Comparison of Dubois and Base-Apex Lead Methods to Calculate QRS Angle (Mean Electrical Axis) in Thoroughbreds

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Abstract. *This study evaluated electrocardiographic profile of 53 Thoroughbreds, clinically healthy, with ages ranging 2-7 years old, 38 males and 15 females, all reared at the São Paulo Jockey Club, Brazil. Two electrocardiograms were recorded in each horse, and the results of mean electrical axis in frontal plane, obtained by measuring QRS complexes amplitude, were compared using two electrode positioning methods, Dubois and the base-apex methodology. QRS axis in both methods was calculated using 2 different formulas. First, from Tilley's table and second, from α tangent. Values obtained through Dubois lead-system, over 2 different formulas, did not show any statistical difference between them. Additionally, this was the best method of ECG acquisition. In conclusion, base - apex is not adequate for horses because of the influence of body limb positioning and because of inadequate relationship between electrode positioning and the heart.*

Keywords: Equine, Electrocardiogram, Thoroughbreds, Mean Electrical Axis.

1. Introduction

The electrocardiogram (ECG) recording has proved to be a low cost, painless, specific examination for diagnosis of cardiac arrhythmia [1]. However, positioning of the electrodes on the animals is controversial in the literature. In the present study, two different techniques were used. The first, called Dubois method, was described by Ayala et al (2000) and Bello (2012) [2, 3]. The other, base - apex method, was described by some authors like Diniz et al (2008), Dumont et al (2010, 2011) and Manesh & Naghadeh (2010) [4-7].

This study has the objective of comparing results of two different methods of determining the QRS complex angles in Thoroughbreds, using two available methods for electrode positioning to obtain electrocardiographic recordings in horses.

2. Methods

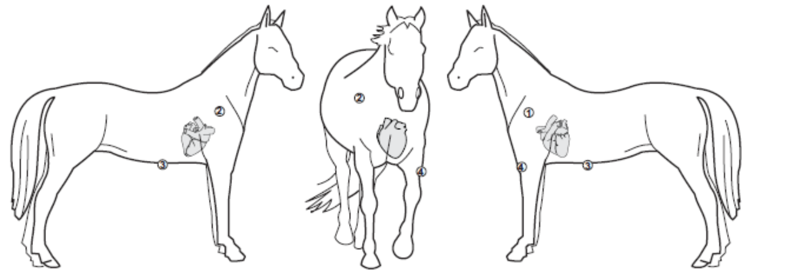
Study subjects

We studied 53 (38 male and 15 female) Thoroughbreds, aged 2 to 7 years old (mean 4.0 ± 1.3 y), mean weight 474 ± 32 kg and 1.62 ± 0.04 m mean height, all reared at the São Paulo Jockey Club. Exclusion criterion was the presence of any health disorder, including cardiopathy, as checked by clinical examination.

The ECG recordings were acquired in quiet environment, with a rubber mat for electrical insulation. The horses remained in orthostatic position, standing with parallel limbs, and no chemical constraint. A portable TEB ECGPC VET 12-channel-electrocardiograph was used, displaying three sensitivities and a paper speed of 25 mm/s or 50 mm/s. The device was set at 25 mm/sec paper speed and sensitivity of 1 cm = 1 mV. Bipolar (DI, DII, DIII), augmented unipolar (aVR, aVL, aVF) and precordial (rV2, V2, V4 and V10) leads were recorded.

The electrodes were fixed to alligator metal clips, which were attached to the horse's skin after being moistened with alcohol. Two ECGs were obtained in sequence from each horse.

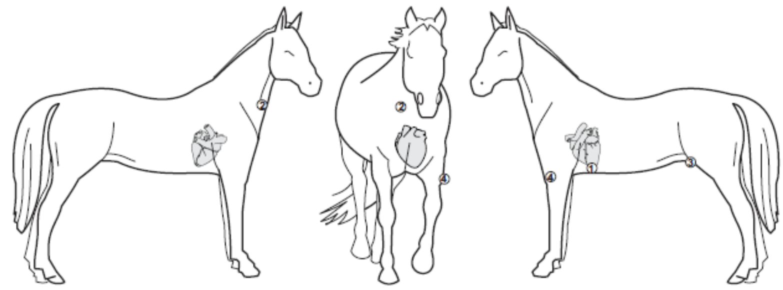
Dubois method was first, by placing electrodes (1) and (2) next to the spine tuberosity of the left and right scapulas, respectively; electrode (3) on the xiphoid process of the sternun, and electrode (4) on the proximal cranial region of the left anterior limb (see Figure 1).



Legends:
(1) On the top of the left scapular spine.
(2) On the top of the right scapular spine.
(3) Over the xiphoid.
(4) Neutral.

Figure 1 – The illustration depicts the disposition of electrodes on the horse using the Dubois method.

The second ECG, using the base-apex method, consists in placing electrode (1) above the left cardiac apex, caudal to the olecranon; electrode (2), cranially to the right shoulder, next to the jugular vein; electrode (3), above the left tibiofemoral patellar joint, and electrode (4) on the proximal cranial region of the left anterior limb (Figure 2).



Legends:
(1) On the left chest, just caudal to the point of the elbow (about the 5th intercostal space).
(2) On the right side of the neck, next to the jugular vein (distal).
(3) Left hindleg, placed on the loose skin at the left stifle in the region of the patella.
(4) Neutral.

Figure 2 – The illustration depicts the disposition of electrodes on the horse using the base-apex method.

