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Blood Pressure Evaluation in Dogs by the Method Doppler and Oscillometric

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Abstract

Blood pressure is currently a very important tool for clinical and veterinary surgery, especially in monitoring patients under anesthesia and in emergency situations. Hypertension can cause a number of changes in the body of dogs and cats, especially those who are middle-aged and elderly. In veterinary medicine, the blood pressure can be measured non-invasively and invasively. The non-invasive, or indirect technique, is frequently used during routine examinations since it presents convenience as it can be carried out quickly, although it is less accurate. For this research 245 dogs were selected, with one to ten years of age, of both sexes, castrated and uncastrated of different breeds and body scores. The dogs were weighed and had the body condition score determined using the system of 9 points, being categorized into: Control group, overweight group or obese group. Systolic blood pressure was obtained by non-invasive method using the Doppler flowmeter and the oscillometric method. 48 animals were excluded due to the high variability of values, with systolic blood pressure greater than 160 mm·Hg, as well as uncooperative and/or aggressive patients. There was agreement between both methods in 197 dogs conscious and asymptomatic and, therefore, this study showed that oscillometric method can be used in normotensive patients as the study was conducted in patients of different sizes, breeds, ages, body scores and sexual status.

Keywords

Canine, Hypertension, Corporal Score, Invasive Pressure

1. Introduction

The measurement of blood pressure is an important parameter used in monitoring anesthetized patients and emergency [1] [2] [3]. Systemic hypertension (SH) is defined as a persistent elevation of blood pressure, which over time can cause serious medical problems in middle-aged and old dogs and cats. Alteration in the target organs is the main reason for the assessment of blood pressure and to investigate for probable causes. In addition, recognizing the importance of hypertension in veterinary clinical practice has been of great importance in understanding the pathogenesis of many diseases in dogs and cats [4]. Hypertension can be classified into primary hypertension/essential which is the persistent elevation of blood pressure without clinical or biochemical evidence of renal or endocrine abnormalities. Secondary hypertension occurs when there is a known cause, usually a process that changes renal function or neurohormonal (hyperadrenocorticism, hypothyroidism, hyperthyroidism, chronic kidney disease, pheochromocytoma, aldosteronism and diabetes mellitus), whether a disease or administration of certain drugs [5] [6].

In addition to diseases, arterial blood pressure is also influenced by different variables, such as age, breed, sex, temperament, anxiety and stress, especially during the appointment ("white coat syndrome"), pain, physical activity and, in a lesser degree, the animal's diet [3] [4] [5].

Determining the blood pressure (BP) of the patient is one of the most effective methods to monitor its response to anesthetic interventions and shock, and provides data on its overall condition. In veterinary medicine, the BP is measured non-invasively (indirectly) or invasive (directly). Both methods have advantages and limitations. Despite of the fact that the direct methods offer greater precision in the results, the indirect measurement techniques are more applicable, because they are simpler and require less restraint [7]. The indirect method is preferably used in veterinary clinical routine because of its practicality and ability to be repeated between short intervals of time [8]. However, indirect methods are less accurate when blood pressure is low, when there is vasoconstriction or when the animal is moving excessively [9].

The technical error, related to lack of operator experience, is the main cause of inaccurate results obtained by non-invasive methods. To obtain reliable results, the operator must be familiar with the method and apparatus, master the technique, know how to choose the right cuff for each animal and especially, be very patient and able to handle the animals [4].

Noninvasive methods for measuring BP are the oscillometric method and the Doppler vascular [4] [5] [7]. The PetMap® is an oscillometric veterinarian model that is easy to use and repeatability [10]. In veterinary medicine, hypertension is still in the early stages of diagnosis and understanding, since, in practice, determination of blood pressure is not a part of clinical routine and there is a need to use practical and accurate methods.

The objectives of this study were to evaluate the blood pressure in the asymp-

tomatic and aware dog population using the Dopller ultrasonic method and the oscillometric (PetMap®).

