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Research Article

Imaging anatomical radiological investigation of rabbit urinary bladder and pelvic urethra

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ABSTRACT

Background/Aim: The imaging anatomical investigation of the urinary bladder can be done by positive and negative contrast cystography as double-contrast cystography. The topic of the study was to investigate the anatomical radiological features of the rabbit urinary bladder and pelvic urethra.

Material and Method: Eight healthy male, sexually mature white New Zealand rabbits were investigated. Following anesthesia an antegrade contrast and retrograde positive and negative cystography and urethrography were performed.

Result and Conclusion: In the non-contrast anatomical radiological study the urinary bladder was visualized with low X-ray attenuation. In the retrograde positive and negative contrast anatomical presenting of the urinary bladder and pelvic urethra, the bladder showed an image with enhanced X-ray attenuation. The bladder was pear-shaped and completely localized in the caudal part of the abdominal cavity, ahead of the pelvic threshold, as cranial it reached the middle of the fourth lumbar vertebra. Bladder mucosa was with smooth relief. Double contrast anatomical presenting showed the bladder image as a soft tissue finding with peripheral negative contrast zone and two positive contrast areas. Lateral projection of the double contrast organs showed that the image of ureter-bladder drainage was found on the dorsocaudal wall of the bladder, in the transition between body and neck, at the level of the seventh lumbar segment. The image of the pelvic urethra's beginning part was visualized caudodorsal to the ureters' openings.

Keywords: Imaging anatomy, Rabbit, Urinary bladder

Tavşanda vesica urinaria ve urethranın pars pelvina'sının radyolojik anatomisi

Özbilgi/Amaç: Vesica urinaria'nın anatomik yapısı pozitif veya negatif kontrast sistografi veya çift kontrast radyografi yöntemleriyle görüntülenebilir. Bu çalışmanın amacı tavşanda vesica urinaria ve urethranın pars pelvina'sısn radyolojik anatomisinin incelenmesidir.

Materyal ve Metot: Bu çalışmada 8 adet erişkin Yeni Zellanda Tavşanı kullanıldı. Anesteziyi takiben antegrad kontrast ve retrograd pozitif ve negatif sistografi ve uretrografi uygulandı.

Bulgular ve Sonuç: Kontrassız radyolojik görüntülerde vesica urinaria düşük yoğunlukta görüldü. Pozitif ve negatif retrograd kontrast uygulandığında vesica urinaria yüksek yoğunlukta görüldü. Vesica urinaria, armut şeklinde ve tamamen abdominal bölgenin caudal'ine yerleşmiş olarak görüldü, cranial'de dördüncü lumbal vertebranın ortasına kadar uzandığı tespit edildi. Kese mukozası düz görünümlüydü. Çift kontrast görüntülerde kesede periferal negatif kontrast ve çift pozitif kontrast bölgeleri vardı. Lateral ve çift kontrast görüntülerde yedinci lumbar vertebra hizasında, kesenin gövde ve boyun geçişinde dorso-caudal olarak üreterlerin keseye drenajı görüntülendi. Urethra'nın pars pelvinası'nın başlangıcı ise ostium ureteris'lerin caudo-dorsal'inde görüntülendi.

Anahtar Kelimeler: Anatomi, Tavşan, Sidik Kesesi

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Introduction

In the contemporary imaging anatomical studies the use of animal models predominates. The interest in live models from small animal increases (Bartling et al., 2007).

When the urinary bladder in the domestic animals is full, it resembles a pear and passes toward the abdominal cavity. When it is empty, its shape is spherical and remains in the pelvic cavity. The bladder is divided into apex, body and neck. In dogs and cats it is pierced by the ureters at the level of the pelvic threshold in caudodorsal direction (König et al., 2004).

The human urinary bladder when is full, is spherical, and when empty it is with pyramid shape. The bladder base takes the ureters in its up-lateral angles and continues into the urethra in its down-medial angle. The folds of bladder mucosa disappear when the bladder is full. Male urethra is divided into prostatic, membranous and penile portion. The penile urethra is divided into bulbar and pendulating portion (Kabala et al., 2003; Ellis, 2006).

