Ultrasound features of kidneys in the rabbit (*Oryctolagus cuniculus*)

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Abstract

Purpose: To determine the normal sonographic features of rabbit kidneys with regard to their use in diagnostic imaging of renal lesions in this species.
Materials: Twelve sexually mature clinically healthy New Zealand White rabbits weighing 2.8 kg to 3.2 kg were examined after anaesthesia.
Methods: A diagnostic ultrasound system with microconvex multifrequency 6.5 MHz probe was used. The animals were positioned in dorsal recumbency. The transabdominal paravertebral imaging approach was used. Longitudinal and transverse scans of the kidneys were obtained. Six rabbits were sacrificed, their kidneys removed and studied in isotonic liquid medium.
Results: The shape of kidneys was elliptical. The fibrous capsule was visualized as a straight hyperechoic band. The fatty capsule was hyperechoic and with irregular borders. The cortex exhibited a heterogeneous echogenicity. The acoustic density of the cortex was lower than that of the liver. The echoicity of the medulla was lower as compared to the cortex and the structures of the kidney pelvis. The latter appeared as a centrally located hyperechoic structure. The post mortem examination showed that kidneys were oval and hyperechoic. The kidney pelvis was seen as a centrally located longitudinal finding, and the renal hilum – as a centrally located hyperechoic finding.
Conclusions: The transabdominal paravertebral approach was a good method for visualization of rabbit kidneys. The dorsal recumbency of the subjects allowed the visualization. The in vivo results corresponded to those from the post mortem study. The rabbit kidney was oval in shape. The hypoechoic peripheral zone is occupied by the cortex and the medulla, while the hyperechoic central zone – by the kidney pelvis. The cortex was less echoic than the liver parenchyma. The kidney pelvic cavity had a lower acoustic density than its walls, due to the presence of peripelvic adipose tissue. The present results could be used in the interpretation of normal and pathological renal findings in the rabbit.
Key words: Anatomy, Kidney, Rabbit, Ultrasonography

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Introduction

Rabbit kidneys are unilobular (unipyramidal), with asymmetrical and retroperitoneal localization. The right kidney is located transversely from the 11th-12th rib to the second lumbar vertebra. Its cranial pole reaches the liver and leaves an imprint on hepatic caudal part, under the last intercostal space. The caudal pole of the right kidney attains the descending part of the duodenum. The left kidney is transversely located between the 2nd and 4th lumbar vertebra and is ventrocaudally to the right one. Ventrally to the left kidney are the jejunal loops, whereas ventrocranially – the descending colon and the body of the pancreas. The left kidney is touching the left abdominal wall (Barone, 2001; Hristov *et al.*, 2006).

A high-quality sonographic image of normal human kidneys is obtained when the patient is in ventral recumbency. The probe is placed parallelly to the vertebral column to obtain a longitudinal scan. When the probe is perpendicular to the vertebral column, transverse scans of kidneys are obtained. In dorsal recumbency, the liver is used as a tissue window to visualize the right kidney. The left kidney is seen less easily due to the adjacent gas-filled hollow organs (stomach, jejunum, colon). The right of left lateral recumbency is the third alternative for good visualization of kidneys (Tomov and Naumov, 1992; Chakarski *et al.*, 1996). On longitudinal ultrasound scans, the kidney is seen as an oval finding. The borders of the fibrous capsule are regular. The adipose capsule is hyperechoic and with irregular borders. The peripheral part of the kidney (parenchyma – cortex and medulla) is hypoechoic. The central hyperechoic part is occupied by the kidney pelvis. On transverse scans, the finding's shape is oval to round. The peripheral part is hypoechoic and the central one – hyperechoic. The normal renal parenchyma is less echoic than the liver parenchyma. The kidney pelvic cavity is hypoechoic against its walls, whose hyperechogenicity is due to the present of fat (Tomov and Naumov, 1992; Chakarski *et al.*, 1996).

Ultrasonography of normal kidneys in horses, cattle, dogs and cats are performed by Penninck *et al.* (1986), Braun (1991), Alkan (1999), Barr (1990), Kealy and Hester (2002), Nyland *et al.* (1995), Burk and Ackerman (1996), Molazem *et al.* (2010) and Park *et al.* (2008). The researchers reported the qualitative and quantitative sonographic features in studied animal species using percutaneous transabdominal approach. In cats, the acoustic frequency of the probe was 8 MHz. For examination of the left kidney, the spleen was used as a tissue window, whereas for the right kidney – the liver. The normal renal cortex was finely granulated, homogeneous and hypoechoic against the parenchyma of adjacent spleen and liver.

