Morphometric and Histological Studies of the Cecum in Mongrel Dogs

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Abstract: The anatomical and histological features of the dog cecum were studied in a five mongrel dogs. In spite of the diseased cecum didn't reveal a specific clinical signs on the living animal, several disorders have been reported to affect the cecum in dogs. Typhlectomy was indicated for such disorders. So, this study throws the light on the size, shape, location, blood supply, attachments and histological structure for the cecum in order to improve the outcome of this operation.

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1. Introduction:

Cecum is usually described as the first part of the large intestine, located to the right of the median plane, and usually within the duodenal loop **(Miller *et al.*,1993)**.

Cecum may be affected by several disorders such as impaction **(Wells *et al.*, 1995)**, perforation **(Moore and Robinette, 1987)**, dilatation (**Le Roux, 1962**), inversion **(Clark and Pavletic, 1992)**, intussusceptions **(Lewis and Ellison, 1987)** and neoplasia **(Kapatkin *et al.*, 1992).**

The cecum of the dog is an irregularly twisted tube which is attached to the ileum and ascending colon by short peritoneal folds (**Nickel *et al.*, 1979)**. **Yildiz *et al.*, 2006** reported that, the cecum, ascending colon, transverse colon, descending colon and rectum are segments of large bowel. It has an irregular blunt apex and ends with the ileocolic sphincter. The ascending colon and cecum are located at the termination of the ileum**.** Moreover **Miller *et al.*, (1993); Kumar (2004) and Budras *et al.*,*2007)*** mentioned that in dogs, the terminal part of the small intestine, communicated only with the colon, and the cecum exists as a diverticulum of the proximal portion of the colon.

Miller *et al.*, (1993) reported that, the communication of the cecum is with the beginning of the ascending colon by means of the cecocolic orifice, this opening lies approximately 1 cm from the ileocolic orifice. The cecocolic sphincter is a specialization of the inner circular muscular coat which guards the cecocolic orifice. The cecum is attached to the terminal portion of the ileum by fascia and peritoneum throughout most of its length. Also **Kumar (2004)** reported that, the cecum is attached to the distal portion of the ileum by an ileocecal peritoneal fold, the blood vessels pass through this fold.

The cecum is extremely variable in size and forms in the living animal. It is about 5 cm long and 2cm in diameter at its colic end. It is irregularly tapers to the rather blunt apex, which is less than 1 cm in diameter and usually point caudoventrally or is located transversely. When the cecum straightened, the length of the cecum is over twice than attached **(Miller *et al.*, 1993; Kumar, 2004 and Yildiz *et al.*, 2006). Nickel *et al.*, (1979)** reported that, the cecum of the dog is 8-30 cm long and that of cat is 2-4 cm long.

The cecum is consists of apex, body and base, located to the right of the median plane, and usually within the duodenal loop. It lies dorsal to and occasionally partly surrounded by the coils of the jejunum, ventral to the right transverse processes of the second to fourth lumbar vertebrae **(Miller *et al.*, 1993*).***

In addition **Nickel *et al.*, (1979) and Kumar (2004)** stated that, the general direction of the cecum is caudad, but its blind end is bent and often points craniad. The cecum is related ventrally to the ileum and jejunum, dorsally to the right kidney, laterally to the descending duodenum and right lobe of the pancreas, caudally to the duodenum, and medially to the root of the mesentery.

Dyce, Sack and Wensing (2002) stated that, the cecum is oriented crainocaudally, although its rounded blind end may finally point in any direction. The cecum communicates with the ascending colon through the cecocolic orifice adjacent to the ileal orifice. The cecum lies to the right kidney dorsally, the descending duodenum and pancreas laterally, and the jejunum ventrally. It lies below the second lumbar

joint and thus is broadly level with the most caudal part of the costal arch.

