Computed Tomographic Anatomy of the Abdominal Cavity in the Jebeer (Gazella Bennettii)

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ABSTRACT

Introduction: Computed tomography (CT) is an imaging technique with gives us an opportunity to review cross sections of the body in live animals. In veterinary medicine although CT is mostly used for diagnostic purposes in small animals, but in recent years CT also has been used as a non invasive modality in non clinical studies. Jebeer Gazelle (Gazella bennettii) is one of the species of the genus Gazella which lives mostly in the south east of Iran and very little anatomic studies are available on it. The aim of this study was preparing detailed anatomic images of the abdominal cavity of the Jebeer as an endangered species using the non invasive CT technique.

Methods: Spiral CT images were acquired from the abdominal region of four healthy Jebeer, perpendicular to long axis of the body. CT windows were adjusted as necessary to have optimized images of the abdominal organs. The images were studied serially and compared anatomically with two dissected goats.

Results: Liver, spleen, reticulum, omasum, abomasum, rumen, right and left kidneys, transverse colon, ascending colon, descending colon, cecum, pancreas, duodenum, uterine horns, urinary bladder and jejunum were distinguished and addressed according to the thoracic and lumbar vertebrae as landmarks.

Conclusion: According to the present study, we identified the abdominal organs, their precise position and related structures in the Jebeer without any invasive procedure. This is the first study which is addressing abdominal organs of a wild ruminant by using CT modality.

Key Words:

Computed tomography, Anatomy, Deer, Abdomen

1. Introduction

Computed tomography (CT) is an imaging technique with gives us an opportunity to review cross sections of the body in live animals. It is a valuable tool for evaluating diseases and makes it possible to have better diagnosis for presence location and extension of pathology and involvement of structures in comparison to standard radiography [1]. In veterinary medicine although CT is mostly used for diagnostic purposes in small animals [1-7], but in recent years CT also has been used as a non invasive modality in non clinical studies [8-23].

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Jebeer Gazelle (Gazella bennettii) is one of the species of the genus Gazella which lives mostly in the south east of Iran [24, 25]. Although the species is fully protected by the law, only around 1300 heads were estimated for this country [26], and it seems that more consideration must be taken into account. In case of Jebeer very little anatomic studies are available [27, 28] and the aim of this study was preparing detailed anatomic images of the abdominal cavity of the Jebeer as an endangered species using the non invasive CT technique.

2. Materials & Methods

Four healthy adult female Jebeers weighting about 20-25kg and aging 2-2.5 years were used in this study. Each Jebeer was given intramuscular Atropine [1] (0.4 mg/kg) and anesthetized by intravenous injection of mixed Ketamine [2] (2.2 mg/kg) and Xylazine [2] (0.11mg/kg). The jebeers 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 3m1m 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 abdominal organs (WW: 415 and WL: 28).

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

1. Daroopakhsh, Iran
2. Alfasan Holland

3. Results

In Figures 1 to 12, CT images, which have been selected from one Jebeer, 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. The selected images have been achieved from each adjacent vertebra, from 8th thoracic to 6th lumbar vertebrae. Then, the positions of abdominal viscera were evaluated and determined according to the adjacent vertebrae (Table 1).

The esophagus (Figure 1 to 3) passed through diaphragm and immediately attached to the region between rumen and reticulum, this attachment was at the level of the 10th thoracic vertebra (Figure 3). The liver (Figure 1 to 8) was observed in the right side and the most cranial part of the abdominal cavity from 8th thoracic vertebra to the cranial extremity of the 1st lumbar vertebra, the gall bladder was also observed between 13th thoracic and 1st lumbar vertebrae (Figure 6 to 7). The spleen situated in the left side of the abdominal cavity and located over the dorsal sac of rumen from 9th thoracic vertebra to 2nd lumbar vertebra (Figure 2 to 8). The reticulum was seen at the cranial part of the abdominal cavity adjacent to the diaphragm between 8th and 9th thoracic vertebra (Figure 1 & 2).