The urinary bladder in small mammals is an organ in the shape of tear, which is located in the caudal part of the abdominal cavity. The dimensions of the normal bladder vary considerably depending on its filling with urine and it rarely reaches cranial to the umbilicus. The imaging anatomical investigation of the urinary bladder can be done by positive and negative contrast cystography, double-contrast cystography etc. These studies require the full elimination of faeces from large intestine, which leads to changes in the shape and location of the bladder. Double contrast cystography is the preferred method for morphological study of the organ. It provides a definitive assessment of the luminal surface of the mucosa and establishes the presence of intraluminal hard and soft tissue findings. The authors monitor the studied structures in ventrodorsal and lateral projections. The urinary bladder is egg shaped. Its caudal end thins and passes in the prostate urethra. The wall of the normal urinary bladder is of uniform thickness. Sometimes there is a minimal reflux of contrast medium towards ureters. This is considered to be normally. Anatomical retrograde contrast urethrogram presents canine urethra as a finding composed of three parts: the prostatic, membranous and penile area. Prostatic portion is widened compared to membranous part. The urethra narrows at the sciatic arch. In the area of seminal colliculus there is a low-grade reflux of contrast material observed into the prostate ducts, which is considered to be a normal finding (Burk and Feeney, 2003).

Rabbit bladder is an elongated structure, filled with fluid that extends cranial to the umbilicus. In guinea pig and chinchilla, the urinary bladder is a small finding and is located at the pelvic inlet. In most cases penile urethra is not radiologically visible (Reese and Hein, 2011).

Double contrast cystography in rabbit is being done. The authors first performed excretory urography and applied positive contrast medium in the caudal ear vein. Then they catheterized the bladder and applied positive contrast medium for holding retrograde cystography. Last authors bring intravesical air which volume's limit is assessed by palpation. Anatomically and radialogically the rabbit urinary bladder is located entirely in the abdominal cavity, as only the pelvic urethra beginning remains at the level of the pelvic threshold (Silverman and Tell, 2005).

The shape of the bladder in the dog is oval, by expanding it becomes elliptical. Cat urinary bladder's shape is always elliptical. The caudal part of the enlarged bladder enters the pelvis. Due to the long neck, feline urinary bladder is abdominal structure, compared to the dog. Minimum dislocation of the small animals' urinary bladder is a normal finding. Normal relief of the bladder mucosa is smooth (Marolf and Park, 2013).

The lack of confirmed literature data for the anatomical radiological features of the rabbit urinary bladder and pelvic urethra in relation to its use as a biological model for investigation motivated us to carry out this imaging anatomical study.

Material and Methods

Object: Eight healthy male, sexually mature white New Zealand rabbits were investigated. The animals were aged 12 months (SD±0.5) and weighed 3.2 kg (SD±0.2).

Imaging protocol

Antegrade contrasting of the urinary bladder

Before administration of the contrast medium, the animals were fasted for 24 hours. Their intake of water was not restricted (11). To facilitate handing the animals when applying the contrast medium and to get good-quality radiographs, the animals were sedated with 15 mg/kg Zoletil® 50 (tiletamine hydrochloride 125 mg and zolazepam hydrochloride 125 mg in 5 mL of the solution) Virbac, France. The study was carried out with stationary X-ray machine TUR 800 D-1 (Röntgenbelichtungsautomat – 20029), Dresden with digitizing camera- iQ-CR ACE, which is a CR reader to digitize X-ray imaging. The lateral and ventrodorsal abdominal radiographies were taken before contrast agent administration, and after the rapid delivery of a non-ionic contrast agent (Omnipaque® 350 – iohexol injection 76%, 350 mg/mL, 3 mL/kg bw, GE Healthcare, Ireland) through the retroauricular vein (GE Healthcare Canada Inc, 2002; Dimitrov and Chaprazov, 2012).

The urograms were obtained after application of contrast medium within the range of 15 min to 30 min (Moeller and Reif, 2000; Silverman and Tell, 2005; Dimitrov and Chaprazov, 2012).

Retrograde positive contrasting of the urinary bladder and pelvic urethra: Then the bladder of the tested animals was catheterized with urethral flexible vinyl tomcat catheter 3½ F (Tomcat" Urethral Cateter – Silicone), SurgiVet®, Dublin, USA (Moeller and Reif, 2000). A radiologically positive contrast agent (Urographin 76% 20 mL, Schering Ltd. Germany) was applied in dose 1.5 mL (from 0.25 to 0.5 mL/kg bw). Dual-contrast radiographs were produced in ventrodorsal and lateral projections. In retrograde cystography the pressure at the filling of the bladder with contrast medium has being terminated after disappearance of the mucosal folds, observed in radiological cystoscopy (Hudson et al., 2002; Burk and Feeney, 2003; Silverman and Tell, 2005; Crow et al., 2009; Marolf and Park, 2013).

