Original Research

Morphological Features of the Renal Collecting System in Goat (*Capra hircus*)**

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*** Part of M.V.Sc thesis submitted to PVNR Telangana Veterinary University in 2017*

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Rec. Date:	Oct 15, 2019 05:58
Accept Date:	Nov 21, 2019 13:27
DOI	10.5455/ijlr.20191015055806

Abstract

Morphology of renal collecting system (RCS) of goat kidney was studied by macroscopic dissection and corrosion cast technique. Dissection was done with help of a magnifying lens and teasing needle. For corrosion cast technique, a mixture of cold cure self-polymerizing acrylic powder and solution was made in 1:2 ratio and injected into the ureter to obtain 3D endo-casts of RCS. These specimens were placed in 75% HCl until corrosion process was completed. Macroscopic and corrosion cast details of RCS of goats revealed a wide funnel shaped renal pelvis with 12 'U' shaped recesses in a renal sinus. Their number varied from 12 to 15. Renal calices were absent in this species. Convex shaped renal crest was observed on mid line of renal pelvis on which several ducts opened. Mean length of right ureter was 31.55 ± 1.81cm which is significantly greater than the left ureter.

Key words: Corrosion Cast, Goat, Renal Pelvis, Renal Collecting System, Ureter

How to cite: Venumadhav, N., kumar, D., Ramya, N., & Rajendranath, N. (2019). Morphological Features of the Renal Collecting System in Goat (Capra hircus). International Journal of Livestock Research, 9(12), 187-197. doi: 10.5455/ijlr.20191015055806

Introduction

Renal collecting system of goat kidneys includes the papillary ducts, renal crest or common papilla and renal pelvis. Renal pelvis is a common cavity around the renal crest into which fused renal papilla open. Ureter is a narrow tube which conducts the urine in a continuous trickle from the renal pelvis to the bladder. Renal pelvis of small ruminants and dog is a common cavity which received the renal crest with variable number of recesses on its margin. Renal parenchyma had several pyramid like structures made up of a base in cortex and an apex fused with other apices to form a single renal crest or common papilla (Sisson and

Grossman, 1975; Nickel *et al*., 1979; Dyce *et al*., 2010 in dogs and small ruminants; Pereira-Sampaio *et al*., 2009 in dog; Singh 2013 and Buys-Goncalves *et al*., 2016 in sheep). Pereira-Sampaio *et al*. (2009) mentioned that in dog kidneys the recesses were U-shaped projections of renal pelvis and their number varied from 9 to 17 each in both kidneys. In sheep kidneys, Buys-Goncalves *et al*. (2016) described these recesses as expansions of the renal pelvis cavity which were filled with renal medullary pyramids in both dorsal and ventral surfaces of the collecting system. Their number varied from 11 to 19.

Several authors described that the kidneys of small ruminants and dogs were unipapillary or nonpapillated in structure. A common papilla or renal crest was formed by fusion of six to twelve pyramids in center of the kidney. Urine produced was drained into the renal pelvis from a single linear region, the renal crest which is positioned along the center of the kidneys in these animals. Narrow grooves were present in between the neighbouring recesses into which the interlobar arteries and veins ascended towards the cortex in dogs and small ruminants (Nickel *et al.,* 1979; Pereira-Sampaio *et al*., 2009 in dogs; Dyce *et al*., 2010; Singh, 2013 and Buys-Goncalves *et al*., 2016 in small ruminants).

Equine renal pelvis was funnel-shaped dorso-ventrally flattened cavity in craniocaudal direction. Multiple papillary ducts from central part of kidney opened along three cm long renal crest that protruded into a renal pelvis. They opened into 2 long (5–10 cm), narrow terminal recesses that terminated on either end of renal crest (Nickel *et al*., 1979; Dyce *et al*., 2010 and Pasquel *et al*., 2013). Sisson and Grossman (1975), Nickel *et al.* (1979), Konig and Leibich (2004) and Dyce *et al.* (2010) mentioned that in all domestic animals the ureter was a narrow tube which conducted urine in a continuous trickle from the renal pelvis to the bladder. It emerged out at the renal hilus and curved caudally towards the pelvic inlet assuming a slightly medial retro-peritoneal course. In abdominal part it lies against the psoas muscles crossing the large terminal branches of the aorta and caudal vena cava ventrally. Its pelvic part entered the genital fold or broad ligament crossing the internal genital ducts and pierced the dorsal wall of the neck of bladder at an acute angle. Several authors have claimed that the ureteric diameter in upper part was significantly greater than the lower part in the domestic animals (Sisson and Grossman, 1975; Nickel *et al*., 1979; Konig and Leibich, 2004 and Dyce *et al*., 2010) and in one-humped camel (Monjezi *et al*., 2014).

