



Evaluation of Blood Pressure and Associated Risks in Canine Disorders: A Diagnostic Perspective

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ABSTRACT

Background: The present study was undertaken to investigate the association of systolic arterial pressure in various clinical conditions in dogs. During the study period, from May 2024 to October 2024, a total of 122 dogs presented at Department of Veterinary Medicine, College of Veterinary Science and Animal Husbandry, Jabalpur (M.P.) were examined. The blood pressure was recorded in 122 dogs, presented with various clinical conditions such as renal affections, cardiac disorders, ascites, ocular affections, diabetes mellitus, epistaxis, haemoprotozoan diseases *etc.*, to determine the relationship between blood pressure and disease-specific clinical manifestations.

Methods: All the diseased dogs were subjected to measurement of blood pressure by Doppler Vet BP machine. Haemato-biochemical parameters and different diagnostic modalities like ultrasonography and electrocardiography were performed to ensure the diagnosis of concerned clinical conditions. The association between blood pressure and clinical conditions in dogs was evaluated using the classification system proposed by American College of Veterinary Internal Medicine (ACVIM) hypertension guidelines.

Result: In renal cases, 21.62% dogs were having SAP ≥ 160 mm Hg. The target organ risk categorization using value of SAP revealed that out of 29 dogs, 20.69%, 51.72%, 13.79% and 13.79% were at minimal risk, mild risk, moderate risk and high risk, respectively. In cardiac cases, 13.51% dogs were having SAP ≥ 160 mm Hg with target organ risk categorization revealed that out of 11 dogs, 27.27%, 27.27%, 36.36% and 9.09% were at minimal risk, mild risk, moderate risk and high risk respectively. In ascites (hepatic origin) cases, 8.10% dogs were having SAP ≥ 160 mm Hg. The target organ risk categorization revealed that out of 23 dogs, 60.86%, 26.08% and 13.04% were at minimal risk, mild risk, moderate risk, respectively. In ocular cases, 8.10% dogs were having SAP ≥ 160 mm Hg. The target organ risk categorization revealed that out of 06 dogs, 50%, 33.33% and 16.67% were at mild risk, moderate risk and high risk, respectively. The mean SAP in diabetes mellitus, epistaxis, obesity, gastroenteritis and haemoprotozoan affected dogs were 161.50 ± 3.50 , 147.60 ± 9.32 , 161.75 ± 8.04 , 139.38 ± 7.75 and 142.18 ± 7.11 , respectively. This study emphasizes the multifactorial nature of hypertension in dogs, its association with clinical conditions and the risk of target-organ damage (TOD).

Key words: Blood pressure, Doppler vet bp machine, Hypertension, Target organ damage.

INTRODUCTION

Blood pressure (BP) is the pressure exerted by circulating blood upon the walls of blood vessels which is the eventual function of cardiac output and total peripheral resistance (Acierno and Labato, 2004). During each heartbeat, BP varies between a maximum (systolic) and a minimum (diastolic) pressure. Systolic arterial blood pressure, diastolic arterial blood pressure and mean arterial blood pressure make up systemic arterial blood pressure (Skelding and Valverde, 2020). In both human and veterinary medicine, systolic blood pressure is the most stressed of the three components of arterial blood pressure as it is an important cause of vascular and hypertensive damage. Systemic hypertension term is applied to sustained increases in SBP.

Recent advancements in diagnostic techniques to determine blood pressure (BP) make possible to obtain rapid and accurate measurements in conscious animals. Due to the increasing accuracy, reliability and promptness of non-invasive blood pressure (NIBP) measurement systems, as well as their reasonable cost, they are now becoming a significant diagnostic tool in daily clinical practice (Agudelo *et al.*, 2016).

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Undiagnosed elevations in blood pressure will over perfuse the organs (barotrauma) thereby affecting multiple organ systems *i.e.* target organ damage (TOD) or end-organ damage and the presence of TOD is typically a significant sign to begin antihypertensive therapy. Early and efficient treatment plays a major role to lower the risk of TOD and to avoid hypertensive emergencies (Charitha *et al.*, 2023). So currently there is an emphasis on the diagnosis of hypertension in veterinary medicine and for this purpose blood pressure monitoring became necessary in small animal population and also evaluation of its effect on various systems of body.

