

Veterinary Bioscience: Cardiovascular System



WEEK 1 – STRUCTURE/FUNCTION RELATIONSHIPS IN THE HEART

LECTURER: PROF. SIMON BAILEY

After time spent in mixed veterinary practice in the UK, Simon undertook a PhD at the Royal Veterinary College, London. He then continued in research at the RVC, working in the fields of equine laminitis and inflammation. Simon then worked as a research scientist at the Heart and Lung Research Institute at the Ohio State University Medical Center, Columbus, Ohio. He then returned to the Royal Veterinary College as a lecturer and moved to the University of Melbourne in 2007. He is currently Professor of Pre-clinical Veterinary Sciences, and conducts research on inflammatory diseases, pharmacology and endocrinology in various species including horses.

Email: bais@unimelb.edu.au



INTENDED LEARNING OUTCOMES

At the end of this lecture, you should:

- be aware of the variation in size, shape and position of the heart in the main domestic mammal species
- have an understanding of the pericardium - its structure and function
- be able to identify the external and internal anatomical features of the heart
- be able to identify the different parts and branches of the aorta within the thorax.

KEYWORDS

Heart, thorax, mediastinum, pericardium, atria, ventricles, auricles, cardiac valves, aorta.

LECTURE 2 – THE HEART WITHIN THE THORAX

The heart accounts for **about 0.6% of total body weight** in most normal domestic animals.

POSITION OF THE HEART:

Lies in the **mediastinum** (the partition between right and left pleural cavities) enclosed within its pericardial sac.

Usually situated **between the third and sixth ribs** (this area of lateral thoracic wall is largely covered by the triceps muscle of the forelimb)

- Dorsal boundary - lies on a horizontal plane through the centre of the first rib Caudal boundary - is the dome of the diaphragm
- Ventral boundary - is the sternum

- Right lung is larger than the left - therefore most of the heart lies to left of the mid-line - and left surface of heart is nearer to the thoracic wall than the right.

The long axis of heart is: essentially vertical in the horse, almost vertical in ruminants, progressively more oblique in the pig, dog and cat.

SHAPE OF THE HEART:

- **Cone shaped** -slightly flattened on left and right sides, to conform to the similar compression of the thorax.
- Base of the heart - most dorsal part of heart - low dome formed by the left and right atria. Great veins - systemic and pulmonary - enter the base of the heart
- Great arteries -aortic and pulmonary - **emerge from the base of the heart.**

The heart is held in position by the great vessels but otherwise lies entirely free within the pericardium (pericardial sac).

- Apex of the heart -tapered portion of the cone, formed by the left ventricle, lies close to the sternum.
- Long axis of heart - extends from middle of the base to the apex. Cranial aspect - extensively related to thymus in the young animal. Right and left lateral surfaces face the corresponding lungs.
- Caudal border faces towards the diaphragm - thus may be directly related to the cranial abdominal organs

THE PERICARDIUM

A serous sac deeply invaginated by the heart. The sac is closed and its lining is a simple squamous (flat) epithelium.

The Functions of the pericardium are to form a protective sac around the heart, to help maintain the heart in position, to help minimise friction and perhaps may have a role in preventing the heart from becoming over distended. The **Pericardial cavity** is occupied by a thin film of serous fluid - lubricant – which enables visceral and parietal layers of pericardial membrane to slide over each other during the cardiac cycle.

Layers of the wall of the pericardium:

Visceral pericardium - inner wall of the pericardial sac, coats the outer surface of the heart

Parietal pericardium - at the neck of the sac the visceral pericardium continues onto the outer wall of the sac. The external surface of the parietal pericardium is reinforced by a strong layer of fibroelastic tissue. This layer is called the fibrous pericardium.

Relationship to thoracic wall

The Cardiac notch is the gap in the ventral border of left and right lungs, which allows the pericardium to make contact with the thoracic wall. This is greater on left side, and provides a useful 'acoustic window' for echocardiography.

EXTERNAL FEATURES OF THE HEART

The base of the heart is formed by the **thin walled atria** - separated from the ventricles by the encircling **coronary groove**. Each atrium has a **blind diverticulum** (or free appendage) called the **auricle**.

The thicker walled left and right ventricles fuse together to form a firm cone. The position of the **interventricular septum** (wall dividing the left and right internal chambers of ventricle) is marked externally by the Left interventricular (or paraconal) groove - on left side of the heart and the right interventricular (or subsinuosal) groove - on the right side of the heart

The left surface of heart (or auricular surface) is formed mainly by the left atrium and left ventricle, but the right ventricle and right auricle extend round the cranial border of the heart - contributing substantially to the left surface.

The **right surface (or atrial surface)** is formed mainly by the right atrium and right ventricle, but the left ventricle extends around the caudal border of the heart - contributing to the right surface.

INTERNAL FEATURES OF THE HEART

The **right atrium** forms a chamber into which the principal systemic veins discharge. It has four main openings:

The cranial vena cava, the caudal vena cava, the coronary sinus and the right atrioventricular (A-V) orifice - guarded by the right A- V valve. The right auricle (a blind diverticulum) opens from the cranial end of the right atrium and winds round the cranial aspect of the heart. The internal wall of atrium is smooth, but that of the auricle is interlaced with muscular ridges, the pectinate muscles

The **Right Ventricle** receives blood from the right atrium and **pumps blood into the pulmonary trunk**. A thick muscular interventricular septum separates the right and left ventricles. The **lumen is crescent shaped in transverse section and its opening is guarded by the right atrioventricular (or tricuspid) valve**.

Valve cusps are composed of a **layer of collagen fibres sandwiched between two layers of endothelium**; the collagen fibres are continuous with those of the fibrous ring that surrounds the right A-V opening. **Chordae tendineae** - arise from **papillary muscles** that project from the internal surface of the ventricular wall and fan out to attach to the cusps of the A-V valve. **Each papillary muscle modulates the movements of two cusps**.

The **Ventricular cavity** is divided into two functional components - an inflow channel and an outflow channel.

Since the pulmonary circulation is a low pressure system, the wall of the right ventricle need only be about half as thick as that of the left ventricle.

The **thick muscular interventricular septum** has two components: The larger muscular part is thick myocardium formed by the combined walls of the two ventricles. The collagenous but thin membranous part is a small inconspicuous area in the extreme dorsal part of the septum.

The **Left atrium** receives arterial blood from the lungs via the pulmonary veins. As in the right atrium, small coronary veins also empty into the left atrium. The **Left auricle** is a blind diverticulum with pectinate muscles present on internal surface; the rest of the atrium has a smooth internal wall.

The **Left ventricle** is connected to the left atrium via the left A-V opening, guarded by **the left atrioventricular (or mitral) valve**. This has two cusps and is also known as the bicuspid valve. As the systemic circulation is a high-pressure system, therefore the wall of the left ventricle is about 2 or even 3 times as thick as the right ventricle.

MAJOR SYSTEMIC ARTERIES

The aorta is the main systemic arterial trunk, distributing oxygenated blood to the various regions of the body. It is divided into 3 main segments: Ascending aorta, Aortic arch and Descending aorta.

Within the thorax, two major vessels arise from the aortic arch: The brachiocephalic trunk and the left subclavian artery. These vessels give rise to branches which supply the head neck, thorax and the thoracic limbs.

FURTHER READING

Boyd, JS, Paterson, C, and May AH, *Color atlas of clinical anatomy of the dog and cat*, Second Edition, 2001. Dyce, Sack and Wensing, *Textbook of Veterinary Anatomy*, 3rd edition, 2002.