Negative contrasting of the urinary bladder and pelvic urethra

After 15 minutes from the beginning of the excretory urography, in catheterized bladder has been applied intravesical 10 cm^3 of air and dual-contrast radiographs have been obtained in ventrodorsal and lateral projections (Hudson et al., 2002; Burk and Feeney, 2003; Silverman and Tell, 2005; Crow et al., 2009; Marolf and Park, 2013). In the negative cystography the pressure at the bladder's filling with contrast medium has being terminated after disappearance of the mucosal folds, observed

in radiological cystoscopy (Marolf and Park, 2013).

Equipment

Lateral and ventrodorsal radiographs were taken prior and after contrast agent administration with focus-film distance of 100 cm, Kilovolt peak of 125 kV and Milliampere per seconds of 500 mAs. Radiography has been done with cassette DICOM 3.0 (24x30 cm; 14``x17``) with size of matrix 2328 x 2928 px (pixel), and 18 x 24 cm (14``x 17``) with size of the matrix 1728 x 2328 px. Space resolution was 10 px/mm, scanning depth 20 bit/px, and depth after processing 16 bit/px. The used operating system was Windows XP SP3. Software by which the radiograms were examined was iQ-VIEW Version 2.7.0 BETA INT EN 002R; Copyright© 2006-2011 IMAGE Information Systems Ltd.

Ethical protocol

The study was approved by the institutional committee of animal care (Approval № 25, published in Government Gazette, No. 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 Ordinance No. 20 from Novemeber 1, 2012 with effect from 1st of January 2013, issued by Ministry of Agriculture and Food, publ. SG, No. 87 from 9th of November 2012 for minimum requirements for protection and welfare of experimental animals and the requirements for their establishment, growth and/or delivery.

Results

In the precontrasted anatomical practice in ventrodorsal and lateral projections, the bladder was visualized as a soft tissue finding with low X-ray attenuation, and therefore sharp borders between bladder and adjacent abdominal organs weren't visible. Shape and different parts of the bladder weren't defined also, due to lack of distinct radiological borders between them. Pelvic urethra's image was covered by the dense image of the spine and it wasn't visualized in both projections (Figures 1, 2 and 3).

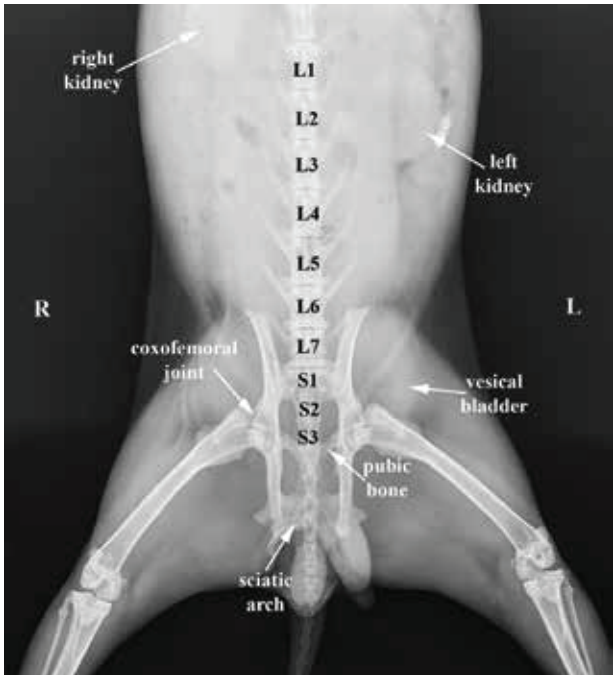

Figure 1. Non-contrast anatomic ventrodorsal cystogram of rabbit.

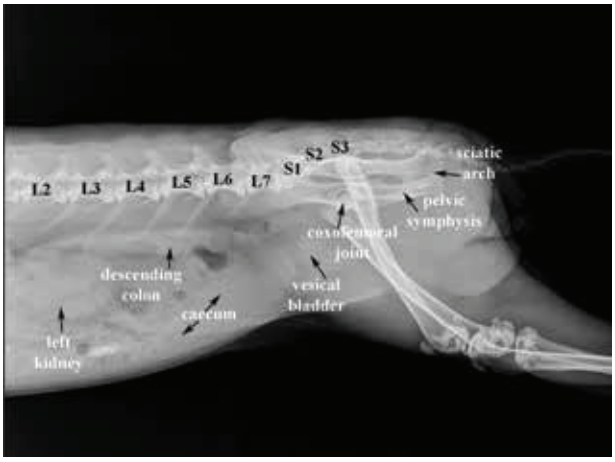

Figure 2. Non-contrast anatomic lateral cystogram of rabbit.