MATERIALS AND METHODS

The proposed study was carried out in the Department of Veterinary Medicine, College of Veterinary Science and Animal Husbandry, Jabalpur, (M.P.) India for the period of 06 months *i.e.*, from May 2024 to October 2024. A total of 122 dogs suffering from different clinical conditions including renal failure, cardiac abnormalities, ascites (liver origin), ocular lesions, epistaxis, etc, were selected to study the association of blood pressure with target organ damage took place under these clinical conditions.

Experimental design

Association of blood pressure with various clinical conditions in dogs was investigated according to Acierno *et al.* (2018) classification of systolic arterial pressure in

dogs which was based on risk for future target-organ damage (Table 1).

Blood pressure measurement

All the dogs were subjected to measurement of systolic arterial pressure by indirect device *i.e.* Doppler Vet BP machine manufactured by the Mano medical company. It consisted of a doppler unit, 8 MHz transversal linear probe, sphygmomanometer, ultrasound gel and 4 cuffs adapted to the different sizes of animal (Fig 1). The patient should be allowed to acclimate to the measurement room for 5-10 minutes to minimize the anxiety or excitement-induced situational hypertension. The cuff width should be approximately 30%-40% of circumference of the cuff site. Hair was trimmed just above the palmar metacarpal pad, aligned with the superficial palmar arterial arch, for forelimb measurements. An occluding cuff was positioned above the flow detection site (mid-radius in the forelimb) and measurements were taken with the cuff positioned at the heart level. Ultrasonic coupling gel was applied to the concave side of the doppler transducer, which was either held in place during measurements. An audible pulse signal was detected and the cuff was inflated using a bulb connected to a pressure gauge. It was inflated to at least 40 mm Hg above the point where the signal became inaudible. The cuff was then gradually deflated and the pressure at which the doppler signal became audible again was recorded as the systolic pressure. The first measurement was discarded and an average of 5-7 consecutive consistent indirect measurements were obtained. Measurement of systolic arterial pressure is illustrated in (Fig 2).

Table 1: Classification of systolic arterial pressure in dogs based on risk for future target-organ damage (TOD).

Risk category	Systolic arterial pressure (mmHg)	Risk of future TOD
Normotensive	<140 mm Hg	Minimal
Prehypertensive	140-159 mm Hg	Low
Hypertensive	160-179 mm Hg	Moderate
Severely hypertensive	≥180 mm Hg	High

RESULTS AND DISCUSSION

Blood pressure levels in different clinical conditions in dogs

The study analysed 122 diseased dogs, with the mean systolic arterial pressure (SAP) varying across different clinical

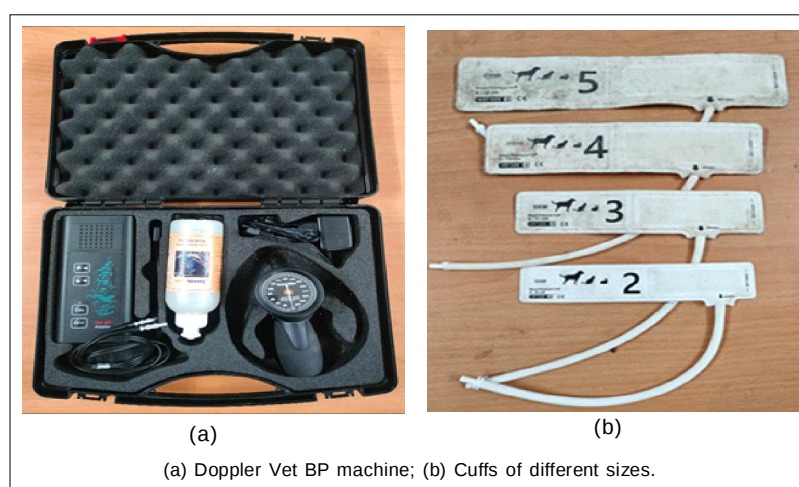


Fig 1: Parts of blood pressure measuring device.

conditions. The varying range of mean systolic arterial pressure (136 to 161 mm Hg) was recorded in different clinical conditions in dogs. Although mean systolic arterial pressure was varying as per the number of the cases of various clinical conditions. Hypertension (SAP ≥ 160 mm Hg) was observed

Table 2: Systolic arterial blood pressure levels in different clinical conditions in dogs.

