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Computed tomography and cross-sectional anatomy of the thorax of goat

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ABSTRACT

Four adult baladi goats of both sexes (two males and two females) weighing about 25–35 kg and aging 1–1.5 years were used for the current study. Computed tomography (CT) scans and cross-sections of the thorax of goats were preformed, photographed, and compared with each other. The thorax was divided into three regions (cranial, middle, and caudal mediastinal regions). The shape and tomography of the thoracic organs were demonstrated. The anatomical features of soft and hard tissues of thorax were identified by both CT and cross-section images and denoted with the aid of anatomical texts. The purpose of this study was to produce an anatomic reference for computed tomography of the thorax of goat for use by radiologists, clinicians, and veterinary students.

1. Introduction

Computed tomography and nuclear magnetic resonance imaging is being performed increasingly on dogs and other animals for diagnostic and research purposes (Fike et al., 1980, 1981; Zook et al., 1981, 1989; George and Smallwood, 1992; Smallwood and George, 1993a,b; Valerie et al., 1998). These techniques were performed widely in goat (Smallwood and Healey, 1982; Abuzaid, 1995; Abuzaid et al., 1999; Abuzaid and Abuzaid, 2000; El Gendy, 2007). CT provides a higher degree of soft tissue contrast resolution than survey radiographs and the ability to produce reconstructed images of the areas of interest in various planes (Henninger et al., 2003; Tidwell and Jones, 1999).

CT scans resulting from these techniques require a thorough knowledge of the regional cross-sectional anatomy; texts on anatomy contain few illustrations of the body in cross-section. The purpose of this report is to provide a succession of photographs of CT scans and cross-sections of the thorax of goat.

2. Materials and methods

Four adult baladi goats of both sexes (two males and two females) weighing about 25–35 kg and aging 1–1.5 years were used for the current study.

2.1. CT scans

After physical examination, the goat was used for the CT scans, was anaesthetized by administering halothane via facemask. The goat was positioned in sternal recumbency during scanning time. Goat's thorax was serially sectioned with the CT scanner (CT-F 3HF/S Siemens) from the level of the base of neck to the level of 8th intercostals spaces with 1 cm interval on the chest (scanning conditions: 130 Kv, 70 mps). CT images were photographed and compared with the anatomic sections to assist an accurate identification of specific structures (Abuzaid, 1995; Shekidef, 1999; Abuzaid and Abuzaid, 2000; Abuzaid and Imam, 2000).

2.2. Cross-sections

The other three goats and the goat used for the CT scans were used subsequently for the anatomical cross-sections. They were well bled via common carotid artery and were placed in a freezer in ventral recumbency, until frozen. The frozen cadavers were placed on the table of a band saw, and serial transverse sections were cut approximately 1 cm apart, beginning from the level of manubrium sterni through xiphoid cartilage. Slices were numbered and gently cleaned of debris with cold running water and light brushing. They were dry blotted and were photographed immediately with the caudal surface of each slice facing the camera (Zook et al., 1989; Smallwood and George, 1993a,b; El Handy, 1999).

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Nomenclature was adapted according to the Nomina Anatomica Veterinaria (1994).

3. Results

3.1. CT scans

All CT scans were viewed from cranial to caudal of the thorax where the left side appear on the viewer's left, and the approximate levels of each CT scan appear on the long axis of thorax at CT frontal scanogram of goat in a sternal recumbency.

Fig. 1 represents all CT scanning of the cranial mediastinal region (from the first rib till the third rib). Muscles of the thoracic wall were displayed clearly between the subcutaneous and endothoracic fascia. Where longus colli muscle (Fig. 1A–D/10), right spinalis cervices muscle (Fig. 1B/17),

