Marie Rippingale
BSc(Hons) REVN clinical coach
G-SQP DipHE CVN DipAVN(Equine)

Marie is head equine nurse and a clinical coach at Scarsdale Vets in Derby. Marie is also a lecturer on the veterinary nursing diploma course at Bottle Green Training, Melbourne, Derbyshire.

Practical nurse's approach to the equine cardiovascular system

Horses are exceptional athletes and a healthy cardiovascular system enables them to achieve impressive athletic feats. Although death as a consequence of heart disease is rare in horses, the registered veterinary nurse (RVN) must have knowledge of the equine cardiovascular system, disorders that can occur, and the diagnostic techniques used.

The equine circulatory system consists of a four-chambered pump – known as the heart – and a system of tubular vessels that circulate the transport medium, the blood (Pilliner and Davies, 2004). As a general rule, the vessels that carry blood away from the heart are known as arteries, whereas the vessels that carry blood back to the heart are known as veins. In addition, there is a system of vessels that carry lymph or tissue fluid to the large veins and these are known as lymph vessels (Pilliner and Davies, 2004).

Intravenous injections in horses

In the horse the jugular vein is most commonly used for intravenous (IV) injections (**Figure 1**). Although the jugular vein is a large structure, care must be taken when administering IV medication in horses. The carotid artery sits directly behind the jugular vein and lies closer to the jugular vein further down the neck. For this reason the best place to perform an IV injection in the horse is within the upper third of the neck.

It is also correct practice to insert the needle without a syringe attached. This way the blood that drips out of the end of the needle hub can be assessed. If the blood is dark red in colour and dripping (**Figure 2**) the syringe can be attached and the IV injection can commence. If the blood coming out of the needle hub is bright red and spurting out under pressure, it can be reasonably assumed that the carotid artery has been punctured.

In the latter case, the needle must be withdrawn immediately and pressure applied to reduce the formation of a haematoma. Medication must never be injected into the carotid artery because this can induce collapse, a seizure and even death.

The equine heart

This is central to the circulatory system and is basically a large muscular pump that has the ability to contract and send blood through the network of vessels that supply the tissues in the body of the horse (Pilliner and Davies, 2004). The heart of a 16-hand horse weighs approximately 4kg. The heart is an organ which responds to exercise by getting bigger; therefore, as the horse becomes fitter, the heart size may increase up to about 5.5kg (Pilliner & Davies, 2004).

The size of the heart also varies with the breed of the horse. Thoroughbreds have markedly larger hearts than draft horses (Fraser and Girling, 2012).

Figure 1. *The jugular vein is most commonly used for intravenous injections in horses.*

Figure 2. *Blood coming out of the end of the needle will be dark red and dripping if the jugular vein has been punctured.*

**Suggested Personal & Professional Development (PPD)*

CARDIOVASCULAR

Figure 3. *Auscultation of the heart is usually achieved on the left-hand side of the horse's chest, just behind the elbow.*

At post mortem, very successful thoroughbred racehorses, such as *Eclipse* and *Pharlap*, were found to have unusually large hearts and this was thought to have contributed to their racing success.

The average equine heart rate is 32 beats per minute. However, horses can increase their heart rate to 220 beats per minute during intense exercise. This gives them a wide cardiovascular range with which to adapt to intense exercise, making them impressive athletes.

Position

The horse's heart lies in the ventral section of the mediastinum. In horses, the mediastinum is incomplete, allowing communication between the two sides of the chest (Fraser and Girling, 2012). The heart can be found between the second to sixth intercostal spaces; auscultation is usually achieved on the left-hand side of the horse's chest, just behind the elbow (**Figure 3**).

For the sake of completeness, the right side of the horse's chest should also be assessed during the first examination of the animal.

Structure and blood flow

The heart is divided into four hollow chambers – the right atrium, the right ventricle, the left atrium and the left ventricle.

The right side of the heart is separate from the left-hand side and this prevents blood mixing between the two. The right-hand side is responsible for moving deoxygenated or venous blood and the veins carry this deoxygenated blood via the body's largest vein, the vena cava, to the right atrium of the heart.

Once the full right atrium contracts, blood is pushed into the more muscular right ventricle. The tricuspid valve snaps shut to prevent any back-flow of blood and this creates the first noise or heart sound that can be heard when using a stethoscope – the 'lub' part of the characteristic 'lub-dup' sound of a heartbeat.

The right ventricle then contracts, pushing blood into the pulmonary artery which takes blood to the lungs. It is important to note that the pulmonary artery and the pulmonary vein are exceptions to the general rule that arteries carry oxygenated blood and veins carry deoxygenated blood – the pulmonary artery carries deoxygenated blood to the lungs, while the pulmonary vein carries oxygenated blood from the lungs to the heart.

"The average equine heart rate is 32 beats per minute. However, horses can increase their heart rate to 220 beats per minute during intense exercise"

Once in the lungs, the blood comes into contact with the alveoli and gaseous exchange takes place.

