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MORPHOLOGICAL DESCRIPTION OF MEDIASTINUM IN GOLDEN JACKAL (*Canis Aureus Moreoticus*)

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Abstract

Golden Jackal expansion in Romania is increasing, starting in the southern and south eastern regions to the central regions. This is based on the ability of this species to adapt to different areas and varied diets. In these circumstances, its ecological niche is very broad, favoring the spread. The detailed anatomical descriptions of this species are few, lacking a fair characterization. The aim of this paper is to describe the anatomical peculiarities of the mediastinum in order to compare with scientific reports related to domestic species. Seven specimens were examined. The thoracic cavity was elongated, the lungs and pleural cavities occupying the most part. The mediastinum was referred as a region with three divisions: cranial, middle and caudal. Due to the obvious delineation of its components, the middle mediastinnum was further subdivided in: ventral, middle and dorsal subregions. Due to the caudal position of the heart in the thoracic cavity, the cranial divisions of the mediastinum were large. The reflection of fibrous pericardium on the diaphragm and sternum formed the strong phreno-pericardial ligament and sterno-pericardial ligament. After a short path, the phreno-pericardial ligament followed a divergent path, each part being inserted at the junction of the aponevrotic with fleshy part of the diaphragm. The sterno-pericardial ligament was inserted on the entire dorsal aspect of the sternum, the most compact part connecting the heart apex to the xiphoid process. The results of this study are useful both to the comparative morphological and clinical studies. Based on our results, the differentiation of this specie could be achieved.

Key words: *thoracic cavity, mediastinum, anatomy, Golden Jackal.*

INTRODUCTION

Caused by a surprisingly high breeding rate of the jackal in Romania, in 1996 this specie was included on the list of species admitted to hunt. The presence of the jackal has been attested in Romania since the neolithic age. Skeletal fossils have been reported in archaeological excavations in areas Techirghiol and Braşov (Almăşan, 1995; Angelescu, 2004). In *Descriptio Moldaviae,* Dimitrie Cantemir makes the first documentary record of this species in our country. However, extensive research linked to this species has not been achieved in recent years. Most studies focused on occupied area and less specific research. The golden jackal adapts easily and spread rapidly in different areas including inhabited zones (Murariu, 2005; Arnold et al., 2012). In Europe, the golden jackal is present mostly in the Danube basin.

The golden jackal is now found in the southern countries of Europe: Turkey, Greece, and Cyprus, continuing in Serbia, Croatia, Italy, Bulgaria, Romania, Moldova, Hungary, and Ukraine until the central countries: Austria, Switzerland and southern Germany (; Krofel, 2008; Lapini et al., 2009; Szabo et al., 2009; Stoyanov, 2012). Other studies have documented the nutritional habits of this specie (Lanszki et al., 2006; Borkowski et al., 2011; Chourasia et al., 2012; Shabbir et al., 2013; Cirovic et al,. 2014). The results of these studies have shown the presence in varying proportions of mammals, arthropods and plants in the diet of the jackal. Specific anatomical studies have focused on the morphometry of the skull in golden jackals. To our knowledge this is the first description of the mediastinum in golden jackal. The descriptions of the thoracic cavity are similar in all mammals. Anatomically, the thoracic cavity is divided in three compartments: two pleural cavities, more or less interconnected, and the mediastinum, the region between the two pleural cavities. With few exceptions (dog and horse) the two pleural sacks are completely separated from each-other,

offering a complete functional independence to the two lungs. Above the aortic arch and caudally from the esophagus, the two pleural sacks (through the two pleura right and left) are in contact with each-other. In all mammals, the heart is enclosed by the pericardium. On its origin the fibrous pericardium is fixed at the base of the heart on the great vessels and has insertions on the diaphragm and the sternum (Barone, 1997). The degree of attachment of the sternum and diaphragm varies between species, some authors claim that the phreno-pericardial ligament is the only attachment in canine (Evans and de Lahunta, 2013). This ligament is well represented in humans and pigs (Goshal, 1975), while the sterno-pericardial ligament is very evident in ruminants (Budras and Habel 2003). In some equine breeds, the pericardium is attached directly to the sternum or a strong sterno-pericardial ligament makes the attachment (Dyce et al., 2002).