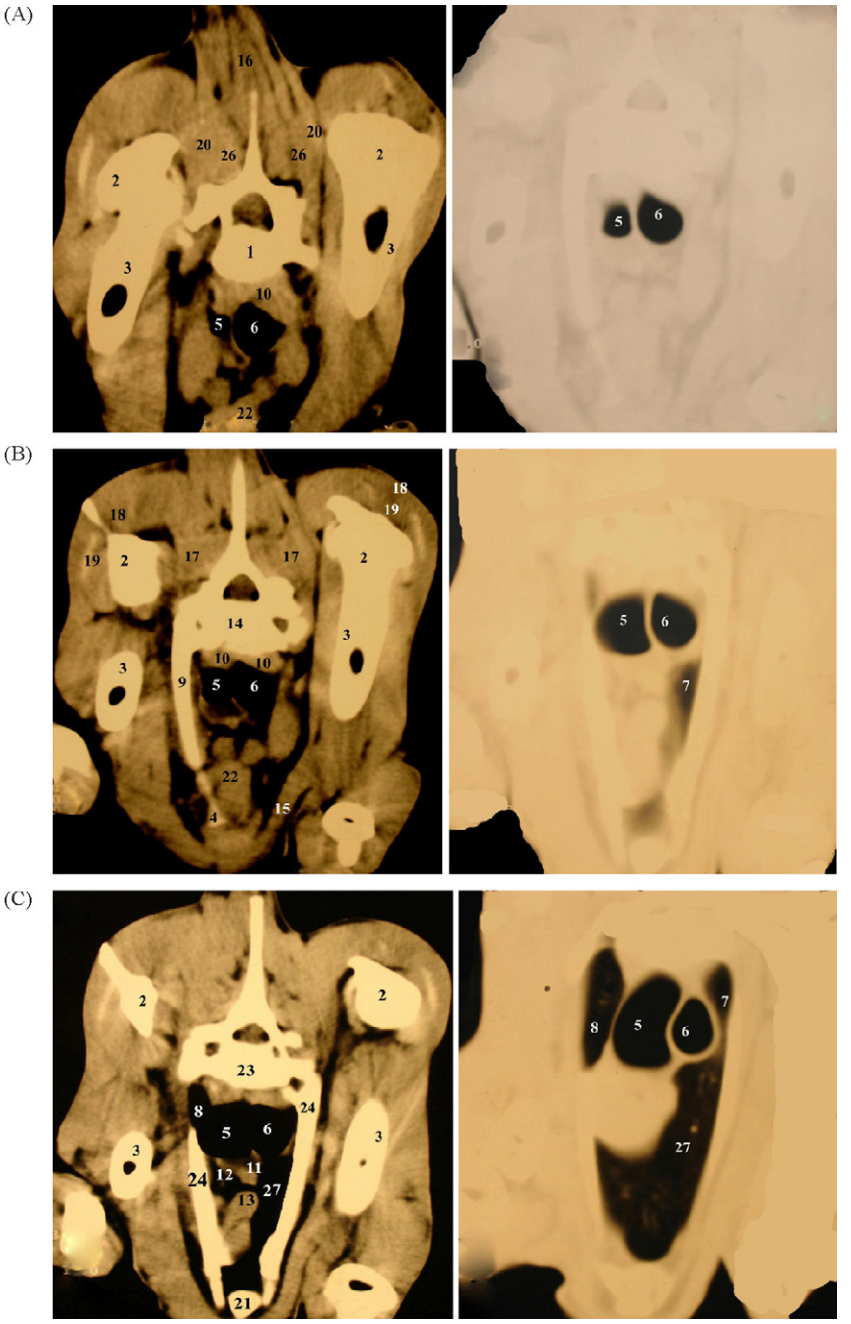

Fig. 1. CT images of the cranial mediastinal region; soft tissue window images on the left side and lung window images on the right side. 1. 1st thoracic vertebrae. 2. Scapula. 3. Humerus. 4. Manubrium sterni. 5. Esophagus. 6. Trachea. 7. Right cranial lobe of lung. 8. Left cranial lobe of lung. 9. 1st rib. 10. Longus colli muscle. 11. Brachio cephalic trunk. 12. Left subclavian artery. 13. Cranial vena cava. 14. 2nd thoracic vertebrae. 15. Right deep pectoral muscle. 16. Nuchal ligament. 17. Spinalis cervices muscle. 18. Supraspinatus muscle. 19. Infraspinatus muscle. 20. Right longissimus thoracic muscle. 21. Sternum. 22. Thymus. 23. 3rd thoracic vertebrae. 24. 2nd rib. 25. 3rd rib. 26. Right multifidus thoracic muscle. 27. Right middle lung lobe.

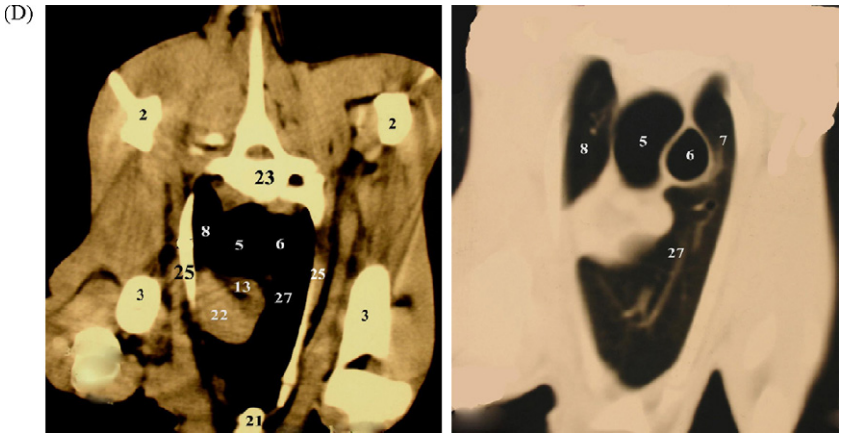

Fig. 1. (*Continued*).

right supraspinatus muscle (Fig. 1A/18), right infraspinatus muscle (Fig. 1B/19), right longissimus thoracic muscle (Fig. 1/20), right deep pectoral muscle (Fig. 1B/15), and right multifidus thoracic muscle (Fig. 1A/26) all were identified. The dense costal bony segments were denoted (Fig. 1B–D/9, 24, 25). The scapula (Fig. 1A–D/2) and humerus (Fig. 1A–D/3) were not imaged symmetrically on each side. The funiculus part of nuchal ligament, which is composed predominantly of elastic connective tissue, was imaged as a distinct opacity (Fig. 1A/16).

Imaging of the cranial mediastinal region demonstrated the esophagus to the left (Fig. 1A–D/5), and the trachea to the right of the midline (Fig. 1A–D/6), both were ventral to the thoracic vertebrae. The distension of the esophagus with gas was artifact, due to the anesthetic gases being administered via a facemask. At the level of 1st thoracic vertebrae (Fig. 1A/1), the first rib (Fig. 1B/9) and manubrium sterni (Fig. 1B/4), the cranial part of the right cranial lung lobe (Fig. 1B–D/7), the thymus (Fig. 1A–D/22), the cranial part of the left cranial lung lobe (Fig. 1C and D/8), the cranial vena cava (Fig. 1C and D/13) were clearly defined ventral to the brachiocephalic trunk (Fig. 1C/11).

