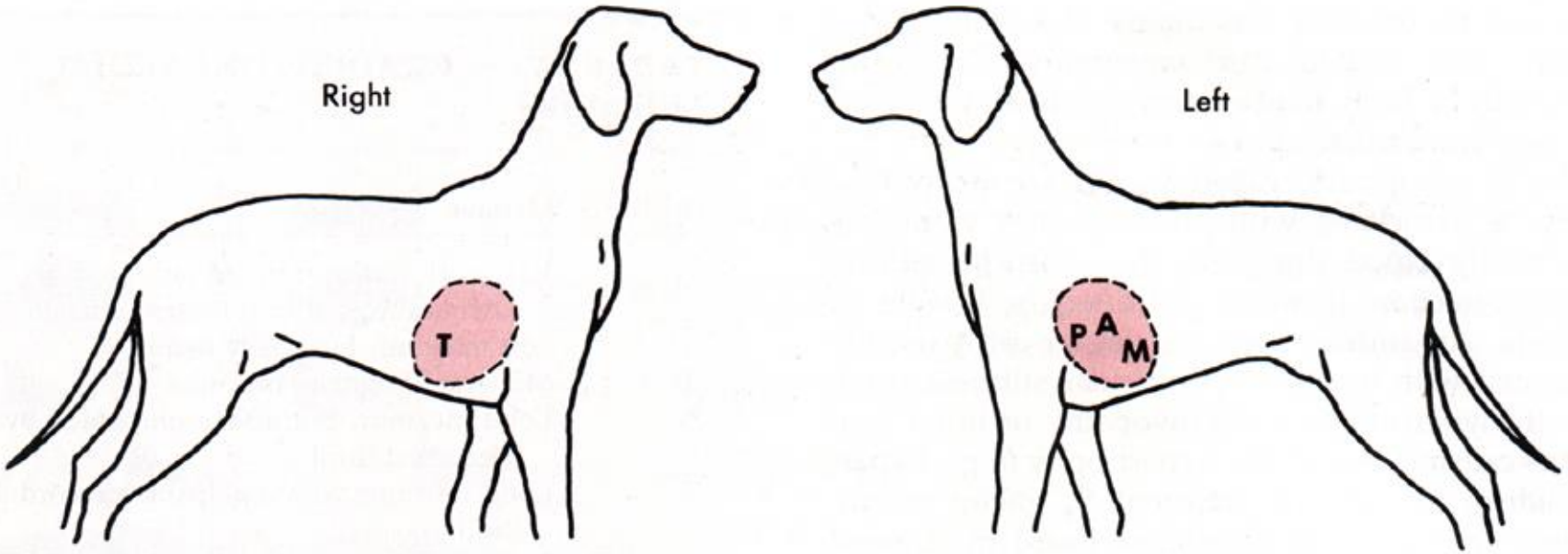
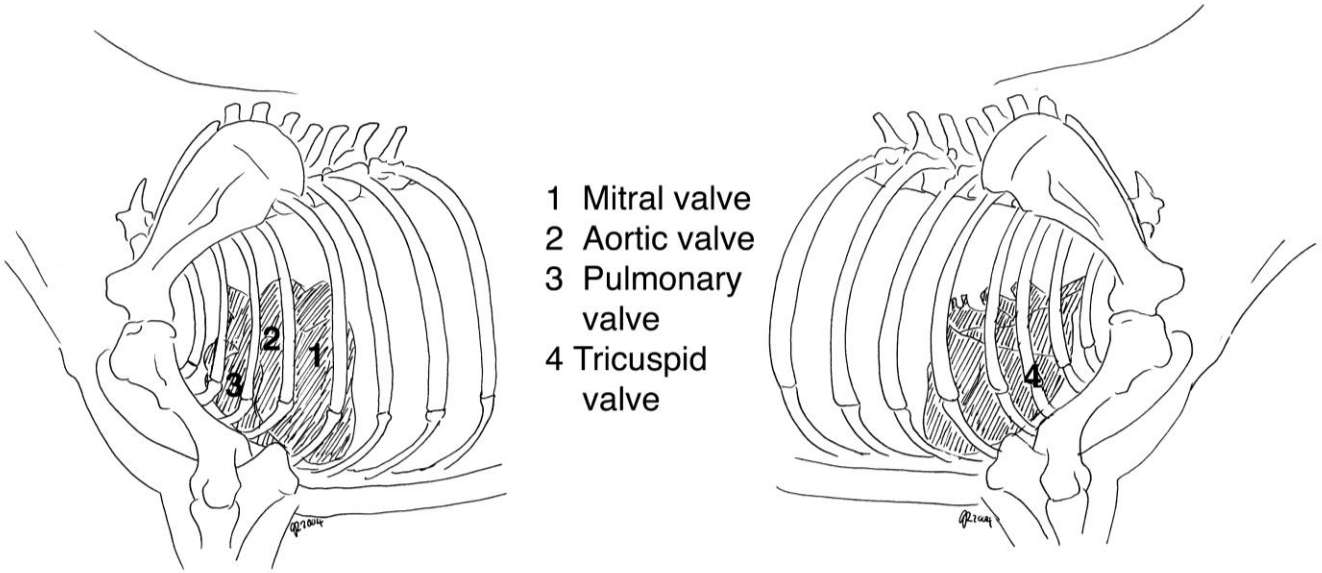