Atrium ruminis, the cranial sac of rumen (Figure 3 to 5) was recognized between 10th and 12th thoracic vertebrae. It continued caudally with the dorsal sac of rumen which was observed between 13th thoracic to 3rd lumbar vertebrae

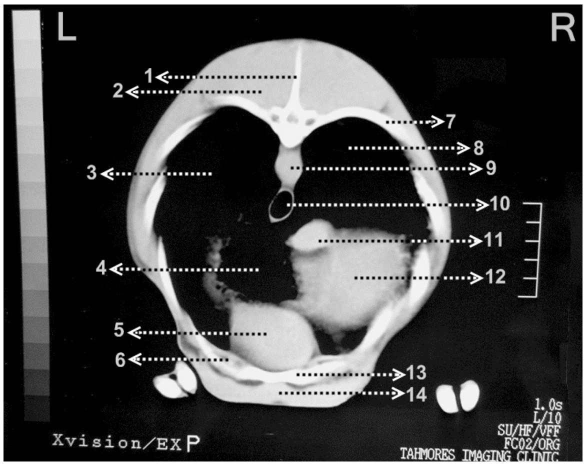

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Figure 1. 1.8th thoracic vertebra, 2. epaxial muscles, 3. Left Lung, 4. Reticulum, 5. base of heart, 6. internal thoracic vessels, 7. 8th rib, 8. right lung, 9. aorta, 10. esophagus, 11. caudal vena cava, 12. liver, 13. sternum, 14. pectoral muscles.

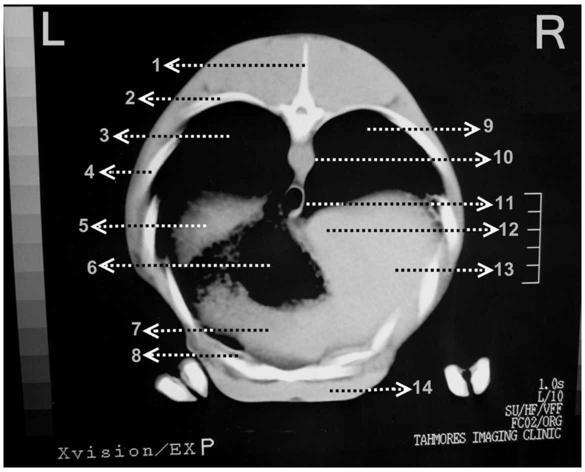

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Figure 2. 1. 9th thoracic vertebra, 2. 9th rib, 3. left lung, 4. 8th rib, 5. spleen, 6. reticulum, 7. base of heart, 8. internal thoracic vessels, 9. right lung, 10. aorta, 11. esophagus, 12. caudal vena cava, 13. liver, 14. pectoral muscles.

Table 1. Topographical position of major abdominal organs according to the thoracic and lumbar vertebrae.

	T8	T9	T10	T11	T12	T13	L1	L2	L3	L4	L5	L6
Liver	+	+	+	+	+	+	+	+				
Spleen		+	+	+	+	+	+	+				
Esophagus	+	+	+									
Reticulum	+	+										
Omasum			+	+	+	+	+	+				
Abomasum			+	+	+	+	+	+				
Left lung	+	+	+									
Right lung	+	+	+	+	+	+	+	+				
Atrium ruminis			+	+	+							
Recessus Ruminis			+									
Dorsal sac of rumen						+	+	+	+			
Caudodorsal blind sac										+	+	
Caudoventral blind sac										+	+	+
Ventral sac of rumen				+	+	+	+	+	+			
Omasoabomasal Opening				+	+							
Right kidney						+	+	+				
Left kidney								+	+	+		
Urinary bladder												+
Uterine horns												+
Gall bladder						+	+					
Pancreas							+	+				
Duodenum				+	+	+	+	+				
Transverse colon									+			
Descending colon									+	+	+	+
Spiral colon									+	+	+	
Ascending colon					+	+	+	+	+	+	+	
Cecum									+	+	+	+
Jejunum						+	+	+	+	+	+	+

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(Figure 6 to 9). The dorsal sac of rumen also continued with the caudodorsal blind sac between 4th and 5th lumbar vertebrae (Figure 10 to 11). The ventral sac of rumen located between 11th thoracic to 3rd lumbar vertebrae (Figure