Fig. 2 denoted CT scanning of the middle mediastinal region (from the 3rd rib till the 6th intercostal space). The esophagus (Fig. 2A–E/5) appeared dorsolateral to the trachea (Fig. 2A and B/6) and the tracheal bifurcation into right and left principal bronchi (Fig. 2C/17 and 17′) was identified clearly at the level of 4th thoracic vertebrae (Fig. 2C/23). The heart compartments were identified firstly at the level of 4th thoracic vertebrae, the right atrium (Fig. 2B/1), left atrium (Fig. 2D/2) were distinguished separately through this region at the central region of thorax on the scan. The right ventricle (Fig. 2B and C/3) was tapered from the right to left as the conus arteriosus (Fig. 2B and C/7) which was defined just proximal to the pulmonary valve (Fig. 2B and C/7). The left ventricle (Fig. 2D/4), aortic bulb and valve (Fig. 2D/14), the pulmonary trunk (Fig. 2C and D/12), the aortic arch (Fig. 2A–C/15) were detected. In addition the caudal vena cava was demonstrated (Fig. 2D and E/19) on the right side away from the heart between the accessory lung lobe (Fig. 2E/28). The descending aorta (Fig. 2D and E/11) was seen ventral to the vertebrae and dorsolateral to the esophagus on the left side.

Fig. 3 clearly defines CT scans of the caudal mediastinal region (from the 6th intercostal space till the disappearance of the diaphragm at the cranial abdominal region). The right caudal lung lobe (Fig. 3A–D/5), the left caudal lung lobe (Fig. 3A–B/6), the diaphragm (Fig. 3A/7) all were denoted. The costal arches (Fig. 3A–D/14) were embedded between the soft tissue dense muscular elements. The liver (Fig. 3A–D/8) occupied the intrathoracic part of the abdominal cavity on the right side and contacts the diaphragm. The caudal vena cava (Fig. 3A/4), left azygous vein (Fig. 3A/3) and the reticulum (Fig. 3A/9) were appeared at the level of 7th thoracic vertebrae (Fig. 3A/16). The dorsal ruminal sac (Fig. 3C and D/10) on the left side, omasum (Fig. 3C/12) and abomasum (Fig. 3C and D/11) on the right side were demonstrated at the level of 9th thoracic vertebrae (Fig. 3C/18).

3.2. Cross-sectional anatomy

Our study denoted cross-sections of the thorax from the manubrium sterni through the xiphoid cartilage, not all structures were labeled in every slice, contra lateral structures of symmetrical tissues or paired organs were not labeled on each side.

The cranial mediastinum was wide dorsally. It contained the trachea (Fig. 4A and B/5) and esophagus (Fig. 4A and B/4) lying side by side at the thoracic inlet dorsally, the cranial vena cava (Fig. 4A and B/15) and brachiocephalic trunk (Fig. 4A and B/14) with their branches ventrally. The thymus (Fig. 4A and B/16), lymph nodes and fats were occupied the ventral part of the cranial mediastinum.

The dorsal part of the middle mediastinum was slightly narrower than the ventral part. The dorsal part contained the bifurcation of trachea into right and left principal bronchi (Fig. 5A/9), esophagus (Fig. 5A and B/5), descending aorta (Fig. 5A and B/11), cranial vena cava (Fig. 5A/19) and left azygous vein (Fig. 5B/2). The ventral part of the middle mediastinum contained the right atrium (Fig. 5A/1), right ventricle (Fig. 5A and B/3), left ventricle (Fig. 5B/4) and aortic valve (Fig. 5A/2).

The dorsal part of the caudal mediastinal region revealed the presence of aorta (Fig. 6/2) dorsally, the esophagus (Fig. 6/1) ventrally, left azygous vein (Fig. 6/3),

