REVIEW PAPER | Anatomy | Volume : 4 | Issue : 11 | November 2014 | ISSN - 2249-555X

A Review of Contemporary Imaging Anatomic Interpretation of Some Rabbit, Feline and Canine Organs of Cranial Abdomen Using Computed Tomography (Ct)

KEYWORDS computed tomography, imaging anatomy, small animals

Kamelia Stamatova-Yovcheva

Department of Veterinary Anatomy, Histology and Embryology
Faculty of Veterinary Medicine, Trakia University, 6000 Stara Zagora, Bulgaria

ABSTRACT *Recently computed tomography (CT) has been widely used as a noninvasive imaging anatomical method for visualization of organs from cranial abdomen in small domestic mammals. CT is suitable for anatomical visualization of bones and soft tissues in small animals used as classical experimental models in biomedical research. The study of anatomical objects using CT is performed in normal functioning biological object that is not subjected to excessive radioactive radiation. The exact interpretation of CT images and description of the organ structures of cranial abdominal region is based on preliminary studied information from topographic anatomy*

Introduction
Computed tomography (CT) is a noninvasive method for anatomical visualization of bones and soft tissues in biological objects. Opposed to dissection techniques, CT provides detailed information about organ anatomical features in living animals (Lauridsen et al., 2011; Stamatova et al., 2011; Dimitrov et al., 2012; Stamatova-Yovcheva et al. 2012).

CT makes possible to be created naturalistic, high resolution interactive images of anatomical models in three dimensional aspects. Researchers have the option to select and examine a specific anatomical structure, which is object of interest (Garland et al., 2002; Henninger et al., 2003; Zwingenbereger et al., 2005; Drake et al., 2008; Hagen, 2012;).

According to some authors (Ober and Freemean, 2009) results from imaging CT studies can be used as morphological basis to be interpreted anatomical structures that are species and breed specific.

Historical Background
Recently CT has been used as imaging anatomical method for visualization of organ structures from different anatomical regions in mammals used as experimental models in biomedical research (De Iuliis and Pulera, 2007; Dimitrov et al., 2009).

CT is applied to study morphological features and functional state of some organs in the domestic rabbit, due to the high resolution and detailed information of obtained anatomical images (Dimitrov et al., 2012).

CT has a wider investigational range in anatomy research compared to the classical anatomical methods where nonliving animals are used (Zwingenbereger and Schwartz, 2004; Badea et al., 2008).

CT anatomical data of the organ structures correlates highly with data for their normal topography. For this reason many authors (Samii et al., 1998; Zotti et al., 2009; Dimitrov et al., 2010[a]; Dimitrov et al., 2010[b]; Dimitrov et al., 2011[a]; Dimitrov et al., 2011[b]) suggest this imaging modality is an appropriate method for contemporary topographic interpretation.

Anatomical study using CT is performed in strict compliance with all the principles of animal welfare. No euthanasia is needed, opposite to classical anatomical studies and radition is minimized, compared to radiology (Novelline et al., 1999; Boyd et al., 2006; Uzunova, 2013).

Detailed anatomical information in transversal CT studies is due to comprehensive definition of the tissue structures because of their different attenuation (Hathcook and Stickle, 1993[a]; Hathcook and Stickle, 1993[b]; De Ricke et al., 2005).

The definition and exact interpretation of CT tissue findings requires knowledge in topographic anatomy (Feeney et al., 1991; Smallwood and George, 1993; König and Liebich, 2004; Alsafy, 2008).

A contemporary aspect of the topographic location of thoracic and abdominal organs in dogs and cats has been interpreted by CT (König and Liebich, 2004).

CT features of the organs from a certain anatomical region are defined. The same bone structures that mark organs' topography are used when studying native frozen postmortal anatomical cuts (Dimitrov et al., 2013[a]).

In goat thoracic anatomical landmarks are used in CT study of thoracic cavity's organs (Alsafy, 2008). The author aims the obtained CT anatomical data to be used as a basis for contemporary interpretation of thoracic organs' anatomical features in this animal.

According to some researchers (Smallwood and George, 1993; Rivero et al., 2009) CT is a suitable noninvasive method for the study of the anatomical topographic features of canine thoracic and abdominal organs.

CT anatomical investigation of the organs from abdominal cavity in small mammals gives information about their topography and closeness to the other organs. The topography of big vessels (abdominal aorta and caudal vena cava) and their branches is defined (Gielen, 2003).

CT anatomy is considered as a unit of topographic anatomy in the dog (Teixeira et al., 2007). CT anatomical visualization of the abdominal organs corresponds to their normal topography on native frozen topograpghic slices. The

Volume : 4 | Issue : 11 | November 2014 | ISSN - 2249-555X

used bone landmarks in CT and in postmortal anatomical studies are the same.

