Determination of Doppler velocimetric measurements of the median artery in horses

Determinação das medidas dopplervelocimétricas da artéria mediana em equinos

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ABSTRACT

Considering the importance of equine culture for the northeast region, the objective was to determine the median artery Doppler velocimetry measurements in horses through Doppler ultrasonography and to correlate changes in these measurements with possible risk factors for laminitis and / or other foot diseases. The project was approved for its

execution through protocol N°. 3769100419 granted by the UFPB Ethics Committee. The analyzes were performed at Horse Training Centers and at the Veterinary Hospital - CCA / UFPB, in Areia, Paraíba State. Fourteen animals were used, which were trichotomized at the time of the third metacarpal bone, medial face of both thoracic limbs. The sonoscape S2V ultrasound device with color Doppler coupled to a 7 MHz linear probe was placed at the height of the median artery, in which B was measured. Then, the color Doppler mode was used to determine the doppler velocimeter measurements. Thus, with a 95% confidence interval in mode B 0,509 ± 0,133 of the median artery diameter was determined and in Doppler mode 2,198 ± 1,451 of the pulsatility index and 0,734 ± 0,906 of the resistivity index (non-parametric data). as reference values for normality of median artery vascularization. It is concluded that more studies need to be developed to attest to the reliability of these values. Moreover, they may help in the early diagnosis, improving the prognosis of these animals prone to laminitis and other foot diseases.

Keywords: doppler, equine, ultrasound.

RESUMO

Considerando a importância da equideocultura para a região nordeste, objetivou-se determinar as medidas dopplervelocimétricas da artéria mediana em equinos através da ultrassonografia Doppler e correlacionar alterações nessas medidas com possíveis fatores de risco para laminite e/ou outras enfermidades podais. O projeto teve parecer favorável a sua execução através do protocolo nº 3769100419 concedido pelo Comitê de Ética da UFPB. As análises foram realizadas em Centros de Treinamento de cavalos e no Hospital Veterinário - CCA/UFPB, em Areia no estado da Paraíba. Utilizaram-se quatorze animais, os quais foram tricotomizados na altura do terceiro osso metacarpo face medial de ambos os membros torácicos. Para realização do exame de imagem foi utilizado o aparelho de ultrassom sonoscape S_2V com Doppler colorido acoplado a uma sonda linear de 7 MHz que foi posicionada na altura da artéria mediana na qual realizou-se em modo B, sua medição. Após, utilizou-se o modo color Doppler para determinar as medidas dopplervelocimétricas. Com isso, foram determinados com intervalo de confiança de 95% os valores em modo B 0,509 ± 0,133 do diâmetro da artéria mediana e no modo Doppler 2,198 ± 1,451 do índice de pulsatilidade e 0,734 ± 0,906 do índice de resistividade (dado não paramétrico), como valores de referência de normalidade da vascularizacão da artéria mediana. Conclui-se que mais estudos precisam ser desenvolvidos para atestar a confiabilidade desses valores, além disso, eles podem auxiliar no diagnóstico precoce, melhorando o prognóstico desses animais propensos a laminite e outras enfermidades podais.

Palavras-chave: doppler, equídeo, ultrassonografia.

1 INTRODUCTION

The locomotor system of equines has an important role in biomechanics and sustentation of these animals because of its weight and impact of the limbs on the ground. Laminitis is the main and most serious disease that affects the equine hooves and may keep the animals away from their sportive life, or even imply in euthanasia.

Several studies constantly present research on the causes, physiopathology, and treatment of laminitis; however, there are divergences in certain aspects. The most accepted theory, currently, is that laminitis is caused by peripheral vasoconstriction resulting from adverse systemic factors of animal metabolism, with release of endotoxins, chemical mediators that determine, for instance, hypoxia and necrosis of the dermal and epidermal laminae of the hoof and, consequently, rotation of the distal phalange (STASHAK, 2005; THOMASSIAN, 2005). After this rotation, there is damage to adjacent structures, such as the solar corium, the local blood system, and the hoof coronary band. The resulting pain is intense and is followed by claudication, which is characteristic of the clinical picture (POLLITT, 2004).

