

**Szent István University
Postgraduate School of Veterinary Science**

**Determination of some cardiac dimensions
and the position of the caudal lung border
by ultrasonography and percussion in
horses**

Ph.D. Thesis Summary

Zoltán Bakos

Budapest

2003

Szent István University
Postgraduate School of Veterinary Science

Head of the Postgraduate School of Veterinary Science:

Prof. Péter Rudas, DVM, D.Sc.

Supervisor:

Prof. Károly Vörös, DVM, D.Sc.
Department and Clinic of Internal Medicine
Faculty of Veterinary Science
Szent István University

Board members:

Prof. Ottó Szenci, DVM, D.Sc.
Clinic for Large Animals
Faculty of Veterinary Science
Szent István University

Prof. László Fodor, DVM, C.Sc.
Department of Microbiology and Infectious Diseases
Faculty of Veterinary Science
Szent István University

Introduction and objectives

Physical examination as the most important part of clinical diagnostics has a long tradition in Hungary due to the work of Azary, Marek and Mócsy. Most of the old physical methods are widely used in daily veterinary practice. Although clinical laboratory and instrumental ancillary diagnostic aids have gone through a fast and considerable development, physical examination preserved its important role in clinical diagnostics. Until recently, no study was published about the reliability of traditional physical diagnostic tools, such as cardiac and thoracic percussion.

Ultrasonography was introduced to equine internal medicine and cardiology in the 1970's. The development and spreading of echocardiography as a non-invasive imaging technique was the largest advance in the diagnostics of equine cardiac diseases in the last 25 years. The first reports on ultrasonic imaging of the equine thoracic cavity and lungs originate from the early and mid 1980's. The

significance of thoracic ultrasonography is high in diagnosing pleural and certain lung diseases in large animals, as radiography can not be used in all cases because of the radiation exposure of the patients, veterinarians and assistants. On the basis of several publications on equine diagnostic ultrasonography, this latter method seems to be suitable to validate cardiac and thoracic percussion.

Measurements of cardiac parameters of the equine heart commenced with unguided M-mode echocardiography. It was followed by validation and application of the two-dimensional echocardiographic (2DE) methods. A new standardized two-dimensional and guided M-mode study was published in 1992. Later the new standardized method was adapted and reference values for adult Thoroughbred horses, small and large ponies and horses of mixed breed were published. Until recently, there were no data about Standardbred trotter horses. However, reference echocardiographic values within a particular breed are

important to compare them when evaluating cases with cardiac diseases.

The aim of the first study was to establish normal echocardiographic values of the most important cardiac parameters in Standardbred trotters using a standardized technique, and compare these dimensions to the normal values of other equine breeds reported earlier.

Estimation of the cardiac size in the adult horse can be performed by percussion of the cardiac dullness area. This method as a part of the physical examination has a long history. Horses have absolute cardiac dullness which means that there is direct contact between the heart and the thoracic wall on both sides of the thorax. The absolute cardiac dullness area on the left side was described as a right-angled triangle with convex hypotenuse.

Hitherto no studies have been published about the reliability of instrumental percussion of the absolute cardiac dullness area in the horse. Although

several publications exist on intracardiac ultrasonographic measurements in horses, no one tried to use this method to determine the outer borders of the cardiac region to our best knowledge.

The objective of the second experiment was to compare the instrumental percussion method with two-dimensional echocardiography when outlining the cardiac border, producing numerical data and using statistical evaluations. Another aspect of this investigation was to determine the area of absolute cardiac dullness more accurately on the left side of the thorax as it was published earlier in standard textbooks.

Percussion of the equine thorax as a diagnostic tool has a long tradition in Europe, particularly in Hungary. Application of this method in horses has been ignored or used in a restricted way due to the spreading of modern imaging techniques, and because percussion was believed to be a technique limited by several factors.

Only one study was published about the ultrasonographic determination of the caudal lung border in the horse. It gave the reference points of the technique both on the left and right side of the thorax. According to this report, the characteristic reverberation artifacts caused by the normal aerated lung provides an accurate delineation of the caudoventral lung border.

As there are no data about the reliability of the percussion in determining the caudal lung border in healthy horses, and ultrasonography is considered to be a convenient tool to determine the outer borders of the lung, it seemed to be a useful method to combine the traditional percussion technique with this new one. Thus the aim of the third study was to compare and to validate the percussion method with ultrasonography applying distance measurements and statistical analyses.

