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Ultrasonographic determined renal dimensions in azotemic non-descript dogs

Shalini Pandey, PB Hase, RV Gaikwad, CN Galdhar and KV Garud

Abstract
Ultrasonographic renal dimensions are important parameter which can be used in the diagnosis of kidney diseases. The aim was to evaluate healthy non-descript dogs with normal kidneys as well non-descript dogs with renal dysfunction, evaluate variation between right and left kidney renal dimensions, and correlate between ultrasonographic renal dimensions particularly kidney length and body weight, aorta diameter with body weight and kidney length and also a correlation among individual kidney length in both normal non-descript dogs and ailing dogs. Total 30 dogs comprising of 15 apparently healthy and 15 non-descript dogs with renal dysfunction owned by either owners or stray dogs residing in various areas of Mumbai and its environs, with varying body weight (kg) and age (years) in the healthy control group and renal dysfunction group, respectively were used for this study. Ultrasonographic renal dimensions were obtained on the sagittal plane. The right kidney was bigger than the left kidney in both the study group of non-descript dogs. A statistically significant difference was recorded between left kidney length and cortical thickness and right kidney length and cortical thickness on comparing both the groups. The diameter of the aorta and aorta to caudal vena cava ratio had increased while the kidney length to aorta ratio had decreased in the renal dysfunction group. Correlation between ultrasonographic renal dimensions particularly kidney length with body weight was moderately correlated while correlation of aorta diameter with body weight was weakly correlated. Alteration in ultrasonographic renal dimensions as compared to the healthy group and their relationship with body weight, aorta diameter, and among themself as well aorta to caudal vena cava ratio and kidney length to aorta ratio can be a valuable parameter for the diagnosis of kidney disorders in non-descript dogs.

Keywords: Kidney, ultrasonography, renal dimensions, aorta, caudal vena cava

Introduction
Ultrasonography has been utilized to investigate the disease conditions and dimensions of the canine kidney (Remichi *et al*., 2014) [1] which is preferable to radiography since no contrast agents or radiations are employed (Nyland *et al*., 1995) [2] Many kidney disease conditions are consistent with an aberration in kidney dimensions (Sohn *et al*., 2016) [3]. Ultrasonographic kidney length is considered the most important kidney dimension used in determining kidney size (Konde *et al*., 1984) [4], so changes in kidney length, as well as other kidney dimensions like kidney width, cortical thickness, medulla thickness, indicate abnormal kidney function which is used in the diagnosis of kidney diseases (Barr, 1990; Sohn *et al*., 2016) [5, 3]. Ultrasonographic kidney dimensions have been correlated with body weight in dogs to evaluate its relationship in diagnosis of kidney diseases (Nyland *et al*., 1989; Barr *et al*., 1990; Felkai *et al*., 1992., Sampaio and Araujo, 2002) [6, 5, 7, 8]. Body weight is the primary result of the body's nutrition and metabolism in order to sustain optimal and engage in physical activities (Hall *et al*., 2012) [9]. Ultrasonographic kidney bipolar length has been identified as a significant dimension employed in the diagnosis of kidney disorders in humans (Hekmatnia and Yaraghi, 2004) [10], and it is favourably correlated with body weight (Raza *et al*., 2011; El-Reshaid and Abdul-Fattah, 2014) [11, 12]. There is a paucity of information on ultrasonographic renal dimensions and their relationship with body weight in non-descript dogs, which has clinical importance in the diagnosis of kidney diseases. Therefore, there is a need to investigate the relationship between ultrasonographic renal dimensions particularly kidney length and body weight in Non-descript Dogs. The goal was to identify healthy non-descript dogs with normal kidneys, non-descript dogs with renal dysfunction, evaluate variation in right and left kidney renal dimensions in both healthy non-descript dogs and non-descript dogs with renal dysfunction, compare ultrasonographic renal dimensions between healthy control and renal dysfunction groups, and correlate ultrasonographic kidney dimensions, especially kidney length and body weight, in both healthy non-descript dogs and non-descript dogs with renal dysfunction.

Materials and Methods
Animal subjects
Total 30 dogs comprising of 15 apparently healthy and 15 non-descript dogs with renal dysfunction owned by either owners or stray dogs residing in various areas of Mumbai and its environs, weight, and age ranges between 7.5 to 16 kg and 0.7 to 11 years in the healthy control group and between 8 to 25 kg and 3 to 15 years in renal dysfunction group, respectively were used for this study. All experimental procedures and protocol were reviewed and approved by the IEC (Institution ethical committee) and consent was obtained from all the dog owners, prior to the commencement of the study.

