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Gross anatomical and biometrical features of the oesophagus in pigeon (*Columba livia domestica*)

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Abstract

The present study was conducted on the esophagus of pigeons to observe their gross anatomical and biometric features. Six pigeons were dissected for this purpose. The esophagus was found to consist of three main parts: the cervical part, crop, and thoracic part. The cervical part extended from the caudal end of the pharynx to the cranial end of the crop. It was located on the right side of the neck, on the lateral aspect. The mucosal surface of the cervical part exhibited longitudinal folds. The crop, a bilobed diverticulum of the esophagus, comprised a middle lobe and two lateral lobes. It was situated at the cranial inlet of the thoraco-abdominal cavity, between the cervical and thoracic parts of the esophagus. The mucosal surface of the lateral lobes displayed irregular folds, while the middle lobe appeared smooth. The thoracic part of the esophagus was tube-like and extended from the caudal end of the crop to the cranial end of the proventriculus. It was positioned in the midline of the body, to the right side of the trachea. It then continued dorsal to the heart and primary bronchi, passing between the two lungs. The mucosal surface of the thoracic part exhibited longitudinal folds. Biometrically, the mean \pm SE values for the length of the cervical part, empty and filled crop, and thoracic part of the esophagus were 3.50 ± 0.13 cm, 2.92 ± 0.13 cm (empty), 4.28 ± 0.08 cm (filled), and 4.03 ± 0.10 cm, respectively. The mean \pm SE values for the number of mucosal folds in the cervical and thoracic parts of the esophagus were 22.67 ± 0.76 and 8.83 ± 0.31 , respectively.

Keywords: Gizzard, pigeon, micrometry, histology, histochemistry

Introduction

The domestic pigeon (*Columba livia domestica*) is a subspecies derived from the rock dove, commonly known as the rock pigeon. Pigeons have been domesticated for various purposes such as meat and feather production. They are also kept by enthusiasts for flying, sporting competitions, and exhibition purposes. In recent times, there has been increasing interest in using pigeons as a source of meat protein, particularly among rural communities in parts of Africa. Additionally, domestic pigeons are frequently utilized in laboratory experiments in the fields of biology, medicine, and cognitive science.

Birds have a coelomic cavity without a diaphragm, and their esophagus is a long and distensible tube that connects the oropharynx and proventriculus (Kadhim and Mohamed, 2015) [5]. At the level of the thoracic inlet, the esophagus expands ventrally to form a crop (Shehan, 2012 in geese; Rus *et al.*, 2000 [10, 8] in white storks). The crop, a diverticulum of the esophagus, acts as a storage area for food particles and also secretes crop milk. From there, the food particles pass into the thoracic part of the esophagus before entering the proventriculus (Bharathi *et al.*, 1997 in pigeons; Luka *et al.*, 2021 in pigeons) [3, 6]. The objective of this research work was to study the gross anatomy and biometry of the esophagus in domestic pigeons (*Columba livia domestica*). This study provides valuable information for anatomical, pathological, clinical, and pharmacological investigations.

Materials and Methods

Sample Collection: The study was conducted using six pigeons. The carcasses of pigeons were obtained from two sources: the Namo Namah Parivar Bird Camp -2020, held in Ahmedabad during the kite festival, and the Department of Veterinary Surgery and Radiology, College of Veterinary Science and Animal Husbandry, K. U., Anand. The entire research work was conducted in the Department of Veterinary Anatomy and Histology, College of Veterinary Science and Animal Husbandry, Anand, Gujarat.

Dissection and Preservation: After collecting the dead pigeons, the entire carcass was defeathered to facilitate better accessibility for the dissection of the esophagus.

A sharp dissection scissors were used to make an incision along the posterior margin of the sternum to expose the abdominal wall. The thoracic region was carefully reflected by further cutting. The cervical region was incised through a mid-ventral incision on the neck to expose the cervical part of the esophagus. Following dissection, the esophagus was fixed in a 10% formalin solution for 48 hours for gross anatomical and biometric studies. The fixed esophagus was examined in situ to observe its topographic position and then dissected out for further examination. The dissected esophagus was examined ex-situ to study its shape, size, and other gross morphological features such as the shape and size of mucosal folds. Biometric measurements of the esophagus, including length, circumference, and number of mucosal folds, were taken.

