How to do: exercise ECG?

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Although cardiovascular causes of poor performance are fairly infrequent, many horses have cardiovascular dysfunction, including resting arrhythmias and cardiac murmurs and consequently the significance of these abnormalities can be difficult to determine. As a result cardiac disease can be blamed for loss of performance when it is completely innocent and conversely, on the rare occasion cardiac disease is performance limiting, it is not uncommon for it to be totally overlooked.

ECGs at rest and during exercise

The technique of taking a resting electrocardiogram (ECG) using a base-apex lead configuration is well established in equine practice. The technique is important to confirm the diagnosis of an arrhythmia and establish the exact origin within the heart. Ambulatory ECGs are used in case of a sustained arrhythmia, like atrial fibrillation, or to diagnose the origin of premature beats. Twenty-four hour ECG monitoring is often used to semi-quantify premature beats or to detect more rarely occurring arrhythmias.

The limitations of a resting ECG arise because of the enormous cardiac reserve of the horse which means that performance limiting cardiac disease, or abnormal rhythms during exercise, rarely manifest themselves at rest. This is compounded by the fact that alterations in resting cardiac rhythm are common in athletic horses because of their normal high parasympathetic tone. As a result, the effect of a resting arrhythmia on performance, or the effect of exercise on an arrhythmia, can only be established, if an ECG can be taken during appropriate exercise when sympathetic tone and myocardial oxygen demand are increased and parasympathetic influence is reduced.

Nowadays, Digital ECG recorders are affordable for equine veterinarians in practice and consequently the technique is becoming part of the standard equipment for all equine clinics.

Methodology

The use of limb leads for recording ECG traces is not appropriate during exercise; wires and electrodes attached to the limbs are poorly tolerated, even at rest and movement artefact during exercise renders them entirely useless. In any event, limb leads, have no practical purpose in equids because the pattern of depolarization of the equine ventricle precludes using multiple vectors to assess cardiac size and mean electrical axis. Most commonly, only a simple positive-negative lead system is used to record

cardiac rhythm. As a result the base apex-lead, in which single electrodes are placed above and below the heart, is generally used as this lead system produces large complexes, which are easy to identify. One should realise that recording of additional leads may be useful in certain cases to facilitate the identification of specific complexes or rhythms. The additional lead recordings may show more movement artefacts and are most useful for ambulatory or 24-hour recordings.

For the conventional base apex lead placement the positive electrode is placed on the sternum and the negative electrode on the right jugular furrow. This recording is very useful at rest but shows more movement artefact during exercise. Electrode position is modified slightly for exercising recordings to reduce movement artefact caused by neck flexion and extension during movement. This more vertical modification of the familiar system still produces large 'QRS' deflections, but the atrial deflection ('P' wave) is slightly smaller in amplitude than that of a true base-apex configuration. Nevertheless the P wave will still be clearly visible. **Figure 1** shows placement of 4 silver/silver chloride adhesive electrodes in a suitable configuration for recording an electrocardiogram during ridden exercise.

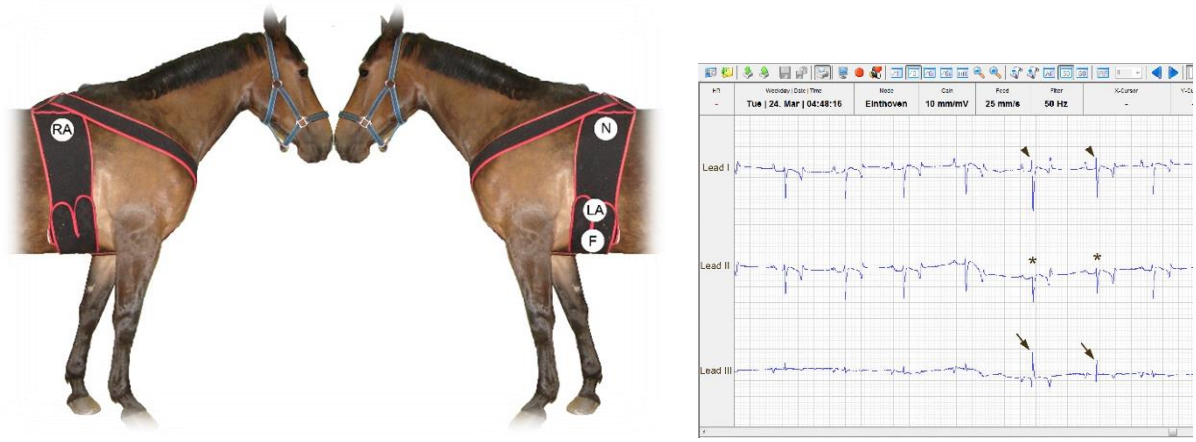
Figure 1a: Configuration of electrodes to record an ECG during ridden exercise

For 4- electrode systems as shown here, the foot electrode (or left leg) (usually green; European colour code) is positioned near to the left cardiac apex, and the right arm (usually red) is placed on the left shoulder area. The right arm (usually yellow) is placed slightly dorsal to the green electrode so that a slightly different lead can be obtained while still of good quality. The fourth earth electrode, when present (usually black) is then attached on the shoulder close to the right arm electrode. This allows 2 similar tracings to be obtained from lead 1 and lead 2 in the Einthoven 3-lead system, allowing for a "spare", should one of the ventral leads be displaced. The trace in Lead 3 which is

recorded between the left arm and foot will often be of no diagnostic value during exercise but may be helpful for recordings taken at rest.