Miller *et al.* (1993) stated that, the cecum is sigmoid in shape, but more often it is in the form of an irregular corkscrew with a large U- shape kink extending to the left from its ileal attachment. He added that, the ileocecal artery continues across the dorsal surface of the ileocolic junction. It leaves the subserosa and disappears in the areolar tissue uniting the cecum to the ileum. It sends ileal branches to the ileum and cecal branches to the cecum. The main part of the vessel, after emerging from between the ileum and cecum, continues proximally in the ileocecal fold as the "ramus ilei anti mesenterialis". Moreover **Kumar (2004)** reported that, the cecum is attached to the distal portion of the ileum by an ileocecal peritoneal fold, the blood vessels pass through this fold. A smaller fold devoid of visible vessels extends from the base of the cecum to the ascending colon. The peritoneal folds affects the definitive form of the cecum which is somewhat coiled in appearance.

The ileocolic artery supplies the ileum, cecum, and ascending and transverse colon. It gives rise to the middle colic and right colic arteries. The right colic artery supplies the cecum, the ascending colon, and part of the transverse colon **(Miller *et al.*, 1993**). The cecum had lymphoid follicles formed lymphoglandular complex. In distinctively of adult dog, the openings of lymphoglandular complexes are seen on macroscopic examination of the mucosal surface. These fine openings were situated at the center of smooth rounded elevations approximately 3 mm in diameter, which were distributed uniformly throughout the cecum, both on and between irregularly disposed mucosal folds **(Atkins and Schofield, 1972**).

Microscopically the cecum of dogs and cats is consisting of four layers; outer serosa, musculosa, submucosa and inner mucosa. The mucosa is lined by a single layer of columnar epithelial cell interspersed with a large numbers of goblet cells. The surface of the mucosa is smooth without villi. The submucosa comprises connective tissue, blood vessels, lymphoid tissues and nerves. The submucosal blood vessels are normally visible through the thin mucosa on endoscopic examination. The muscular layer is composed of the outer longitudinal muscle fibers and inner circular muscle fiber. The serosa is a thin sheet of transparent connective tissue which is continuous with the peritoneum **(Fossum *et al.*, 2007).**

Gut-associated lymphoid tissue in the large intestine has been characterized in normal dogs. It is present as solitary lymphoid follicles throughout the large intestine. In addition, there are lymphoid patches at the ileocecal entrance and in the proximal colon. Histologically, lymphoid follicles forming units, termed lymphoglandular complexes which are lymphoid follicles in the submucosa that contain epithelial diverticula which extend from the mucosa **(Liebler, 1986)**.

The submucosal lymphoid nodules which form a part of lymphoglandular complexes are rounded or oval in section and their greatest diameters ranged between 0.1 and 0.4 cm. The nodules were closely applied to the deep aspect of the muscularis mucosa and they seldom occupied the whole thickness of the submucosa. The mucous membrane overlying the center of each lymphoglandular complex has a depression or a pit shape. From the depths of the pit, glands resembling mucosal glands extended into the submucosal lymphoid nodule through a localized deficiency in the muscularis mucosa. The epithelial cells lining the submucosal glandular extensions ranged from squamous to columnar in outline. Goblet cells were absent at the fundus and scanty elsewhere in the submucosal glands. Many lymphoid cells were seen within the epithelium of the lymphoglandular complexes. Whatever their location in the large intestine, submucosal lymphoid aggregates are homogeneous in appearance. There is no evidence of division into cortical and medullary areas, and germinal centers are also absent. Lymphocytes are the predominant cells and phagocytes are identified by their acidophilic cytoplasm (**Atkins and Schofield 1972; Eurell *et al.*, 1993)**. The apical part of the cecum in cat and dog showed heavy infiltration of lymphoid tissues in the mucous and sub-mucous coats as in appendix. These animals take a diet and get the nourishment by absorption of food products digested by their own bowel juices in their cecum (**Malla, 2003)**.