The gross anatomical study was conducted using the naked eye and a magnifying lens. The biometric study utilized a magnifying lens, calibrated Vernier calipers, non-elastic thread, and a measuring tape. Statistical analysis of the data was performed using IBM SPSS Statistics 20 (Trial Version). The biometric data were expressed as Mean \pm SE (Standard Error) values and coefficient of variation. An independent samples t-test was used to determine significant differences between two parts of the esophagus, and One-Way Analysis of Variance (ANOVA) was used to determine significant differences among the three parts of the esophagus. Gross photographs of the organs were taken using a Sony Cyber-Shot DSC-HX400 Prosumer Camera with 20.4 MP.

Results and Discussion

Gross Anatomy and Biometry: The esophagus of the pigeon was found to consist of three parts: the cervical part (pre-crop part), crop, and thoracic part (post-crop part). Similar findings have been reported in homing pigeons (Kadhim and Mohamed, 2015)^[5] and common wood pigeons (Al-Juboory *et al.*, 2015)^[1]. However, the crop was absent in captive bustards (Bailey *et al.*, 1997)^[2].

Cervical Part (Pre-Crop Part): The cervical part of the esophagus was a distensible tubular segment that extended from the caudal end of the pharynx to the cranial end of the crop (Figure 1, 2). This is consistent with observations in *Elanus caeruleus* (Hamdi *et al.*, 2013)^[4], homing pigeons (Kadhim and Mohamed, 2015)^[5], and common wood pigeons (Al-Juboory *et al.*, 2015)^[1]. Topographically, it was located on the right side of the neck, on the lateral aspect (Figure 3, 4). These findings align with those reported in homing pigeons (Kadhim and Mohamed, 2015)^[5]. However, in common wood pigeons, the cervical esophagus was intertwined with the trachea (Al-Juboory *et al.*, 2015)^[1]. The external surface of the cervical part of the esophagus appeared smooth (Figure 1-4), while the mucosal surface exhibited cream-colored longitudinal folds (Figure 7). These observations are in line with those reported in *Elanus caeruleus* (Hamdi *et al.*, 2013)^[4], homing pigeons (Kadhim and Mohamed, 2015)^[5], common wood pigeons (Al-Juboory *et al.*, 2015)^[1], and guinea fowl (Saran *et al.*, 2019)^[9]. The longitudinal folds displayed a wavy appearance at the cranial end and the distal third area of the cervical part of the esophagus (Figure 7).

Biometrically, the mean \pm SE value of the length of the cervical part of the esophagus was 3.50 \pm 0.13 cm in domestic pigeons. In male and female homing pigeons, it was reported as 82.8 \pm 4.3 mm and 68.84 \pm 5.6 mm, respectively (Kadhim

and Mohamed, 2015)^[5]. In common wood pigeons and barn owls, the lengths were 6.96 cm and 8.04 cm, respectively (Al-Juboory *et al.*, 2015)^[1]. The length of the cervical esophagus in the presently studied pigeons was found to be shorter. The mean \pm SE value of the circumference of the filled cervical part of the esophagus at the cranial, middle, and caudal parts was 3.38 \pm 0.03 cm, 3.58 \pm 0.04 cm, and 3.95 \pm 0.11 cm, respectively. The mean \pm SE value of the circumference of the empty cervical part of the esophagus at the cranial, middle, and caudal parts was 2.67 \pm 0.09 cm, 2.55 \pm 0.11 cm, and 2.47 \pm 0.18 cm, respectively. This indicates that the circumference of the filled cervical part of the esophagus gradually increases from the cranial to caudal part, while the circumference of the empty cervical part of the esophagus gradually decreases from the cranial to caudal part. However, Mal (2016)^[7] reported the mean \pm SE value of the circumference (external diameter) of the cervical esophagus in frizzled feather and naked neck pigeons as 2.10 \pm 0.15 cm and 1.91 \pm 0.18 cm, respectively. This is nearly similar to the circumference of the empty esophagus in the presently studied pigeons.

Crop: The crop in the pigeon studied in this research was observed to be a bilobed diverticulum of the esophagus (Figure 1, 2). These findings are consistent with observations reported in homing pigeons (Kadhim and Mohamed, 2015)^[5] and common wood pigeons (Al-Juboory *et al.*, 2015)^[1]. However, the findings differ from those reported by Al-Juboory *et al.* (2015)^[1] in barn owls, where the crop was not clearly distinguished and showed a fusiform shape. Topographically, the crop was located at the cranial inlet of the thoraco-abdominal cavity between the cervical and thoracic parts of the esophagus (Figure 3, 4), similar to the findings in homing pigeons (Kadhim and Mohamed, 2015)^[5] and common wood pigeons (Al-Juboory *et al.*, 2015)^[1]. The lateral lobes of the crop were thick and membrane-like, while the middle lobe was thin and membrane-like in structure. In most of the pigeons studied, the crop was filled with grains, indicating its function as a food storage organ (Figure 3). These observations align with those reported in homing pigeons (Kadhim and Mohamed, 2015)^[5] and common wood pigeons (Al-Juboory *et al.*, 2015)^[1]. However, the crop in barn owls was not swollen and did not store food, as reported by Al-Juboory *et al.* (2015)^[1], which contrasts with the present study. The external surface of the crop exhibited an irregular appearance (Figure 1-4). The mucosal surface of the lateral lobes displayed some irregular folds, while the middle lobe appeared smooth (Figure 8). These findings are in agreement with observations reported in common wood pigeons (Al-Juboory *et al.*, 2015)^[1].