Materials and Methods

Specimens collected were carefully washed in normal saline solution and extra fat around the kidneys and ureters was removed by gentle dissection. Morphology of the RCS of goat was studied by macroscopic dissection and corrosion cast technique.

Macroscopic Dissection

Formalin fixed paired kidneys along with the ureters were used for macroscopic dissection by using magnifying lens and teasing needle. Eosin dye was injected into the kidneys through ureters for effective

 DOI 10.5455/ijlr.20191015055806

visualization of the renal pelvis, their structures like recesses and renal papilla. Gross observations of the renal pelvis and their structures were studied after gentle dissection. Description regarding the shape, size of the renal pelvis; number of recesses in both left and right kidneys were recorded. Photographs of macroscopic details of RCS were taken and documented accordingly.

Morphometrical Studies

Morphometrical observations of the RCS such as the height and width of the renal pelvis and their structures were recorded. The length and width of both the ureters of goats were recorded at three levels *i.e.* close to the kidney, mid part of its course and close to the urinary bladder with a thread, scale and digital Vernier calliper's (Mitutoyo). Basic statistical values such as mean and S.E were calculated and tabulated (George and Cochran, 1994).

Corrosion Cast Technique

Morphological features of the renal collecting system (RCS) in goat were studied by corrosion cast method as per the procedure described by Buys-Goncalves *et al*. (2016) with slight modification of the technique to suit local needs. Procedure (Slight modification to Buys-Goncalves *et al*., 2016 technique):

1. Paired kidneys of goat were flushed with warm normal saline solution through the ureters to clear the lumen.
2. Replacing "polyester resin" (Buys-Goncalves *et al.*, 2016) with locally available cold cure self-polymerizing acrylic powder (used as dental repair material / dental filling material) and solution was made in a 1:2 ratio to which few drops of yellow color dye was mixed.
3. The coloured dye was injected into cannulated ureter to fill the RCS of goat kidney and the ureters were clamped and kept at room temperature for effective polymerization.
4. Subsequently, the specimens were immersed in a glass container containing 75% HCl till the corrosion process was completed.
5. The specimens were cleaned, dissected and RCS was exposed.
6. Shape, location and relations of renal crest, pelvis and its structures were recorded and photographed.
7. Morphometry of RCS in terms of length and width were recorded by adopting thread and scale method and Statistical analysis was done as per George and Cochran (1994).

Results and Discussion

Macroscopic Details

RCS of goat revealed a wide funnel shaped renal pelvis which continued to emerge out as the ureter (Fig. 1). The latter coursed caudally to end in urinary bladder. Dorso-ventral cross section of the mid region of the kidney showed a renal sinus surrounded by renal fat in which the renal pelvis was lodged. A large oval shaped renal papilla was seen in mid region of kidney which formed due to merging of several papillae of renal pyramids (Fig. 2). Apex of these pyramids fused with the apex of a large central pyramid to form a single renal papilla or renal crest in center of kidney which was surrounded by wall of renal pelvis (Fig. 2).

 DOI 10.5455/ijlr.20191015055806

These observations are similar to the renal pelvis described in sheep and dog by Nickel *et al*. (1979), Pereira-Sampaio *et al*. (2009), Singh (2013) and Buys-Goncalves *et al*. (2016). Funnel shaped renal pelvis on its dorsal and ventral surfaces comprised 12 'U' shaped recesses among which 5 each were dorsal and ventral, whereas one each were in anterior and posterior position (Fig. 1). These findings slightly differed with dog kidneys described by Pereira-Sampaio *et al*. (2009) and our findings were similar to the recesses in sheep kidneys described by Buys-Goncalves *et al*. (2016).

