

GROSS AND SCANNING ELECTRON MICROSCOPIC STUDIES ON OESOPHAGUS OF CAMEL (*Camelus dromedarius*)

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ABSTRACT

The present study was conducted on 10 oesophagus of adult camels (*Camelus dromedarius*). Oesophagus of camel was musculo-membranous tube extending from *aditus oesophagi* of pharynx to junction of C1 and C2 compartment of stomach. It was divided into cervical part (larger) and thoracic part (smaller). No abdominal part was observed. At the junction of pharynx and oesophagus, a transverse fold of mucous membrane was present in mid ventral portion of the wall and extending to dorsal region. The SEM studies, the surface of oesophagus was undulating and wavy and covered with square or hexagonal cells.

Key words: Camel, oesophagus, Scanning Electron Microscopy

Regurgitation of partly digested contents of forestomach for remastication is a tough task of the oesophagus (Lechner-Doll and Hoffrogge, 2011). The length of oesophagus, presence or absence of glands as well as type of musculature of the wall largely affected the passage of food inside the oesophagus (Abass, 2009). The cervical and thoracic course of the oesophagus of llama has been described by the Sukon *et al* (2009) and about the musculature and glands by Jamdar and Ema (1982). The present study describes the gross and scanning electron microscopic structure of oesophagus of dromedary camel.

Materials and Methods

The present study was conducted on oesophagus obtained from recently dead 10 camels irrespective to age and sex brought at Clinics of Teaching Veterinary Clinical Complex, RAJUVAS, Bikaner. These were free from any pathological condition of tongue, mouth and GIT. All samples were subjected to gross anatomical study and 4 samples were used for electron microscopic studies.

The length of dissected out oesophagus was measured from *aditus oesophagi* to the thoracic inlet for the cervical part, and from thoracic inlet to *hiatus oesophagi* for thoracic part, respectively. The diameter of oesophagus was measured at *aditus oesophagi*, middle of cervical part, middle of thoracic part and at atrium ventriculi by Vernier caliper. The gross and

topographic anatomical study of oesophagus was done.

The ultra structural surface morphology of oesophagus was studied by Scanning Electron Microscope (SEM) at Department of Microbiology, College of Veterinary & Animal Sciences, Bikaner, RAJUVAS, Bikaner. The samples were processed by the technique as described by Bozzola and Russell (1999).

Tissue section (2 – 3 mm) were taken from representative areas and were gently washed with isotonic buffer and were primarily fixed in Karnovsky's fixative (mixture of 4% paraformaldehyde and 1% glutaraldehyde in 0.1M Phosphate buffer) at 4°C. After primary fixation, tissue were washed with 0.1M phosphate buffer (3 changes, each of 15 minutes) followed by post fixation in 1% solution of Osmium tetroxide, and again washed with 0.1M phosphate buffer (3 changes, each of 15 minutes). The tissues were chemically dried by acetone (3 changes, each of 15 minutes) and dry acetone (2 changes, each of 15 minutes). Up to this, all steps were carried out at 4°C. The samples were then dried in critical dryer (Biostag, New Delhi) at 31.5°C and 1100 Psi. The samples were mounted on stub, gold coating using gold target in sputter coater (Polalis, South Korea) and viewed by Scanning Electron Microscope (Genesis – 1100, Emcraft, South Korea).

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Data generated from the study were analysed using standard statistical methods as described by Kaps and Lamberson (2004).

Results and Discussion

Gross examination

Shape and Colour

Oesophagus of camel was musculo-membranous tube extending from *aditus oesophagi* of pharynx to junction of C1 and C2 compartment of stomach (Fig 1 & 2) which was in accordance with studies of Raghavan (1964) and Frandson (1981) in ox. The complete course of oesophagus was divided into cervical part (larger) and thoracic part (smaller) (Fig 1), the similar findings were reported by Raghavan (1964) in ox, Nabipour *et al* (2001) in camel and Sukon *et al* (2009) in llama. Abdominal part oesophagus was not observed, however, Nabipour *et al* (2001) found a short abdominal part in oesophagus of camel. In fresh state the colour of external surface of oesophagus was reddish brown and luminal surface was pink.

