ACTA VET. BRNO, 50, 1981: 207–212

ANGLE OF THE ELECTRICAL CARDIAC AXIS AND MAGNITUDE OF THE VENTRICULAR VECTOR IN THOROUGHBRED FOALS

J. HANÁK

Department of Diagnostics, Therapy and Prevention of Animal Diseases, University of Veterinary Science, 612 42 Brno

Received December 17, 1979

Abstract

Hanák J.: *Angle of the Electrical Cardiac Axis and Magnitude of the Ventricular Vector in Thoroughbred Foals.* Acta vet. Brno, 50, 1981: 207–212.

In 60 thoroughbred foals the vector changes of the ventricular complex were investigated in three time intervals from weaning (6 months) until their transfer to a training centre (about 20 months). The vector changes were studied in the horizontal, transversal and in three sagittal planes.

The results indicate that in growing foals a significant rotation of the electric cardiac axis occurs to the right and in caudohorizontal direction up to the age of 13 to 15 months. At this age also a significant increase in the magnitude of the ventricular vector occurs. From the age of 13 to 15 months the angle of the electrical cardiac axis remains stabilized. A further increase in magnitude of the ventricular vector in planes T and Sl depends upon bilateral hypertrophy of ventricular walls.

Age, heart, hypertophy, training.

Horses have lost their original significance in agriculture. Instead they have become important sporting animals. Therefore the Ministry of Agriculture of Czech and of Slovak Socialist Republic proposed a conception of horse breeding until 1990 aimed not only at an increace in number of horses but also at a substantial improvement in breeding and performance of race horses.

Under these new conditions a variety of problems have arised for veterinary diagnostics with special emphasis on pursuit of health in young and race horses in which the state of cardiovascular system seems to be a limiting factor of performance.

The heart makes ca 0.7 % of body mass in horses (Brody 1945). In thoroughbred horses, for centuries selected for high speed, the heart mass percentage is higher than in other breeds. It was found to be 0.7–1.04 % of body mass; there was a positive correlation between heart mass and age of the horse (Herrmann 1929). The increase in heart mass is in these horses due to the so-called training hypertrophy (Kubo et al. 1974).

With ventricular hypertrophy and heart size the angle of the electrical cardiac axis is closely connected. A morphological and ECG-study of the size of heart ventricles and the angle of electrical cardiac axis in young foals was made by Matthiesen and Deegen (1977) and Deegen and Matthiesen (1977). In newborn foals they found a physiological hypertrophy of the right ventricle characterized by an inclination of the electrical cardiac axis by 46° to the left. In 12-month-old foals a physiological growth hypertrophy of the left ventricle occurred with an inclination of the electrical cardiac axis by 2.5 °. Hypertrophy of various parts of the heart due to heart deffects affecting the changes in the angle of electrical cardiac axis was described by Holmes and Else (1972), White and Rhode (1974), Mill and Hanák (1978) and others.

The aim of the present work was to study the development of angle of the electrical cardiac axis and of magnitude of the ventricular vector in growing thoroughbred foals from weaning (6 months) until their transfer to a training centre at the age of about 20 months.

Materials and Methods

The vector changes (angle of the electrical cardiac axis and magnitude of the ventricular vector) were investigated in 60 English thoroughbred foals of both sexes. The ECG records in the tetrahedron lead system (Hanák 1979) were done repeatedly at the age of 5—7 months (weanlings), 13—15 months (foals) and prior to transfer to a training centre at the age of 17—20 months (yearlings). During the entire experimental period the heart sounds of all animals were clear, well distinguished, with no murmurs and no arrhythmias. There were no clinical signs of illness observed, the horses were fed in a conventional manner, they had abundant movement on pastures.

The ECG records were taken on a STARTEST (Chirana) apparatus with calibration 10 mm = = 1 mV at 25 mm . s^{-1} speed of the thermosensitive paper. The vector evaluation of the ventricular complex was done by determination of the angle of electrical cardiac axis and magnitude of the vector on a cross a diagram according to Holzmann (in Perlick and Böhme 1967) in the horizontal (H), transversal (T), sagittal right (Sr), sagittal left (Sl) and sagittal middle (Sm) planes intersecting the centre of tetrahedron.

