



Anatomical and histological studies of esophagus of one-humped camel (Camelus dromedarius)

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Abstract

This study was designed to describe the anatomical and histological features of the normal esophagus in one-humped dromedary camel (*Camelus dromedarius*). Twelve adult male camels were used for this study. Anatomical features were described and samples were collected from 8 animals. Samples were kept in 10% neutral buffered formalin

and processed with routine histological procedures. The present study revealed that the length of the esophagus of camel was 148 ± 2.3 cm. The esophageal outer diameter began in the cervical portion at 2.6 ± 0.5 cm and gradually enlarged to 4 ± 0.2 cm in thoracic inlet. In the cranial part the esophagus of camel lied dorsally to the cricoids cartilage of the larynx and trachea. However, the cervical region deviates to the left of the trachea and maintains this relation until it reaches to the end of cervical region, where it again slopes to the dorsal region of the trachea. Later on, the esophagus continues caudally in thoracic cavity and passes through the esophageal hiatus of the diaphragm and after a short abdominal part it joins to the cardiac region of the stomach. The histological study showed that the esophagus of camel composed from many layers. It is arranged from internal to external in order: the mucosal layer consist of keratinized stratified squamous epithelium, the lamina propria (contain a relatively dense connective tissue with amount of elastic fibers), the Muscularis (consist from two layer of smooth muscle bundles that are relatively large). The sub mucosal glands abundant throughout the esophagus (this gland were less numerous towards the caudal end of the esophagus), while the number of lobules of sub-mucosal glands found in each region of the esophagus ranged from 42 in the cranial cervical region to 31 in the middle thoracic region. The tunica muscularis of the esophagus are stratified muscle and it is occurred in two general layers inner circular muscularis layer and outer longitudinal muscularis layer.

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Introduction

The one-humped Dromedary (*Camelus dromedarius*) is the largest mammalian species. It is adapted to the desert where thorny plants with rough and hard stems grow and with its high temperatures and extreme desiccation (Bello *et al.*, 2012).

The oesophagus connects the oral cavity with the stomach and serves as a passage for food. The architecture is that of a typical hollow organ with four layers: mucosa, submucosa, muscularis externa, and serosa/adventitia (Adnyane *et al.*, 2011). The camel's mouth and oesophagus is very sturdy and is developed to maintain efficient feeding of these plants and is rubbery so that thorns and branches won't damage it (Bello *et al.*, 2015; Bello *et al.*, 2014). Oesophageal anatomic differences among species reflect phylogenetic adaptation for different foodstuffs consumed by the different species and behavioural adaptations (Bello *et al.*, 2014). Camel oesophagus is a long tube of large capacity, in camel it can be 1 to 2 m long. It is lined by glands which secrete mucus helping to lubricate the often rough forage consumed by the camel (Al-Ani and Qureshi, 2004; Nabipour *et al.*, 2001).

The number of oesophageal glands that present in the sub-mucosa and distribution of the mucus secreting glands are varying considerably in different species; the lamina Muscularis mucosae present throughout the entire length of the oesophagus in the ruminants but are incomplete. The tunica muscularis externa usually consists of inner circular and outer longitudinal muscle coats, the muscle being striated in the entire oesophagus in the ruminants and for the greater part of its length in the horse (Dellmann & Brown, 2007).

This study designed to describe the gross and microscopic features of the sub mucosal glands and muscle fiber type of the one-humped Dromedary (*Camelus dromedarius*) oesophagus.

Materials and methods

Oesophagus of twelve healthy adult male camels were used in this study. These adult camels ranged in age from 2 to 9 years (with mean age 6.5 years) and weight from 98.2 – 186.4 kg (with mean weight 147.3 kg). The specimen were collected in January from the Basra slaughterhouse.

Gross Anatomy

The oesophagus was observed after exposed along the entire length. The cervical, thoracic, abdominal and total lengths of the oesophagus were measured in situ. The cervical part length was done from the initial entrance of the oesophagus into the neck to the flexure at the thoracic inlet, while the thoracic oesophageal length was from the thoracic inlet to the diaphragm, and the abdominal oesophagus was from the diaphragm to the expansion of the wall of the first compartment of the stomach.