Ultrasonographic Renal Dimensions
The dogs were restrained physically on left /right lateral recumbency and in some cases on dorsal recumbency. Then acoustic gel was liberally applied to both the probe contact surface and skin at the cranial abdomen, caudal to the last rib cage. The scanning procedure was carried out with a portable B-mode scan machine Sonoscape (S2V) with the help of a convex transducer (curvilinear transducer) of frequency 5-8 MHz mostly, however, if required convex transducer (curvilinear transducer) of frequency 7-10 MHz was also used for a clear view of the image. i.e., change in frequency, gain, depth, and section width was done as per requirement. Sagittal plane scan of right and left kidneys was carried out to obtain the ultrasonographic renal dimensions viz kidney length, kidney width, cortical thickness, and medulla thickness. The left kidney was examined with the transducer in contact with the ventral abdominal wall or flank caudal to the last ribs. The spleen was used as an acoustic window, to scan the left kidney. The transducer was directed caudolaterally. The right kidney was scanned in dorsal recumbency by placing the transducer caudal to right costo-spinal angle as the right kidney was found to be deeper. It was also scanned on left lateral recumbency, by placing the transducer in the middle of the last intercostals space the scan beam directing caudally in necessity. Movement of the transducer at these locations assisted in targeting the impulse from the transducer on the kidneys which appeared on the B-mode monitor. A clear image of the kidney on the monitor was frozen, and distance measurement mode was activated to measure the renal dimensions in centimeter (cm) for both right and left kidneys, The entire kidney was scanned on sagittal /longitudinal planes and its echo texture, anatomical location and size was recorded.
Following parameters were recorded:

a) **Kidney length:** A minimum of three measurements of kidney length (both left and right) in the sagittal plane were recorded to calculate the mean for further data analysis.
b) **Kidney width:** Minimum of three measurements of kidney width (both left and right) sagittal plane were recorded to calculate mean for further data analysis.
c) **Cortical thickness:** Cortical thickness was measured at a minimum of three different locations in an image in the sagittal plane and recordings were used for further data analysis in each kidney.
d) **Medullary thickness:** Medullary thickness was measured at three different locations in an image in the sagittal plane and recordings were used for further data analysis in each kidney.

In addition, aorta diameter, caudal vena cava diameter, aorta to caudal vena cava ratio and kidney length to aorta ratio were also determined ultrasonographically.

Abdominal Vessels
a) **Abdominal Aorta diameter:** Measurement of aorta diameter in centimeters was made from longitudinal/sagittal still images from the outer border to the outer border of the aorta.
b) **Venacava diameter:** Measurement of diameter in centimeters was made from longitudinal/sagittal still images from outer border to the outer border of caudal vena cava in the caudal abdomen just cranial to the origin of the external iliac vessels.

Data analysis
Data collected were subjected to statistical analysis using Microsoft excel and mean ± SE for each variable was calculated. The paired t test, ANNOVA and correlation coefficient was used to analyse data between paired kidneys. Pearson’s correlation coefficient test was used to relate between ultrasonographic kidney bipolar length and body weight. The value of $p<0.05$ was considered significant.

Results
Thirty nondescript dogs comprising 15 healthy dogs and 15 renal dysfunction non-descript dogs included males and females: body weight (kg) ranged from 7.5 to 16 with a mean of 11.6 ± 0.82 and age (years) 0.7 to 11 with a mean of 3.56 ± 0.89 in healthy dogs and 8 to 25 kg with mean of 13.48 ±1.32 and age ranges 3 to 15 years with a mean of 10 ±1.14 in ailing dogs.
The mean values and standard error for renal dimensions (both left and right kidney) viz. kidney length, kidney width, cortical thickness and medulla thickness were recorded. Simultaneously, aorta diameter and vena cava diameter were also recorded in both apparently healthy control group and kidney disease group. Ultrasonographical determined renal dimensions in apparently healthy control group for left kidney were: kidney length (cm) 5.46 ± 0.06, kidney width (cm) 2.89 ± 0.06, cortical thickness (cm) 0.63 ± 0.02 and medulla thickness (cm) 0.74 ± 0.02 while for the right kidney were: kidney length (cm) 5.70 ± 0.07, kidney width (cm) 3.35 ± 0.21, cortical thickness (cm) 0.63 ± 0.02 and medulla thickness (cm) 0.75 ± 0.03. Correspondingly, ultrasonographical determined renal dimensions in kidney disease group for left kidney were: kidney length (cm) 4.85 ± 0.24, kidney width (cm) 3.03 ± 0.12, cortical thickness (cm) 0.85 ± 0.05 and medulla thickness (cm) 0.68 ± 0.05 while for the right kidney were: kidney length (cm) 5.15 ± 0.23, kidney width (cm) 3.36 ± 0.08, cortical thickness (cm) 0.85 ± 0.04 and medulla thickness (cm) 0.76 ± 0.03.

