



Prevalence of persistent hypertension and situational hypertension in a population of elderly cats in The Netherlands

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Marieke Knies^{1,2} , Hans S Kooistra² and Erik Teske²

Abstract

Objectives Systemic arterial hypertension is increasingly recognised and can have serious adverse consequences in cats. Unfortunately, the act of measuring blood pressure itself may cause an increase in blood pressure, known as situational hypertension. It is currently unknown how often this phenomenon occurs. The aim of this study was to evaluate the prevalence of persistent hypertension and situational hypertension in an elderly population of cats in a first-opinion clinic and to assess which factors were associated with systolic hypertension.

Methods In this prospective study, systolic blood pressure was measured in 185 cats aged ≥ 10 years using the Doppler sphygmomanometry method according to the recommendations of the American College of Veterinary Internal Medicine consensus statement. Age, sex, body weight, body condition score, position during blood pressure measurement and apparent stress level were assessed. If a systolic blood pressure >160 mmHg was found, measurements were repeated to evaluate if persistent hypertension or situational hypertension was present. The first set of blood pressure measurements were used for all the statistical analyses.

Results The median systolic blood pressure for this population was 140 mmHg. The prevalence of persistent hypertension was at least 14.6% and situational hypertension at least 5.4%. Factors significantly associated with hypertension were age, higher apparent stress levels and a sitting position during measurement. Sex, body weight or body condition score did not significantly influence systolic blood pressure.

Conclusions and relevance Both persistent hypertension and situational hypertension are common in elderly cats. There are no reliable parameters to distinguish between the two, underlining the importance of a standard protocol and repeating measurements during a follow-up visit when hypertension is found. Age, demeanour and body position during blood pressure measurement influenced blood pressure in this population of elderly cats.

Keywords: blood pressure; blood pressure measurement; white coat hypertension; screening; Doppler

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Introduction

In cats, advancing age increases the risk of several, mostly chronic, diseases, including systemic arterial hypertension.^{1–8} Systemic arterial hypertension (henceforth referred to as hypertension) is defined as a persistent elevation from normal arterial blood pressure. Hypertension can be classified as idiopathic hypertension and secondary hypertension, for example, due to chronic kidney disease and hyperaldosteronism.²

Sustained increases in blood pressure may cause tissue injury, so-called ‘target organ damage’ (TOD) in certain organs, such as the eyes, brain, kidneys and myocardium.^{1–4,8–11} In veterinary medicine, mainly systolic blood pressure (SBP) is determined, in contrast to

human medicine, where hypertension is divided into the presence of isolated or combined systolic and diastolic hypertension.^{1–3} Various studies have reported different values for SBP in normal cats, because of differences in

¹AniCura Clinic Drechtstreek, Dordrecht, The Netherlands

²Department of Clinical Sciences, Faculty of Veterinary Medicine, Utrecht University, Utrecht, The Netherlands

Corresponding author:

Marieke Knies DVM, MANZCVS (Feline), EMSAVM (Internal Medicine), AniCura Diergeneeskundig Verwijscentrum Dordrecht, Jan Valsterweg 26, Dordrecht, 3315 LG, The Netherlands
Email: marieke.knies@anicura.nl



study populations, measurement techniques and animal handling. In young, healthy cats, studies using direct radio telemetric blood pressure monitoring devices have reported normal SBP of approximately 125 mmHg. There is a slight age-related increase in SBP in cats, as there is in humans.^{1,2,4,8–10} Interpreting SBP in cats can be complicated because of the presence of situational hypertension, an increased SBP that occurs in situations of stress or excitement, such as a visit to the veterinary clinic.^{1–3,8,12,13}

The most common methods for SBP measurement in cats are indirect techniques, such as Doppler sphygmomanometry, high definition oscillometry and oscillometry. Ideally, SBP should be measured using devices that have been validated for use in cats. However, to date, no device has met the human standard for validation of indirect SBP measurements. Doppler sphygmomanometry and high definition oscillometry are more reliable than standard oscillometry, providing the machines are properly used.^{1,2,7,14–21}

The objectives of the present study were to investigate the prevalence of hypertension in a population of elderly cats (aged ≥ 10 years) using the Doppler method, to investigate the prevalence of situational hypertension and to assess factors associated with the variation in SBP.