The result were graphically evaluated and for statistical analysis the Duncan test and simple analysis of variance were employed.

Results

The magnitude of angle of the ventricular complex vector or angle of the electrical cardiac axis related to the age of horses is shown in Fig. 1. It is obvious that the greatest changes in the angle of the electrical cardiac axis occurred in the horizontal plane. In weanlings aged 5—7 months the axis rotated from the right to the left by 3.1° with a large standard deviation. With increasing age, the axis rotated caudad so that at the age 17—20 months the angle was 45.75° left and caudal. The effect of age upon changes in the direction of the electrical cardiac axis in the horizontal plane was highly significant ($P < 0.01$) between weanlings and foals, and between weanlings and yearlings ($P < 0.01$). However, no significant differences were found between foals and yearlings ($P > 0.05$).

The same statistical significance was found with

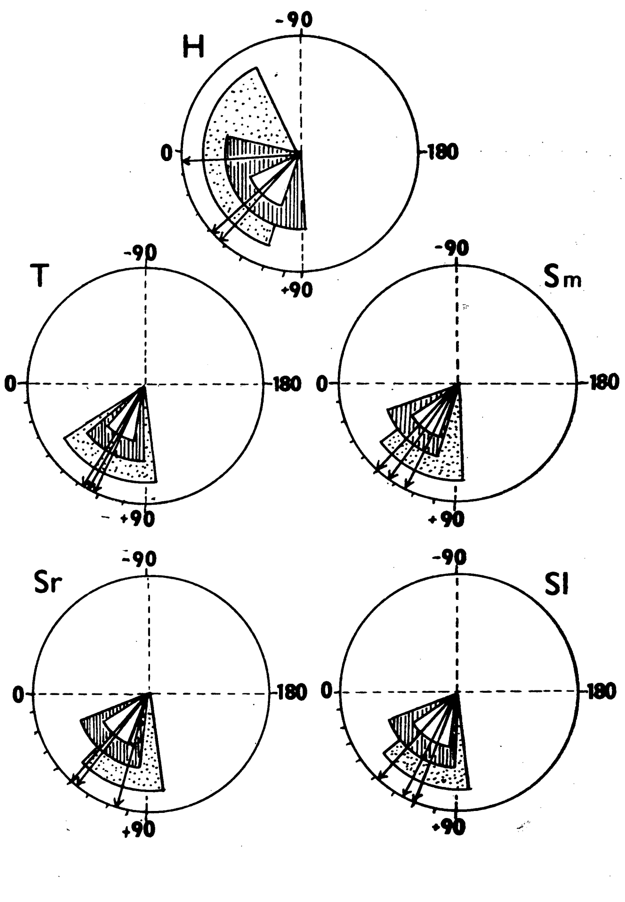

Fig. 1. Changes in angle of the electrical cardiac axis related to the age of the foals ($n = 60$)
dotted area: 5—7 months
lined area: 13—15 months
empty area: 17—20 months

the effect of age on the angle of the electrical cardiac axis in sagittal right plane (Sr). In weanlings, the axis rotated caudoventrally by 72.0°. With ageing, the angle magnitude decreased so that in yearlings the angle was only 49.05° caudoventrally. The originally vertical position of the electrical cardiac agis changed into a semivertical one in older animals.

In the transversal (T) and sagittal left (Sl) planes no significant effect of age upon the angle of electrical cardiac axis was found. In the sagittal middle (Sm) plane the effect of age on transfer of the vertical angle of the cardiac axis in weanlings (70.86°) to semivertical position in foals (49.05°) was significant ($P < 0.01$). In yearlings, the electrical cardiac axis tended to return to vertical position (54.90°), however, not significantly ($P > 0.05$).

The effect of age on magnitude of the ventricular vector is shown in Fig. 2. In all tetrahedron planes an increase in magnitude of the ventricular vector occurred with ageing. A significant increase in the vector magnitude in all planes was found in yearlings as compared to weanlings ($P < 0.01$). A significant difference in sagittal middle (Sm) plane was observed between weanlings and foals ($P < 0.01$), and in the transversal plane (T) between foals and yearlings ($P < 0.01$).