2. Materials and Methods

The present study was carried out on a total number of 5 mature Mongrel dogs of both sexes, ages ranged from 1 to 2 years and weight from 14 to 40 k. g. (with an average of 30 k. g.). The morphometric studies were performed with regards to measurements of the cecum length at its location and when detached by using electronic digital caliber (Shenzhen Liance Electronic Technology Com., Ltd.) (Fig.1.a).

The diameter of the detached cecum was measured after its incision longitudinally at the level of apex, body and base (Fig.1.b). The thickness of the cecal wall at apex, body and base was measured. The distance between cecocolic and ileocolic orifices was also measured. The morphology of the cecum including: Shape, location, attachment with the surrounding structures, blood supply of the cecum, cecal folds and lymphoglandular complexes openings were characterized. Contrast radiography of the cecum was done on a resected segment of the intestine about, 5 cm proximal and distal the cecum level. The

segment was closed at the colonic-end then filled with 25% Barium sulfate as contrast medium through ileal stump then closed. The specimens were radiographed by an X-ray apparatus using 3 MAS, 50 KV (Shimadza, Japan).

For histological examination, tissue specimens were obtained from the cecum after its removal and immersed into 10% neutral formalin for fixation. The specimens were dehydrated and embedded in paraffin wax in the usual manner. Sections of 5 µ thickened were prepared and stained by Haematoxalin and Eosin and by Van Gieson stain.

3. Results

The metric results of the cecum in the present study revealed that, the mean length of the cecum at its location was 63.18 mm and the mean length of detached cecum was 76.46 mm (Table 1). The mean diameter of the cecum at the level of the base, body and apex was 23.76 mm, 27.63 mm and 14.75mm respectively (Table 2). The mean thickness of the cecum at the base, body and apex was 1.24 mm, 1.23 mm and 1.15 mm respectively (Table 3). The mean distance between ileocolic and cecocolic orifices was 9.28 mm (Table 4).

Table (1): The mean length (mm) of the cecum at its location and detached cecum:

Animal No.	The length of the cecum at its location (mm)	Mean±SD (mm) length of the cecum at its location	The length of detached cecum (mm)	Mean±SD (mm) length of the detached cecum
1	78.39	63.18±11.92	84.49	76.46±11.11
2	66.67		71.00	
3	60.33		71.51	
4	65.05		91.31	
5	45.46		64.00	

Table (2): The mean diameter (mm) of cecum at different levels:

Animal No.	Diameter at the level of the base (mm)	Mean±SD (mm) Base	Diameter of at the level of the body (mm)	Mean±SD (mm) Base	Diameter at the level of the apex(mm)	Mean±SD (mm) Apex
1	19.71	23.76±8.3	27.91	27.63±3.75	10.68	14.75±5.38
2	17.00		30.00		10.00	
3	27.00		30.00		15.00	
4	18.2		21.1		14.6	
5	36.9		29.17		23.51	

Table (3): The mean thickness (mm) at different parts of the cecum:

Animal No.	Thickness at base (mm)	Mean±SD (mm) Base	Thickness at body (mm)	Mean±SD (mm) body	Thickness at apex (mm)	Mean±SD (mm) apex
1	2.06	1.24±0.9	3.13	1.23±1.2	1.75	1.15±.81.15
2	0.22		0.16		0.45	
3	1.39		0.9		1.21	
4	0.32		0.37		0.25	
5	2.22		1.63		2.1	

Table (4): The mean distance (mm) between ileocolic and cecocolic orifices

Animal No.	Distance (mm)	Mean±SD (mm)
1	8.20	9.28±1.73
2	12.02	
3	8.20	
4	8.00	
5	10.00	

Morphologically, the cecum appears as a letter S-structure (Fig. 2. b) and is located to the right of the median plane within the duodenal loop. It lies dorsal to and partly surrounded by the coils of the jejunum,

ventral to the right transverse processes of the second to fourth lumbar vertebrae.