Computed tomographic anatomical algorithm

CT anatomical study in the small mammals requires immobilization of the animal on the patient table. Intramuscular injection of sedatives is considered to be the most suitable for immobilization in order to obtain objective computed tomographic anatomical images in minimum stress of the studied animals (Samii et al., 1998; Boyd et al., 2006; Teixeira et al., 2007; Dimitrov et al., 2009; Rivero et al., 2009; Dimitrov et al., 2010[a]; Dimitrov et al., 2010[b]; Dimitrov et al., 2011[a], Dimitrov et al., 2011[b]; Stamatova et al., 2011; Dimitrov et al., 2012; Stamatova-Yovcheva et al., 2012; Dimitrov et al., 2013[a]).

The use of relatively small number of clinically healthy animals is a great advantage of CT. Detailed CT anatomical images of the abdominal organs in the dog are obtained in the studies of many authors (Smallwood and George, 1993; Teixeira et al., 2007; Rivero et al., 2009). The number of the studied animals varies from two to four.

CT anatomical features of feline abdominal organs are studied by some researchers (Samii et al., 1998). The authors use two sexually mature clinically healthy animals.

CT anatomical characters of rabbit organs are studied (Zotti et al., 2009). Number of the investigated animals is four. In other researches (Dimitrov et al., 2010[a]; Dimitrov et al., 2011[a]; Stamatova et al., 2011; Dimitrov et al., 2012; Stamatova-Yovcheva et al., 2012; Dimitrov et al., 2013[a]) from eight to ten rabbits are used.

To obtain accurate interpretation of CT anatomical findings, some authors (Dimitrov et al., 2009; Dimitrov et al., 2010[a]; Dimitrov et al., 2010[b]; Dimitrov et al., 2011[a]; Dimitrov et al., 2011[b]; Dimitrov et al., 2012; Dimitrov et al., 2013[a]) use bone structures as anatomical landmarks. The topography of the investigated anatomical region is defined.

To obtain CT anatomical results, concerning the imaging anatomical features of soft tissues and bones is required algorithm of investigation that is specific for the anatomical region (Frank et al., 2003).

The soft tissue window and its parameters (width and height) are used to improve the quality of the CT anatomical images. Thus the observed structures are defined maximum (Samii et al., 1998; Zotti et al., 2009; Dimitrov et al., 2012). CT anatomical visualization of abdominal soft tissue structures in the dog is detailed, when using soft tissue window with length (WL) of 14 and width (WW) of 658 (Rivero et al., 2009).

Data of some authors (Teixeira et al., 2007) show, that to visualize CT anatomical findings in canine cranial abdominal region, a soft tissue and mediastinal-vascular window are used.

Detailed CT anatomical images of the rabbit liver and its closeness to soft tissue and bone structures are studied (Stamatova-Yovcheva et al., 2012). A width of window 399 and center 53 are used.

CT anatomical data for the organs, vascular and bone structures from cranial abdominal region are studied, as recumbency, scanning levels and CT scans' thickness are selected freely. CT anatomical presenting of abdominal structures in the dog is possible at sternal recumbency of the studied animals (Smallwood and George, 1993; Teixeira et al., 2007; Rivero et al., 2009). CT scans' thickness is 5 mm (Teixeira et al., 2007), 10 mm (Rivero et al., 2009) and 13 mm (Smallwood and George, 1993). CT images are oriented so that the left and right CT anatomical findings are presented left and right to the researcher (Rivero et al., 2009).

A number of authors (Zotti et al., 2009) investigate by CT the rabbit organs, as the animals are positioned in sternal recumbency and the scans' thickness is 5 mm.

CT anatomical studies in cats and rabbits are carried out to find the imaging anatomical features of the thoracic and abdominal organs in dorsal recumbency of the studied animals (Samii et al., 1998; Stamatova et al., 2011; Dimitrov et al., 2012; Stamatova-Yovcheva et al., 2012). The obtained CT images are interpreted as the right anatomical structures are visualized left to the researcher. Objective anatomical computed tomographic results for some abdominal soft tissue structures in cat and rabbit are obtained with distance between scans' levels (thickness of CT slices) of 3 mm in the rabbit (Dimitrov et al., 2012), 5 mm in the cat (Samii et al., 1998) and 5 mm and 8 mm in the rabbit (Stamatova et al., 2011; Stamatova-Yovcheva et al., 2012).

