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Computed Tomographic Anatomy of the Thoracic Cavity Vessels in the Rayini Goat

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Abstract

Objectives- To provide a reference anatomy of the thoracic cavity vessels of the Rayini goat by using Computed tomography.
Design- Experimented study.
Animals- Five healthy Rayini goat.
Procedures- Spiral CT images (with and without contrast media) were acquired from the thoracic region perpendicular to long axis of the body. CT windows were adjusted as necessary to have optimized images of the vessels. The images were studied serially and compared anatomically with two dissected goat.
Results- Caudal and cranial vena cavae, descending aorta, brachiocephalic and subclavian arteries, costocervical and azygos veins, internal thoracic vessels and pulmonary trunk, arteries and veins were distinguished and addressed according to the thoracic vertebrae as landmarks.
Conclusions and clinical relevance- Identification of the thoracic vessels, their precise position and related structures is important in therapeutic or experimental surgery of this region. Moreover differential diagnosis of space filled abnormalities need to know the anatomy of normal structures. This is the first study which is addressing thoracic vessels of a ruminant by using CT modality.
Keywords: Computed Tomography, Anatomy, Goat, Thoracic, Vessel

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Introduction

Computed tomography (CT) is an imaging technique which gives us an opportunity to review cross sections of the body in live animal. It is a valuable tool for evaluating intrathoracic diseases and makes it possible to have better diagnosis for presence, location and extension of pathology and involvement of thoracic structures in comparison to standard radiography[1]. It also represents a better contrast for solid, fatty, cystic, calcified and vascular structures[2]. In veterinary medicine, although CT is mostly used for diagnostic purposes in small animals[1-7] reports of use of this modality in identification of mass filled abnormalities[8-10], calculating the volume of tissues[11] operation and management of fractures[12,13] in herbivores are growing increasingly. In recent years, CT also has been used as a non invasive modality in non clinical studies[14-19] specially those studies which need to monitor a structure of an individual in different periods of time[20,21].

In the thoracic region, discern between vessels and pathologic structures is important in CT diagnosis of diseases[6,22]. Despite of possibility to manipulate the gray scale in order to have optimal visualization of organs in the CT images, identification of anatomic from pathologic structures need to have detailed information of organ's size and place[22-24]. Therefore in present study, although the gross anatomy of the thoracic vessels in the small ruminants has been described[25,26], we used CT technique to reproduce another anatomic reference of these vessels in goat with more detailed information and possible three dimensional application.

Materials and methods

Five healthy adult male Rayini goats weighting about 30-35 kg and aging 3-3.5 years were used in this study. Each goat was given intramuscular Atropine[Daroopakhsh, Iran] (0.4 mg/kg) and anesthetized by intravenous injection of mixed Ketamine[Alfasan Holland] (2.2 mg/kg) and Xylazine[Alfasan Holland] (0.11mg/kg).

The goats were positioned in sternal recumbency and X- ray radiation was adjusted by an angle of 90 degrees to the longitudinal axis of the trunk. Tomograms were acquired at a thickness of 1 mm using a third generation CT scanner with dynamic scanning capabilities (Toshiba Xvision EX, Japan). The acquisition parameters were as follows: kVp 120, mA 100 and scan-time of 1-S. Window width and level were adjusted as necessary to obtain the optimal image of the vessels (WW: 233 and WL: 100). Water souluable iodinated contrast medium (Visipaque[Berlimed Spain]) was then administered intravenously at a dose of 2mg/kg using a pressure injector and the animals were scanned once more by the same position and parameters.

Following image acquisition, two goats were euthanized with an overdose of pentobarbital while still under anesthesia. CT images were labeled by comparison with dissected thorax of the euthanized goats. Thoracic vertebrae were used as landmarks to describe the location and extension of the vessels.

Results

In plates 1 to 16, CT images, which have been selected from one goat, are viewed from cranial to caudal. Transverse images have been presented how the left and dorsal aspects of the animal are in the left and top sides of the images respectively. Each plate included two CT images, with (right) and without (left) contrast media, which have been acquired in a same level. In these images, the major vessels of thoracic cavity have been identified and labeled.

Caudal vena cava (Plate. 11 to 16) was seen as an evagination of the right atrium at the level of the 6th thoracic vertebra. In the next caudal images it was observed as the most ventral of those vessel situated on the dorsal of the heart and in common with the aorta had the greatest diameter of them. It was detached the cranial phrenic vein at the level of the 8th thoracic vertebra.

Cranial vena cava (Plate 2 to 7) was formed by two external jugular veins at the level of the 1st thoracic vertebra. It was seen firstly ventral to the brachiocephalic trunk, but beyond the caudal part of the 2nd thoracic vertebra it gradually displaced to the right side of the mentioned artery. According to its course, the cranial vena cava was seen as a round structure in all images from the 1st to the caudal part of the 3rd and in one case cranial part of the 4th thoracic vertebrae, where entered to the right atrium.

Aortic arch was seen along the 3rd to 4th thoracic vertebrae as a relatively vertical structure left to the junction of cranial vena cava with the heart (Plate 7). At the level of the 3rd thoracic vertebra, it detached brachiocephalic trunk cranially as a round structure left to the cranial vena cava (Plate 6). Descending aorta (Plate 8 to 16) was recognized dorsal to the base of the heart and in the left side of the esophagus at the level of the caudal part of 4th and cranial part of the 5th thoracic vertebrae (Plate 8). It shifted dorsally in the mediastinum during its caudal course and situated on the dorsal of the esophagus and ventral to the longus colli muscles between 5th and 6th thoracic vertebrae. From the 6th thoracic vertebra caudally, which longus colli muscles disappeared, the aorta was seen just beneath the vertebral bodies.

