



Ultrasonography of the Urinary and Genital System of the Dog and Cat

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Ultrasonography of the Urinary System

Ultrasonographic examination of the urinary tract is commonplace in veterinary medicine. Indications to perform an ultrasonographic examination of the urinary tract include: serum biochemistry findings, physical findings, species or age-related indications (e.g. breeds with familial renal disease, suspicion of congenital abnormalities in young animals) and radiographic findings that include abnormal appearing kidneys and/ or urinary bladder.

Examination Technique

For most dogs a 5-7.5MHz transducer is adequate while a 7.5-10MHz transducer is adequate for cats. For large and giant breeds of dogs a 3.5 MHz transducer may be required. The animal can be positioned in dorsal or lateral recumbency (the technique will be described with the assumption that the animal is in lateral recumbency however a similar technique can be applied with the animal positioned in dorsal recumbency). Preparation of the abdomen includes clipping the hair and applying acoustic coupling gel on the skin. The transducer positioned at the level of the expected location of the kidney, usually caudal to the last rib at the level of the dorsal abdomen near the spine for the left and at the level of the last intercostal space or just behind the last rib for the right kidney. Images in sagittal, dorsal and transverse plane can be acquired. Full examination by means of sliding and/ or angling the probe in a way that the whole kidney is examined in at least two planes (sagittal or dorsal and transverse) is recommended. In the sagittal plane the cortex, medulla and two hyperechoic lines (representing the peripelvic fibrous tissue), can be identified. In the dorsal plane the cortex and medulla of the kidney and the area of the renal pelvis can be identified along with the renal diverticuli. On the

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transverse plane the renal cortex and medulla, the area of the renal pelvis and renal vessels can be identified.

Normal Anatomic Appearance

The renal cortex is finely granular, uniform in echogenicity, hyperechoic to the renal medulla, hypoechoic to the spleen, and commonly hypoechoic or isoechoic to the hepatic parenchyma. The renal medulla, which is hypoechoic to almost anechoic, is interrupted by the diverticuli. In some dogs and cats a hyperechoic line can be seen just within the renal medulla running parallel to the corticomedullary junction representing the medullary rim sign. This line is usually a non-specific finding in both dogs and cats. It can be seen in normal animals but also in animals with hypercalcaemic nephropathy and in animals with ethylene glycol toxicity. The medullary rim sign may appear discreet in some cases and indistinct in other cases.

The renal pelvis lies within the fat filled, highly echogenic renal sinus. The renal pelvis cannot be normally seen ultrasonographically. Acoustic shadowing can be identified distal to the renal sinus within which the renal pelvis lies.

A recent study has suggested that most normal canine kidneys should measure between 5.5x and 9.1x the cross-sectional diameter of the abdominal aorta¹, although further validation of this range is required. There is positive correlation of kidney length or volume with body weight; the standard deviation is large²⁻⁵. Furthermore, there is marked variation of kidney length and volume between dogs of similar body weights⁴. In the beginning it is better to use radiographic evaluation of the renal length till the examiner acquires the experience to use the ultrasonographic measurement and subjectively assesses the renal length.

Linear renal measurements in cats are more useful since there is less variation on body size. By direct anatomic measurement the renal length in cats is reported to range from 3.8-4.4cm⁶. To the authors experience Persian cats and Chinchillas tend to have smaller renal length than other breeds of cats and they may normally be as small as 3.5 cm in length.

Alterations in the Renal Pelvis

The renal pelvis may be dilated and fluid filled and this can vary from mild to severe. Mild dilatation may be seen in animals that are polyuric or having intravenous fluid administration.

Increased echogenicity of the renal pelvis can be seen associated with distal acoustic shadowing secondary to mineralised material within the renal pelvis (e.g. calculi) or with nephrocalcinosis. It is not always easy to ultrasonographically distinguish between mineralised material within the renal pelvis and nephrocalcinosis and they should both be considered.