Size

The mean length of oesophagus at cervical region was 121.5 ± 1.514 cm and mean value of circumference at *aditus oesophagi* was 15.24 ± 0.193 cm and at mid cervical part it was 8.61 ± 0.213 cm. The mean length of oesophagus at thoracic region was 72.8 ± 1.1 cm and mean circumference at mid thoracic was 8.28 ± 0.186 cm and at *hiatus oesophagi* it was 15.53 ± 0.189 cm. The total mean length of oesophagus was 194.3 ± 2.55 cm, whereas according to Sisson and Grossman (1958), average diameter of oesophagus was about 2 inches, and its total length in an ox of medium size was about 3-3.5 feet, according to Raghavan (1964) total length was about 0.75 to 1 metre and its diameter was about 50 mm in ox, according to Nabipour *et al* (2001) total length was 165 - 215 cm in camel, according to Sukon *et al* (2009) total length was 121 cm, with the cervical portion 80 cm and the thoracic portion 40 cm and oesophageal outer diameter began in the cervical portion at 2.5 cm and gradually enlarged throughout the length to 3.9 cm at the caudal thorax in llama. According to Abass (2009) total length of the oesophagus appeared to be in the range of 110-120 cm, where in the cervical portion was 68-70 cm and the thoracic portion was 50 cm. Both the portions had 8-10 cm diameter. According to Hussein *et al* (2016) length of the oesophagus of camel was 148 ± 2.3 cm. The oesophageal outer diameter at cervical portion was 2.6 ± 0.5 cm which gradually enlarged to 4 ± 0.2 cm at thoracic inlet.

Topography and Course of oesophagus

The cervical portion of oesophagus commenced at *aditus oesophagi*, dorsal to cricoid cartilage of larynx and extended caudally on the dorsal aspect of trachea up to the level of 3rd cervical vertebrae (Fig 1), which was in congruence with the findings of Raghavan (1964) in ox, Nabipour *et al* (2001) and Hussein *et al* (2016) in camel. Later it traversed to the left side of trachea and extended caudally on the left side of trachea, slightly inclined and entered in the thoracic inlet (Fig 1), whereas in musk-ox calf (Sack and Ballantyn, 1965) opposite the sixth cervical vertebra, which was approximately 5 cm cranial to the cranial border of the first rib, the oesophagus deviated sharply to the left from its previous midline position and came to lie lateral to the trachea. However, according to Nabipour *et al* (2001) and Hussein *et al* (2016), at the level of sixth cervical vertebra oesophagus again slopes to the dorso-median of the trachea in camel.

The complete thoracic part was laid in the mediastinal space, which was also reported by Smuts and Bezuidenhout (1987) in camel. The thoracic part started at 1st rib and it gained the dorsal aspect of trachea at 2nd thoracic and continued it up to the bifurcation of trachea. In the middle at mediastinum, the aortic arch pushed it slightly towards the right side of midline. In the caudal mediastinum, the oesophagus extended caudally, inclined upward. It entered into abdominal cavity through *hiatus oesophagi* of the diaphragm. It opened immediately into C1 compartment of stomach (Fig 1). Similar findings were observed by Raghavan (1964) in ox. Abdominal part was not observed in camels of present study which was in conformity with the findings of Sisson and Grossman (1958) in ox and Abass (2009) in camel, whereas it was contrary to the findings of Sack and Ballantyn (1965) in musk-ox calf and Nabipour *et al* (2001) and Hussein *et al* (2016) in camel and Sukon *et al* (2009) in llama.

Interior of Oesophagus

At the junction of pharynx and oesophagus, a transverse fold of mucous membrane was present in mid ventral portion of the wall and extended to dorsal region (Fig 3). At the terminal part, oesophagus was dilated as also reported by Abass (2009) in same species. The mucosa of empty oesophagus exhibited the transitory longitudinal folds (Fig 4).