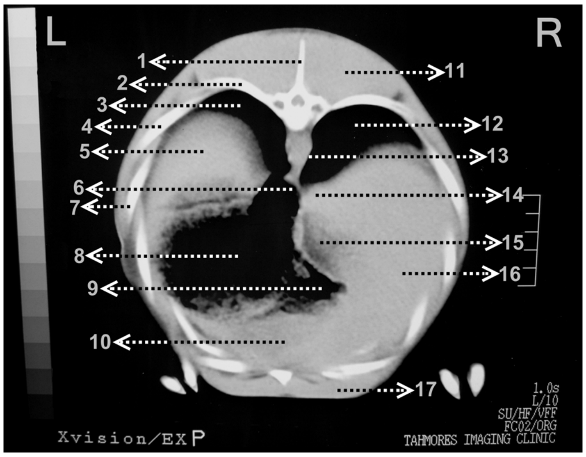

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Figure 3. 1.10th thoracic vertebra, 2. 10th rib, 3. left lung, 4. 9th rib, 5. spleen, 6. esophagus, 7. 8th rib, 8. atrium ruminis, 9. recessus ruminis, 10. base of abomasum, 11. epaxial muscles, 12. right lung, 13. aorta, 14. caudal vena cava, 15. omasum, 16. liver, 17. pectoral muscles.

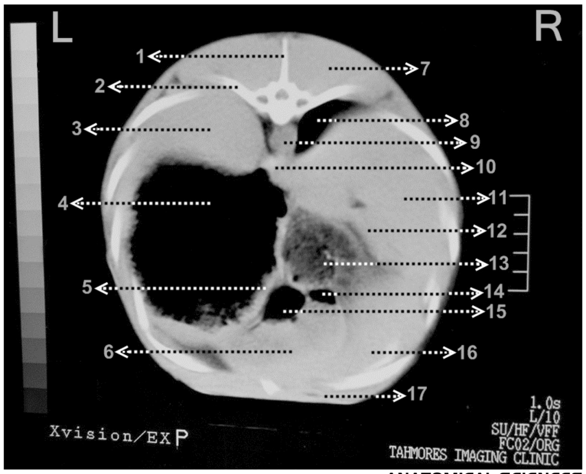

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Figure 4. 1. 11th thoracic vertebra, 2. 11th rib, 3. spleen, 4. atrium ruminis, 5. cranial pillar, 6. base of abomasum, 7. epaxial muscles, 8. right lung, 9. aorta, 10. caudal vena cava, 11. liver, 12. cranial part of duodenum, 13. omasum, 14. omasoabomasal opening, 15. ventral sac of rumen, 16. body of abomasum, 17. pectoral muscles.

4 to 9). The most cranial part of this sac, recessus ruminis, was observed at the level of 10th thoracic vertebra (Figure 3). The ventral sac also replaced with the caudoventral blind sac and continued to the 6th lumbar vertebra (Figure 10 to 12). The omasum was ellipsoidal in form and situated at the right side of the abdominal cavity between 10th thoracic to 2nd lumbar vertebrae (Figure 3 to 8). Fundus, body and pyloric part of the abomasum were seen at the same level of the omasum (Figure 3 to 8). The right kidney began from the 13th thoracic vertebra and extended to the 2nd lumbar vertebra (Figure 6 to 8). On the contrary, the left one was seen between the 2nd to 4th lumbar vertebrae (Figure 8 to 10).

Pancreas (Figure 7 & 8) was seen in the right side of the abdominal cavity from 1st to 2nd lumbar vertebrae. The pyloric sphincter was observed in the right side of the abdominal cavity between 13th thoracic to 2nd lumbar vertebrae (Figure 6 to 8), it was continued by the cranial part of duodenum (Figure 4 to 8) between 11th thoracic to 2nd

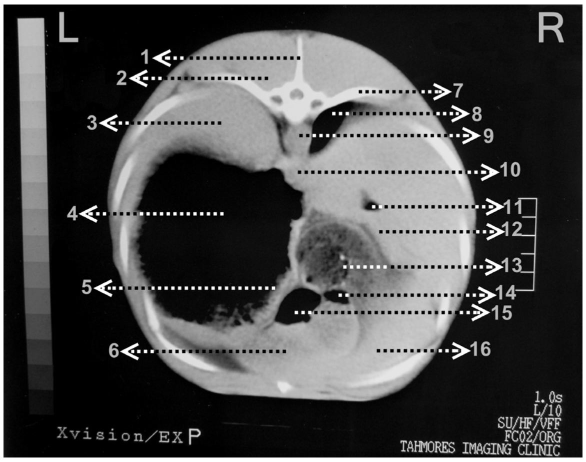

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Figure 5. 1. 12th thoracic vertebra, 2. epaxial muscles, 3. spleen, 4. atrium ruminis, 5. cranial pillar, 6. base of abomasum, 7. 12th rib, 8. right lung, 9. aorta, 10. caudal vena cava, 11. ascending colon, 12. cranial part of duodenum, 13. liver, 14. omasum, 15. omasoabomasal opening, 16. ventral sac of rumen, 17. body of abomasum.

