Anatomical Imaging Analysis of the Prostate gland in Rabbit (Oryctolagus cuniculus) - Helical computed tomography study

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SUMMARY

The aim of the study was to analyze the anatomical image of the normal rabbit prostate complex (gland) by the utilization of helical computed tomography (CT) method. Ten male mature New Zealand white rabbits with a weight between 2.8 kg to 3.2 kg were used. The animals were anesthetized. The contrast media were applied intravenously and orally. The helical CT imaging was done according to the following bone markers: acetabular part of the pelvic bone (lateral), the pectineal line of the pubis (ventral), first and second sacral vertebrae (dorsal). The cranial part of the prostate complex (prostate part and the front segment of the prostate parts) is oval and dorsoventrally flattened. The glandular tissue was a relatively hyperdense, heterogeneous structure that showed soft tissue density characteristic. Ventromedially, the prostate urethra was visualized, the lumen of which was hypodense and the wall relatively hyperdense with soft tissue characteristic. The image of the caudal part of the prostate complex (the caudal segment of prostate part and paraprostate parts) showed heterogeneity and hyperdensity. The rectal lumen showed contrast image. The helical computed tomographic investigation of the prostate complex in rabbit is a highly definitive method for imaging of the anatomical specificities of the gland. The results of the present study could serve as good investigational base for imaging anatomical and diagnostic examination of the prostate in small domestic mammals. The branches of prostatic artery showed contrasted image and was observed laterally. Their arrangement is very important from clinical and surgical point of view.

Keywords : Prostate, helical computed tomography, anatomy, rabbit.

RESUME

Le but de l'étude était d'analyser l'image anatomique du complexe prostatique normal (glande) chez le lapin, par l'utilisation de la tomographie helicoïdale. Dix Lapins Néo-Zélandais Blancs, matures et pesant 2.8 kg à 3.2 kg ont été utilisés. Les animaux ont été anesthésiés. Les agents de contraste ont été appliqués par voie orale et par voie intraveineuse. L'image helicoïdale tomographique a été obtenue à partir des marqueurs osseux: la partie acétabulaire de l'os pelvien (latéralement), la ligne pectinale de l'os pubien (ventralement), les première et deuxième vertèbres sacrées (dorsalement). La partie crâniale du complexe prostatique (prostate et le segment cranial des parties prostatiques) est ovale, et aplatie dorsoventralement. Le tissu glandulaire est une structure relativement hyperdense et hétérogène, qui a une densité de tissu mou. L'urètre prostatique a été visualisée avec une lumière hypodense et une paroi relativement hyperdense présentant les caractéristiques d'un tissu mou. L'image de la partie caudale du complexe prostatique (le segment caudal de la partie prostatique et des parties paraprostatiques) a montré une hétérogénéité et une hyperdensité. La lumière rectale présente une image contrastée. L'étude tomographique helicoïdale de la prostate chez le lapin représente une méthode définitive pour caractériser les spécificités anatomiques de la glande. Les résultats de l'étude présentée pourraient servir de base pour l'imagerie anatomique et lexamen à visée diagnostique de la prostate chez les petits animaux domestiques.

Mots clés : Prostate, tomographie helicoïdale, anatomie, lapin.

INTRODUCTION

The rabbit prostate complex consists of 3 lobes: prostatic prostate, prostate, and paraprostatic parts. Previous studies [14, 25] have shown that the prostatic prostate part is localized caudally to the vesicular gland and cranially to the prostate part. The prostate part is located cranially to the bulbourethral glands. The prostatic prostate and prostate parts are located dorsally to the middle region of the pelvic urethra and are connected laterally to the deferent ducts. The left and right paraprostatic parts are located ventrolaterally to the prostatic prostate and laterally to the urethra.

The rodent prostate gland is divided into four lobes. Each lobe is surrounded and separated from the others by fibrous and adipose connective tissue. The mouse prostate is separated into anterior prostate (coagulating gland), ventral prostate, dorsal prostate and lateral prostate. The dorsal prostate and lateral prostate are often grouped together as dorsolateral prostate [11].

The imaging anatomy methods are of great importance for the contemporary biomedical research, as they play a role as a bridge between the preclinical (including anatomical) and the clinical examinations. The computed tomography (CT) provides anatomical image of the studied organs. For imaging anatomical research in animals, computed tomography (CT) and magnetic resonance imaging (MRI) can be applied, as for functional imaging - positron emission tomography (PET). The most frequently used animals for scientific imaging investigations are dogs, sheep, goat, swine and primates. The CT scans gives images of the studied objects with greater, more definite dimensional and contrast resolution [2, 13, 18, 20].

