MRI ANATOMICAL INVESTIGATION OF RABBIT PROSTATE GLAND

R. S. DIMITROV
Department of Veterinary Anatomy, Histology and Embryology, Faculty of Veterinary Medicine, Trakia University, Stara Zagora, Bulgaria

Summary

The aim of the study was to provide diagnostic imaging data on rabbit prostate complex by means of magnetic resonance imaging (MRI) with regard to their use in morphological investigations of the gland. Six anaesthetised sexually mature clinically healthy New Zealand White rabbits, 8 months of age, with body weight 2.8–3.2 kg were used. The pelvic cavity and pelvic organs were investigated in the sagittal, dorsal and transversal planes from the 7th lumbar (L7) to the 1st coccygeal (C1) vertebra with 2-mm slice thickness using a Magnetom Essenza 1.5T tunnel MRI scanner. The prostate complex (proprostate, prostate and paraprostate parts) demonstrated signal hyperintensity on T1-weighted MRI images. The prostate capsule was hyperintense compared to glandular parenchyma. The prostate complex was visualised on slices between the caudal part of the first sacral and cranial part of the third sacral vertebrae. The prostate part signal was hyperintense on T2-weighted MRI images. The shape of the prostate complex in dorsal view was cranio-caudally elongated, oval and localised bilaterally from prostatic urethra in ventrodorsal view. The transverse T2 image of the pelvis through the 2nd sacral vertebra delineated the prostate part of the gland as a bilateral bilobed oval structure with hypointense parenchyma, embraced by a hyperintense capsule. The intrapelvic localisation and the shape of MRI image of healthy rabbit prostate complex is a species-specific morphological feature. The signal hyperintensity of rabbit prostate complex was higher on T2-weighted images. The T2 hyperintensity of prostate part vs hypointensity of proprostate and paraprostate parts provide evidence for the presence of substantial amount of glandular elements, presuming a dominating role of prostate part in the secretory function of the glandular complex.

Key words: imaging anatomy, MRI, prostate gland, rabbit

INTRODUCTION
The prostate is a glandular complex of organs (parts) comprising (from cranial to caudal direction): proprostate, prostate and paraprostate parts (Holtz & Foote, 1978; Barone, 2001; Vella & Donnelly, 2012).

The morphological picture of accessory sex glands of rabbits is unique, yet MRI data referring to them have been neither reported nor interpreted so far (Varga, 2013).
The advantages of MRI in morphological evaluation of soft tissue findings consist in multispatial visualisation, high contrast-enhanced resolution of images and lack of exposure to ionising radiation. MRI allows morphological distinction between normal and abnormal tissues through different imaging sequences. MRI images are based on proton resonance. They are obtained as a set of slices, 3 to 5 mm thick, from different body sections (White & Werpy, 2005; Kastler, 2005; D’Anjou, 2013). T1- and T2-weighted MRI sequences obtained in transverse, sagittal and dorsal planes are used (Blaik et al., 2000). The precision of T2 images is lower compared to that of T1 (Blaik et al., 2000; Soler et al., 2007).

MRI investigations of abdominal and pelvic organs provide a precise and detailed diagnostic imaging picture. In animals, the study algorithm recommends general anaesthesia to reduce the motility of internal organs and breathing intensity. The most commonly used MRI sequences, before and after contrast enhancing, are T1- and T2-weighted images. The animals are positioned in dorsal recumbency. Investigations are done in different imaging planes in order to depict the complex geometry referring to the localisation and shape of some organs (Gavin, 2009). MRI allows visualisation of abdominal and pelvic organs depending on their location and image features. For dogs with body weight over 20 kg, the appropriate body slice thickness is 1 cm (Gavin, 2009). Canine prostate is isointense on T1-weighted images and hyperintense on T2-images (Gavin, 2009). It embraces dorso-laterally the prostatic urethra, being localised ventrally to the rectum and caudally to the urinary bladder, predominantly in the pelvic cavity. The gland could be distinguished on images only in cases of prostatomegaly, when it enters cranially the abdominal cavity. The impossibility for visualisation of normal canine prostate is due to its direct contact with the rectum, resulting on non-detection of its dorsal border, especially when the rectum if full (Johnson, 2008; Lattimer & Essman, 2012).

So far, the rabbit prostate gland has been investigated, mainly by computed tomography (CT) between transverse planes passing through the first and second sacral vertebrae, with slice thickness of 2 mm. The prostate complex is a shaped soft tissue finding, located on the dorsolateral surface of prostatic urethra. It is observed as oval heterogeneous, relatively hyperdense structure unlike periprostatic soft tissues. The CT image of the gland’s prostatic part in rabbits is obtained from transverse scanning of the pelvis through the second sacral vertebra (dorsally), the hip joints (laterally) and the cranial margin of the pubic bone (ventrally). The glandular margins are well-delineated from adjacent soft tissue structures. The proprostate with cranial prostate segment is oval dorsoventrally flattened soft tissue finding situated in the transverse plane between the first and second sacral vertebrae. The prostatic urethra is visualised ventromedially; its lumen is hypodense, and the wall – relatively hyperdense. The image of caudal prostate complex (caudal prostate segment and the paraprostate part) is located in the transverse plane between the second and third sacral vertebrae (Dimitrov, 2010; 2013).

