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The role of imaging anatomy in the contemporary anatomical studies of domestic rabbits in veterinary and agricultural science

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Abstract

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The development of Imaging technics allows anatomy to be transformed into an interdisciplinary science that includes as principles of research both classical anatomical methods and those applied in clinical disciplines. These facts are motifs for the development of a relatively new branch in the anatomical science-Imaging Anatomy. It is a contemporary trend in Anatomy, which investigates the normal images of the anatomical objects. Anatomical findings are interpreted by the imaging methods – 2 dimensional ulstrasound, computed tomography and magnetic resonance imaging.

Keywords: 2D ultrasound; computed tomography; magnetic resonance imaging; anatomy; abdominal organs

Introduction

Ultrasound

Ultrasound (US) is an important and perspective method for education and training in many universities in USA. It is included as method for investigation in morphological and anatomical science. US is evaluated as precise modality for the modern anatomist, who train the students and the same time conduct experiments, including US. Ultrasound gives detailed information, which is focused on the anatomical features of the organs, but in a living and functioning organism. This is a modern challenge for effective presentation in the anatomical classes, because it is a safe and no-radiating modality. The obtained results, used either for science, either for training are in real time (Kapur et al., 2016; Royer, 2016).

US is an imaging anatomical method, whose role is processing and obtaining of detailed anatomical images of abdominal and pelvic organs in the small domestic animals. The rabbit has been involved in the US anatomical protocols as farm and veterinary object for investigation. Many anatomical data for the shape, size, location and closeness of the liver, kidneys, spleen, pancreas and accessory sex glands have been obtained. The results have been used as for scientific anatomical interpretation and as for modern and innovative anatomical education for the students in the preclinical anatomical course (Dimitrov, 2012; Stamatova-Yovcheva et al., 2012a; Stamatova-Yovcheva et al., 2012b; Dimitrov et al., 2013).

The precision of the abdominal US for anatomical studies has been compared to the Radiology. US is appropriate method for investigation of small area of the body cavities and the organs, located in, but in the same time it allows a perfect visualization of the parenchyma organs. To interpret the US anatomical findings in a living organism, the ultrasonographer must handle with rich source of anatomical knowledge and basic sciences. For example, when is necessary to study the liver, data for its parenchyma visualization according to the grey-white scale have to be compared to the sonographic features of the spleen and cortex kidney (Biller et al., 1992; Redrobe at al., 2001).

Computed Tomography

Computed Tomography (CT) is a contemporary imaging anatomical method for visualization of internal organs in farm animals as sheep and rabbits. It gives detailed information, which concerns the location of the studied objects, either organs, either bones, metric parameters, closeness to adjacent soft tissues and bones. There are correlations between the imaging anatomical results and data, given in the native anatomical cadaveric studies (Zotti et al., 2009; Braun et al., 2011).

In the same time many contradictions, which have been found in the classic anatomical studies have been specified in CT anatomical studies, using living animals. Thus Dimitrov (2013) have studied the rabbit prostate glands. The anatomical data on cadaveric cuts demonstrated three parts of prostate gland. Helical CT data confirmed and clarified the anatomical data of Dimitrov (2013) for location and topography of proprostate, prostate and paraprostate part.

Stamatova-Yovcheva (2016) has investigated the rabbit liver via CT and cross-section anatomical method. The researcher must choose one of both theories evaluated the organ lobation. Therefore, an axial and helical CT study has been involved. CT results clarified the native anatomical data and rejected the contradictions, found in the post mortem anatomical investigation. Both axial and helical CT have proved five lobes in the liver

CT results are with high resolution. The morphological information is obtained in minimal-invasive and fast way. The number of the studied animals is low. Additionally, the researcher could study the object in three different planes, in accordance to the body symmetry. Sometimes there is a dilemma – axial or helical CT. Nowadays helical CT is more preferable to axial, because the obtained anatomical images are with high resolution and the artefacts during the breathing are skip (Lauridsen et al., 2011; Dimitrov, 2013; Stamatova-Yovcheva, 2016).