The caudal shift of the caudal lung border in horses is a well-known phenomenon. It occurs in

many cases of recurrent airway obstruction (RAO) or chronic obstructive pulmonary disease (COPD) as this disease complex was nominated earlier. The easiest and most cost-effective examination method in the diagnostics of this alteration is thoracic percussion. Thoracic percussion was described as a technique limited by several factors. It was suggested to compare the results of percussion with the findings of radiography, ultrasonography and necropsy, but such examinations have never been published to our best knowledge.

As RAO is a common problem in the northern hemisphere and we consider thoracic percussion an essential part of the physical evaluation of the patient, examination of the reliability of percussion in horses with caudal shift of the caudal lung border seems to be necessary because of uncertainty in the existing literature.

Based on the results of the third experiment, the goals of the fourth investigation were to demonstrate the diagnostic value of ultrasonography and percussion, and to compare ultrasonographic results

with those of percussion, in order to validate this latter, traditional examination technique in horses with recurrent airway obstruction.

Materials and methods

In the *first study* normal echocardiographic values of healthy Standardbred trotters were established. Twenty-three clinically normal horses weighing between 350 and 490 kg were examined. Standardized two-dimensional (2D) and guided M-mode echocardiographic imaging techniques were used to measure interventricular septal thickness (IVS), left ventricular internal diameter (LVID), left ventricular wall thickness (LVW), left atrial internal diameter (LAID) in systole (s) and diastole (d) and aortic diameter (AOD) in diastole. Mean, range and standard deviations of the different parameters were calculated.

In the *second investigation* we applied two different methods for the determination of the area of cardiac dullness. The techniques of percussion and echocardiography were used, and the obtained values of the examinations were compared to each other.

Since ultrasound imaging has recently been a great improvement in cardiovascular disease examination and percussion was becoming a method forgotten and untrusted by many practitioners, the main idea was to demonstrate whether percussion could deliver exact data if performed accurately and by an experienced examiner.

The trial included thirty-one warm-blooded healthy horses chosen randomly without respect to breed, sex, weight, height and age. The horses first underwent a thorough physical examination to exclude cardiovascular and respiratory problems. This was followed by percussion of the area of cardiac dullness, and then by the echocardiographic imaging of the same region. To obtain the relevant measurement points, the 4th and 5th intercostal spaces (ICS) were used on the left and the 4th intercostal space was used on the right side. On the left, the dorsal border of cardiac dullness was determined in the 4th ICS (1st point). Then, at the same place, the dorsal border of the sternum (the ventral border of cardiac dullness) was determined (2nd point), this was followed by

percussion and echocardiography of the same points in the 5th ICS (3rd and 4th point). The next step was to measure the distances of these points from the ventral border of the thorax, and also between the 2nd and the 4th points. The same procedure was used on the right side in the 4th ICS only.

From the data of distance measurements, mean values, standard deviations, standard errors and ranges were calculated.

In the *third experiment* the traditional percussion method was compared and validated with ultrasonography with the help of distance measurements and statistical methods in the determination of the caudal lung border in healthy horses. The importance of this study was that equine thoracic percussion has been ignored or used in a restricted way in several countries due to the spreading of modern imaging techniques, although it could provide valuable information, and ultrasonography was a reliable tool in determining the caudal lung border of the horse.

No similar studies have been reported previously on the reliability of the percussion technique.

Examinations were done on 15 healthy, warm-blooded horses with different breeds and ages. First, the caudal lung border was determined with the traditional indirect percussion method at the end of the inspiration and expiration phases on both sides of the thorax. To apply standardized measurements, a fix point close to the withers was chosen. The distance between this point and the caudal lung border in the 10th, 12th, 14th and 16th intercostal spaces was determined with a tape-measure. Percussion was followed by the ultrasonographic determination of the caudal lung border in the same intercostal spaces.

In the *fourth study* the diagnostic value of thoracic percussion and ultrasonography was evaluated with the help of distance measurements and statistical methods in the determination of the caudal

lung border in horses with recurrent airway obstruction (RAO).

Examinations were performed on 11 warm-blooded horses with different breeds, ages and grades of the disease. First, the caudal lung border was determined with the traditional indirect percussion method in the 10th, 12th, 14th and 16th intercostal spaces at the end of the inspiration and expiration phases on both sides of the thorax. To apply standardized measurements, a fix point was chosen as described earlier for healthy horses. The distance between this point and the caudal lung border was measured with a tape-measure. Percussion was followed by ultrasonographic determination of the caudal lung border. Measurements were performed in the same way as described for the percussion technique.

