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ค่าความดันซิสโทลิกในแมวสุขภาพดีเปรียบเทียบระหว่างที่บ้านกับที่โรงพยาบาลสัตว์ โดยใช้คลื่นเสียงความถี่สูงชนิด Doppler

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บทคัดย่อ: การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาความดันซิสโทลิก (systolic blood pressure; SBP) ในแมวสุขภาพดี จำนวน 30 ตัว เปรียบเทียบระหว่างที่บ้านกับที่โรงพยาบาลสัตว์ โดยใช้คลื่นเสียงความถี่สูงชนิด Doppler และเพื่อศึกษาระยะที่เหมาะสมสำหรับพักแมวเมื่อมาถึงโรงพยาบาลสัตว์ก่อนวัดความดันโลหิต แมวทุกตัวถูกวัดความดันโลหิตทั้งหมด 4 ช่วงเวลา ได้แก่ ที่บ้าน (SBP0) ทันทีที่มาถึงโรงพยาบาลสัตว์ (SBP1) 30 นาทีหลังจากที่มาถึงโรงพยาบาลสัตว์ (SBP2) และ 60 นาทีหลังจากที่มาถึงโรงพยาบาลสัตว์ (SBP3) ในการวัดความดันซิสโทลิกแต่ละช่วงเวลา แมวถูกวัดความดันโลหิตจำนวน 3 ครั้ง แต่ละครั้งมีระยะห่าง 1 นาที ผลการศึกษาพบว่า ค่าเฉลี่ยของความดันโลหิต SBP0, SBP1, SBP2 และ SBP3 ได้แก่ 124.31±9.74, 167.61±18.21, 153.07±17.28 และ 136.52±9.11 มิลลิเมตรปรอท ($P<0.05$) ตามลำดับ นอกจากนี้ยังพบค่าความแตกต่างของ SBP1, SBP2 และ SBP3 จาก SBP0 คิดเป็นร้อยละ 34.83, 23.14 และ 9.82 ($P<0.001$) ตามลำดับ โดยสรุป การวัดความดันโลหิตในแมวสุขภาพดีไม่ควรทำทันทีที่แมวเดินทางถึงโรงพยาบาลสัตว์ เนื่องจากความดันซิสโทลิกสูงกว่าความดันพื้นฐานที่วัดได้ขณะอยู่ที่บ้านมากกว่าร้อยละ 30 การวัดความดันโลหิตในแมวสุขภาพดีควรทำในสถานที่เงียบสงบ และไม่มีสิ่งรบกวนเมื่อแมวเดินทางถึงโรงพยาบาลแล้วอย่างน้อย 60 นาที เพื่อลดผลกระทบจาก white coat effect ที่ส่งผลให้ความดันโลหิตสูงขึ้นชั่วขณะ ซึ่งอาจทำให้เกิดการวินิจฉัยที่คลาดเคลื่อนกับภาวะความดันโลหิตสูงที่แท้จริง

คำสำคัญ: แมว ความดันซิสโทลิก white coat effect

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Comparative Systolic Blood Pressures in Healthy Cats Measured at Home and Different Times at a Veterinary Hospital using Doppler Ultrasonograph

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Abstract: The purposes of the present study were to investigate the systolic blood pressure (SBP) of 30 healthy cats between at home and at hospital using Doppler ultrasonography at a veterinary hospital in Thailand, and to validate the appropriate resting period prior to re-measuring blood pressure. All the cats were measured for SBP at home (SBP0), then immediately upon arrival at the hospital (SBP1), 30 min after arrival (SBP2), and 60 min after arrival (SBP3). Each of measurements was triplicated at one-minute interval. The results revealed that mean SBP0, SBP1, SBP2, and SBP3 of the cats were 124.31±9.74, 167.61±18.21, 153.07±17.28, and 136.52±9.11 mmHg ($P<0.05$), respectively. In addition, the differences of SBP1, SBP2, and SBP3 from SBP0 were 34.83%, 23.14%, and 9.82% ($P<0.001$), respectively. In summary, blood pressure measurement in healthy cats should not be conducted abruptly upon arrival at the hospital since the SBP was > 30% higher than blood pressure at home. Therefore, SBP measurement at the hospital should be performed at least one hour after arrival in silent and private places to minimize the white coat effect, a situational hypertension, which may result in a misdiagnosis of true hypertension.

