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THE HEART OF THE MATTER
Atrial Fibrillation

While a large heart has obvious advantages in equine athletes, there is also a higher likelihood for the electrical circuitry of the organ to become disrupted, leading to a lack of oxygen during strenuous exercise

We have been breeding horses for speed for hundreds of years and this has selected characteristics such as conformation and, perhaps less obviously to many, supremely effective heart and lung function. There are few things that will limit the ability of a horse or human to perform athletically than a significant heart problem. Such problems might be present from birth – for example a septal defect (a hole between heart chambers), valve disease or irregularity in the heart rhythm. Atrial fibrillation (AF) is the most common performance-limiting arrhythmia diagnosed in horses (McGurrin 2015). As was well publicised at the time, the heroic Denman was diagnosed with and successfully treated for this condition several years ago.

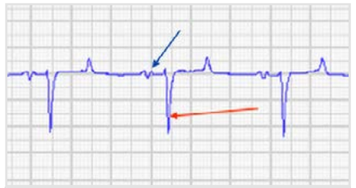

Fig 1 Normal ECG trace showing normal P wave (blue arrow) and QRS complex (red arrow)

The heart – the body's engine

The heart is essentially a muscular pump with filling and pumping phases to each beat. It has four chambers: two atria and two ventricles. There is a left side, consisting of the left atrium and left ventricle and a right side, similarly consisting of the right atrium and ventricle. In the simplest terms, the left side is responsible for receiving oxygen-rich blood from the lungs and pumping it around the body. The right side receives de-oxygenated blood from the body and delivers it to the lungs so that oxygen can be absorbed and carbon dioxide removed from the system. There are also four valves associated with the heart and these help to ensure that the blood continues to flow in the right direction. For example, when the left ventricle is pumping blood out into the aorta to be delivered to the muscles and organs, the valve between the left atrium and left ventricle (the mitral valve) will close but the aortic valve will be open. When the heart is in the filling phase, the aortic valve will be closed so that the ventricle can fill and the mitral valve will be open to allow blood to move from the atrium into the ventricle.

What controls heart rate?

The cardiac muscle is regulated by waves of electrical activity which originate in a small bundle of cells known as the sino-atrial node. This sends an electrical message to the muscle of the atria to contract and to a second node between the atria and ventricles stimulating another wave of electrical activity which tells the ventricles to contract. In the normal heart, these electrical pulses and muscular contractions are co-ordinated and this allows the heart to function efficiently and effectively. An electrocardiogram (ECG) records this electrical activity as a series of waves, the P, Q, R, and S waves. (*Fig 1*). P waves indicate the electrical activity of the atria and the QRS 'complex' represents the ventricular electrical activity. Because the ventricles are larger than the atria, the QRS complex is taller and of longer duration than the P wave and is usually biphasic (has positive and negative parts).

What happens in AF?

We know that a larger heart gives certain advantages when it comes to athletic performance. However, this larger heart can come at a cost. The larger a heart, the more likely it is for the electrical circuitry to become 'confused'. In AF, the normal electrical impulses and contractions of the atria are lost and the atria contract out of sync with the ventricles (*Fig 2*).The electrical messages to the ventricles are also interrupted and the ventricular contractions become irregular at a much slower rate than the atrial contractions. This means that the ventricles aren't properly filled before they contract and so less blood is ejected with each contraction and there may be fewer ventricular contractions. At rest, this is not usually a problem, but at exercise when the demands for increased heart rate and increased blood supply to muscle become significant, the muscles are effectively starved of both oxygen and energy and the exercise cannot be supported or maintained. A young racehorse can have a resting heart rate of 36 but at peak exercise levels, this will reach 240 beats per minute. At these high rates, any slight abnormality can have enormous effects.

Why does AF occur?

We don't fully understand why AF occurs in most cases as there does not appear to be any underlying metabolic abnormality or evidence of heart disease in the vast majority of cases. AF is rare in young horses and also in ponies. Interestingly, it is occasionally discovered as an incidental finding at pre-purchase examinations in horses used for eventing, dressage and hunting without ever giving their owners cause for concern. Each case must be assessed on its own merits at the time. A definitive diagnosis of AF requires an ECG. In AF, the pattern is of irregularly spaced QRS complexes interspersed with numerous smaller 'f' waves which replace the normal 'P' waves. If AF is diagnosed, a full cardiac investigation should be performed to find out if there is any underlying heart disease or damage as the presence of muscle or valve damage can significantly affect prognosis. In a series of 67 horses with AF reported by Reef et al in 1988, 57% had no other cardiac disease. If concurrent cardiac or systemic disease is discovered, treating the AF might become either irrelevant, dangerous or actually contra-indicated.

