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ELECTROCARDIOGRAPHIC INTERVAL CHANGES DURING HYPERINFUSION IN HORSES WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE

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This study describes investigations into the electrocardiogram changes in 27 horses with chronic obstructive pulmonary disease (COPD), during hyperinfusion therapy with isotonic saline solution. Immediately after hyperinfusion therapy the equine ECG showed a temporary sinus tachycardia without atrial and ventricular rhythm disturbances. After infusion a highly significant shortening of the PQ-, QT and TP-intervals was observed. There was a positive correlation between the RR-interval and the duration of the PQ- and QT-intervals, but not with the duration of the P-, QRS- and T-waves.

Key words: ECG, hyperinfusion, chronic obstructive pulmonary disease.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a functional description of a complex of respiratory abnormalities that occurs in horses. Prominent histopathological findings include bronchiolitis, plugs of mucus or neutrophils in the small airways, and bronchitis with diffuse epithelial hyperplasia and metaplasia (Robinson et al., 1996).

Successful secretolytic therapy of equine chronic obstructive pulmonary disease is possible through overhydration or hyperinfusion (according to Deegen et al., 1980). Approximately 60-90 % of horses show improved lung function after therapy (Deetlef et al, 1982; 1983; Schusser et al., 1987; Kovač et al., 1998). The hyperinfusion therapy primarily improves lung function in COPD-horses through a decrease in the alveolar-arteriole difference (A-aDO2) (Walden, 1984; Kovač et al. 1998). Occasionally, however infusion brought with it the risk of lung edema with fatal consequence (Waller and Jacht, 1989).

No data to date refer to changes in the cardiovascular system during hyperinfusion therapy in COPD-horses. The most easily applicable diagnostic technique for cardiovascular examination is the electrocardiogram (ECG). It is clear that the ECG is most important in evaluating cardiac rhythm. However, through measurment of the amplitude and duration of the ECG waveforms and intervals, as well as vectoriographic estimation of the frontal QRS-komplex axis, it is also possible to make an indirect study of other aspects within the organism

(e.g. electrolyte alteration, hypervolemia etc.) (White und Rhode, 1974; Epstein, 1984 ; Kovac et al., 2000). Due to the lack of information about the effects of hyperinfusion on changes in the cardiovascular system, the effects of isotone saline infusion on the equine ECG-interval duration were studied here.

MATERIALS AND METHODS

Twenty seven adult (3 -20 years old) German warmblood horses, of both sexes, admitted to the Equine Veterinary Clinic, Hochmoor (Germany) with diagnosed COPD, were used in this study.

On admission, patients were examined (clinical and laboratory: i.e blood-gas analysis). Following this the horses were subjected to hyperinfusion therapy over the course of 3 days (according to Deegen et al., 1980).

Hyperinfusion was induced by infusing isotonic saline (NaCl) via a catheter in the jugular vein at a rate of 30 l/ for 3 h/ per day for a 500 kg horse.

Before, during and immediately after therapy an electocardiographic (ECG) examination was performed in all horses (standard bipolar limb - Einthoven and unipolar limb - Goldberger methods). The standard bipolar limb leads were located on the right foreleg and left foreleg (lead I), on the right foreleg and left hind leg (lead II), and on the left foreleg and left hind leg (lead III). In the augmented unipolar limb leads, two of the three limbs used in the standard bipolar leads were paired against the third limb and were labelled as aVR (right foreleg), aVL (left foreleg) and aVF (left hind leg). Data were recorded using an ECG -channel direct-writing recorder of the "Hellige 51" type, at a paper speed of 25 mm/s and a deflection (sensitivity) of 1 cm = 1 mV.

Measured wave amplitude and duration of waves and intervals were in accordance with the Commite of the American Heart Association for the Standardisation of Electrocardiographic Nomenclature.

The value for wave amplitude was averaged over 5 consecutive cycles.

Analysis of the ECG was performed using an 8 x magnifier to assist in the accuracy of interval measurement. In all horses heart rate (HR) was measured using the following formula:

$$HR = \frac{\text{paper speed in mm/sec} \times 60}{\text{RR-interval in mm}}$$

In addition to this the vectorcardiographic changes of the mean electrical QRS axis (MEA) in the frontal plane before and after hyperinfusion (according to the method of Fregin, 1982) were studied.