Scanning Electron Microscopy

The surface of oesophagus was undulating and wavy and covered with square or hexagonal cells

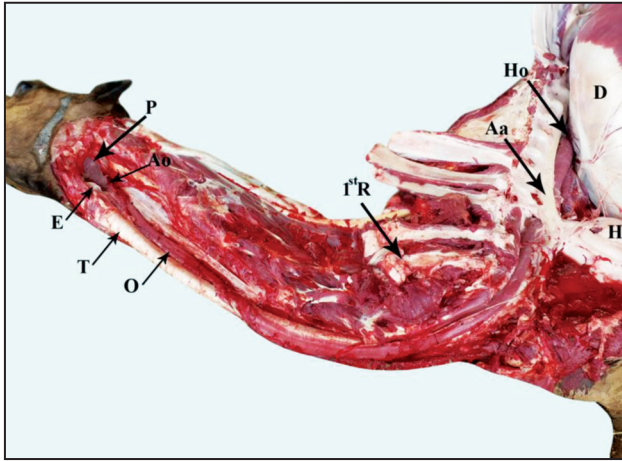


Fig 1. Photograph showing oesophagus of camel. P - Pharynx, E - Epiglottis, Ao - Aditus oesophagi, T - Trachea, O - Oesophagus, 1st R - 1st Rib, Aa - Abdominal aorta, Ho - Hiatus oesophagi, D - Diaphragm, H - Heart.

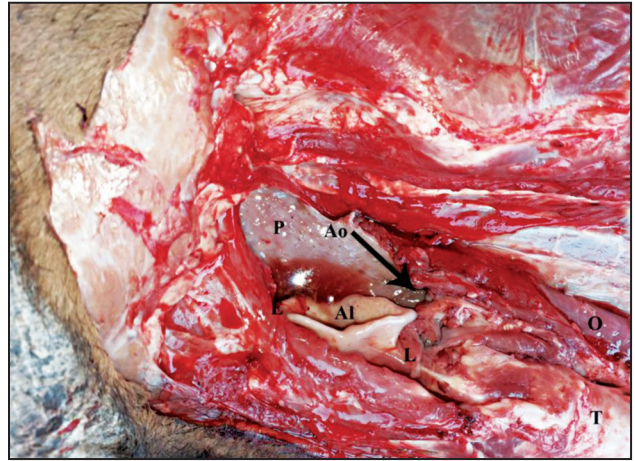


Fig 2. Photograph showing pharynx of camel. P - Pharynx, E - Epiglottis, Al - Aditus laryngus, O - Oesophagus, L - Larynx, T - Trachea.

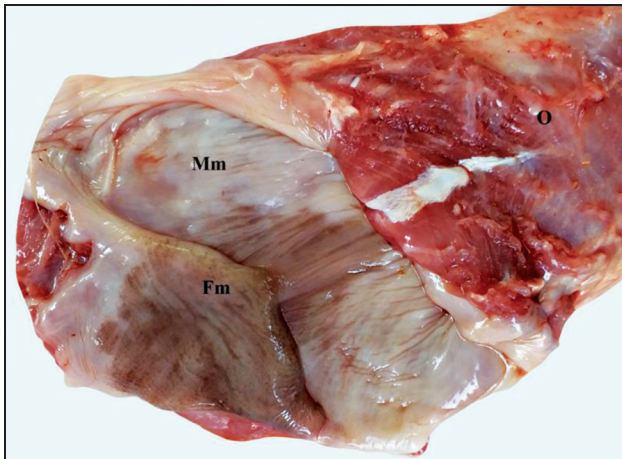


Fig 3. Photograph of oesophagus at the opening of pharynx. Fm - Fold of mucous membrane at the junction of pharynx and oesophagus at ventral part. Mm - Mucous membrane, O - Oesophagus.

