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Microscopic features of the renal collecting system in goat (*Capra hircus*)



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Abstract

Histological features of goat Renal Collecting System (RCS) revealed collecting tubules lined by simple cuboidal epithelium forming papillary ducts deep in medulla. Epithelium changed to transitional type at the tip of renal crest which had numerous papillary duct openings. Renal pelvis lined by transitional epithelium. Sub epithelial tissue of renal pelvis consisted thick wavy bundles of collagen fibres. Thickness of renal pelvis wall decreased towards the edges of renal crest. Inner mucosa of ureter showed 5 to 8 folds projecting into the lumen giving it a star shaped structure. Transitional epithelium of 8 to 10 cell layers lined the ureter below which was propria-submucosa. Tunica muscularis of ureter had three layers of which the inner layer was inconstant, whereas the middle layer was distinctly circular and continuous. Renal pelvis and ureteral segments showed mild reaction to PAS and PAS-AB which was restricted to surface lining of epithelium and basement membrane.

Keywords: Renal collecting system, goat, transitional epithelium, renal pelvis, ureter

1. Introduction

Renal collecting system (RCS) of small ruminants and dog kidneys includes the collecting and papillary ducts, renal crest, renal pelvis and ureter. Renal pelvis is a common cavity around the renal crest lined by transitional epithelium, into which fused renal papilla (renal crest) open. Collecting tubules are lined by simple cuboidal epithelium. Papillary ducts are lined by tall cuboidal epithelium and opens on renal crest or common papilla. Transitional epithelium lines the renal crest.

1.1 Review of literature

The papillary ducts or inner medullary collecting ducts in adult kidney of domestic animals were lined by tall cuboidal or simple columnar epithelium which changed to transitional before opening into the papilla (Aughey and Frye, 2001; Eurell and Frappier, 2006 and Bacha and Bacha, 2012)^[1, 5, 2]. Similar observations were made by Singh (2013)^[10] in the renal papillary ducts in sheep.

Chaudhury *et al.* (2006)^[4] studied the histo-architecture of excretory portions of metanephros of goat foeti of either sex at different stages of gestation. In Group I (31-60 days) the papillary ducts were located in renal medulla lined by simple columnar epithelium. The oval nuclei of epithelium were situated more towards the luminal side whereas in Group II (61-90 days) they were placed closer to apical border of the cells. The position of nucleus continued up to the age of 105 days. Their cytoplasm showed mild to moderate PAS reaction in all age groups. Mild reaction to acid mucopolysaccharide was seen in Group I, while it was mild to moderate in remaining groups.

Monika and Neelam (2010)^[7] stated that buffalo foeti (from 4.1 cm CVRL onwards) comprised collecting ducts lined by two types of cells viz. light and dark cells. The light cells were more in number as compared to the dark cells and showed pale cytoplasm due to less number of organelles. The authors concluded that these ducts ultimately formed the large papillary ducts which terminated at the renal papilla.

Histologically both the ureter and the renal pelvis of domestic animals have a similar structure except that the latter is a complete tubular organ. Renal pelvis was lined by transitional epithelium which was 3-10 cell layer thick. Several blood vessels were seen coursing along the base of sub-epithelial tissue in pigs (Woldemeskel *et al.*, 1998)^[13] and in domestic animals (Eurell and Frappier, 2006)^[5].

Three cell types were seen in the epithelium viz. basal cells, the intermediate cells and superficial squamous cells. Superficial cells showed less intensely with toluidine blue when

compared with the intermediate and basal cells in pig (Woldemeskel *et al.*, 1998) [13].

Propria-submucosa of renal pelvis of domestic animals consisted few lymphocytes and blood vessels. Tunica muscularis was ill defined three layered smooth muscle structure with an inner longitudinal, middle circular and outer longitudinal layers. Tunica adventitia consisted loose connective tissue with numerous small blood vessels and nerve fibres (Aughey and Frye, 2001 and Eurell and Frappier, 2006) [1, 5].