Morphometric post mortem examination of kidneys in healthy dogs by ultrasonography was performed by Barrera *et al.* (2009). The used probe was convex, with frequency between 2 MHz to 5 MHz. The dimensions of kidneys were reported.

Some authors have carried out a comparative ultrasonography in cattle with healthy, cystic and dysplastic kidneys (Seif and Bakr, 2007). Using a routine ultrasound imaging protocol, they defined the normal sonographic features of bovine kidneys. The right kidney was examined by a convex 3.5 to 5 MHz transducer, whereas the left one – with linear 6 to 8 MHz transducer. The animals were deprived from food and water for 12 hour prior to the study. The ultrasonographic approach for the right kidney is percutaneous transabdominal in fossa paralumbalis dextra, and for the left kidney – transrectal. The reason for the different methods of visualization is the different anatomic topography of kidneys. The renal parenchyma is hypoechoic against the renal sinus. The cortex is hyperechoic as compared to kidney pyramids (Seif and Bakr, 2007).

Normal cattle kidneys have examined and their features compared to human anatomic renal traits (Carvalho *et al.*, 2009). The authors recommended bovine kidney as an appropriate animal model for performing some urological procedures in men.

Ultrasound visualization of normal kidneys was used by Wang *et al.* (2007) in laboratory animals with regard to biomedical research issues. Using a 3 MHz transducer, he authors found out hydronephrosis in some of studied rats.

Cramer *et al.* (1998) examined by ultrasonography the nephrocalcinosis in rabbits, using a convex 10 MHz transducer. The results confirmed that the experimental designs and the data obtained could serve as an experimental model of nephrocalcinosis research in neonate children.

The polycystic kidney syndrome in rabbits was investigated by Maurer *et al.* (2004). It was established that the clinical and pathological traits of rabbit syndrome were similar to those in humans and therefore, the data could be used as an experimental model for investigation of this kidney lesion in men. Kim *et al.* (2004) reported the sonographic changes in rabbit kidneys due to obstructive urethral lesions.

The contradictory data reported with regard to qualitative and quantitative features of renal ultrasonographic anatomy of the rabbit motivated this anatomy imaging study. It aims first, at determining the qualitative and quantitative features of normal rabbit kidneys and second, using the data obtained as a biomodel for diagnostic imaging study of renal lesions in animals.

Materials and methods

Ethical approval: The study was approved by the institutional committee of animal care. The experiments were made in strict compliance with European convention for vertebrate animals' protection, used for experimental and other scientific purposes (Starsbourg /16th May, 1986), European convention for companion animals' protection (Starsbourg /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, No.13, 2008).

Animals: Twelve clinically healthy New Zealand White rabbits, 8 months of age, weighing 2.8 to 3.2 kg were used. They were anaesthetized with 15 mg/kg Zoletil® 50 (Tiletamine hydrochloride 125 mg and zolazepam hydrochloride 125 mg in 5 ml of the solution, Virbac, France).

Transabdominal ultrasonography: The B-mode ultrasonography was performed by ultrasound equipment Diagnostic Ultrasound System: model DC-6V Shenzhen Mindray Bio-medical, Electronics Co. Ltd (CHINA) and microconvex, multifrequency

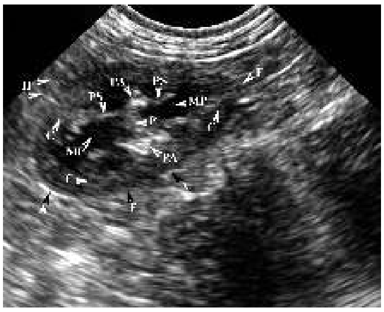

Fig. 1. Longitudinal ultrasonographic image of normal right rabbit kidney (in vivo): C - renal cortex, P - renal pelvis, MP - medullary pyramid, PS - pelvic septa, PA - peripelvic adipose tissue, A - adipose capsule, F - fibrous capsule, H - liver (6.5 MHz microconvex probe)

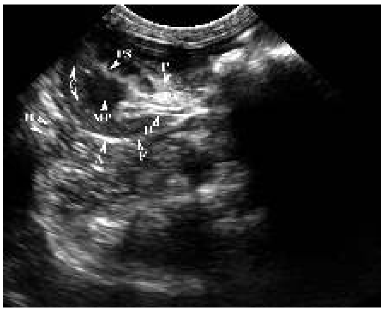

Fig. 2. Transversal ultrasonographic image of normal rabbit right kidney (in vivo): C - renal cortex, P - renal pelvis, MP - medullary pyramid, PS - pelvic septa, PA - peripelvic adipose tissue, A - adipose capsule, F - fibrous capsule, H - liver. (6.5 MHz microconvex probe)