The brachiocephalic trunk (Plate 1 to 6) was seen ventral to the trachea at the mid third of the mediastinum along the first three thoracic vertebrae.

Left and right subclavians were detached from the brachiocephalic trunk at the level of the caudal (Plate 2) and cranial (Plate 1) part of the 1st thoracic vertebrae correspondingly. Right and left axillary arteries were detached from the respective parent artery and coursed a transverse course cranial to the first rib to exit, with their correspond vein, the thoracic cavity (Plate 1 to 2).

Pulmonary trunk was observed in continuation with the conus arteriosus under descending aorta at the level of the 5th thoracic vertebra (Plate 8). It coursed a short distance caudally to the level of caudal part of aforementioned vertebra where bifurcated to the right and left pulmonary arteries (Plate 9 to 10). Caudal branch of each pulmonary artery coursed caudally in the middle of thorax height and branched of some ramies to the different segmentations of the lungs (Plate 11 to 16).

At the level of 6th thoracic vertebra the pulmonary veins converged to meet the heart at the midline (Plate 11). From this point caudally they diverged to form distinct right and left pulmonary veins which were observed medial to their respective pulmonary arteries.

The internal thoracic veins situated medial to their corresponding arteries. These vessels were seen along the 2nd to 8th thoracic vertebrae (Plate 4 to 16).

The costocervical (Plate 3) and right azygos (Plate 6) veins entered the cranial vena cava at the level of the 2nd and 3rd thoracic vertebrae respectively.

Left azygos vein was observed along the 7th to 8th thoracic vertebra caudally on the dorsolateral aspect of the aorta (Plate 13 to 16).

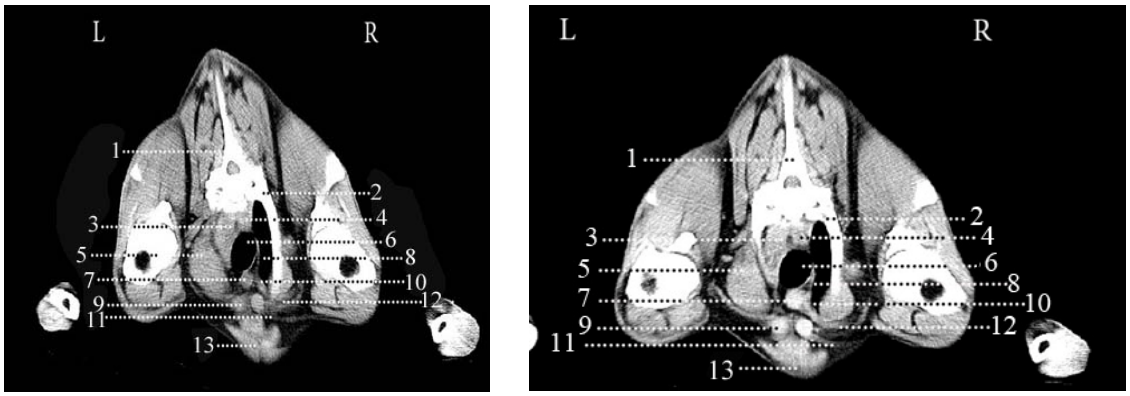

Plate 1. 1.1st thoracic vertebra, 2.First rib, 3.esophagus, 4.longus colli m., 5.Scalenus m., 6.trachea, 7.bicarotid trunk, 8.costocervical a., 9.jugular v., 10.right subclavian a., 11.axillary vein, 12.axillary a., 13.sternum.

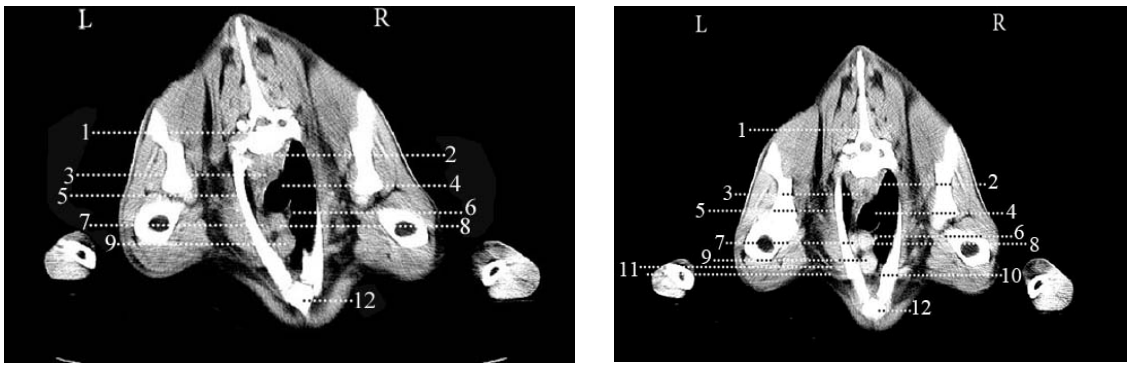

Plate 2. 1.1st thoracic vertebra, 2.longus colli m., 3.esophagus, 4.trachea, 5. First rib, 6. costocervical vessels., 7.left subclavian a., 8.brachiocephalic trunk, 9.cranial vena cava, 10.internal thoracic a., 11.axillary vessels, 12.sternum.