In the left side of the heart, the now oxygenated blood returns via the pulmonary vein to the left atrium of the heart. Once this is full, blood is forced into the left ventricle and the bicuspid valves shut to prevent any back-flow of blood.

The left ventricle has the thickest muscular wall of any of the four chambers this is because blood from the left ventricle is forced out under great pressure into the aorta which is the largest artery in the body and blood from the left ventricle has to travel a greater distance to all parts of the horse's body and not just to the lungs, hence the need for the thicker muscular wall.

Valves at the entrance of the aorta – known as the 'semi-lunar' valves – prevent back flow and lead to the second sound of the heart beat the 'dup' part of the 'lup-dup' (Pilliner and Davies, 2004).

The heart beat

The heart beat has four phases involving the filling and contraction of each of the four chambers; but because the atria and ventricles empty almost simultaneously, often only two phases can be heard through an ordinary stethoscope (Pilliner and Davies, 2004).

Diastole is the period of relaxation when the heart fills with blood, and systole is the period of contraction, during which blood is ejected from the heart (Clegg et al, 2012). All four heart sounds may be heard when the resting heart rate is low.

These fours sounds are (Pilliner & Davies, 2004):

- S4 – LUB systolic
- S1 – LUB systolic
- S2 – DUP diastolic
- S3 – DUP diastolic

Regulation of the heart beat

The heart is essentially a self-contained organ that can carry on working without the direct intervention of the voluntary or involuntary nervous system. The heart has its own in-built nervous system in the form of a pacemaker – otherwise known as the sino-atrial node (SAN). The SAN is situated in the right atrium of the heart.

An impulse originates at the SAN and spreads in all directions at a rapid rate, causing contraction of the atria. The muscle fibres of the atria are not continuous with those of the ventricles and so this impulse stops at the atrial-ventricular border. The mass of ventricular tissue is much larger than that of the atrial tissue and so a special conducting system is required. This system is situated at the base of the septum or wall between the left and the right atria.

A small area of tissue known as the atrio-ventricular node (AVN) conducts the impulse at a much slower rate, ensuring a pause between the contraction of the atria and the ventricles.

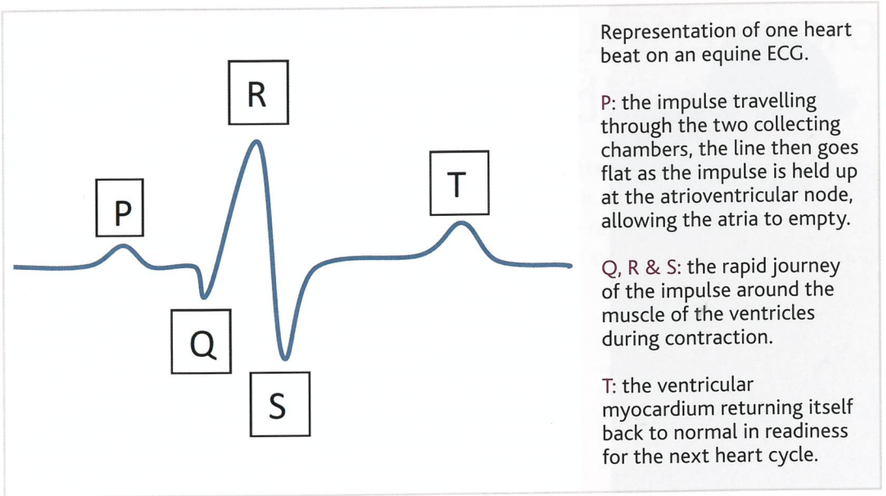

Figure 4. *Diagrammatic representation of an equine heart beat on an ECG.*

From the AVN, the impulse travels through a series of modified cardiac fibres, called Purkinje fibres, which are arranged into a special bundle known as the Bundle of His. These structures cause the contraction of the ventricles (Pilliner & Davies, 2004).

Circulatory system diseases

Heart 'murmurs' and changes in rhythm (arrhythmias) are common in horses. However, in contrast to small animals, the majority of these are not clinically significant (Pilliner and Davies, 2004).

The accurate assessment of cardiovascular status is an essential nursing task when monitoring the health of hospitalised horses, particularly critical cases (Slater and Knowles, 2012). RVNs must also be familiar with using electrocardiograms (ECG).

Electrocardiography

An ECG records on the surface of the horse the electrical activity of the heart (**Figure 4**).

The way in which the electrical impulses travel through the equine heart means that, in contrast with small animals, equine electrocardiography can be used only to determine the heart rate and rhythm and is restricted to the investigation of arrhythmias (Slater and Knowles, 2012).

The following are key practical points for veterinary nurses to bear in mind when using an ECG:

- There is no advantage in using complex lead arrangements in horses
- The horse should not be sedated because this affects the heart rate and rhythm
- The simple, practical lead position used is the base-apex lead, which requires three electrodes – a positive, a negative and an earth
- The negative electrode is positioned on the left neck, usually in the jugular groove
- The positive electrode is positioned over the cardiac apex region on the ventral thorax
- The earth electrode can be positioned anywhere, but is usually positioned behind the scapula to make a triangle with the other two electrodes
- There is usually no need to clip the horse, unless it has a long winter coat
- Most recordings are made in the stable with a static machine, but exercising and 24 hour ECGs can be recorded with systems attached to halters (Slater and Knowles, 2012)

It is worth remembering that, unlike humans, horses seldom die from heart disease (Pilliner and Davies, 2004). The list of commonly occurring cardiovascular disorders is comparatively short for horses – the two very common cardiovascular disorders seen in equine practice are second-degree atrioventricular block and atrial fibrillation.