Clinical conditions	No. of case (n=122)	SAP (Mean $\pm$ S.E)
Renal affection	29	152.66 $\pm$ 4.00
Cardiac disorders	11	156.09 $\pm$ 6.76
Haemoprotozoan	11	142.18 $\pm$ 7.11
Ascites (Hepatic origin)	23	136.26 $\pm$ 4.52
Diabetes mellitus	02	161.50 $\pm$ 3.50
Epistaxis	05	147.60 $\pm$ 9.32
Obesity	04	161.75 $\pm$ 8.04
Ocular affection	06	161.66 $\pm$ 6.85
Gastroenteritis	13	139.38 $\pm$ 7.75
Miscellaneous*	18	144.50 $\pm$ 4.16

*Pyometra, Dermatitis, Degenerative joint disease, Lymphoma, Respiratory affections, Pyoderma, Exocrine pancreatic insufficiency.

Table 3: Distribution of hypertension in dogs in different clinical conditions.

Clinical conditions	No. of dogs affected (n=31)	Distribution (%)
Renal affection	08	21.62
Cardiac disorders	05	13.51
Haemoprotozoan	02	05.40
Ascites (Hepatic origin)	03	08.10
Diabetes mellitus	01	02.70
Epistaxis	02	05.40
Obesity	02	05.40
Ocular affection	03	08.10
Gastroenteritis	04	10.81
Respiratory affection	01	02.70

in obese dogs, as well as in dogs with ocular conditions and diabetes mellitus. The results shown in Table 2.

The findings of our study revealed variations in mean systolic arterial pressure among dogs with different clinical conditions, underscoring a lack of comprehensive literature on disease-specific blood pressure regulation. This variability may stem from diverse pathophysiological mechanisms, including altered RAAS activity, vascular tone and fluid balance in conditions like renal disease, hyperlipidemia, hyperadrenocorticism and hypothyroidism. Endocrine imbalances, systemic inflammation, oxidative stress and progressive organ damage further contribute to these differences, alongside individual variations in compensatory responses.

Distribution of hypertension (SAP ≥ 160 mm Hg) in dogs in different clinical conditions

The distribution of hypertension (SAP ≥ 160 mm Hg) across various clinical conditions in dogs showed that hypertension was most commonly associated with renal affections (21.62%), followed by cardiac conditions (13.51%). These findings are illustrated in Table 3.

The findings coincide with Ware *et al.* (2021), who reported that the prevalence of hypertension in dogs with renal disease varied widely, ranging from less than 20% to over 75%. Similarly, Charitha *et al.* (2023) found that chronic kidney disease accounted for the highest percentage (53.16%) of cases associated with secondary hypertension. Elliott and Brown (2020) explained that several factors, including activation of the renin-angiotensin-aldosterone system (RAAS), over-activity of renal afferent nerves, decreased reninase production and phosphate retention causing bone and mineral disturbances, contribute to increased vascular tone in chronic kidney disease. These factors, combined with changes in body fluid volume relative to vascular volume and heightened vascular tone, result in elevated blood pressure.

Target organ damage (TOD) by clinical conditions

A total of 29 dogs diagnosed with renal affections were classified based on the risk of target organ damage (TOD)



Fig 2: Measurement of systolic arterial pressure using Doppler Vet BP machine in different breeds.