It is found as a diverticulum originated from the proximal portion of the ascending colon at 9.28 mm from ileocolic sphincter. The cecum has three parts; base, body and apex. The cecum is attached to the distal portion of the ileum by an ileocecal peritoneal fold which contains the blood supply. The cecum communicates only with the colon by means of cecocolic orifice, and guarded by cecocolic sphincter. A smaller fold extends from the base of the cecum to the ascending colon was present and known as accessory cecocolic fold (Fig. 2.b).

The general direction of the cecum is caudad, but its blind end is bent and often points cranially. The relations of the cecum are; ventrally to the ileum and jejunum, dorsally to the right kidney, laterally to the descending duodenum and right lobe of the pancreas, caudally to the duodenum, and medially to the root of the mesentery. The blood supply of the cecum originates in a form of 20-25 cecal branches from the ileocecal artery which also gives 13-17 ileal branches to the ileum. Ileocecal artery originates from the ileocolic artery which originates from aorta. The main part of the ileocecal vessel continues proximally in the ileocecal fold as anti mesenteric ileal branch (Fig.2. a). The number of the cecal folds was ranged from 22 to 33 folds with a mean 28 ± 4. They arranged in a vertical manner along the entire circumference of the cecum. The openings of the lymphoglandular complexes in the cecum were seen at the top of the cecal folds of the mucosal surface in a number ranged between 21- 40 openings with a mean 30 ± 8. They randomly distributed and appeared as pin-head grey submucosal structure slightly elevated from the surrounding mucosal surface (Fig.3. a). Radiography of specimens of the cecum and related structures revealed the presence of the cecum as out pouching of the colon close to the ileocolic junction. The cecocolic orifice was detected as a constriction between the cecum and the colon. The diameter of the colon is nearly equal to the diameter of cecum, while diameter of the ileum is less than both of them (Fig. 3. b).

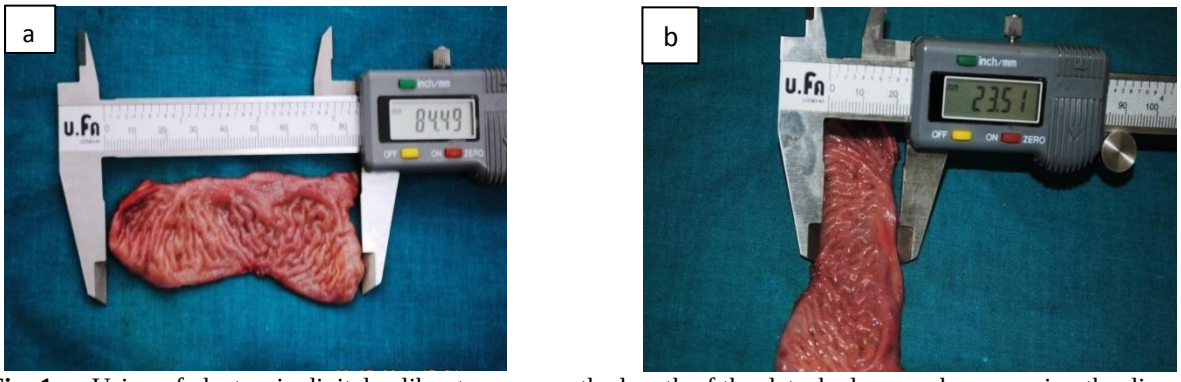

Fig. 1. a. Using of electronic digital caliber to measure the length of the detached cecum b. measuring the diameter of the cecal apex.