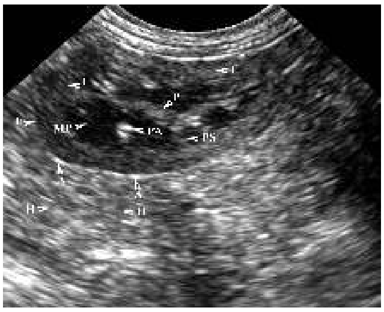

Fig. 3. Longitudinal ultrasonographic image of normal left rabbit kidney (in vivo): C - renal cortex, P - renal pelvis, MP - medullary pyramid, PS - pelvic septa, PA - peripelvic adipose tissue, A - adipose capsule, F - fibrous capsule, H - liver (6.5 MHz microconvex probe).

transducer model 6C2 with working frequency 6.5 MHz and radius 20 mm. The abdominal wall hair was shaved between the last rib with the proximal part of the rib arc, the transverse processes of the lumbar vertebrae and tuber coxae (from left to right) by means of Animal clipper device - Moser Animalline: ARCO, Type 1854, Production: Wahl Gmbh (Germany). Contact gel was used for better contact between the skin and the transducer (Ecoultragel Pirrone & Cö., Italy). The findings were documented on a thermo printer Mitsubishi P 93.

The experimental animals (*in vivo* study) were deprived from food and water in order to avoid intestinal gas collections and the fluid distension of the renal pelvis (Seif and Bakr, 2007). They were positioned in dorsal recumbency. The ultrasonographic approach was percutaneous transabdominal paravertebral (right and left). The kidneys are scanned both longitudinally and transversely. The experimental design was adopted from the examination of normal human kidneys (Tomov and Naumov, 1992; Chakarski *et al.*, 1996). The respiratory movements of the abdominal wall were reduced by the anaesthesia in order to obtain quality ultrasonographic images.

Six rabbits (*ex vivo* study) were removed after euthanasia with 150 mg i. v. Thiopental® (thiopental sodium 1000 mg, Biochemie, Austria) (Posner and Burns, 2009). The preparations were studied in isotonic liquid medium, (Natrii chloridum 0.9% - Sodium chloride 9.0 g in 1000 water solution; Balkanpharma, Bulgaria), in order to compare the sonographic features of kidneys with their normal topography (Dimitrov and Russenov, 2006). In this study, a microconvex multifrequency transducer with working frequency of 6.5 MHz and a linear multifrequency 5 MHz probe (model 7L4A) was used.

Results

On longitudinal and transversal scans, the kidneys were seen as an oval shaped finding (Fig. 1, 2, 3 and 4). The organ's borders were well defined against the adjacent soft tissues. The fibrous capsule appeared as a fine, regular hyperechoic band against the underlying cortex. The adipose capsule was relatively hyperechoic, with rough and irregular borders. The renal cortex had a rough granular appearance, heterogeneous echogenicity and consisted of multiple linear hyperechoic findings. The cortical acoustic density was lower than that of the liver. The kidney medulla, represented in rabbits by the kidney pyramid, had a lower echogenicity in comparison to the cortex and the pelvic structures. Pelvic septa were situated among the parts of the renal pyramid, which were hyperechoic against the previous two renal parts. The pelvis was a centrally located hyperechoic structure surrounded by the hyperechoic peripelvic adipose tissue (Fig. 1, 2, 3). The cranial pole of the right kidney contacted directly the caudal hepatic lobe (Fig. 1).

Discussion

The rabbit kidney was oval, and the kidney pelvis was strongly elongated and relatively narrow. The shares of kidney cortex and medulla with respect to organ width were almost equal. The data were very similar for left and right kidneys, determined *in vivo*, as well as *ex vivo*. The data about the echogenicity of renal structures and the shape were confirmed by post mortem ultrasonography (*ex vivo* study).

Our results confirming the oval shape of rabbit kidneys corresponded to those of Tomov and Naumov (1992) and Chakarski *et al.* (1996) in humans.

The close contact between the cranial pole of the

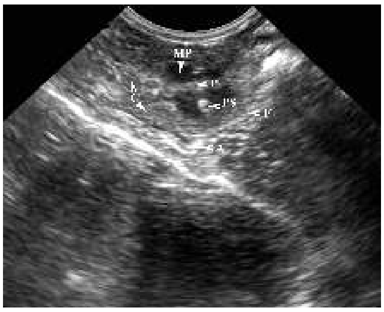

Fig. 4. Transversal ultrasonographic image of normal rabbit left kidney (in vivo): C - renal cortex, P - renal pelvis, MP - medullary pyramid, PS - pelvic septa, A - adipose capsule, F - fibrous capsule. (6.5 MHz microconvex probe)

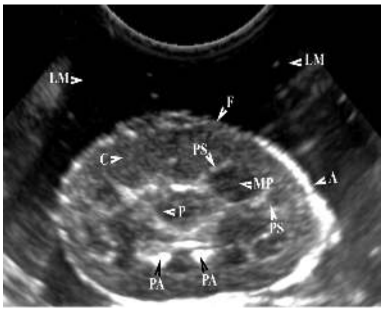

Fig. 5. Longitudinal ultrasonographic image of normal right rabbit kidney (ex vivo): LM - isotonic liquid medium, C - renal cortex, P - renal pelvis, MP - medullary pyramid, PS - pelvic septa, PA - peripelvic adipose tissue, A - adipose capsule, F - fibrous capsule (6.5 MHz microconvex probe).

