

Non-invasive Blood Pressure Measurements in Cats: Clinical Significance of Hypertension Associated with Chronic Renal Failure

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ABSTRACT. The systolic, mean and diastolic pressures as well as the heart rate were measured using the oscillometric method, on a total of 104 cats (60 cats in the normal group, and 44 in the renal disease group) which were brought into Azabu University Animal Hospital. The blood pressure in the normal group was systolic: 115.4 ± 10.1 mmHg, mean: 96.2 ± 12.2 mmHg, and diastolic: 73.7 ± 10.7 mmHg. Although no difference in heart rate, the renal disease group showed significantly ($p < 0.05$) higher values for systolic, mean, and diastolic pressure when compared with the normal group. Moreover, when plasma renin activity, angiotensin I and II, and aldosterone concentrations were measured in other cats (11 normal and seven with chronic renal failure), all cats with chronic renal failure showed significantly ($p < 0.05$) higher values than the normal group. It is, therefore, indicated that hypertension due to stimulating renin-angiotensin-aldosterone system may have manifested in cats with renal dysfunction. — **KEY WORDS:** blood pressure, feline, hypertension, renin-angiotensin-aldosterone system.

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Hypertension has been recognized as a risk factor in human patients with cerebral hemorrhage, heart and renal diseases, therefore diagnosis of hypertension is carried out by measuring blood pressure on a routine basis.

Although blood pressure measurement is theoretically possible in animals as for humans, the routine measurement of blood pressure to diagnose hypertension is extremely rare. Thus, there has been very little research on hypertension in the field of veterinary medicine. Hypertension per se progresses without displaying any specific clinical symptoms, and there is difficulty in measuring the blood pressure in awake animals.

Hypertension consists of essential and secondary hypertension, and the most common cause of secondary hypertension is considered to be renal parenchymatous disease [6, 9, 15, 17]. In our previous work, a correlation between renal disease and hypertension was identified in dogs using the oscillometric method [12]. In the present study, the blood pressure was measured in clinical cases of cats to identify the normal range as well as the relationship between blood pressure and renal disease.

MATERIALS AND METHODS

A total of 104 cats (57 male, 47 female), each weighing between 1.5 to 7.5 kg and the ages of one to 12 years, which were brought into Azabu University Animal Hospital were subjected to the study. As a result of clinical, blood and serum biochemical examinations, the 60 cases (25 male, 35 female) with no clinical abnormality were classified as the normal group. Moreover, the 44 cases (30 male, 14 female) diagnosed as chronic renal disorder based on clinical symptoms (i.e., loss of vigor, anorexia, polydipsia-polyuria,

vomitus and anemia), and high concentrations (range: 2.1–13.8 mg/dl; mean: 3.9 ± 3.0 mg/dl) of serum creatinine, were classified as the renal disease group.

A sphygmomanometer (USM-700GTM : Ueda Electronic Works, Ltd.), oscillometric method, was used to measure the systolic, mean, diastolic pressures and the heart rate in both groups. The blood pressure measurement sites were either the forelimb or the tail, and a measuring cuff was selected based on the size of approximately 40% circumference of the measuring site. In order to avoid stress to the patients as much as possible, blood pressure was measured in an isolated room apart from the regular consulting room. Moreover, the blood pressure was measured a total of five times at one minute intervals with the owner's presence. The results obtained under the physical movements of the patient were deleted from the values as artifacts.

The effects of the number of measurements on the blood pressure and heart rate were firstly examined in the normal group. To examine the effects of measuring sites on the blood pressure, the blood pressure of both the forelimb and the tail was compared using a total of 24 cats selected randomly from the normal group. The effects of both gender and age on blood pressure were examined in the normal group. Thereafter, these values obtained from both the normal and the renal disease groups were analyzed.

The plasma renin activity, angiotensin I and II, and aldosterone concentrations were measured to by radioimmunoassay compare 11 normal to seven cases with chronic renal dysfunction.

The statistical analysis on the number of measurements were conducted, first using the Friedman method, followed by the Wilcoxon method. The Spearman raking correlation

coefficient was used for analyzing the correlation. The other factors were analyzed using the Mann-Whitney test, $p < 0.05$ was considered significant. All values are expressed as a mean \pm standard deviation.

RESULTS

No significant difference ($p < 0.05$) was identified in systolic, mean, diastolic pressures, or in the heart rate, whereas the values obtained from the fifth measurement were considerably lower. In order to reduce the margin of error in the measurements, the mean of the blood pressure values obtained from all five measurements were used in the following experiments (Table 1).

No significant difference was seen in the blood pressure obtained from the forelimb and the tail (Table 2), and between males and females (Table 3). A significant correlation was, however, identified ($p < 0.05$) between age and mean pressure, and between age and diastolic pressure, although no significant correlation was noted between age and systolic pressure (Fig. 1).

