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A Comparison of Ultrasonic Doppler and Oscillometric Methods in Systemic Blood Pressure Measurement of Dogs

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Abstract : The present study compared two indirect blood pressure methods at thoracic limb, pelvic limb, and coccygeal sites. For measurement of blood pressure, 48 client-owned dogs in a clinical setting were used. When comparing the results obtained by doppler and oscillometric methods, there were significant differences in blood pressure of the thoracic and pelvic limbs. The Doppler machine produced significantly higher blood pressure value than oscillometry measured at thoracic and pelvic limbs. The difference in blood pressure between the two methods was not significant when measured in the tail. Comparison of blood pressure measured at three different sites by doppler, blood pressure measured at pelvic limb was higher than at thoracic limb and tail. In case of oscillometry, there were no significant differences between the three sites. The results of this study indicate that mechanical and positional differences were existed in blood pressure measurements at the canine thoracic limb, pelvic limb and tail.

Key words **:** Blood pressure, oscillometic method, Doppler sphygmomanometry, dog.

Introduction

Systemic blood pressure measurement is an important tool for diagnosis, treatment and prognosis of veterinary patients (1,3). Reliable measurement of blood pressure in veterinary patients would be a valuable clinical tool (6). Abnormalities in systemic blood pressure have been associated with a variety of diseases in veterinary medicine. Systemic hypotension can lead to tissue ischemia and injury during anesthesia, as well as loss of extracellular fluid volume. Hypertension is associated with underlying diseases, such as hyperadrenocorticism, kidney disease, hypothyroidism, diabetes mellitus, and idiopathic form (11,14,21). Systemic hypertension can result in blindness, cardiovascular and neurologic complication, and renal injury in dogs (8,22).

Blood pressure can be measured in several ways. Noninvasive (Indirect) and invasive (Direct) blood pressure measurements both have advantages and disadvantages (2,11,15). Invasive blood pressure measurements (direct), which measure by an intra-arterial catheter connected to a fluid-filled pressure transducer system, are generally considered the gold standard of blood pressure measurements (2,4,15), However, the potential for infection and risk from anesthesia prevent its use in the clinical practice. Indirect blood pressure measurement methods are more widely used in clinical situations than direct blood pressure measurements (7). Doppler and oscillometric methods are commonly used in veterinary medicine to obtain indirect measurements. Oscillometric devices use variations in amplitude of oscillations during compression of the arterial wall to estimate arterial pressure. Another commonly used method is the ultrasonic doppler flow detector, which detects blood flow during external compression by an inflatable cuff.

Several studies have evaluated indirect blood pressure measurements in dogs. However, most have used anesthetized animals to compare between direct and indirect measurements (9,17,18,19), which is not indicative settings in the clinical practice. A few studies have addressed this issue by comparing indirect methods in a clinical setting (10,12,20).

The purpose of this study was to evaluate the oscillometric and doppler methods for systemic blood pressure measurements in dogs in a clinical setting. In addition, we evaluated the differences in blood pressure measurements obtained from three different sites commonly used in veterinary medicine.

Materials and Methods

Animals

Forty-eight client-owned dogs at the Gyeongsang National University Veterinary Hospital were enrolled in this study. All 48 dogs were measured by the doppler method; however, only 27 dogs were measured using the oscillometic method. For both methods, we obtained systolic blood pressure at three different sites. Dogs on medication known to impact blood pressure were excluded, as well as, anxious or excited dogs (i.e.. non-cooperative patients).

Measurement of systolic blood pressure

An ultrasonic doppler flow detector (Model 812, Parks Medical Electronics Inc., USA) or an oscillometric device (Model 9401, Cardell Inc., USA) with an inflatable cuff

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detector (Welch Allyn, NY, USA) were used to measure systolic blood pressure. The doppler flow probe was placed in the palmar of the thoracic limb (median artery), plantar of the pelvic limb (metatarsal arteries), and tail (coccygeal artery). An aqueous ultrasonic transmission gel (Eco gel 99, Seung Won Medical Corp., Korea) was applied between the probe and the skin. The occluding cuff was placed proximally to the doppler flow probe. The pressure of the cuff was increased until the flow signal disappeared, then the pressure was gradually decreased. Systolic blood pressure was taken when the first audible signal was detected, and measurements were taken more than 5 times to calculate the average Systolic blood pressure. After 5 min, the oscillometric device was used to automatically measured systolic blood pressure at the 3 sites. For oscillometry readings, a cuff the same size and measuring time was used as those used during the doppler procedure.

Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS version 21.0; SPSS Inc., IBM Corporation, USA) program. Data were expressed as mean ± standard deviation (SD). A one-way ANOVA was used to determine if there was a relationship between different sites. A paired t-test was used to compare the blood pressure values obtained by the 2 indirect blood pressure methods. For all analyses, a value of less than 0.05 ($P < 0.05$) was considered statistically significant.

Results

Baseline characteristics of dogs

This retrospective study examined 48 dogs. Of the 48 dogs, 7 were intact females, 15 were spayed female, 11 were intact males and 15 were castrated males. The breeds represent in this study were varied. The mean age was 7.9 years (standard deviation [SD]; 3.4 years range, of 2-15 years) and the mean body weight was 7.9 kg (SD, 5.2 kg; range, 2-25 kg). The doppler method was able to measure blood pressure in all dogs (100%), while the oscillometric method was only successful in 27/48 dogs (56%).

Comparison of doppler and ocillometric methods

Comparisons of 2 indirect blood pressure measurements at 3 different sites are shown in Table 1. Statistical differences in blood pressure of thoracic limb, Pelvic limb and tail among groups are described in Table 1. There were statistically significant differences in blood pressure of the thoracic and pelvic limbs. The mean ± SD of thoracic limb and pelvic limb blood pressure using the doppler method were 138.4 ± 4.176 mmHg and 148.9 ± 3.959 mmHg, respectively. These values were significantly higher than those obtained by the oscillometric method for the same body sites (127.6 ± 2.902, [P = 0.01] and 133.1 ± 2.708 [P = 0.0021], respectively). The difference in blood pressure between the two methods was not significant when measured in the tail.

Table 1. Blood pressure measurement obtained by doppler and oscillometric method in 3 different sites

	Doppler	Oscillometry
Sites	Mean (± standard deviation)	
Thoracic limb (n = 27)	138.4 ± 4.176	127.6 ± 2.902
Pelvic limb (n = 27)	148.9 ± 3.959*	133.1 ± 2.708**
Tail (n = 17)	133.9 ± 4.338	133.164 ± 2.241

(*p value < 0.05, Pelvic limb versus Thoracic limb in Doppler, and **p value < 0.05, Pelvic limb versus Thoracic limb in Oscillometry).

The comparison of systolic blood pressure measured at three different sites

1. The comparison of blood pressure measured by doppler method at 3 sites.

Results of mean ± SD of blood pressure measures obtained by Doppler method are shown in Table 2. Statistical differences in measures of 3 sites are described in Table 2. The mean pelvic limb blood pressure by the doppler method (149.8 ± 2.766 mmHg) was higher than at the thoracic limb (139.4 ± 3.328 mmHg, P = 0.03) and tail (134.7 ± 2.995 mmHg, P = 0.004) sites. There was no difference between the blood pressure measured in the thoracic limb and tail.

2. The comparison of blood pressure measured by oscillometric method at 3 sites.

Results of mean ± SD of blood pressure measures obtained by oscillometric method are shown in Table 3. Statistical differences in measures of 3 sites are described in Table 3. There were no statistically significant differences between the three sites.

Discussion

Measurement of blood pressure is a valuable clinical tool in veterinary medicine for the identification systemic hypertension (21). There are several ways to measure blood pressure in veterinary medicine. Although direct methods for measuring blood pressure are reliable, the procedures are invasive,

Table 2. Blood pressure measurement obtained at 3 different sites by Doppler method

	Doppler
Sites	Mean (± standard deviation)
Thoracic limb (n = 48)	139.4 ± 3.328
Pelvic limb (n = 48)	149.8 ± 2.766*
Tail (n = 31)	134.7 ± 2.995

(*p value < 0.05, Pelvic limb versus Thoracic limb, and Pelvic limb versus Tail).