Materials and methods

Study population

This prospective study was performed between December 2015 and December 2017 at Anicura Clinic Drechtstreek in Dordrecht, and 185 client-owned cats were included. Clients of the clinic were actively recruited through letter, email and/or leaflet, if they owned a cat aged ≥ 10 years and were willing to participate in a study on the measurement of blood pressure. All owners provided informed consent. Data collected included date of birth (if known), sex, neuter status and breed. Cats were excluded if the SBP measurement proved impossible due to the temperament of the cat.

Procedure

All cats were examined in the same, quiet, feline-only consultation room. Besides the owner, one veterinary nurse and the observer (MK) were present. Cats were allowed a minimum 5 mins acclimation period. Hereafter, cats underwent indirect SBP measurement, performed using a standardised procedure following the American College of Veterinary Internal Medicine (ACVIM) consensus statement.² SBP was measured using the Doppler ultrasonic technique with a Parks Doppler unit (Model 811-B Doppler Ultrasonic Flow Detector, Parks Medical Electronics). All procedures were performed by a single observer (MK) who had >5 years of experience using Doppler sphygmomanometry. Sedation was not used in any cat.

Blood pressure cuff size was chosen so that the cuff width was 30%–40% of the circumference of the limb at the cuff location. The default limb used was the right forelimb. If this was not possible, the left limb or tail was used. The cat was loosely held by its owner. If the owner was not willing or able to hold the cat, a veterinary nurse would hold the cat. The cats could choose the position that was comfortable for them on the table. After placing the cuff, it was gently filled once, to acclimatise the cat. The hair over the first palmar common digital artery was moistened with a cotton pad dampened with water; next, ultrasound gel was applied. None of the cats had the hair on their leg clipped. The probe was placed over the region of the artery. The machine was then turned on, the area of the strongest signal was located and measurements were made. Headphones were used to avoid startling the cats. During the measurements, the outliers were discarded, and measurements were repeated until at least five measurements within 10% of each other remained. Throughout the assessment, the cuff was kept as close as possible to the level of the right atrium.

Cuff size, cuff position, position of the cat (sitting, standing, lateral recumbency or sternal recumbency), blood pressure measurements and subjective assessment of the level of stress during the measurements were recorded (Table 1). The different categories for the assessment of stress were based on the ISFM guidelines¹ and are defined in Table 1. A mean blood pressure was calculated from five consecutive measurements after excluding any outliers ($>10\%$ variance or obvious downward trend).

Normotension was defined as SBP <140 mmHg, prehypertension as SBP 141–160 mmHg, hypertension as SBP 161–180 mmHg, and severe hypertension as SBP ≥ 180 mmHg according to the ACVIM 2018 consensus statement.² When SBP was >160 mmHg, owners were invited to return for another SBP measurement, in general 7–21 days later. In cats where multiple blood pressure measurements were performed on different days, the mean value of the first set of measurements was used for statistical analysis. If the SBP was still >160 mmHg on the second visit or if there was blindness in combination with bilateral mydriasis, hyphaema and/or vitreal haemorrhage, persistent hypertension was assumed. If SBP was <160 mmHg on the second visit, the cat was categorised as having situational hypertension.

A standard physical examination was performed in almost all cats, including body weight, evaluation of body condition score (BCS) on a 9-point scale, based on the Purina scale,²³ respiratory rate (RR), heart rate (HR) and auscultation of heart and lungs. The owners were asked about their opinion of the visual acuity of their cat. If there was any doubt about the vision of the cat or if there were signs of mydriasis, hyphaema or vitreal haemorrhage, the cat's vision was tested by performing a visually guided paw placement test, pupillary light reflex, menace response and palpebral reflex.