In the modern anatomical science has been introduced as technic Magnetic Resonance Imaging (MRI). As animal objects for investigation have been used rabbit, rat and pig. MRI data were used to be created the modern interactive Comparative Anatomy. There is a computerized dissection of the studied object, and the soft and hard tissues are digitalized. There is no X-ray radiation, and the magnetic field is not harmful and dangerous for the studied living model (Lauridsen et al., 2011).

The application of MRI is widely dispread in the morphological science. There are anatomical representations of the internal objects. These data are obtained by the reconstruction of the studied structures in a given plane, which is important for the researcher. MRI method is closely connected to functional anatomy. It provides volumetric analysis, anatomical specifics of the investigated organs in T1 and T2 sequences and gives a clear picture as for functional condition of the studied organs in the living anatomical model. MRI does not acquire bone landmark as CT, but gives precise information for the organs' parts, topography of large vessels, topography and location (Stamatova-Yovcheva, 2016).

Materials and Methods

Materials

Twenty sexually mature and healthy clinically rabbits, with body weigh from 2.8 to 3.2 kg and aged 8 months have been used. The animals have been bought from Agriculture Institute in Stara Zagora, with ID 1236503070041. The studies were carried out in compliance with the European Convention for the protection of vertebrate animals used for experimental and other scientific purposes (Strasbourg/16.05.1986) and the Animal Protection Law in the Republic of Bulgaria (Section IV – Experiments with Animals, Article 26, 27 and 28 adopted on 24.01.2008 and published in SG. 13 of 2008).

US anatomical protocol

Five animals have been used. They were positioned in spine recumbency. The hear in the region between the ribs, costal arch, lumbar vertebra and tuber coxae have been cut with animal clipper device – Moser Animalline: ARCO, Type 1854, Wahl Gmbh Germany. The used US device was Diagnostic Ultrasound System (model DC-6V SHENZHEN MINDRAY BIO-MEDICAL, Electrnics CO. LTD, CHINA) and the used probe was 7 MHz microconvex, multifrequent (model 6C2, with radius 20 mm). For better contact between skin and probe a contact gel was used (Ecoultragel Pirrone & Cö., Italy). The findings were documented by Mitsubishi P93 device. The kidneys were studied in transverse scan planes (Dimitrov, 2013).

Axial CT anatomical protocol

Five animals have been used. We used axial CT scanner Picker Marconi-USA, 1995, with table height 395 mm, FOV – 180, filter 1, electric current's intensity was 125 mA, the anode tension – 100 kV and scanning time – 1.2 sec. The window (W) was – 399 and the center – 53. The recumbence was abdominal. The abdominal cavity was studied in dorsal aspect from the middle of the thoracic cavity to the pelvic inlet. The liver, stomach with its parts, small intestines and colon were studied. The scan slices were consecutive (Stamatova-Yovcheva, 2016).

Helical CT anatomical protocol

Five animals have been used. The scanner was Whole body multi-slice helical computed tomography scanner (Light Speed QX/I GE, Genaral Electric USA). The resolution was high – 512. Window settings were set for window width WW – 350 HU and window level WL – 35 HU. The field was SFOV and 50. Regio abdominis cranialis was studied from 13th thoracic vertebra (Th13) to 4th lumbar vertebra (L4) in CT distance of 5 mm (Dimitrov, 2013). The right and left kidney, colon and jejunum were studied.

MRI anatomical protocol

Five animals have been used. MRI tomograph was 1.5-T Magnetom Essenza (Tim+Dot, Siemens Healthcare, USA). The thoracic and abdominal cavity was studied dorsally from the beginning of the thoracic cavity to the pelvic inlet. The lungs, liver, gall bladder, the right and left kidney, and colon were studied. The slices' thickness varied from 3 to 4 mm. The strength of the magnetic field was 1.5 Tesla with Active Shielding, FOV was homogeneous and the diameter was 70 cm. The shape of FOV was spherical and with values 50 x 50 x 50 cm (as the moderate were 250*250). The resolution was high. MRI tomography was set for T2 weighted sequence (Stamatova-Yovcheva, 2016)