Alterations in the Renal Parenchyma

Increased cortical echogenicity with enhancement of the corticomedullary differentiation in the canine kidney can be found with glomerular and interstitial nephritis, acute tubular

necrosis or nephrosis resulting from toxic agents, end-stage renal disease and nephrocalcinosis as preliminary reports indicate⁷⁻¹⁰. In dogs with hypercalcaemic nephropathy a medullary rim sign has been observed during ultrasonography at the level of the corticomedullary junction¹¹. This has been associated with calcification of the basement membrane of Bowman's capsule and tubular epithelium of the adjacent cortex and medulla. A similar medullary band has been reported with: acute tubular necrosis, pyogranulomatous vasculitis due to feline infectious peritonitis, chronic interstitial nephritis, leptospirosis, deposition of fat in obese animals and in normal cats¹²⁻¹⁴. In cats increased cortical echogenicity with increased corticomedullary differentiation has been reported with glomerular and interstitial nephritis, diffuse renallymphosarcoma, metastatic squamous cell carcinoma and feline infectious peritonitis¹⁵. Increased renal echogenicity with reduced corticomedullary differentiation has been identified with congenital renal dysplasia, chronic inflammatory diseases and end-stage kidneys in the dog and cat^{7,15}.

The appearance of end-stage kidneys is characteristic: small, irregular and diffusely echogenic with poor corticomedullary differentiation and internal architecture kidneys. Diffuse renal changes may be difficult to identify. Comparison with the splenic and hepatic parenchyma may help. Often with supportive clinical findings renal aspirate or biopsy is required to confirm the pathology.

Focal changes include: renal tumours, infarcts, abscesses, cysts and haematomas. Renal cysts can be solitary or multiple and commonly involve both kidneys. Cysts are round with anechoic contents, well marginated with distal acoustic enhancement. Haematomas and abscesses may appear as complicated cysts. All infarcts may appear as hyperechoic areas in the renal cortex and commonly have a triangular shape. Flattening of the renal outline at the level of the infarct may be seen. It is not always possible to distinguish renal infarcts from scarring secondary to pyelonephritis though other abnormalities or lack off may provide an insight. Acute renal infarcts can be variable in appearance depending on the site, number and duration. Tumours may have a variety of appearances and may be cystic or not.

Perinephric fluid accumulation may be seen and may reflect urinoma, haematoma or perinephric pseudocysts. It may also be transudate or exudate secondary to trauma, infection, acute obstruction, toxicity or neoplasia. The appearance does not always provide the answer and aspiration of the fluid may help in identifying the type of fluid.

Ureters

The ureters are not normally seen. They can be readily identified, at least in part, if dilated. Ureteral jets may be seen at the level of the ureterovesicular junctions. Ultrasonographic "smoke" can be seen. Doppler ultrasound can also be used for the identification of the ureteral jets.

Ultrasound is very sensitive for identifying ectopic ureters, which can be seen bypassing the urinary bladder¹⁶.

Urinary Bladder

The urinary bladder can be readily examined when distended with urine. A 7.5-10 MHz transducer is suitable for the examination of the urinary bladder in the dog and cat depending on the size of the animal and the level of filling of the bladder. A very filled bladder in a large/ giant breed dog may require a 5MHz transducer for complete examination. The transducer is placed caudally at the level of the bladder and the organ should be examined in at least two planes. In a full urinary bladder the wall thickness should not exceed 2mm while in an empty bladder the wall thickness may normally measure up to 5mm in the dog. Bladder wall thickness varies from 1.3-1.7mm in normal cats¹⁷. Although not commonly seen, sometimes a hypoechoic mucosa, a hyperechoic submucosa, a hypoechoic/ mixed muscular layer and a hyperechoic serosal surface may be visible. The ureterovesicular junctions may be seen as small protuberances in the dorsocaudal trigone area.

Diffuse or focal bladder wall thickening can be identified. Commonly in cases of cystitis the thickening is mainly seen at the cranioventral bladder wall while in cases of neoplasia the thickened irregular wall is seen at the level of the bladder neck.

Blood clots and mural haematomas may also be seen. Calculi are seen as hyperechoic focal echogenicities with distal acoustic shadowing visible on the dependent aspect of the bladder. Blood clots appear as hyperechoic, non-shadowing, irregular echogenicities that settle on the dependent portion of the bladder lumen.

Ultrasonography of the Reproductive System of the Dog and Cat

Female Reproductive System

Ultrasonography of the reproductive system has been extensively used in small animals. Indications include: pregnancy, evaluation of foetus, suspected pyometra, endocrine abnormalities, dysuria, haematuria, bloody discharges, painful defaecation and locomotor problems.