The renal disease group showed significantly ($p < 0.05$) higher values for the systolic, mean, and diastolic pressure when compared with the normal group. However, no significant difference was identified between the normal and the renal disease groups in heart rate (Table 4).

Significantly ($p < 0.05$) higher values for plasma renin activity, angiotensin I and II, and aldosterone concentrations were obtained in the renal disease group as compared with the normal group (Table 5).

DISCUSSION

Methods of measuring blood pressure are categorized as

either invasive, which a catheter or needle is placed into a major artery such as the femoral artery, or non-invasive, which is based on such methods as the Doppler method or on the oscillometry. Correlation in the blood pressure using either invasive or non-invasive methods in anesthetized cats was reported [1, 5, 7]. The techniques per se for measuring blood pressure are thought to be well established, but, since measuring the blood pressure of awake cats is known to be extremely difficult, blood pressure measurements are not taken routinely in the clinic. The problems relating to hypertension complicated with certain diseases and pathological nature of hypertension per se have not been considered with significant importance.

In the present study, to minimize stress an isolated room

Table 1. The effect of the number of measurements on indirect blood pressure and heart rate in conscious cats

	SBP (mmHg)	MBP (mmHg)	DBP (mmHg)	HR (beats/min)
1	115.4 \pm 14.4	96.6 \pm 15.8	74.8 \pm 15.9	155.3 \pm 29.1
2	116.1 \pm 11.5	97.1 \pm 13.0	74.8 \pm 13.5	151.9 \pm 30.0
3	116.4 \pm 15.6	97.8 \pm 16.4	76.3 \pm 15.1	151.2 \pm 32.3
4	116.6 \pm 15.9	98.0 \pm 15.7	75.0 \pm 15.4	153.1 \pm 28.3
5	112.0 \pm 14.2	93.6 \pm 13.8	69.8 \pm 12.9	151.9 \pm 30.8
Overall mean	115.4 \pm 10.1	96.2 \pm 12.2	73.7 \pm 10.7	153.8 \pm 27.2

Values are means \pm SD. SBP=systolic blood pressure; MBP=mean blood pressure; DBP=diastolic blood pressure; HR=heart rate (n=60).

Table 2. A comparison between forelimb and tail indirect blood pressure measurements and heart rate in conscious cats

	SBP (mmHg)	MBP (mmHg)	DBP (mmHg)	HR (beats/min)
limb (n=24)	117.0 \pm 15.6	101.2 \pm 17.5	75.6 \pm 17.0	156.5 \pm 28.4
tail (n=24)	122.5 \pm 22.4	99.6 \pm 19.9	76.0 \pm 19.7	166.8 \pm 27.7

Values are means \pm SD. SBP=systolic blood pressure; MBP=mean blood pressure; DBP=diastolic blood pressure; HR=heart rate.

Table 3. A comparison in indirect blood pressure measurements and heart rate between male and female cats

	SBP (mmHg)	MBP (mmHg)	DBP (mmHg)	HR (beats/min)
male (n=25)	115.3 \pm 11.8	96.6 \pm 14.5	75.5 \pm 11.6	153.0 \pm 25.8
female (n=35)	115.5 \pm 8.9	95.8 \pm 10.5	72.5 \pm 10.1	154.4 \pm 18.6

Values are means \pm SD. SBP=systolic blood pressure; MBP=mean blood pressure; DBP=diastolic blood pressure; HR=heart rate.

for measuring blood pressure with the owner's presence was prepared and measured non-invasively using the oscillometric method. In addition, measurements were taken a total of five times at one minute intervals, and the dispersion of the measurements obtained was minimized as much as possible by taking the mean value of the blood pressure for each individual patient. Although the measuring sites of the blood pressure was of importance, no significant difference could be identified in the values obtained from

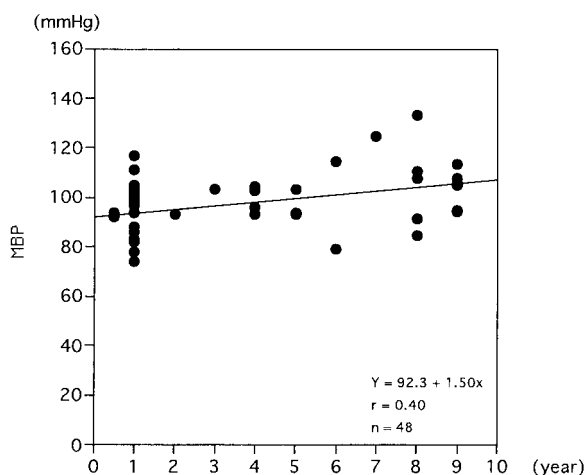


Fig. 1. Correlation between indirect mean blood pressure measurements and ages in normal cats.

the forelimb and the tail. Therefore, it was thought to be most favorable to select the measurement sites where the patient feels more at ease.

In normal dogs, Bodey and Michell [2] and Mishina *et al.* [12] reported that a difference in blood pressure could be observed based on gender. However, in our experiments, no significant difference was observed, suggesting that no consideration is given to gender.