In the positive contrast anatomical studies of the urinary bladder and pelvic part of urethra in ventrodorsal projection, the bladder showed an image with increased X-ray attenuation that has been visualized to adjacent abdominal structures. Different parts of the organ were well defined, due to contrasting of the anatomical borders. Filled with positive contrast medium urinary bladder was pear-shaped and completely localized in the caudal part of the abdominal cavity in front of the pelvic threshold, as cranially it reached the caudal end of the fourth lumbar vertebra. Bladder mucosa was with smooth relief due to loss of folds, as a result of the bladder filling (Figure 3).

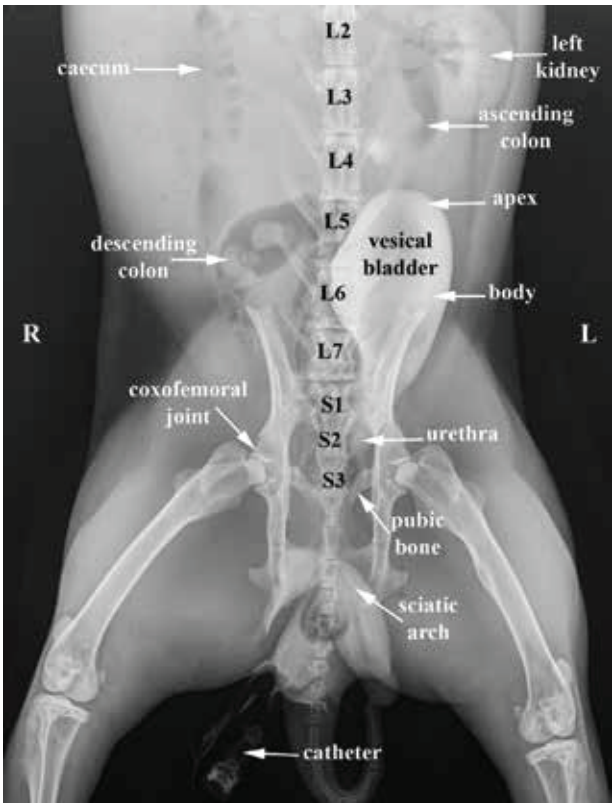

Figure 3. Positive contrast anatomic ventrodorsal cystogram of rabbit.

Positive contrast studies of the bladder in lateral projection revealed the bladder as a soft tissue structure with increased X-ray attenuation that was localized in the abdominal cavity's caudal part. The bladder was partly covered by the image of the ascending colon. The neck of the urinary bladder was cranioventral to the pelvic threshold. In lateral projection pelvic urethra was not visualized due to lack of contrast media in it (Figure 4).

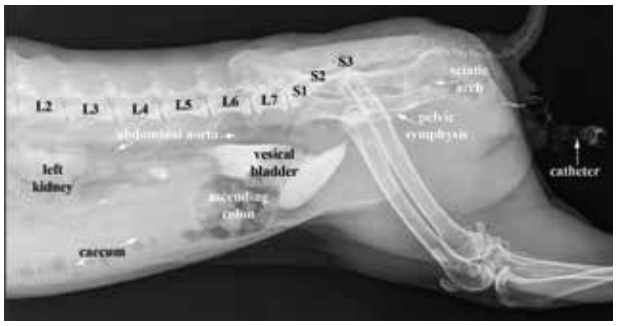

Figure 4. Positive contrast anatomic lateral cystogram of rabbit.

In the negative contrast study of the urinary bladder and pelvic urethra in ventrodorsal projection the soft tissue finding of the bladder was observed. It was with pear-like shape, which narrowed in caudal direction and without distinct borders it passed in the neck and pelvic urethra. The organ reached cranial to the middle of the fourth lumbar vertebra. The bladder's portions and the border between the organ and adjacent abdominal structures were well defined. Bladder's mucosa was well marked by the outer borders of the organ. Bladder's wall was with increased positive density and was with smooth luminal relief, due to its filling. Pelvic urethra was not visualized (Figure 5).