Results

The mean values of two-dimensional and M-mode echocardiographic measurements in centimeter were as follows (2D/M-mode): IVSs: 4.6/4.7; IVSd: 3.1/3.0; LVIDs:7.0/7.0; LVIDd: 10.7/10.7; LVWs: 3.9/3.9; LVWd: 2.7/2.7; LAIDs: 10.4/-; LAIDd: 11.3/- ; AODd: 7.2/-.

The most important cardiac parameters of healthy Standardbred trotters were determined by standardized two-dimensional and guided M-mode echocardiography. Such results have not been published before. These parameters can serve as reference values of this breed in the future, when comparing them with pathological conditions.

Results of percussion and echocardiography in determining the cardiac dullness area were found to be close to each other, showing only small deviations. The mean values/standard errors (in cm) of the absolute values of differences between percussional and echocardiographic measurements were the

following. Left side, 4th intercostal space (ICS), dorsal border: 0.8/0.1; ventral border: 0.7/0.1; 5th ICS, dorsal border: 0.8/0.1; ventral border: 0.9/0.2; right side, 4th ICS, dorsal border: 0.8/0.2; ventral border: 0.7/0.1. Due to the close correlation between the results of the two techniques it is reasonable to consider cardiac percussion as an integrated part of the physical examination. It is a valuable tool in the hands of the experienced clinician, because it enables him / her to determine cardiac enlargement without using ultrasonography.

An examination method was developed to determine the cardiac dullness area of healthy horses by two-dimensional echocardiography.

It was demonstrated that the results of cardiac percussion did not differ significantly from the echocardiographic results, hence cardiac percussion was a reliable diagnostic tool.

By way of area calculation, the size of the cardiac dullness on the left hemithorax was determined more accurately than in previous reports.

In the third study the mean values and standard errors of the absolute values of differences between percussional and ultrasonographic measurements were the following in centimeter (10th;12th;14th;16th intercostal spaces). Left side expiration: 0.9/0.2; 1.6/0.5; 1.6/0.4; 1.0/0.2; left side inspiration: 1.4/0.3; 1.3/0.3; 2.0/0.4; 1.0/0.2; right side expiration: 1.3/0.4; 1.0/0.3; 2.3/0.4; 1.3/0.4; right side inspiration: 0.8/0.3; 0.7/0.2; 1.9/0.5; 1.6/0.5 respectively.

Percussional results were similar and did not differ significantly from those of the ultrasound method, which was used as a reference technique. Thus, the percussion technique can be suggested as a reliable means to determine the caudal lung border in the healthy horse. However, differences caused by the displacement of the lung during inspiration and expiration must be taken into consideration when performing both methods.

Ultrasonography was found to be adaptable to determine the caudal lung border in a larger population of healthy horses.

The morphological validation of thoracic percussion was performed in one horse.

It was confirmed using distance measurements and statistical methods that there were no significant alterations between the results of thoracic percussion and ultrasonography. Thus, percussion can be suggested as an important part of the physical examination in experienced hands and with proper instruments.

It was emphasized with the help of numerical data that the displacement of the caudal lung border during the phases of respiration must be taken into consideration, no matter which diagnostic method we use.

Since the caudal lung border could not be detected in the 16th intercostal space at the level of the tuber coxae, issues of forensic veterinary medicine would be raised, and further investigations are necessary.

In the fourth investigation the mean values and standard errors of the absolute values of differences

between percussional and ultrasonographic measurements were the following in centimeter (10th;12th;14th;16th intercostal spaces). Left side expiration: 1.4/0.4; 0.8/0.2; 0.9/0.2; 0.8/0.4; left side inspiration: 0.8/0.3; 1.5/0.3; 1.4/0.3; 1.1/0.3; right side expiration: 2.1/1.0; 2.1/0.5; 1.6/0.5; 0.8/0.1; right side inspiration: 1.5/0.7; 1.2/0.6; 0.8/0.2; 0.8/0.3 respectively.

Ultrasonography proved to be reliable in determining the caudal lung borders in horses with RAO. Results of the percussion examination did not differ significantly from the ultrasound method, which was used as a reference technique. The differences between inspiration and expiration were greater in horses with RAO than in healthy horses in our previous study. Based on these results, percussion can be used as an integral part of the physical examination in diagnosing caudal shift of the caudal lung border of horses suffering from RAO.

It was demonstrated that ultrasonography is a suitable diagnostic tool in determining the caudal

lung border in horses with chronic pulmonary disease.

Using the measurement method developed for the examination of healthy horses, it was proved that the results of thoracic percussion did not differ significantly from the results of ultrasonography.

