A Clinical Evalution of Blood Pressure through Non-Invasive Measurement Using the Oscillometric Procedure in Conscious Dogs

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ABSTRACT. The oscillometric procedure was used to measure the heart rate as well as the systolic, mean, and diastolic blood pressures of 152 dogs (102 in the control group, 13 in the group with renal disease, 37 in the group with heart disease) who were brought to Azabu University of Veterinary Teaching Hospital. It was demonstrated that the blood pressure and heart rate of the control group lowered and tended to become stable as the number of measurements increased. No appreciable difference was identified in the measurements of either blood pressure or heart rate in the forelimbs and tail head. With regard to gender, males showed a significantly higher value than females ($p<0.05$). No interaction was identified between age and blood pressure. No difference was identified in the heart rate in all groups. In an investigation of blood pressure in all groups, the renal disease group showed significantly higher values ($p<0.05$) than either the control or the heart disease group in all values of systolic, mean and diastolic pressures. These results indicated that dogs with renal disease can manifest hypertension. — KEY WORDS: blood pressure, canine, hypertension.

Hypertension is a disease which causes a pathologically persistent high pressure within the arteries that damages the internal organs, especially the cerebral blood vessels, the heart, and the kidneys. Moreover, it is considered important as a risk factor in cerebral hemorrhage, heart failure, renal failure, and the like in the field of human medicine.

There are two types of hypertension, namely, essential hypertension and secondary hypertension. The most common cause of secondary hypertension is renal dysfunction [8, 9, 18].

In recent years, there has been an increase in the cases of renal failure in small animals as well as for humans with a high risk of the manifestation of renal hypertension. However, it is extremely important to measure blood pressure accurately at the time of the examination since there are no clear clinical symptoms in hypertension. Since direct measurement of blood pressure is not suitable for repeated use due to its highly invasive nature, this study investigates the use of the simpler oscillometric procedure in small animal practice as a non-invasive means of measuring blood pressure. However, various stresses on the body during measurement of blood pressure have a great effect on blood pressure in small animals. Accordingly, it is often difficult to diagnose hypertension due to inaccurate evaluations of blood pressure.

The objective of our study is to compare blood pressure in clinical cases of renal and heart diseases against blood pressure in normal, control dogs using the oscillometric procedure.

MATERIALS AND METHODS

Patient population: 152 dogs (68 males, 84 females) between 1–17 years of age, weighing between 1.5–50 kg, who were brought to Azabu University of Veterinary Teaching Hospital were examined. These patients were divided as follows: control group—102 cases (42 male, 60 female) with no abnormality diagnosed by physical, blood and serum biochemical examinations; renal disease group—13 cases (8 male, 5 female) who were diagnosed as chronic renal failure due to an increase in serum creatinine (Cr) of 2.0 mg/d*l* or more as well as their clinical symptoms; heart disease group—37 cases (19 male, 18 female) who were diagnosed as heart disease due to an audible heart murmur and an expansion in heart shadow.

Measurement equipment: Equipment (USM-700GTM, UEDA Electronic Works, Ltd.) which operates on the principle of oscillometry was used to measure heart rate as well as the systolic, mean, and diastolic blood pressures.

Measurement sites and procedure: The blood pressure were measured at either the forelimbs or the tail head. The blood pressure cuff selected was approximately 40% of the cuff width of the circumference of the sites to be measured. When measuring blood pressure, a separate room was used apart from the general consulting room to avoid stress to the patient as much as possible. Blood pressures were measured five times at one-minute intervals, with the patient accompanied by its owners.

Number of measurements: The effects of the numbers of measurements on their values was examined in blood pressure and heart rates. Further, the blood pressure of the forelimbs and tail head in 33 dogs selected randomly from the control was compared to examine the effects of measurement sites.

The effects of gender and age: The effects of gender and age on blood pressure values was examined in the control group. Thereafter, the values in the control, heart and renal disease groups were compared to investigate the same effects.

Statistics: For the statistics, a Friedman test was carried

out regarding analysis of the number of measurements followed by a Wilcoxon test. A Speaman rank correlation coefficient test was used for analysis relating to age. The other factors were analyzed using the Mann-Whitney test, and were considered significant at the level of 5%. All values are expressed as a mean ± standard deviation.