In horses simple branched tubule-alveolar mucous glands were present in the mucosa of renal pelvis which contributed to the viscous, stringy nature of equine urine (Aughey and Frye, 2001; Eurell and Frappier, 2006 and Bacha and Bacha, 2012) [1, 5, 2]. Pasquel *et al.* (2013) [9] reported that terminal recesses were lined with transitional urothelium similar to that covering the renal crest and renal pelvis of horses.

Chaudhury *et al.* (2006) [4] reported the renal pelvis of 50 days goat foeti was lined by 2 – 4 layered transitional epithelium. Few cells dipped down into the surrounding mesenchyme and formed chains and clusters at few places indicating a continuous process of development of papillary ducts. Lamina propria contained mesenchymal cells amongst fine reticular and collagen fibres.

Ureter was a thick walled circular tubular structure with a star shaped lumen in domestic animals (Eurell and Frappier, 2006) [5], in goat (Smita *et al.*, 2006) [12] and in buffalo foetuses at 25.0 cm CRL (Bansal *et al.*, 2006) [3]. These authors described three layers in ureter wall *viz.*, tunica mucosa, muscularis, and adventitia. Tunica mucosa was subdivided into epithelium and propria-submucosa.

Ureter mucosal surface comprised a folded transitional epithelium with three to six cell layers. Most of these layers showed clear and vacuolated cytoplasm. Flattened surface cells had a regular margin facing the lumen and they were polyhedral with rounded nucleus and a prominent nucleolus. Typical pyriform cells of the second layer were not seen whereas basal cells were cuboidal and form a row in pig (Woldemeskel *et al.*, 1998) [13], in goat (Smita *et al.*, 2006) [12], in domestic animals (Eurell and Frappier, 2006) [5] and in one-humped camel (Monjezi *et al.*, 2014) [8].

Smita *et al.* (2006) [12] stated that many tubular alveolar glands were seen in the propria-submucosa present at different layers. Few were just at the depth of the epithelium, while others were nearer to the muscular layer in goat ureter. The glandular epithelium was very thin with flattened or short cuboidal cells.

Simple branched tubuloalveolar glands were seen amongst muscularis mucosa of the proximal part of pig ureter (Woldemeskel *et al.*, 1998) [13] and also in the proximal part of ureter in horses (Aughey and Frye, 2001; Eurell and Frappier, 2006 and Bacha and Bacha, 2012) [1, 5, 2].

Smita *et al.* (2006) [12] cited that the tunica muscularis of ureter in goat consisted smooth muscles arranged in three layers, both an outer and inner longitudinal layer with a much thicker circular layer in between (also reported by Eurell and Frappier, 2006 in small ruminants) [5]. Innermost longitudinal muscle layer was the thinnest.

Tunica muscularis in the ureter of one-humped camel was arranged in two layers *viz.*, circular and longitudinal. These layers were mixed and intermingled. Collagen and elastic fibers were seen between the muscles. The longitudinal layer was thinner than the circular layer and is composed of bundles that were located between the circular muscles. The thickness

of the tunica muscularis and tunica adventitia was significantly greater in the upper parts than in the lower parts (Monjezi *et al.*, 2014) [8].

Tunica adventitia of ureter is composed of areolar connective tissue with blood, lymph vessels, and nerves in domestic animals (Eurell and Frappier, 2006) [5], in buffalo foetus at 25.0 cm CRL (Bansal *et al.*, 2006) [3], in one-humped camel (Monjezi *et al.*, 2014) [8], in goats which also had thick tunica adventitia with large muscular arteries (Smita *et al.*, 2006) [12]. Bansal *et al.* (2006) [3] revealed that the histology of the buffalo foetal ureter showed a lamina epithelialis comprised of 3-5 cell layers of transitional epithelium. The differentiation of superficial and basal layers of transitional epithelium was observed in the ureter of buffalo foetuses at 25.0 cm CRL. The epithelium was thin as compared to adult animals. A moderate to strong PAS reaction was observed in the ureteral epithelium. It was found to be strong in the superficial layer and moderate to weak in the basal layer of lamina epithelialis. They cited that the lamina propria submucosa consisted large number of collagen fibers along with few elastic and reticular fibers amongst which diffuse lymphocytic tissue and capillary plexus were very few. Tunica muscularis was mainly made up of circularly arranged smooth muscle cells. One or two bundles of longitudinal muscles were seen occasionally towards the propria submucosa during foetal life which developed as inner longitudinal muscle layer in adult buffaloes.