Results

2D US anatomical study of the left rabbit kidney gave detailed anatomical information for the oval beam shape of the organ. A thin fine hyperechoic linear fibrous capsule outlined the kidney from surrounding adipose capsule, which was thick, hyperechoic and sharply distinguished to the kidney parts. According to the grey-white scale, the kidney cortex was with higher fine grain heterogeneous echogenicity, compared to this of the papilla. It consisted of fine linear hyperechoic findings. Kidney papilla was well defined and hypoechoic to the pelvis and homogenous. Its shape was triangular and distinguished to the pelvis, as the pelvis borders were asymmetric. The kidney pelvis was with heterogeneous echogenicity with rough grain structure, compared to the fine homogeneous arrangement of the papilla. It was located centrally (Fig. 1).

CT dorsal anatomical study of the rabbit abdomen defined the intrathoracic location of the liver between both costal arches. The organ was transversally situated and was

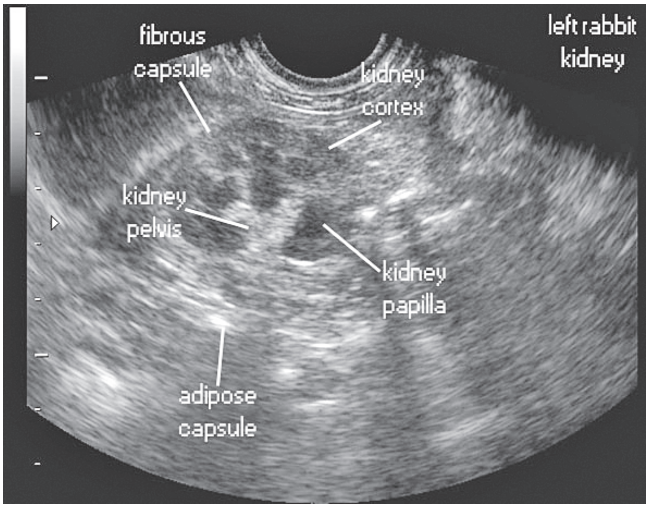

Fig. 1. Transversal US anatomical image of the left rabbit kidney

visualized as symmetrically bilateral norm attenuated heterogeneous finding. Behind the liver the stomach was defined with its three anatomical parts – fundus, body and pylor. The CT attenuation of the stomach fundus was uniform to this of the liver, as the body and pylor were hypo attenuated and heterogeneous structures. Behind the stomach in the left half of the abdominal cavity was found the left kidney, as its peripheral cortical part was hyper attenuated and the middle one – medulla was hypo attenuated. In this scan level were found jejunum folds, visible as hypo attenuated findings, compared to the stomach parts. Colon compartments were massive irregular norm attenuated homogeneous findings, crossing from right to the left halves of the abdominal cavity (Fig. 2).

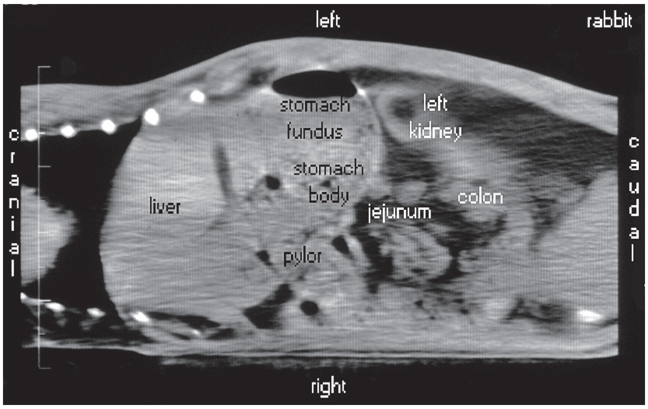

Fig. 2. Dorsal CT anatomical image of the rabbit abdominal cavity at the level of the plane, lined 20 mm ventrally to the spine

The transversal helical CT anatomical study at the level of L2, both kidneys right and left were visualized as norm dense oval beam shape findings with sharply defined borders and contours. Parts of the jejunum folds were presented as irregular structures whose CT attenuation was lower than this of the both kidneys. Transversal CT anatomical image of the colon was well outline. According to the grey white scale