Many racehorses will suffer from a single episode of AF (paroxysmal AF) and recover without any treatment. According to reports in the press, this is what happened to Sprinter Sacre in 2014 when he pulled up in the Desert Orchid Chase at Kempton. His irregular heart beat corrected itself and he (eventually) went on to win the Champion Chase in March 2016. Paroxysmal AF can be very frustrating to diagnose as it might have corrected itself before an ECG can be performed. In a few horses, these paroxysmal episodes might recur and this can lead to inconsistent performance and further frustration as treatment options are limited. Racecourse and other vets now have access to a smartphone device called 'AliveCor®' which allows an ECG trace to be taken immediately after a race without the need for cables and awkward equipment (***Fig 3***).

Other horses may have persistent AF and in these cases treatment is usually necessary if the horse is to return to high-intensity exercise. Once any other cardiac problems have been diagnosed, treatment options can be considered. The aim of treatment for AF is to restore normal (sinus) rhythm to the heart and this can be attempted either medically or using electrical stimulation.

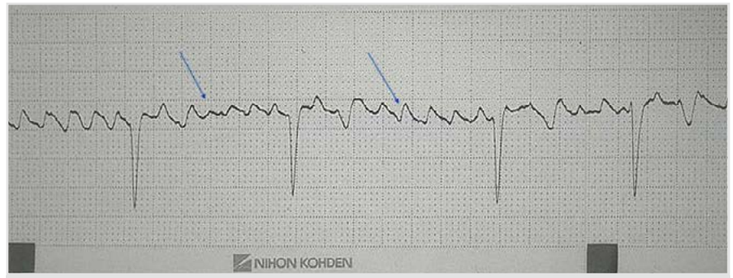

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Fig 2 Atrial Fibrillation ECG showing numerous f waves (blue arrows)

What are the common treatments?

The most common treatment used is medical using repeated doses of quinidine sulphate. This should be undertaken in a hospital environment as there are quite severe side effects including colic, diarrhoea, weakness, ataxia, collapse or even death. The dose is given by stomach tube every 2 hours and the heart rate monitored closely until the conversion or toxicity occurs. (In some situations, the intravenous quinidine product might be available and might be considered a safer option). According to some authors, (Muir et al 1990) the prognosis for cardioversion using quinidine is good in horses where the AF is present alone, has been present for less than 4 months or where resting heart rate is less than 60 bpm. In few cases, digoxin might be used to help control the heart rate in horses with AF which are not going to undergo treatment, possibly because of concurrent heart or systemic disease, or which are going to receive quinidine. Such horses must be very closely monitored.

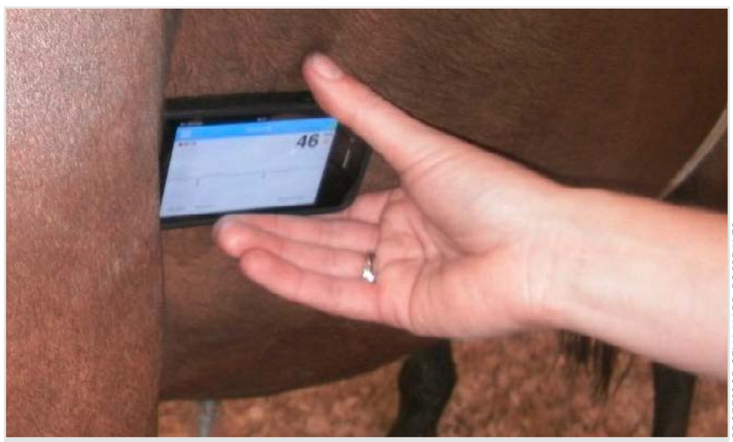

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Fig 3 Using a smartphone to check a horse's ECG

The other treatment option is known as transvenous electrical cardioversion (TVEC). This is really only used if there is no underlying cardiac disease present. The aim is to deliver enough electrical energy to the atria to 'shock' them out of AF and restore normal rhythm. Because of the facilities and expertise required to undertake this procedure, only a small number of specialist centres offer it. Catheters are placed in the right jugular vein and electrodes attached to long catheters are passed into the right atrium (*Fig 4*). The horse is anaesthetised and placed on a padded mat away from metal structures and other electrical sources and conductors. Radiographs are taken to ensure the electrodes are in the correct position. Electrical 'shocks' are applied at incremental energy levels until normal rhythm is restored, as seen on an ECG, or maximum recommended energy level has been reached.