Ethical Protocol

The study about abdominal organs in rabbit was approved by the institutional committee of animal care in Trakia University, Faculty of Veterinary Medicine, Stara Zagora, Bulgaria (Approval № 51/29. 09. 2012). The images of feline abdominal organs were obtained during the preparation of dissertation of Dr. Rosen Dimitrov. The dissertation was entitled Morphofunctional and imaging features of the male accessory sex glands and pelvic part of the urethra in the tomcat (Dimitrov, 2009). The CT images of dog's abdominal organs were obtained during the preparation of the study for the imaging anatomical features of prostate gland in the dog (Dimitrov et al. 2010[c]). The experiments were made in strict compliance with the Decision of European Union Council 1999/575/EO from 23. 03. 1998 about contracted convention by European Committee for vertebrate animals protection, used for experimental and other scientific purposes, and the Animal protection's law in Republic of Bulgaria (Section IV - Experiments with animals, art. 26, 27 and 28, received on 24[th] January 2008 and published in Government Gazette, № 13, 2008).

CT visualization and anatomic interpretation

Liver

The interpretation of CT anatomical images of the cranial abdomen is consistent with the gray-white scale. It is related to the degree of absorption of X-rays by the bone and soft tissues. The bones as vertebra and ribs are hyper attenuated structures because they have the highest density and are visualized in white (Rivero et al., 2009).

Precontrast CT study of the liver provides detailed information for the anatomic features of the mammals' organs. Contrast CT investigation of the hepatic parenchyma is used often for morphological definition of benign and malignant lesion alterations (Kleiter et al., 1999).

Many authors (Teixeira et al., 2007; Rivero et al., 2009) study by CT the topographic location of the abdominal organs in the dog. Bones are used (vertebra from eight

Volume : 4 | Issue : 11 | November 2014 | ISSN - 2249-555X

thoracic (Th8) to first lumbar (L1) and relevant sternebra to determine the liver topography in transversal plane.

CT anatomic investigation of the liver in the cat finds the intrathoracic localization of the organ and its closeness to the stomach, jejunum and parts of colon. Caudate process touches the right kidney (Samii et al., 1998).

CT anatomic borders of the rabbit liver in transversal aspect are from Th8 to L1 (Zotti et al., 2009). CT presentation of the organ corresponds to its normal topography on postmortal transversal cuts.

Other authors (Stamatova et al., 2011; Stamatova-Yovcheva et al., 2012) perform comparative imaging anatomical study of the rabbit liver. CT anatomic borders of the organ in transversal and sagittal aspect are defined. Used bone landmarks are vertebra from Th8 to L3 and costal arch, and soft tissue markers are the soft abdomen, diaphragm, stomach and the right kidney.

The liver and stomach in the dog (level - Th11) are well defined soft tissue findings with close location in the epigastric region. Stomach wall is gray, as the lumen of its body and fundus have a low attenuation and cover the liver lobes. Right hepatic lobe and caudate are only visualized. Right hepatic lobe is presented as a whole norm attenuated structure, distinguished by the hyper attenuated heterogeneous parts of the stomach. On the dorsal edge of the right hepatic lobe is found the intermediately attenuated profile of caudal vena cava. Left and dorsal, close to the body of vertebra is the abdominal aorta. It is with intermediate soft tissue density.

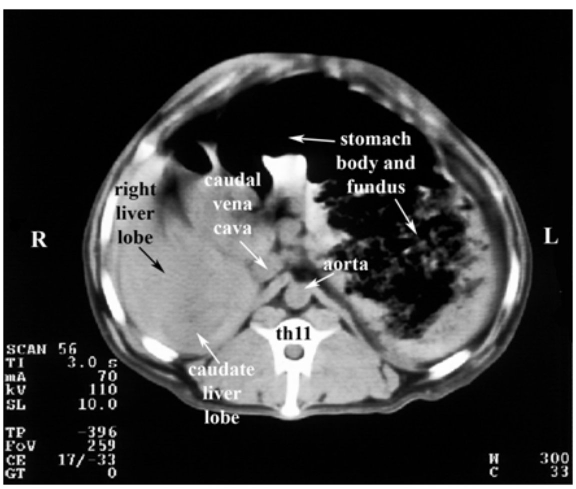

Figure 1. Precontrast transversal CT image of the cranial abdominal region in dog (at the level of 11th thoracic vertebra - Th11). (Original)

For CT visualization of the liver a lung vascular window is used sometimes. It provides information for the topographic location of the organ and its contacts with the close soft tissue findings. Their nuance is consistent with gray-white color scale.