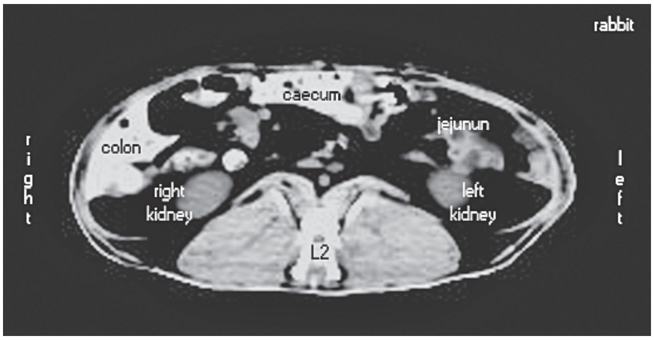

Fig. 3. Transversal helical CT anatomical image of the rabbit abdomen, at the level of 2nd lumbar vertebra (L2)

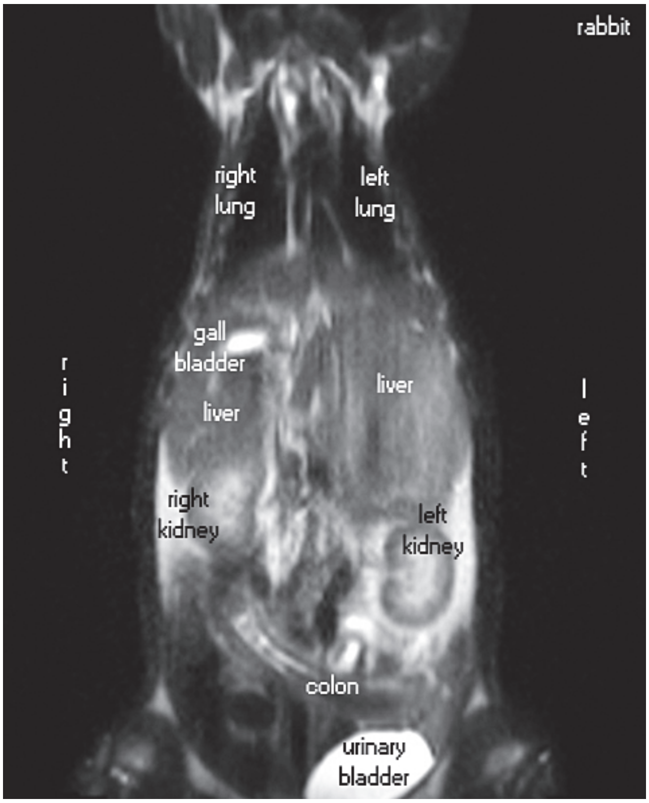

Fig. 4. Dorsal T2 weighed image of the rabbit thoracic and abdominal cavity

it was in the nuances of rich white, which defined its hyper attenuated features, compared to jejunum folds. Regarding cecum, it was also hyper attenuated, compared to the norm attenuated kidneys, but its CT density was uniform to that of the colon (Fig. 3).

Dorsal MRI anatomical study of the rabbit thoracic and abdominal cavities, defined the lungs as symmetric hypo intensive findings, situated in thoracic cavity. The liver was with intermediate intensity of the magnetic signal and was visualized as bilaterally symmetric finding, transversally located and occupying the both halves of the cranial abdominal cavity. The gallbladder was hyper intensive ellipsoid finding within the liver with well-defined edges towards liver parenchyma. There was found the direct anatomical contact between the liver and right kidney. Between the cranial pole of the right kidney and the liver there were not defined borders. The peripheral cortex of the both kidneys was hypo intensive, compared to the central medulla, which was hyper intensive. Parts of the colon passed across the middle plane from left to right and were defined as hypo intensive findings, compared to the hyper intensive pear shape profile of the urinary bladder (Fig. 4).

