Recent Advances in Diagnosing Cardiac Abnormalities With an EKG During Exercise: A Review

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An EKG at rest provides only limited information in equine athletes, but now the technology to record heart rhythm during exercise is affordable and practical for the veterinarian in the field. Author’s address: Specialist Equine Cardiology Services, Moat End, Dunstall Green Road, Ousden, Newmarket, Suffolk, UK, CB8 8TZ; e-mail: lesleyeyoung@googlemail.com. © 2007 AAEP.

1. Introduction

Cardiac disease is a rare primary cause of poor performance in the equine athlete. On the rare occasion that performance is affected by cardiac disease, dysrhythmia is the most common underlying cause.¹

The technique of taking a resting electrocardiogram (EKG) using a base-apex lead configuration is now well established in equine practice²; most equine practices are equipped with both the expertise and the technology to perform the task. The method can be valuable in confirming a diagnosis of sustained arrhythmias like atrial fibrillation or in diagnosing the origin of premature beats. However, a resting EKG usually offers little to the client in establishing a prognosis for future use of their horse.

The limitations of a resting EKG arise largely because of the enormous cardiac reserve of the horse,³ 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 normal high parasympathetic drive,⁴ yet some of these rhythms can also occur as a result of cardiac pathology. 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 EKG can be taken during strenuous exercise when sympathetic tone and myocardial oxygen demand are increased and parasympathetic influence is reduced.

In the past, exercising EKG examination, although well described in the equine literature, was restricted to the specialist cardiologist or the performance laboratory¹; this was largely because of the very high cost of radiotelemetric EKG equipment. However, the newest technology, based on palm-top and laptop computers or specialized battery-operated devices, has become increasingly affordable for equine veterinarians in Europe. This equipment is rapidly becoming standard for equine practitioners in the United Kingdom and is now available in North America. As a result, it is timely to review the methodology and potential applications of the new generation of EKG devices capable of producing high-quality exercising electrocardiographs in performance horses.

NOTES
This paper details the indications and diagnostic yield of this technique using data from an ambulatory cardiology practice in the United Kingdom.

2. Materials and Methods

Horses
Seventy-three of a total of one hundred three horses were referred for cardiovascular examination. These horses came from 22 equine and mixed practices in the United Kingdom between January 2006 and February 2007.

Methodology
The use of limb leads for recording EKG traces is not appropriate during exercise. Wires and electrodes attached to the limbs are poorly tolerated, even at rest, and movement artifact during exercise renders them entirely useless. Crocodile clips to make electrical contact with the skin are also contraindicated for similar reasons. Therefore, limb leads have no practical purpose in equids. The pattern of depolarization of the equine ventricle precludes using multiple vectors to assess cardiac size and mean electrical axis, so there is no point to using anything other than a simple positive-negative lead system to record cardiac rhythm. As a result, the base-apex lead in which single electrodes are placed above and below the heart is used for all equine EKG recordings, because this lead system produces large complexes that are easy to identify.

The conventional base-apex lead placement where the positive electrode is placed on the sternum and the negative electrode is placed on the right jugular furrow is modified slightly for exercising recordings; this reduces movement artefact that is 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 during exercise.

Figure 1 shows the placement of four silver/silver-chloride adhesive electrodes that is suitable for recording an EKG during ridden exercise.

For four-lead systems, the positive left-arm electrode (usually green) is positioned near to the left cardiac apex, and the negative right-arm electrode (usually red) is placed on the left shoulder area. The third Einthoven lead (usually yellow) is also placed caudal to the cardiac apex. This allows two identical tracings to be obtained from lead 1 and lead 2 in the Einthoven three-lead system; as a result, a “spare” is produced in case one of the ventral leads is displaced. The trace in lead 3 that is recorded between the left arm and left leg will be of no diagnostic value because of the close apposition of these electrodes at the cardiac apex. However, a rhythm trace only is required from a horse, so this is not a serious limitation. The fourth earth electrode (usually black), when present, is then attached on the shoulder close to the negative, right-arm electrode.

The precise positioning of the electrodes is unimportant provided that the positive is below and slightly caudal to the heart and the negative is above and slightly cranial to it. Ideally, the electrodes should remain visible to the rider and/or the examiner, so they can be reattached easily if they become dislodged. A position where they are least likely to be affected, such as by the saddle or girth 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. For harness racing, the electrodes must be similarly positioned away from any moving harness straps. The precise location of the ventral electrodes and the device must often be varied slightly depending on the style of tack or the rider’s leg position.

EKG Equipment
Traditionally, radiotelelemetric or digital Holter® recording systems were used to obtain exercising traces. The radiotelelemetric units use a local
transmitter carried by the horse that continuously radio transmits the EKG signal to a local recorder. These units are expensive and also require that the recorder remain within at least 250 m of the exercising horse. This can create practical problems for many equine athletes, unless the horse regularly exercises with a scurry or there is good vehicular access to the exercise grounds.

Digital Holter monitors are also effective, but they can be expensive unless they can also be used for other applications such as 24-h EKG recordings in a small-animal environment. These devices require specialized software for reading and interpretation of the stored EKG data, although data can be acquired for days at a time and is especially valuable for investigating horses with sporadic collapse. Commercial companies or individuals will read these recordings on a per-case basis, which reduces the practice's capital outlay; however, these providers are generally more familiar with small-animal traces.

The newest technology used to obtain these data is based on personal computers and a digital data logger. These units are the most widely applicable and affordable for equine practitioners in a field environment. For general practitioners who might be unfamiliar with interpretation of EKG recordings during exercise, the digital format of the data allows them to be emailed easily for specialists for review.