The aim of the study was to provide additional diagnostic imaging data on rabbit prostate complex by MRI with regard to their application in anatomical and diagnostic investigations on the gland.
MATERIALS AND METHODS

The study was performed with six sexually mature clinically healthy New Zealand White rabbits, 8 months of age, with body weight 2.8–3.2 kg after obtaining permission from the Animal Ethics Committee of the Faculty of Veterinary Medicine, Trakia University – Stara Zagora (permit 51/29.09.2012 and permit 59/17.05.2013). The rabbits were housed at 25°C under 12:12 h light:dark cycle. They were fed according to the requirements of the species, with free access to drinking water.

A Magnetom Essenza 1.5T tunnel MRI scanner (Tim+Dot, Siemens HealthCare, USA, Whole body imaging) was used in the experiments. The pelvic cavity and pelvic organs were investigated in the sagittal, dorsal and transversal planes from the 7th lumbar (L7) to the 1st coccygeal (C1) vertebra with 2-mm slice thickness (Stamatova-Yovcheva, 2016).

The animals were anaesthetised with 15 mg/kg Zoletil® 50 (IM) (tiletamine hydrochloride 125 mg and zolazepam hydrochloride 125 mg in 5 mL of the solution) (Virbac, France). Potentiation of anaesthesia was done with Ketaminol® 10 solution (Intervet) (IM) (ketamine hydrochloride 100 mg/mL and benzethonium chloride 0.1 mg/mL), applied at 0.5 mL/kg. Rabbits were positioned in dorsal recumbency (Stamatova-Yovcheva, 2016).

The imaging study was performed according to the following algorithm: magnetic field strength of 1.5 T with Active Shielding; superconducting magnet; field of view and bore diameter of 70 cm. A total of 1,131 images per second were obtained at high resolution, simultaneously in dorsal (coronal), sagittal and transverse aspects, at matrix size 256/256. In T1-weighted and T2-weighted scans (both tissue magnetisation types are longitudinal magnetisation – parallel to the magnetic field and connected with T1 and transverse magnetisation – perpendicular to the magnetic field and associated with T2), MRS sequence imaging parameters were as followed: time to echo (TE) – 120 ms and repetition time (TR) – 1,410 ms. For detailed results, obtained dorsal, sagittal and transversal anatomical images were dominated in T2-weighted sequences. To enhance the signal in T1-weighted scans, TR was 500 ms and TE – 20 ms. The pelvis scans were done with moderately filled urinary bladder (Kastler, 2005; Stamatova-Yovcheva, 2016).

RESULTS

In T1-weighted sagittal MRI scans of the rabbit prostate complex (proprstate, prostate and paraprostate), the gland was located dorsoventrally vs the prostatic urethra (between vesiculous and bulbourethral glands). The glandular complex was entirely visualised within the pelvic cavity, dorsolaterally to prostatic urethra and ventrally to the rectum. The gland shape resembled a craniocaudally elongated oval. The prostate complex signal was relatively hyperintense compared to urinary bladder lumen and prostatic urethra. The gland signal was isointense vs bladder and urethral walls yet hypointense vs dorsally located rectum (Fig. 1).

The prostate was relatively hyperdense on T2-weighted images relatively to peripheral soft tissue structures (urethral wall and rectum). Urinary bladder lumen was hyperintense as compared to prostate. The gland shape was longitudinally oval, widening in cranial direction. The prostate capsule was relatively hyperintense vs the glandular parenchyma. The prostate complex was observed in the sections between
MRI anatomical investigation of rabbit prostate gland

Fig. 1. T1-weighted sagittal image. CR – cranial, CC – caudal, V – ventral, D – dorsal; p – prostate gland (complex), vb – vesical bladder, u – urethra, r – rectum.

Fig. 2. T2-weighted sagittal image. CR – cranial, CC – caudal, V – ventral, D – dorsal; p – prostate gland (complex), vb – vesical bladder, u – urethra, s1, s2, s3 – first, second and third sacral vertebra.

transverse planes through the caudal part of S1 and the cranial part of S3 (Fig. 2). The prostate part was hyperintense compared to proprostate and paraprostate.

The signals of walls of urinary bladder and prostatic urethra, as well as of the rectal lumen were less intense than those of adjacent soft tissue structures. The dor-
sal, ventral, cranial and caudal prostate gland borders were well defined (hypointense). The hypointensity of boundaries between the three part of prostate gland was defined (Fig. 3 and 4).