MATERIALS AND METHODS

The study was conducted on a lot of seven golden jackals (*Canis Aureus Moreoticus*), four males and three females, of various ages and weights. The entire study was conducted in accordance with the Protocol on Medical Ethics and in compliance with the Directives 63/2010 of the European Parliament and of the Council on the Protection of Animals Used in Scientific Research. The subjects provided from hunting. Given the need to preserve accurate topography and especially the ligaments and connection elements, stratigraphic and regional dissection was performed following an own protocol.

A median incision was performed, starting from the submandibular region, along the neck, laterally from the sternum On the abdominal cavity the incision was performed along the white line. The organs were photographed both *in situ* and after extraction from the cavities.

The components were measured, photographed and the data was recorded.

RESULTS AND DISCUSSIONS

In all subjects the mediastinum (*Mediastinum*) showed the same general characteristics present in domestic mammals (Barone 1997). Situated between the right and left pleural sacks, the mediastinum was observed as a well delimited region, whose components were surrounded by connective tissue. This tissue performs both the morphological and dynamic connections between the different organs of the mediastinum forming various ligaments, being considered "the physiological mediastinum skeleton" (Goshal, 1975; Iaizzo, 2005) (Figure 1). Considering the position of the heart we defined the three mediastinal regions: cranial, middle and caudal, in accordance with anatomic nomenclature. The cranial and caudal regions of the mediastinum were divided in two smaller subregions: dorsal and ventral. Due to the clear delineation of the components, the middle region was divided in the following subregions: cranial, median (or middle) and caudal (Figure 2). Generally, in mammals, except

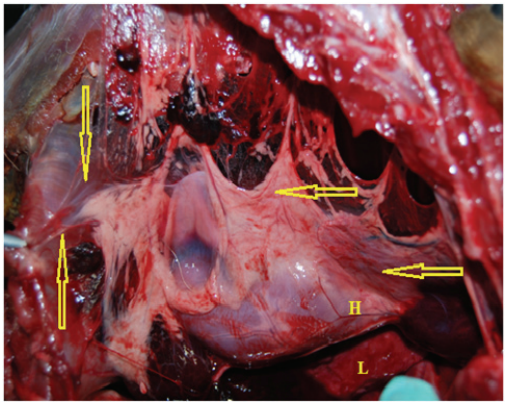

Figure 1. Mediastinal connective tissue organization and ligaments establishment. H-heart; L-lungs.

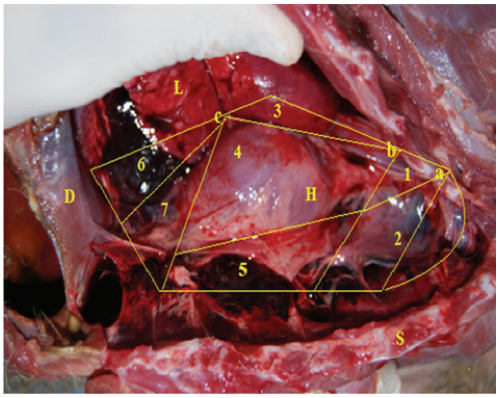

Figure 2. Schematic delineation of mediastinal regions. a-cranial mediastinum: 1-dorsal, 2-ventral region; b-middle mediastinum: 3-dorsal, 4-middle 5-ventral regions; c-caudal mediastinum:6-dorsal, 7 ventral region. H-heart;L-lungs; D-diaphragm; S-sternum. Curved line-cranial thoracic inlet

humans, each mediastinal region has only the dorsal and ventral sub-regions (Barone 1997; Dyce et al., 2002; Cotofan et al., 2007).