RESULTS

Number of measurements: Blood pressures were measured five times at one-minute intervals for the control, and each value and the mean of the five measurements were compared to examine the effect of the number of measurements on blood pressure and heart rate. With each successive measurement, a significant reduction was identified in heart rate as well as the systolic, mean, and diastolic blood pressures ($p < 0.05$). Moreover, the fifth values were the lowest among the five, and a significantly lower value was also shown compared to the mean value of the five measurements ($p < 0.05$) (Fig. 1). In view of this finding, the blood pressure from the fifth measurement was used during the course of our experiment.

Measurement sites and procedure: Although tail head measurements for systolic pressure and heart rate tended to be lower than forelimb measurements, the difference between the two sites was not significant (Fig. 2).

The effects of gender and age: As regards gender, males showed significantly higher values than females for systolic and mean pressures ($p < 0.05$) (Fig. 3). No interaction between age and blood pressure was identified for systolic, mean, or diastolic pressure (Fig. 4).

Comparison of blood pressure and heart rates in the three groups: Systolic pressures were 118.6 ± 18.7 mmHg in the control group, 146.6 ± 35.3 mmHg in the renal disease group, and 113.3 ± 18.1 mmHg in the heart disease group. The renal disease group showed a significantly higher value than the control and the heart disease groups ($p < 0.05$).

However, no significant difference was identified between the control and the heart disease group.

Mean pressures were 93.8 ± 15.8 mmHg in the control group, 117.8 ± 27.4 mmHg in the renal disease group, and 94.6 ± 16.6 mmHg in the heart disease group. The renal disease group showed a significantly higher value than the control and the heart disease group ($p < 0.05$). However, no significant difference was identified between the control and the heart disease group.

Diastolic pressures were 67.4 ± 14.4 mmHg in the control group, 88.8 ± 25.6 mmHg in the renal disease group, and 67.7 ± 14.2 mmHg in the heart disease group. The renal disease group showed a significantly higher value than the control and the heart disease group ($p < 0.05$). However, no significant difference was identified between the control and the heart disease group.

The heart rate was 115.3 ± 24.8 beats/min in the control group, 123.3 ± 27.6 beats/min in the renal disease group, and 116.5 ± 29.6 beats/min in the heart disease group. No significant difference was identified among three groups (Fig. 5).
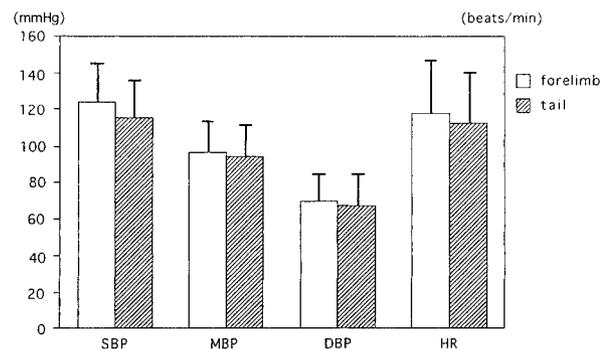
Fig. 2. A comparison between forelimb and tail indirect blood pressure measurements and heart rate in conscious dogs. Each column represents mean ± S.D. from control group. (forelimb: n=33 ; tail: n=33.) The abbreviations as in Fig. 1.
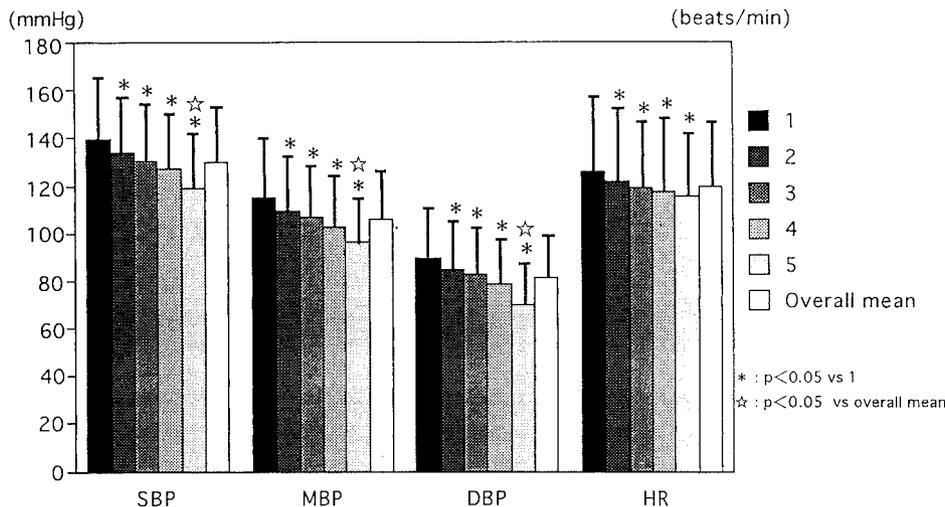