3. Results

There are many indications for exercising EKG examinations in the equine practice based on the U.K. experience.

From the 103 cases referred for cardiovascular examination, 73 were deemed to require an exercising EKG examination. The type of exercise varied depending on the function and fitness of the horse, but in general, every attempt was made to replicate or slightly exceed the intensity of the horse’s normal activity. In this series, 52 horses were exercised under saddle, and 21 were worked on the lunge.

The horses not subjected to exercising EKG examination were horses with clear physical signs of cardiac failure at rest (tachycardia, tachypnea, or dependent edema; six horses), horses with bacterial endocarditis (three horses), horses with low-grade regurgitant murmurs or functional murmurs for whom procedure was not deemed necessary (fifteen horses), horses that were not used for ridden work (two unbroken youngsters and one retired horse), and horses affected by concurrent lameness or other problems that precluded fast exercise (three horses).

In summary, the distribution of cases and conditions in which the technique was used and their diagnostic yields were as follows:

- There were twelve Thoroughbred horses with disappointing training or race performance. The procedure was performed to elucidate whether or not exercise-induced arrhythmias such as paroxysmal atrial fibrillation, a condition with relatively high prevalence in racing Thoroughbreds, was present. No case was positive for paroxysmal atrial fibrillation nor were any atrial premature beats, which are potential triggers for the condition, identified in this group of horses. However, two horses had multiple ventricular premature beats during exercise and recovery, and four horses had one or more ventricular premature depolarizations during recovery. The latter group was considered to be “normal,” and they underwent further investigations of their upper airway function. The abnormalities in the former group were considered to be potentially significant, and these horses underwent further cardiac investigations. An abnormally high heart-rate response to exercise occurred in one horse.

- There were nineteen horses with diastolic murmurs of aortic valve regurgitation. The procedure was performed alongside echocardiography to ensure that ventricular premature beats were not present and that the animals were not at an increased likelihood of sudden death. A normal EKG was obtained from fourteen of nineteen horses. Ventricular premature beats during appropriate ridden work were detected in five cases, all of which were then immediately retired. Advanced aortic valve regurgitation results in left ventricular dilation and increases cardiac work and afterload, which directly increases myocardial oxygen demand. Simultaneously, diastolic aortic pressure progressively decreases as valve dysfunction progresses, reducing coronary perfusion and myocardial oxygen delivery. Myocardial oxygen demand is further increased during exercise, and in advanced cases of aortic valve regurgitation, ventricular ischemia can lead to ventricular ectopic activity and increase the risk of sudden death or collapse during exercise (Fig. 2). These changes are often present before the onset of clinical signs of heart failure, and as a result, regular exercising EKGs are mandatory in this group of patients if they continue to be ridden.

- There were two horses assessed for the effect of exercise on an abnormal rhythm at rest to better determine the prognosis and the horse’s suitability for ridden work. One horse was affected by atrial tachycardia with second-degree atioventricular (AV) block, and another horse had multiple atrial premature beats at rest (Fig. 3). Both were asymptomatic, and in both cases, cardiac
Ten horses with sustained atrial fibrillation were assessed. Conversion of atrial fibrillation to normal sinus rhythm is not always indicated in pleasure horses. However, before making this decision, it is important to ensure that their heart-rate response is reasonable and that they do not suffer from uncontrolled supraventricular tachycardia during exercise. This is crucial to determine if a horse with atrial fibrillation is safe to be ridden without treatment or if treatment has failed. In this group, only one horse failed to maintain acceptable heart rates during its usual levels of work (Fig. 4).

- Thirty-two horses affected by murmurs of mitral- and tricuspid-valve regurgitation were assessed to ensure that these horses’ heart-rate responses to exercise were normal and that no abnormal rhythms developed during exercise. Twenty-two of these horses were examined after their murmur was detected at a pre-purchase or insurance examination. No significant EKG abnormalities were detected in this group of animals.

4. Conclusion

Given that the horse is endowed with a large cardiac reserve, evaluation of the equine cardiovascular system and EKG at rest provides only limited information. An EKG during exercise, however, is an integral tool in the clinical evaluation of horses presented for episodes of exercise-associated collapse, decreased exercise tolerance, poor athletic performance, or cardiac murmurs. Recent technological advances now allow this technique to be easily performed in the equine practice, and the new devices are ideally suited to performing resting EKG and long-term monitoring. Additionally, digital storage of the acquired EKG data allows the traces to be easily transferred to a specialist cardiologist for interpretation, if required.
Fig. 4. This trace was taken from a 6-yr-old Warmblood gelding used for dressage. An irregularly irregular rhythm was diagnosed when the horse was presented for a pre-purchase examination. There was no history of performance problems since the gelding had been imported from Holland 1 yr previously. Resting heart rate was 38 beats/min, and resting EKG confirmed that the irregularly irregular rhythm was caused by atrial fibrillation. The trace, taken during sustained canter, shows that the gelding develops a rapid supraventricular rhythm with a rate of almost 400 beats/min that is sustained for 1.4 s. The complexes are wide and bizarre. This is probably caused by aberrant conduction of the rapid supraventricular rhythm and not a ventricular problem. Regardless of the rhythm diagnosis, ventricular filling and myocardial oxygenation would be severely compromised if this rhythm and rate were sustained for any length of time. Therefore, the horse is not safe for his rider, unless his rhythm can be treated, despite the fact that the abnormal rhythm was not adversely affecting his performance. In this case, conversion to normal sinus rhythm was achieved with quinidine sulphate orally, and the repeat EKG taken during similar strenuous exercise 18 wk later was entirely normal.

References and Footnotes


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