Table 1: Ultrasonographic Examination of Kidney Morphometry in Healthy Control Group

Parameter	Left Kidney (Mean ± SE) (n=15)	Right Kidney (Mean ± SE) (n=15)	Calculated ‘t’	Table ‘t’ (p<0.05)
Kidney Length (cm)	5.46 ± 0.06	5.70 ± 0.07	2.41 *	2.05
Kidney Width (cm)	2.89 ± 0.06	3.35 ± 0.21	2.10*	
Cortical Thickness (cm)	0.63 ± 0.02	0.63 ± 0.02	0.06 NS	
Medulla Thickness (cm)	0.74 ± 0.02	0.75 ± 0.03	0.14 NS	

*=p<0.05, NS = non-Significant

Table 2: Ultrasonographic Examination of Kidney Morphometry in Kidney Disease Group

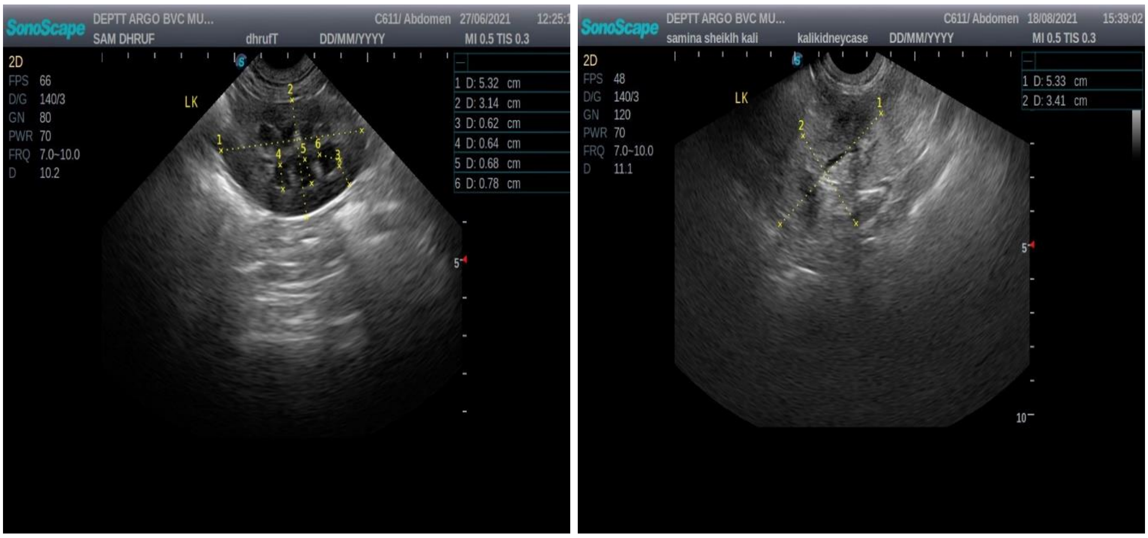
Parameter	Left Kidney (Mean ± SE) (n=15)	Right Kidney (Mean ± SE) (n=15)	Calculated 't'	Table 't' (p<0.05)
Kidney Length (cm)	4.85 ± 0.24	5.15 ± 0.23	0.89 NS	2.05
Kidney Width (cm)	3.03 ± 0.12	3.36 ± 0.08	2.22 *	
Cortical Thickness (cm)	0.85 ± 0.05	0.85 ± 0.04	0.02 NS	
Medulla Thickness (cm)	0.68 ± 0.05	0.76 ± 0.03	1.14 NS	

*=p<0.05, NS = non-Significant

When left kidney length (cm) 5.46 ± 0.06 was compared with right kidney length (cm) 5.70 ± 0.07 in apparently healthy control group statistically significant difference (p<0.05) was recorded between them. A similar pattern of statistically significant difference (p<0.05) was recorded when left kidney width (cm) 2.89 ± 0.06 was compared with right kidney width (cm) 3.35 ± 0.21. However, a non-significant difference was observed between left and right kidney cortical thickness and medulla thickness in the healthy control group.