Fig. 1.   The effect of the number of measurements on indirect blood pressure and heart rate in conscious dogs. SBP=systolic blood pressure; MBP=mean blood pressure; DBP=diastolic blood pressure; HR=heart rate. Each column represents mean ± S.D. from control group (n=102).
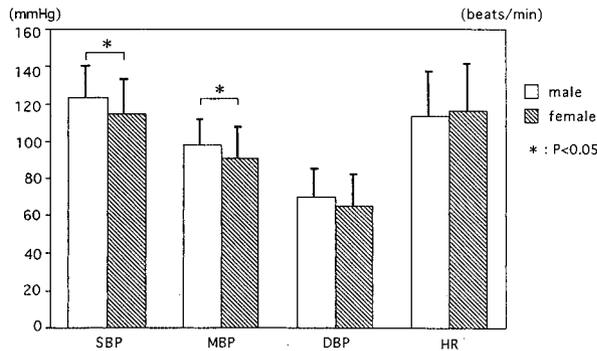
Fig. 3. A comparison in indirect blood pressure measurements and heart rate between male and female dogs. Each column represents mean ± S.D. from control group. (male: n=42; female: n=60.) The abbreviations as in Fig. 1.

DISCUSSION

There are two kinds of procedures for measuring blood pressure-invasive and non-invasive methods. Clinically, non-invasive methods are considered to be the most suitable since they are simple, repeatable, and cause less stress to the patient. It is expected that non-invasive methods have the same accuracy as the invasive if the proper cuff width and measurement sites are selected. However, stress has a great effect on blood pressure due to the circumstances in which clinicians measure blood pressures non-invasively using equipment which is placed on the examining table in small animal practice. Consequently, there are more than a few cases where it is extremely difficult to obtain a measurement of the blood pressure when at rest.

Further, a rise in blood pressure which is identified only in a medical environment in humans even though the normal measurements are usually obtained in the home, i.e. "white coat hypertension", is often noted [12, 13, 21].

In our study, the patient's owner was in attendance and a separate room for measuring blood pressure was prepared apart from the regular examination room. Moreover, the patient's blood pressure was measured non-invasively using the oscillometric procedure under conditions in which environmental stress was reduced to a minimum.

The heart rates and the systolic, mean, and diastolic blood pressures tended to be highest in the first set of measurements. This is thought to be caused by the attachment of measuring equipment. The second through fifth measurements showed a gradual reduction, with the most stable blood pressure obtained on the fifth measurement. Consequently, it is thought that blood pressure must be measured several times before measurement values can be evaluated accurately.