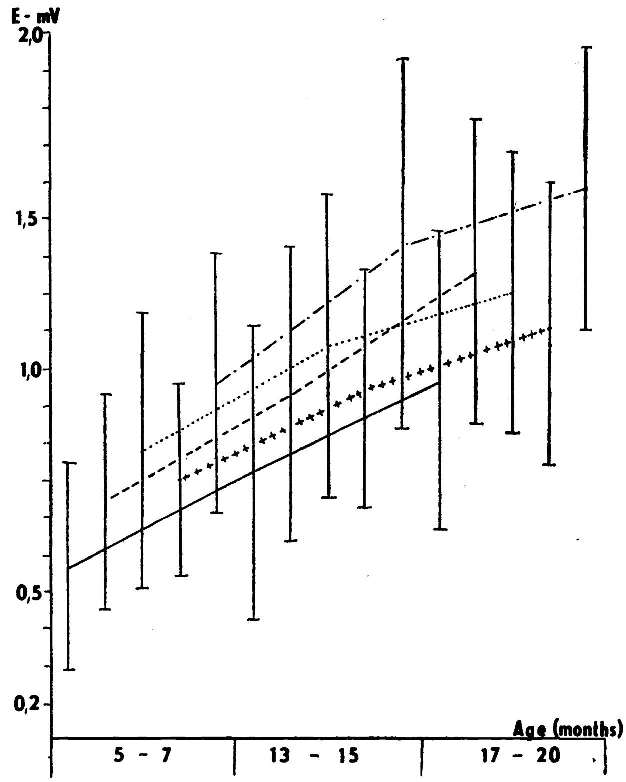

Fig. 2. Changes in magnitude of the ventricular complex vector related to depending the age of the foals ($n = 60$).

——— H
– – – T
. . . . Sr
+ + + Sl
—·—·— Sm

In the remaining planes of tetrahedron (H, T, Sr, Sl) the difference between weanlings and foals, i. e. effect of age on increase in the magnitude of the vector was significant ($P < 0.05$). Similarly, in the sagittal left plane (Sl) there was a difference between foals and yearlings ($P < 0.05$). No effect of age on the ventricular vector was found in yearlings as compared to foals in the planes Sr and Sm ($P > 0.05$).

Discussion

The age and growth of foals affect the size and position of the heart (Herrmann 1929; Matthiesen and Deegen 1977). Although the anatomical and electrical cardiac axes are not identical, changes in the heart size and its position in the thorax affect considerably the direction and magnitude of the ventricular vectors including the electric cardiac axis (Jonáš 1950).

The changes in direction of the electrical cardiac axis dependent on age and growth of the foals described Deegen and Matthiesen (1977). A significant effect of age and growth of the foals on rotation of the electrical cardiac axis in the horizontal plane (rotation to the right and caudad along the vertical axis Z) and in the sagittal plane (rotation caudohorizontally along the transversal axis X) (Hanák 1979).

The present study was aimed at accomplishment of data by Deegen and Matthiesen (1977) and our own results (Hanák 1979). It provides information about more age categories and dynamics of the vector changes in thoroughbred foals from weaning up to their transfer to the training centre. Besides the horizontal plane, however, we used further 4 tetrahedron planes to enable a better space orientation in the changes under study.

In 5—7-month old weanlings the angle of the electrical cardiac axis in the horizontal plane was 3.1° resembling that of 12-month-old foals found by Deegen and Matthiesen (1977). A this age, however, in our animals an angle of 40.72° was found. These differences may originate in experimental material since in our study exclusively thoroughbred foals were employed, the physical development of which is faster than that of other breeds.

A significant effect of age on rotation of the electrical cardiac axis in the horizontal plane (rotation to the right and caudad) and sagittal middle plane (caudohorizontal rotation) was found. This is in good agreement with our previous findings (Hanák 1979). Further a highly significant rotation in the sagittal right plane (caudohorizontally) was observed. On the other hand, in the sagittal left and transversal planes no effect of age was found.