according to the ACVIM hypertension guidelines. Among these, the majority of dogs (51.72%) were in the prehypertensive stage, followed by 24.14% in the normotensive stage, while the remaining cases were evenly distributed between the hypertensive (12.07%) and severe hypertensive (12.07%) stages. Out of 11 dogs affected with cardiac disorders, 36.36% were classified in the hypertensive stage. An equal proportion (27.27%) were categorized as normo-tensive and pre-hypertensive, while 9.09% of the cases were in the severe hypertensive stage with systolic arterial pressure (SAP) ≥ 180 mmHg. Among the 06 dogs with ocular affections, 50.00% were in the prehypertensive stage, followed by 33.33% in the hypertensive stage and 16.67% in the severe hypertensive stage. In dogs presenting with ascites (n=23), the majority (60.86%) were normotensive, while 26.08% were in the prehypertensive stage and 13.04% were hypertensive. Of the 11 dogs diagnosed with haemoprotezoan infections, 45.45% were normotensive, 36.36% were prehypertensive and 9.09% were equally distributed between the hypertensive and severe hypertensive stages. In the group of 13 dogs suffering from gastroenteritis, 38.46% were normotensive, while 30.77% each were in the prehypertensive and hypertensive stages. Notably, no cases were observed in the severe hypertensive stage. Among the 05 dogs with epistaxis, 40.00% were in the prehypertensive stage, 40.00% were hypertensive and no dogs exhibited severe hypertension. Out of 04 dogs with obesity, 50.00% were prehypertensive, while 25.00% each were hypertensive and severe hypertensive. The results are depicted in Table 4.

Our findings are in partial agreement with the observations of Singla (2015), who categorized dogs based on the risk of target organ damage (TOD) associated with systemic hypertension. Charitha *et al.* (2023) reported that, among 48 dogs presenting kidney damage as TOD, 12 were classified in the moderate TOD risk group (SBP: 160-179 mm Hg), while 36 were categorized in the high TOD risk group (SBP ≥ 180 mm Hg). Chronic renal failure is associated with various alterations in blood pressure regulation, including sodium retention, extracellular fluid volume expansion, activation of the renin-angiotensin-aldosterone system (RAAS), increased norepinephrine

levels, heightened vascular responsiveness to nor-epinephrine, reduced activity of vasodilatory substances, increased cardiac output, elevated total peripheral vascular resistance and secondary hyperparathyroidism. The pathophysiology of hypertension in renal failure is likely multifactorial, involving complex interactions of these factors (Bartges *et al.*, 1996).

Similarly, our findings partially align with the results of Charitha *et al.* (2023) regarding cardiac TOD. They observed that among 22 dogs with heart involvement as TOD, 05 were classified under the moderate risk group, while the remaining 17 were in the high-risk group. Yamini *et al.* (2020) also carried out a study to evaluate the clinical, electrocardiographic, radiographic and echocardiographic changes in dogs suffering from pulmonary hypertension (PH) secondary to mitral valve disease (MVD). Their findings revealed that 15.5% of the dogs with MVD had mild PH, 8.7% showed moderate PH and 4.8% were affected by severe PH. Mahendran *et al.* (2022) also stated that in early cardiac disease, such as hypertension, increased pressure causes heart wall stress, triggering the release of natriuretic peptides like BNP and ANP. These peptides help lower blood pressure by promoting vasodilation and fluid excretion. Their rise reflects the heart's response to persistent high pressure and volume overload in hypertension. Structural and anatomical abnormalities in the cardiovascular system are well-established causes of hypertension. Elevated systolic arterial pressure is recognized as a significant risk factor for cardiovascular diseases, including left ventricular hypertrophy and heart failure, both of which may result from sustained hypertension.

In accordance with LeBlanc *et al.* (2011), our findings corroborate the frequent association of ocular issues with systemic hypertension in dogs. LeBlanc *et al.* emphasized the importance of systematic monitoring for ocular TOD in hypertensive dogs or those with related systemic conditions. Charitha *et al.* (2023) reported that, among 32 dogs with hypertensive ocular effects, 07 were categorized in the moderate risk group and 25 in the high-risk group. Similarly, Singla (2015) identified 05 cases of ocular abnormalities, including corneal opacity and blindness, linked to hypertension. Ocular involvement is a well-

Table 4: Categorization of systolic arterial pressure in dogs affected with various clinical conditions.