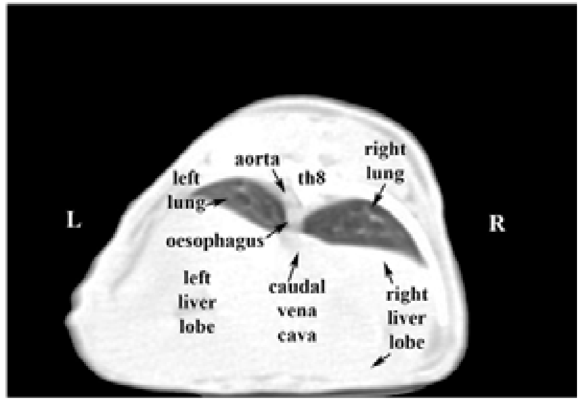

Figure 2. Precontrast transversal CT image of the cranial abdominal region in rabbit (at the level of 8th thoracic vertebra - Th8). (lung and vascular window) (Original

Stomach

Transverse CT study of the stomach in small mammals (carnivores and lagomorphs), provides a detailed anatomical analysis of gastric parts and their proximity to the other organs. Borders that outline transition between pyloric part and duodenum beginning depend on food mass in the stomach and intestinal lumen (Fike et al., 1980; Samii et al., 1998; Teixeira et al., 2007; Zotti et al., 2009; Stamatova-Yovcheva et al., 2012). The vertebra that define the topography of the stomach in the dog are thoracic vertebra in the segment from Th8 to Th12 (Teixeira et al., 2007; Rivero et al., 2009), and in the rabbit – from Th8 to L3 (Zotti et al., 2009).

CT image of the rabbit stomach (level – Th12) gives information for its anatomical parts and borders in the epigastric region. Food content affects gastric topography and that of the adjacent soft tissue structures. Due to cecotrophy (Sotirov and Semerdjiev, 2009) contrast CT anatomic image of the stomach lumen is rarely observed. Filled stomach covers almost the liver. Parts of the right liver lobe, duodenum and jejunum are observed.

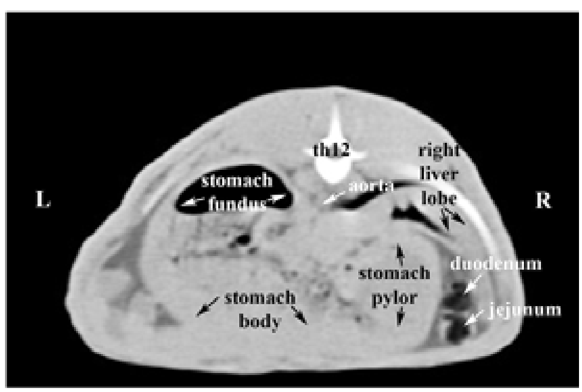

Figure 3. Precontrast transversal CT image of the cranial abdominal region in rabbit (at the level of 12th thoracic vertebra - Th12). (Original)

Spleen and parts of intestinal canal

Precontrast CT study of the spleen gives available information for its topography (Patsikas et al., 2001). CT transversal anatomical image of the spleen in the dog and rabbit is obtained at the level of L1 (Teixeira et al., 2007; Rivero et al., 2009; Zotti et al., 2009).

Volume : 4 | Issue : 11 | November 2014 | ISSN - 2249-555X

The costal arch is used as anatomical bone landmark to define the spleen topography in the cat (Samii et al., 1998).

CT transversal image of the spleen in carnivores and rabbit is norm attenuated with soft tissue density similar to that of the liver. The spleen is close to the stomach (on the left) and reaches the left abdominal wall. Parts of duodenum, jejunal ansa and ascending colon are visualized as norm attenuated structures with oval contours. Peritoneum is not visualized.

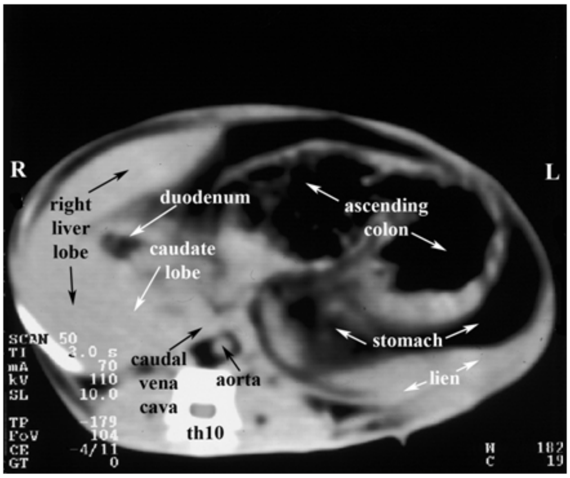

Figure 4. Precontrast transversal CT image of the cranial abdominal region in cat (at the level of 10th thoracic vertebra - Th10). (Original)