Second-degree atrioventricular block

Second-degree atrioventricular block is a normal phenomenon in fit horses or very large horses at rest. It is thought to occur because the heart is so large it simply does not need to beat regularly to maintain the required blood flow.

The heart rate is normal and has regular pauses consisting of missed or 'dropped' beats. Typically the rhythm consists of one dropped beat every four to six beats, although this is variable. For this reason, second-degree atrioventricular block is known as a regularly irregular arrhythmia.

The phenomenon disappears with exercise or excitement once the heart rate increases over 60 beats per minute (Slater and Knowles, 2012).

Atrial fibrillation

Atrial fibrillation (AF) is the most common pathological arrhythmia in the horse (Slater and Knowles, 2012). It usually occurs spontaneously (without any underlying heart disease) mainly in large horses. It may cause poor performance and so is a significant concern within the equine sector.

AF results in an irregular heart beat and peripheral pulse because the atria beat out of sync with the ventricles, thereby limiting blood flow. For this reason, AF is known as an irregularly irregular arrhythmia.

Some spontaneous cases can be treated with quinidine sulphate given by stomach tube (Slater and Knowles, 2012). Also some clinics offer electrocardioversion as another treatment option, usually if medical treatment is unsuccessful.

Quinidine has a number of unwanted effects and can result in dangerous tachycardia, hypotension and even death (Slater and Knowles, 2012); so the veterinary nurse must monitor the horse for signs of toxicity including:

- Depression
- Tachycardia
- Hypotension
- Sweating
- Muscle tremors
- Diarrhoea
- Colic
- Nasal mucous membrane oedema
- Urticaria
- Ataxia
- Death

Treatment should be stopped if six doses have been given and the horse is still in fibrillation, tachycardia over 100 beats per minute develops, or other ECG abnormalities develop.

If toxicity develops, then the horse requires urgent treatment, with which the RVN should assist:

- Keep the horse calm and do not take it out of the stable
- Give digoxin (1mg/450kg BW IV)
- Fit large-gauge IV catheters and give 40-50 litres of Hartmann's solution as rapidly as possible
- Give bicarbonate (1mg/kg BW IV)
- The horse may require phenylephrine (2% solution IV to effect)
- Give activated charcoal or mineral oil by stomach tube to reduce absorption of quinidine from the gut (Slater & Knowles, 2012)

Conclusion

The heart is an amazing organ in the horse with its ability to enlarge in response to exercise. As the horse is a 'performance animal', a healthy cardiovascular system is paramount in assisting it to achieve maximum functionality and potential.

For the veterinary nurse, practical knowledge of the equine cardiovascular system is very important to facilitate accurate assessment and identification of problems. The RVN can also be involved with the diagnosis of cardiovascular disorders in the horse by setting up appropriate diagnostic procedures and performing an examination with an ECG machine. Intensive care nursing skills are also required for the management and treatment of certain arrhythmias, such as atrial fibrillation.

With a detailed knowledge of the equine cardiovascular system, the RVN can become an essential part of the veterinary team that is treating patients with cardiovascular disease and putting them back on the road to recovery. ■

"Heart 'murmurs' and changes in rhythm (arrhythmias) are common in horses"

"As the horse is a 'performance animal', a healthy cardiovascular system is paramount in assisting it to achieve maximum functionality and potential"

PPD Questions

1. Where is the best site to perform an IV injection in the horse?
2. What is the average weight of the heart of a horse measuring 16-hands?
3. What does ECG stand for?
4. What is electrocardiography primarily used to assess in the horse?
5. What is the name of the common arrhythmia that causes poor performance in the horse?

Answers
1. In the jugular vein within the upper third of the neck
2. 4kg
3. Electrocardiogram
4. Equine electrocardiography can be used only to determine the heart rate and rhythm and is restricted to the investigation of arrhythmias (Slater and Knowles, 2012)
5. Atrial fibrillation

References

Clegg PD et al (2012). 'Anatomy and physiology' in: Coumbe K. (Ed), Equine Veterinary Nursing Manual 2nd edn, Blackwell Science, Oxford.

Fraser M and Girling S (2012). 'Anatomy and physiology' in: Cooper B et al (eds) BSAVA Textbook of Veterinary Nursing 5th edn, BSAVA, Gloucester.

Pilliner S and Davies Z (2004). Equine Science, Blackwell Science, Oxford.

Slater JD and Knowles EJ (2012). 'Medical nursing' in: Coumbe K (Ed) Equine Veterinary Nursing Manual 2nd edn, Blackwell Science, Oxford.