2. Material and Methods

The dogs used in this study were routine patients at the private clinic Espaço Vida Veterinária, in Londrina (Parana State) and the Veterinary Hospital of the State University of Northern Parana—*Campus* LuizMeneghel (UENP-CLM). All owners signed the free and informed consent form authorizing the collection of materials and use of data in publications. In addition, the project (number 2335) was approved by the Ethics Committee in the use of animals from the State University Northern Parana on October 10th, 2011.

There were selected 245 dogs, aged one to ten years, of both sexes, castrated and uncastrated of different breeds and body scores, from January 2012 to March 2015. The dogs were weighed and had the body condition score (BCS) determined using the BCS system of 9 points proposed by [11] categorized into control group (ECC 4-5/9), overweight group (ECC 6-7/9) or group obese (ECC 8-9/9).

The exclusion criteria of the study were patients with endocrine (diabetes mellitus, hyperadrenocorticism, hypothyroidism), heart, liver and kidney diseases. There were also excluded the dogs that were being treated with systemic or topical glucocorticoids, anticonvulsants, hypo or hyperglycemic drugs and hypotensive drugs such as furosemide, inhibitors of angiotensin converting, pimobendan and amlodipine. In order to eliminate hyperadrenocorticism, a suppression test with low-dose of dexamethasone (2 trials) as described by [12] was conducted. To eliminate hypothyroidism a thyroid function test including the total thyroxine (TT4), free thyroxine (FT4) and canine thyroid stimulating hormone (CTSH) was performed. Clinical examination as well as blood count, urinalysis and serum biochemical profile were used to rule the heart, kidney and liver disease. The results of blood count, urinalysis and serum biochemical profile were within the reference range. Patients who had alterations in these exams were excluded.

Systolic blood pressure was obtained by the non-invasive method using the Doppler flowmeter (Doppler Vascular DV 610, Medmega Industry Medical Equipment), as described by Henik *et al*. (2005) and the oscillometric method (PetMap®, Ramsey Medical Inc. Tampa, FL, USA).

Cuffs were used to measure the blood pressure, and their selection was made according to the diameter of the right forelimb (40% of the circumference member). For better accuracy and reliability, the most suitable cuff was placed on the forelimb in the distal radius portion, not exceeding the dotted lines indicated in the cuff itself. After placing the cuff, the dogs were positioned so that there was no weight bearing on the limb where the cuff was positioned, remaining at rest in a peaceful and quiet room for about 10 minutes, accompanied by the owner. The patient restraint was performed by the owner in the most possi-

ble comfortable position, minimizing thus the influence of stress [3] [12]. Firstly, the blood pressure measurement was made by using the oscillometric method and after 5 - 10 minutes the blood pressure measurement was made using ultrasonic Dopller.

Based on ACVIM consensus classification of blood pressure in dogs and cats based on risk for future target-organ damage as minimal (<150), mild (150 - 159), moderate (160 - 179) and severe (≥180), only animals with minimal risk (<150) or mild risk (150 - 159) were included in the study. The hypertension findings were based on average levels of SBP above 150 mm·Hg after five consecutive measurements [4] [12].

In total, 48 animals were excluded due to the high variability of values, with systolic blood pressure greater than 160 mm·Hg, as well as uncooperative or aggressive patients. Systolic blood pressure (SBP) was obtained in five different measurements in a single time by a single operator. The results were averaged and the smallest and largest measurement were discarded [4] [7] [12]. In each evaluation were obtained systolic blood pressure (SBP), diastolic blood pressure (DBP), mean (MBP) in the case of the oscillometric method and only the systolic pressure in the case of Doppler and heart rate of each animal, discarding the first measurement and being the final value of the arithmetic mean of three measurements.

3. Statistical Analysis

To evaluate the correlation between Doppler and oscillometric method, diastolic and systolic the blood pressure of 197 dogs were analyzed by Bland-Altman methodology. To assess whether the differences between the methodologies had some association, we used the Pearson correlation. The hypothesis of bias equal to zero was tested by T test for paired samples with 5% significance.