The cranial mediastinum (*Mediastinum craniale*) was ranged between the cranial aperture of the thorax and the cranial part of base of the heart (Figure 2). The lateral margins were formed by the mediastinal parietal pleura (its cranial segment). Dorsally it was bordered by the first thoracic vertebrae, and ventrally by the endothoracic side of the sternal manubrium. The aortic arch showed a slight ascension in the cranial mediastinum. This feature was also noted in domestic canines (Barone, 1997). In ungulates, the inferior limit is given by the aortic arch (Goshal, 1975; Budras et Habel 2003), while in humans and rabbits the aortic arch is situated completely in the cranial mediastinum (Papilian, 2001; Quesenberry and Carpenter 2012). Due to the higher volume of the cranial lobe of the right lung, the cranial mediastinum was slightly deviated to the left. This aspect is present, according to anatomical descriptions, in swine and cattle too (König and Liebich 2014).

The components of the *cranial dorsal mediastinum* (Figure 3 and 4) were identified after removal of the superficial structures. The thoracic part of the trachea up to its bifurcation was clearly visualized together with proximal thoracic segment of the esophagus. The esophagus was initially situated on the left and then dorsally from the trachea; The great arterial vessels: the brachiocephalic trunk, subclavian arteries, common carotid arteries

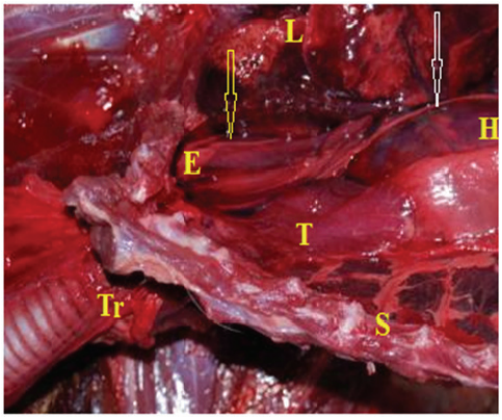

Figure 3. Components of cranial mediastinum. E-esophagus; Tr-tracheea before passing through the toracic inlet; T-thymus; H-heart; S-sternum; L-lifted lungs for beter visualisation; Vagus nerve lateralto the esophagus-yellow arrow: Left phrenic nerv-white arrow.

(Figure. 4) were carefully dissected. Ventrally and to the right of the trachea, the roots of the cranial cava vein were visualized. The terminal segment of the thoracic duct ascends to the cranial dorsal mediastinum to the left to join the venous system at the junction of the left external jugular vein with the left subclavian vein. (Evans and de Lahunta, 2013; König and Liebich 2014). The cranial mediastinal lymph nodes were identified near to the cranial vena cava. Evans and de Lahunta (2013) claim that in domestic dogs, the cranial mediastinal lymph center is the only centre which drains the mediastinum. Its nodes vary in number and shape, and most of them are associated with the large vessels of the heart that run in the dorsal

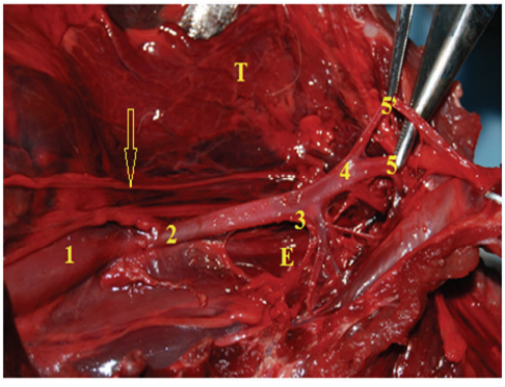

Figure 4. The brachiocephalic trunk-2, a major vessel of dorsal cranial mediastnum. 1-ascendant aorta; 3-left subclavian artery; 4-bicarotic trunk; 5,5' carotid arteries; T-thymus; e-esophagus; Right phrenic nerve-arrow