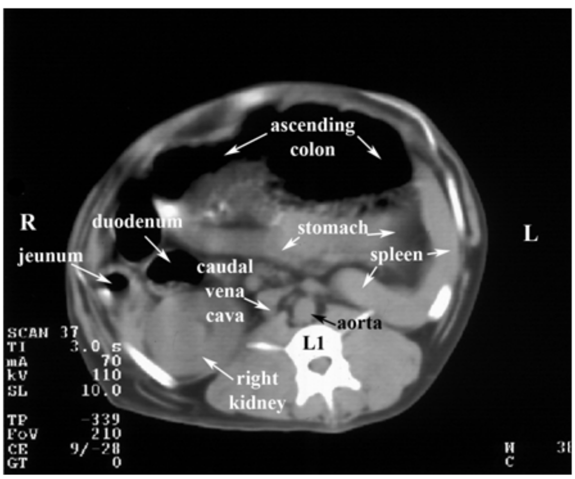

Figure 5. Precontrast transversal CT image of the cranial abdominal region in dog (at the level of the 1st lumbar veretbra - L1). (Original)

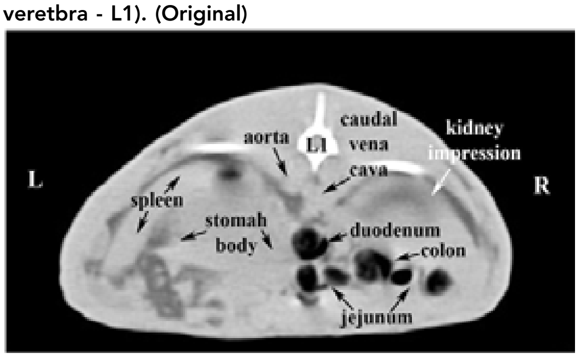

Figure 6. Precontrast transversal CT image of the cranial abdominal region in rabbit (at the level of the 1st lumbar veretbra - L1). (Original) Pancreas

CT visualization of the rabbit pancreas is hampered by the features of its anatomical structure. The organ is composed of small lobes. It is disseminated in the mesoduodenal adipose tissue (Barone, 1997; Zotti et al., 2009; Dimitrov et al., 2013[b]; Stamatova-Yovcheva et al., 2013).

CT is a suitable noninvasive method for carnivores' pancreas visualization (Samii et al., 1998; Teixeira et al., 2007; Rivero et al., 2009). As bone landmarks, marking the anatomical lines of this organ in the dog are used the vertebra from Th12 to L1 (Teixeira et al., 2007; Riviero et al., 2009).

Carnivores' pancreas is visualized as a soft tissue finding with intermediate attenuation. Its soft tissue density is similar to that of the liver and spleen. At the level of Th12 the pancreas in the dog is visualized well defined to the adjacent liver lobes, stomach and ascending colon.

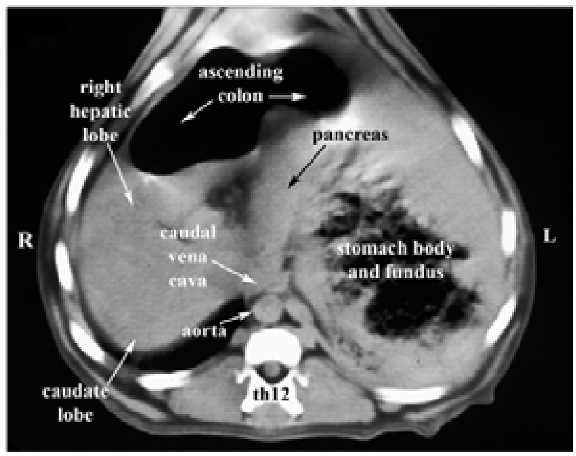

Figure 7. Precontrast transversal CT anatomical image of the cranial abdominal region in dog (at the level of 12th thoracic vertebra - Th12). (Original)

CT anatomical studies (Zotti et al., 2009; Stamatova-Yovcheva et al., 2013) present information for imaging anatomical features of pancreas and its topography in the rabbit, because of the morphological features of the organ (Barone, 2013; Dimitrov et al., 2013[b]).

Anatomical application of the computed tomography

CT soft tissue findings are visualized as anatomical structures with high resolution. The reconstruction of certain images of anatomical objects' parts is motivation CT to be used as imaging anatomical modality (Henninger et al., 2003).

Precontrast CT anatomical study of small mammals' intraperitoneal soft tissue findings is enough to investigate their topographic and imaging anatomical features (Bartling et al., 2007).

CT is more widely applied to study the anatomical predisposition and pathogenesis of many diseases of thoracic and abdominal organs in the companion animals (Ohlert and Scharf, 2007).

CT anatomical investigation of canine organ structures from cranial abdomen is used as a morphological basis to diagnose actual diseases, specific for this animal species (Rivero et al., 2009).

CT is widespread non-invasive method for anatomical vis-

Volume : 4 | Issue : 11 | November 2014 | ISSN - 2249-555X

ualization of the abdominal organs in the small domestic mammals, used as models to investigate many abdominal human diseases. The obtained anatomical data are also applied to study the contrast level in the vascular structures. CT modality is important to precise the dose of contrast agents, used for radiological investigations (Han et al., 2001).