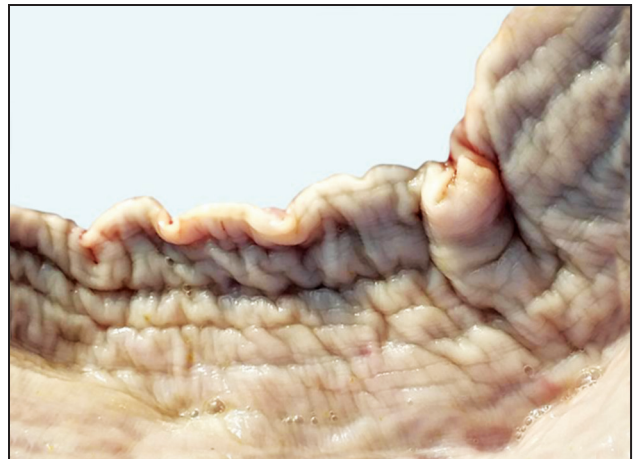


Fig 4. Photograph of oesophagus of camel showing folds of mucous membrane. Lfm - Longitudinal folds of mucous membrane.

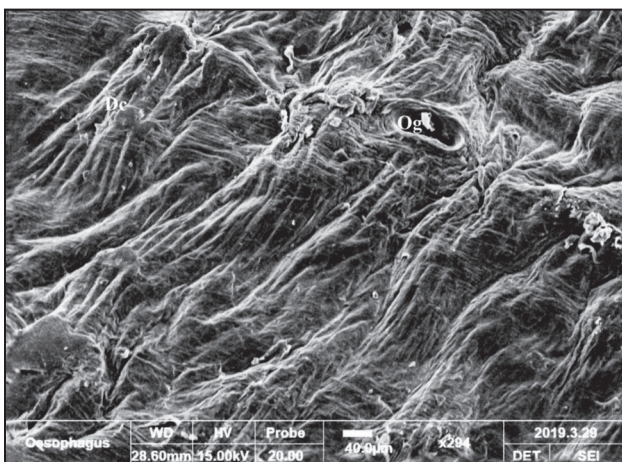


Fig 5. Scanning electron micrograph of oesophagus of camel showing wavy and undulating surface. Og - Opening of gland, Dc - Desquamating cell. (40.0 µm x 294).

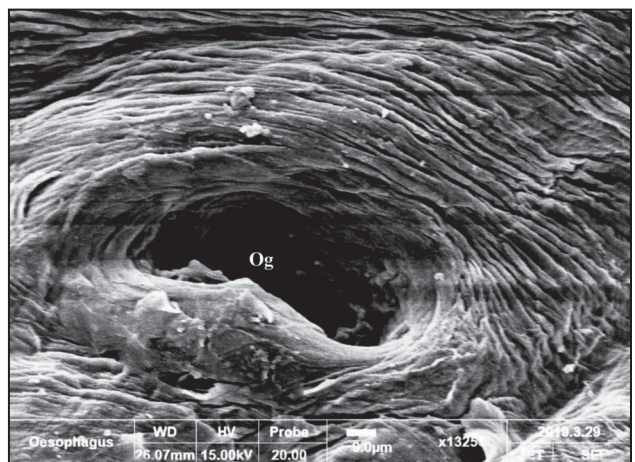


Fig 6. Scanning electron micrograph of oesophagus of camel showing micro ridges. Og - Opening of gland (9.0 µm x 1325).

which had well defined, fairly straight boundaries. The sloughing of cells was observed and edges were raised (Fig 5), which was in accordance with the findings of Carr *et al* (1974) in human. The openings of the glands were seen on the surface (Fig 5 & 6). The micro ridges were found on surface of the superficial cells of all parts of the oesophagus. The ridges were arranged parallel and the intervals between them were greater at many places (Fig 6). These findings were in close agreement with the findings of Gardner and Scott (1976) in ovine oesophagus. However, Kathleen *et al* (1978) reported small microvillous processes in human oesophagus. The whorl-like arrangement of ridges was observed around the openings of the glands and these became more numerous as the cells approached the junction (Fig 6), which was supported by the findings of Henk *et al* (1986) in dogs.

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