Ovaries and Uterus

For the examination of the uterus and ovaries high frequency transducers (7.5-10MHz) are ideal. Lower frequency transducers, up to 5MHz, can be used for the evaluation of advanced pregnancy and in cases of pyometra and ovarian tumours however they may not provide adequate resolution for subtle pathologic changes.

Ovaries

The ovaries are found by their relationship to the kidneys. They can be identified up to 2cm caudal to the respective kidney. In anoestrus, the ovaries may be very difficult to identify because they have similar echogenicity to the surrounding tissues. Ovaries are easier to identify during proestrus, oestrus and early metoestrus. Follicular development starts in proestrus and reaches maturations during oestrus when the ovulation occurs.

Ovulation occurs 24-48 hours after a peak in luteinizing hormone. At the same time there is a rise in progesterone levels above baseline anoestrus levels¹⁸. Anechoic follicles become hypoechoic solid corpora lutea. In proestrus the ovaries are oval approximately 1.5cm in length having similar echogenicity to the renal cortex. Follicular cysts appear 2-7 days after the onset. They are small anechoic with a diameter that ranges from 0.3 to 1.2cm just before ovulation. During oestrus the follicular cysts reduce in number but some may develop further up to 2.5 cm in diameter. In metoestrus we have the development of the corpora lutea.

Uterus

The uterus is seen dorsal to the urinary bladder, using the urinary bladder as acoustic window. It is difficult to identify in the non-pregnant animal. It is easier if it is an older animal or if the animal had previous pregnancy. During oestrus the uterus becomes enlarged and hypoechoic. A normal, small, non-gravid uterus can be seen sometimes as a solid, homogeneous, hypoechoic structure. The endometrium and myometrium cannot be usually differentiated. The uterine lumen may not be identified or it may be seen as a hyperechoic central line.

The uterus can be differentiated from intestine from the lack of peristalsis, lack of luminal gas or fluid in the lumen and different layering of the wall. The uterine wall becomes increasingly hypoechoic during proestrus and oestrus. A very small amount of fluid may be seen in the uterine lumen during oestrus.

With pyometra, hydrometra, mucometra or haemometra fluid can be seen in the uterine lumen. In pyometra the fluid may be anechoic to echogenic with changes in the uterine wall and the animal may display clinical signs. In mucometra and hydrometra the fluid is usually anechoic while in haemometra the fluid commonly is echogenic or contains echogenic foci. The appearance of the uterine fluid is not a reliable indicator for distinction of the type of fluid within the uterus.

The uterine wall thickness may be increased and the wall may contain small cystic structures in cases of cystic endometrial hyperplasia that is considered a precursor to pyometra. Ultrasonographic appearance of stump pyometra varies. The uterine remnant is usually located cranial to the pubis between the urinary bladder and the colon. A large complex mass is typically identified, however smaller lesions may be seen and sometimes are difficult to image.

Pregnancy can be detected ultrasonographically very early and usually 2-3 weeks after the first breeding. Commonly 21-35 days after breeding is the easiest and most accurate time to detect pregnancy. There are reports of early pregnancy diagnosis, as early as 10 days after breeding in the bitch¹⁹ and 11 days after breeding in the cat²⁰. Ultrasound examination does not allow accurate estimation of the litter size.

The first sign that confirms the presence of pregnancy is the identification of the gestational sac. The gestational sac is anechoic and only several millimetres in diameter. Clinically we prefer to wait till 30 days after the last mating for ultrasonographic detection of pregnancy when we can identify the gestational sac containing viable embryos with high level of confidence. The foetal heart rate has been reported to be at least twice the maternal heart rate^{21,22}. An increased or decreased heart rate is suggestive of foetal stress. Foetal movement is observed by day 33 to 35²³.

With ultrasonography we can calculate the gestational age using available formulas.

Male Reproductive System

Prostate

For the examination of the prostate typically more than 7.5MHz transducers are used. For large/ giant breed of dogs a 5MHz transducer may be required. In small animal medicine, transabdominal ultrasonography rather than transrectal ultrasonography is commonly employed. Transrectal ultrasonography is used in the reproductive studies of large animals. In cases that the prostate is intrapelvic the help of an assistant that would push the organ forward may be necessary.