Statistical analysis: Calculations made with standard methods using the following computer software: "Statistic Analysis System" (SAS). The results are presented as mean values and standard deviations (SD). The differences between groups (before and after the hyperinfusion therapy) were determined using Student's t-test. The correlation between the RR-intervals and other ECG - interval variables the (i.e. the P-wave (atrial depolarisation); the PQ-intervals (early ventricular repolarisation); the QRS-complex (late ventricular depolarization); the QT-intervals and the T-wave (ventricular repolarization) were determined using Spearman correlation analyses.

RESULTS

The electrocardiographic data (durations and intervals) of 27 warmblood horses are presented in Table 1.

Table 1. Duration of ECG-waves and intervals (seconds), before and after hyperinfusion therapy

ECG-intervals		Before Hyperinfusion	After Hyperinfusion	Significance
P-wave	X	0.13	0.09	p<0.01
	SD	0.04	0.04	
PQ-interval	X	0.31	0.24	p<0.001
	SD	0.06	0.04	
QRS-complex	X	0.12	0.10	p<0.05
	SD	0.02	0.04	
QT-interval	X	0.54	0.47	p<0.001
	SD	0.04	0.05	
T-wave	X	0.16	0.13	n.s.
	SD	0.05	0.05	
RR-interval	X	1.57	1.11	p<0.001
	SD	0.27	0.20	
Heart rate	X	38.21	54.05	p<0.001
	SD	6.57	9.73	

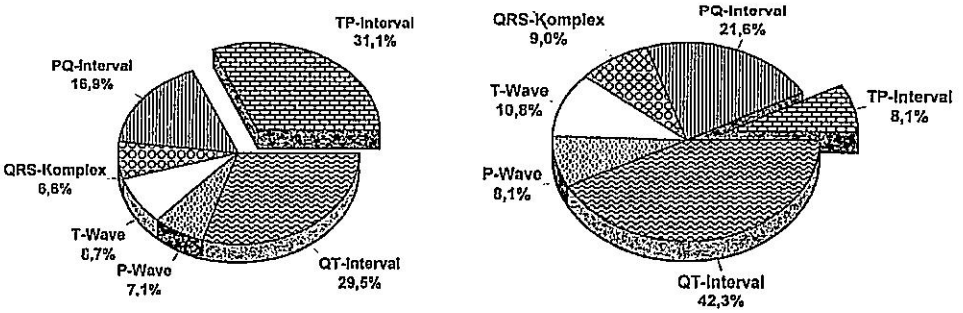
The most frequent ECG-changes, during and directly after the hyperinfusion therapy in COPD-horses was sinus tachycardia. Atrial and ventricular rhythm disturbances before and after therapy were not observed. Conduction disturbances (AV-block 2nd degree) were only seen in 3 horses before hyperinfusion and this was temporarily eliminated on hyperinfusion.

Immediately after hyperinfusion a highly significant ($p<0.001$) decrease in the RR (on average 1.11 sec), PQ-(0.24 sec) and QT- intervals (0.47 sec), and a significant ($p<0.05$) decrease in the QRS-complex (0.10 sec) (Table 1) were found when compared to the value prior to therapy. In addition to this the heart rate increased temporarily after hyperinfusion therapy, on average to 54 beats/min (Table 1).

According to our correlation analysis, the PQ and QT intervals were heart rate-dependent, with the intervals shortening considerably when there was an increase in heart rate. The correlation coefficients (r) between the RR-interval and other ECG-duration variables were:

P-wave	r = 0.34	QT-interval	r = 0.59
PQ-interval	r = 0.65	T-wave	r = 0.22
QRS-complex	r = 0.31		

The change in the TP-interval duration (i.e. electrical diastole) was most clearly expressed as a percentage of the entire ECG-cycle (Figure 1).



Before Hyperinfusion
RR-Interval 1.57 Sec

After Hyperinfusion
RR-Interval 1.11 Sec

Figure 1. ECG intervals before and after hyperinfusion in COPD - horses

DISCUSSION

The electrocardiogram (ECG) is the most commonly used clinical tool for the diagnosis of electrical dysfunction of the heart. As the predominant waves in an ECG correspond to specific electrical events in the heart, the time between these waves can be measured to determine the timing of these events. Several investigations have considered ECG-changes in COPD-horses (Littlejohn et al., 1983; Grauerholz, 1990; Ferro et al., 1991). There is, however, a lack of information on equine ECG-interval changes, making a comparison with our investigation difficult.