Bansal *et al.* (2006) [3] further stated that the muscle layer was better developed with the advancement of gestation, as the outer layer of longitudinal muscles could not be demonstrated in the ureter of buffalo foetuses. It may be concluded that the outer longitudinal muscle layer is formed in later stages of prenatal life. All the layers of buffalo foetal ureter were well differentiated histo-morphologically at 25.0 cm CRL except tunica muscularis in which only circular layer of smooth muscles were developed.

2. Materials and methods

To study the detailed microscopic features, fresh kidney tissue samples were collected from 12 pairs of specimens along with left and right ureters of goat. Samples were taken at three places of the ureter *viz.*, one closer to the hilus (proximal part), other in the mid course of the ureter, and the third closer to the bladder (caudal part). Immediately they were preserved in 10% NBF solution and later processed for routine paraffin method (Singh and Sulochana 1998) [11]. About 4-5 μ m thick paraffin sections were obtained and subjected to the following staining techniques:

1. Haematoxylin and Eosin (H & E) method to study the detailed histological features (Singh and Sulochana, 1998) [11].
2. Masson's Trichrome method for differential staining between collagen and muscular fibers (Singh and Sulochana, 1998) [11].
3. Periodic Acid Schiff method (PAS) for mucopolysaccharides (Luna 1968) [6].
4. PAS-Alcian blue method for acid and neutral mucopolysaccharides (Singh and Sulochana, 1998) [11].

3. Results and Discussion

3.1 Collecting tubules and papillary ducts

Numerous collecting tubules lined by simple cuboidal epithelium arose at regular intervals forming medullary ray like appearance in the renal parenchyma (Figs. 1 and 2) which

extended from cortical zone to medulla portion of the kidney. Between two such medullary ray like arrangement the renal tissue formed a renal column which comprised cortical and medullary portions of the kidney.

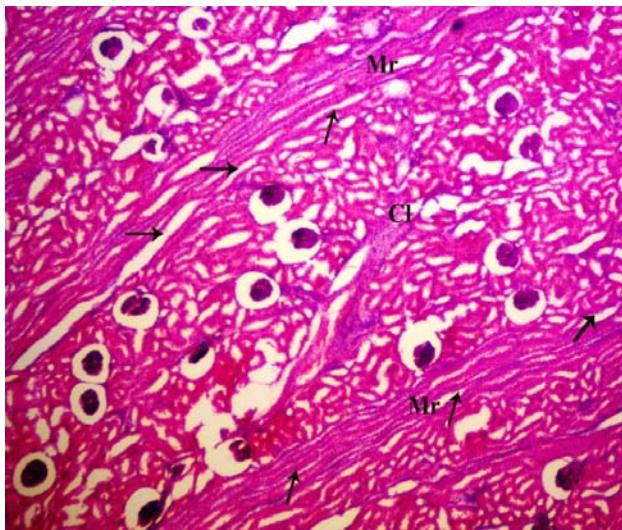


Fig 1: Photomicrograph of goat renal cortex showing collecting tubules forming medullary rays. (H & E 10X)

→ - collecting tubules Mr - medullary rays Cl - cortical labyrinth

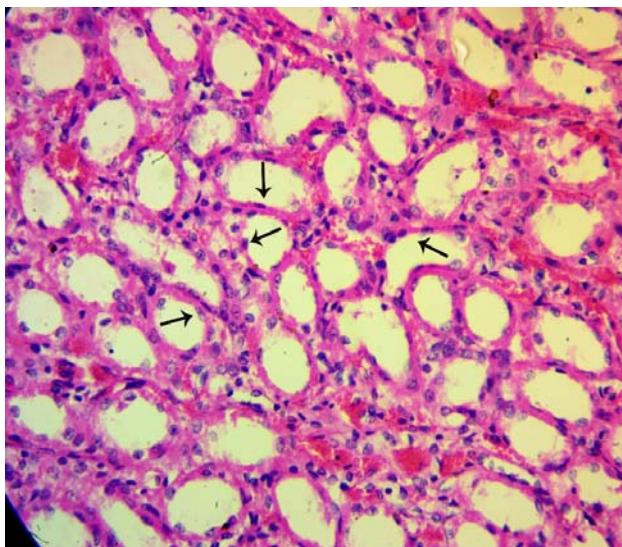


Fig 2: Photomicrograph of goat renal medulla showing simple cuboidal epithelium (→) lining collecting tubules. (H & E 40X)