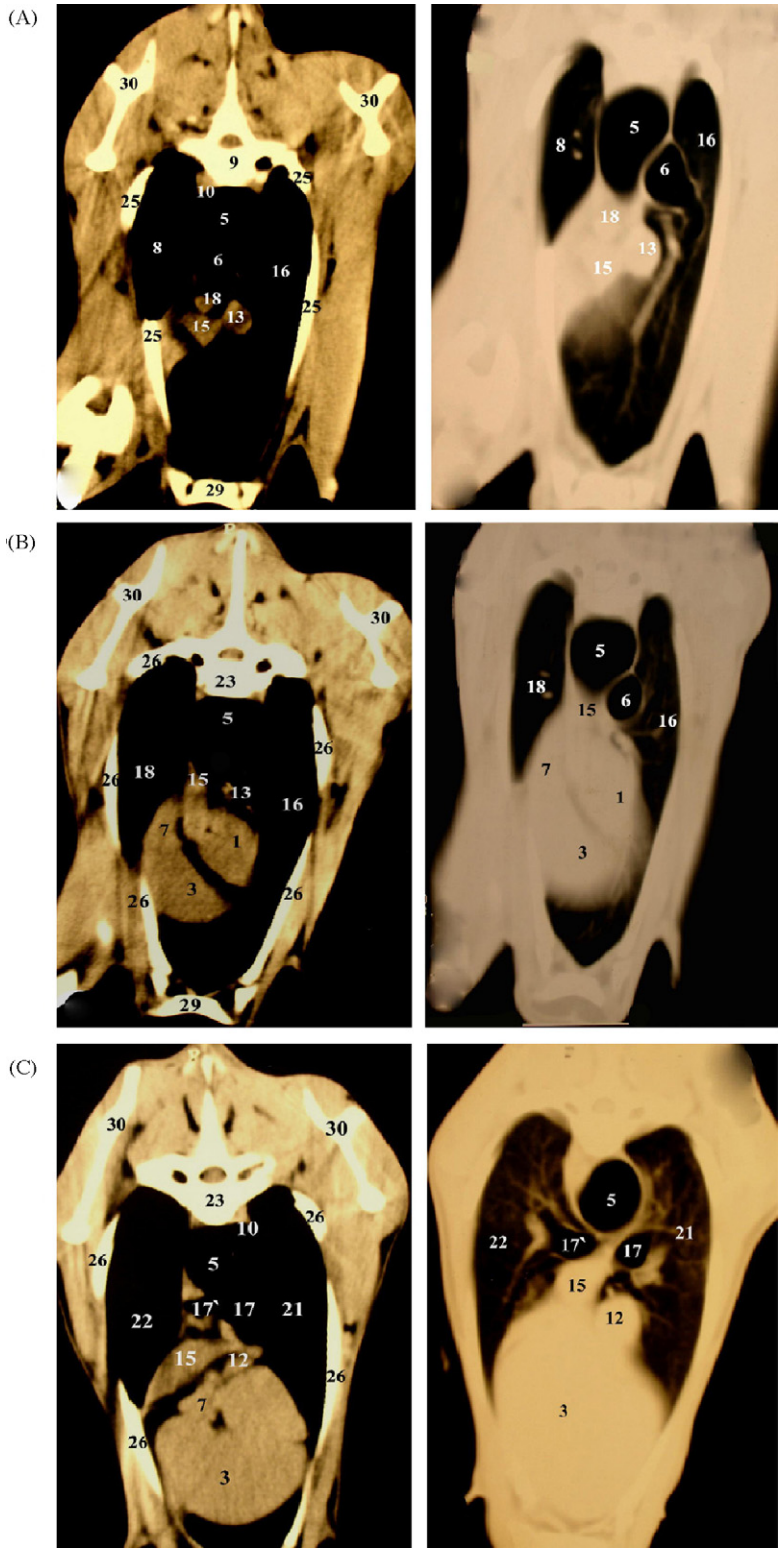

Fig. 2. CT images of the middle mediastinal region; soft tissue window images on the left side and lung window images on the right side. 1. Right atrium. 2. Left atrium. 3. Right ventricle. 4. Left ventricle.5. Esophagus. 6. Trachea. 7. Conus arteriosus just proximal to pulmonary valve. 8. Left cranial lung lobe. 9. 3rd thoracic vertebrae. 10. Longus colli muscle. 11. Descending aorta. 12. Pulmonary trunk. 13. Cranial vena cava. 14. Aortic bulb and aortic valve. 15. Aortic arch. 16. Right middle lung lobe. 17. Right pulmonary bronchus. 17′. Left pulmonary bronchus. 18. Origin of brachiocephalic trunk from aortic arch. 19. Caudal vena cava. 20. Caudal wall of the left ventricle. 21. Right caudal lung lobe. 22. Left caudal lung lobe. 23. 4th thoracic vertebrae. 24. 5th thoracic vertebrae. 25. 3rd rib. 26. 4th rib. 27. Transverse thoracic muscle. 28. Accessory lung lobe. 29. Sternum. 30. Scapula. 31. 6th thoracic vertebrae. 32. 5th rib. 33. 6th rib.