The helical CT is used for the imaging anatomical study and early diagnosis of intrahepatic lesions in dogs. The obtained morphological results are used to plan surgical interventions in cranial abdomen (Hylands, 2007).

Canine liver is anatomical CT model for early diagnosis and to proceed with human portal shunt. This is a motif for some researchers (Frank et al., 2003) to perform CT anatomical study of the liver in dogs, in order to submit anatomical data.

CT provides information for the functional status and topography of canine spleen. The obtained data are applied in the interpretation and early diagnosis of the spleen torsion (Patsikas et al., 2001).

CT anatomical presentation of the small mammals' stomach is used as anatomical basis to diagnose gastrointestinal lesions (Fike et al., 1980).

The rabbit liver is investigated in order to be compared CT and routine radiology as non-invasive anatomical modalities (Momose et al., 1995). CT has advantages in the visualization of soft tissue structures.

CT is a qualitative method to study the anatomical predisposition for liver steatosis and early necrotic hepatic alteration in the rabbit (Ducommun et al., 1979; Kawata et al., 1984; Kato et al., 1996).

The rabbit liver and spleen are CT anatomical models to study the microcirculation's alterations that occur in humans by improper use of contrast agents (Ivanchev et al., 1989).

Detailed CT anatomical image of the canine pancreatic parenchyma is obtained at maximum expiration. The organ's excretory ducts are not found. Pancreas is visualized difficultly, compared to liver, stomach and spleen (Probst and Kneissl, 2001).

Concluding remarks
CT is non-invasive imaging anatomical method. CT images of the organs from cranial abdomen are as transverse anatomical topographic cuts of the selected area of investigation. Precontrast CT study is a definitive method for anatomical visualization of small mammals' abdominal organs and to obtain imaging anatomical information.

CT image collections are preferred for visualization of normal topography of the carnivores' thoracic and abdominal organs, compared to photographic images of native frozen transverse sections.