Papillary ducts were formed by several collecting tubules and were deep in the medulla (Fig. 3). These ducts were lined tall cuboidal epithelium with a spherical centrally placed nucleus. These observations concur with reports of Aughey and Frye (2001)^[1], Eurell and Frappier (2006)^[5] and Bacha and Bacha (2012)^[2] in domestic animals and papillary ducts in buffalo foeti (Monika and Neelam, 2010)^[7] and in sheep (Singh 2013)^[10]. They also cited that papillary or inner medullary collecting ducts in adult kidneys were lined by tall cuboidal or simple columnar epithelium which changed to transitional before opening into the papilla.

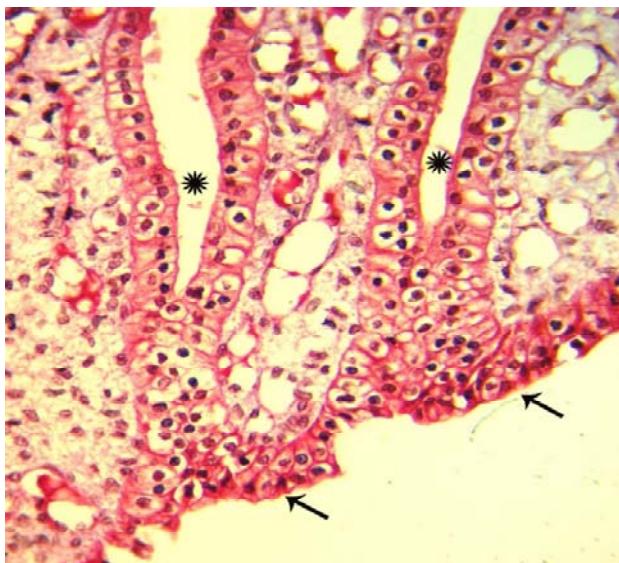


Fig 3: Photomicrograph of goat renal papilla showing two layer epithelium in papillary ducts and transitional epithelium on renal crest. (Masson's Trich- 40X) → - Epithelium * - Papillary ducts

In this study the papillary ducts coursed through the medulla to reach the renal crest (Figs. 3 and 4). During the course of the papillary ducts the epithelium being a single layer changed gradually to two layers (Fig. 3) and became more than two cell layers forming a transitional type of epithelium on the tip of the renal crest (Fig. 3 and 4). Entire length of the renal crest was lined by transitional epithelium of 4-5 cell thickness resting on a basal lamina over a bed of connective tissue (Figs. 3 and 4). The crest had numerous openings into the renal pelvis which were openings of the papillary ducts. The epithelial surface of ducts and crest reacted moderately to PAS and PAS-AB. These findings agree with Chaudhury *et al.* (2006)^[4] who stated that cytoplasm of excretory ducts of metanephros of goat foeti showed mild to moderate PAS reaction in all age groups.



Fig 4: Photomicrograph of goat renal pelvis and renal crest showing transitional epithelium. (Masson's Trich-4X) P - Papillary ducts Rc - Renal crest Rp - Renal pelvis Te - Transitional epithelium

3.2 Renal pelvis and recesses

In this present study goat renal pelvis was a wide funnel shaped cavity lined by transitional epithelium consisting of 8 - 12 cell layers (Fig. 5). Three cell types were seen in the

epithelium lining the renal pelvis viz., basal, intermediate and superficial cells (Figs. 5 and 6). Basal cells were smaller and darkly stained cells located on the basement membrane. Intermediate cells were spherical with a clear nucleus and formed the bulk of this epithelium. Superficial cuboidal cells covered the free luminal surface of the renal pelvis (Fig. 6). These reports coincided with the description of renal pelvis in pigs by Woldemeskel *et al.* (1998)^[13], in goat foeti by Chaudhury *et al.* (2006)^[4] and in domestic animals by Eurell and Frappier (2006)^[5] who cited a 3-10 cell layer thick transitional epithelium. Propria-submucosa was relatively thin and populated with blood vessels, nerve fibres, collagen and few elastic fibres.