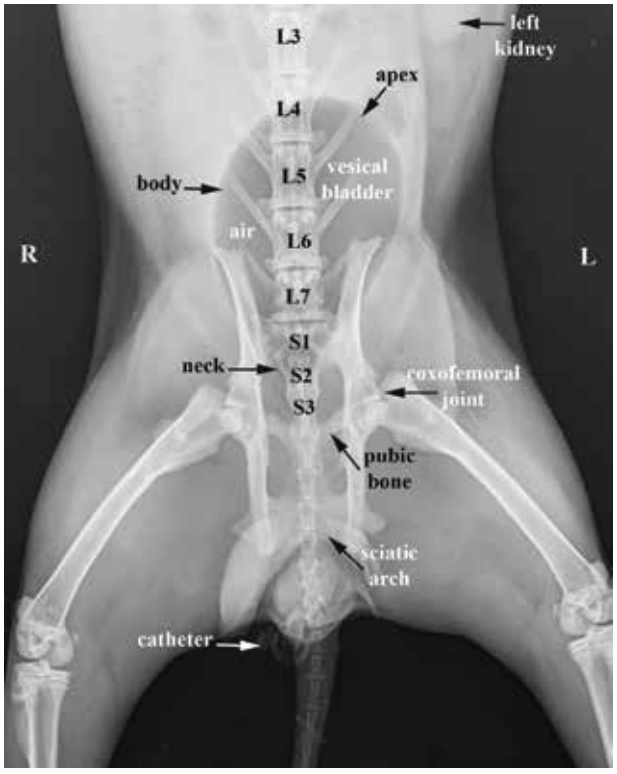

Figure 5. Negative contrast anatomic ventrodorsal cystogram of rabbit.

The negative contrast radiographs in lateral projection, revealed the urinary bladder as a soft tissue negative pear-shaped cavity finding. Caudal to the beginning of the pelvic urethra was visualized at the level of the pelvic threshold and ventral to the spine's sacral part. The mucosal folds of bladder and urethra were regular. The bladder's cranial pole reached the middle of the fourth lumbar vertebra (Figure 6).

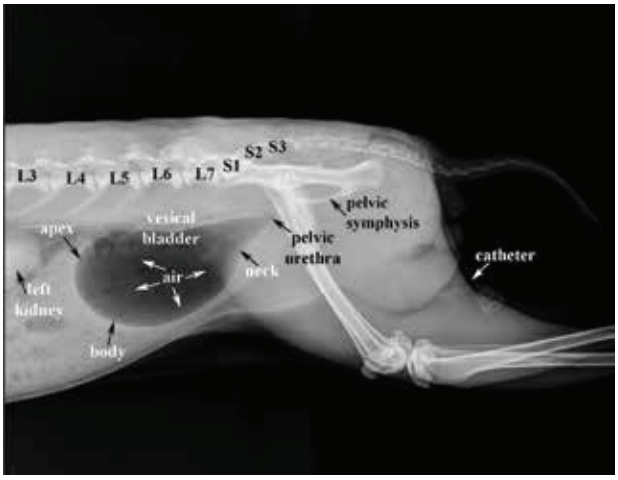

Figure 6. Negative contrast anatomic lateral cystogram and urethrogram of rabbit

The double contrast anatomical studies of the rabbit urinary bladder and urethra (dorsoventral plan) showed the image of the bladder as a soft tissue structure with peripheral negative contrast zone and two positive contrast areas (cranial and caudal). The negative peripheral zone was relatively larger than the apical positive contrast area, as the border between them was with transient X-ray density, determined by both contrast. Part of the urinary bladder's body and neck and the beginning of the pelvic urethra were only positive contrasted. Contours of the bladder and urethral mucosa were smooth and continuous (Figure 7).

On the lateral view, of double contrast anatomical studies, ureteral openings were visualized into the bladder wall. The peripheral part of the bladder was negatively contrasted, and the central – positively. The image of the drainage ureter-urinary bladder was found at the dorsocaudal wall of the bladder, at the transition between the bladder's body and neck, at the level of seventh lumbar segment (in front of the pelvic threshold). The positive contrast images of the ureters pierced obliquely the bladder's wall caudoventral, reached the bladder's lumen, twisted cranial to the body and drained X-ray positive urine. The image of pelvic urethra beginning was visualized caudodorsal to the ureters' openings (Figure 8).