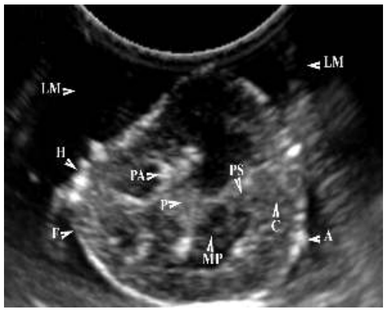

Fig. 6. Transverse ultrasonographic image of normal left rabbit kidney (ex vivo): LM - isotonic liquid medium, C - renal cortex, P - renal pelvis, MP - medullary pyramid, PS - pelvic septa, PA - peripelvic adipose tissue, A - adipose capsule, F - fibrous capsule (6.5 MHz microconvex probe).

right kidney and the liver supports the investigations of Barone (2001) and Hristov *et al.* (2006) on the topography of rabbit abdominal organs.

The unilobular (unipyramidal) structure of rabbit kidneys (Barone, 2001) was not visualized, which could be attributed to the limitations of the method used.

A quality ultrasonography image of rabbit kidneys was obtained in dorsal recumbency of animals, contrary to what was affirmed by Tomov and Naumov (1992) and Chakarski *et al.* (1996) in men (ventral recumbency). The liver was used as a tissue window for visualization of the right kidney, similarly to imaging studies in humans (Tomov and Naumov, 1992; Chakarski *et al.* 1996). Other similarities detected in our examinations were as followed: The fibrous capsule of rabbit kidneys was with regular borders, the adipose capsule was hyperechoic and with irregular borders; the peripheral zone of kidneys was hypoechoic and was occupied by the cortex and the medulla, while the central hyperechoic zone was occupied by the kidney pelvis; the renal cortex was less echoic than the liver parenchyma; the pelvic cavity was less echoic than its walls due to peripelvic adipose tissue.

The frequency of the used transducer was similar to those utilized by Nyland *et al.* (1995) and Burk and Ackerman (1996) for ultrasonography of feline kidneys. Unlike them, we have not used the spleen as a tissue window for observation of the left rabbit kidney. The rabbit kidney cortex was heterogeneous unlike the findings of Nyland *et al.* (1995) and Burk and Ackerman (1996) for the kidney cortex in cats.

The sonographic features of the kidney parenchyma and pelvis confirmed the findings in cattle (Seif and Bakr, 2007).

The ultrasonography of urinary organs in rabbits performed by Moarabi et al. (2011) utilized a linear probe of 8 MHz. The animals were in dorsal recumbency. The kidney cortex was reported to be homogeneous, hyperechoic against the medulla, hypoechoic against the spleen and isoechoic to the liver. The centrally located renal sinus was hyperechoic vs the adjacent medulla and cortex. The relationship between the acoustic density of kidneys, liver and spleen is essential for the diagnostics of renal lesions. In our study, we achieved a good visualization of rabbit kidneys with a convex probe. The echogenicity of the renal cortex was found to be heterogeneous. Similarly to Moarabi *et al.* (2011) we evidenced that the echogenicity of the cortex was higher than that of the medulla, but lower than that of the liver parenchyma. Another supporting finding was the fact that the kidney pelvis was a hyperechoic centrally located artefact, differentiated from the peripheral parenchymal zone by the peripelvic adipose tissue.

Unlike data reported for bovine kidneys (Seif and Bakr, 2007), we present only the normal sonographic traits of rabbit kidneys. No comparative analysis was made between healthy or pathologically changes organs. The experimental design used in this study was adopted from ultrasonography of kidneys in healthy humans (Tomov and Naumov, 1992; Chakarski *et al.*, 1996).

Similarly to what was concluded by Cramer *et al.* (1998), Maurer *et al.* (2004), Wang *et al.* (2007) and Carvalho *et al.* (2009), we assume that the sonographic features of normal rabbit kidneys presented in this investigation could be used for comparative purposes to interpret the normal and pathological nephrological imaging data.

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Conflict of interest

Author declare that they have no conflict of interest.

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