Regarding the measurement sites, tail head measurements for systolic pressure tended to be lower than forelimb measurements. Measurements from the tail head are generally easy, depending on the breed of dog and individual dogs of the same breed. Furthermore, there are also cases
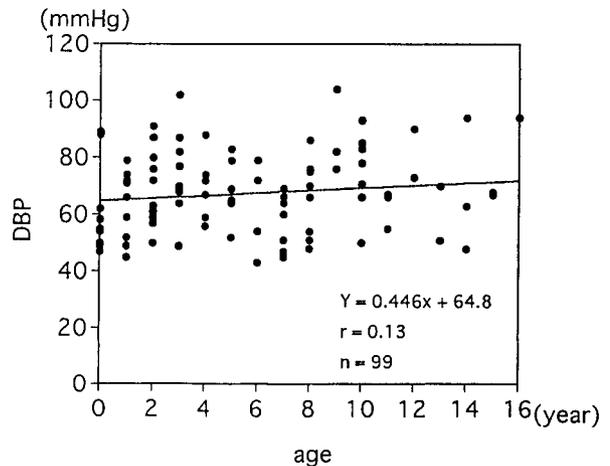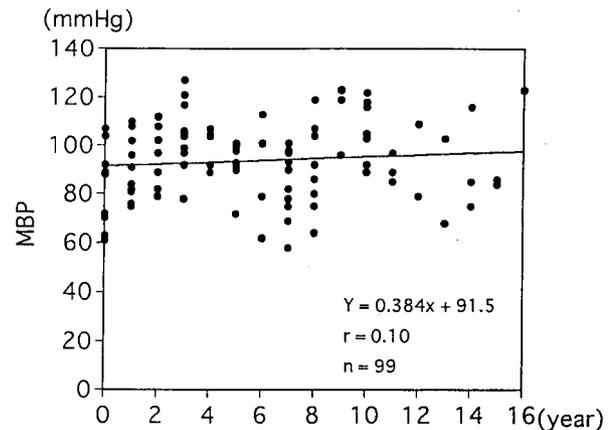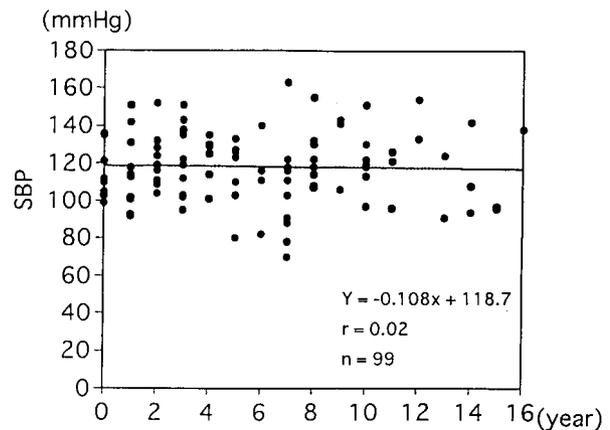

Fig. 4. Correlation between indirect blood pressure measurements and age in control group dogs. (n=99) The abbreviations as in Fig. 1.

where it is impossible to measure at forelimbs. It is thus thought that the best procedure is one which allows the patient to be measured in the most stable condition possible.

The reason why male dogs showed a higher pressure is not clearly understood. However, it is thought that there is a difference in temperament between males and females, and a difference in their sensitivity to stress as well. Bodey and Michell [2] also report similar findings, namely, that it
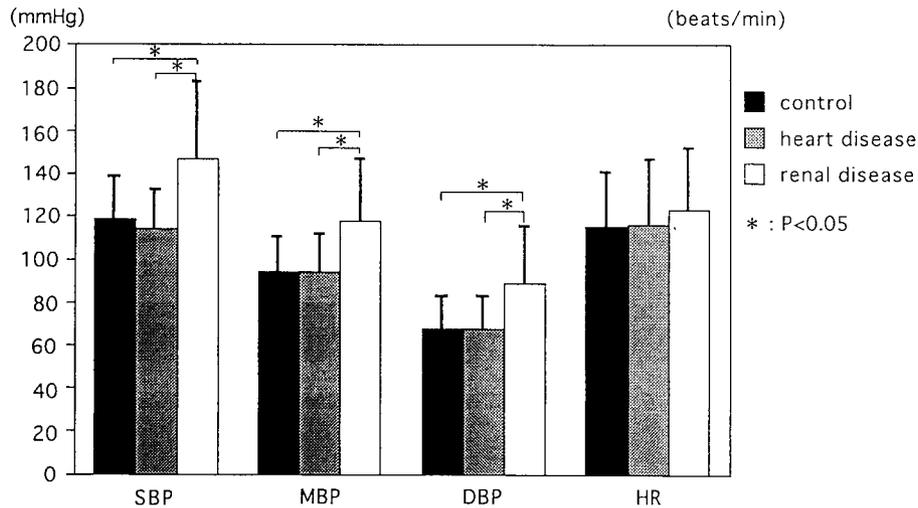
Fig. 5.   A comparison of indirect blood pressure measurements and heart rate among control, heart
disease and renal disease dogs. Each column represents mean ± S.D. from control group. (control :
n=102; heart disease: n=13; renal disease: n=37.) The abbreviations as in Fig. 1.