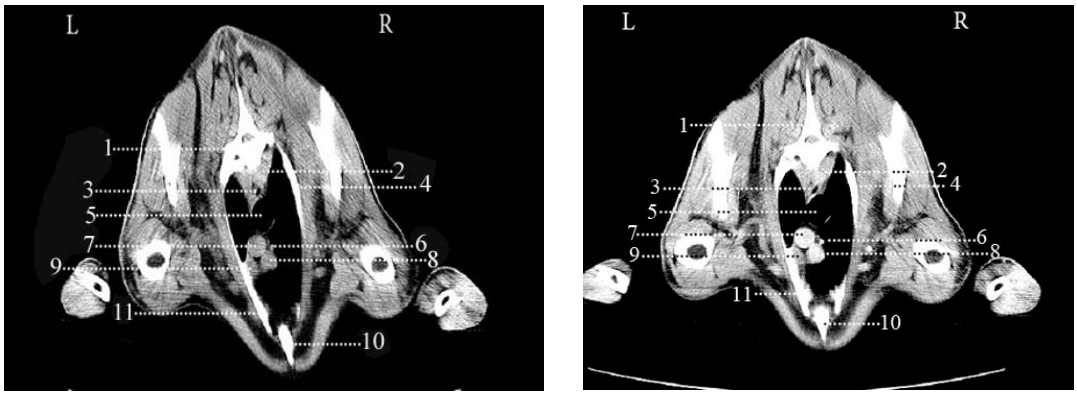

Plate 3. 1.2nd thoracic vertebra, 2.longus colli m., 3.esophagus, 4.2nd rib, 5.trachea, 6.costocevical v., 7.brachiocephalic trunk., 8.cranial vena cava, 9.mediastinal mass, 10.sternum, 11.left 1st rib

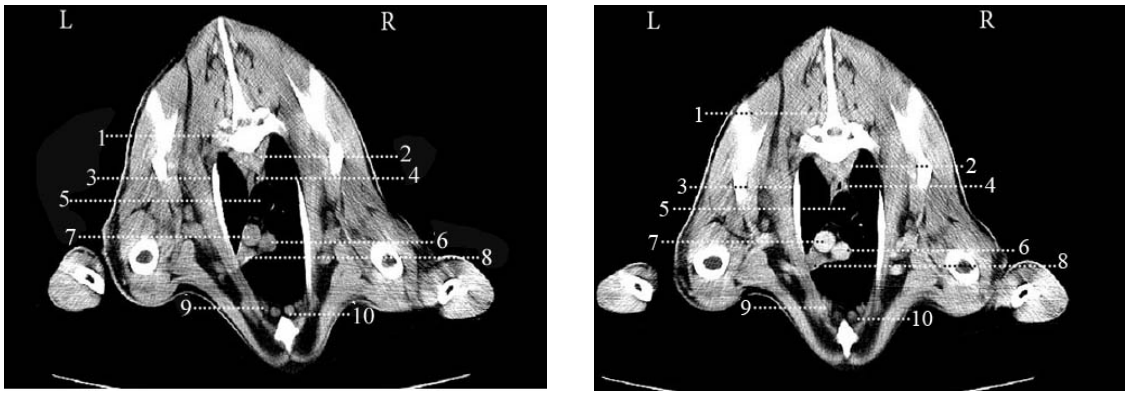

Plate 4. 1.2nd thoracic vertebra, 2.longus colli m., 3.2nd rib, 4.esophagus, 5.trachea, 6.cranial vena cava, 7.bicarotid a., 8. mediastinal mass, 9.left internal thoracic a., 10. Right internal thoracic v.

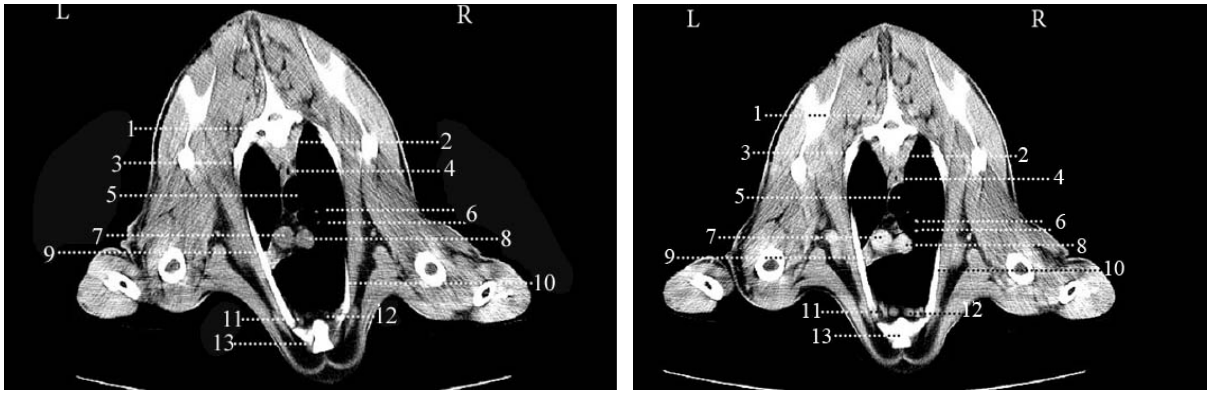

Plate 5. 1.3rd thoracic vertebra, 2.longus colli m., 3.3rd rib, 4.esophagus, 5.trachea, 6.apical branches of the right pulmonary vessels, 7.brachiocephalic trunk, 8.cranial vena cava, 9. mediastinal mass, 10.2nd rib, 11.left internal thoracic a, 12. Right internal thoracic v., 13.sternum