FIGURE 1-1. Approximate locations of various valve areas on chest wall. *T,* Tricuspid; *P,* pulmonic; *A,* aortic; *M,* mitral.

Heart position in the chest

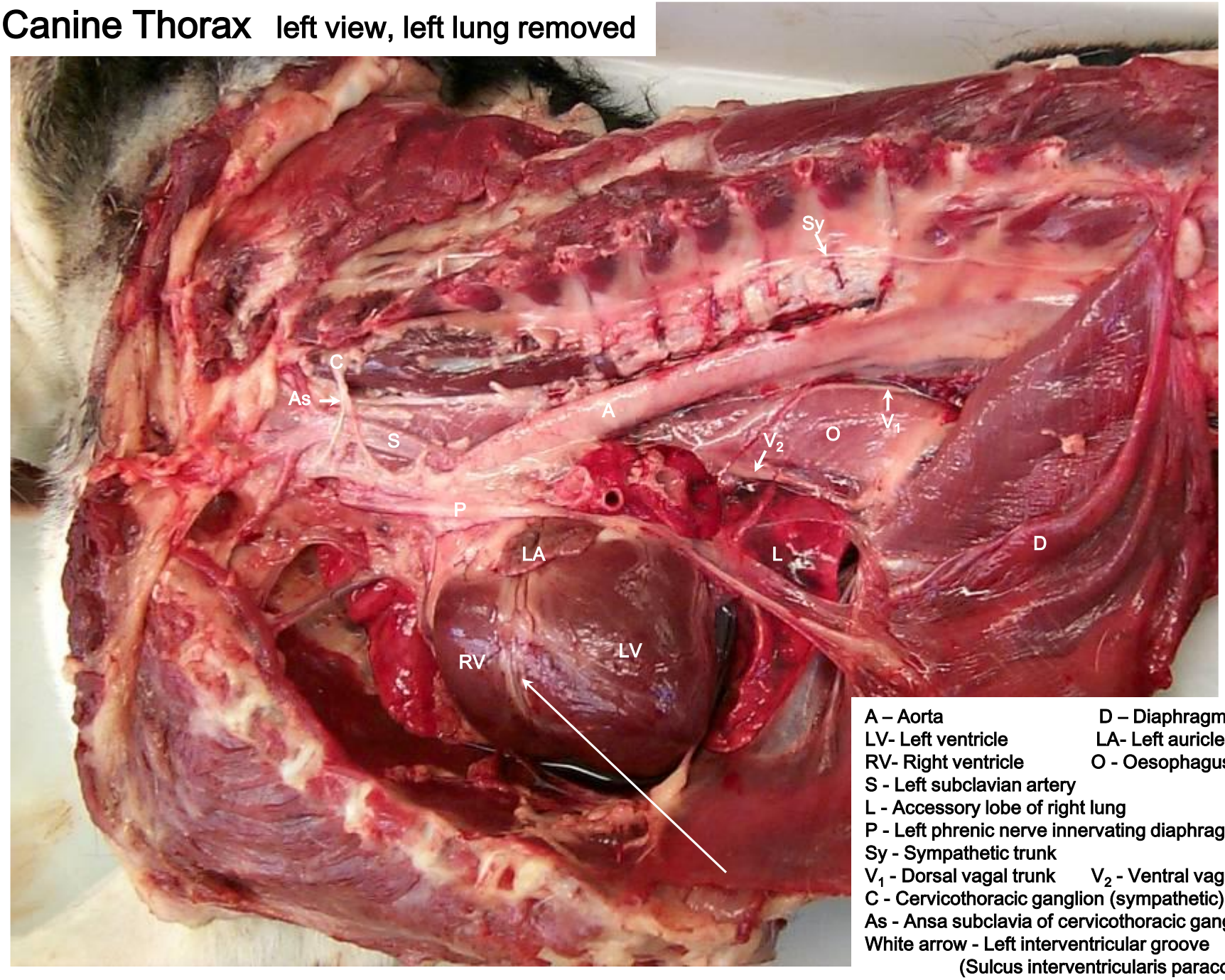


Sites of maximum audibility of endocardial sounds. Horse.

- In the horse, the heart is positioned almost vertically on the sternum, with the long-axis in a dorso-ventral direction.

(see addendum to notes – auscultation of the heart)

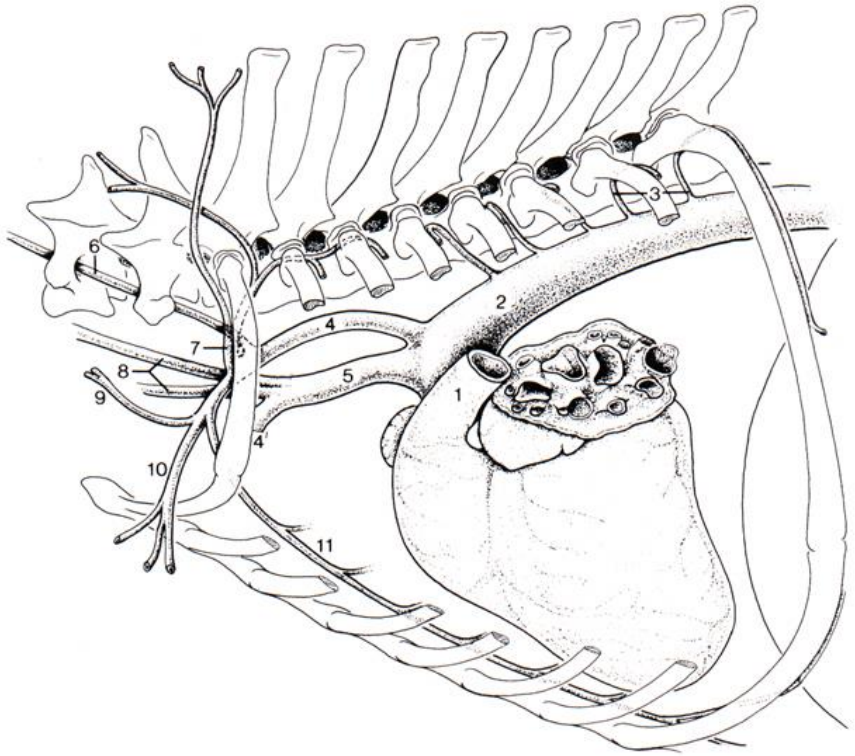
Canine Thorax left view, left lung removed



A – Aorta D – Diaphragm
LV- Left ventricle LA- Left auricle
RV- Right ventricle O - Oesophagus
S - Left subclavian artery
L - Accessory lobe of right lung
P - Left phrenic nerve innervating diaphragm
Sy - Sympathetic trunk
V_1 - Dorsal vagal trunk V_2 - Ventral vagal trunk
C - Cervicothoracic ganglion (sympathetic)
As - Ansa subclavia of cervicothoracic ganglion
White arrow - Left interventricular groove
(Sulcus interventricularis paraconalis)