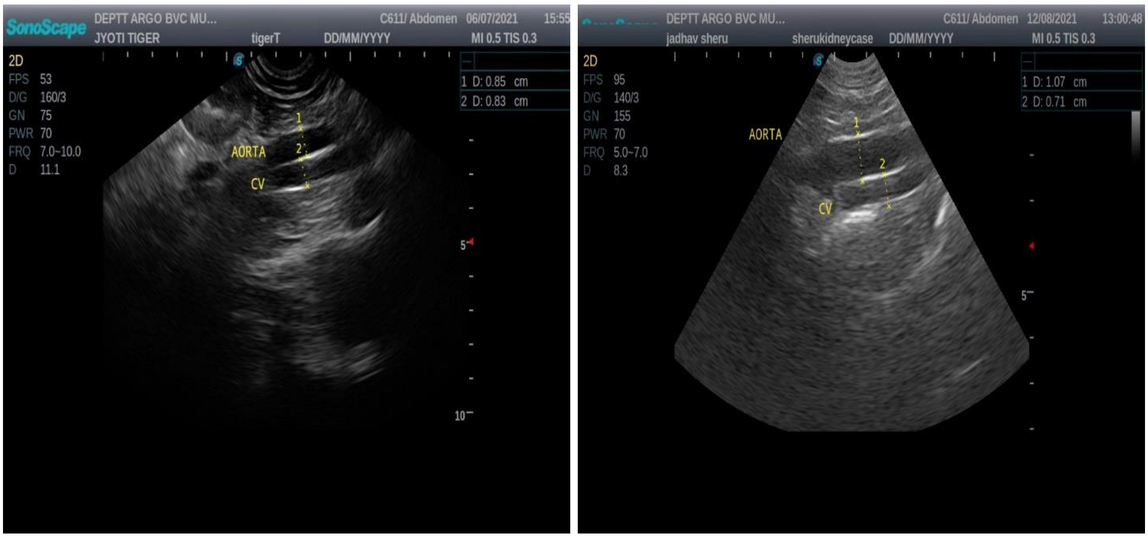
In patients with renal dysfunction ultrasonographic examination of each kidney (right and left kidney) morphometry viz. kidney length, cortical thickness, and medulla thickness revealed a non-significant difference however statistically significant (p<0.05) increase in right kidney width (cm) 3.36 ± 0.08 was observed in comparison to left kidney width (cm) 3.03 ± 0.12.

In the renal dysfunction group, bilateral loss of architectural details was observed in 10 dogs i.e., 66.67% (n=10/15) while Unilateral loss of renal architecture (either left or right) kidney) was observed in 20% (n=3/15) of dogs having renal dysfunction however in 13.33% (n=2/15) patients with renal dysfunction, no ultrasonographic architecture alteration was observed while kidney cortex was extremely hyperechoic. The hyperechogenicity of the kidney was observed in 60% (n=9/15) of cases. Indistinct contour or irregular contour of the cortex was observed in 60% (n=9/15).



(A) (B)

Fig 1: Ultrasonographic Examination of Left Kidney in Apparently Healthy Control Group (A) and Kidney Disease Group Showing Loss of Architectural Details and Poor Differentiation of Corticomedullary Junction (B)



(A) (B)

Fig 2: Aorta and Caudal Vena Cava Dimensions in healthy control group (A) and Kidney Disease Group Showing Aorta to Caudal Vena Cava Ration 1.445 Revealing Dilation of Aorta (B)

In the current study, a statistically significant difference (*p*<0.05) was recorded between left kidney length (cm) 5.46 ± 0.06 and 4.85 ± 0.24 of the healthy control group and kidney disease group, respectively. Correspondingly, a statistically significant difference (*p*<0.05) was recorded between left kidney cortical thickness (cm) 0.63 ± 0.02 and 0.85 ± 0.05 of the healthy group and renal dysfunction group, respectively. Equivalently, a statistically significant difference (*p*<0.05) was recorded for right kidney length (cm) in the healthy control group and kidney disease group, respectively viz.5.70 ± 0.07 and 5.15 ± 0.23 and right kidney cortical thickness (cm) 0.63 ± 0.02 of healthy and 0.85 ± 0.04 of disease group. However, kidney width and medulla thickness in both the kidneys among both groups were non-significant.