Table 1 Assessment of cat demeanour during blood pressure measurement (modified from Payne et al²²)

Value	Subjective assessment of stress	Description
1	No stress	Relaxed during the procedure, looking around, body position relaxed, ears forward, slow eye blinks, encourages head rubs, purring and/or kneading
2	Cooperative but slightly anxious	Generally calm and still looking around, but some signs of nervousness (such as crouched position, tail tucked between legs)
3	Moderately nervous	More signs of nervousness, sometimes trying to pull paw back or trying to hide (under blanket or into owner). Position tense/crouched. Head rubs not appreciated and avoided
4	Very nervous	Trying to hide (under blanket or into owner), crouched position, shivering, avoiding eye contact, ears sideways and downwards, tail between legs or swishing
5	Aggressive	Hissing, growling, trying to bite and/or swipe with claws

Statistical analysis

The statistical analysis was performed using SPSS version 26 (IBM). The normality of continuous data was assessed using the Shapiro–Wilk test, ZED values and Q-Q plots. Univariate analysis was performed with the Mann–Whitney U-test or Kruskal–Wallis as appropriate to compare continuous non-normally distributed data. Correlations were determined using Spearman's

rank correlation coefficients. $P < 0.05$ was considered significant.

Results

Study population

A total of 215 blood pressure measurements were performed in 185 cats between December 2015 and December 2017. In a proportion of cats, SBP was measured two ($n = 27$) or three times ($n = 1$).

The populations consisted of 98 females (all neutered), 84 males (83 neutered and one intact) and three cats in which sex was not recorded. Most ($n = 139$) were domestic shorthair cats, 43 were pure breeds (eight British Shorthair, five Maine Coon, six Russian Blue, five Persian, four Norwegian Forest Cat, three Abyssinian, three Siamese, three Birman, two Eastern Shorthair and one Bengal, Somali, Tonkinese and Turkish Van, respectively). Three cats were of unknown breed.

The cats were divided into two age categories: senior (10–14 years, 122 cats) and super senior (≥ 15 years, 50 cats). In 13 cats, the exact date of birth was unknown. Age, body weight and BCS are presented in Table 2.

Blood pressure measurement

All cats required cuff size 3 (3.3 cm). In 97.8% ($n = 181$) of cats, the right forelimb was used for the blood pressure measurement; in one cat, the left forelimb was used because the right forelimb was missing; and in three cats, the tail was used because the cats did not tolerate touching of the forelimbs.

Most cats ($n = 88$, 47.6%) seemed to prefer a sitting position for the measurement of SBP. The cats were in sternal recumbency in 22.2% ($n = 41$), standing up in 2.2% ($n = 4$) or in lateral recumbency in 1.1% ($n = 2$). In 27.0% of measurements ($n = 50$), the position of the cat was not recorded.

The majority of cats were assessed as being reasonably calm (categories 1 + 2) (43.2%) during SBP measurement, with 13.5% ($n = 25$) of cats estimated to have no stress ('1') and 29.7% ($n = 55$) to be cooperative but slightly anxious

Table 2 Age, body weight, body condition score (BCS), systolic blood pressure (SBP), respiratory rate, heart rate and stress assessment in a population of 185 elderly cats

Parameter	Number	Mean \pm SD	Median	Range
Age (years, months)	172	13 years 6 months	13 years 2 months	10 years 0 months to 20 years 0 months
Body weight (kg)	184	4.30 \pm 1.18	4.08	1.78–8.50
BCS (scale of 1–9)	168	5 \pm 1.12	5	2–9
SBP (mmHg)	185	146 \pm 31.2	140	90–254
Respiratory rate (breaths/min)	178	36 \pm 10.6	32	18–90
Heart rate (beats/min)	180	179 \pm 26.6	180	120–260
Stress assessment (scale of 1–5)	177	2.6 \pm 1.0	3	1–5

('2'). Of the cats, 33% ($n = 61$) were classified as being moderately nervous and 16.8% ($n = 31$) as being very nervous. A small number of cats ($n = 5$, 2.7%) showed signs of aggression. In 8 (4.3%) of the cats, the assessment of stress was not recorded.

The median SBP for the population was 140 mmHg (range 90–254 mmHg). In total, there were 89 (48.1%) cats with normotension and 46 (24.9%) cats with prehypertension. A high SBP (mean SBP >160 mmHg) was found in 50 (27.0%) cats. This was divided over 20 (10.8%) cats with hypertension and 30 (16.2%) cats with severe hypertension (Figure 1).