On T2-weighted images, the prostate (proprostate, prostate and paraprostate) parts were not visualised in front of pecten of the pubis, however the hyperintense urinary bladder and relatively hypointense

Fig. 3. T2-weighted sagittal image. CR – cranial, CC – caudal, V – ventral, D – dorsal; p – prostate gland (complex), vb – vesical bladder, u – urethra, r – rectum.

preprostatic urethra were observed (Fig. 5).

The pelvic soft tissue structures on T2-weighted scans demonstrated the relatively hypointense intrapelvic prostate gland compared to hyperintense extrapelvic urinary bladder. The prostate complex shape in the dorsal plane was craniocaudally elongated and oval, and was visualised bilaterally from prostatic urethra in ventrodorsal projection. The signal intensity of the urethral wall was the lowest (Fig. 6).
The caudal section (T2-weighted dorsal scan) of pelvic soft tissues showed definitely the three prostate complex parts. The proprostate part was located cranially to the prostata. It was visualised as a soft tissue finding with hypointense parenchyma and hyperintense periphery (capsule). The prostate had a relatively hypointense parenchyma than the proprostate and was lined by a hyperintense capsule. The paraprostate part appeared caudally from the prostate part as a relatively hyperintense finding (Fig. 7).

Dorsal parts (glandular lobes) of the prostate were visualised as relatively hyperintense findings on the background of hypointense urethral wall on T2 scans. Their shape was craniocaudally oval with convex lateral borders. Prostate lobes were laterally identified by hypointense terminal parts of both seminal ducts (Fig. 8).

The transverse T1-weighted scan through the cranial part of S1 did not show the prostate gland. Here, the relatively hypointense structure of pre-prostatic urethra vs the hyperintense urinary bladder could be observed (Fig. 9).
ture with hypointense parenchyma and hyperintense capsule. The signals of urinary bladder and the urethra were relatively hyperintense. The transverse prostatic image shape was oval (Fig. 10). The transverse T2-weighted scan between the first and second sacral vertebrae showed the prostatic part as an object with hypointense central part (parenchyma) and hyperintense periphery (capsule).

The urinary bladder and the urethra were relatively hyperintense unlike the prostate complex. The transverse glandular shape was oval (Fig. 11).

The T2-weighted transverse image of the pelvis through S2 presented the prostate part as a bilateral bilobed oval structure with hypointense parenchyma inside the hyperintense capsule. The gland’s borders were excellently defined. The relatively hyperintense urinary bladder could be seen cranioventrally from the prostate complex, and the isointense rectum – dorsally (Fig. 12). The T2-weighted transverse image of the pelvis between S2 and S3 visualised the paraprostate part of the gland as a soft tissue structure with hypointense parenchymal zone and slightly hyperintense capsule. The signals of the urinary bladder and the rectum were relatively more intense (Fig. 13).

**DISCUSSION**

The performed MRI morphological study determined rabbit prostate as a complex glandular organ, composed of prostatic, prostate and paraprostate parts in line with reports of Holtz & Foote (1978) and Vella & Donnelly (2012). The analysis of MRI images of the prostate complex confirmed the thesis of Blaik et al. (2000) about the imaging advantages of the technique for anatomical research on soft tissue findings. The intrapelvic localisation and the craniocaudally elongated oval shape of the normal rabbit prostate complex on MRI scans is an important species-specific morphological feature.

For the MRI study, the animals were positioned in dorsal recumbency similarly to position used by Blaik et al. (2000) and Soler et al. (2007) for MRI study of organs in the dog. The relative hyperintensity of the sagittal prostate image vs the
urinary bladder lumen, prostatic urethra and the rectum on T1-weighted scans was due to the soft tissue features of the gland. The same intensity of the sagittal gland finding as those of the urinary bladder and prostatic urethra walls on T1 images does not provide reliable information for diagnostic imaging discrepancy between these pelvic soft tissue structures.

The obtained data showed that T2-weighted scans provide precise anatomical soft tissue images dissimilar to affirmations of Blaik et al. (2000) and Soler et al. (2007) about the excellent anatomical determination of T1 images. The relative hyperintensity of T2 sagittal sequences of the gland compared to peripheral soft tissue findings originated from the secretory elements of the gland parenchyma.
MRI anatomical investigation of rabbit prostate gland

The algorithm of MRI examination for visualisation of topographic geometry of rabbit prostate complex corresponded to that applied by several authors for examination of abdominal and pelvic organs of small domestic mammals and humans. The applied anaesthesia allowed reduction of pelvic organs’ motility (White & Werpy, 2005; Kastler 2005; Gavin, 2009; D’Anjou, 2013). Compared to MRI sequences obtained with 1-cm slices (Gavin, 2009), the present MRI study demonstrated prostate complex sequences from 2-mm slices. Therefore, the present imaging data are relatively more precise. The hyperintense signal from the urinary bladder lumen (T2-weighted scan) confirmed the fluid character of finding.