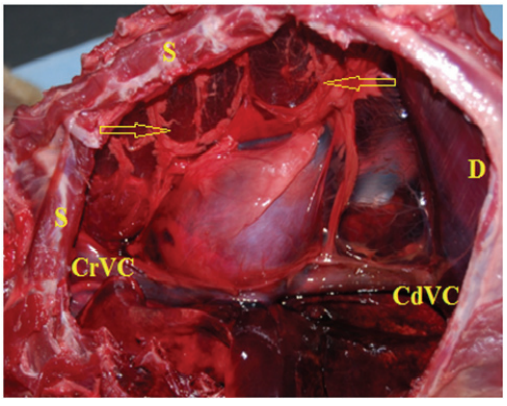

Figure 5. Ventral region of middle mediastinum, with obvious sterno-pericardial ligament-arrows. S-sternum; CrVC-cranial vena cava; CdVC-caudal vena cava; D-diaphragm.

part of cranial mediastinum. The vagus nerves and the phrenic nerves have passed through the dorsal cranial mediastinum. On the right, the phrenic nerve has passed lateral to the subclavian artery (Figure 4), while on the left side the phrenic nerve has passed lateral to the cranial vena cava. On the right, the vagus crosses cranial to the subclavian artery. On the left its path was laterally to the arch of the aorta. In young subjects (3 subjects), the *cranial ventral mediastinum* was occupied by the thymus (Figure 3) supported and covered by the endothoracic fascia, and in older subjects, the place of the thymus was taken by a small amount of adipose tissue. The ventral cranial mediastinum was slightly deviated to the left of the median plane. This feature is present in domestic canines too (Dyce et al., 2002; Evans and de Lahunta 2013). In swine and lagomorphs this region is situated almost median, while in cattle the cranial ventral mediastinum is pushed by the cranial lobe of the right lung towards to the left wall (Barone, 1997; Budras and Habel, 2003). In humans the division of the mediastinum in superior and inferior mediastinum is made by the thoracic transverse plane which passes through the sternal angle and the junction of the thoracic vertebrae T4-T5 (Iaizzo, 2005; Papilian, 2001). In animals, the mediastinum has a different shape due to quadruped position and due to the heart topography (Figure 6) (Barone, 1997; Coțofan, 2007).

The *middle mediastinum* was much more voluminous compared to the cranial or caudal mediastinum, because of the heart which holds the greatest part of it (Figure 5 and 6). Compared to the previous one, we have divided this region in three subregions: cranial, medial (or middle) and ventral. The same divisions are also present in humans referring to the inferior mediastinum: anterior, middle and posterior (Papilian, 2001; Iaizzo, 2005). The *ventral middle mediastinum* was separated by the next compartment by a small band of adipose connective tissue, more or less visible, depending on the subject, and by the sterno pericardial ligament (Figure. 7). This ligament was detached from the ventral side of the heart to be inserted on the dorsal side of the sternal manubrium, continuing up to the xifoid process. Compared to humans, in whom the sterno-pericardial ligament is divided into two segments, a superior and an inferior one, in our subjects, this ligament showed an almost continuous insertion on the dorsal side of the sternum. The most well developed segment was the one between the apex of the heart and the dorsal wall of the xiphoid process (Figure 7). The medial compartment of the middle mediastinum contained the heart. Its projection was situated between the ribs III-VI. This applies to most animals, except swine and lagomorphs, in which the heart's projection is between the ribs II-V (Barone, 1997; Coțofan, 2007). The fibrous pericardium (*Pericardium*

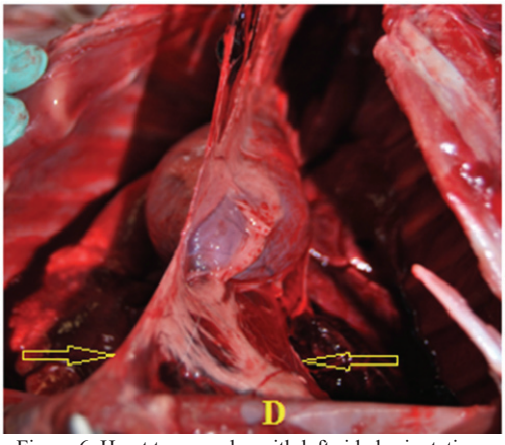

Figure 6. Heart topography with left sided orientation and ventrally tilted long axis of the heart. Divergent orientation of phreno-pericardial ligament-arrows. The distance to the diaphragm is obvious. The heart define overall orientation.