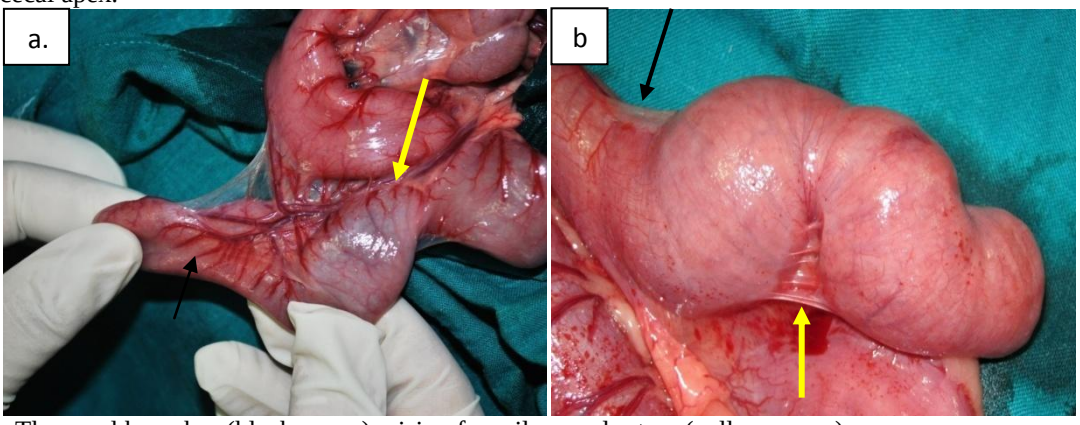

Fig. 2. a. The cecal branches (black arrow) arising from ileocecal artery (yellow arrow).
b. The shape of the cecum in the form of letter "S" and attached to ileum and colon. Note the ileocecal fold (yellow arrow) and cecocolic fold (black arrow).

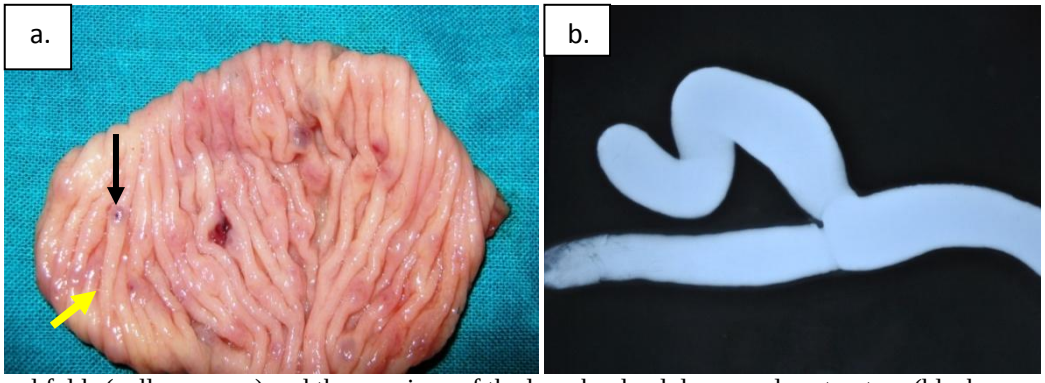

Fig. 3. a. Cecal folds (yellow arrow) and the openings of the lymphoglandular complex structure (black arrow) in the cecal mucosal fold. b. Contrast x-ray radiography revealed the morphology and attachment of the cecum to the colon.

Results of histological studies revealed, the cecal wall composed of four layers; tunica mucosa, submucosa, musculosa and serosa (Fig.4. a). The mucosal surface is composed of several mucosal folds. These folds are lined by a single layer of tall columnar epithelial cells and mucous-secreting goblet cells. The tall columnar epithelial cells contain basal nuclei. The goblet cells have a wide upper part filled with mucinous granules and lower narrow part contains rounded nucleus (Fig. 4.b). Cecal crypts or glands (crypts of lieberkühn) are present at the base of the mucosal folds and lined by columnar epithelium. Lamina properia of the epithelium is a thin layer of loose connective tissue with a few inflammatory cell infiltrations. Muscularis mucosa consists of two layers of smooth muscle fibers separate the crypts from the underlying submucosa. The submucosal layer consists of dense connective tissue infiltrated with blood vessels and lymphoid nodules (Fig.5. a). The submucosal lymphoid nodules which form part of lymphoglandular complexes are closely related to the deep aspect of the muscularis mucosa and they seldom occupy the whole thickness of the submucosa. The submucosal lymphoglandular complexes are rounded or oval structures closely related to the deep aspect of the muscularis mucosa. The mucous membrane overlying the lymphoglandular complex presented depressions or pits, the lymphoglandular structure opened in the mucosal glands. The locations of the openings lack the muscularis mucosa (Fig.5. b). There are no cortical and medullary zones of the lymphoid structure. Moreover, no germinal centers were observed. Lymphocytes were the predominant cells with a few phagocytes. The tunica musculosa consists of an inner circular layer and outer longitudinal layer which is made up of fasiculae of smooth muscle fibers. The tunica serosa is composed of a thin layer of mesothelial cells and a subserosal connective tissue. The connective tissue composed of blood vessels, fibrocytes and collagenous fibers.