Positioning the left arm and foot electrode slightly apart (**Figure 2**), so that the foot electrode is on the left thorax 5 cm below the elbow and the left arm is placed 15 cm dorsal to the foot electrode, lead I and II will be fairly similar but lead III can now also be used for interpretation. This configuration can be used during exercise (e.g. lungeing) but may show more movement artefacts, and is very useful at rest or during 24-hour ECG monitoring. The additional value of lead III facilitates differentiation between supraventricular and ventricular arrhythmias.

Figure 2: Adapted electrode configuration that allows lead III to be of diagnostic value. The ECG on the right shows ventricular (!) ectopy (fusion beats) which is more easy to identify from lead III than from the other leads.



The precise positioning of the electrodes is of limited importance provided that the positive is below and slightly caudal to the heart, and negative above and slightly cranial to it. Ideally the electrodes should remain visible to the rider and/or the examiner, so that they can be reattached easily, should they become dislodged. A position where they are least likely to be affected by the saddle or girth slipping backwards, or by the rider's hands or legs is obviously ideal. The recording device can be attached to the metal "d" ring just below the pommel of most saddles or attached to the rider's leg. For lungeing, harness racing, and carriage driving, the electrodes must be similarly positioned away from moving straps. The precise location of particularly the ventral electrodes or the device must often be varied slightly depending on the style of tack, or rider's leg position.

Diagnostic approach to exercising ECG's

1) Is the trace of sufficient quality?

If the answer is "no", start again! Movement artefact is much greater during exercise and a bad situation is made worse in fat, barrel-chested horses, whose ECG's signal to noise ratio is already less than in that of thin skinned athletic breeds. Use high quality, sticky electrodes, although in some hairy horses clipping will be necessary and then super glue (might result in permanent hair discoloration) will also be needed. In general it is better to avoid clipping, if at all possible, as the electrodes tend to stick better to hair. Always apply electrodes when the horse is dry and before it starts to sweat.

In some cases, trace quality may be adequate for most of the recording, but trace quality deteriorates, or an electrode becomes detached at some stage. When this happens judgement will be needed to determine whether the procedure needs to be repeated. If quality of the trace is poor be careful about making judgements about single abnormalities. Look for the same thing in a better quality section, or repeat the procedure.

2) Was the exercise you used appropriate for the horse

Try to simulate or exceed the horse's normal competition intensity, if the trainer/rider is not prepared to do this, you cannot be certain that abnormalities will not become apparent during competition and the value of the procedure is significantly limited. Including a recording during sudden stress (strange environment, excitement because of noise or another horse,…) is useful to assess cardiac rhythm as the horse is likely to face stressful situations during his on-going career.

3) Assess the horse's heart rate and determine whether it was appropriate for the work that was performed

Digital ECG units are equipped with algorithms to automatically detect the R wave, but during exercise, movement artefacts are inevitable and these automatic heart rate measurements should not be taken on trust. For horses in sinus rhythm, set the RR analysis software to detect complexes 5-10% shorter or longer than the preceding RR interval. Setting the detection at a low level will increase the sensitivity to detect arrhythmias but will also result in more detection of artefacts. However, in any case you will need visual inspection of the whole ECG trace. Wider detection limits are generally used for ECGs taken at rest. Use of a GPS speed monitor alongside the ECG, allows the horse's heart rate speed relationship to be determined simultaneously. This is invaluable to help to determine the significance of moderate acquired and congenital cardiac disease on performance and also for ruling the heart out as a cause of poor performance in many individuals.

4) Is there a P:QRS ratio of 1

Is there a P wave for every QRS complex and a QRS complex for every P wave with a stable PR relationship? P waves are harder to distinguish as heart rate increases and at very high heart rates, you will need to rely on the RR, or TT interval to determine whether underlying rhythm is sinus.

5) What is the predominant rhythm?

Inspection of the regularity of the QRS complexes will indicate if there is a dysrhythmia present. Inspect the regularity and configuration of the QRS complexes and importantly the lengths of the RR intervals. The automated RR detection and summary screens greatly facilitate this processes in long recordings made during exercise. Did you find a beat that came too early or one that was delayed? Check if there is a compensatory pause (more likely to be a ventricular premature beat) or not. Remember that the normal sinus rhythm results in the narrowest QRS complex. Narrower and sharper deflections than the normal QRS complex are artefacts and these have no T-waves.

6) Equipment settings

Base-apex traces in horses at rest are normally recorded at a paper speed of 25mm/sec and a sensitivity that gives very large QRS deflections, however at high speed exercise, you may need to reduce QRS height and increase the sweep speed to 50 mm/s to make the trace easier to analyse. Use the summary screen, provided by the software to highlight irregularities and allow you to home in on abnormally shaped beats. Have the artefact filter set “on”, if available.

7) Get help

It takes time and lots of practice to develop the skills needed to analyse exercising ECG traces with confidence, so be prepared to get help from others who are more experienced. ECG analysis service is available.