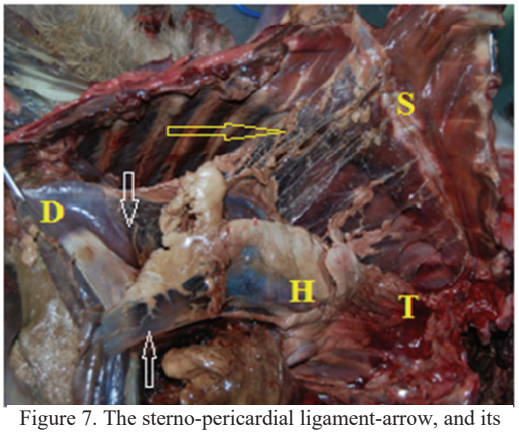

Figure 7. The sterno-pericardial ligament-arrow, and its insertion on the dorsal aspect of the sternum. In young subjects, this ligament formed the lateral walls of thymus-T loja. D-diaphragm; Phreno-pericardial ligaments-white arrows.

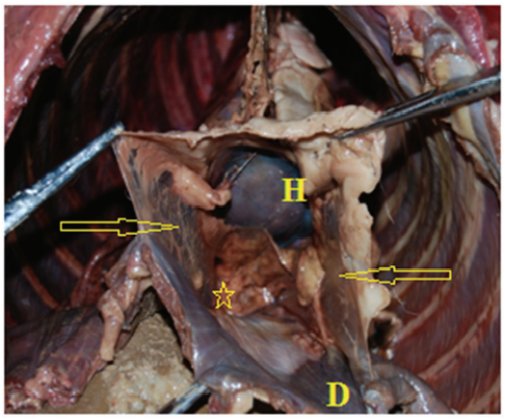

Figure 8. After a short path, the phrenopericardic ligament is divided into two parts: left and right phreno-pericardial ligaments-arrows. Accessory lobe of right lung-asterix

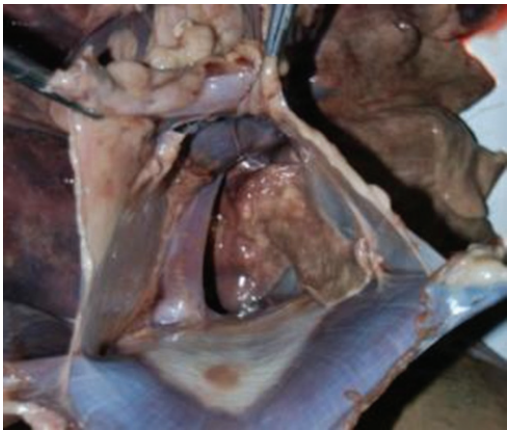

Figure 9. The phreno-pericardial ligaments and their insertion, lateral to the tendineous center of diaphragm in Golden Jackal.

fibrosum) was fixed at the base of the heart on the great vessels. Its reflection from the caudal margin of the heart on the diaphragm realized the phreno-pericardial ligament (Figure 8). The origin of this ligament was common, but after a short distance two ligaments were separated, a left one and a right one. Their diaphragmatic insertion was at the junction between the aponevrotic and the fleshy portions (Figure 9) ventrally being continued on fleshy portions This divergent aspect of the phreno-pericardial ligament was also reported in guinea pigs (Stan, 2015) and in humans (Papilian, 2001; Iaizzo, 2005). The presence and development of sterno-pericardial and phreno-pericardial ligaments is variable depending on the specie. In equine, cattle and swine the sterno-pericardial ligaments attach the heart to the sternum in the absence (or weak presence) of the phreno-pericardial ligament, while in canines, according to some authors (Evans and de Lahunta, 2013) the phreno-pericardial ligament is the only attachment of the fibrous pericardium to the diaphragm. Other authors attest in dog the presence of a tiny sterno-pericardial ligament (Barone 1997). In the middle compartment of the middle mediastinum we identified the structures which realized different reports between them and with pericardium. The left phrenic nerve was attached through a small fold to the left side of the pericardium (Figure 10). The right phrenic nerve has passed the pericardium to be attached to the caudal vena cava, leaving the mediastinum. The endings of the cava veins and the right azygos vein were observed in the right side. The same feature is present in canines, equines and lagomorphs (Dyce et al., 2002; Coțofan, 2007; Quesenberry and Carpenter 2012).The pulmonary veins (Figure 10) were observed from the lungs hillum in their path to the left atrium;