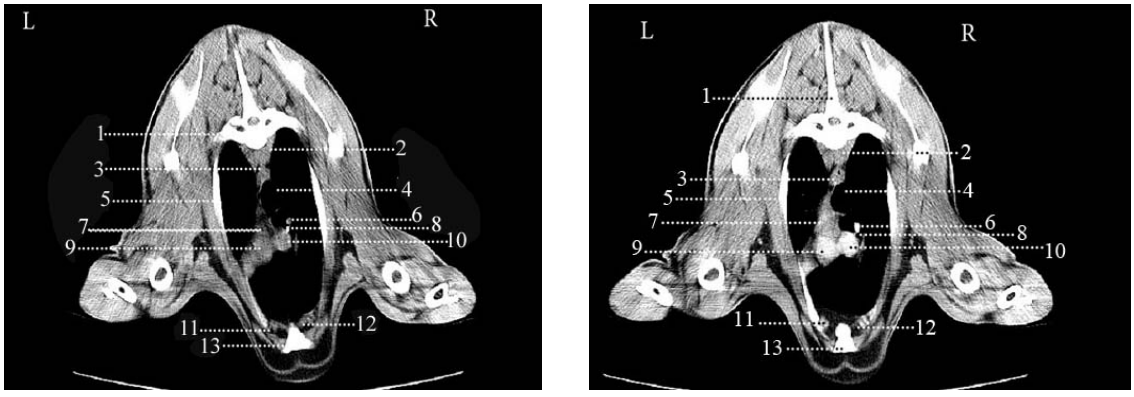

Plate 6. 1.3rd thoracic vertebra, 2.longus colli m., 3.esophagus, 4.trachea, 5.3rd rib, 6.pulmonary vein of the right apical lobe 7. mediastinal mass 8. right azygos, 9.brachiocephalic trunk, 10.cranial vena cava, 11.internal thoracic vessels, 12.transverse thoracis m., 13.sternum

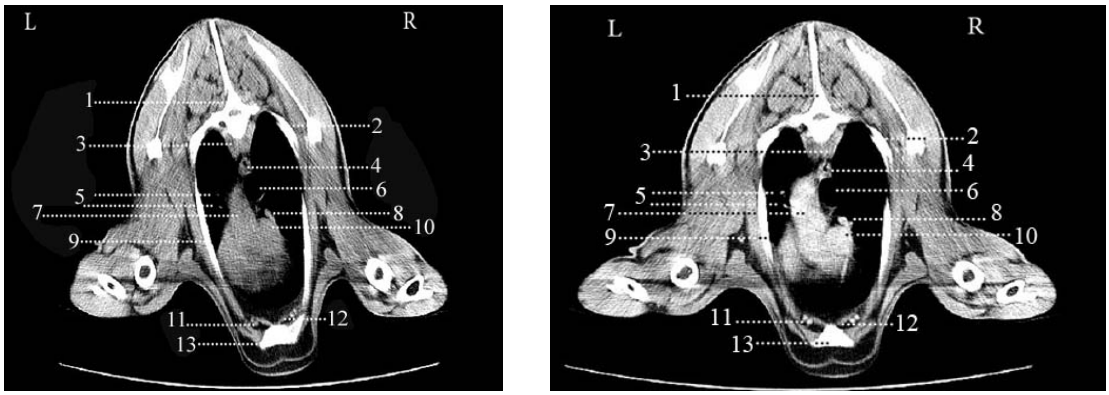

Plate 7. 1.4th thoracic vertebra, 2.4th rib, 3.longus colli m., 4.esophagus, 5.pulmonary vessels of the left apical lobe, 6.trachea, 7.aortic arch, 8.pulmonary vein of right apical lobe, 9.3rd rib, 10.cranial vena cava, 11.internal thoracic vessels, 12.transverse thoracis m., 13.sternum

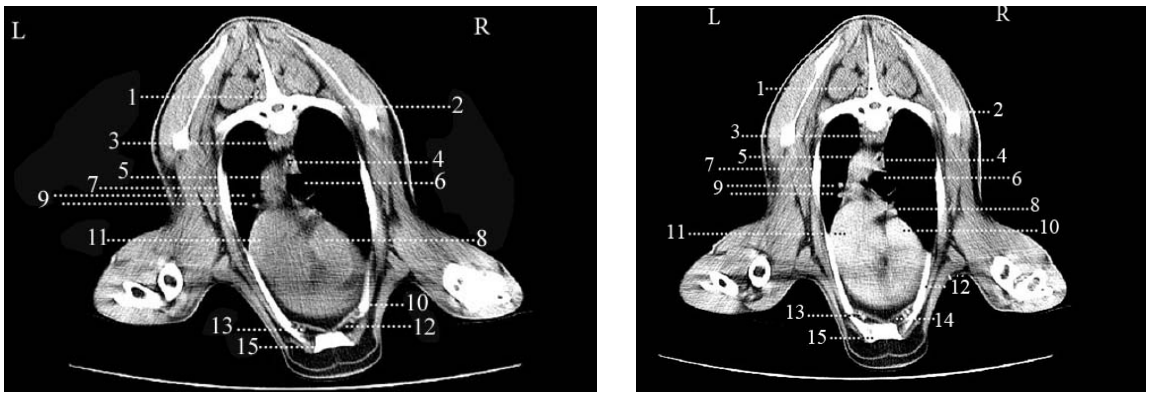

Plate 8. 1.5th thoracic vertebra, 2.5th rib, 3.longus colli m., 4.esophagus, 5.descending aorta, 6.trachea, 7.4th rib, 8. pulmonary vessels of the right apical lobe, 9. pulmonary vessels of the left apical lobe, 10.right atrium, 11.conus arteriosus, 12.3rd rib, 13.internal thoracic vessels 14.transverse thoracis m., 15.sternum