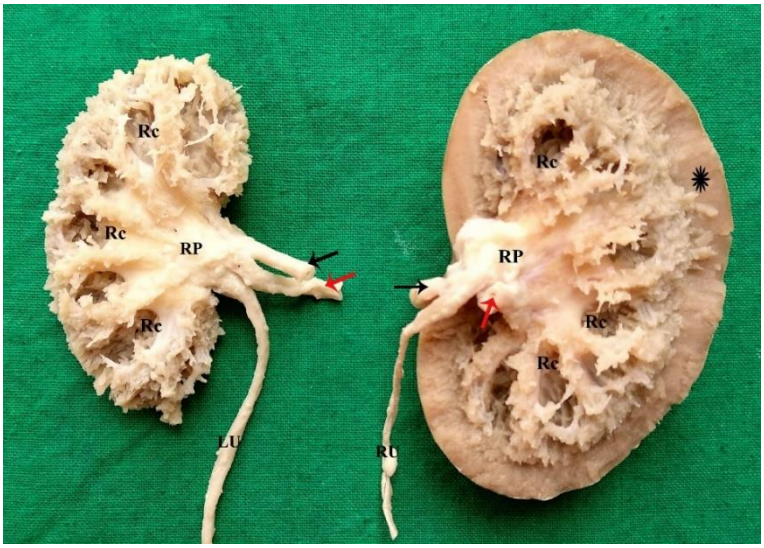

Fig. 1: Photograph showing partially dissected dorsal surface of left and right goat. Kidneys with structures of renal pelvis and ureters. (Rp – Renal pelvis * – Cortex Rc – Renal recesses →Renal artery; Lu – Left ureter →Renal vein Ru – Right ureter

Numerous renal pyramids were lodged in these recesses between which inter lobar arteries ascending in tiny inter recess spaces were observed. Covering these recesses was a mass of tissue which is the microscopic collecting system. These findings are in agreement with the reports of Nickel *et al*. (1979), Pereira-Sampaio *et al*. (2009) in dogs, Singh (2013) and Buys-Goncalves *et al*. (2016) in sheep. There were no calices in the kidneys of goats, instead 'U' shaped recesses were present into which renal parenchyma forming individual renal pyramids fitted into it. Ureter converged from the underside of the wide renal pelvis and emerged out from the renal hilus (Fig. 1). It was surrounded by renal fat all through its course up to its opening into dorsal wall of the neck of urinary bladder.

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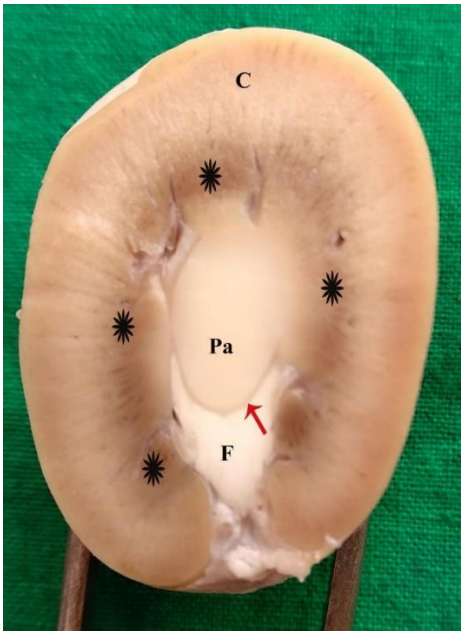

Fig. 2: Photograph of dorso-ventral C/S of goat kidney showing large renal papilla (Pa), renal pelvis and renal fat (F) present in renal sinus. (→ Renal pelvis * Renal pyramids C – Cortex)

Corrosion Cast Features

Corrosion casts of the RCS in goats revealed a wide renal pelvis with several recesses on its margin. These were 'U' shaped shallow structures pointing towards the dorsal and ventral surfaces (Nickel *et al*., 1979 in small ruminants, Pereira-Sampaio *et al*., 2009 in dogs, Singh, 2013 and Buys-Goncalves *et al*., 2016 in sheep) whereas few were directed towards the cranial and caudal poles (Fig. 3). Their number varied from 12 to 15 of which majority of them faced the surfaces *i.e.*, six specimens had 5 dorsal and 5 ventral recesses (Fig. 3), whereas as three specimens had 6 each on both surfaces (Fig. 4). In one specimen less than five recesses were seen in both kidneys. There were more recesses on the dorsal surface than the ventral surface in the specimens studied (Table 1).