Volume : 4 | Issue : 11 | November 2014 | ISSN - 2249-555X

REFERENCE Alsafy, M. (2008). Computed tomography and cross-sectional anatomy of the thorax of goat. Small Ruminant Research 79, 158-166. | Badea, C., Draganova, M., Holdsworth, D., & Johnson, G. (2008). In vivo small animal imaging using micro-CT and digital subtraction angiography. Physics in Medicine and Biology 53 (19), 73-89. | Barone, R. (1997). Chapitre VII - Pancraes. In R Barone (Ed.), Anatomie comparée des mammifères domestiques. Splanchnologie I. Tome troisieme (pp.560-575). Paris: Vigot. | Bartling, S., Stiller, W., Semmler, W., & Kiessling, F. (2007). Small Animal Computed Tomography Imaging. Current Medical Imaging Reviews 3, 45-59. | Boyd, S., Davison, P., Muller, R., & Gasser, J. (2006). Monitoring individual morphological changes over time in ovariectomized rats by in vivo micro-computed tomography. Bone 39 (4), 854-862. | De Iuliis, G., & Pulera, D. (2007). Digestive system. In G. De Iuliis & D. Pulera (Eds.), The dissection of vertebrates. A laboratory manual (pp. 111-122). London: Elsevier Academic Press. | De Ricke, L., Gielen, I., Simoens, P., & Van Bree, H. (2005). Computed tomography and cross-sectional anatomy of the thorax in clinically normal dogs. Am J Vet Res 66(3), 512-524. | Dimitrov, R. (2009). Morphofunctional and imaging features of the male accessories glands and pelvic part of the urethra in the tomcat (Doctoral dissertation). Trakia University, Stara Zagora, Bulgaria. | Dimitrov, R., Toneva, J., Stamatova, K., & Yonkova, P. (2009). Computed Tomographic Study On the Peivic Urethra in the Male Rabbit. Uludag Univ J Fac Vet Med 28 (1), 9-14. | Dimitrov, R., Toneva, J., Yonkova, P., & Stamatova, K. (2010a). Comparative transversal imaging anatomic study on domestic rabbit prostate. Journal of Mountain Agriculture on the Balkans 13 (3), 582-594. | Dimitrov, R., Toneva, J., Yonkova, P., & Stamatova, K. (2010b). Comparative transversal imaging anatomic study on domestic rabbit bulbourethral glands. Journal of Mountain Agriculture on the Balkans 13 (1), 59-70. | Dimitrov, R., Yonkova, P., Vladova, D., & Kostov, D. (2010c). Computed tomography of the topographical anatomy of canine prostate. Trakia Journal of Sciences 8 (2), 78-82. | Dimitrov, R., Yonkova, P., Stamatova, K. (2011a). Agreement between sagittal plane cross-sectional anatomy, sonoanatomy and computed tomography of rabbit prostate and bulbourethral glands. Bulgarian Journal of Veterinary Medicine 14 (1), 11−16. | Dimitrov, R., Toneva, Y., Vladova, D., Stamatova, K., & Stefanov, M. (2011b). Computed Tomographic Imaging of Vesicular Glands in Rabbits. Journal of Animal and Veterinary Advances 10 (1), 55-59. | Dimitrov, R., Vladova, D., Stamatova, K., Kostov, D., & Stefanov, M. (2012). Anatomical computed tomographic study of the heart and some mediastinal vessels of the rabbit (Oryctolagus cuniculus). Bulgarian Journal of Agricultural Science 18 (5), 784-788. | Dimitrov, R., Stamatova, K., & Kostov, D. (2013a). Comparative imaging of the vesicular glands in New Zealand white rabbits (Oryctolagus cuniculus). Turkish Journal of Veterinary and Animal Sciences 37, 97-101. | Dimitrov, R., Russenov, A., Stamatova-Yovcheva, K., Uzunova, K., & Yordanova, V. (2013b). Ultrasonographic caharacteristics of rabbit's pancreas. Istanbul Univ Vet Fak Derg 39 (2), 139-147. | Schmitt, W., & Gruliow, R. (Eds.). (2008). Gray's atlas of anatomy. Philadelphia, PA: Churchill Livingston Elsevier. | Ducommun, J., Goldberg, H., Korobkin, M., Moss, A., & Kressel, H. (1979). The Realtion of Liver Fat to Computed Tomography Numbers: a Preliminary Experimental Study in Rabbits. Radiology 130 (2), 511-513. | Feeney, A., Fletcher, T., & Hardy, R. (Eds.). (1991). Atlas of Correlative Imaging Anatomy of the Normal Dog: Ultrasound and Computed Tomography. Philadelphia: WB Saunders Co. | Fike, J., Druy, E., Zook, B., Davis, D., Tompson, J., Chaney, E., Bradley, E. (1980). Canine anatomy as assessed by computerized tomography. American Journal of Veterinary Research 41 (11), 1823-1832. | Frank, P., Mahaffey, M., Egger, C., & Cornell, K. (2003). Helical computed tomographic portography in ten normal dogs and ten dogs with a portosystemic shunt. Veterinary Radiology and Ultrasound 44 (4), 392-400. | Garland, M., Lawler, L., Whitaker, B., Walker, I., Corl, F., & Fishman, E. (2002). Modern CT applications in veterinary medicine. Radiographics 22 (1), 55-62. | Gielen, H. (2003). Computed tomography (CT) in small animals. Part 2. Clinical applications. Vlaams Diergeneeskundig Tijdschrift 72, 168-179. | Hagen, R. (2012). Cross-sectional imaging: the key to anatomy. Veterinary Record 170, 17-18. | Han, J., Choi, B., Kim, A., & Kim, S. (2001). Contrast Media in Abdominal Computed Tomography: Optimization of Delivery Methods. Korean Journal of Radiology 2 (1), 28-36. | Hathcock, J., & Stickle, R. (1993a). Interpretation of computed tomographic images. Vet Clin North Am Small Anim Pract 23 (2), 417-435. | Hathcock, J., & Stickle, R. (1993b). Principles and concepts of computed tomography. Vet Clin North Am Small Anim Pract 23 (2), 399-415. | Henninger, W., Frame, M., William, M., Simhofer, H., Malleczek, D., Kneissl, S., & Mayrhofer, E. (2003). CT