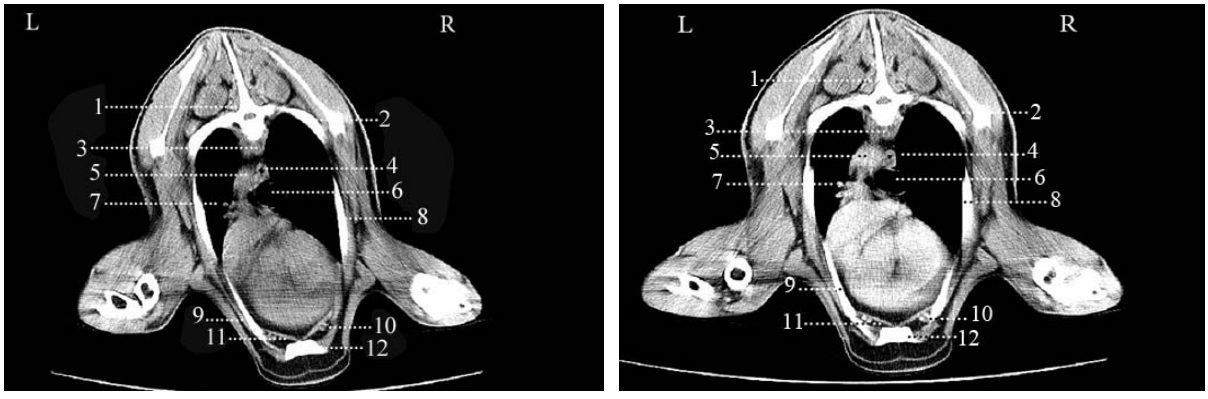

Plate 9. 1.5th thoracic vertebra, 2.5th rib, 3.longus colli m., 4.esophagus, 5.descending aorta, 6.trachea, 7. Ascending and descending branches of the left pulmonary a., 8.4th rib, 9.3rd rib, 10. internal thoracic vessels, 11.transverse thoracis m., 12.sternum

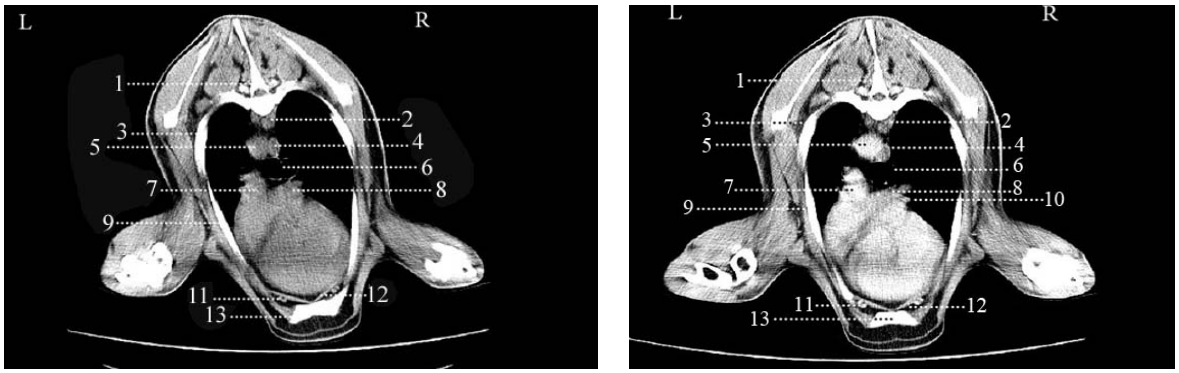

Plate 10. 1.5th thoracic vertebra, 2.longus colli m., 3.5th rib, 4.esophagus, 5.descending aorta, 6.tracheal bifurcation, 7.left pulmonary a., 8.right pulmonary a., 9.4th rib, middle branch of the right pulmonary a., 11.internal thoracic vessels, 12.internal thoracic vessels, 13.sternum

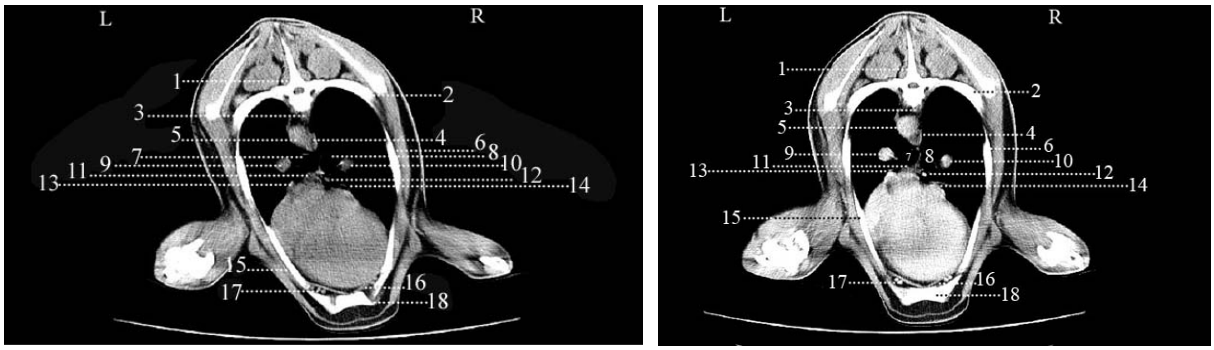

Plate 11. 1.6th thoracic vertebra, 2. 6th rib, 3.longus colli m., 4.esophagus, 5.descending aorta, 6.5th rib, 7.left bronchus, 8.right bronchus, 9.caudal branch of the left pulmonary a., 10.caudal branch of the right pulmonary a., 11.Pulmonary vv., 12.accesory branch of the right pulmonary a., 13.pulmonary vein of the left apical lobe, 14.caudal vena cava, 15.4th rib, 16.transverse thoracis m., 17. internal thoracic vessels, 18.sternum