DOI 10.5455/ijlr.20191015055806

Fig. 3: Photograph of dorsal surface of corrosion cast of one goat kidney. Showing five recesses (numbered 1,2,3,4 and 5). (U – Ureter * – Renal pelvis)

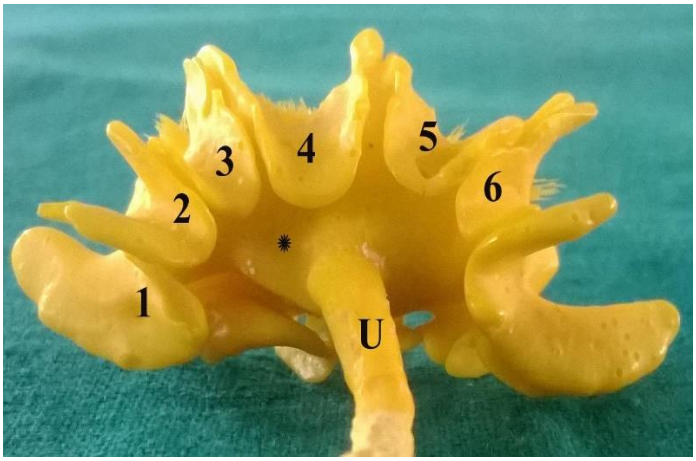

Fig. 4: Photograph of ventral surface of corrosion cast of one goat kidney showing six recesses (numbered 1,2,3,4,5 and 6). (* - Renal pelvis U – Ureter)

In goats the typical calices which are present in omnivores and large ruminants were absent. A groove formed by renal crest was observed on the mid line of the pelvis in casts studied. The surface called renal crest faced towards the cortical region of the kidney and was a convex one on which several small papillary ducts opened (Fig. 5). These findings are in agreement with several authors like Nickel *et al*. (1979) in small ruminants, Pereira-Sampaio *et al*. (2009) in dogs, Singh (2013) and Buys-Goncalves *et al*. (2016) in sheep. Above findings are in partial agreement with description of equine renal pelvis by Nickel *et al*. (1979), Dyce *et al*. (2010) and Pasquel *et al* (2013). They noticed multiple papillary ducts from central part of kidney opening along three cm long renal crest that protruded into a renal pelvis.

DOI 10.5455/ijlr.20191015055806

Table 1: Number of 'U' shaped recesses per kidney in goats

Specimen No.	Dorsal surface	Ventral surface	Anterior pole	Posterior pole	Total
1	6	6	1	1	14
2	6	6	1	1	14
3	5	5	1	1	12
4	5	5	1	1	12
5	5	5	1	1	12
6	5	5	1	1	12
7	7	6	1	1	15
8	6	7	1	1	15
9	6	5	1	1	13
10	5	5	1	1	12
11	6	6	1	1	14
12	5	5	1	1	12
MEAN	5.58	5.5	1	1	13.08
SE	0.19	0.19	0	0	0.35

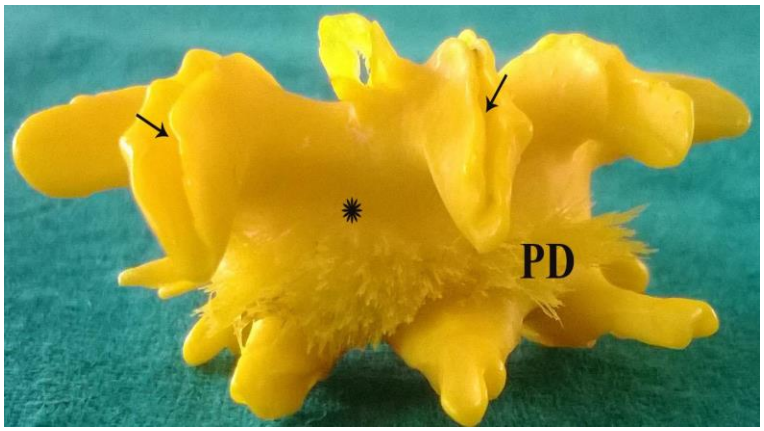

Fig. 5: Photograph of corrosion cast of goat kidney showing numerous small ducts.

(★ - Renal crest PD - Papillary ducts mass → inter recess space)

No statistical difference was found between the number of pelvic recesses in left and right kidneys or their association with the dorsal and ventral surfaces of the same specimen. There was one recess on each pole of the renal pelvis in all 3D endo casts studied. The renal crest on it's under surface formed a dome shaped renal pelvis from which the ureter arose to emerge out of the hilus (Fig. 3). In between the walls of the recesses there were narrow inter spaces (Fig. 3, 4 and 5) into which the branches of the inter-lobar renal arteries ascended (Fig. 6). In all corrosion cast specimens studied the ureter arose from the under surface of the renal pelvis and had a slightly smaller diameter than its caudal course.