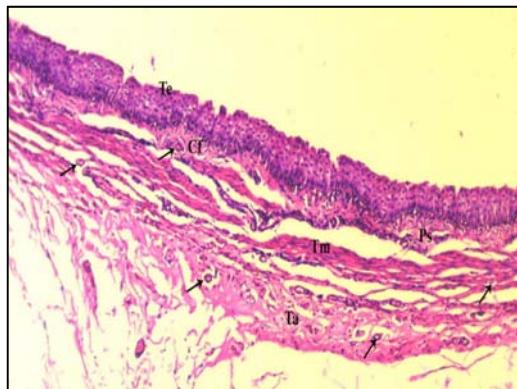


Fig 5: Photomicrograph of L/S of goat renal pelvis showing transitional epithelium (Te). (H & E 10X) Ps – Propria – submucosa
Cf – Collagen fibres Tm – Tunica muscularis → Blood vessels Ta – Tunica adventitia

Sub epithelial tissue in central portion of the renal pelvis consisted thick wavy bundles of collagen fibres (Fig. 6) below which smooth muscle fibres in typical arrangement was observed in tunica muscularis (Figs. 5 and 6). Blood vessels were noticed in between the smooth muscle fibres of this region. Similar features were cited by other authors who reported few lymphocytes and blood vessels in propria-submucosa of renal pelvis (Chaudhury *et al.*, 2006 in goat foeti and Aughey and Frye 2001; Eurell and Frappier, 2006 and Bacha and Bacha, 2012 in domestic animals)^[4, 1, 5, 2].

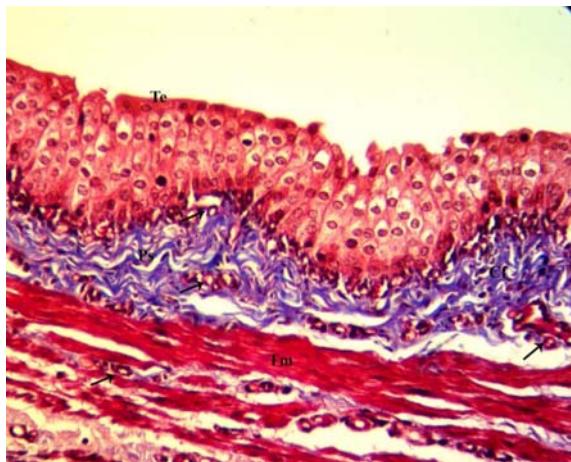


Fig 6: Photomicrograph of L/S of goat renal pelvis showing transitional epithelium (Te). (Masson's Trich-40X) Ps – Propria – submucosa Cf – Collagen fibres → Tm – Tunica muscularis
Blood vessels

Renal recesses were narrow spaces lined by transitional epithelium consisting two cell layers below which was loose connective tissue in which large blood vessels were seen (Fig. 7). At junction with wall of the renal pelvis the recesses epithelium increased to 4 - 5 cells thick. Propria-submucosa was indistinct in this junction and adventitia consisted of blood vessels and nerve fibres (Fig. 7). Thickness of the wall of the renal pelvis decreased towards the edges of the renal crest (Fig. 4) and thickness of all layers in the wall of the renal pelvis except tunica adventitia was found to decrease towards the renal papilla. The transitional epithelium is thin with a thick connective tissue layer in the walls of the renal pelvis close to its junction with recesses (Fig. 7). Akin to this study Pasquel *et al.* (2013)^[9] reported that terminal recesses were lined with transitional urothelium similar to that covering the renal crest and renal pelvis in horses. However, in goat renal pelvis mucus glands were absent in propria-submucosa unlike in horses wherein simple branched tubulo-alveolar mucous glands were seen in mucosa of renal pelvis which contributed to the viscous, stringy nature of equine urine (Aughey and Frye 2001; Eurell and Frappier, 2006 and Bacha and Bacha, 2012)^[1, 5, 2].