The normal prostate gland is ovoid with a flattening on the dorsal surface. The urethra passes slightly dorsal to the centre of the gland. The normal prostate gland has smooth, well-defined margins and uniform coarse echotexture and it is mildly hyperechoic to the surrounding tissues. To locate the prostate, we first locate the urinary bladder in transverse plane and slide/ angle our probe caudally maintaining the urinary bladder in the middle of the screen. We can see the prostate caudal to the bladder.

Prostatic enlargement can be seen with benign prostatic hyperplasia, infection, inflammation, neoplasia and prostatic cystic lesions.

Benign prostatic hyperplasia is commonly seen in older dogs, usually older than 4 years old, and it is considered as normal variation in the dog. It can appear as subtle inhomogeneity of the prostatic parenchyma without any obvious enlargement. Often the prostate is enlarged, commonly symmetrical enlargement but it can be asymmetrical, smooth or nodular, distorting the margins of the gland. Intraparenchymal cysts of varying sizes and number may be present.

Bacterial prostatitis can be acute or chronic. Symmetrical or asymmetrical enlargement of the prostate may be present although it is commonly symmetrical. The prostate has heterogeneous appearance and echogenicity. Cysts or cyst-like structures of varying size may be present and abscess formation may also be seen.

Prostatic neoplasia occurs in older, intact dogs of medium to large breeds as well as in neutered males⁷. The ultrasonographic appearance varies greatly. Commonly the prostate is enlarged with irregular shape and heterogeneous echotexture. Hyperechoic foci with distal acoustic shadowing (mineralization) may be present. Neoplasms may also be cavitory. It can be difficult to differentiate from prostatitis based on the ultrasonographic findings alone. Prostatic neoplasms commonly metastasize in regional lymph nodes, bony structures and lungs^{24,25}. Diagnosis of prostatic neoplasia should be confirmed with biopsy. Prostatic cysts can be seen in benign prostatic hyperplasia, prostatitis and neoplasia. Prostatic cysts can be developmental or congenital. In the dog they are classified into cysts associated with prostatic hypertrophy or squamous metaplasia, retention cysts and paraprostatic cysts²⁶. True cysts have hypoechoic/ anechoic contents surrounded by a thin hyperechoic wall with distal acoustic enhancement.

Paraprostatic cysts are thought to originate by embryologic remnants of the müllerian ducts or as extensions from a prostatic lobe²⁶. Direct communication with the prostate and urethra can happen. Ultrasonographically they typically appear as anechoic fluid

filled structures with variable wall thickness. Their size varies and they can be extremely large at the time of presentation. Larger cysts can become infected. They may be confused with the urinary bladder, however careful evaluation of the bladder trigone area and the prostate usually allows differentiation with the urinary bladder.

Testes

Testes should be evaluated in all cases with evidence of urinary tract or reproductive disease. The pair testes are contained within the scrotum separated by the median septum. The testis has finely grained, homogeneous parenchyma with medium echogenicity. A linear echo seen centrally reflects the mediastinum testis. The epididymis can be identified around the testis as a homogeneously hypoechoic (relative to the testis) structure.

Three common types of testicular tumours are seen: Sertoli cell, interstitial cell and seminomas. Sertoli cell tumours often cause testicular enlargement and are associated with feminizing syndrome and bone marrow suppression due to high oestrogen production. Interstitial cell tumours are commonly composed of nodules singular or confluent to form larger masses. Seminomas are large, solitary, unilateral lesions with internal necrosis and haemorrhage. The ultrasonographic appearance of testicular tumours varies and it is not specific for a tumour type.

Orchitis is commonly seen with epididymitis. Ultrasonographically, acute infectious disease, appears as diffusely, patchy, hypoechoic parenchyma with testicular and epididymal enlargement.

Testicular torsion appears as testicular enlargement with diffuse increase in parenchymal echogenicity, concurrent epididymal enlargement and scrotal thickening with loss of Doppler signal. Also, enlargement of the spermatic cord may be seen. These changes occurred very rapidly after the torsion.

Retained testicles in the dog may be difficult to identify. With the transducer we follow the path of the testicle from caudal to the kidney up to the scrotum. The retained testicle is usually small and may resemble a lymph node. The presence of the mediastinum testis aids in the differentiation from lymph nodes.

Ultrasonographic examination of the reproductive tract is safe and it has a wide range of indications. It can provide functional and morphological information and significant diagnostic exclusions.

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