The outer oesophagus diameter was measured at three levels: (1) cranial cervical, (2) thoracic inlet, (3) caudal thoracic. Cranial cervical was the first part of oesophagus in the neck; thoracic inlet was defined as part between the first ribs and the caudal thoracic

was directly below the diaphragm. Each level was then marked and the oesophagus removed intact from the body.

Histology

Oesophagus specimens were collected from eight adult healthy one-humped Dromedary for histological study. The specimens were washed with normal saline solution (0.9%) and 3 samples from different regions of each part of the oesophagus were taken and fixed by 10% phosphate buffered formalin for 24 hours at room temperature. The samples were treated by routine histological process (Luna, 1968). Later on the samples were embedded with paraffin wax (58-60C°) and sectioning to 5-6µm. The sections were stained with Haematoxylin and Eosin stain. Ocular micrometre was used to adjust the thickness of the all sections of the tunicae of each part of oesophagus in each sex. The mean (M) and the standard error (SE) were calculated for 5 slides for each part of the oesophagus (Al-Rawi and Kalaf-Allah, 1980).

Results

Anatomical study

In the present study, the gross examination of the oesophagus revealed a long, muscular, longitudinally folded tube, the oesophagus of dromedary camel consists from three parts (Figure. 1) the cervical oesophagus placed dorsal and somewhat to the left of the trachea. As the oesophagus passed through the thoracic inlet it occurs dorsal to the trachea. (Figure.2) Within the mediastinum, while the thoracic oesophagus crossed to the right of the arch of aorta dorsal to the base of the heart. Camel oesophagus grossly showed very irregular lumen on mucosal layer (Figure.3).

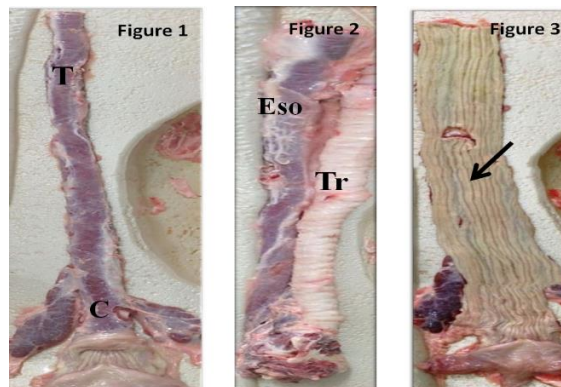


Figure.1: Shows the oesophagus of dromedary camel cervical region(C) and thoracic region (T)

Figure.2: Shows the oesophagus (Eso.)Of dromedary camel occurs dorsal to the trachea (Tr.)

Figure. 3: Shows the irregular lumen on mucosal layer arrow

In adult camel, the total length of oesophagus was approximately 148 cm, where the cervical portion was approximately 92 cm and the thoracic portion was approximately 52 cm long (Table.1). The length of the abdominal portion was very short, approximately 4 cm, because the placing the cardiac region of the stomach in close contact with the diaphragm. Oesophageal outer diameter began in the cervical portion at 2.6 ± 0.5 cm in cervical region and gradually enlarged to 4 ± 0.2 cm in thoracic inlet.

Table. 1: Shows the length and outer diameter of the oesophagus of the camel. A, B, C: Means with different superscripts are significantly different in oesophageal diameter between regions ($P \leq 0.05$).

Esophageal segments	Length (cm)	Outer diameter (cm)
Cervical	92.21 ± 3.12	2.6 ± 0.5 A*
Thoracic	52.16 ± 4.55	3.78 ± 0.76 B*
Abdomen	4.1 ± 3.78	4.1 ± 0.2 C*
Total	148.47 ± 5.65	

Histological study

The structures of all oesophagus regions (cervical, thoracic and abdominal) were similar and their walls composed of four layers: Tunica mucosa, Tunica sub-mucosa, Tunica muscularis and Tunica adventitia (serosa) (Figure. 4). The oesophageal epithelium was a keratinized stratified squamous epithelium along its length. The stratum corneum of the epithelium was composed of approximately 9-12 cell layers. The outer surface cell was revealed a lacked nuclei (Figure. 5).