Clinical conditions	Category			
	Normotensive (<140 mm Hg)	Prehypertensive (140-159 mm Hg)	Hypertensive (160-179 mm Hg)	Severe hypertensive (≥ 180 mm Hg)
Renal affections (n=29)	06(20.69%)	15(51.72%)	04(13.79%)	04(13.79%)
Cardiac disorders (n=11)	03(27%)	03(27%)	04(36.36%)	01(09.09%)
Ocular affections (n=06)	00(00%)	03(50%)	02(33.33%)	01(16.67%)
Ascites (hepatic origin) (n=23)	14(60.86%)	06(26.08%)	03(13.04%)	00(00%)
Haemoprotezoan (n=11)	05(45.45%)	04(36.36%)	01(09.09%)	01(09.09%)
Gastroenteritis (n=13)	05(38.46%)	04(30.77%)	04(30.77%)	00(00%)
Epistaxis (n=05)	01(20%)	02(40%)	02(40%)	00(00%)
Obesity (n=04)	00(00%)	02(50%)	01(25%)	01(25%)

documented and easily detectable clinical consequence of systemic hypertension in dogs, necessitating prompt identification and management.

Our study supports the conclusions of Singla (2015) concerning ascites in hypertensive dogs. Among 08 cases of ascites reported by Singla, 06 dogs exhibited systolic arterial pressure (SAP) values <150 mm Hg, corresponding to minimal risk, while 1 dog had SAP in the range of 160-179 mm Hg, indicating moderate risk. Another case had SAP $\geq$ 180 mm Hg, placing it in the severe risk category. Buob *et al.* (2011) described the liver's dual blood supply from the portal vein and hepatic artery, which mix in the hepatic sinusoids. Portal hypertension arises from increased resistance to portal blood flow, often due to structural liver abnormalities like cirrhosis. Elevated portal pressure and altered sinusoidal permeability drive fluid into the peritoneal cavity, causing ascites.

The findings of this study indicate a significant association between hypertension and canine hemoprotozoan diseases. These results are consistent with the observations of Koma *et al.* (2005), who attributed hypertension in dogs with hemoprotozoan diseases to chronic anaemia caused by the etiological agents. Chronic anaemia induces a hyperdynamic cardiovascular response, characterized by increased cardiac output and blood flow, along with a compensatory reduction in vascular resistance. This decreased vascular resistance is primarily attributed to reduced blood viscosity due to lowered haematocrit levels. While these vascular adaptations aim to maintain adequate oxygen delivery, they may inadvertently contribute to hypertension.

Our observations concur with Fishbein *et al.* (2020), who identified hypertension in dogs with gastroenteritis as a result of enhanced sympathetic activation, upregulation of the renin-angiotensin-aldosterone system (RAAS) and impaired blood pressure autoregulation. These mechanisms, along with dehydration and electrolyte imbalances, exacerbate vasoconstriction, oxidative stress and vascular damage, contributing to acute severe hypertension. Patel and Mitsnefes (2005) similarly noted that gastrointestinal infections, such as bacterial diarrhoea and haemolytic uremic syndrome, can worsen renal injury and chronic hypertension.

This research substantiates the conclusions drawn by Brown *et al.* (2007) and Bala *et al.* (2021), who associated epistaxis in dogs with systemic hypertension-induced vascular abnormalities. Bala *et al.* (2021) categorized cases into prehypertensive and hypertensive risk groups, while Bissett *et al.* (2007) highlighted hypertension-driven vascular damage as a cause of epistaxis. Hypertension induces endothelial damage, increased vascular permeability and reduced elasticity, predisposing vessels to rupture. While hypertension is a key factor, secondary conditions like trauma, coagulopathies, or inflammation may complicate diagnosis. Chronic hypertension exacerbates vascular fragility, reinforcing its role in the pathogenesis of epistaxis.

The analysis parallels that of Bala *et al.* (2021), who reported the prevalence of hypertension risk categories in

overweight and obese dogs (BCS 4 and 5), with 23.08% at minimal risk, 15.38% at mild risk, 48.72% at moderate risk and 12.82% at severe risk. Montoya *et al.* (2006) also emphasized the role of weight status as a key risk factor for secondary hypertension. Obesity contributes to hypertension through mechanisms such as increased sympathetic nervous system activity, RAAS activation, endothelial dysfunction and vascular remodelling. Early obesity is characterized by renal sodium retention and extracellular fluid expansion, resetting the kidney-fluid apparatus to a hypertensive state. Elevated renin, angiotensin II and aldosterone levels exacerbate vasoconstriction and fluid retention. Insulin resistance and systemic inflammation further impair vascular function by promoting arterial stiffness. Additionally, adipocyte-derived hormones like leptin and neuropeptides influence central nervous system pathways, driving sympathetic over activation and linking obesity to hypertension (Kotsis *et al.*, 2010).