Keywords: Cat, Systolic blood pressure, White coat effect

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Introduction

In the recent past, feline hypertension was commonly diagnosed in veterinary practice, due to increased availability of blood pressure (BP) measurement devices in feline clinics. The causes of feline systemic hypertension can be primary, which is mostly idiopathic (Glaus et al., 2019), or be related to underlying diseases (secondary hypertension), such as hyperthyroidism (Kobayashi et al., 1990), chronic kidney disease (Kobayashi et al., 1990; Syme et al., 2002), and pheochromocytoma (Wimpole et al., 2010). According to the guidelines of the American College of Veterinary Internal

Medicine, the degrees of systemic hypertension in cats are classified based on the risk of target organ damage into normotension (systolic blood pressure; SBP < 140 mmHg), prehypertension (SBP 140–159 mmHg), hypertension (SBP 160–179 mmHg), and severe hypertension (SBP ≥ 180 mmHg). In general, treatment for hypertension is indicated by the presence of target organ damage (Acierno et al., 2020), such as choroidopathy or retinopathy (Maggio et al., 2000; Sansom et al., 2004), left ventricular hypertrophy (Chetboul et al., 2003; Nelson et al., 2002), and encephalopathy (Brown et al., 2005).

BP measurement can be done with either invasive direct or non-invasive indirect methods. The gold standard method is an invasive direct measurement; however, it requires intra-arterial catheterization, accompanied by anesthesia or sedation. As a result, an invasive direct BP measurement is mainly used in research or more appropriately for critical or intra-operative patients who have already been sedated. (Belew et al., 1999; Brown et al., 1997). For non-invasive indirect methods, BP can be measured by oscillometry (Bodey and Sansom, 1998; Mishina et al., 1998) or Doppler ultrasonography methods (Bijsmans et al., 2015; Kobayashi et al., 1990; Lin et al., 2006; Sparkes et al., 1999). A number of previous studies demonstrated that non-invasive indirect methods are acceptable for clinical aspect and more commonly used to measure BP of the cats than a direct method (Binns et al., 1995; Bodey et al., 1996; Haberman et al., 2004; Klevans et al., 1979; Pedersen et al., 2002; Sparkes et al., 1999) which is difficult to conduct in the clinics (Sansom et al., 2004). The previous study found that BP values from doppler ultrasonography are more accurate than those from oscillometry when compared to direct methods (Haberman et al., 2004). However, the lack of automatic functions and difficult measurement of diastolic pressure are still a disadvantage of doppler ultrasonography methods.

BP measurement in cats can be challenging due to the feline stress, anxiety, or fractious behavior often seen during hospital visits. Nervousness or stress during the BP measurement can cause increased BP which can contribute to a misdiagnosis of true hypertension (Belew et al., 1999). That phenomenon is known as the “white coat” effect, which is characterized by an increase in BP of patients visiting clinics or hospitals. Subsequently, the BP keeps declining toward a normal value (Pickering et al., 2002). This effect is exerted by the responses from both central and autonomic nervous systems to stress, resulting from anxiety travelling to the hospital. This stimulates the cardiovascular system which subsequently contributes to higher BP (Brown et al., 2007).

At present, some studies have confirmed the white coat effect in cats (Belew et al., 1999; Quimby et al., 2011). Nonetheless, information on the decrease in SBP related to a resting period of the cats affected by white coat effect has been very scant, especially in Thailand. Accordingly, the present study aimed to

investigate the white coat effect in healthy cats visiting a veterinary hospital in Thailand and the alteration patterns of feline SBP at home compared to different times after arriving at the veterinary hospital.

Materials and methods

Animals and inclusion criteria

The present study was conducted at a veterinary teaching hospital in central Thailand. The cats of random sex and breed visiting the outpatient department of the veterinary teaching hospital were the target population of this study. All of the cats were clinically assessed on the basis of detailed physical examinations, including mucus membrane color, capillary refill time, hydration status, heart rate, and respiratory rate. All physical examinations were performed by one veterinarian throughout the study. In addition, the previous treatment history of each cat was taken into the consideration. The inclusion criteria were healthy cats without any obvious systemic diseases after complete physical examinations. Finally, 30 healthy cats aged 1–5 years old with 2.5–5.0 kg and body condition score of 2.0–4.0 were included to the study. All of the animal interventions in the present study were approved by the Institutional Animal Care and Use Committee, Mahasarakham University *(*IACUC-MSU*)*, Thailand *(*Approval no. IACUC-MSU-003*/* 2020*)*.