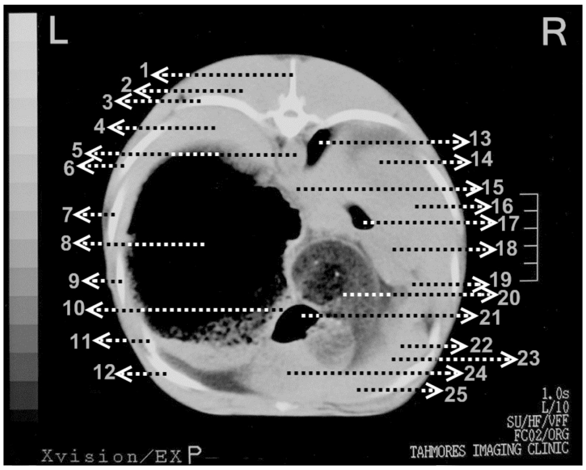

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Figure 6. 1. 13th thoracic vertebra, 2. epaxial muscles, 3. 13th rib, 4. spleen, 5. aorta, 6. 12th rib, 7. 11th rib, 8. dorsal sac of rumen, 9. 10th rib, 10. cranial pillar, 11. 8th rib, 12. costal arch, 13. right lung, 14. cranial pole of right kidney, 15. caudal vena cava, 16. liver, 17. ascending colon, 18. gall bladder, 19. cranial part of duodenum, 20. omasum, 21. ventral sac of rumen, 22. pylorus spinchter, 23. pyloric part of abomasum, 24. base of abomasum, 25. body of abomasum

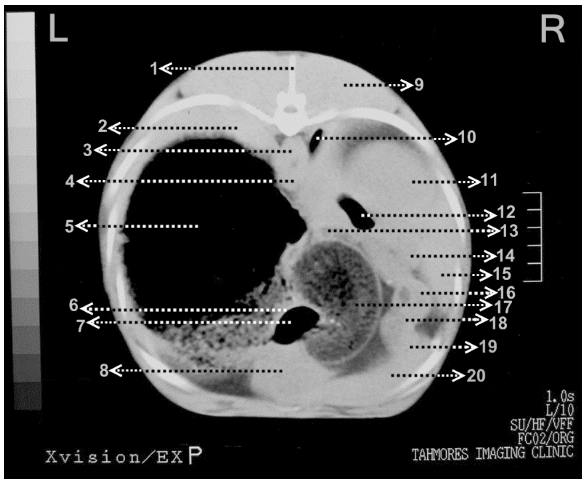

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Figure 7. 1. 1st lumbar vertebra, 2. spleen, 3. aorta, 4. caudal vena cava, 5. dorsal sac of rumen, 6. cranial pillar, 7. ventral sac of rumen, 8. base of abomasum, 9. epaxial muscles, 10. right lung, 11. right kidney, 12. ascending colon, 13. pancreas, 14. gall bladder, 15. liver, 16. cranial part of duodenum, 17.omasum, 18. pylorus spinchter, 19. pyloric part of abomasum, 20. body of abomasum.

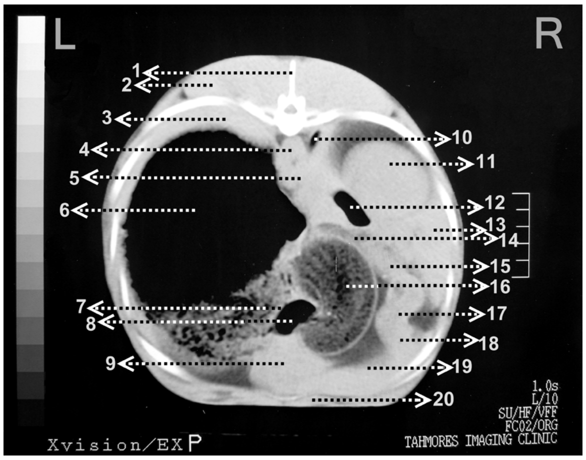

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Figure 8. 1. 2nd lumbar vertebra, 2. epaxial muscles, 3. spleen, 4. aorta, 5. caudal vena cava, 6. dorsal sac of rumen, 7. cranal pillar, 8. ventral sac of rumen, 9. base of abomasum, 10. right lung, 11. right kidney, 12. ascending colon, 13. liver, 14. pancreas, 15. cranial part of duodenum, 16. omasum, 17. pylorus spinchter, 18. pyloric part of abomasum, 19. body of abomasum, 20. base of abomasum.