Table 3: Comparative Ultrasonographic Evaluation of Left Kidney Morphometry in Apparently Healthy Control Group and Kidney Disease Group

Parameter	Apparently Healthy Group Left Kidney (Mean ± SE) (n=15)	Kidney Disease Group Left Kidney (Mean ± SE) (n=15)	Calculated 't'	Table 't' (*p*<0.05)
Kidney Length (cm)	5.46 ± 0.06	4.85 ± 0.24	2.45 *	2.05
Kidney Width (cm)	2.89 ± 0.06	3.03 ± 0.12	0.96 NS	
Cortical Thickness (cm)	0.63 ± 0.02	0.85 ± 0.05	3.89*	
Medulla Thickness (cm)	0.74 ± 0.02	0.68 ± 0.05	1.14 NS	

*=*p*<0.05, NS = non-Significant

Table 4: Comparative Ultrasonographic Evaluation of Right Kidney in Apparently Healthy Control Group and Kidney Disease Group

Parameter	Apparently Healthy Group Right Kidney (Mean ± SE) (n=15)	Kidney Disease Group Right Kidney (Mean ± SE) (n=15)	Calculated 't'	Table 't' (*p*<0.05)
Kidney Length (cm)	5.70 ± 0.07	5.15 ± 0.23	2.27 *	2.05
Kidney Width (cm)	3.35 ± 0.21	3.36 ± 0.08	0.05 NS	
Cortical Thickness (cm)	0.63 ± 0.02	0.85 ± 0.04	4.13*	
Medulla Thickness (cm)	0.75 ±0.03	0.76 ± 0.03	0.45 NS	

*=*p*<0.05, NS = non-Significant

A moderate correlation was observed between left kidney length and body weight (r=0.50) however with right kidney length and mean kidney length (both kidneys together) correlation was poor or insignificant between two variables in a healthy control group. Similarly, the Correlation coefficient of ultrasonographical determined kidney measurements especially kidney length with bodyweight in the renal dysfunction group found to be moderately correlated, however, the relation between them was negatively correlated when compared with each. The correlation coefficient of aorta diameter with body weight was weakly associated in both the healthy control group (r = 0.255) and the renal failure group (r = 0.233). The paucity of a correlation between body weight and the aorta might be attributed to exceptionally low body weight.

Ultrasonographic examinations of abdominal aorta diameter (cm) in the healthy control group and kidney disease group were 0.76 ± 0.01 and 1.12 ± 0.13, respectively. In the present study, the correlation coefficient of aorta diameter with left kidney length was (r=0.39) and with right kidney length (r=0.31) in healthy control group while in dogs with renal dysfunction they were r=0.08 and r=0.33, respectively.

A statistically positive and significant correlation (*p*<0.05) was recorded among the individual kidney length (left kidney length and right kidney length) in both the study group viz. for healthy control group correlation coefficient was r= 0.46 and for renal dysfunction group r= 0.46.

Ultrasonographical determined the diameter of the abdominal aorta and caudal vena cava in the apparently healthy control group were 0.76 ± 0.01and 0.73 ± 0.02, respectively.

Cognitively, in renal dysfunction group, abdominal aorta diameter (cm) and caudal vena cava (cm) diameter were 1.12 ± 0.13 and 0.75 ± 0.07, respectively. The aorta to caudal vena cava ratio measures 1.04 ± 0.02 in the healthy group while 1.51 ± 0.16 in the renal dysfunction group Kidney length to aorta ratio for respective kidneys i.e., right kidney and left kidney were 7.41 ± 0.16 and 6.83 ± 0.31 in the apparently healthy control group however this ratio in the renal dysfunction group were 5.38 ± 0.54 and 5.10 ± 0.51. Moreover, the mean kidney length to aorta ratio recorded for the healthy group and renal dysfunction group were 7.12 ± 0.19 and 5.24 ± 0.50, respectively.