Measurement of systolic blood pressure

Each of the cats was measured for SBP with Doppler ultrasonography (Parks Medical Electronics Inc., Oregon, USA) in the quiet room at home (SBP0) and three consecutive times: immediately after arrival at the hospital (SBP1), 30 min after arrival (SBP2), and 60 min after arrival (SBP3) by the same veterinarian who conducted the physical examinations. Each measurement was triplicated at one-minute interval. During the measurement, all cats were restrained by their owners in the position of the right lateral recumbency; SBPs were measured at the median metacarpal area of the left forelimb. The cuff size was 30–40% of the left forelimb circumference (Brown et al., 2007) as demonstrated in Figure 2. All procedures were carried out only in the morning period between 09.00 and 12.00 hours. Once SBP had been measured at home, each cat was placed in an individual cage in the owner's car in which temperature was maintained at 25°C and transported to the hospital within 30 min.

Statistical analyses

All data were manipulated and analyzed statistically with SPSS version 17.0. SBP was measured at four different times (SBP0, SBP1, SBP2, and SBP3) and reported as mean±SD. The normality of data was tested using Kolmogorov-Smirnov Test and the data were found normally distributed. The homogeneity of variance was examined using Levene's test for equality of variances and found that the variances of SBP measured for different four times were not homogenous; one-way ANOVA was applied, together with the Brown-Forsythe Test. Moreover, the comparisons between each group

of SBP (SBP0 vs SBP1, SBP0 vs SBP2, SBP0 vs SBP3, SBP1 vs SBP2, SBP1 vs SBP3, and SBP2 vs SBP3) were analyzed using the Dunnett T3 method. Values with P<0.05 were considered statistically significant.

Results

According to the measurements of SBP using Doppler ultrasonography, mean SBP0, SBP1, SBP2, and SBP3 were 124.31±9.74, 167.61±18.21, 153.07±17.28, and 136.52±9.11 mmHg, respectively, as shown in Figure 1. The lowest mean SBP of the cats was SBP0 (124.31±9.74 mmHg), meanwhile the highest mean SBP was SBP1 (167.61±18.21 mmHg). Moreover, mean SBPs of four different times were significantly different from one another (P<0.001).

The differences of SBP measured at each time are shown in Table 1. Providing SBP0 as a base SBP, the largest deviation was found immediately after the cats arrived at the hospital (34.83%, P<0.001), whereas the least deviation from SBP0 was found when the cats had been held in a peaceful environment at the hospital for 60 min (9.82%, P<0.001).

Discussion

The measurement of BP in cats should be carefully conducted because the high BP may be either from white coat effect or true hypertension. In feline clinics, BP measurement is rather difficult for practitioners since the cats may be so anxious that the measurement is not accomplished. For this reason, BP measurement in cats at hospitals or clinics requires the cat owners to be accompanied with their cats in order to reduce stress from visiting hospital and staying with unfamiliar animals. In this study, mean SBP at home of the cats was approximately 125 mmHg. This corresponded with previous studies reporting that normal SBPs in cats measured with the Doppler method were 118±11 (Kobayashi et al., 1990), 134±16 (Lin et al., 2006),

Table 1 Paired comparisons of systolic blood pressure (SBP) (mean±SEM) of 30 healthy cats measured at home (SBP0), immediately after arrival at the hospital (SBP1), 30 min after arrival (SBP2), and 60 min after arrival (SBP3).

SBP comparison	Difference		Significance level
	mean±SEM (mmHg)	Percentage (%)	
SBP0 vs SBP1	+ 43.30±3.77	+ 34.83	P<0.001
SBP0 vs SBP2	+ 28.76±3.62	+ 23.14	P<0.001
SBP0 vs SBP3	+ 12.21±2.43	+ 9.82	P<0.001
SBP1 vs SBP2	- 14.54±4.58	- 8.68	P=0.014
SBP1 vs SBP3	- 31.09±3.72	- 18.55	P<0.001
SBP2 vs SBP3	- 16.55±3.57	- 10.81	P<0.001