According to our examination the ECG-interval durations decreased after hyperinfusion therapy. The PQ, QT and TP-intervals were dependent on heart rate and shortened as the heart rate increased.

Correlation analysis showed that the PQ and QT interval durations (but not the P, QRS and T -wave) had a significant positive correlation with the RR-interval.

It is known, that the PQ and QT-intervals are dependent on the breed of horse, as well as on body growth and genetic factors. According to the investigations of Matsui et al. (1983), the PQ- and QT-intervals are longer in thoroughbreds than in ponies.

According to our measurement, the mean P-wave duration before therapy was 0.13 sec and decreased after therapy to 0.09 sec. Fregin (1982) found that the physiological value for the P-wave is 0.08-0.16 sec.

We observed that the QT-interval duration temporarily decreased, significantly after hyperinfusion therapy. Other authors reported that the QRS-complex and QT-interval duration are dependent on heart rate (Grauerholz and Jeaschen, 1986; Heider, 1983; Matsui et al., 1983). According to Tschudi

(1978) the dependence of the QT-interval duration on heart rate (HR) can be demonstrated with the following mathematical formula:

$$QT \text{ in } 1/100 \text{ sec} = 2.4 \times RR + 24 \ (+/-6.8).$$

The shortening of the ECG-duration interval after hyperinfusion was most obvious in the TP-intervals (ventricular electrical diastole). It is known, that through the ratio of the TQ interval to QT interval (ventricular electrical systole) (i.e.diastole-systolic quotient) it is possible to evaluate the functional capacity of the heart. It is clear, that the increase in heart rate results in a greater shortening of diastole than systole. A relationship to performance is assumed as well-trained horses appear able to shorten systole sooner, thus reaching a higher heart rate before the ratio reaches unity. Reduced performance has been nonspecifically associated with a lengthening of the QT-interval (Mill, 1977).

We also found other ECG-changes during hyperinfusion therapy in COPD-horses (Kovač et al., 2000). Immediately after hyperinfusion therapy a decrease in ECG-amplitudes occurred. The significant reduction in the R-amplitude correlated with the concentration of protein in the plasma (Kovač et al., 2000). The explanation for this is that hyperinfusion therapy results in hypoalbuminemia as well as hypertension (hypervolemia), leading to low transudation of flow in the lungs and increased thorax (lungs) electrical absorption ("thorax impendancy"). White and Rhode (1974) found that the height of the QRS-amplitude in horses is decreased in the following diseases: ascites, adiposis, pneumonia, pleuritis and pneumothorax. The height of wave amplitudes are also influenced by the anatomic location and configuration of the heart, by the shape of the thorax and by the electrical conductivity of the tissues between the heart and the recording electrodes (Stewart, 1980).

According to our vectocardiographic investigation, the changes in the mean electrical axis (MEA) of the QRS-komplex in the frontal plane before and after hyperinfusion therapy were not statistically significant (Kovač et al., 2000). However, a low deviation in the electrical cardiac axis towards the right and horizontally occured in 20 horses out of 27. The average frontal plane QRS MEA ranged from +16.07°degree (before therapy) to -0.61° (after therapy) (Kovač et al., 2000). It is our opinion that vectorcardiography needs to be further evaluated in experimental and clinical studies in COPD-horses.

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PROMENE EKG TOKOM HIPERINFUZIONE TERAPIJE KONJA SA HRONIČNIM OPSTRUKTIVNIM OBOLJENJIMA

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SADRŽAJ

Ova studija opisuje ispitivanja promena u elektrokardiogramu 27 konja sa hroničnim plućnim oboljenjima (COPD) u toku hiperinfuzione terapije izotoničnim rastvorom soli. Neposredno posle hiperinfuzione terapije, EKG konja je pokazivao postojanje povremene sinusne tahikardije bez poremećaja ritma rada pretkomora i komora. Posle infuzije zapaženo je veoma izraženo skraćenje PQ, QT, TP intervala. Izražena je povezanost između RR intervala i trajanja PQ i QT intervala, ali ne i sa pojavom P, QRS i T talasa.