DOI 10.5455/ijlr.20191015055806

Fig. 6: Photograph showing partially dissected dorsal surface of right goat kidney showing interlobar arteries (⟶ in tiny inter recess spaces. (★ – Renal recesses U – ureter P – Pyramids)

Morphometry

In corrosion cast specimens the mean height and width of the renal pelvis of goat was 12.31±1.29mm and 20.43±0.77mm respectively (Table 2 and Plate 1). In fresh state the mean length of right ureter was 31.55±1.81cm which is greater than the left ureter (24.98±1.07cm) which is significant (Table 3and Plate 2). These results are in accordance with Sisson and Grossman (1975) and Nickel *et al*. (1979). The luminal diameter of goat ureter from proximal part increased from 2.19±0.18 mm to 3.03±0.18mm in distal part. These results are not correlated with the reports of Konig and Leibich (2004) in domestic animals and Monjezi *et al*. (2014) in camel. There was no significant difference in the diameter of right and left ureters within the same animal (Table 3 and Plate 3).

Table 2: Morphometric measurements showing the width and height (in mm) of renal pelvis in goat kidney (millimetres)

	Goat – renal pelvis	
Specimen No.	**Width**	**Height**
1	18.2	7.2
2	22	15
3	20	12
4	22.5	16
5	18.3	13
6	21.6	10.7
Mean	20.43	12.31
SE	0.77	1.29

DOI 10.5455/ijlr.20191015055806

Table 3: Morphometric measurements of left (L) and right (R) ureter of goat showing length and diameter at three different levels.

Specimen No.	Length (in cm)		Diameter (in mm)					
			Proximal		Middle		Caudal	
	L	R	L	R	L	R	L	R
1	24	30.3	1.6	1.8	1.98	2.01	2.7	2.4
2	27	36	2.1	2.2	2.4	2.3	2.5	2.7
3	23	28	2.4	2.5	2.8	2.9	3.3	3.5
4	29	38	2.6	2.5	2.9	2.9	3.4	3.6
5	21.9	27	1.7	1.9	1.9	2.6	2.9	3
6	25	30	2.6	2.25	2.5	2.6	2.9	3
Mean	24.98	31.55	2.16	2.19	2.41	2.55	2.95	3.03
SE	1.07	1.81	0.18	0.12	0.16	0.14	0.14	0.18

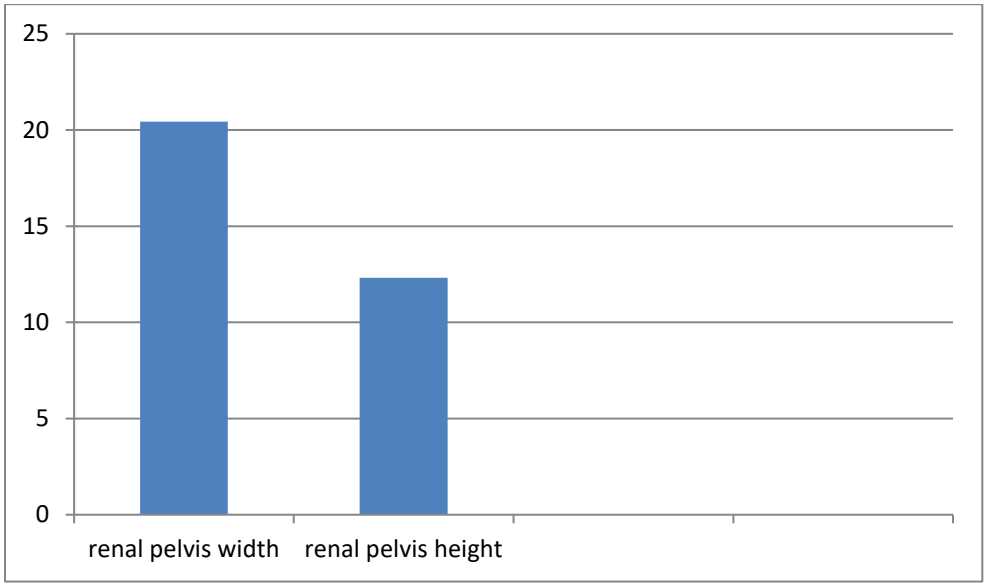

Plate 1: Mean values of width and height of renal pelvis in goat kidney (in mm).