The *dorsal middle mediastinum* (Figure 11) showed the axial structures: the trachea, esophagus and the great vessels. The distal segment of the trachea, placed dorsally from the bifurcation of the pulmonary arterial trunk was attached to the pericardium through fibrous connective tissue. In this region, the esophagus was situated dorsally to the trachea. The aorta crossed the trachea and the esophagus on the left. It arched towards the caudal direction

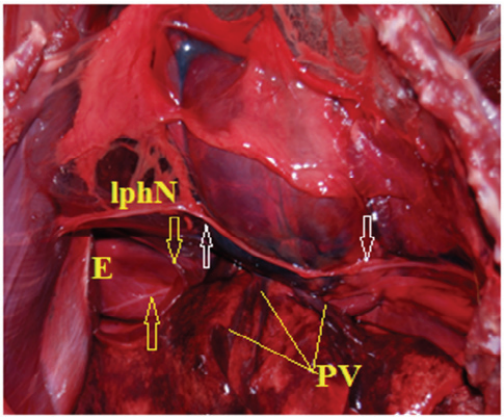

Figure 10. Left phrenic nerve-lphN and its thiny attachement to the pericardium-white arrow; Dorsal and ventral vagal trunk-yellow arrow; PV-pulmonary veins

along the vertebral column, becoming the descending aorta. In this region, dorsally from the heart, the esophagus is frequently the place of foreign body obstruction (Budras and Habel 2003; König and Liebich 2014).The arterial pulmonary trunk leaves the pericardial sack on the right side of the aorta and caudally from it. Dorsally to the tracheal bifurcation the arterial pulmonary trunk divided into two branches, namely the right and left pulmonary arteries. Laterally and to the left from the aortic arch, the left vagus nerve gave birth to the recurrent laryngeal left branch. The right vagus nerve was positioned in the right of the trachea. The dorsal and ventral vagal trunks were visible on each side of the esophagus. Regarding the tracheo-bronchial lymph nodes, they were situated at the tracheal bifurcation at the origin of the main bronchi (Figure 12).

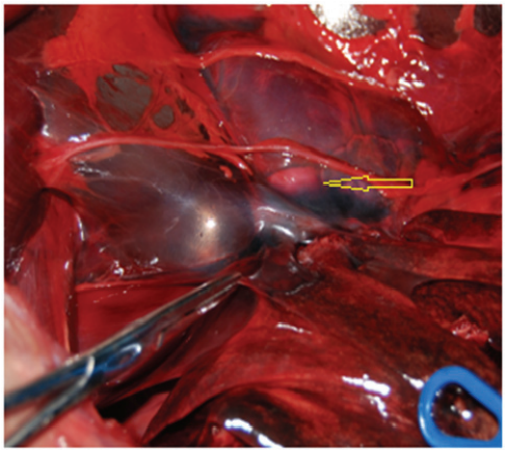

Figure 12. Tracheo-bronhial lymph node-arrow in middle mediastinum

The caudal mediastinum (*Mediastinum caudale)* was very visible due to distance between the heart and diaphragm. In all domestic mammals, the caudal mediastinum is much more visible compared to human (Barone, 1997; Iaizzo, 2005). Situated between the dorso-caudal margin of the heart, the lungs root and the diaphragm, the caudal mediastinum showed an approximately triangular shape. Ventrally, it was extended to the xiphoid process. Its dorsal margin is reported to the vertebral column. Due to the larger size of the right lung, the caudal mediastinum was slightly deviated to the left. The clear longitudinal insertion of the pulmonary ligament has divided this region in dorsal and ventral sub-regions.