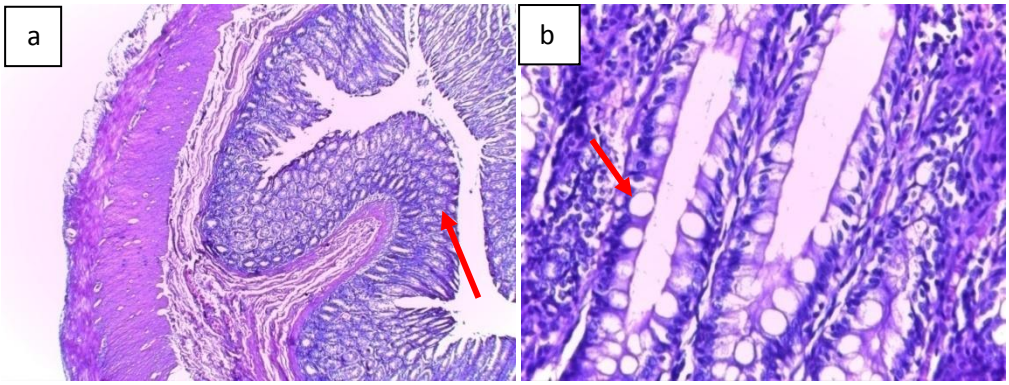

Fig.4. a. Cecal wall composed of four layers; Tunica mucosa, submucosa, musculosa and serosa. Note the mucosal fold (arrow) **(H & E, 4X)**. b. Cecal fold lined by simple columnar epithelial cells and mucous-secreting goblet cells (arrow) **(H & E, 10X)**.

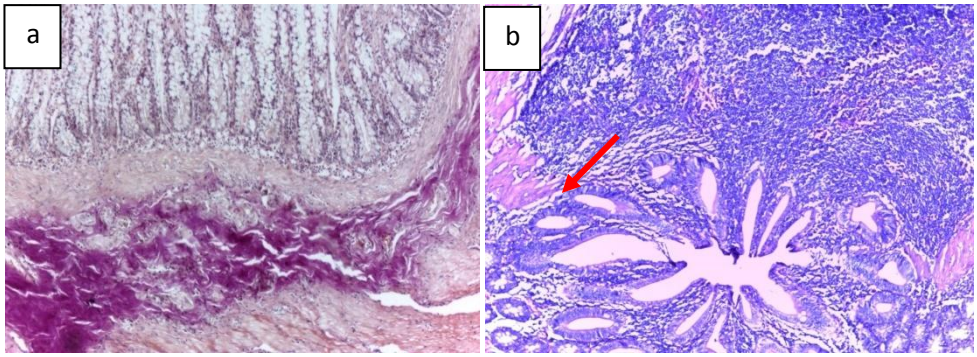

Fig.5. a. Dense connective tissues of the submucosa (**Van Gieson, 10X**). b. Lymphoglandular complex opened to the mucosal surface with glands resembling mucosal glands. Note the discontinuity of muscularis mucosa (arrow) (**H & E, 10X**).