Situational hypertension was concluded to be present when after the first SBP measurement of >160 mmHg, a repeated SBP measurement of <160 mmHg on a separate occasion was found. Situational hypertension was diagnosed in 10 cats (5.4% of the total population, 20% of the population in which an SBP >160 mmHg was found). In 13 cats, it was unknown whether the high SBP found was due to persistent hypertension because they were lost to follow-up. In three of these cats, situational hypertension was suspected because they were very aggressive during the procedure.

In 27 of the cats with an SBP >160 mmHg (14.6% of the total population, 54.9% of the population of cats with an SBP >160 mmHg), the hypertension was considered persistent because of the presence of obvious blindness ascribed to TOD (8/27) or hypertension measured on two occasions (19/27) (Tables 3 and 4).

The median SBP of cats with blindness ascribed to TOD was significantly higher than the median SBP of cats with situational hypertension (Table 3). None of the cats with obvious blindness had an SBP <182 mmHg. Furthermore, there was a significant difference between the median SBP of cats with persistent hypertension (SBP >160 mmHg on two occasions) and cats with blindness ascribed to TOD. No significant difference was found between the median SBP of cats with true hypertension and cats with situational hypertension (Figure 2).

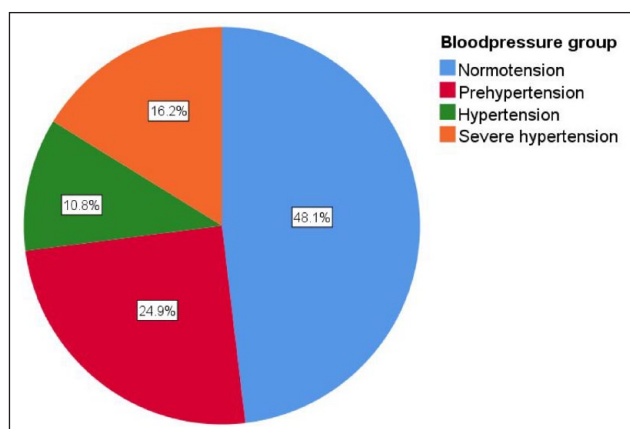


Figure 1 Distribution of blood pressure in 185 elderly cats

Table 3 Classification of hypertension in 50 elderly cats with a systolic blood pressure (SBP) >160 mmHg

	Total number	Median SBP (mmHg) on first visit	Range in SBP (mmHg)
Multiple readings >160 mmHg	19	185	161–214
Cats with blindness (target organ damage)	8	209	182–254
Situational hypertension	10	177	163–214
Suspected situational hypertension	3	164	161–235
Unknown	10	167	161–202

Table 4 Median systolic blood pressure (SBP) during the first and second visits for cats with persistent hypertension

Cat number	Median SBP (mmHg) at first visit	Median SBP (mmHg) at second visit
1	177	161
2	235	196
3	182	176
4	193	175
5	177	175
6	184	188
7	181	187
8	211	198
9	178	184
10	177	214
11	204	184
12	185	183
13	181	180
14	176	167
15	185	206
16	204	185
17	195	163
18	203	200
19	185	171

The median difference between the mean SBP of the first and second sets of measurements was -39 mmHg. The cat with the biggest difference in SBP (70 mmHg) at the first and second measurements had an SBP of 214 mmHg on the first occasion and 144 mmHg on the second occasion 7 days later. The cat with the smallest difference in SBP had a difference of 3 mmHg (163 mmHg and 160 mmHg) (Table 5).

No significant difference was found between the mean respiratory rate ($P = 0.44$), mean heart rate ($P = 0.22$) or mean stress assessment level ($P = 0.26$) of cats with persistent hypertension and cats with situational hypertension.

The median SBP (150 mmHg, range 90–254 mmHg) in the super senior cats was significantly higher ($P = 0.021$) than in the senior cats (137 mmHg, range 96–235 mmHg).