Systemic arteries - Aorta

- Main systemic arterial trunk
- Arises from the L. ventricle
- Divided into 3 main segments
  - Ascending aorta
  - Aortic arch
  - Descending aorta



Ascending Aorta

- Very short, arises from L. ventricle
- Passes dorsally and cranially between the pulmonary trunk and the right atrium
- Supplies blood to the wall of the heart
  - L. coronary artery
  - R. coronary artery

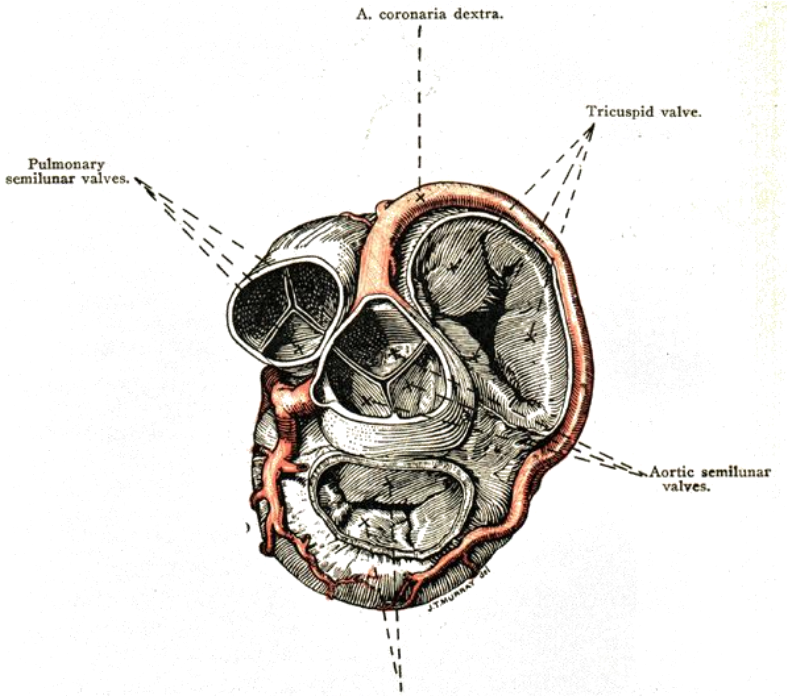
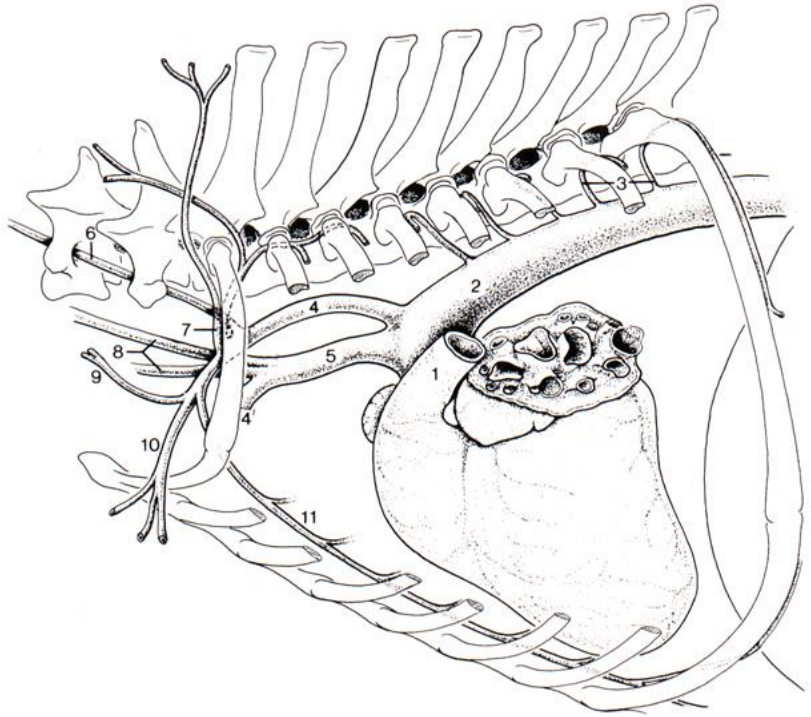


Fig. 12.—The base of the ventricles of the heart. The atria have been removed to show the arrangement of the valves.