In this study, two diabetic dogs were evaluated, of which one (50%) was classified as prehypertensive (SAP: 140-159 mm Hg) and one (50%) as hypertensive (SAP: 160-179 mm Hg). These findings are consistent with Herring *et al.* (2014), who reported systolic hypertension in 55% of diabetic dogs and Priyanka *et al.* (2018), who observed higher mean systolic arterial pressure in diabetic dogs compared to healthy controls, with a hypertension prevalence of 58.82%. Similarly, Singla (2015) documented one diabetic dog in the mild risk category (SAP: 150-159 mm Hg) and one in the moderate risk category (SAP: 160-179 mm Hg), with no cases of severe hypertension (SAP $\geq$ 180 mm Hg).

Hypertension is frequently associated with diabetes due to various pathophysiological mechanisms, as noted by Kour *et al.* (2020). Disturbed lipid metabolism in diabetes induces vascular stiffness and reduced compliance, impairing blood pressure regulation. Generalized glomerular hyperfiltration in diabetic nephropathy leads to increased renal sodium retention and extracellular fluid expansion, contributing to elevated systolic arterial pressure. Additionally, increased peripheral vascular resistance and vasculopathy, driven by chronic hyperglycaemia and oxidative stress, further promote hypertension. These vascular changes, coupled with inflammation and activation of the renin-angiotensin-aldosterone system, establish a pro-hypertensive state, highlighting the necessity for integrated management strategies for diabetic dogs.

Systolic arterial pressure according to the stages of renal failure

According to the IRIS (International Renal Interest Society 2019) guidelines, chronic renal failure (CRF) in dogs is staged based on serum creatinine levels. In the present study, the mean systolic arterial pressure (SAP) increased with the progression of renal disease, with values of 146.90 ± 3.04 mm Hg in stage 2, 156.00 ± 14.34 mm Hg in

Table 5: Systolic arterial pressure according to the stages of renal failure (stages as per IRIS, 2019).

Stage of CRF as per IRIS	No. of cases (n=29)	SAP (Mean± SE)	Hypertension (SAP ≥160 mm Hg)
Stage 2 (Cr-1.4-2.8 mg/dl)	11	146.90±3.04	02
Stage 3 (Cr-2.9-5 mg/dl)	05	156.00±14.34	03
Stage 4 (Cr->5 mg/dl)	11	159.00±7.55	03

stage 3 and 159.00±7.55 mm Hg in stage 4. Hypertension (SAP ≥160 mmHg) was observed in 8 dogs. The prevalence of hypertension was notably higher in stages 3 and 4, emphasizing its strong association with advanced renal dysfunction. These results are detailed in Table 5.

Our findings are consistent with Mann (2013) who reported 30.7% and 36% prevalence of hypertension in stage 3 and stage 4 of renal failure cases, respectively. The mean SAP gradually increased with increasing stage. Jacob *et al.* (2003) demonstrated that dogs with elevated systolic arterial pressure (≥160 mm Hg) are at an increased risk of uremic crises and mortality due to a more significant decline in renal function. Syme (2011) indicates that in dogs with chronic kidney disease, impaired renal sodium excretion results in heightened salt sensitivity, contributing to the development and exacerbation of hypertension.

CONCLUSION

The present study highlights the significant association between hypertension and various clinical conditions in dogs, emphasizing the role of systolic arterial pressure as a critical parameter in veterinary practice. Among the various clinical conditions, hypertension was mostly associated with renal affection (21.62%) followed by cardiac disorders (13.51%). The prevalence of hypertension was notably higher in stages 3 and 4 of renal failure, specifies its strong association with advanced renal dysfunction. The observations accentuate the multifactorial nature of hypertension in dogs, driven by mechanisms like RAAS activation, systemic inflammation and altered vascular responses. Routine blood pressure monitoring in dogs with chronic conditions is crucial for early detection of target organ damage, enabling timely intervention to improve clinical outcomes and reduce hypertensive complications.

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Informed consent

All experimental procedures involving animals were conducted following approval from the institutional animal ethical committee.

Conflict of interest

The authors confirm that they have no conflict of interest.

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