The mean \pm SE value of the length of the empty crop was 2.92 \pm 0.13 cm, while the length of the filled crop was 4.28 \pm 0.08 cm. In comparison, the length of the crop in common wood pigeons and barn owls was reported as 4.0 cm and 2.5 cm, respectively (Al-Juboory *et al.*, 2015)^[1], and in frizzled feather and naked neck fowl, it was 4.90 \pm 0.37 cm and 4.80 \pm 0.24 cm, respectively (Mal, 2016)^[7]. The mean \pm SE value of the circumference of the empty crop was 12.05 \pm 0.10 cm, while the circumference of the filled crop was 16.20 \pm 0.62 cm. The t-test indicated a highly significant difference in length and circumference between the empty and filled crop.

Thoracic Part (Post-Crop Part): The thoracic part of the esophagus in the pigeon studied was tube-like and extended

from the caudal end of the crop to the cranial end of the proventriculus (Figure 1, 2). This is similar to the findings reported in homing pigeons (Kadhim and Mohamed, 2015)^[5], common wood pigeons, and barn owls (Al-Juboory *et al.*, 2015)^[1]. Topographically, it was located in the midline of the body, to the right side of the trachea. It continued dorsally to the heart and primary bronchi and passed between the two lungs, extending up to the cranial end of the proventriculus (Figure 5, 6). These observations are consistent with those reported in homing pigeons (Kadhim and Mohamed, 2015)^[5]. The external surface of the thoracic part of the esophagus appeared smooth and did not show any demarcation between the caudal end of the thoracic part and the cranial end of the proventriculus (Figure 1, 2). The mucosal surface of the thoracic part of the esophagus in the studied pigeons was cream-colored and exhibited numerous longitudinal folds. These observations coincide with findings reported in *Elanus caeruleus* (Hamdi *et al.*, 2013)^[4], homing pigeons (Kadhim and Mohamed, 2015)^[5], common wood pigeons, and barn owls (Al-Juboory *et al.*, 2015)^[1]. These longitudinal folds were thicker at the junction between the crop and the esophagus (Figure 9) and decreased in thickness towards the caudal end of the thoracic part of the esophagus.

The mean \pm SE value of the length of the thoracic part of the esophagus was 4.03 ± 0.10 cm. Kadhim and Mohamed (2015)^[5] reported lengths of 42.4 ± 3.9 mm and 37.52 ± 4.9 mm in

male and female homing pigeons, respectively, while Al-Juboory *et al.* (2015)^[1] reported lengths of 6.96 cm and 1.32 cm in common wood pigeons and barn owls, respectively. The length of the thoracic part of the esophagus in the present study is similar to that of homing pigeons, longer than that of common wood pigeons, and much shorter than that of barn owls. These differences can be attributed to species variations. The mean \pm SE value of the circumference at the cranial, middle, and caudal parts of the thoracic esophagus was 1.37 ± 0.03 cm, 1.53 ± 0.04 cm, and 1.21 ± 0.05 cm, respectively. The ANOVA indicated that the circumferences of the cranial, middle, and caudal parts were significantly different from each other. Conversely, Mal (2016)^[7] reported circumferences (external diameter) of the thoracic part of the esophagus in frizzled feather and naked neck fowl as 1.91 ± 0.13 cm and 1.75 ± 0.11 cm, respectively. These differences can be attributed to the variations in bird size.

Number of Mucosal Folds: The mean \pm SE value of the number of mucosal folds in the cervical and thoracic parts of the esophagus was 22.67 ± 0.76 and 8.83 ± 0.31 , respectively. The t-test indicated that the number of mucosal folds in the cervical esophagus was significantly higher than that in the thoracic parts. This suggests that the cervical part of the esophagus is more distensible than the thoracic part.