features of alveolitis and sinusitis in horses. Veterinary Radiology and Ultrasound 44 (3), 269-276. | Hylands, R. (2007). Veterinary Diagnostic Imaging. Canadian Veterinary Journal 48 (2), 207-209. | Ivanchev, K., Lunderquist, A., McCuskey, R., McCuskey, P., Wretlind, A. (1989). Effect of intravenously injected iodinated lipid emulsion on the liver. An experimental study correlating computed tomography findings with in vivo microscopy and electron microscopy findings. Acta Radiol 30 (3), 291-298. | Kato, T., Suto, Y., & Hamazoe, R. (1996). Effects of microwave tissue coagulation on the livers of normal rabbits: a comparison of findings of image analysis and histopathological examination. British Journal of Radiology 69 (822), 515-521. | Kawata, R., Sakata, K., Kunidea, T., Saji, S., Doi, H., & Nozawa, Y. (1984). Quantitative evaluation of fatty liver by computed tomography in rabbits. American Journal of Roentgenology 142 (4), 741-746. | Kleiter, M., Henninger, W., Hirt, R., & Lorinson, D. (1999). Portosystemic shunt in a dog - computed tomography as a successful imaging method. Wien Tierarztl Monatssch 86, 64-70. | König, H., & Liebich, H. (2004). Body Cavities. In H. König & H. Liebich (Eds.), Veterinary anatomy of domestic mammals (pp. 267-276). Schtuttgard: Schattauer GmbH. | Lauridsen, H., Hansen, K., Wang, T., Agger, P., Andersen, J., Knudsen, P., Rasmussen, A., Uhrenholt, L., & Pedersen, M. (2011, March). Inside out: Modern Imaging Techiniques to Reveal Animal Anatomy. Plos One 6 (3) e17879. doi: 10.1371/ journal. pone. 0017879. | Momose, A., Takeda, T., & Itai, Y. (1995). Phase-contrast x-ray computed tomography for observing biological specimens and organic materials. Rev Sci Instrum 66 (2), 1434-1437. | Novelline, R., Rhea, J., Rao, P., & Stuk, J. (1999). Helical CT in emergency radiology. Radiology 213 (2), 321-339. | Ober, C., & Freemean, L. (2009). Computed tomographic magnetic resonance imaging and cross-sectional anatomic features of the manus in cadavers of dogs without forelimb disease. American Journal of Veterinary Research 70 (12), 1450-1458. | Ohlert, S., & Scharf, G. (2007). Computed tomography in small animals-basic principles and state of the art applications. The Veterinary Journal 173 (2), 254-271. | Patsikas, M., Rallis, T., Kladakis, S., & Desseris, A. (2001). Computed tomography diagnosis of isolated splenic torsion in a dog. Veterinary Radiology and Ultrasound 42 (3), 235-237. | Probst, A., & Kneissl, S. (2001). Computed tomographic anatomy of the canine pancreas. Veterinary Radiology and Ultrasound 42 (3), 226-230. | Rivero, M., Vasquez, J., Gil, F., Ramirez, J., Vilar, J., De Miguel, A., & Arencibia, A. (2009). CT-soft tissue window of the cranial abdomen in clinically normal dogs: an anatomical description using macroscopic cross-sections with vascular injection. Anatomia Histologia Embryologia 38 (1), 18-22. | Samii, V., Biller, D., & Koblik, P. (1998). Normal cross-sectional anatomy of the feline thorax and abdomen: comparison of computed tomography and cadaver anatomy. Veterinary Radiology and Ultrasound 39 (6), 504-511. | Smallwood, J., & George, T. (1993). Anatomic atlas for computed tomography in the mesaticephalic dog: thorax and cranial abdomen. Veterinary Radiology and Ultrasound 34 (2), 65-84. | Sotirov, L., & Semerdjiev, V. (2009). Rabbit breeding. In L. Sotirov & V Semerdjiev (Eds.), Private Livestock. (pp. 371-374). Stara Zagora, Bulgaria: Matkom. | Stamatova, K., Dimitrov, R., Yovchev, D., & Kostov, D. (2011). Computed tomographic anatomical investigation of the rabbit liver (Oryctolagus cuniculus). Scientific Research of the Union of Scientists in Bulgaria. Technics and Technologies 8, 226-229. | Stamatova-Yovcheva, K., Dimitrov, R., Toneva, J., Yonkova, P., Kostov, D., Russenov, A., Uzunova, K., & Yordanova, V. (2013). Helical computed tomography application in rabbit liver anatomy: comparison with frozen cross-sectional cuts. Turkish Journal of Veterinary and Animal Sciences 37 (5), 553-558. | Stamatova-Yovcheva, K., Dimitrov, R., Yonkova, P., Russenov, A., Yovchev, D., & Kostov, D. (2012). Comparative imaging anatomic study of domestic rabbit liver (Oryctolagus cuniculus). Trakia Journal of Sciences 10 () 57-63. | Teixeira, M., Gil, F., Vasquez, J., Cardoso, L., Arencibia, A., Ramirez-Zarzosa, G., & Agut, A. (2007). Helical computed tomographic anatomy of the canine abdomen. The Veterinary Journal 174 (1), 133-138. | Uzunova, K. (2013). Hygiene, Ethology and Rabbit Protection. In K. Uzunova (Ed.), Animal Welfare. (pp. 224-265). Stara Zagora, Bulgaria: Jemmy Stratus Ltd. | Zotti, A., Banzato, T., & Cozzi, B. (2009). Cross-sectional anatomy of the rabbit neck and trunk: Comparison of computed tomography and cadaver anatomy. Research in Veterinary Science 87 (2), 171-176. | Zwingenbereger, A., & Schwartz, T. (2004). Dual-phase CT angiography of the normal canine portal and hepatic vasculature. Veterinary Radiology and Ultrasound 45 (2), 117-124. | Zwingenbereger, A., Schwartz, T., & Saunders, M. (2005). Helical computed tomographic angiography of canine portosystemic shunts. Veterinary Radiology and Ultrasound 46 (1), 27-32. |