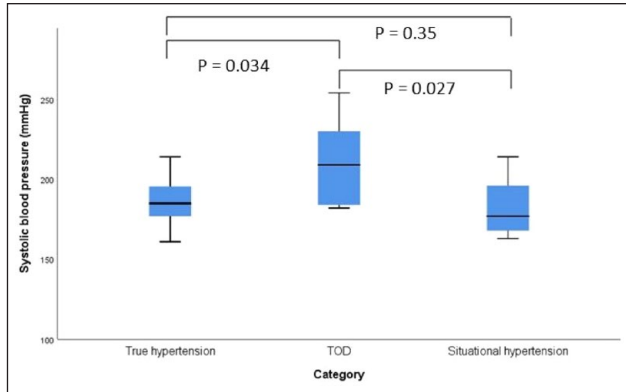


Figure 2 Box-and-whisker plots for elderly cats with systolic blood pressure >160 mmHg, grouped by category. The bottom and top of the box are the first and third quartiles, the band within the box is the median. The whiskers correspond to the lowest and highest value

Table 5 Median systolic blood pressure (SBP) during the first and second visits for cats with situational hypertension

Cat number	Median SBP (mmHg) at first visit	Median SBP (mmHg) at second visit	Median SBP (mmHg) at third visit
1	177	169	155
2	168	140	
3	182	158	
4	214	144	
5	188	138	
6	163	160	
7	165	108	
8	172	151	
9	196	145	
10	203	150	

A significant (weak) correlation was found between age and blood pressure (Spearman's rank test, $\rho = 0.27$, $P < 0.001$). In the senior group, there were 27 (22.1%) cats with an SBP >160 mmHg. In the super senior group, a higher ($P = 0.017$) percentage of cats ($n = 20$, 40%) had an SBP >160 mmHg. In the senior group, 10 cats had an SBP repeatedly >160 mmHg and four cats presented with blindness due to TOD. Eight cats had proven situational hypertension and in five cats it was unknown whether their hypertension was persistent because they were lost to follow-up. In the super senior group, there were eight cats with an SBP repeatedly >160 mmHg and four cats with blindness due to TOD. Two cats had a proven situational hypertension and in six cats it was unknown whether their hypertension was persistent because they were lost to follow-up. There was no significant difference between the prevalence of situational hypertension in the senior versus super senior cats ($P = 0.15$), nor was

Table 6 Median systolic blood pressure (SBP) for different body conditions scores, position of the cat and stress assessment

	Total number of cats	Median SBP (mmHg)	Range
BCS			
Underweight (BCS ≤ 4)	45	144	104–235
Ideal weight (BCS = 5)	84	138	90–254
Overweight (BCS ≥ 6)	39	137	102–211
Position			
Sitting	88	142	102–234
Sternal recumbency	41	129	90–235
Stress assessment			
1 = No stress	25	123	90–193
2 = Cooperative but slightly anxious	55	132	90–254
3 = Moderately nervous	61	141	102–214
4 = Very nervous	31	151	110–203
5 = Aggressive	5	161	149–235

a significant difference found between the prevalence of blindness assumed to be due to TOD in the senior versus super senior cats ($P = 0.64$).

Sex, body weight or BCS (Table 6) did not significantly influence SBP. SBP was significantly affected by the position of the cat. Cats that were sitting during the SBP measurement had a significantly higher SBP ($P = 0.003$) compared with cats that were in sternal recumbency (Table 6).

There was a significant correlation found between SBP and assessed stress levels ($\rho = 0.31$, $P < 0.001$). SBP was significantly influenced by the assessed levels of stress ($P = 0.001$) (Table 6). Cats that were thought to have 'no stress' had a significantly lower SBP than cats that were 'cooperative but slightly anxious' ($P = 0.028$), 'moderately nervous' ($P = 0.003$), 'very nervous' ($P = 0.001$) or 'aggressive' ($P = 0.004$). Furthermore, cats that were deemed to be 'cooperative but slightly anxious' had a significantly lower SBP than cats that were 'very nervous' ($P = 0.018$) or cats that were 'aggressive' ($P = 0.016$). No significant difference was found in SBP between the cats in groups 2 and 3, 3 and 4, 3 and 5 or 4 and 5.