Highly significant changes in angle of the electrical cardiac axis in the H, Sm and Sr planes were found especially between weaning and 13—15 months of age. At this time also the growth rate of foals was found to be most rapid (Green 1969, 1976). During this intensive growth phase also the heart undergoes an intensive growth period and its position in thorax changes. It can affect the rotation of cardiac axis until the age of 13—15 months.

In older animals no substantial changes in angle of the electrical cardiac axis occurred as indicated by small differences between foals and yearlings. However, these two groups were rather close as far as their age is concerned. Similarly, Deegen and Matthiesen (1977) demonstrated a rotation of the electrical axis in foals until 12 months of age. The authors described a physiological growth hypertrophy of the left ventricle rotating the whole heart from the left side of thorax more medially (to the right) and the apex directing caudad as a cause of the above-mentioned rotation. In our animals the changes in rotation of the electric cardiac axis in foals up to 13—15 months of age be can ascribed to left ventricle hypertrophy as well. This explains that the changes in heart position make themselves felt in rotation of the electric cardiac axis predominantly in planes H, Sr and Sm and remain unchaged in Sl and T planes.

In a previous study (Hanák 1979) we demonstrated a significant effect of age and body growth of foals on increase in magnitude of the ventricular vector in the horizontal, transversal and sagittal planes. The present study shows the development of changes in magnitude of the ventricular vector in foals from weaning until 20 months of age.

The results of our study indicate a significant effect of age on the enlargement of the ventricular vector only in the period between weaning and the age of 13 to 15 months. In older animals no substantial increase in magnitude of the ventricular vector occurred. Any changes in this phenomenon are thus due to rotation of the electrical cardiac axis.

Only in the T and Sl planes the magnitude of the ventricular vector continued to significantly increase beyond the age of 13—15 months. However, this increase cannot be explained by rotation of the electrical cardiac axis since its angle is in foals aged 13—15 months already stabilized. There is obviously another factor involved. This factor does change neither the heart position in thorax nor the angle of the electric cardiac axis.

According to the vector interpretation of ventricular hypertrophy and dilatation based on the so-called Brody's effect (blood volume capacity of vetricles related to thickness of the ventricular walls) by Ishikava et al. (1971), the ventricular vector decreases in dilated heart and increases in ventricular hypertrophy. If, according to this theory, a further increase in magnitude of the ventricular vector in the T and Sl planes is due to heart hypertrophy, a bilateral hypertrophy must be assumed by which no further changes in heart position and other phenomena occur.

Hypertrophy of the ventricular walls increases the vector in radial direction as related to electrodes (Ishikava et al. 1971). Closest to this position are the planes T and Sl as related to direction of the electrical cardiac axis. Therefore in these planes there was a highly significant enlargement of the ventricular vector from weaning until the transfer of horses to the training centre. The direction of the vector from its stabilization at the age of 13—15 months was no more radial to planes H, Sr and Sm. This is why the vector enlargement in these planes was not significant.

It can be concluded that this study has shown a significant effect of age on rotation of the electrical cardiac axis to the right and caudoventrally in foals up to the age of 13—15 months. At the same time the magnitude of the ventricular vector increased. Due to a rapid growth rate of animals changes in size and position of their heart in the thorax occurred. The vector changes are, for the most part, due to the so-called growth hypertrophy of the left ventricle.

From the age of 13—15 months onwards the angle of the electrical cardiac axis was stabilized. A further enlargement of the ventricular vector may only be due bilateral heart hypertrophy increasing the vectors in a direction radial to the planes. Bilateral hypertrophy does not affect position and electric cardiac axis of the heart.

Sklon elektrické osy srdeční a velikost komorového vektoru u plnokrevných hříbat

U 60 plnokrevných hříbat byly studovány vektorové změny komorového komplexu opakovaně ve třech časových rozmezích od odstavu (kolem 6 měsíců) do doby odchodu koní na tréninkové ústředí (kolem 20 měsíců stáří). Vektorové

změny byly studovány v rovině horizontální, transverzální a třech rovinách sagitálních.