Contrary to findings of Gavin (2009), presenting the T1-weighted signal of prostate as isointense and the T2-weighted signal – as hyperintense, our MRI study demonstrated the rabbit prostate complex as relatively hyperintense, with higher intensity on T2 sequences. The signal hyperintensity of the glandular capsule compared to the parenchyma (T2-weighted sagittal images) was due to the different character of soft tissue features of both objects: the parenchyma is rich in fluid (secretory) components, whereas the capsule – in thick fibrous components. The rabbit prostate complex on T2 scans was visualised as an elongated finding, situated transversely from the caudal part of S1 to the cranial part of S3. The hyperintensity of prostate part (T2-weighted sagittal images) evidenced the presence of a substantial amount of glandular elements in this part. Therefore, the prostate part was more involved in the secretory function of the glandular complex. The visualisation of glandular borders on T2-weighted sequences was attributed to the permanent presence of the hyperintense capsule. Similarly to human prostate, the signal of the rabbit prostate gland was hypointense in the central part and hyperintense in the periphery (Geert et al., 2005). Therefore, rabbit prostatic glandular tissue contains a large amount of parenchymal elements, responsible for its hypointensity on T2 sequences. The hyperintense stroma on T2 images is due to thick fibrous elements. On T2-weighted dorsal sequences, normal rabbit prostate complex did not enter the abdominal cavity, but was located caudally to the pelvic...

Fig. 13. T2 - weighted transversal image. R - right, L - left, D - dorsal, V - ventral; vb - vesical bladder, pp - paraprostatica, r - rectum, s2-s3 - between second and third sacral vertebrae.
inlet. Soft tissue components, bilaterally prominating vs the prostatic urethra (glandular lobes), confirmed the symmetrical structure of prostate in ventrodorsal view. The relatively high signal intensity of the gland compared to that of prostatic urethral wall on T2 sequences is explained by the larger amount of glandular secretory elements. Therefore, the contribution of the prostate to the secretory events at that site was higher than that of urethral glands, hence the specific MRI appearance of the glandular complex. The MRI image of rabbit prostate urethra, similar to that in men (Geert et al., 2005), depicts the urethra as a hypointense linear finding, embraced by a peripheral hyperintense area. Contrary to data reported by Johnson (2008) and Latimer & Essman (2012), affirming that normal canine prostate was indistinguishable, the normal rabbit prostate was surely visualised as a pelvic finding, especially on T2-weighted sequences. The location of the hyperintense glandular finding (oval shape cranio-caudally, with convex lateral margins) in the vicinity of the hypointense terminal parts of both seminal ducts demonstrated the entry of the latter in prostatic urethral wall. The observed full transverse image of prostate in the plane through S2 was heterogeneous due to the low signal intensity of glandular body and the high intensity of the capsule. The MRI examination presented the three parts of the prostate complex as regular oval structures – a proof about the species-specific shape of gland’s transverse section (on transverse T1- and T2-weighted sequences).

The soft tissue prostate complex signals in the transverse planes from the caudal end of S1 to the cranial end of S3 were hypointense in the central part (parenchyma) and hyperintense in the periphery (capsule). Therefore, in both T1- and T2-weighted transverse images, glandular features were ascertained, yet on T2 images the tissue determination was better. Contrary to the prostate complex, the relative hyperintensity of the transverse images of the urinary bladder and the urethra was due to the presence of fluid elements in lumens, visualised on T2-weighted sequences. The MRI results about rabbit prostate complex corresponded to CT results of the same organ, confirming the topography of glandular part relative to respective sacral vertebrae (Dimitrov, 2010; Dimitrov, 2013).

The data showed that determinant MRI image of rabbit prostatic part could be observed in the transverse plane between the first and second sacral vertebrae, of prostate part – in the transverse plane through S2 and of paraprostatic part – between S2 and S3. The performed MRI study outlined the rabbit as a suitable animal model for investigation of soft tissue findings in disagreement to the thesis of Hau (2003), proposing only domestic mice and black rats as animal models. The observed potential of MRI for multiplanar anatomical representation of the rabbit prostate complex, accompanied by defining contrast resolution, contributes to determination of imaging features of the normal morphological state of the gland.


Correspondence:

Rosen Dimitrov
Department of Veterinary Anatomy, Histology and Embryology, Faculty of Veterinary Medicine, Trakia University, Stara Zagora, Bulgaria, email: rosstefdimitrov47@gmail.com

Paper received 12.07.2021; accepted for publication 07.10.2021