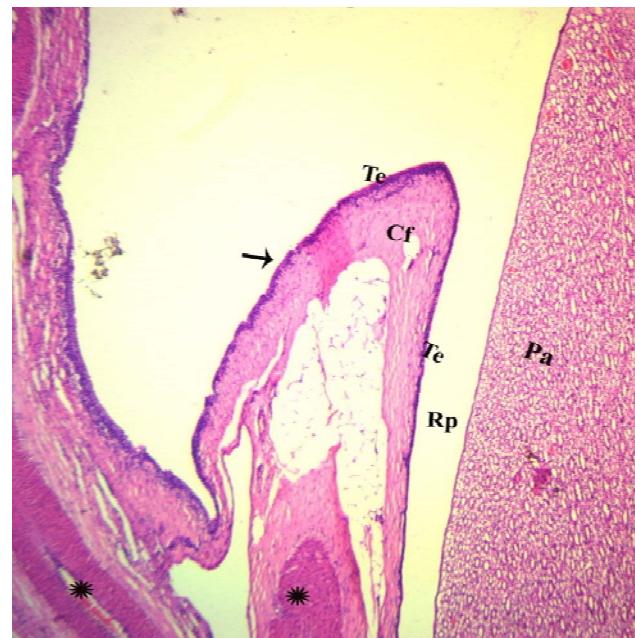


Fig 7: Photomicrograph of L/S of renal recess, renal pelvis (Rp) and papilla (Pa) of goat showing transitional epithelium (Te). (H & E 4X) Cf – Collagen fibres → Renal recess * - Blood vessels

Pyelo-ureteral junction was situated in between the wall of renal pelvis and wall of the ureter. The epithelium was thicker with circular smooth muscle bundles at the junction in tunica muscularis. Renal pelvis continued to form the origin of ureter wherein the propria-submucosa comprised relatively thick bundles of collagen fibres over tunica muscularis (Fig. 8). In this study surface lining of epithelium and basement membrane of renal pelvis reacted moderately to PAS and PAS-Ab (Fig. 8).

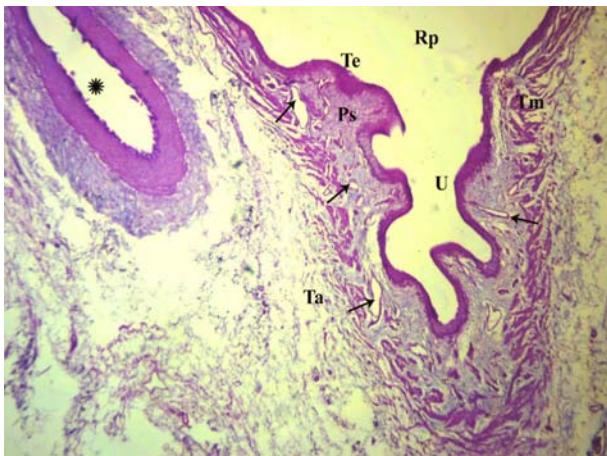


Fig 8: Photomicrograph of L/S of pyelo-ureteral junction of goat showing circular smooth muscle bundles and blood vessels (→). (PAS-AB 4X) * - Renal artery Rp - Renal pelvis Te - Transitional epithelium Tm - Tunica muscularis Ps - Propria-submucosa Ta - Tunica adventitia U - Ureter

3.3 Ureter

In the present study all three segments (proximal, middle and distal) of right and left goat ureters consisted of four layers within outwards viz., tunica mucosa, lamina propria-submucosa, tunica muscularis and tunica adventitia respectively. Goat ureter in this study originated from renal pelvis and emerged out of the hilus. Its sub epithelial tissue consisted of collagen fibres which abruptly turn towards the ureter (Fig. 8). In all segments tunica muscularis consisted of relatively thick coat of smooth muscle cells mostly arranged in three layers, predominantly circular in nature (Figs. 9).