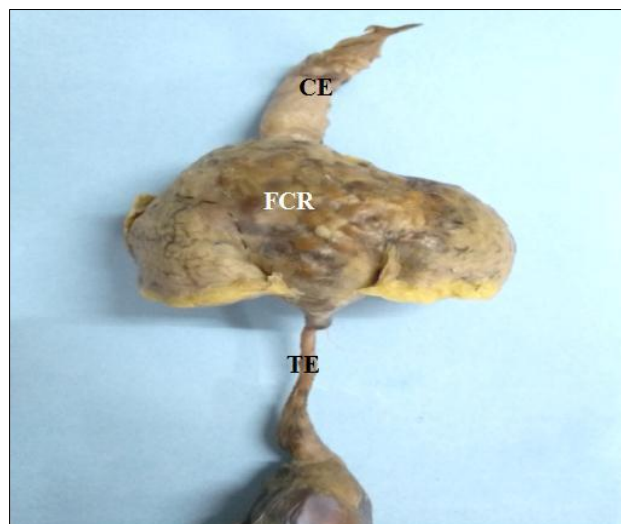


Fig 1: Gross photograph of oesophagus showing cervical oesophagus (CE), filled crop (FCR) and thoracic oesophagus (TE)

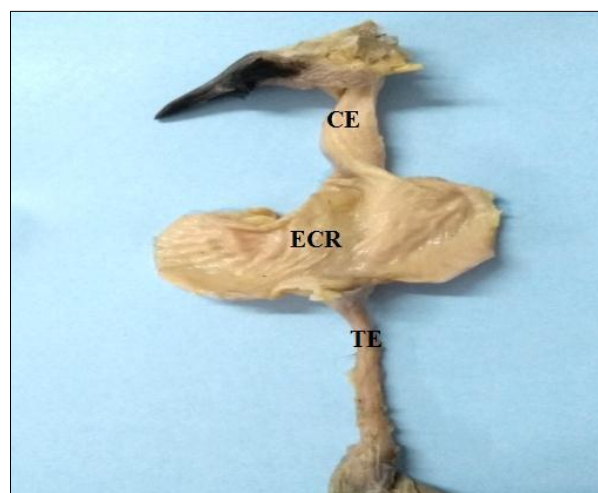


Fig 2: Gross photograph of oesophagus showing cervical oesophagus (CE), empty crop (ECR) and thoracic oesophagus (TE)

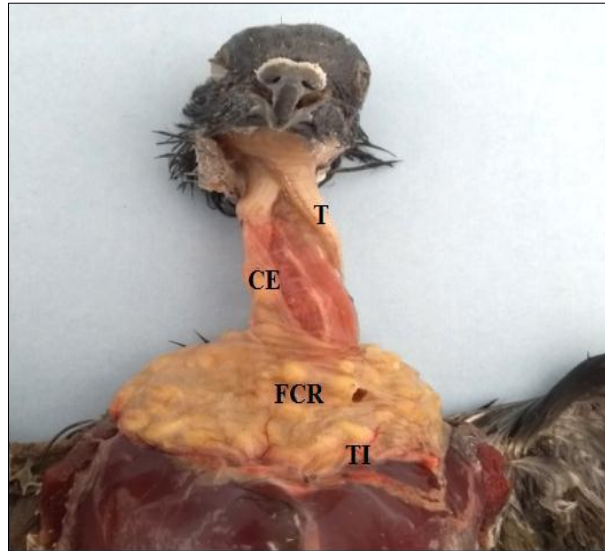


Fig 3: Gross photograph of oesophagus showing cervical oesophagus (CE) located right lateral aspect of the trachea (T) and filled crop (FCR) located on the thoracic inlet (TI)

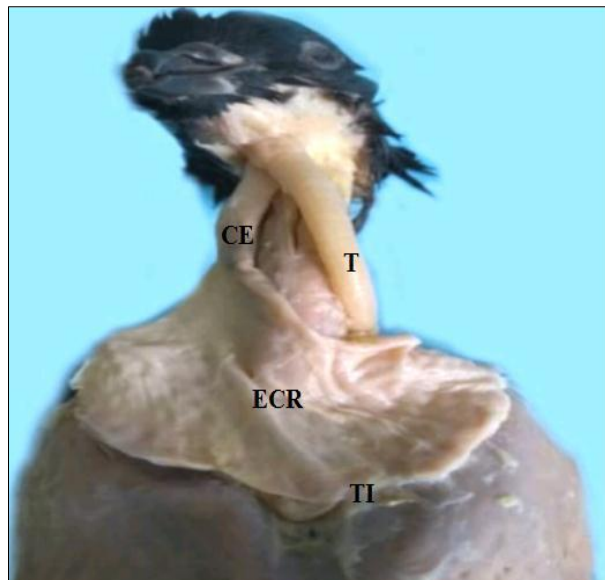


Fig 4: Gross photograph of oesophagus showing cervical oesophagus (CE) located right lateral aspect of trachea (T) and empty crop (ECR) located on the thoracic inlet (TI)