Table 1.   Reported blood pressure values in normal dogs

Auther	Method	SBP	MBP	DBP	Reference
McCubbin	Direct	not available	111 – 140	not available	9
Cowgill	Direct	148 ± 16	102 ± 9	87 ± 8	4
Harvey	Auscultation	145 ± 25	not available	84 ± 14	5
Weiser	Doppler	130 – 180	not available	60 – 90	23
Remillard	Oscillometric	147 ± 28	104 ± 17	83 ± 15	14
Coulter	Oscillometric	144 ± 27	110 ± 21	91 ± 20	3
Bodey	Oscillometric	131.3 ± 0.6	96.9 ± 0.5	73.8 ± 0.4	2
Mishina	Oscillometric	118.6 ± 18.7	93.8 ± 15.8	67.4 ± 14.4	–

is necessary to consider gender differences in dogs when measuring blood pressure.

It is known that blood pressure increases with age in humans. This is thought to be caused by a reduction in vascular compliance and changes in renal vascular resistance due to a reduction in the amount of renal blood flow with age [16, 22]. No detailed examination has been conducted on dogs, but there are reports that identify a similar tendency [2]. Nevertheless, no interaction between age and blood pressure was confirmed in our study.

There have been various reports on blood pressure in normal dogs. In this study, the blood pressure in the control group, measured using the oscillometric procedure, is lower than what has been reported elsewhere (Table 1). However, it is difficult to make direct comparisons because these reports and our study were carried out with different methods and conditions. These results can only apply to the hospital where the study was conducted. Blood pressure has been overestimated in the past due to problems in the measurement procedures. Therefore, it is considered necessary to establish standard values by using uniform measurement procedures and conditions.

The standard values measured as causal blood pressure for human hypertension are classified according to WHO/ISH recommendations as follows: 140 mmHg or more for the systolic and 90 mmHg or more for diastolic blood pressure [19]. There is a report, however, which sets the standard for canine hypertension at systolic blood pressure of 180 mmHg or more, and diastolic blood pressure of 95 mmHg or more [5], while another report suggests systolic blood pressure of 202 mmHg or more, and diastolic blood pressure of 102 mmHg or more [14]. All works show that the systolic standard values tend to be higher in dogs than in humans. However, our results demonstrate that there is no significant difference in standard blood pressure between humans and dogs.

There are two types of hypertension, namely essential hypertension and secondary hypertension. It is said that 80–90% of human patients with hypertension have essential hypertension, while the remaining 10–20% have secondary hypertension with known causes. The causes of secondary hypertension include renal parenchymal disease, renovascular disease, diabetes, Cushing's syndrome, primary aldosteronism, chromaffinoma, hypothyroidism, and the like.

Renal disease is the most frequent cause of hypertension [8, 9, 18].

On the contrary, essential hypertension is said to be extremely rare although there have only been a few studies on canine hypertension [3, 11, 20]. Further, there are also reports that indicate an interaction between renal disease and hypertension in dogs [1, 4, 17]. It is also reported that dogs with renal disease have higher blood pressure than normal dogs, but there is no clear interaction between decreased renal function and blood pressure [2, 11].

In our study, we investigated the blood pressure and heart rate of the control, the renal disease and the heart disease groups using the oscillometric procedure. The renal disease group showed significantly higher systolic, mean and diastolic pressures than the control and the heart disease groups, although no significant difference was identified in the heart rate among these three groups ($p<0.05$).

With measurements using the oscillometric procedure, it is thought that excitement due to attachment of the measuring equipment may cause variations in blood pressure. It is thus questionable whether values obtained via this procedure offer absolute reliability. Nevertheless, there was a difference of greater than 20 mmHg in the blood pressures of the control and the renal disease groups. These results suggested that higher blood pressure can be manifested in cases of renal disease in dogs.

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