Z provedené vektorové studie vyplývá, že u rostoucích hříbat dochází k signifikantní rotaci elektrické osy srdeční směrem doprava a kaudohorizontálně až do stáří 13—15 měsíců. V této době se také signifikantně zvětšuje velikost komorového vektoru. Od stáří 13—15 měsíců je sklon elektrické osy srdeční již stabilizován. Další zvětšení komorového vektoru v rovinách T a Sl podmíněno bilaterární hypertrofií komorových stěn.

Наклон электрической оси сердца и величина вектора желудочка сердца у полнокровных жеребят

На 60 полнокровных жеребятах проводились изучения векторных изменений комплекса желудочков сердца в трех интервалах времени с периода отсадки (около 6 месяцев) до передачи лошадей тренировочному центру (в возрасте около 20 месяцев). Векторные изменения изучались на горизонтальном, трансверсальном уровнях сагиттальных.

На основе проведенного векторного изучения вытекает, что у растущих жеребят наблюдается заметное вращение электрической сердечной оси по направлению направо и в каудогодизонтальном направлении до возраста 13—15 месяцев. В данный период также существенно увеличивается вектор желудочка сердца. С возраста 13—15 месяцев наклон электрической сердечной оси уже стабилизуется. Дальнейшее увеличение вектора на уровнях Т и С1 обусловлено билатеральной гипертрофией стенок желудочков.

References

BRODY, S.: Bioenergetics and growth. Reinhold Publ. Comp., New York, 1945, 402 s.

DEEGEN, E. — MATTHIESEN, T.: Untersuchungen zum EKG des Fohlens. II. Entwicklung des QRS-Komplexes in den Standard-Extremitäten-Ableitungen innerhalb des ersten Lebensjahres. Zbl. Vet. Med., **24 A,** 1977, 799—816.

GREEN, D. A.: A study of growth rate in thoroughbred foals. Brit. Vet. J., **124,** 1969, 539—546.

GREEN, D. A.: Growth rate in thoroughbred yearlings and two year olds. Eq. Vet. J., **8,** 1976, 133—134.

HANÁK, J.: Elektrokardiografický svodový systém v diagnostice u plnokrevných koní. Ph. D. thesis, Brno, 1979, 198 p.

HERRMANN, G.: The heart of the thoroughbred race horse. Proc. Soc. Exp. Biol., New York, **26,** 1929, 549—551.

HOLMES, J. R. — ELSE, R. W.: Further studies on a new ead or equine electrocardiography. Eq. Vet. J., **4,** 1972, 81—87.

ISHIKAVA, K. — BERSON, H. S. — PIPBERGER, H. V.: Electrocardiographic changes due to cardiac enlargement. Am. Heart J., **84,** 1971, 635—641.

JONÁŠ, V.: Klinická kardiologie. SZdN Praha, 1950, 748 p.

KUBO, K. — SENTA, T. — SUGIMOTO, O.: Relationship between training and heart in thoroughbred racehorse. Exp. Rep. Eq. Hlth. Lab., **11,** 1974, 87—93.

MATTHIESEN, T. — DEEGEN, E.: Untersuchungen zum EKG des Fohlens. I. Untersuchungen zur Entwicklung des Massenverhältnisses der Herzmuskulatur bei Fohlen im Zusammenhang mit der postnatalen Kreislaufumschaltung. Zbl. Vet. Med., **24 A,** 1977, 709—716.

MILL, J. — HANÁK, J.: Abnorme Herzbefunde bei Vollblutrennpferden. Mh. f. Veterinärmed., **33,** 1978, 508—511.

PERLICK, E. — BÖHME, H.: Elektrokardiographische Untersuchungsmethoden. In: Arbeitsmethoden der inneren Medizin. VEB G. Fischer Verlag, Jena, 1967, 100—296.

WHITE, N. A. —RHODE, E. A.: Correlation of electrocardiographic findings to clinical disease in the horse. J. Am. Vet. Med. Ass., **164,** 1974, 46—56.