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The helical computed tomography is one of the best methods for noninvasive images of the studied patients that shows list of advantages in comparison to axial CT scans. Due to the higher spatial resolution this type of tomography is more definitive in the organ imaging. The faster scanning by the helical scans gives the ability of obtaining images of big portions of the body within the frames of a single respiratory phase. The helical tomography is a good alternative of the conventional imaging methods, as the angiography and irigography [7].

The first generation of CT apparatus is presented as scanner for examination of human skull and head, as the studied object is suspended in liquid. The second generation is already a scan for the entire body as the examination is done in dry environment and with shortened time for scanning. The third generation is an apparatus that has the ability of greater rotations. That effect is being achieved by the widening of the X-ray emits, as to uptake the whole width of the object with greater complex of detectors. The forth generation is a scan that includes big stationary ring of detectors and rotates around the patient [8].

The helical CT scan is based on the rotation of the detector and the movement of the scanned object in intervals corresponding to the width of the slides of scans. The helical tomography allows greater anatomical objects to be scanned as with temporary produce of multiple anatomical sections with various thicknesses [9].

Computed axial study gives data for the anatomical objects as it makes cross sections through the investigated areas of distance from 1 mm to 10 mm. The helical computed imaging gives better, more complete and detailed picture of the anatomical objects for shorter time in greater resolution [26].

Using radiographic approach for studying the prostate in the dog, it has been determined that the gland is positioned around the neck of the urinary bladder and that the adjacent urethra goes through the central part of the gland. In castrated animals, the gland, being in intrapelvic position is more difficult to examine using anatomical radiography. In older dogs the gland has variable size and is detected as a solid structure cranial to the pectineal line of the pubis [15].

The axial CT scan of the prostate complex in the rabbit has been done by [4]. The prostate complex is a massive, oval, heterogeneous, relatively hyperdense soft tissue finding located dorsolateral to the contrasted prostate urethra. The prostate complex (prostate, prostate and paraprostate parts) in the rabbit has been visualized in transverse scans of axial CT of the pelvis through the second sacral vertebrae (dorsal), coxofemoral joints (lateral) and craniodorsal of the pelvic cavity parts) in the rabbit has been visualized in transverse scans of axial CT of the pelvis through the second sacral vertebrae (dorsal), coxofemoral joints (lateral) and craniodorsal of the pectineal line of the pubis (ventral). The density characteristic of the rabbit prostate is that of a soft tissue.

The axial CT scan of the prostate in dog has been done by [5]. The prostate has been visualized when scanning the pelvis using anatomy topographical parameters of the first sacral vertebrae (dorsal), the ilium bones’ bodies (lateral) and cranially of the front edge of the pelvic symphysis (ventral). The body of the gland is found as homogenous and relatively hyperdense finding with a soft tissue characteristic.

The literature search shows that the anatomic helical CT scans of the prostate have been done in humans mainly. In cats, rabbits and dogs the prostate gland was only examined using axial computed tomography. The presented data of the normal characteristics of the gland is a secure premise for the successful interpretation of the prostate lesions. Therefore, the goal of the helical anatomic CT scanning of the prostate...
in rabbits was to use the obtained results as a biological model for imaging diagnostics of the prostate lesions in small domestic animals.

MATERIALS AND METHODS

OBJECT

Ten mature, clinically healthy male rabbits 12 months of age from New Zealand white with weight between 2.8 kg to 3.2 kg were used. The experimental animals were housed at 25°C, with a 12 h dark/light cycle [24].

PROTOCOL OF ANESTHESIA

The animals were anesthetized (IM) with Ketaminol® 10 solution (Intervet) (Ketamine hydrochloride 100 mg/ml and Benzethonium chloride 0.1 mg/ml) at a dose of 0.5 ml/kg [6].

IMAGING PROTOCOL

The contrast media for the Helical computed tomography (CT) used were Optiray 350 (non-ionic low osmotic contrast substance) (Healthcare Ltd. UK) and UROGRAFIN 76% 20 ml (SCHERING LTD. GERMANY) (water-soluble iodine dye). The first was applied parenterally (IV) into cephalic vein at a dose of 3 ml/kg m, immediately before the scanning. The second contrast media was administered orally (per os) as 1.52 % water solution (30 ml/kg m) three hours before the examination [23]. Before administration of the contrast medium, the animals were fasted for 4 hours. Water intake was not restricted.

The whole body multi-slice helical CT scanner (Light Speed QX/I GE, General Electric USA) was used for the scanning. The animals were positioned in ventrodorsal (supine) recumbency. The CT scans were done by the following protocol: electric current’s intensity – 200 mA, anode tension – 120 kV, scanning time – 0.8, 1 maximum to 2 seconds, rotational speed – 360 degrees in 0.8, 1, 2, 3 and 4 seconds, slice thickness of the pelvis and accessory sex glands – 3.75 mm, pitch – 6, converting filter – standard, tilt – 0.5, exposure time – 1981 sec, zoom – 6.97, window (W) – 350, high resolution – 512, SFOV – 50, MTF 10 in lp/cm (Modulation Transfer Function) – 13.6. The films were obtained by Printing device (Drystar AXYS – model AGFA) with film’s size DT 2B 14/17 inches. The image were documented and interpreted as in order using the analytical approach in the interpretation (Fig. 1A and Fig. 1B).