Doppler ultrasonography is a noninvasive and low-cost method of relatively recent application in veterinary medicine. It is believed that it can satisfactorily assist in obtaining normal parameters and consequently in the detection of foot disorders due to the high specificity and sensitivity of the method (VIEIRA, 2016).

The Doppler technique provides qualitative and quantitative data in real time on vascular identity, presence, direction, velocity, characterization of vascular patterns and the type of blood flow. It also makes it possible to document disease-associated flow disturbances and to acquire information regarding the vascular perfusion of various vital organs through the velocity spectrum characteristic of each vascular structure. It determines the architecture (dimensions and contours) and hemodynamic aspects of the major peripheral and central blood vessels (MARTIN, 2009).

The physical principle of Doppler mode ultrasound is based on the Doppler effect, which describes the change in the wave frequency of sound that occurs when there is relative motion between the emitting source and the receiver (NAQVI et al., 2013). In contrast to two-dimensional gray-scale ultrasound, which displays information of tissue interfaces, Doppler ultrasound instruments are optimized to display flow information. It thus allows the assessment of hemodynamics by analyzing the emitted sound, velocity spectral waves, and color mapping (MCDICKEN et al., 2014; VIECELLI et al., 2008).

The color representation is independent of whether the vessel conducts arterial or venous blood (CARVALHO et al., 2008). The concomitant presentation of the conventional B-mode image (of the assessed organ region or vessel region) and the Doppler spectral tracing constitute the duplex system.

Considering the importance of the vascularization of the digit in the occurrence of foot diseases such as laminitis and the socio-economic importance of these animals in the

agricultural and cattle raising scenario, the goal is to increasingly minimize losses due to lesions that compromise the performance of horses. Therefore, the evaluation of the equine vascular system by duplex Doppler ultrasonography has been used to describe pathological hemodynamic incidences of the equine muscular blood flow and digital blood flow in horses affected by podochondrosis and laminitis (SCHMUCKER et al., 2000), helping in the early diagnosis and in the improvement of the prognosis of such patients. Therefore, the present study aims to determine the Doppler velocimetric measurements of the median artery in horses by means of Doppler ultrasonography and correlate changes in these measurements with possible risk factors for laminitis and/or other podal diseases.

2 MATERIALS AND METHODS

The research took place at Horse Training Centers and at the Veterinary Hospital - CCA/UFPB, in Areia, Paraíba state. We used 14 horses of both sexes (11 females and 3 males), with ages ranging from 6 to 15 years old. The project was approved by the UFPB Ethics Committee under protocol number 3769100419.

For the ultrasound study, the animals did not need to be sedated, only restrained with the use of a halter, and were also trichotomized in the palmaromedial region of the third metacarpal bone in both thoracic limbs. We used only one operator and a single Sonoscape S2V ultrasound device coupled to a 7 MHz linear probe with ultrasound gel, and in B mode the first image of the median artery was taken with the position of the transducer in longitudinal section, aiming to obtain its location and measurement.

The measurement of the arterial diameter was performed from a curled image in longitudinal section followed by a manual tracing extending from the external part of the wall to the internal part of the other vascular extremity. In the same two-dimensional image, new measurements were performed in two other distinct points of the vessel, obtaining a mean diameter between the three measurements to calculate the mean flow. (Figure 1).

Subsequently, the color Doppler mode or color flow mapping was activated, in which the frequency shift is shown as a spectrum of one or two colors within an area defined as a color box. In longitudinal section, the cursor was manually positioned in the central region of the vessel to capture the region of highest flow velocity, forming a 60-degree angle between the long axis of the vessel and the transducer sound beam. Automatic measurements of the Sonoscape software model S2V were performed with a

cursor positioned at the peak of a spectral wave and a second cursor at the beginning of the next peak to obtain the pulsatility and resistivity index parameters (PI and RI). (Figure 2).