After removal of the urethral catheter and release of the urethral lumen, involuntary leakage of X-ray positive urine was observed. The pelvic urethra could be visualized as soft tissue tubular X-ray positive contrast finding. It was visualized ventral to the sacral part of the spine and dorsomedial to the pelvic symphysis. The craniolateral zone of the bladder was negatively contrast, and the caudomedial – positively (Figure 9).

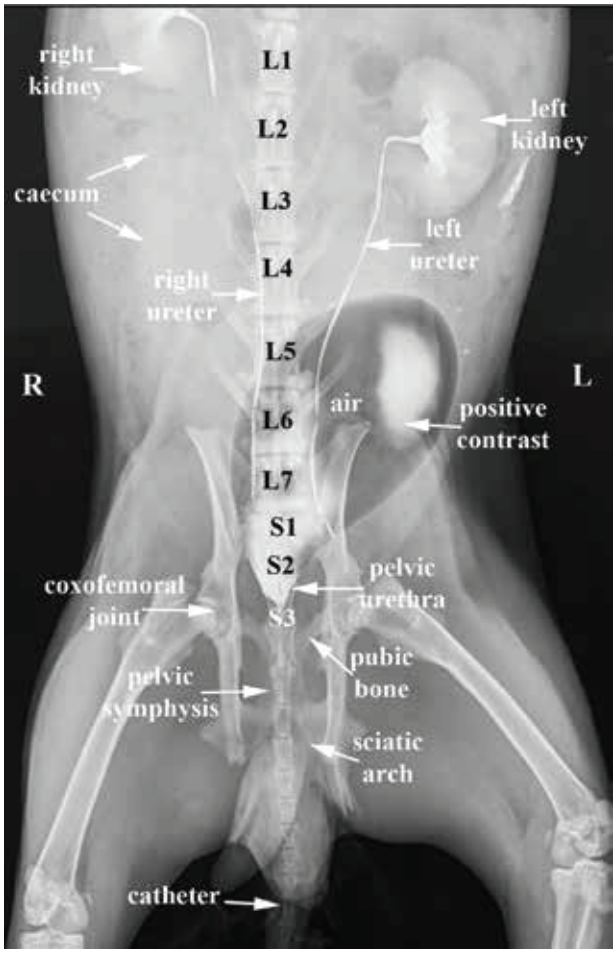

Figure 7. Double contrast anatomic ventrodorsal cystogram and urethrogram of rabbit.

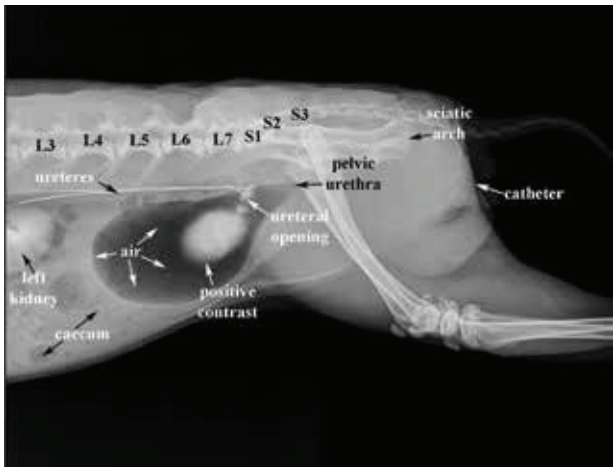

Figure 8. Double contrast anatomic lateral cystogram and urethrogram of rabbit.

Discussion

The results for the intraabdominal localization of the full rabbit urinary bladder and its shape corresponded to published data (König et al., 2004). According to the authors the full urinary bladder resembles a pear and passes in the abdominal cavity, and when is empty its shape is spherical and remains in the pelvic cavity. As opposite to the found for canine and feline ureters' drainage at the level of the pelvic threshold in caudodorsal direction (König et al., 2004), the rabbit ureters drain into dorsocaudal part of the bladder before the pelvic threshold at the level of the seventh lumbar vertebra, in caudoventral direction.