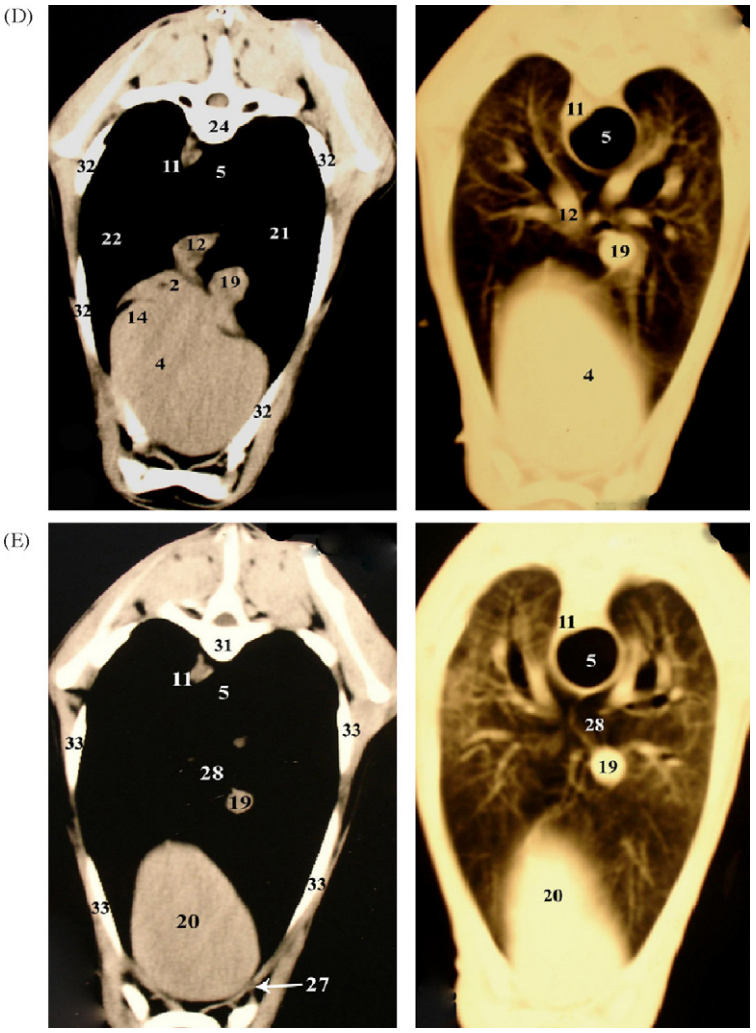

Fig. 2. (*Continued*) .

right caudal lung lobe (Fig. 6/5) and left caudal lung lobe (Fig. 6/6).

The ventral part of the caudal mediastinum contained reticulum (Fig. 6/9), liver (Fig. 6/8), and diaphragm (Fig. 6/7).

4. Discussion

Our intent was to produce an atlas of computed tomography and cross-sectional anatomy on the thorax of goat that could be used as an aid in the interpretation of any cross-sectional imaging study. In the present study, the thorax was divided into three regions, cranial, middle, and caudal mediastinal regions and all the detailed structures in CT scans and cross-sections were documented according to Smallwood and Healey (1982), Zook et al. (1989), Alsafy (2005). The shape and tomography of the thoracic organs were varied according to the imaging position and scanning level, so our results were compared with the cross-sections and anatomical texts that mentioned by King (1974), Popesko (1975), Smallwood and Healey (1982), Alsafy (2005).

Regarding the relations of most CT and cross-sections images, imaging of the cranial mediastinal region demonstrated the esophagus to the left and the trachea to the right of the midline, both were ventral to the thoracic vertebrae in CT images in Fig. 1A–D was matched with cross-sections in Fig. 4A and B.

The right cranial lobe of lung, left cranial lobe of lung, thymus and cranial vena cava in CT images in Fig. 1B and D was matched with cross-sections in Fig. 4B.

The cranial vena cava in CT images in Fig. 2C/12 was matched with cross-sections in Fig. 5C/19.

There is a perfect match between Fig. 1C CT images with Fig. 4A cross-sections in the relation of right cranial lobe of lung, left cranial lobe of lung, thymus and cranial vena cava and brachiocephalic trunk.

The tracheal bifurcation into right and left principal bronchi, heart parts, right middle lung lobe, left cranial lung