Table 3. Blood pressure measurement at 3 different sites by oscillometric device

	Doppler
Sites	Mean (± standard deviation)
Thoracic limb (n = 27)	127.5 ± 2.902
Pelvic limb (n = 27)	133.4 ± 2.733
Tail (n = 17)	133.1 ± 2.241

technically difficult, and have the potential for complications and artifact (4). For this reason, indirect blood pressure methods are preferable. Previous studies have compared indirect and direct methods in anesthetized or sedated patients. There are only few studies comparing blood pressure measurement in the clinical settings (12,20). In this study, blood pressure was measured in the clinic by 2 indirect methods the three mostly widely used sites.

Comparing thoracic limb, pelvic limb and tail site, systolic blood pressure was measured at 3 sites for 5 consecutive times by Doppler and oscillometric method. By the doppler method, blood pressure in the pelvic limb sites was significantly higher than in the thoracic ($P = 0.03$) or tail ($P = 0.004$). Blood pressure values in pelvic limb was approximately 10 mmHg higher than in the fore limb and 15 mmHg higher than in the tail. However, blood pressure levels measured by oscillometric methods were consistent across the three sites. Previous study, showed differences between the thoracic and pelvic limbs (4). Most of previous studies have used anesthesia or sedation. In a conscious patient, blood pressure measurements are technically difficult and have the potential for complications and artifacts. In this study, movement of anxiety of the patient could have altered results. Humans are most uncomfortable when blood pressure is measured in the calf compared with the arm or ankle; this led to higher blood pressure values (16). In this study, blood pressure in the pelvic limb by the doppler method was significantly higher than other sites. This should be noted when measuring blood pressure of conscious patients, as discomfort likely played a role in the elevated values.

The present study examined 48 dogs. Of the 48 dogs, 11 dogs were heavier than 10 kilograms (> 10 kg) and 36 dogs were less than 10 kilograms (< 10 kg). There was no difference in blood pressure between the two weight groups; additionally, there were no differences by sex (i.e., male, female), age (i.e., geriatric, adult), breed (i.e., large, small).

In this study, blood pressure values were only able to measure using the oscillometric machine in 56% of all patients. In contrast, Attempts with doppler machine were successful in all attempts. In previous study, the oscillometric machine did not always require the attempts of obtaining blood pressure (13). They were successful in 52% of attempts of blood pressure measurement by oscillometric machine. Shivering or other movements by conscious patients could interfere with the accuracy of the machine. Blood pressure readings obtained during these instances may result in inaccurate values. Compared with the doppler method, the oscillometric method requires minimal skills and does not rely on operator interpretation. However, measurements of blood pressure were recommended using more than one method to obtain the most accurate results.

Blood pressure measured by the doppler was higher than that measured by the oscillometric method at the pelvic and thoracic limbs ($P = 0.021$ and $P = 0.01$, respectively); there was no difference in the tail measurements. These results are congruent with previous study (12). In one study, systolic blood pressure levels obtained by Doppler method at thoracic limb were approximately 18 mmHg higher than those obtained by the oscillometric method. In this study, blood pressure levels at the pelvic limb obtained by doppler method were approximately 15 mmHg higher than those obtained by the oscillometric method, while the values were 11 mmHg higher in the thoracic limb. Thus, a different reference range should be established for each method when measuring at the thoracic and pelvic limbs, as the oscillometric device may underestimate blood pressure.

There were a number of limitations to this study including the small population size, multiple examiners, the limited number of blood pressure machines, and the comparison between disease groups. For all patients, 2 assistants helped 1 examiner. For precise readings, blood pressure should be measured on 2 separate occasions by 2 or more examiners. In this study, all dogs were measured by two machines. High definition oscillometry, which improves upon the existing ocillometric machine, could reduce the time for blood pressure measurements by the oscillometric method.

The present study reported mechanical and positional differences in blood pressure measurements at the canine thoracic limb, pelvic limb and tail. The oscillometric method could be underestimating the systolic blood pressure measuring at the thoracic and pelvic limbs. The tail produced measurements that were consistent between two methods. In case of monitoring the canine blood pressure regularly, assessment in the tail site of patient is recommended.

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