lumbar vertebrae. The ascending colon was recognized ventral to the right kidney (Figure 6 to 8) and dorsal to the omasum and the cranial part of duodenum (Figure 5 to 8), it was started at the level of the caudal part of 11th and the cranial part of 12th thoracic vertebrae (Figure 4 to 5) and continued at the right side of abdominal cavity to the level of 5th lumbar vertebra (Figure 11). The cecum was started at the level of 3rd lumbar vertebra (Figure 9) and continued caudally to the pelvic cavity. The transverse colon (Figure 9) crossed the abdominal cavity from the right to the left side where the descending colon was started (Figure 9 to 12) and continued caudally to the pelvic cavity. The uterine horns and the urinary bladder were seen at the level of 6th lumbar vertebra (Figure 12).

According to the diaphragmatic convexity, CT images of the intra thoracic part of the abdominal cavity illustrated several thoracic organs beside the intra thoracic organs of the abdominal cavity, such as the right lung (Figure 1 to 8),

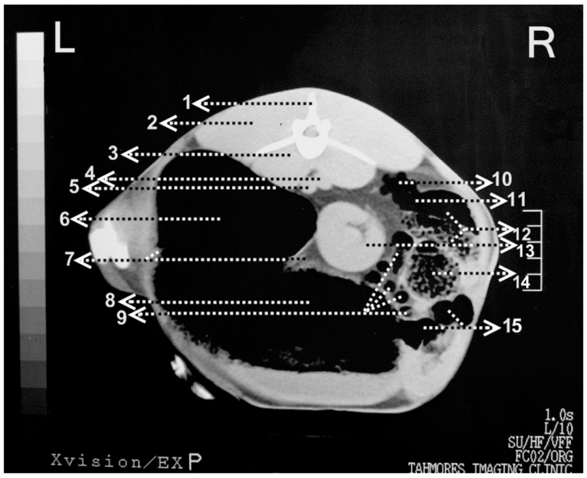

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Figure 9. 1. 3rd lumbar vertebra, 2. epaxial muscles, 3. sublumbar muscles, 4. caudal vena cava, 5. aorta, 6. dorsal sac of rumen, 7. right and left longitudinal pillars, 8. ventral sac of rumen, 9. spiral part of ascending colon, 10. descending colon, 11. transverse colon, 12. proximal and distal part of ascending colon, 13. left kidney, 14. cecum, 15. jejunum.

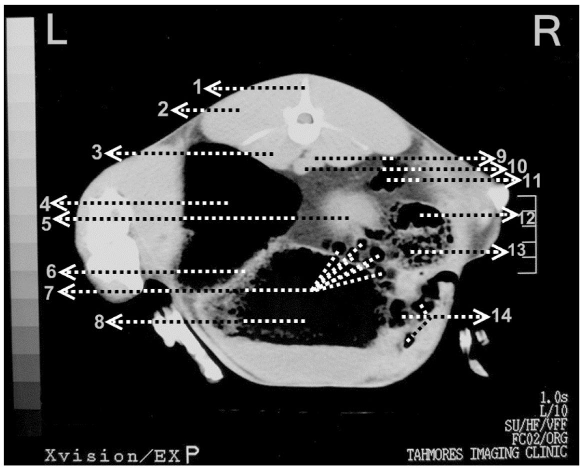

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Figure 10. 1. 4th lumbar vertebra, 2. epaxial muscles, 3. sublumbar muscles, 4. caudodorsal blind sac, 5. caudal pole of left kidney, 6. caudal pillar, 7. spiral part of ascending colon, 8. caudoventral blind sac, 9. caudal vena cava, 10. aorta, 11. descending colon, 12. ascending colon, 13. cecum, 14. jejunum.