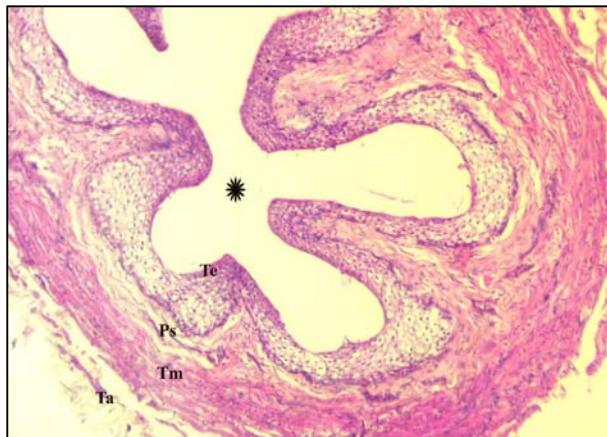


Fig 9: Photomicrograph showing C/S of goat ureter thick smooth muscle layers in mid part of the ureter. (H & E 10 X)
Te - Transitional epithelium Tm - Tunica muscularis
Ps - Propria-submucosa Ta - Tunica adventitia *- Lumen

Tunica mucosa in these ureteral segments showed 5 to 8 folds which projected interiorly forming a star shaped lumen. They were lined by thick transitional epithelium which consisted of 8 to 10 cell layers resting over a basement membrane (Figs. 9). Transitional epithelium of ureter showed clear and vacuolated cytoplasm in large cuboidal cells with a spherical nucleus. Three cell types were seen in the epithelium viz., compact basal cuboidal cell layer, an intermediate 4 - 5 cell thick polyhedral cell layer with a prominent nucleus and superficially placed squamous cell layer with an intense

nucleus (Figs. 10). Similar studies were recorded by other authors in domestic animals who stated that ureter was a thick walled circular tubular structure with a star shaped lumen in domestic animals (Eurell and Frappier, 2006) [5], in goat (Smita *et al.*, 2006) [12] and in buffalo foetuses at 25.0 cm CRL (Bansal *et al.*, 2006) [3]. These authors described three layers in ureter wall viz., tunica mucosa, muscularis, and adventitia. In mucosal folds the sub-epithelial connective tissue consisted of collagen fibres in plenty amongst which few blood vessels were seen (Fig. 10). The collagen fibres almost formed a membrane along the basal part of the epithelium with blood and lymph vessels. Propria-submucosa was wide and prominent at the lumen which became thinner between the folds.

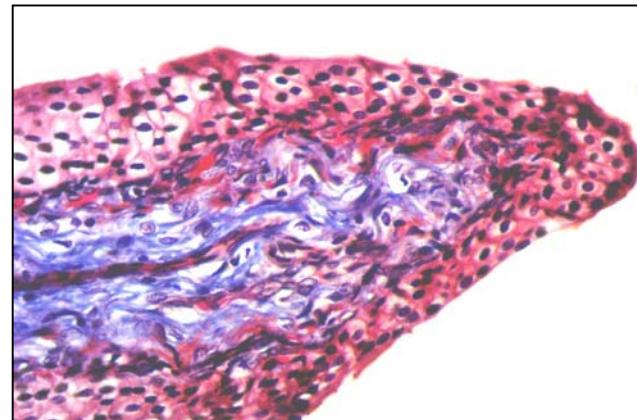


Fig 10: Photomicrograph of lamina propria of mucosal folds of goat ureter showing collagen fibres (Blue color) intermingled with few muscle fibres (Red color). (Mason's trichrome 40 X)

However, in this study there no glands in sub-epithelial zone of goat ureter which is in partial disagreement with Woldemeskel *et al.* (1998) [13] in pig; Aughey and Frye, 2001 [1]; Eurell and Frappier, 2006 [5]; Bacha and Bacha, 2012 [2] in horses and Smita *et al.* (2006) [12] who reported a thin glandular layer in mucosa of goat ureter. Presence of collagen fibres in mucosa and rest of the tunics in this study is also appreciated by above authors.