4. Discussion.

Studies on the cecum of the dog are meager in comparison to that seen in the available literature of equine cecum. In spite of this fact, many authors try to explain the secret of this structure in the animal body, as the affected cecum didn't reveal a specific clinical signs on the living animal. Many publications were seen dealing with the macro and micro anatomy of this structure to explain its role as a part of the gastrointestinal tract **(Atkins and Schofield, 1972; Miller *et al.*, 1993; Dyce *et al.*, 2002).**

From our point of view, studies on the cecum anatomy may play a role in a satisfactory level to perform typhlectomy. The shape, location, blood supply, attachments and histological structure of the cecum are considered to be an important knowledge before dealing with such operation.

Miller *et al.* (1993), Kumar (2004) and Budras *et al.* (2007) mentioned that, the cecum is usually described as the first part of the large intestine, but this is not true in the dog because the ileum, the terminal part of the small intestine, communicated only with the colon, and the cecum exists as a diverticulum of the proximal portion of the colon.

Our results also indicated that the cecum is originated from the proximal part of the colon at a distance about 1 cm caudal to the ileocolic valve. **Miller *et al.* (1993), Kumar (2004) and Yildiz *et al.* (2006)** stated that, when the cecum straightened, the length of the cecum is over twice than attached. **Nickel *et al.* (1979)** reported that**,** the cecum of the dog is 80-300 mm long. Our results indicated that, the length of the cecum at its location is about 63.18 mm while the straighten cecum is about 76.46 mm. This contradiction may be due to the variation in different breed's size of dogs. **Nickel *et al.* (1979) and Kumar (2004)** stated that, the general direction of the cecum is caudad, but its blind end is bent and often points craniad. Our results are in agreement with that mentioned by aforementioned authors. We found that the direction of the cecum is caudad due to its attachments with the caudal part of the ileum by ileocecal fold and its blind end is bent craniad. In spite of this fact the S-shape of the cecum and the presence of ileocecal fold may constrict the cecum at its middle and may give it several directions. Moreover when the cecum is filled with ingesta it may had different directions.

The blood supply of the cecum is confined to ileocecal artery, a branch from the ileocolic artery, which is considered to be one of the main branches of the cranial mesenteric artery (**Miller *et al.*, 1993**). Our results are in agreement with this fact and the ileocecal artery is the main blood supply to the cecum. The presence of the ileocecal artery differentiates the curvature of the cecum into well nourished mesenteric border and ill-nourished antimesenteric border. So it is better to perform typhlotomy, when dictated, at the anti mesenteric border to avoid hemorrhage looks like that performed in small and large enterotomy incisions.

Borenstein *et al.* (2001) mentioned that, collateral circulation to the large intestine is poor when compared with small intestine. In our results we cannot justify this fact because the 5 cm cecal length was supplied by more than 20 cecal branches from ileocecal artery. The distance between these branches is not more than 2- 3 mm. The author believed that, these branches were sufficient to supply the cecum and it is considered to be a well vascularized organ when compared with the other parts of the small or large intestine.

Since a deficient in literature concerning cecal folds and numbers of lymphoglandular complexes openings except what stated by **Atkins and Schofield (1972**). Our results illustrated the number of the cecal folds was ranged from 22 to 33 folds with a mean 28 ± 4. They arranged in a vertical manner along the entire circumference of the cecum. The openings of the lymphoglandular complexes in the cecum were seen at the top of the cecal folds of the mucosal surface in a

number ranged between 21- 40 openings with a mean of 30 ± 8.

The histological structure of dog cecum in the present study shows that, it had lymphoglandular complexes in the submucosal layer. Lymphocytes were the predominant cells in these lymphoglandular complexes in addition to few numbers of phagocytes which play an important role in immune defense. These lymphoglandular complexes have openings in the mucosal surface at gross examination. The openings are present over the mucosal folds and distributed randomly. Our results are in agreement with that described by **Atkins and Schofield (1972**) **and Malla (2003)** who stated that, the apical part of the cecum showed heavy infiltrations of lymphoid tissues in the mucous and sub-mucous coats. Also **Eurell *et al.* (1993)** reported that, the cecum has a substantial number of lymphatic nodules scattered throughout its length. Lymphatic nodules are especially numerous around the ileal ostium.