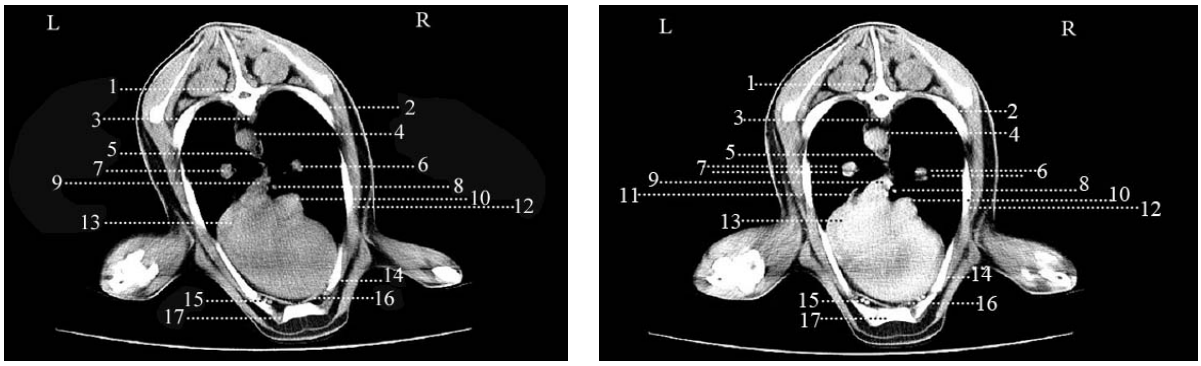

Plate 12. 1.6th thoracic vertebra, 2.6th rib, 3.longus colli m., 4.descending aorta, 5.esophagus, 6.caudal branch of the right pulmonary a., 7.caudal branch of the left pulmonary a., 8. accesory branch of the right pulmonary a., 9.Pulmonary vv., 10.caudal vena cava, 11. pulmonary vein of the left apical lobe, 12.5th rib, 13.left atrium, 14.4th rib, 15.internal thoracic vessels, 16.transverse thoracis m., 17. Sternum

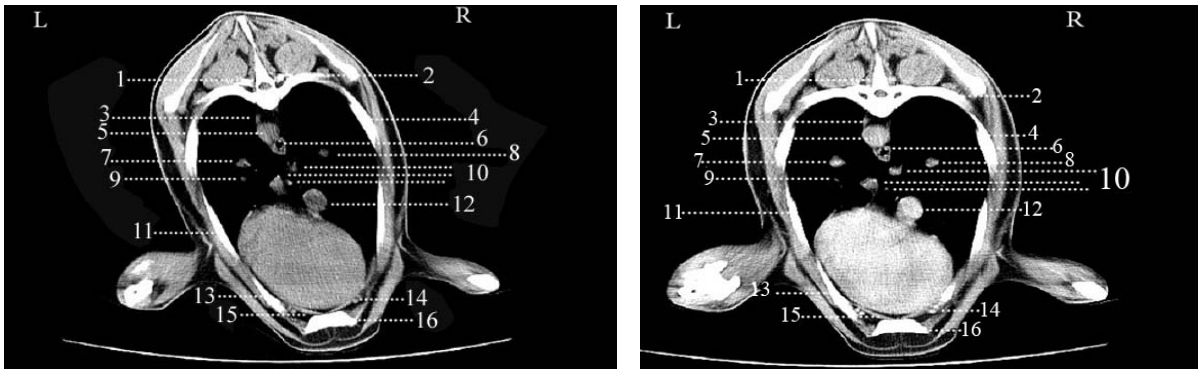

Plate 13. 1.7th thoracic vertebra, 2.7th rib, 3.left azygos, 4.6th rib, 5.descending aorta, 6.esophagus, 7.caudal branch of the left pulmonary a., 8.caudal branch of the right pulmonary a., 9.a branch of 7, 10. pulmonary vv., 11.5th rib, 12.caudal vena cava, 13.4th rib, 15.internal thoracic vessels, 16.transverse thoracis m., 17. sternum