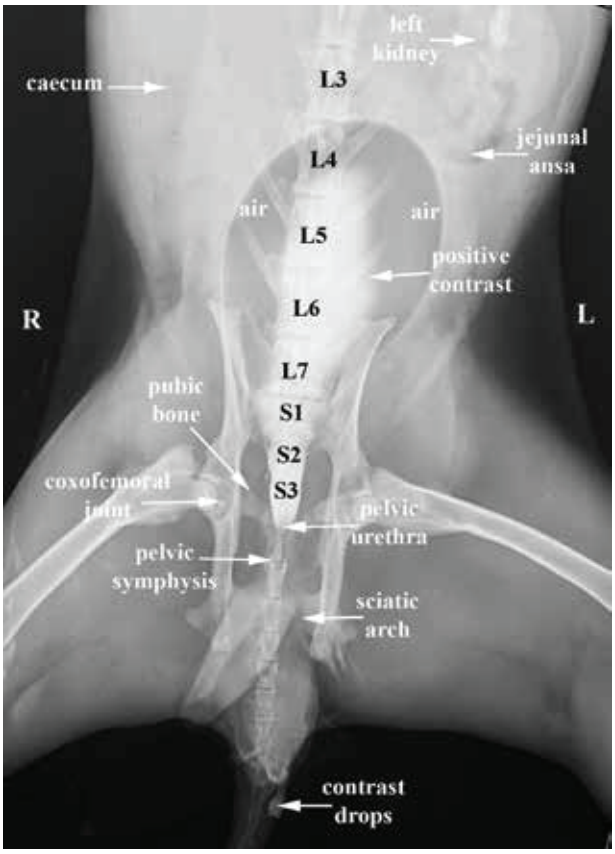

Figure 9. Double contrast anatomic ventrodosral cystogram and urethrogram of rabbit.

The drainage ureter-urinary bladder in rabbit, like human (Kabala et al., 2003; Ellis, 2006) is in dorsocaudal angle of the urinary bladder, as the pelvic urethra is caudomedial continuation of the bladder. Full urinary bladder in rabbit, similar to that of human has no folds (Kabala et al., 2003; Ellis, 2006).

In contrast to the available results (Burk and Feeney, 2003) that defined the cranial border of bladder distension according to the organ's position to the umbilicus, we define this boundary of bladder distension according to the bladder's apex position to the corresponding vertebra. As compared to the bladder in small mammals that is teardrop-shaped (Burk and Feeney, 2003) rabbit urinary bladder is a pear-shaped imaging anatomic finding. Similar to the localization of the bladder in the small mammals (Burk and Feeney, 2003), and in the rabbit the organ is located in the caudal part of the abdominal cavity. Similar to the findings for imaging anatomic visualization of the urinary bladder (Burk and Feeney, 2003), we performed positive contrast and negative contrast cystography and double contrast cystography. The latter is better and definitive method for morphological study of the lumen and luminal surface of the rabbit urinary bladder. Our results for the shape of the rabbit urinary bladder do not support established anatomic radiological ovoid shape of the bladder in small mammals (Burk and Feeney, 2003). Compared to data for retrograde contrast urethrography represent the three parts of the pelvic urethra (preprostatic, prostatic and membranous part), we present only the first and second parts. According to us this fact is probably due to the great difference in the width of the

first portion of the rabbit urethra compared to the other two parts (Burk and Feeney, 2003).

As opposite to found that the rabbit urinary bladder is an elongated structure filled with fluid that extends cranial to the umbilicus (Reese and Hein, 2011), we describe the shape of the urinary bladder (pear) its topography depending on its localization to the lumbar spine.

We performed excretory urography, retrograde cystography, and double contrasting of the rabbit urinary bladder (Silverman and Tell, 2005). We found that the investigated organ is located entirely within the abdominal cavity, as only the beginning of the pelvic urethra is at the level of the pelvic inlet (Silverman and Tell, 2005).

In comparison to the urinary bladder shape in the dog (from oval to elliptical) and in the cat (elliptical), in the rabbit the shape of the full urinary bladder is pear (Marolf and Park, 2013). In contrast to the dog urinary bladder, in the rabbit the bladder does not enter the pelvic cavity. Similar to that in the cat, it is entirely abdominal (Marolf and Park, 2013). Like to the relief of the normal urinary bladder in small mammals, in the rabbit the bladder's mucosa is smooth and it is visualized best by double contrast of the studied findings (Marolf and Park, 2013).

As cats and rabbits are prone to various diseases of the urinary tract, which may be grouped as urinary tract diseases like feline urological syndrome (FUS). The exact etiology is unknown and this syndrome includes rabbit urinary incontinence, cystic lesions and urolithiasis (Harcourt-Brown, 2002). Therefore our results for anatomic radiological features of rabbit urinary bladder would be useful in the morphological interpretation of urinary lesions in this animal.

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