Discussion

Our presented 2D US anatomical data for the left rabbit kidney, concern its topographical features, sharp definition of the adipose capsule to the fine fibrous capsule, according to the nuances of the grey-white scale. In addition, we defined the peripheral cortex and compared it to the centrally located medulla, and gave brief explanation for the kidney pelvis and papilla. Thus we assumed that 2D US is an important and modern innovative method for investigation to obtain detailed and verified data which are applicable in the anatomical and morphological science. The information, which was obtained by us was detailed and reflecting the anatomical features of the rabbit kidney in a living organism and in a real time. That is in strict correspondence to the published data for US, which concern its introduction as a modern and safe anatomical method, used to study the anatomical features the organs, but in a living and functioning organism (Kapur et al, 2016; Royer, 2016).

We propose US as an imaging anatomical method, to obtain detailed anatomical images of the abdominal organs in the rabbit. We report the rabbit as proper animal model, which could be included in the US anatomical protocols as an object for investigation. Our anatomical data are focused on the shape, location and morphological specifics of the kidney, in accordance to the grey-white scale. We assume that these results are applicable for scientific anatomical interpretation and for innovative alternative for the anatomical education of the students in the preclinical anatomical course (Dimitrov, 2012; Stamatova-Yovcheva et al., 2012a; Stamatova-Yovcheva et al., 2012b; Dimitrov et al., 2013).

US anatomical results give detail information for the adipose and fibrous capsules of the rabbit kidney, and in the same time accentuate the imaging anatomical features of the kidney cortex, medulla and pelvis. This fact motivates us to propose 2D US as a suitable method for excellent anatomical visualization of the abdominal organs, incl. the kidney. Mean time we summarize that the adequate interpretation of 2D US kidney anatomical features suggests rich and precise anatomical knowledge (Biller et al., 1992; Redrobe et al., 2001).

Our presented axial and helical images are with high resolution and give detail anatomical information, by prospective reconstruction of the liver, stomach, left and right kidneys, small intestines, cecum and colon.

The axial and helical CT anatomical results, which concern the rabbit abdominal organs (topography, shape, CT attenuation and closeness) add and confirm the published data of Dimitrov (2013) and Stamatova-Yovcheva (2016). According to us axial and helical CT are important, because the obtained results could clarify and add the native anatomical data. In addition, the studied object is living and the CT images (both axial and helical) are naturalistic and with high resolution and demonstrate the alive specific anatomical features of the rabbit abdominal organs. Therefore, we add new facts for the interpretation of the precontrast CT anatomical visualization of the rabbit abdominal organs, using the natural tissue contrast.

According to us to obtain CT topographic anatomical data for the rabbit abdominal organs (topography, localization and anatomical closeness) is necessary a low number of animals (5 for axial CT and 5 for helical CT). Thus our algorithm corresponds to that, described by Dimitrov (2013) and Stamatova-Yovcheva (2016) for the rabbit.

According to us when study the rabbit abdominal organs, helical CT study has advantages to the axial. The helical CT images are with higher resolution. They define the anatomical localization of the studied organs (in this case kidneys, colon and cecum), toward soft tissue findings which are with close CT attenuations. No then these arguments confirm the published data for helical CT (Lauridsen et al., 2011).

Our MRI anatomical results, concern the anatomical features of the rabbit thoracic and abdominal organs in T2 weighed sequence. These data are obtained by digitalizing of the studied findings, and the anatomical “dissection” is performed on digitalized computer model. Additionally, the studied object is living, hasn’t been posed to harmful conditions during the experiment. That proves the positivity for application of MRI as a suitable anatomical method to study the rabbit thoracic and abdominal organs (Lauridsen et al., 2011).

The anatomical MRI images of the rabbit thoracic and abdominal organs are reconstructed automatically during the study. We refer to the published data (Stamatova-Yovcheva, 2016) that this method is proper for visualization of the rabbit abdominal and thoracic organs in a given plane. We accept that the dorsal MRI anatomical study is suitable for obtaining detailed data for the topography, localization, closeness and definition of the thoracic and abdominal organs in T2 weighed sequence. The given data presented that the magnetic signal in elongated magnetization define the intensity of the signal in the studied organs, which varies from black to dark-grey in the lings, grey in the liver, kidney cortex and colon, to white in the gall and urinary bladder. Thus we obtain precise information for the organs’ parts, topography and closeness without using bone landmarks (Stamatova-Yovcheva, 2016).

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