With the help of distance measurements, it was demonstrated that the movements of the caudal lung border of horses suffering from recurrent airway obstruction were larger than the same values in clinically normal horses.

Thus, the percussion method can be suggested as a useful and reliable tool to determine the caudal shift of the caudal lung border in horses with recurrent airway obstruction.

New scientific results

1. The most important cardiac parameters of healthy Standardbred trotters were determined by standardized two-dimensional and guided M-mode echocardiography. These parameters can serve as reference values of this breed in the future, when comparing them with pathological conditions.
2. It was demonstrated that the results of cardiac percussion did not differ significantly from the echocardiographic results, hence cardiac percussion was a reliable diagnostic tool.
3. It was confirmed that there were no significant alterations between the results of thoracic percussion and ultrasonography. Thus, percussion can be suggested as an important part of the physical examination in experienced hands and with proper instruments.

4. It was emphasized that the displacement of the caudal lung border during the phases of respiration must be taken into consideration, no matter which diagnostic method we use, and the movements of the caudal lung border of horses suffering from recurrent airway obstruction were significantly larger than the same values in clinically normal horses.

5. It was demonstrated that the caudal lung border could not be detected by ultrasound in the 16th intercostal space at the level of the tuber coxae which was contradictory to previous statements.

Publications related to the thesis

1. Hungarian journals, in Hungarian

- 1.1. **Bakos, Z.** – Vörös, K. – Tóth, N.:
A kétdimenziós és az M-mód kvalitatív és kvantitatív echokardiográfia alkalmazása lovakban. Irodalmi összefoglaló és saját tapasztalatok.
Magy. Állatorv. Lapja, 2003. Közlésre elfogadva.

2. Hungarian journals, in English

- 2.1. **Bakos, Z.** – Vörös, K. – Kellokoski, H. – Reiczigel, J.:
Comparison of the caudal lung borders determined by percussion and ultrasonography in horses with recurrent airway obstruction.
Acta Vet. Hung., 2003. 51. 249-258.
- 2.2. **Bakos, Z.** – Vörös, K. – Järvinen, T. – Reiczigel, J.:
Two-dimensional and M-mode echocardiographic measurements of cardiac dimensions in healthy Standardbred trotters.
Acta Vet. Hung., 2002. 50. 273-282.

3. Proceedings

- 3.1. **Bakos, Z.** – Vörös, K. – Kutasi, O.: Comparison of the caudal lung borders determined by percussion and ultrasound in healthy horses. 8th Congress of the World Equine Veterinary Association. Buenos Aires, 2003. 49-50.
- 3.2. **Bakos, Z.** – Vörös, K.: A hátulsó tüdőhatár kopogtatásos és ultrahangos meghatározásának összehasonlító vizsgálata krónikus obstrukciós tüdőbetegségben szenvedő lovakban. Akadémiai Beszámoló. Budapest, 2002.
- 3.3. **Bakos, Z.** – Vörös, K.: Comparison of the caudal lung borders determined by percussion and ultrasound in healthy horses. University of Veterinary Medicine, Kosice, 2001. 133-135.
- 3.4. **Bakos, Z.** – Vörös, K.: A szívtompulat kopogtatásos és ultrahangos meghatározásának összehasonlító vizsgálata lovakban. Akadémiai beszámoló. Budapest, 2001.
- 3.5. **Bakos, Z.** – Vörös, K.: A hátulsó tüdőhatár kopogtatásos és ultrahangos megállapításának összehasonlító vizsgálata lovakban. In: Péntek, G. – Bakos, Z. – Halas, M. (szerk.): VIII. Lógyógyászati Kongresszus, Kongresszusi

összefoglaló. Klinikus Állatorvosok
Egyesülete Ló Szekció. Budapest, 2000. 4-5.

- 3.6. **Bakos, Z.** – Vörös, K. – Vrabély, T.: A lovak szívének standardizált ultrahangvizsgálata. Akadémiai beszámoló. Budapest, 1999.

4. Manuscripts submitted for publication, related to the thesis

- 4.1. **Bakos, Z.** – Vörös, K. – Paár, L.: Comparative examination of percussional and echocardiographic determination of the cardiac dullness area in healthy horses. Submitted for publication to Equine Veterinary Education (2003).
- 4.2. **Bakos, Z.** – Vörös, K. – Kutasi, O.: Comparison of the caudal lung borders determined by percussion and ultrasound in healthy horses. Submitted for publication to the Journal of Veterinary Medicine Series A (2003).