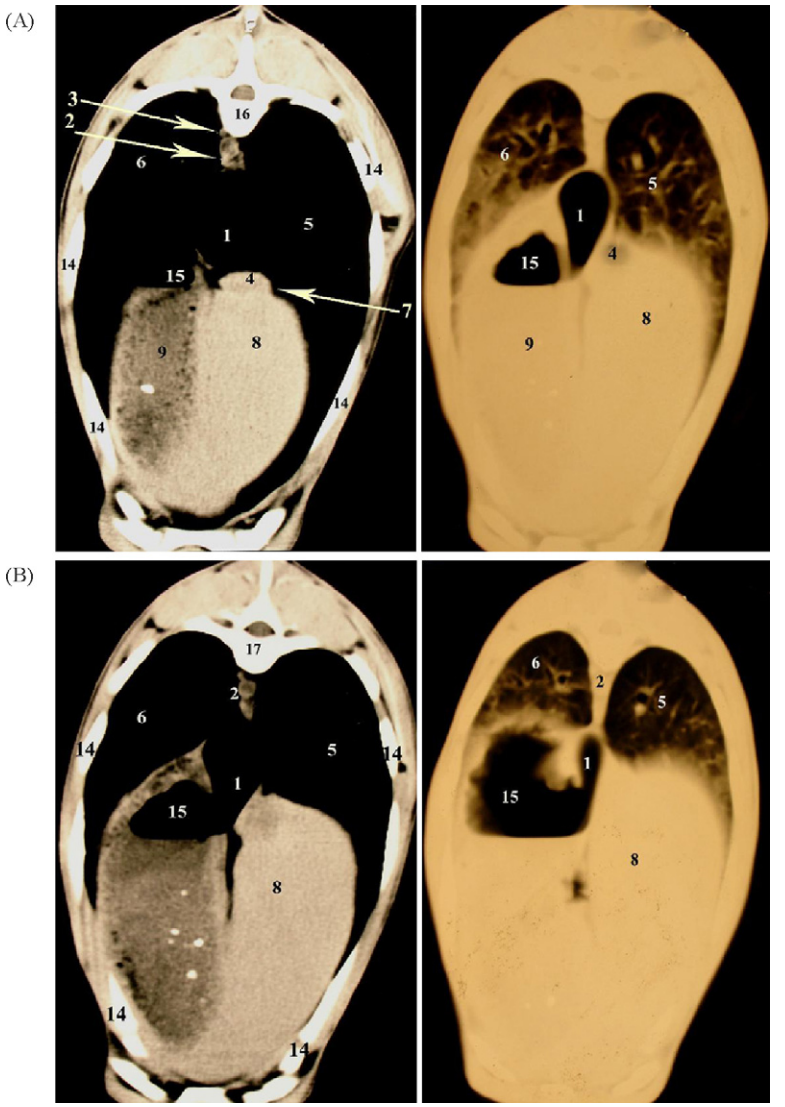

Fig. 3. CT images of the caudal mediastinal region; soft tissue window images (A–D) on the left side and lung window images (E–H) on the right side. 1. Esophagus. 2. Aorta. 3. Left azygous vein. 4. Caudal vena cava. 5. Right caudal lung lobe. 6. Left caudal lung lobe. 7. Diaphragm. 8. Liver. 9. Rerticulum. 10. Dorsal ruminal sac. 11. Abomasum. 12. Omasum. 13. Spleen. 14. Right and left costal arches. 15. Ingesta (fluid level) in reticulum. 16. 7th thoracic vertebrae. 17. 8th thoracic vertebrae. 18. 9th thoracic vertebrae. 19. 10th thoracic vertebrae.

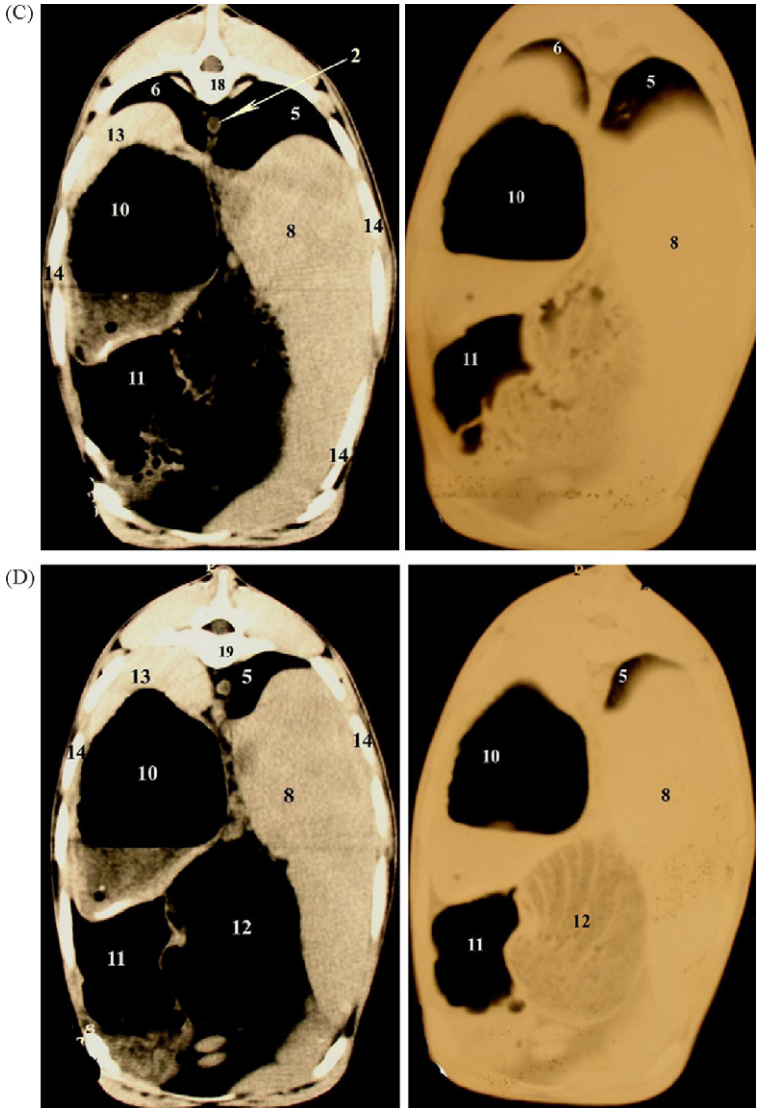

Fig. 3. (*Continued*).