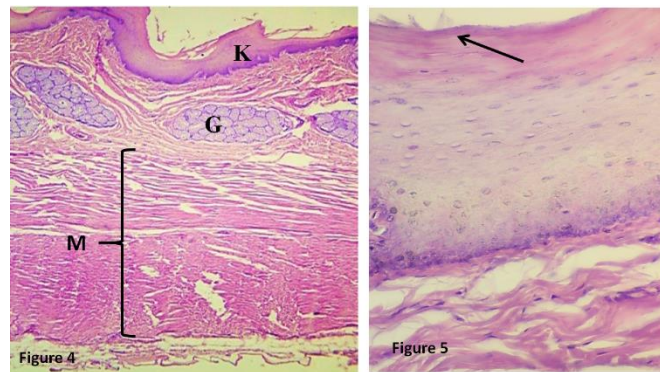


Fig.4 showed the layer of oesophagus (K) keratinized epithelia,(G) oesophageal gland, (M) muscularis externa $\times 100$ H&E Stain.

Fig. 5 Showing keratinized stratified squamous epithelium (arrow), outer layer loss the nucleus $\times 100$ H&E Stain.

The epithelium and the lamina propria were separated by the basal lamina. The lamina propria was consisted of connective tissue, scattered lymphocytes and vascular structure. There were many of dermal papillae that appeared as finger-like extensions. The lamina

propria was appeared interdigitated with the epithelium (Figure.6). The muscularis mucosa was located between lamina propria and sub mucosa and it was identifiable along length of oesophagus. It was consisted of a few thin scattered strands of smooth muscle (Figure.7). The Sub mucosal glands were abundant and found throughout the length of the oesophagus (Figure. 8). The glands less numerous towards the caudal end of the oesophagus; the number of lobules of sub mucosal glands found in each region of the oesophagus ranged from 35 in cross section of the cervical region to 26 in the thoracic region (Table. 2).

Table.2: The thickness of tunica muscularis and the number of lobules of submucosal glands in each region of the camel esophagus. A, B, C Within columns means with different superscript letters are significantly different ($P \leq 0.05$).

Criteria	Cranial cervical	Cranial Thoracic	Caudal thoracic
Thickness of tunica muscularis (mm)	3.90 ± 0.30 A	4.40 ± 0.5 B	4.98 ± 0.3 C
Number of lobules of Submucosal glands per cross section	42 ± 2 AB	34 ± 1 BC	31 ± 2 C

The glands were oval or elliptical in shape. In addition, large and small groups or lobules of tubule-alveolar mucous glands were also found (Figure 9). In each cross section throughout the oesophagus, the glands were equally distributed around the wall of the oesophagus. Tunica muscularis was composed of striated muscle throughout the length of the oesophagus. The thickness of tunica muscularis in thoracic segment was greater than that of the cervical segment (Table 2). Myenteric plexus was noted between the layers of the tunica muscularis (Figure 10). The adventitia was located at the outer layer of cervical and thoracic region. It was composed of loose connective tissue. The tunica serosa composed of loose connective tissue and a mesothelium layer and it was noted in outer layer of abdominal region (Figure 11).