The animals were classified according to sex, castration, body score and age (young, adults or elderly dogs). Within each group, differences between the pressure measured by the Doppler method and the oscillometric method were evaluated by T-test, $P < 0.05$. Differences between groups with less than 30 dogs were evaluated by paired Wilcoxon test with $P < 0.05$. All analyzes were done in Statistica 10.0.

4. Results

Considering the measurements of systolic pressure, oscillometric method had strong and significant correlation when compared to Doppler ($R = 0.9652$; $P < 0.01$). Note that the main differences between the values of Doppler and oscillometric method were close to zero (P e 0.05), with a bias −0.3909 (**Figure 1**). Thus, the oscillometric method showed good agreement with the Doppler in relation to systolic pressure, with differences ranging between +11.68 mm·Hg and −2.36 mm·Hg in 95% of observations.

Of the measured values of systolic blood pressure, 95.43% showed difference

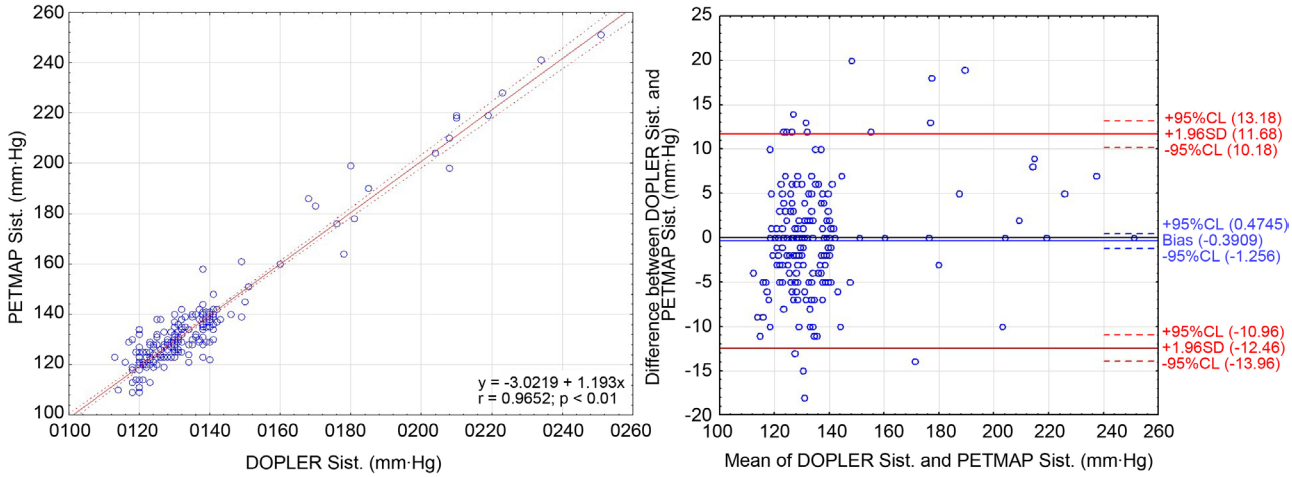

Figure 1. Association and agreement between the Doppler and Petmap method for systolic pressure measurements in 197 dogs.

less than 10%, 4.57% difference between 10% - 20% and none had a difference greater than 20%. As for the measured values of diastolic pressure, 83.25% had difference less than 10%, 15.23% showed differences between 10% - 20% and only 1.52% had a difference greater than 20%.

The good agreement in systolic blood pressure between the methods can also be observed when categorizing the study population. In **Table 1** it can be observed that the average of oscillometric method did not differ when compared to Doppler in any group.

Considering the measures of diastolic pressure, the mean differences between the values of Doppler and oscillometric method were different from zero ($P < 0.05$), with a bias of −2.228, even with strong and significant correlation between them ($R = 0.8937$; $P < 0.01$) (**Figure 2**). In this case, the oscillometric method has tendency to underestimate diastolic blood pressure on average of 2.228 mm·Hg when compared to Doppler. The differences between the methods ranged from +10.80 mm·Hg to −15.26 mm·Hg in 95% of observations. However, when analyzing the distribution of values in the Bland-Altman graphic, we noted that there is homogeneity, with no relationship between differences and mean diastolic blood pressure ($R = 0.1057$, $P = 0.1394$). Thus, even though the measures are not consistent, you can use the diastolic pressure increased oscillometric method bias (2.228 mm·Hg) to better match between methods.