Table 5: Comparative Ultrasonographic Examination of Abdominal Aorta diameter, Caudal Venacava diameter, and Aorta to Caudal Venacava ratio in Apparently Healthy Group and Kidney Disease Group

Parameters	Measurements in Healthy Group (Mean ±SE) (n=15)	Measurements in Kidney Disease Group (Mean ±SE) (n=15)	Calculated 't'	Table't' (*p*<0.05)'
Abdominal Aorta Diameter (cm)	0.76 ± 0.01	1.12 ± 0.13	2.57*	2.05
Caudal Venacava Diameter (cm)	0.73 ± 0.02	0.75 ± 0.07	0.34^{NS}	
Aorta To Caudal Vena Cava Ratio (AO/CVC)	1.04 ± 0.02	1.51 ± 0.16	2.85*	

*=*p*<0.05, NS = Non-Significant

Table 6: Comparative Ultrasonographic Evaluation of Kidney Length to Aorta Ratio in Apparently Healthy Control Group and Kidney Disease Group

Parameters	Measurements in Healthy Group (Mean ± SE) (n=15)	Measurements in Kidney Disease Group (Mean ± SE) (n=15)	Calculated 't'	Table 't' (*p*<0.05)'
Right Kidney Length to Aorta Ratio	7.41 ± 0.16	5.38 ± 0.54	3.58*	2.05
Left Kidney Length to Aorta Ratio	6.83 ± 0.31	5.10 ± 0.51	2.84*	
Mean Kidney Length to Aorta Ratio (Km/AO)	7.12 ± 0.19	5.24 ± 0.50	3.44*	

*=*p*<0.05, NS = Non-Significant

Discussions

There were significant findings that revealed that the right kidney was bigger than the left kidney in the healthy control group. Barr *et al.* (1990) [5], Mareschal *et al.* (2007) [13] and Chaudhary and Paudel (2020) [14] reported similar findings while some studies reported that the left kidney was bigger than the right kidney (Kolber and Borelli, 2005 and Cunha *et al*., 2009) [15, 16] and others reported no differences between right and left kidneys (Sampaio and Araujo, 2002; Barella *et al*., 2012) [17, 8]. In the renal dysfunction group also, the right kidney was bigger than the left kidney but non significantly. Statistically significant (*p*<0.05) increase in right kidney width (cm) 3.36 ± 0.08 was observed in comparison to left kidney width (cm) 3.03 ± 0.12 in renal dysfunction group. The possible reason could be more pathological damage to the right kidney as compared to the left kidney and one of the confounding factors in assessing kidney measurements could be ill differentiation of echogenicity between kidney and surrounding tissues misleading to substantial errors while measuring the dimensions and thereby making right kidney width appeared to be increased. However, such a significant difference was not observed between left and right kidney cortical thickness and medulla thickness in both the healthy control group and renal dysfunction group. There was a moderate but negative correlation between body weight and kidney length in azotemic dogs. In dogs with renal dysfunction or failure, this could be the scenario. It is pretty apparent that as an illness advance, bodyweight declines. Since the kidney is a crucial organ of the body degenerative changes take place over time and thereby it takes a long time for the dimensions of the kidney to fluctuate, and so kidney length seems to be increasing in terms of bodyweight as body weight decreases. This might cause a negative relationship between body weight and kidney length in dogs with renal dysfunction.

A statistically significant difference (*p*<0.05) was recorded between left kidney length (cm) and correspondingly left kidney cortical thickness (cm) of the healthy control group and kidney disease group. Equivalently, a statistically significant difference (*p*<0.05) was recorded for right kidney length (cm) and right kidney cortical thickness (cm) in the healthy control group and kidney disease group. However, kidney width and medulla thickness in both the kidneys among both groups were non-significant. In the present study decrease in kidney length and an increase in cortical thickness in the renal dysfunction group which was in agreement with Bhadwal and Mirakur (2000) [18] who also observed atrophied kidneys with loss of architectural details, hyperechoic periphery, and anechoic core ultrasonography. The result of any chronic progressive and irreversible parenchymal disease is fibrosis and scarring of tissues. Another possible reason could be any chronic renal parenchymal disease which is generally depicted as an atrophied kidney with thickened hyperechoic corticomedullary tissue.