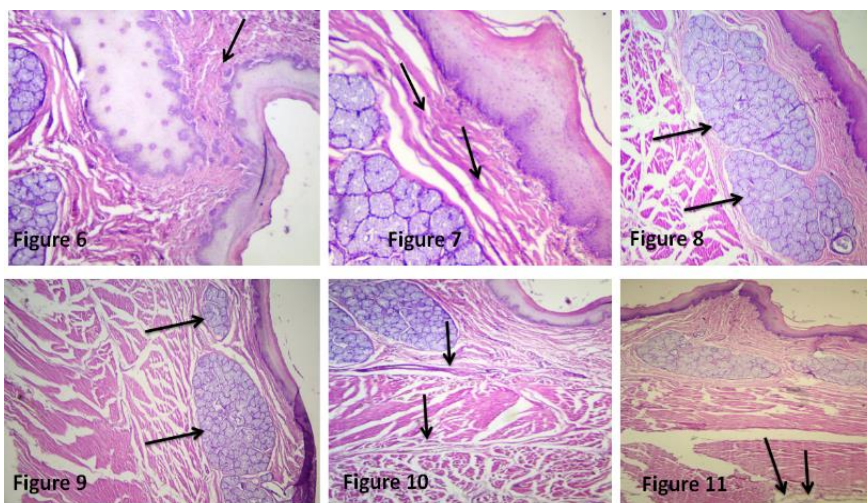


Figure.6: shows dermal papillae (arrow) Finger-like extensions ×400 H&E

Figure.7: Shows the muscularis mucosa (arrows) ×400 H&E

Figure.8: Showed the Sub mucosal glands oesophageal gland (arrow) ×100 H&E

Figure.9: Shows the oesophageal gland large and small groups (arrows) ×100 H&E

Figure.10: Shows the Myenteric plexus (arrow) ×100 H&E

Fig.11 showed the adventitia (arrow) ×100 H&E

Discussion

The present study revealed that the length of the oesophagus cervical portion of the dromedary camel was approximately twice that of the thoracic portion. This result is compatible with previous study (Schummer *et al.*, 1979). Anatomically, the camelids have a long neck and consequently the cervical portion of the oesophagus is long and this result is in agreement with previous study (Sukon *et al.*, 2009). Sukon *et al.*, (2009) showed that the total length of lama esophagus is approximately 120 cm. Moreover, the length of oesophagus cervical and thoracic portion are approximately 70 cm 50 cm respectively. The results of this study is also in agreement with the observations of (Murray *et al.*, 1988), who reported the total oesophageal length in cow. According to Murray *et al.*, (1988), the total oesophageal length in cow is approximately 90-95 cm and it is divided into the cervical and thoracic portion with approximately length reach 42-45 cm and 48-50 cm respectively.

The results of this study is also compatible with Smith *et al.*, (1992). They showed that the outer diameter of the llama oesophagus like that of the cow and sheep with significantly increases from the cranial portion to the caudal portion. The oesophageal diameter in the llama is 2.5 cm in the cranial cervical portion and 3.9 cm in the caudal thoracic portion. These measurements are smaller than that of the cow which were 3-4 cm and 7 cm in the neck in the caudal thorax portions respectively.

The results of this study also showed that the sub mucosal glands were abundant and found throughout the length of the oesophagus. This result is disagreed with (Dellmann, 1971; Dellmann and Brown, 1976). These studies mentioned that the sub mucosal glands in the ruminants were only seen in the pharyngeo-oesophageal region. The muscularis mucosa was seen to be located between lamina propria and sub mucosa and it was identifiable along length of the oesophagus. It was consisted of a few thin scattered strands of smooth muscle. This results are in disagreement with (Jamdar and Ema, 1982), who showed the presence of lamina muscularis mucosae in the form of a few scattered strands of smooth muscle, only in the caudal oesophagus of the camel, and this results is also contrary to that found in the ruminants.

The results of this study is in agreement with (Salimi *et al.*, 2012), who revealed that the tunica muscularis of oesophagus of the camel composed of entirely striated muscle fibers and divided into two layers: the inner (circular) and outer (longitudinal) and it is similar to the ruminants. In conclusion, this study presented information regarding the gross and microscopic features of the oesophagus of one-humped Dromedary (*Camelus dromedarius*). The authors considered that this information can be used as a basis for further studies of dromedaries' oesophageal. In addition, to determine any pathological changes in this species, Moreover, this could be aid in surgical treatment of oesophageal obstruction in camels.

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