Aortic arch

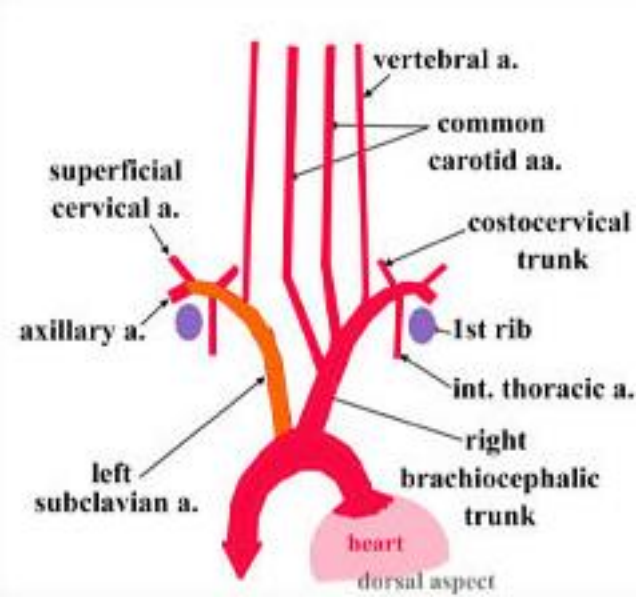
- Aorta makes a dorso-caudal u-turn
- Penetrates the pericardium
- Ascends within the mediastinum
- Reaches ~ 7th thoracic vertebrae
- Supplies blood to:
  - The head, neck, shoulders, forelimbs and thoracic wall



Aortic arch - major branches

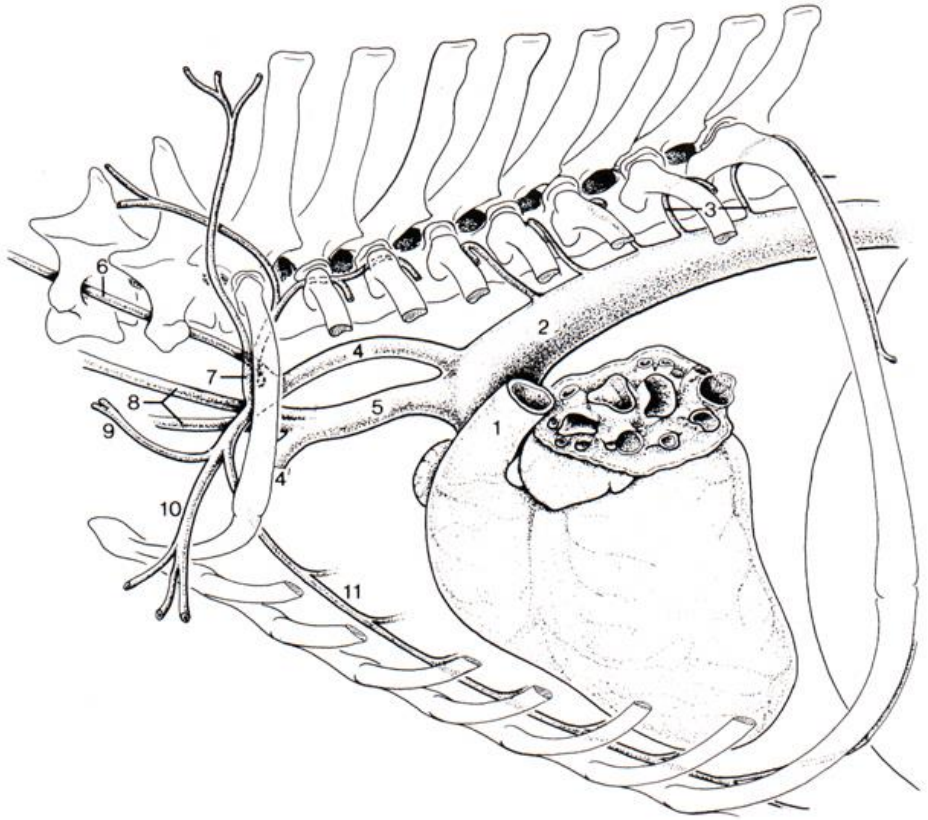
- 1 to 3 major branches - species variation

- Two major vessels arise from the aortic arch:
  - Brachiocephalic trunk
  - Left subclavian artery



Brachiocephalic trunk

- Larger than L. subclavian a.
- Is short ~ 4 cm
- Passes cranio-obliquely to R. ventral to trachea
- Branches:
  - L. common carotid a.
  - R. common carotid a
  - R. subclavian a.