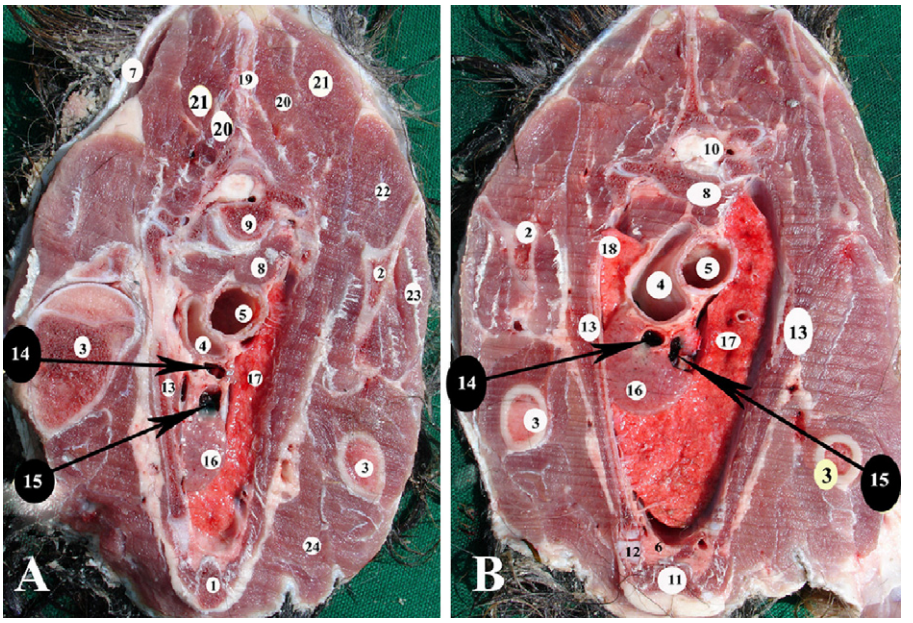

Fig. 4. Cross-sections of the cranial mediastinal region. 1. Manubrium sterni. 2. Scapula. 3. Humerus. 4. Esophagus. 5. Trachea. 6. Transverse thoracic muscle. 7. Skin. 8. Longus colli muscle. 9. 1st thoracic vertebrae. 10. 2nd thoracic vertebrae. 11. Sternum. 12. 3rd costal cartilage. 13. Body of the 2nd left rib. 14. Brachiocephalic trunk. 15. Cranial vena cava. 16. Thymus. 17. Right caudal part of the cranial lung lobe. 18. Left cranial part of the cranial lung lobe. 19. Nuchal ligament. 20. Right multifidus thoracic muscle. 21. Right longissimus thoracic muscle. 22. Right supra spinatus muscle. 23. Right infraspinatus muscle. 24. Right deep pectoral muscle.

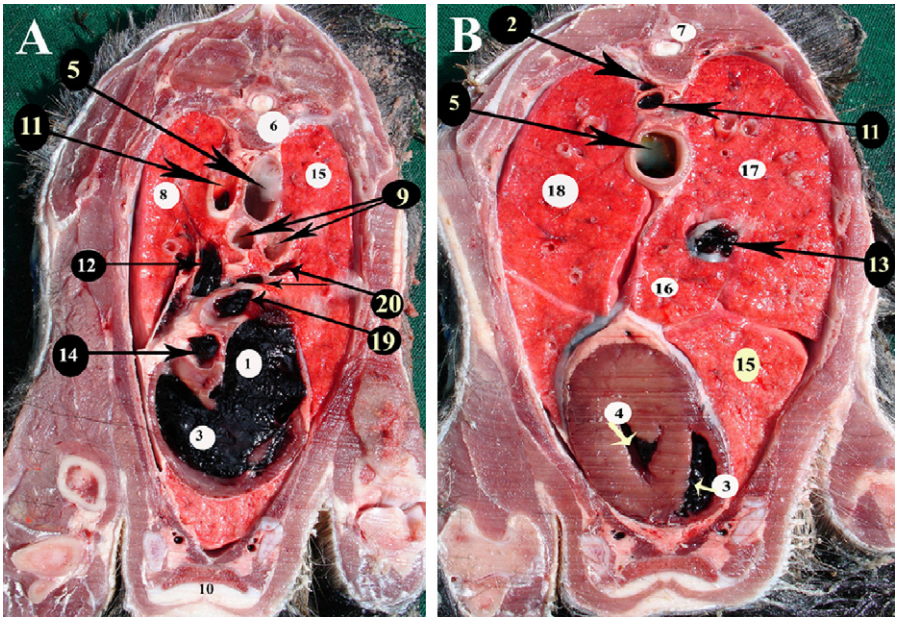

Fig. 5. Cross-sections of middle mediastinal region. 1. Clotted blood in right atrium. 2. Left azygous vein. 3. Clotted blood in right ventricle. 4. Left ventricle. 5. Esophagus. 6. 4th thoracic vertebrae. 7. 6th thoracic vertebrae. 8. Left cranial lung lobe. 9. Bifurcation of the trachea into right and left principal bronchi. 10. Sternum. 11. Descending aorta. 12. Pulmonary trunk. 13. Caudal vena cava. 14. Aortic bulb and aortic valve. 15. Right middle lung lobe. 16. Accessory lung lobe. 17. Right caudal lung lobe. 18. Left caudal lung lobe. 19. Cranial vena cava. 20. Pulmonary veins.

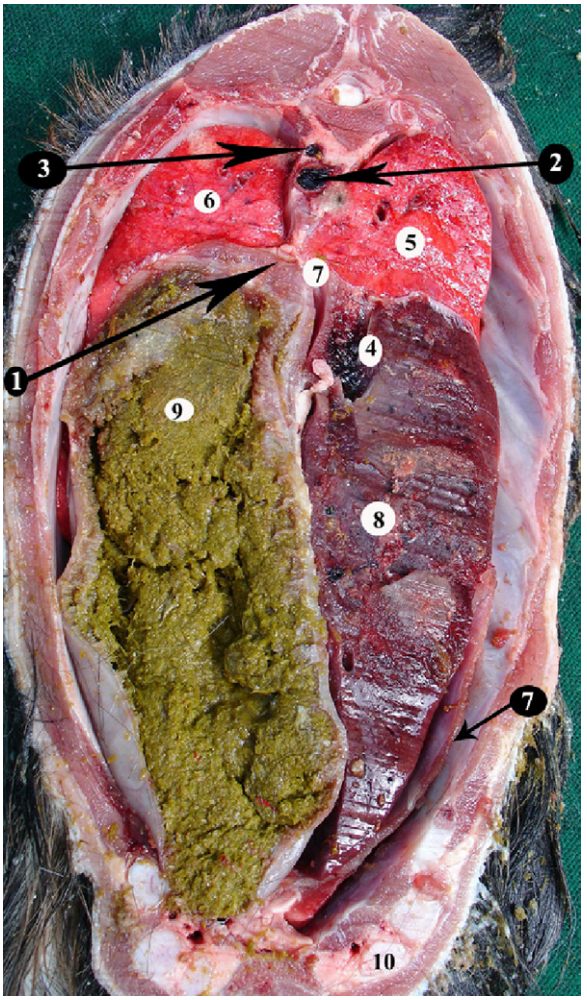

Fig. 6. Cross-section of the caudal mediastinal region. 1. Esophagus. 2. Aorta. 3. Left azygous vein. 4. Caudal vena cava. 5. Right caudal lung lobe. 6. Left caudal lung lobe. 7. Diaphragm. 8. Liver. 9. Reticulum filled with ingesta. 10. 9th right costal cartilage.