After determining the Doppler velocimetric measurements, the results were submitted to descriptive analysis to obtain the mean, median and standard deviation. Then the Kolmogorov-Smirnov normality test was applied to verify the normal distribution of results found between groups. For all analyses, a significance level of 5% was adopted (VIEIRA, 2016). The data were analyzed in SPSS (version 25). Initially, the trend of data distribution was checked to decide which would be the most representative form.

3 RESULTS AND DISCUSSION

The Kolmogorov-Smirnov test indicated that the RI has a high probability of not having a parametric distribution ($p < 0.001$, Asymmetry = -0.492 and kurtosis = -1.625). Thus, considering that there are data that can be non-parametric, the median was adopted in addition to the mean and standard deviation. In addition, we also estimated the 95% confidence interval, which is presented numerically.

The ultrasonographic evaluations of the median artery in adult horses are shown in table 2. In the B mode, the mean and standard deviation of the median artery diameter was 0.509 ± 0.133, with the 95% confidence interval ranging from 0.457 to 0.561. In the Doppler mode, the PI presented a mean and standard deviation of 2.198 ± 1.451, with the 95% confidence interval ranging from 1.637 to 2.762. The RI was the only measure that showed no evidence of normal distribution, so we chose to describe the median that showed a value of 0.980.

The vascularization of the equine forelimbs extremities is done through the median artery that originates the medial palmar artery, also described as common palmar digital artery (COCHARD et al., 2000). This artery in turn originates in the lateral and medial portions of the limb, tangent to the metacarpophalangeal joint and the digital palmar artery, lateral and medial respectively, distal to the sesamoid bones (COCHARD et al., 2000). In this case, animals without foot affections, adults, and non-athletes were chosen to measure the Doppler velocity parameters of the median artery since it originates the smaller arteries, besides being easier to locate and measure because it has a large caliber.

Vieira (2016) compared two groups of animals, among them athletes in a resting period and foals never submitted to endurance races or any physical activity. Thus, he

observed that the constant permanence of hemodynamic parameters in both groups demonstrates the non-relationship between the history of physical activity with possible sonographic alterations of the lateral palmar digital artery. Furthermore, he noted similarity between the parameters of both groups. Unlike the age and activity range reported above, we chose to work with non-athletic adult animals, due to the ease and habit of manipulating the limbs, thus avoiding physiological changes caused by stress.

Wongaumnuaykul et al. (2006) compared Doppler data between animals with laminitis and septic pododermatitis with a control group and observed that the PI was significantly lower in animals affected by the disease, due to reduced vascularization. Thus, we chose healthy animals for the study to avoid significant differences in Doppler parameters as reported by Wongamnuaykul et al (2006). It is worth noting that the authors state that they have no knowledge of using Doppler ultrasound in digital arteries with animals with spontaneously occurring or induced laminitis and septic pododermatitis.

The PI and RI values reported by Wongamnuaykul et al. (2006) of the palmar digital artery in control horses were 1.93 ± 0.227 and 0.69 ± 0.022, respectively. In our study the values were PI 2.198 ± 1.451 and RI 0.980 (median).

Probably the discrepancy in data is due to the vessel chosen for measurement since the median artery has a large caliber and consequently has a greater pulsatility compared to the palmar digital artery.

The endothelium of the vessels is influenced by the sympathetic stimulation to which they were subjected. Therefore, the diameter of the peripheral arteries of horses sedated by acepromazine was described by Hoffman et al. (1999) with a subjective increase, while the diameter was shown to be smaller when xylazine was applied. Otherwise, Finding et al. (FINDING et al., 2012) considered that arterial vasodilation in horses was much more subject to the interferences of the cardiac cycle than to the role imposed by the sympathetic component of the autonomic nervous system. Therefore, it was decided not to use anesthetics to avoid interference of vasoactive effects caused by sedatives on the diameter of the artery, since it was possible to perform the ultrasonographic study with only the halter and lunge restraint to determine the feasibility and usefulness of the method.