Our results indicated that, the cecum hasn't cortical and medullary zones of lymphoid structure and also no germinal centers can be detected. This result is different from that present with lymphoid structures of other organs such as spleen which has cortex and medulla in addition to germinal centers **(Cesta, 2006)**.

References

1. Atkins, A. M. and Schofield, G. C. (1972): Lymphoglandular complexes in the large intestine of the dog: J. Anat.: 113: 2: pp. 169-178.
2. Borenstein, N.; Deneuche, A. and Monnet, E. (2001): Three case reports of typhlectomy using mechanical sutures. Point Vet: 32:50–54.
3. Budras, K. D.; Patrick, H.; McCarthy, P. H.; Fricke, W. and Richter, R. (2007):
4. Anatomy of the Dog: 5th revised edition Schlutersche: Pp 56-57.
5. Cesta, M. F. (2006): Normal Structure, Function, and Histology of the Spleen Toxicologic Pathology: 34:455–465.
6. Clark, G. N. and Pavletic, M. (1992): Typhlectomy in dogs using a stapling instrument, J. Am. Animal Hosp Assoc: 28. 511- 517.
7. Dyce, K. M.; Sack W. O. and Wensing C. J. (2002): Textbook of Veterinary Anatomy, Philadelphia: WB Saunders Company: Pp 427-428.
8. Eurell, J.; Brian, L. and Frappier, R. (1993): Dellmann's Textbook of Veterinary Histology. Sixth edition: Blackwell publisher: pp 543-545.
9. Fossum, T. W.; Hedlund, C. S.; Johnson, A. L.; Schulz, K. S; Seim, H. B.; Bahr, A. and Carroll, G.L. (2007): Small Animal Surgery: C.V. Mosby: 3st edition: PP 480-490.
10. Kapatkin, A. S.; Mullen, H. S.; Matthiesen, D. T. and Patnaik, A. K. (1992): Leiomyosarcoma in dogs: 44 cases (1983.1988). J. Vet. Med A: 201: 1077-1079.
11. Kumar, A. (2004): Veterinary Surgical Techniques: Fourth edition; Vikas Publishing House Pvt Ltd: PP.298-300.
12. Le Roux, P. H. (1962): Dilatation of the cecum in dogs: J. the South Africa. Vet. Med. Assoc: 33: 73-76.
13. Lewis, D. D. and Ellison, G. W. (1987): Intussusceptions in dogs and cats. Compendium on Continuing Education for the Practicing Veterinarian: 9: 523- 534.
14. Liebler, E. M. (1986): Mucosa-associated lymphoid nodules in the large intestine of young calves: a morphological study with special regard to lymphoepithelial relationship and epithelial ultra structure. MS Thesis, Iowa State University, Ames, IA.
15. Malla, B. K. (2003): A study on 'Vermiform Appendix'-a cecal appendage in common laboratory mammals: Kathm. Uni. Med. J.: Vol. 1: No. 4, Issue 4: 272-275.
16. Miller, M. E.; Howard, E. and Christensen, G. (1993): Millers Anatomy of the Dog, 3rd ed.: WB Saunders, Company Philadelphia: pp 444-445.
17. Moore, M. P. and Robinette, J. D. (1987): Cecal perforation and adrenocortical adenoma in a dog: Journal of the J. Vet. Med. A: 191. 87- 88 New York. pp 665-693.
18. Nickel, R.; Schummer, A. and Seiferle, E. (1979): The Viscera of the Domestic Mammals, 2nd ed.; Verlag Paul Parey, Berlin Pp: 128-130.
19. Wells, K.; Bright, L .and Wright, K. N. (1995): Cecal impaction in a dog: J. Small. Anim. Pract.:36.455-457.
20. Yildiz, H.; Arslan, k.; COÞKUN, Ü. and Yildiz, B. (2006): A Geometric Modeling of Dog Intestine: Turk. J. Vet. Anim. Sci.vol. 30 pages: 483-48.

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