The tendency of oscillometric method present values of diastolic blood pressure when compared to Doppler can also be observed to categorize the population studied. The oscillometric method had lower averages for diastolic pressures in most groups, except for overweight dogs (BCS 6-7), obese (BCS 8-9) and over 8 years of age (**Table 1**). In these groups, there was wide variation in values between individuals (high standard deviation) which may have influenced the lack of difference between the average of the two methods.

5. Discussion

The method considered the gold standard for the measurement of blood pressure

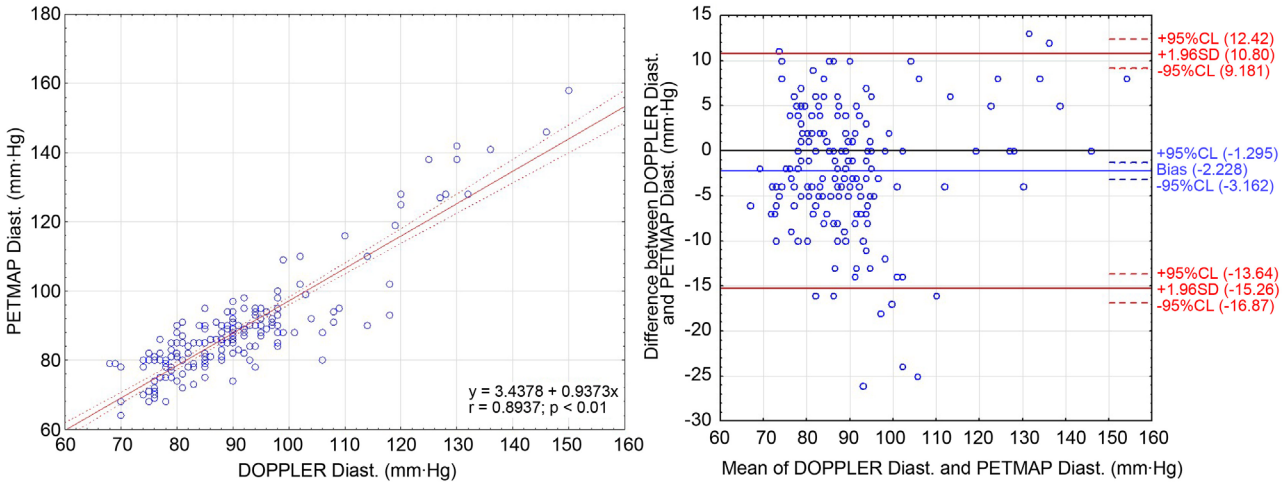

Figure 2. Association and agreement between the Doppler method and PetMap® for diastolic pressure measurements in 197 dogs.

Table 1. Mean and standard deviation (x ± σ) of diastolic and systolic pressures measured by Doppler and Petmap® method in 197 dogs grouped by sex, castration, body score and age.

		Diastolic pressure (mm·Hg)		Systolic pressure (mm·Hg)	
	n	Doppler	Petmap®	Doppler	Petmap®
Male	79	91.78a ± 14.77	89.51b ± 16.20	137.97a ± 23.90	138.01a ± 25.18
Female	118	89.53a ± 13.45	87.33b ± 13.58	135.59a ± 21.14	134.92a ± 22.34
Castrated	86	90.15a ± 15.24	88.71b ± 15.10	137.29a ± 25.14	137.87a ± 26.02
Uncastrated	111	90.65a ± 13.03	87.81b ± 14.41	135.97a ± 19.84	134.83a ± 21.38
BCS 4 - 5	117	88.53a ± 6.86	85.74b ± 6.40	132.19a ± 7.44	131.05a ± 7.85
BCS 6 - 7	56	89.89a ± 17.05	88.29a ± 18.06	135.79a ± 24.97	136.48a ± 26.50
BCS 8 - 9	24	100.96a ± 24.56	100.04a ± 25.96	159.58 ± 42.43	160.29 ± 44.47
Age: ≤ 3 years	39	89.23a ± 12.05	86.69b ± 11.71	133.18a ± 16.40	133.23a ± 19.34
Age: 4 to 7 years	105	90.81a ± 13.48	88.13b ± 14.43	137.47a ± 23.36	136.73a ± 24.58
Age: ≥8 years	53	90.57a ± 16.37	89.45a ± 17.11	137.21a ± 23.85	137.17a ± 24.35
Total	197	90.43a ± 14.00	88.20b ± 14.69	136.55a ± 22.26	136.16a ± 23.51