DOI 10.5455/ijlr.20191015055806

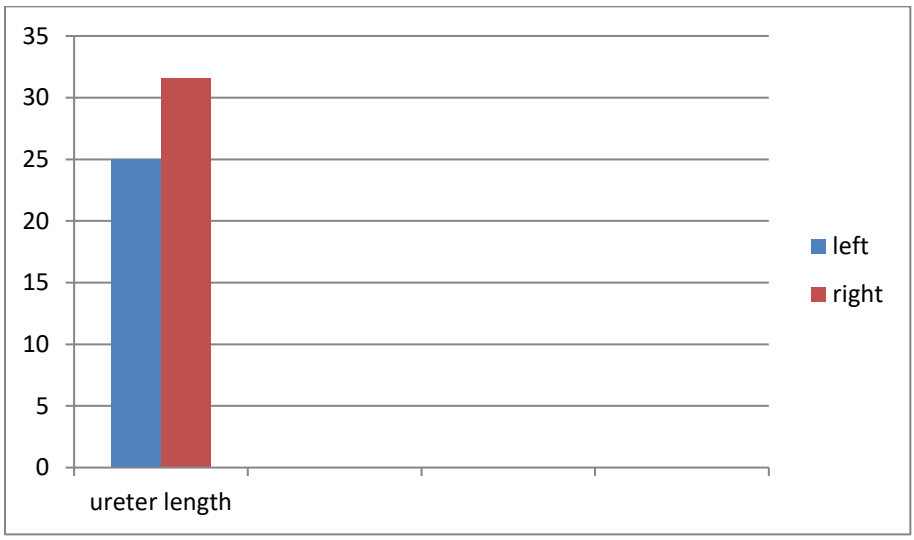

Plate 2: Morphometric observations of mean length of left and right ureter of goat (in cm).

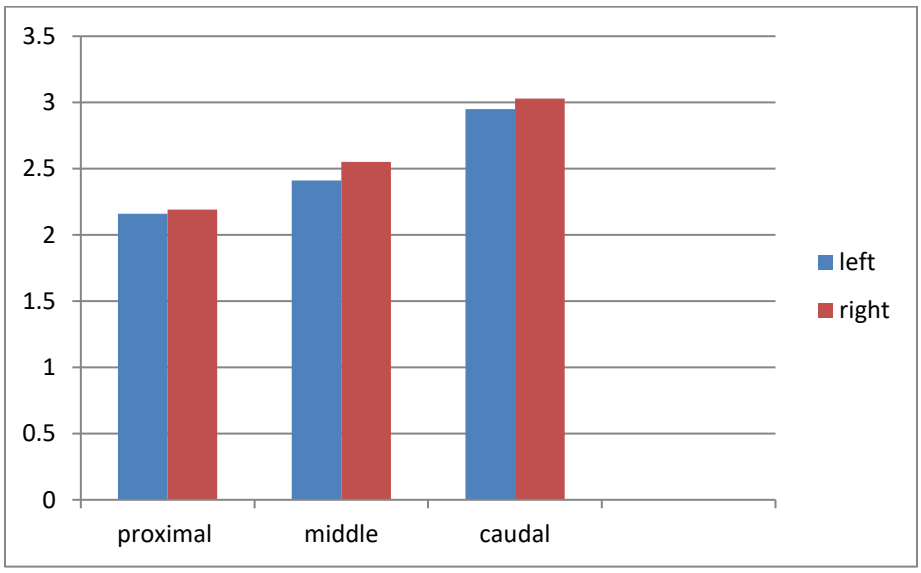

Plate 3: Mean values of diameter of left and right ureters of goat from proximal to distal part (in mm).

Conclusion

The findings of the present study enrich the information about the morphometry of the RCS of the goat. An adequate knowledge of the morphometric aspects and the characterization of the renal pelvis facilitates the performance of non-invasive surgical procedures, with the resulting prevention of iatrogenic injuries. Thus, the goat model allows for excellent training for the skills required for the manipulations of the pyelocalyceal system.

DOI 10.5455/ijlr.20191015055806

Acknowledgement

The authors are very thankful to the P. V. Narsimha Rao Telangana Veterinary University to carry out the present work.

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 DOI 10.5455/ijlr.20191015055806