In humans, it is already well known that blood pressure rises concomitant with an increase in age [14]. Bodey and Michell [2] also indicated a correlation between blood pressure and age in dogs. However, Kobayashi *et al.* [8] have reported that no significant difference was identified in 33 normal cats. In our study, there is a possible relationship between blood pressure and age, but it is still needed for further examination.

Reports concerning blood pressure in normal cats are extremely scarce [3, 4, 8]. Also, a major difference can be obtained in the range of "normal values" according to between Gordon and Goldblatt [4] (systolic: 171 ± 22 mmHg, mean: 149 ± 24 mmHg, diastolic: 123 ± 17 mmHg) using invasive method and Kobayashi *et al.* [8] (systolic: 118 ± 11 mmHg, diastolic: 84 ± 12 mmHg) using the Doppler method. Compared with other reports, the oscillometric method conducted in our study showed lower values. It is also possible to achieve these results by minimizing stress to the patient as far as possible, even when the casual blood pressure is measured non-invasively.

Table 4. A comparison of indirect blood pressure measurements and heart rate among normal and renal disease cats

	SBP (mmHg)	MBP (mmHg)	DBP (mmHg)	HR (beats/min)
normal (n=60)	115.4 ± 10.1	96.2 ± 12.2	73.7 ± 10.7	153.8 ± 27.2
renal disease (n=44)	$135.1 \pm 15.4^*$	$115.9 \pm 16.8^*$	$92.3 \pm 14.4^*$	161.6 ± 17.8

Values are means \pm SD. SBP=systolic blood pressure; MBP=mean blood pressure; DBP=diastolic blood pressure; HR=heart rate. (n=60). * Significance in $p < 0.05$ compared with normal.

Table 5. A comparison of plasma renin activity (PRA), angiotensin I (ANG I), angiotensin II (ANG II) and aldosterone (ALD) concentrations among normal and renal disease cats

	PRA (ng/ml/hr)	ANG I (pg/ml)	ANG II (pg/ml)	ALD (ng/dl)
normal (n=11)	1.1 ± 0.5	546.1 ± 262.4	194.5 ± 190.9	4.4 ± 2.5
renal disease (n=7)	$7.9 \pm 5.0^*$	$7584.0 \pm 3021.3^*$	$6782.6 \pm 5484.5^*$	$95.9 \pm 127.1^*$

Values are means \pm SD. PRA=plasma renin activity; ANG I=angiotensin I concentrations; ANG II=angiotensin II concentrations; ALD=aldosterone concentrations. *Significance in $p < 0.05$ compared with normal groups.

In humans, the standard values for hypertension are classified as systolic: 140 mmHg or higher, and diastolic: 90 mmHg or higher as casual blood pressures [18]. On the other hand, there are reports which indicate that the standard values were systolic: 160 mmHg or higher, and diastolic: 100 mmHg or higher, suggesting a tendency whereby the standard systolic pressure in cats is higher than in humans. A simple comparison of the blood pressure between previous and current data is not possible since the measurement methods and conditions used are different. However, if the mean + 2SD in the blood pressure obtained from the normal cats is considered to be the standard value for hypertension in our study, the systolic pressure is 140 mmHg or higher, and the diastolic pressure is 95 mmHg or higher. It is, therefore, considered that the blood pressures reported previously have been excessively over-estimated due to inconsistency in methods.

Hypertension consists of essential and secondary hypertension. In human patients with hypertension, 80 to 90% are essential hypertension and the remainings are secondary hypertension with clear causes. Renal parenchymal disease, renovascular disease, diabetes, Cushing's syndrome, primary aldosteronism, pheochromocytoma and hypothyroidism have all been cited as main causes of secondary hypertension. Hypertension with renal disease (renal hypertension) occurs with the highest frequency [6, 9, 17]. On the other hand, hypertension is related to impaired renal function in cats, although there has been little research into feline hypertension [7, 8, 11, 16]. There are some reports that indicate relationships between hypertension and hyperthyroidism, chronic anemia, and sudden hypertrophic cardiomyopathy [8, 10, 11, 13, 16].

In our study, blood pressure and heart rate were measured on normal and renal disease groups using the oscillometric method. The renal disease group showed significantly ($p < 0.05$) higher systolic, mean, and diastolic pressures when compared with the normal group, although no significant difference could be identified in heart rate. A difference of approximately 20 mmHg in blood pressure was identified between the two. From these results, it is thought that hypertension can be manifested in cases of cats with renal disorder.

It is thought that both an increase in body fluids due to the accumulation of water and potassium and the stimulation of the renin-angiotensin system, are greatly involved with manifestations of renal hypertension [6, 15]. In this study, Cats with chronic renal dysfunction showed clearly higher values in the renin activity, angiotensin I and II, and aldosterone concentrations as compared with the normal cases. From the above, it is indicated that the renin-angiotensin-aldosterone system could be may have renal dysfunction.

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