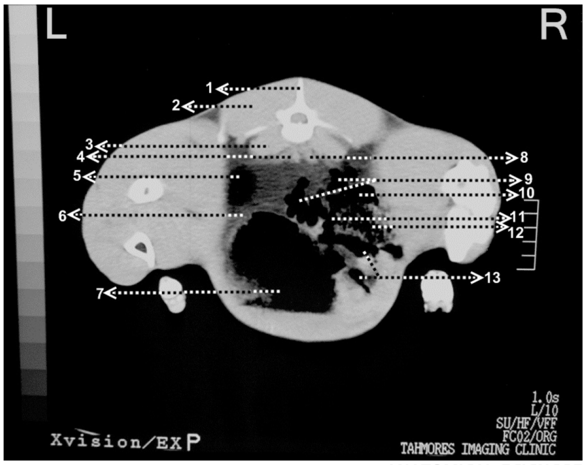

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Figure 11. 1. 5th lumbar vertebra, 2. epaxial muscles, 3. sublumbar muscles, 4. aorta, 5. caudodorsal blind sac, 6. caudal pillar, 7. caudoventral blind sac, 8. caudal vena cava, 9. descending colon, 10. ascending colon, 11. spiral part of ascending colon, 12. cecum, 13. jejunum.

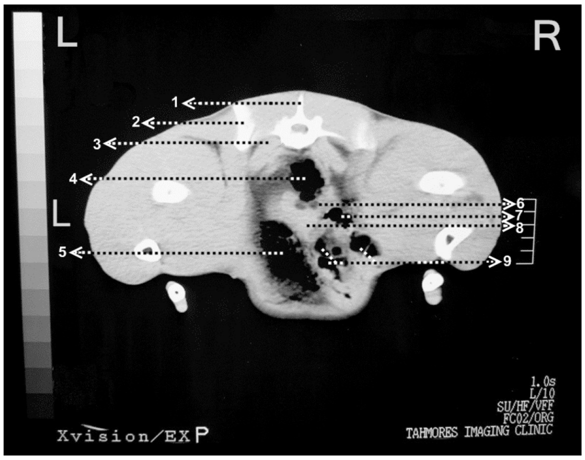

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Figure 12. 1. 6th lumbar vertebra, 2. wing of Ilium, 3. sublumbar muscles, 4. descending colon, 5. caudoventral blind sac, 6. uterine horn, 7. cecum, 8. urinary bladder, 9. jejunum.

the left lung (Figure 1 to 3), the base of heart (Figure 1 to 2) and the thoracic part of esophagus (Figure 1 to 2).

4. Discussion

Although the conventional radiology and ultrasonography are more practical and easily performed procedures, CT scan is superior for the soft tissue differentiation [29, 30]. It has been effectively used to evaluate the abdominal cavity of the domestic animals [16, 20, 31]. CT also enables us to obtain a quick and accurate image of internal organs of those animals which routine invasive anatomic studies were not recommended on them [32, 33]. It is slightly difficult to do anatomic studies on the Jebeer as an endangered wild ruminant. In this study CT modality make us possible to evaluate the abdominal organs of the Jebeer anatomically without euthanasia or any other invasive procedure.

In order to have the reproducibility in the normal CT anatomic studies, consistency of the CT performance parameters are very important. Any deviation in the angle of radiation to the body axis, results in the appearance of various organs in cross sectional CT images, so it is important to use a proper and standard angle of radiation. This angle is 90° to the longitudinal axis of the body and has used in many normal CT anatomic studies which aim to generally demonstrate the body organs [17, 27, 29, 30]. In the present study the radiation was performed vertical to the longitudinal axis of the trunk to produce the standard CT images demonstrating the position of the abdominal organs and their vicinities accurately.

In those CT anatomic studies which no landmark were offered [14, 20], an organ only could be roughly addressed, but in the present study we used the thoracic and lumbar vertebrae as references to describe the topographic position of the abdominal organs. Relative anatomic position of the body organs to the respective vertebrae may be due to the segmental formation of the body during the embryonic period [34] and has been used in other studies for precise description of the location of the internal organs [16, 19, 27, 30].

In this manner we have prepared a sectional imaging anatomic atlas of the abdominal organs in the Jebeer. By this atlas one can find out the situation and extension of these organs according to the vertebral column (Table 1).

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