Smooth muscles in the tunica muscularis of goat ureter were arranged in three layers i.e., an outer and inner longitudinal muscle layer between which a thick circular smooth muscle layer was seen (Figs. 9 and 11). The inner longitudinal muscle layer was inconstant being very thin at some places or even scanty. Only the middle circular layer was distinct and continuous in all three ureteral segments. Blood vessels were seen in outer parts of the tunica muscularis. Similar reports were made by Eurell and Frappier (2006) [5] in domestic animals, Smita *et al.* (2006) [12] in goat and partial disagreement with Monjezi *et al.* (2014) [8] they stated that tunica muscularis in the ureter of one-humped camel was arranged in two layers viz., circular and longitudinal. These layers were mixed and intermingled. Tunica adventitia of goat ureter contained mostly loose connective tissue with blood vessels and nerve fibres (Fig. 11).

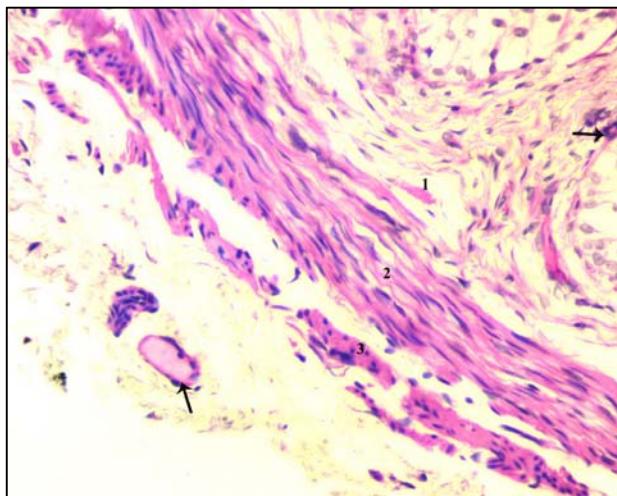


Fig 11: Photomicrograph of goat ureteral wall showing three layers of smooth muscle in tunica muscularis. (H & E 40 X) 1. Inner long. Layer 2. Middle circular layer 3. Outer long. layer

All three segments showed a uniform mild reaction to PAS and PAS-Ab method which was restricted to the surface lining of epithelium and basement membrane of ureter (Figs. 12). Thickness of tunica mucosa, muscularis and tunica adventitia increased significantly from proximal to distal portion of both left and right ureters which is in partial disagreement with Monjezi *et al.* (2014)^[8] in one-humped camel. There was no significant difference in thickness of propria-submucosa between various parts of ureter in left and right sides.

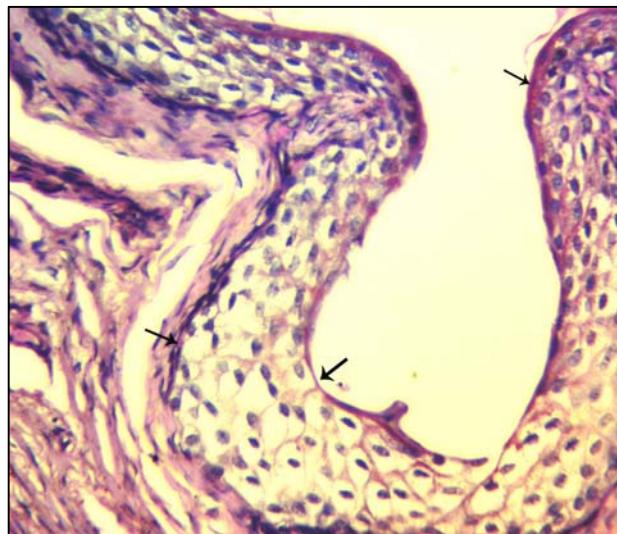


Fig 12: Photomicrograph of transitional epithelium of goat ureter showing mild reaction to PAS (→) on epithelium and basement membrane. (PAS 40 X)

4. Conclusion

Histological features of the goat RCS reported in this present study were similar with the other mammalian species except in one-humped camel.

5. Acknowledgement

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