The parameters for evaluation were obtained by systematic analysis of the QRS complex amplitude values in millivolts (mV), which were semi-automatically measured in leads DI, DIII and aVF with the software of the electrocardiograph, by a sole observer (CFC).

Values of the QRS complex angles were obtained: first, using pre-defined tables, which were developed to be used in cats and dogs to determine the mean electrical axis in the frontal plane from QRS complex amplitudes measured in leads DI and DIII, according to the description by Tilley (1992)[8]; second, from trigonometric calculations (α tangent) of QRS complex amplitudes in leads DI and aVF. Both modes of calculation were applied to the two methods for ECG acquisition (Dubois and base-apex).

Continual variables were expressed as mean and standard deviation values; categorical variables in percent values. Paired *t*-test and Fisher's test were used to compare groups; significance level was set to be lower than 5%.

3. Results

ECGs were divided into two groups, A = base-apex, and B = Dubois, according to acquisition method. The cardiac axis values obtained from leads DI and DIII, as calculated according to Tilley method, composed subgroups A1 and B1. The trigonometric calculations obtained from the intersection of QRS amplitudes in leads DI and aVF, similar to those made for humans, composed subgroups A2 and B2. Figure 3 displays all these results.

Cardiac axis in the ECGs of group A (base-apex), as calculated by Tilley (A1), had mean

+135.1° ± 90.9°, and those trigonometrically calculated (A2) had -15.0° ± 11.3°, $p < 0.0001$. In the ECGs of group B (Dubois), Tilley (B1) method resulted in -81.1° ± 3.6°, while trigonometric calculation (B2) resulted in -79.9° ± 7.4°, p = 0.3128 (NS).

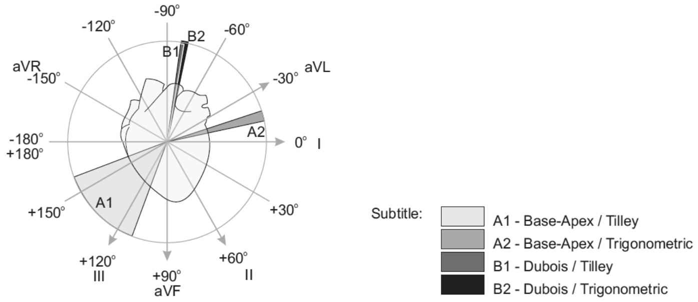


Figure 3 – Graphic representation of the cardiac axis (degrees) in the frontal plane measured in Thoroughbreds.

4. Discussion

Presently, there is no standardization for recording electrocardiograms in horses. Several studies came to different results using distinct methodologies. We worked on the assumption that the most reliable results are obtained after centralizing the heart inside the Einthoven triangle. Thus, we studied two methods for positioning the electrodes reported in literature, the base - apex and the Dubois methods. Their main difference relies in the localization of the caudal electrode: the base - apex places it on the tibiofemoral patellar joint, and the Dubois, on the xiphoid process. Given the extent of the animal's long axis, the distance of this electrode in the two approaches can range up to 70 centimeters, which can substantially modify the amplitude values of all ECG waveforms.

Calculation of the P-wave, QRS complex and T-wave angles are based on their voltage and duration; thus, the positioning of electrodes has a key role on results. In order to obtain the values for the QRS complex angles we tested both, the table developed by Tilley and the conventional trigonometric formula. The first, Tilley [8], is composed by values obtained from studies in small animals (cats and dogs). We can consider the results from Tilley´s table as made of values for animals with hearts centered inside the Einthoven triangle. For the second approach we used the conventional trigonometric formula for calculating the α tangent.

The overlapping results of QRS angles obtained by Dubois method, using either approach, the Tilley table or the α tangent, were vertically located in the left quadrant. This result was already expected, since positioning the caudal electrode on the xiphoid process tends to better center the heart, even considering the big dimensions of horses. On the other hand, the base-apex method revealed significantly different values when compared to those acquired by Dubois method, using either formula for QRS axis calculation. The axes are oriented in opposite directions, i.e., there is an axis in ventral and rightward direction (Tilley), and an axis in slightly dorsal and leftward direction (tangent).

The finding of an axis in rightward direction clearly proves that Tilley table cannot be used with the base - apex methodology, since it is inconceivable to have a QRS axis deviated to the right in healthy horses. On the contrary, the results obtained by α tangent calculation showed the QRS axis deviated leftward and dorsally. We understand that the caudal electrode positioned so far from the heart tends to minimize the QRS complex amplitudes, therefore with a smaller projection on the frontal plane leads, and consequently, a more horizontally located angle (Figure 4).

From the anatomical viewpoint, the equine heart is displaced, with 60 % of its volume on the left of the median plane between the 3rd and the 6th rib directly cranial to the diaphragm and quite protected by the forward limbs [9]. Therefore, it is expected that its axis is caudal-ventrally inclined and to the left [10]. This anatomical concept demonstrates that the results provided by the base-apex method (by Tilley) (axis in a ventral orientation and to the right) are incorrect, a fact that was also described by AYALA and col. [2].

Figure 4 – Electrocardiograms differences of a 5 years old male Thoroughbred acquired by the Dubois (left) and the base-apex (right) methods in the same animal.

5. Conclusions

In Thoroughbreds, the electrocardiogram should be performed only by the Dubois method, independent of the QRS complex calculation (Tilley table or α tangent). Otherwise, the heart in this breed will be decentralized in relation to the Einthoven triangle, thus providing significantly distinct and incorrect results.

6. References

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