No significant difference ($P = 0.24$) was found in the level of perceived stress between cats with situational hypertension and cats with true hypertension (cats with repeated SBP >160 mmHg or cats with blindness assumed to be due to TOD).

Physical examination

There was a significant (but weak) correlation between heart rate and perceived stress level ($\rho = 0.18$, $P = 0.018$). No correlation was found between respiratory rate and perceived stress level or respiratory rate and heart rate.

A heart murmur was found in 43 (24.4%) cats. Cats with a heart murmur had a significantly higher SBP (154 mmHg) compared with the whole population (140 mmHg) ($P = 0.005$). The prevalence of SBP >160 mmHg in cats with a heart murmur (48.8%) was significantly higher ($P < 0.001$) than in the cats without a heart murmur (18.0%).

Discussion

The median SBP in this population of elderly cats was 140 mmHg, which is higher than that reported in a number of previous studies but similar to some others; in one of these studies by Paepe et al,⁶ cats were aged >10 years, as in our study.^{10,12,21,22,24} In our study, as in most studies, an association was found between increasing age and increase in SBP, as cats in the super senior group had a significantly higher SBP compared with the senior group.^{6,9,21,22,25,26} This correlation between age and SBP is also found in people^{27–29} and dogs.³⁰

The overall prevalence of cats with an SBP >160 mmHg was 27%, and if only super senior cats were evaluated, this number rose to 40%. These numbers are (much) higher than in the study by Paepe et al,⁶ where the overall prevalence was 8%. The prevalence of persistent hypertension in our total cohort of cats was at least 14.6%, which is still higher than the results of Paepe et al.⁶ The prevalence might be even higher because 10 of the cats where an SBP >160 mmHg was found were lost to follow-up. The median SBP of cats with blindness assumed to be due to TOD was higher than the median SBP of cats with situational hypertension. None of the cats with obvious blindness had an SBP <182 mmHg. However, smaller ocular TOD might have been present and unnoticed in the other cats, since retinal examination was not performed routinely.

No influence of sex, BCS or body weight was found on SBP. In people and dogs, males have higher SBP than females.^{27,30} In cats, some studies found a higher SBP in males,^{10,14} while others did not find any differences.^{11,18} Obesity is associated with increases in SBP in several species, such as dogs³¹ and people.³² In cats, various results have been reported.^{2,11,21,22,26,33}

There was an effect of position of the cat on SBP: cats that were sitting had a significantly higher median SBP compared with cats that were in sternal recumbency. To the authors' knowledge, this effect has not been reported before in cats. In humans, it is known that body position has an influence on SBP measurement findings; diastolic pressure is higher while sitting and systolic pressure has been reported to be higher in the supine position, if the cuff on the arm is at the level of the right atrium in both positions.³⁴

A higher estimated level of stress in the cat during the measurement of SBP was associated with an increased SBP. This is likely caused by varying degrees of situational

hypertension, which has been described in cats.^{2,3,12,13,24} The stress of the examination leads to peripheral vasoconstriction, an increase in cardiac output and thus an increased SBP, which may not be reflective of the blood pressure of the cat at home.^{1,3,16}

Until now, the prevalence of situational hypertension in cats has been unknown. The prevalence of situational hypertension in this cohort of elderly cats was surprisingly high. In 1/5 cats with an SBP measurement of >160 mmHg, situational hypertension was diagnosed. This percentage might even be higher because, in 13 of the cats, it was unknown whether the increased SBP was due to persistent or situational hypertension because the cats were lost to follow-up. In three cases, there was a suspicion of the latter because of the behaviour of the cat during the procedure. The median decrease in SBP between the first and second sets of measurements was 39 mmHg, which is higher than that previously reported in the studies by Quimby et al¹³ (6 mmHg) and Belew et al¹² (17.6 mmHg). One cat had a staggering difference of 70 mmHg between the two sets of SBP measurements. Even though, in general, cats with a higher level of perceived stress had a higher SBP, there was no statistical difference in the stress assessment scale between cats with situational hypertension and cats with persistent hypertension. There were several cats with proven situational hypertension with a perceived stress level of 1 or 2. This means it is very hard to estimate in advance which cats will be persistently hypertensive and which cats will have situational hypertension. Veterinarians should therefore take a cautious approach to diagnosing hypertension in cats. Blood pressure should be interpreted within the context of the age, the setting in which the blood pressure measurement was done and assessment of the perceived level of stress of the cat. A diagnosis of hypertension should always be confirmed by repeated measurements and/or by evidence of TOD. In humans, there is some evidence that the presence of situational hypertension in an otherwise normotensive person is a risk factor for consecutive hypertensive damage. However, currently, there is no consensus recommendation for treating situational hypertension in cats.^{1–3,5,6,12,13,16,18,35,36}