To obtain quality Doppler ultrasound images, it is necessary that the operator be familiar with the technique and be able to properly adjust and explore the functions of the equipment (COCHARD et al., 2000). The most used indices are the resistance index and the pulsatility index. These parameters are more widely used than absolute velocity

measurements because they are independent of the insonation angle and less subject to error. Changes in these indices can aid in identifying changes in vascular resistance (CARVALHO et al., 2008).

Vieira (2016) reports that the coefficient of variance of blood flow and the index of lateral variation of the digital artery lower velocity in animals move less velocity during blood flow move less velocity of lateral flow if move less velocity of lateral flow they move less speed of the flow of moving animals. The remaining uses of a temperature-controlled environment to carry out inspections can considerably conform to significant flow parameters. In our study, there was no significant difference in the values of the resistivity index between the calmer and more agitated animals.

The relationship of feeding, limb positioning, body weight and foot disorders on the hemodynamic aspects of the blood flow of the palmar digital arteries, such as the pulsativity and resistivity index, flow velocity and vessel diameter, using ultrasound Doppler in horses have been investigated (HOFFMANN et al., 2010). The same is true for the case of the treatment media, as it is based on recent studies in veterinary medicine.

4 CONCLUSION

It is concluded that the reference values for normality of median artery vascularization determined with a confidence interval of 95% were in B-mode 0.509 ± 0.133 for the median artery diameter and in the Doppler mode 2.198 ± 1.451 for the pulsatility index and 0.734 ± 0.734 ± 0.906 of the resistivity index (non-parametric data). However, more studies need to be developed to attest to the reliability of these values, in addition, they can help in the early diagnosis, improving the prognosis of these animals prone to laminitis and other foot diseases. Although Doppler ultrasound is considered a complementary method in veterinary medicine, it should be used in association with two-dimensional images, other complementary exams and the clinical signs presented by the patient.

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ANNEXES

Table 1. Distribution of the data of evaluated doppler velocimetry parameters

Teste de Kolmogorov-Smirnov			
	Modo B	**IR**	**IP**
Estatística do teste	0,105	0,304	0,148
Significância Sig. (bilateral)	0,200	<0,001	0,120
Assimetria	-0,226	-0,492	1,043
Curtose	-0,443	-1,625	0,631

Table 2. Description of the data of evaluated doppler velocimetry parameters

	Modo B	**IR***	**IP**
Mediana	0,495	0,980	1,840
Média	0,509	0,811	2,198
Desvio padrão	0,133	0,222	1,451
IC 95%	0,457 – 0,561	0,734 – 0,906	1,637 – 2,762

Note: *Non-parametric distribution

Figure 1. Arterial diameter in B mode with three markings (proximal, median and distal)

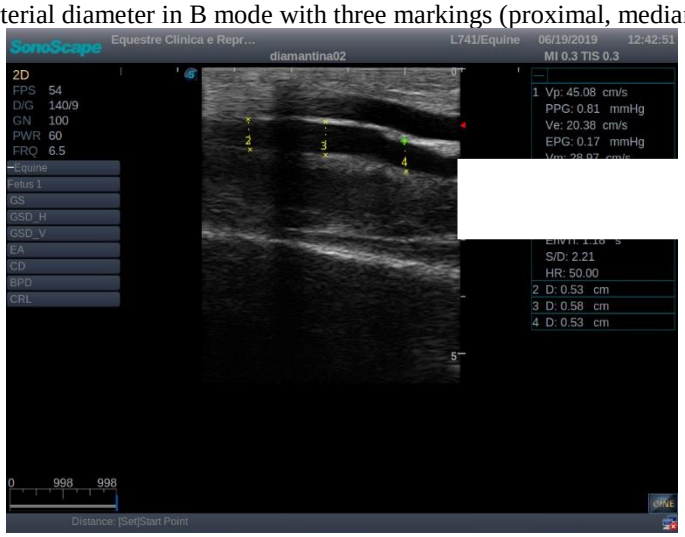

Figure 2. Automatics measurements performed in Doppler color mode.