The caudal ventral mediastinum, delimited by the pericardium and diaphragm was very narrow. It contained the left phrenic nerve, on its dorsal side. Its ventral margin gave insertion area to the caudal vena cava plica (Figure 13). This fold was inserted on the diaphragm, from the caudal vena cava foramen to the sternum going up to the pericardium. Its dorsal margin was attached to the caudal vena cava and its short ventral margin was attached to the ventral part of the caudal mediastinum. Between the two, a profound mediastinal recess was formed in which the accessory lobe of the right lung has entered. In domestic canines and swine, the

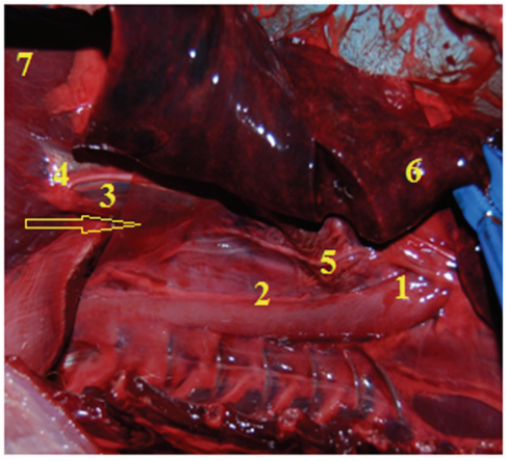

Figure 11. Esophagus-1 path in caudal mediastinum. 2-ventral trunk of vagus;pulmonary ligament-arrow; 3-caudal vena cava and 4-right phrenic nerve; 5-left phrenic nerve; 6-lungs; 7-diaphragm.

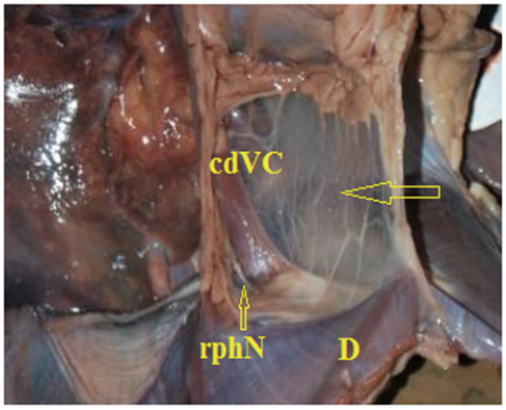

Figure 13. Caudal vena cava plica-arrow. On its passage to the diaphragm, the caudal vena cava is accompanied by the right phrenic nerve-rphN.

right accessory lobe is only partially positioned in this recess (Barone, 1997). From what we presented, results that the biggest part of the caudal cava vein and much of the path of the right phrenic nerve don't belong to the mediastinum.

The caudal dorsal mediastinum was marked by the presence of the aorta, which starting from the aortic arch to its passage through the diaphragm. This segment of descending aorta belongs to the caudal mediastinum. Also, the esophagus has presented in this region an extended path, being accompanied by the dorsal and ventral vagal trunks and the esophageal vessels. These features are similar to those described in domestic dogs (Barone, 1997; Evans and de Lahunta 2013).

CONCLUSIONS

In the Golden Jackal, the mediastinum presents characteristics similar to those of domestic canines.

Due to clear separation of the components of the middle mediastinum of GoldenJjackal, it can be divided into three sub-regions: dorsal, middle (or medial) and ventral.

Plica vena cava together with the mediastinum wall form a deep mediastinal recess in which the accessory lobe of the right lung enters.

Most of the path of the caudal vena cava and the right phrenic nerve which accompanies it does not belong to the mediastinum.

In the golden jackal, the phreno-pericardial ligament is double. After a short path from its origin it separates in two parts whose insertions are at the junctions of the aponevrotic and fleshy parts of the diaphragm.

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