The CT scan was done in the following boundaries: cranial – acetabular part of the pelvic bone (lateral), in front of and over the pectineal line of the pubis (ventral) and the first sacral vertebrae (dorsal); caudal – the acetabular part of the pelvic bone (lateral), the midline of the pelvic symphysis (ventral) and the end of the second sacral vertebrae (dorsal).

The study was approved by the institutional committee of animal care (Approval № 25, published in Government Gazette, № 59, 2003). The experiments were made in strict compliance with European convention for vertebrate animals’ protection, used for experimental and other scientific purposes (Strasbourg/16th May 1986), European convention for companion animals’ protection (Strasbourg/13th November 1987) and animal protection’s law in Republic of Bulgaria (Section IV - Experiments with animals, art. 26, 27 and 28, received on 24th January 2008 and published in Government Gazette, № 13, 2008).
RESULTS

The helical computed tomography image of the proprostate and the prostate part of the rabbit prostate complex was visualized at the level of the first sacral vertebrae (dorsal), acetabular part of the pelvic bone (lateral) and the dorsal two thirds of the pubic bones cranial segment (ventral). The cranial part of the prostate gland (proprostate and cranial prostate part) was seen. It was an oval and dorsoventrally flattened structure. The glandular tissue was relatively hyperdense, heterogeneous finding with a soft tissue density. Prostate urethra was seen ventromedial to the gland. Its lumen was hypodense and showed soft tissue density characteristic. The ventral surface of the prostate cranial part was located in front of the cranial edge of the pelvic symphysis. At this level only dorsal two thirds of the pubic bones cranial branches (without the pelvic edge) were visualized. The coxofemoral joints and both pelvic bones' acetabular parts were seen lateral to the glandular finding. The body of the first sacral vertebrae was seen dorsally. A relatively hypodense area was found between the gland dorsal surface and rectum. The rectal lumen was contrasted structure. (Fig. 2A and Fig. 2B).

The prostate and paraprostate parts of the rabbit prostate gland was visualized at the level of the second sacral vertebrae (dorsally), pelvic bone's acetabular part (laterally) and the cranial branch of the pubic bones (the pelvic edge) (craniocaudally) (Fig. 3A and Fig. 3B). The image of the prostate gland's caudal part (the caudal segment of the prostate and paraprostate) showed heterogeneous and relative hyperdensity. The shape of that glandular part was oval and flattened dorsoventrally. The glandular structures showed soft tissue characteristics. A hypodense area was seen between the ventral urethral wall and os pubis. The ventral surface of the rabbit prostate complex caudal part was located dorsal to the pelvic edge; due to that the entire cranial branch of the pubic bones were visualized. Lateral to the gland finding were seen the coxofemoral joints. The body of the first sacral vertebrae was seen dorsal. The rectal lumen was contrasted structure. (Fig. 3A and Fig. 3B).

The rabbit membranous urethra (behind the prostate segment of the pelvic urethra) was visualized at the level of the third sacral vertebrae (dorsal), acetabular part of the pelvic bone (lateral) and the pelvic symphysis (ventral). The image of the rabbit membranous urethra was oval and with heterogeneous and the wall relatively hyperdense with soft tissue features. It was positioned dorsal to the pelvic symphysis. At that level of scanning the anatomical images of the prostate elements were not determined. The entire cranial branch of the pubic bones was visualized there. The coxofemoral joints were seen lateral of the urethral finding. The third sacral vertebra was observed dorsal. The rectal lumen showed contrasted image (Fig. 4A and Fig. 4B).
When studying the rabbit prostate complex in positive and negative aspects, analogous data for investigated anatomical structures of the gland and the nearing tissues were obtained.

**DISCUSSION**

The helical computed tomography study of rabbit prostate complex confirmed the anatomical data of [14, 25] for the prostate morphological features and its subdivision in three parts.

Contrary to rodent prostate, which is composed of four lobes [11], rabbit prostate complex was observed by helical CT as a three lobed structure. The rabbit prostate complex was visible only dorsolateral to the prostate urethra, while the rodent prostate gland surrounded the same urethral part with its ventral lobe [11].

Our results support the hypothesis of [7], who suggest that the helical CT is one of the best methods for noninvasive imaging of the studied anatomical objects. Analogous to authors’ opinion, it could be confirmed that that the helical CT has list of advantages we compared to the axial computed tomography when imaging the rabbit prostate gland.