On the ECG, the heart appears to 'stop' momentarily before resuming normal activity (*Fig 5*). The catheters are removed and the horse allowed to recover from anaesthesia. In most cases, no medication is administered but the horse's heart rate and rhythm are closely monitored over the following few days. In some cases, medication might be given to help stabilise the heart rate over the first few days following TCEV.

Once the normal heart rhythm has been restored, the duration of the recuperation period will be determined by several factors, chiefly how long the AF had been present and the presence of any other condition. Slow return to exercise in horses which have had AF for a longer period of time, might reduce the risk of early recurrence (Decloedt et al). It is very possible that ››

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Fig 4 Catheters being placed for TVEC

›› having AF will have affected the horse's confidence and this will also have to be considered once the horse resumes exercise.

The prognosis for return to athletic activity is good in most cases of lone AF (ie where there is no other condition) that respond to treatment. In those cases which are refractory or which recur, the prognosis is considerably poorer.

Other cardiac conditions

There are other less commonly encountered conditions that can affect the horse's heart and cause a drop off in form. In ventricular premature complexes (VPCs) the normal heart rhythm is interrupted by premature electrical activity and muscular contraction in the ventricle. This results in an irregular and inefficient heart contraction. If it occurs without any evidence of underlying heart disease, many cases will recover with rest and a course of corticosteroids. However, if there is damage to the heart muscle or other cardiac disease, the prognosis is poor.

As mentioned, there are four valves in the heart which are responsible for helping to control the direction of flow. These can be affected by infection, inflammation and trauma, or might not have developed properly (congenital abnormality). As a result, they might become narrow (stenotic) which restricts flow in the right direction, or less effective at closing (valvular insufficiency) thus allowing back flow. In both situations, the output from the heart is reduced and the alteration in blood pressure combined with the increased effort the heart makes to try to ensure adequate circulation can result in abnormal enlargement of the heart and increase the risk of further abnormalities developing, such as AF and VPCs. Stenosis (narrowing of the vessels) is rare in the horse. Regurgitation through 'leaky' valves causes heart murmurs which might be heard on one or both sides of the chest, depending on the valve(s) involved.

It is not unusual for a fit and healthy hose to have a low grade (soft) heart murmur when the heart is listened to using a stethoscope. Normal flow of blood out of the left ventricle and through the aortic valve during the pumping phase (systole) can create a normal short ejection murmur audible on the left side of the chest. Racehorses often also have a 'normal' murmur audible during the filling phase caused by tricuspid (right atrio-ventricular valve) regurgitation. It takes considerable experience and confidence to be able to recognise these 'normal' murmurs. However, if the murmur is loud or there is any doubt about the significance of the murmur, an ultrasonographic examination of the heart (echocardiography), should be performed.

A recent BHA-approved project was undertaken by Imogen Comyn (Rossdales LLP) and a team of veterinary students from the University of Nottingham led by Celia Marr (Rossdales LLP) and Mark Bowen and Gayle Halliwell (University of Nottingham). Over 18 months, post-race ECG traces were taken from 587 horses at 28 different race meetings, including National Hunt, turf and all-weather flat meetings. Thirty-three horses had premature complexes (5.6%), three had physiological rhythm abnormalities (0.5%) and two had AF (0.3%).

None of these horses required treatment. The work was funded by Beaufort Cottage Educational Trust and University of Nottingham.

Fortunately, cardiac conditions are not that common in horses and many do not affect the horse's quality of life but might influence their ability to perform as an athlete.

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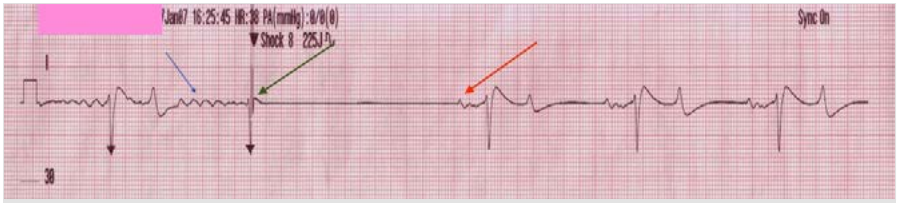

Fig 5 ECG trace during TVEC showing conversion from AF (blue arrow) to normal rhythm (red arrow) after application of electric shock (green arrow)