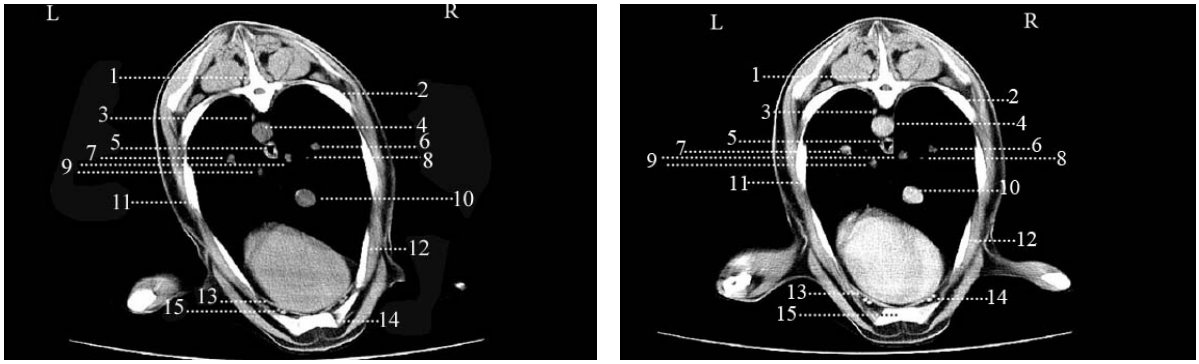

Plate 14. 1.7th thoracic vertebra, 2.7th rib, 3.left azygos, 4.descending aorta, 5.esophagus, 6.caudal branch of the right pulmonary a., 7.caudal branch of the left pulmonary a., 8.a branch of 6, 9.pulmonary vv., 10.caudal vena cava, 11.6th rib, 12.5th rib, 13.transverse thoracis m., 14.internal thoracic vessels, 15.sternum

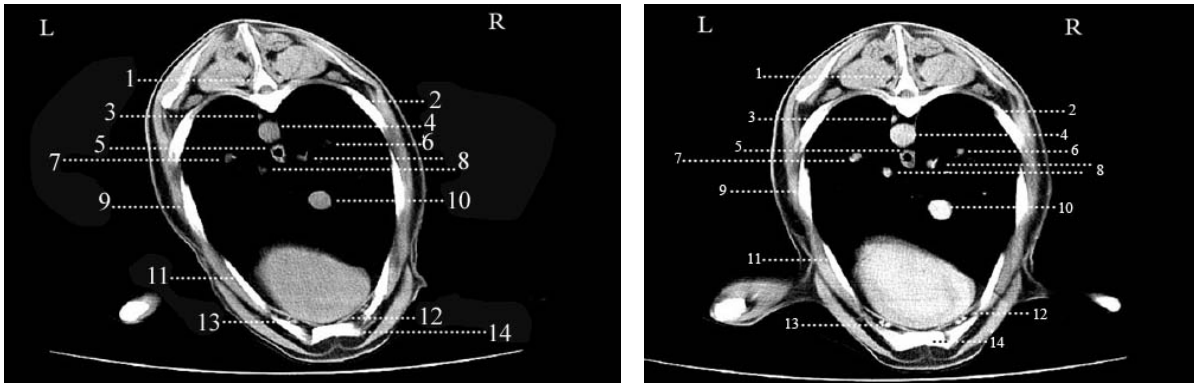

Plate 15. 1.7th thoracic vertebra, 2.7th rib, 3.left azygos, 4.descending aorta, 5.esophagus, 6.caudal branch of the right pulmonary a., 7.caudal branch of the left pulmonary a., 8.pulmonary vv., 9.6th rib, 10.caudal vena cava, 11.5th rib, 12.transverse thoracis m., 13.internal thoracic vessels, 14.sternum

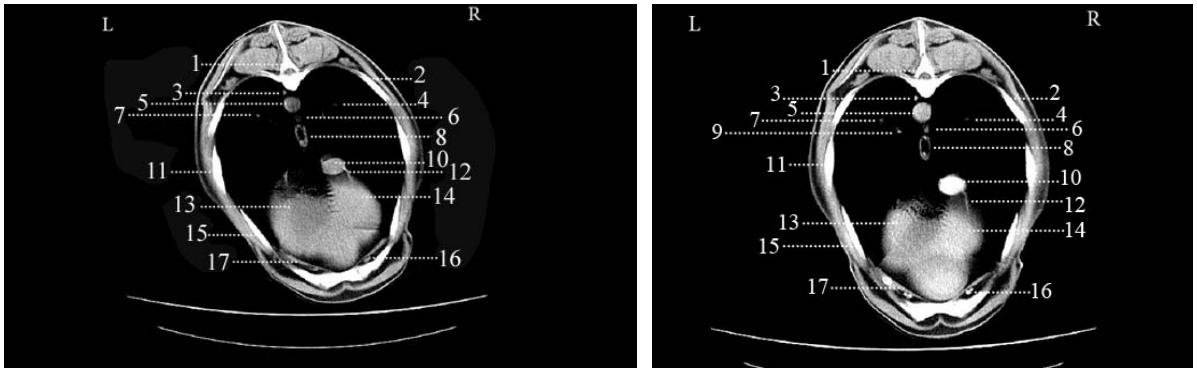

Plate 16. 1.8th thoracic vertebra, 2.8th rib, 3.left azygos, 4.caudal branch of the right pulmonary a., 5.descending aorta, 6.caudal mediastinal lymph node, 7.caudal branch of the left pulmonary a., 8.esophagus, 9.pulmonary v., 10.caudal vena cava, 11.7th rib, 12.right cranial phrenic v., 13.reticular shadow, 14.liver shadow, 15.6th rib, 16.internal thoracic vessels, 17.transverse thoracic m.

Discussion

In the most anatomic references, topography of the thoracic vessels are described according to the ribs and intercostals spaces[26,27] which is due to the lateral approach to these vessels during dissection. Because of curvature of ribs, in each cross sectional CT image, two or even three ribs would be observed, so they would not be suitable landmarks for addressing these structures. In present study we used thoracic vertebrae as a reference to describe the topographical position of thoracic vessels. Relativity of anatomical position of the body organs and the respective vertebrae may be due to precise position and formation of vertebrae during embryonic period. This relationship has been used in other studies for precise description of the location of body regions structures[18,24,28-30]. In other word, in those studies without having a landmark for determination of organ situation in CT slices[22,31], identification of organs place would be a randomly sectioning and will not give detailed information of an organs address.