lobe, cranial vena cava and aorta in CT images in Fig. 2C was matched with cross-sections in Fig. 5A.

CT lung window images in Fig. 2D was matched with cross-sections in Fig. 5B in the relation of caudal vena cava, esophagus, right ventricle, left ventricle and right and left caudal lung lobe.

CT image in Fig. 3B was similar to Fig. 5 cross-section in the position of reticulum, liver, and right and left caudal lung lobe.

References

Abuzaid, R. M. M., 1995. Radio and sonographic anatomical studies on the goat. Ph.D. Thesis, Fac. of Vet. Med., Suez Canal University.

Abuzaid, S.M., Sugamma, T., Elnahla, S.M., AbdelTawab, M., Abuzaid, R.M., 1999. Cross-sectional anatomy of the abdomen of the goat. A study by computed tomography, magnetic resonance imaging and gross anatomy. In: Summer AAVA meeting, July.

Abuzaid, S.M., Abuzaid, R.M., 2000. Computed tomography and Magnetic resonance imaging of normal caprine male genital organs. Minufyia Vet. J. I 1, 19–25.

Abuzaid, S.M.S., Imam, H.M., 2000. Computed tomographic anatomy of the abdomen on the normal wild African fennec (fennecus Zereda). SCVM J. III 1, 63–77.

Alsafy, M.A.M., 2005. Clinical anatomical studies on the thorax of dog. Ph.D. Thesis. Fac. Vet. Med., Alex. Univ.

El Gendy, S. A. A., 2007. Surgical anatomical approach of the abdomen in the goat. Ph.D. Thesis. Fac. Vet. Med., Alex. Univ.

El Handy, F.A.O., 1999. Modern educational technology in teaching veterinary anatomy with special references to applications practice. Ph.D. Thesis, Vet. Med., Cairo University.

Fike, J.R., Druy, E.M., Zook, B.C., 1980. Canine anatomy assisted by computerized tomography. Am. J. Vet. Res. 41, 1823–1832.

Fike, J.R., Lecouteur, R.A., Cann, C.E., 1981. Anatomy of the canine brain using high resolution computed tomography. Vet. Radiol. 22, 236–243.

George, T.F., Smallwood, J.E., 1992. Anatomic atlas for computed tomography in the mesaticephalic dog: head and neck. Vet. Radiol. Ultrasound 33 (4), 217–240.

Henninger, W., Frame, E.M., Willmann, M., 2003. CT features of alveolitis and sinusitis in horses. Vet. Radiol. Ultrasound 44, 269–276.

King, A.S., 1974. A Guide to the Physiological and Clinical Anatomy of the Thorax Department of Veterinary Anatomy, 3rd ed. Univ. of Liverpool, Liverpool, L69, 3 Bx.

Nomina Anatomica Veterinaria, 1994. 4th ed., Copyright by the World Association of Veterinary Anatomists. Printed in the USA.

Popesko, P., 1975. Atlas of Topographical Anatomy of the Domestic Animals, vol. 1., 2nd ed. Saunders, Philadelphia, WB.

Shekidef, M.H., 1999. Studies on chemical immobilization in some wild animals. M.V.Sc. Thesis. Vet. Med., Suez Canal Univ.

Smallwood, J.E., Healey, W.V., 1982. Computed tomography of the thorax of the adult Nubian goat. Vet. Radiol. 23 (4), 135–143.

Smallwood, J.E., George, T.F., 1993a. Anatomic atlas for computed tomography in the mesaticephalic dog: thorax and cranial abdomen. Vet. Radiol. 34, 65–84.

Smallwood, J.E., George, T.F., 1993b. Anatomic atlas for computed tomography in the mesaticephalic dog: caudal abdomen and pelvis. Vet. Radiol. 34, 143–167.

Tidwell, A.S., Jones, J.C., 1999. Advanced imaging concepts: a pictorial glossary of CT and MRI technology. Clin. Tech. Small Anim. Pract. 14, 65–111.

Valerie, F., David, S., Philip, D., Koblik, M.S., 1998. Normal cross-sectional anatomy of the feline thorax and abdomen: comparison of computed tomography and cadaver anatomy. Vet. Radiol. Ultrasound 39 (6), 504–511.

Zook, B.C., Hitzelberg, R.A., Fike, J.R., Bradley, E.W., 1981. Anatomy of the Beagle in cross section: head and neck. Am. J. Vet. Res. 42, 844–849.

Zook, B.C., Hitzelberg, R.A., Bradley, E.W., 1989. Cross-sectional anatomy of the beagle thorax. Vet. Radiol. 30, 277–281.