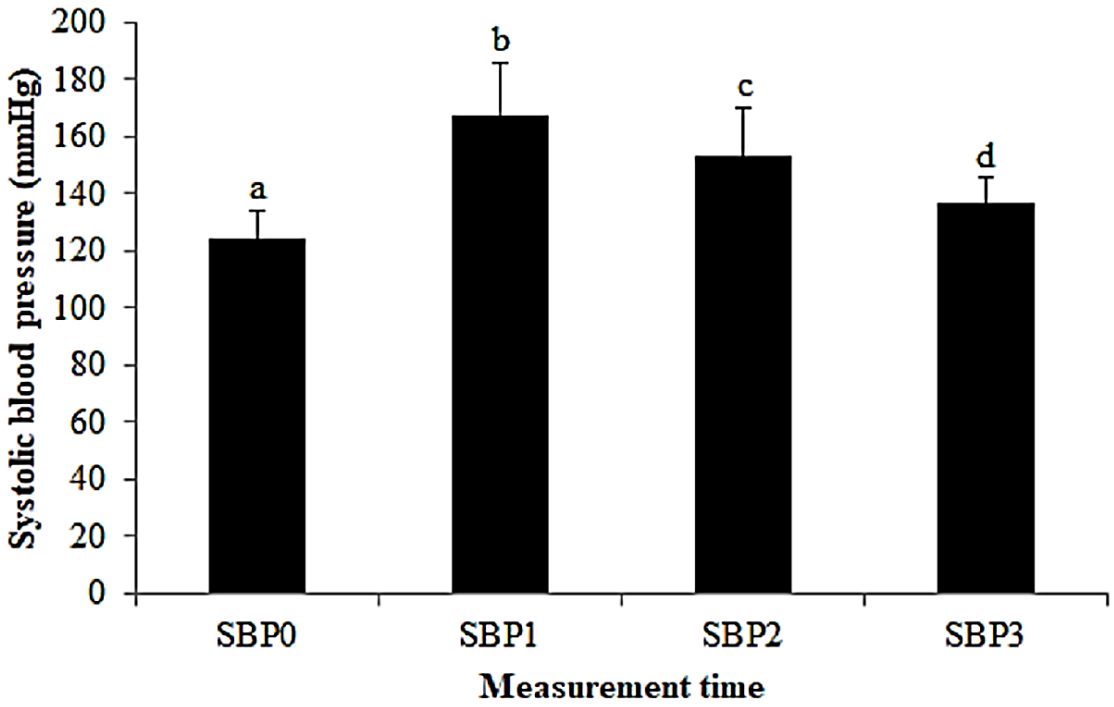

Figure 1 Systolic blood pressures (mean±SD) of 30 healthy cats measured at home (SBP0), immediately after arrival at the hospital (SBP1), 30 min after arrival (SBP2), and 60 min after arrival (SBP3). [a, b, c, d] Different letters indicate statistical significance ($P<0.05$).

Figure 2 Blood pressure measurement using a Doppler ultrasonography in a healthy cat.

and 120.6 mmHg (Payne et al., 2017) Moreover, mean SBP taken at home in the current study was also similar to that measured with the direct method using intra-arterial radiotelemetric implants (126.0±4.4 mmHg) (Belew et al., 1999). Immediately after arriving at the veterinary teaching hospital, mean SBP of the cats was approximately 35% higher than SBP at home. After the cat rested in a quiet area at the hospital for 60 minutes, SBP was approximately 10% higher than SBP at home. Our results demonstrated an obvious white coat effect in healthy cats visiting a veterinary teaching hospital, as the result showed that all the SBPs measured from three different periods of time at the hospital were significantly higher than the SBP measured at home. The results from this study corresponded with previous studies in terms of nervous conditions affecting the cat's BP, resulting in the white coat effect (Belew et al., 1999; Bright and Dentino, 2002; Quimby et al., 2011). Based on the results from this study, we recommended that the measurement of BP in cats be taken at least 60 min after arrival at hospitals or clinics and be performed in a quiet and private environment in order to minimize the white coat effect. Likewise, a previous study in humans suggested that patients rest in a placid room prior to being measured for BP. In addition, the measurement in cats should be conducted three consecutive times at one-minute interval. However, the appropriate resting time for humans was suggested at five minutes after arriving at the hospital (Mancia et al., 2013).

If BP measurement in cats was taken immediately on arrival at the hospital or clinic, the white coat effect might result in a misdiagnosis for systemic hypertension. Afterwards, the cats may be mistreated with antihypertensive drugs due to a false hypertension measurement. As a result, cats should rest for some periods of time to prior to being measured for BP in order to reduce the white coat effect. Based on resting period, BP of healthy cats is suggested to be carefully measured and considered in association with the arrival time at hospitals or clinics in order to acquire values closest to the base SBP of the cats, and to prevent a misdiagnosis of feline hypertension.

Conclusion

BP of the healthy cats should be carefully measured and individually performed in a quiet place in order to minimize the white coat effect. Moreover, it is recommended that the healthy cats be rested for at least one hour prior to the measurement so as to acquire the closest value of base SBP. In addition, BP values examined at the hospital should be carefully considered proportional to the arrival time in order to avoid a misdiagnosis of feline hypertension.

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