Normal CT features of the thoracic cavity of the small animals have been studied in recent years[22,23,28-31], but we could find few articles which have focused on CT anatomy of the ruminants[16,18,19,21,32-35], which only one of them has roughly described some thoracic vessels of the goat[36]. In most of aforementioned studies, only some great vessels, like cranial and caudal vena cava and descending aorta, according to their diameter, position and neighboring organizations, simply were identified from other structures[22,28,31,36] but precise addressing of mentioned vessels and determination of the other thoracic vessels have not been done in reviewed articles. In present study we focused on the route, thoracic position, branching of the thoracic vessels and by contrast media, differential determination from non vascular thoracic structures.

Caudal vena cava was observed in the same position as Alsafy[36] has found but descending aorta was seen in one more cranial vertebra. We also observed pulmonary artery bifurcation one more vertebra cranial to that was seen in the mentioned work[36]. Differential identification of the caudal vena cava and right pulmonary artery can be made by paying attention to the greater diameter and more ventral position of the former vessel.

As a result of different topography and angle of the heart of the goat with that of carnivores[25,26], the proximal part of vessels which directly have been attached to the heart were observed in this study greatly differ from that were seen in related studies[22,28-31].
Mislabeling of cranial vena cava may be occurred[36] if we do not pay attention to its position and course that was mentioned in this study. Brachiocephalic trunk, bicarotid trunk and thymus in young animals are those structures which may be confused with the cranial vena cava.
According to the anatomy of the right azygos and costocervical veins[26] these two veins were detected at their entrance to the cranial vena cava at the level of 3rd and 2nd thoracic vertebrae correspondingly. Up to our knowledge this is the first CT report of detection of these two veins in the cranial mediastinum.
Except two studies[22,30] which have detected internal thoracic vessels in the cat and dog (without addressing them), we could not find any CT report of these vessels. Right and left transverse thoracic muscles were appropriate landmarks for identification of their underlying internal thoracic vessels which were observed from 2nd to 8th thoracic vertebrae in this study.
More cranial location of the pulmonary trunk bifurcation in comparison to the caudal vena cava incorporation into the right atrium[22,28] makes it possible to prevent mislabeling of these arteries which has been done previously[36].
Both left pulmonary artery and vein were seen closer to the median plane than the right vessels and all of them dorsal to the level of the caudal vena cava. The pulmonary veins also positioned more medially than the corresponding arteries.
The topographical position of above vessels has been shown in table 1 according to the thoracic vertebrae.

Table 1. topographical position of major thoracic vessels according to the thoracic vertebrae.

	T1	T2	T3	T4	T5	T6	T7	T8
Cranial vena cava	+	+	+	+				
Caudal vena cava						+	+	+
Aortic arch				+				
Descending aorta					+	+	+	+
Brachiocephalic trunk	+	+	+					
Left subclavian a.	+							
Right subclavian a.	+							
Pulmonary trunk				+				
Right and Left pulm. Arteries					+			
Pulmonary veins						+	+	+
Left azygos							+	+
Right azygos			+					
Costocervical v.		+						
Internal thoracic vessels		+	+	+	+	+	+	+

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چکیده

بررسی کالبد شناختی تصاویر لایه نگاری رایانه ای عروق قفسه سینه بز رائینی

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هدف-تهیه یک منبع کالبدشناختی از عروق قفسه سینه بز نژاد راینی به کمک لایه‌نگاری رایانه‌ای .
طرح مطالعه- مطالعه تجربی .
حیوانات- پنج راس بز راینی .
روش کار- تصاویر سی تی (با و بدون ماده حاجب) از ناحیه قفسه سینه عمود بر محور طولی بدن تهیه شدند. پنجره های سی تی به نوعی تنظیم شد که بهترین تصویر از عروق قفسه سینه به دست آید. تصاویر مطالعه و از نظر کالبد شناختی با دو راس بز تشریح شده مقایسه شدند .
نتایج- بزرگ سیاهرگ‌های قدامی و خلفی، آئورت نزولی، تنه بازویی راسی، سرخرگ‌های تحت ترقوه ای، سیاهرگ‌های سینه ای گردنی و آزیگوس، عروق داخل قفسه سینه ای و سرخرگ ها، سیاهرگ ها و تنه ششی مشخص و با توجه به مهره های سینه به عنوان نشانه، نامگذاری شدند .
نتیجه‌گیری و کاربرد بالینی- شناخت موقعیت دقیق عروق قفسه سینه و ارتباط آنها با ساختارهای مجاور در موفقیت جراحی این ناحیه نقش مهمی دارد. همچنین برای تشخیص تفریقی ضایعات فضاگیر از ساختارهای طبیعی سینه، کالبد شناسی این ناحیه از اهمیت به سزایی برخوردار است. در این مطالعه برای اولین بار عروق قفسه سینه یک حیوان نشخوارکننده به کمک سی تی اسکن مشخص و نامگذاری شده اند. به علاوه نتایج این مطالعه می تواند سبب درک بهتری از ارتباط کالبد شناختی ساختارهای قفسه سینه با یکدیگر گردد .
کلید واژگان- لایه نگاری رایانه ای، کالبدشناسی، بز، سینه، رگ .