Species variation

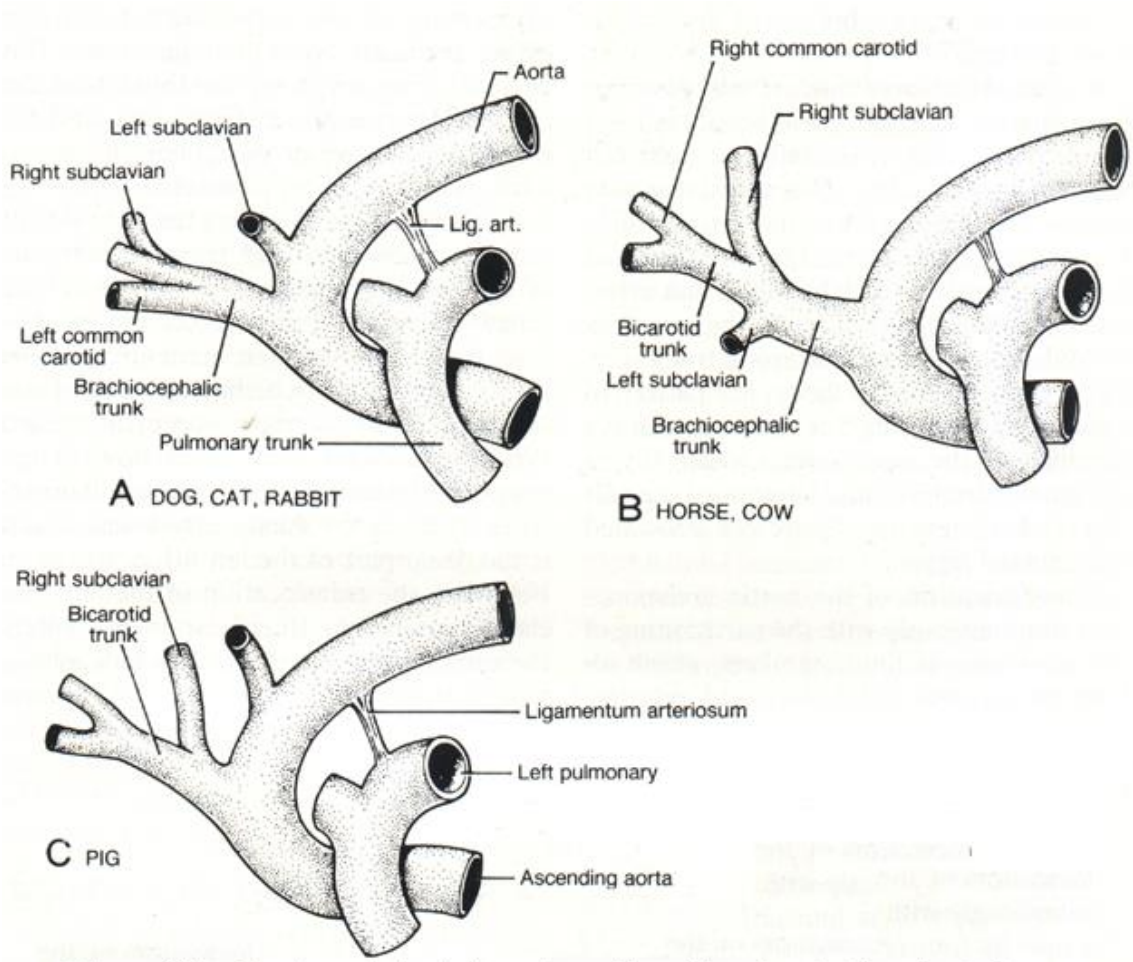
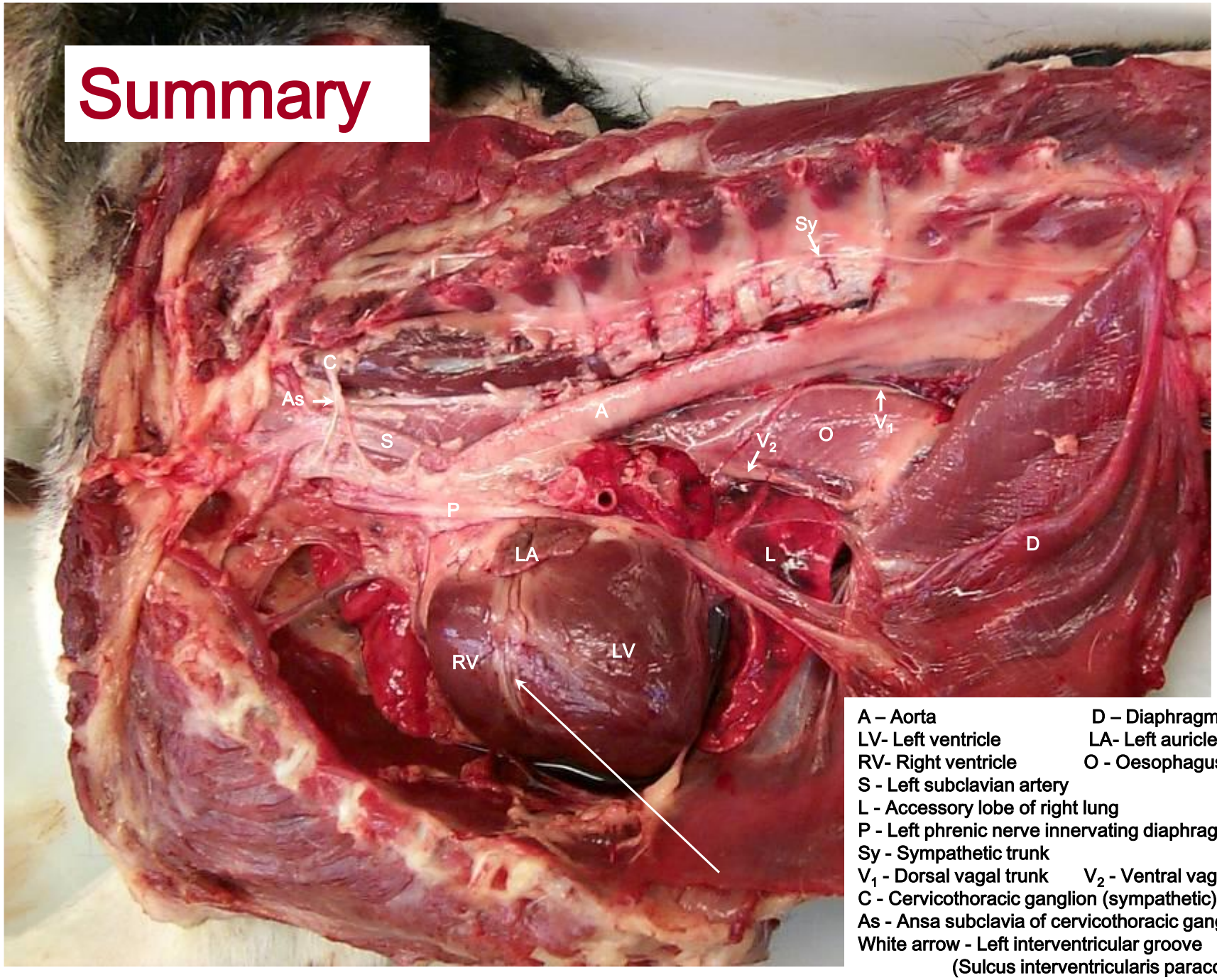


Figure 11.5. Species variation in the pattern of branching of major thoracic arteries.

(see addendum to notes – comparative species anatomy of the heart)

Summary



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