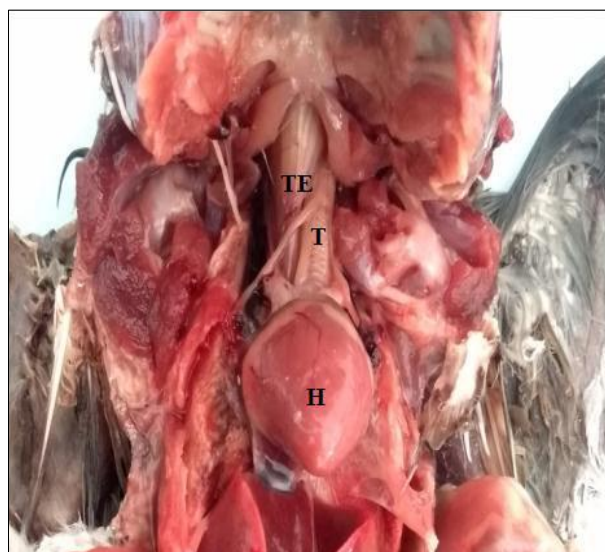


Fig 5: Gross photograph showing thoracic oesophagus (TE) located right side of trachea (T) and dorsal to the heart (H)

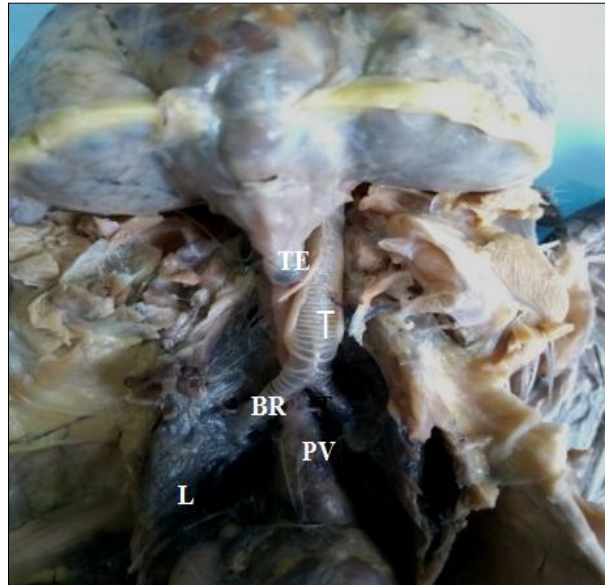


Fig 6: Gross photograph showing thoracic oesophagus (TE) located on the ventral aspect of lung (L) and right side to the trachea (T) then continued in between two bronchi (BR) up to the cranial end of proventriculus (PV)



Fig 7: Gross photograph of mucosal surface of cervical oesophagus showing longitudinal folds (LF)

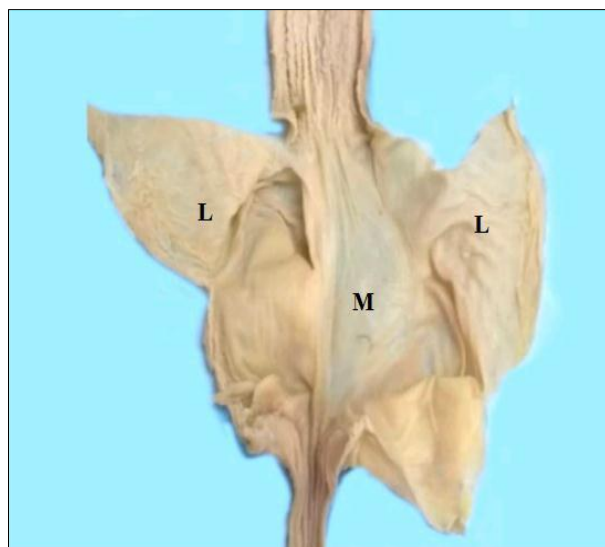


Fig 8: Gross photograph of mucosal surface of crop showing lateral lobes (L) and middle lobe (M)



Fig 9: Gross photograph of mucosal surface of thoracic oesophagus showing Longitudinal Folds (LF)

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