The overall prevalence of cats with a heart murmur was 24.4%. This is comparable to what is found in some studies (15.5%–34%),^{37–39} but lower than what was found by Payne et al⁴⁰ in a study of 780 apparently healthy cats (40.8%). The difference might be partly explained by the fact that in the latter study multiple auscultation periods were used. Repeated auscultation has been shown to increase the overall prevalence of heart murmurs.^{26,38} The prevalence of SBP >160 mmHg in cats with a heart murmur was significantly higher (48.8%) than in the cats without a heart murmur (18.0%). This is comparable to the findings of Maggio et al⁴¹ (54%) but seems lower than the findings of Chetboul et al⁴² (62%). The increased

prevalence of murmurs in hypertensive cats can be explained by increased left ventricular wall stress caused by hypertension, leading to concentric left ventricular hypertrophy. Cats with cardiovascular abnormalities, such as a heart murmur, should have their blood pressure measured, as is indicated in several guidelines.^{1,3,5}

One of the strengths of this study is that all measurements were done by the same experienced operator using the same machine. Technical errors associated with personnel inexperience are major causes of unreliable blood pressure measurements and studies have shown that operator experience can have a significant impact on blood pressure measurements. Furthermore, different devices will give different results in the same cat.^{14,15,19,20} In addition, none of the cats had hair clipped from their front legs before having a blood pressure measurement taken. Fur clipping is still widely recommended; however, not doing it significantly reduces the time required to get the measurements and presumably also reduces the stress to the cats. Because this study population was collected from a first-opinion clinic, the characteristics of these elderly cats are likely to be similar to the population seen by other first-opinion veterinarians, in contrast to cat populations from referral centres.

The limitations of the study were that retinal examinations were not performed routinely, so less severe retinopathies secondary to underlying systemic hypertension were not identified. In total, 13 cats with an SBP >160 mmHg on one occasion were unfortunately not seen again, either because they were very aggressive (n = 3) or because they were lost to follow-up (n = 10). In this subset of cats, it was therefore impossible to determine whether they had persistent hypertension or situational hypertension. Finally, the prevalence of underlying comorbidities, such as chronic kidney disease, was unknown. Such comorbidities might have influenced the blood pressure in this population of cats.

Conclusions

The median SBP in this population of elderly cats measured using the Doppler technique was 140 mmHg. Age, stress level and body position of the cat during measurement had impact on SBP, while sex, BCS or body weight did not. The prevalence of persistent hypertension in this population was at least 14.6%, which is higher than that previously reported. One in every five cats with an SBP >160 mmHg proved to have situational hypertension. These results show measuring blood pressure is very important in elderly cats, but that one occasion of an SBP >160 mmHg cannot be used to diagnose persistent hypertension.

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Ethical approval The work described in this manuscript involved the use of non-experimental (owned or unowned) animals. Established internationally recognised high standards ('best practice') of veterinary clinical care for the individual patient were always followed and/or this work involved the use of cadavers. Ethical approval from a committee was therefore not specifically required for publication in *JFMS*. Although not required, where ethical approval was still obtained, it is stated in the manuscript.

Informed consent Informed consent (verbal or written) was obtained from the owner or legal custodian of all animal(s) described in this work (experimental or non-experimental animals, including cadavers) for all procedure(s) undertaken (prospective or retrospective studies). For any animals or people individually identifiable within this publication, informed consent (verbal or written) for their use in the publication was obtained from the people involved.

ORCID iD Marieke Knies  <https://orcid.org/0000-0002-4586-7025>

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