In the renal dysfunction group, loss of architectural details was observed which could be either bilateral, unilateral however in a few patients with renal dysfunction no ultrasonographic architecture alteration was observed while the kidney cortex was extremely hyperechoic. Overall hyperechogenicity of the kidney was also observed. An indistinct contour or irregular contour of the cortex was observed. Increased echogenicity may be indicative of fibrosis, sclerosis, or infiltration. In dogs, increased echogenicity may be present in the case of glomerulonephritis, amyloidosis (Kealy and Meallister, 2005) [19], interstitial nephritis, acute tubular necrosis, or nephrosis, end-stage disease, and parenchymal calcification due to nephrocalcinosis. A general increase in both cortical and medullary renal echogenicity, with reduced or absent corticomedullary differentiation, is related to the presence of chronic kidney lesions (Koch *et al*., 2013) [20] and can occur in chronic inflammatory disease and end-stage renal failure in dogs. Irregular contour or indistinct contour of kidney in renal dysfunction may be due to scarring and fibrosis (Zwingenberger, 2008) [21] and this finding is more common in advanced stages of the disease and indicative of a poor prognosis (Babicsak *et al.*, 2012) [22].

A moderate correlation was observed between left kidney length and body weight (r=0.50) however with right kidney length and mean kidney length (both kidneys together) correlation was poor or insignificant between two variables in a healthy control group. Similarly, the Correlation coefficient of ultrasonographical determined kidney measurements especially kidney length with bodyweight in the renal dysfunction group found to be moderately correlated, however, the relation between them was negatively correlated. This could be a scenario in dogs with renal dysfunction group It is pretty apparent that as an illness advance, bodyweight declines. Since the kidney is a crucial organ of the body degenerative changes take place over time and thereby it takes a long time for the dimensions of the kidney to fluctuate, and so kidney length seems to be increasing in terms of bodyweight as body weight decreases. Analysis of the linear correlations between renal length and the aorta diameter revealed a weak correlation in both healthy dogs and renal dysfunction dogs. The paucity of a correlation between body weight and the aorta diameter might be attributed to exceptionally low body weight. These findings were similar to the previous literature proposed by *Barr et al*., 1990 [5]; Mareschal *et al*., 2007 [14]; Lobacz *et al*., 2012 [23]; Seamus *et al*., 2016 [24]., Chaudhary and Paudel.,2020 [15].

A positive and significant correlation was noted between aorta diameter and kidney length in both i.e., apparently healthy control group and renal dysfunction group except correlation between aorta diameter and right kidney length in kidney disease group which was recorded positive and insignificant. This clearly depicts that the diameter of the aorta is influenced by respective changes in kidney length.

A statistically positive and significant correlation (p<0.05) was recorded among the individual kidney length (left kidney length and right kidney length) in both the study group viz. for the healthy control group as well as renal dysfunction group of non-descript dogs. This finding corroborates with the findings of Chaudhary and Paudel (2020) [15] who reported a linear correlation between the Length of the Left kidney (LL) with Length of the Right kidney (RL) (r=0.89, P<0.05)

The diameter of the aorta (cm) and aorta to caudal vena cava ratio had increased in the renal dysfunction group as compared to the healthy control group and the difference between them was statistically significant (p<0.05) while vena cava diameter (cm) was also mildly increased, however, increase in diameter was statistically non-significant. 49% increase in abdominal aorta diameter was recorded in renal dysfunction group on comparison with healthy control group. The possible reason for the increase in diameter of the abdominal aorta and thereby aorta to caudal vena cava ratio could be the result of compensatory mechanism as dilation /expansion of the aorta occurs to normalize luminal diameter and shear stress. Excessive aortic remodeling results in the thinning of the medial layer along with an inflammatory process ultimately aorta dilation. In the present study also, an increase in abdominal aorta diameter and aorta to caudal vena cava ratio was mostly observed in dogs who were showing high blood pressure on measurements with the oscillometric devices. These findings are in close agreement with Holland *et al.* (2020) [24] who reported that the mean aorta to caudal vena cava ratio was 1.028 in controlled dogs with normal blood pressure and 1.515 in dogs with systemic hypertension

Kidney length to aorta ratio (right kidney length to aorta ratio, left kidney length to aorta ratio, and mean kidney length to aorta ratio) has declined in renal dysfunction patients and the difference between them was statistically significant (p<0.05) when compared among healthy control group and renal dysfunction group. The possible reason for the decline in kidney length to aorta ratio (KL/AO) could be due to a decrease in the size of the kidney and an increase in abdominal aorta diameter in renal dysfunction patients. The findings in the current study on healthy non-descript dogs revealed a ratio of 5.54 to 8.15 of kidney length to aorta ratio.

The present findings study was in agreement with Mareschal *et al.* (2007) [14] who documented that based on 95% confidence intervals, renal size should be considered reduced if the K/AO ratio is <5.5 and increased when >9.1; Barella *et al.*, (2015) [19]: Chaudhary and Paudel (2020) [15].

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