Previous observation concerning the fact that the helical CT scanning allows large anatomical objects to be examined by the simultaneous scanning of many anatomical objects was used when imaging anatomical visualization of the prostate gland in the rabbit [9].

Like some authors [12, 17] who claimed that the helical CT allows detailed and complete visualization of the different anatomical structures, we suggest this method for CT scans as sufficiently definitive when doing imaging anatomical study of the prostate complex in the rabbit.

Our data concerning the helical CT visualization of the prostate gland in the rabbit support the research results of [26], according to which the spiral CT had list of advantages compared to the axial CT.

The localization of the cranial part of the prostate complex, we determined in the rabbit in front of the pelvic edge resembles the localization of the gland in the dog [15]. Despite the results from the dogs, whose gland is being positioned around the neck of the bladder [15], in the rabbit the gland is found to be dorsolateral to the urinary bladder neck. The localization of the rabbit prostate gland’s caudal part explained why this part is found as an intrapelvic image (localized caudal to the pectineal line of the pubis). This result is in agreement with the findings of [15] that prostate gland in castrated dogs is visualized into the pelvic cavity.

Despite the study done from [22] who performed axial CT scans of the abdominal organs in dogs in sternal recumbency, we performed our helical CT of the rabbit prostate complex in dorsal recumbency. In comparison to the results of [22]
who presented the axial CT sections with a thickness of 13 mm, we used helical CT sections with thickness of 3.75 mm. This approach allowed more detailed structural and topographical imaging of the prostate complex in the rabbit.

Collected detailed anatomical image of the rabbit prostate gland by helical CT is in agreement with the assumption according to which due to the lower contrast resolution, the axial CT has restricted role in finding the intraprostatic lesions, compared to the helical CT [21]

Opposite to the computed tomography of the zonal anatomy of the prostate in human [10, 19] we didn’t determine zonal differentiation of the rabbit prostate gland into three parts (prostate, prostate and paraprostate). The heterogeneous density did not correlate with the localization of the three glandular parts in the rabbit.

In comparison to previous studies that have conducted helical CT and showed the prostate in humans as homogenous and hypodense anatomical finding [1], we present prostate gland in the rabbit as one heterogeneous and hyperdense soft tissue finding. According to the authors the finding size varies depending upon the presence or the absence of hyperplastic changes in the central part of the gland [1].

As opposed to the data of [23] which relate to the helical CT examination of the abdominal organs of the dog in sternal recumbency, we scanned the rabbit prostate gland in dorsal recumbency of the animals. Contrarily to the authors [23], we investigated our anatomical object in thickness of the slides of 3.75 mm. Similarly to the authors [23] we have also applied venous and oral contrast medium in the study subjects for better dimensional resolution.

The observed hypodense area, localized between the dorsal surface of the prostate gland and the rectal ampulla is perhaps analogous to rectovesical septum or fascia of Denonvillier in humans [16]. The hypodense zone, seen between the ventral surface of the prostate urethra and the pubic bone is perhaps analogous to retropublic space filled with adipose and connective tissue (the space of Retzius) in humans [16].

The helicoidal CT method has given us the ability to present more complete, detailed image analysis of the topography and the tissue density characteristics of the prostate gland. Similarly to other authors [3, 4, 5], who presented definitive axial CT definition of the prostate in the cat, rabbit and the dog, we found that helical CT gives more detailed and completed data for the normal characteristics of the rabbit prostate gland. Bone and soft tissue markers for the spatial helical computed tomography imaging of the gland rabbit derived and corresponded with the used markers for axial scanning visualization of the prostate gland in the cat, rabbit and dog [3, 4, 5]. In difference of the determined homogenous image of the gland in cats and dogs [3, 4, 5] we determined that the helical CT scan image of the prostate complex of the rabbit had a heterogeneous character. That observation could be due to the specifications of the distinguished three zones (prostate, prostate and paraprostate). Contrarily to authors [3, 4, 5] who performed axial computed tomographic study of the prostate gland in cat, rabbit and dog with positive configuration of the images, we investigated the rabbit prostate complex in positive and negative configurations of the helical CT scan images. The study of the rabbit prostate gland features in positive and negative aspects is an additional tool for comparing and proving the identity of the images for the examined anatomical objects.

CONCLUSION

The helical CT of normal prostate complex in rabbit is a highly definitive method for imaging of the gland's anatomical characters. The obtained helical CT slices show complete and comprehensive information of the glandular structures and the near pelvic anatomical findings. The results of the present study could be a great foundation in further anatomical imaging and diagnostic examinations of small domestic mammals' prostate gland. The blood vessels showed contrasted image and were observed laterally, suggesting that their arrangement is very significant from clinical and surgical point of view.

REFERENCES


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