a, b: Means followed by the same letter did not differ in the t test with 5% significance.

is the invasive method, however, in conscious animals is not possible to accomplish it. In addition, values obtained in anaesthetized or sedated animals should not be considered in conscious patients [4].

The ultrasonic Doppler is an indirect method and applicable, practical and acceptable for measuring blood pressure in asymptomatic and conscious dogs to a clinical environment [4] [13] [14], and it was chosen in this study to compare compliance with the oscillometric monitor portable oscillometric method. The Doppler method is more accurate for measuring systolic pressure versus diastolic [4] [8] and shown that the systolic pressure is important to evaluate the tissue damage associated with hypertension [12] [15].

Correlation was observed between the two methods used to bias −0.3909 and

2.228 for systolic and diastolic blood pressure, respectively. And there was agreement with the criteria established by ACVIM [4] [12], where 50% of the measurements must show variation of up to 10mmHg and 80% of the measurements must show variation of up to 10mmHg. Similar results were obtained in conscious dogs [4] [13] [16] [17] [18] and anesthetized [18] [19]. Normotensive anesthetized dogs and the placement oscillometric method monitor cuff in forelimb had more accurate results, showing better performance for the readings of systolic and diastolic blood pressure, with 81.4% and 61.2% of the readings, respectively, with difference <10 mm·Hg between the invasive method, being clinically acceptable. These values are higher than those observed in this study.

There was good agreement of the ultrasonic Doppler with oscillometric method in normotensive and hypotensive anesthetized dogs, but this did not occur in hypertensive [20], corroborating our results. But these results cannot be extrapolated to conscious dogs. Comparative work is required between these two methods in hypertensive conscious dogs.

The good agreement in systolic blood pressure between the methods can be observed in this study; it is possible to observe that the mean oscillometric method did not differ when compared to Doppler in either group (**Table 1**). The values of diastolic blood pressure (DBP) and systolic (SBP) by the ultrasonic Doppler and the oscillometric method were similar to those reported in other studies [3] [8] [13] [16] [17] [18] [21]. But values using the oscillometric method were superior to those described by Tebaldi *et al.* [22]. Differences in the positioning and technical objectives of the studies and the inclusion and exclusion criteria, probably influenced the results.

According to reference [4] arterial blood pressure values in normal dogs are being studied often, however, the wide variation between them is a reflection of the differences among populations, the measurement techniques and handling of animals. This range of values emphasizes the importance of standardizing the arterial blood pressure measurement techniques in veterinary practice.

In this study, the dogs were placed at random, according to the most comfortable recumbent for the dog. The animal must be restrained in a comfortable position, preferably in the prone or side to limit the distance from the base of the heart toward the cuff [4] [12] The dog's position, at the time of measurement significantly influenced the systolic and mean, being lower in the lateral decubitus when compared to ventral [22].

This study showed that oscillometric method can be used in normotensive patients because the study was conducted in patients of different sizes, breeds, ages, body scores and sexual status. Although there was no statistical difference between the two methods in the measurement of DBP in different groups, the variations between the methods are likely to have little clinical significance. For both groups the healthy values similar to those described previously [4] [10] [19].

There was agreement between the oscillometric method and the ultrasonic

Doppler in 197 dogs conscious and asymptomatic. The oscilometry tested met all the guidelines set by ACVIM to validate a device for blood pressure measurement. Therefore, the model tested and not the method can be used to measure blood pressure in normotensive patients.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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