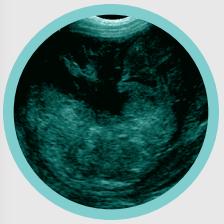

Small Animal Abdominal Ultrasonography

THE URINARY TRACT: URINARY BLADDER & URETHRA

Elizabeth Huynh, DVM, and Clifford R. Berry, DVM, Diplomate ACVR
University of Florida

Welcome to our series of articles on small animal abdominal ultrasonography. The initial articles provided an overview of basic ultrasonography principles and a discussion about how to perform a sonographic tour of the abdomen. The rest of the series discusses ultrasound evaluation of specific abdominal organs/systems.

Read the Small Animal Abdominal Ultrasonography articles published in *Today's Veterinary Practice* at **tvpjournal.com**. The latest articles include:

- A Tour of the Abdomen: Part 1 (January/February 2016) and Part 2 (March/April 2016).
- Liver & Gallbladder: Part 1 (May/June 2016) and Part 2 (September/October 2016).

As discussed in the articles, **A Tour of the Abdomen** (Part 1, January/February 2016, and Part 2, March/April 2016), ultrasound (US) examination of the urinary tract is typically completed in a counterclockwise fashion in the following order:

- Left kidney
- Urinary bladder
- Proximal urethra
- Right kidney.

PREPARATIOIN

Prior to beginning the examination, clip the patient's hair and apply ultrasonic gel to the skin.

The bladder is usually examined when it is distended with urine as an empty or minimally distended urinary bladder may appear to have thickened walls on ultrasonographic examination. Methods of distending the urinary bladder are described under **Urinary Bladder** on page 62.

SCANNING TECHNIQUE

A 5-, 7.5-, or 10-MHz convex, linear, or vector transducer is required to examine the distal ureters, urinary bladder, and proximal urethra, while a microconvex transducer with a small footprint allows the ultrasonographer to easily view the intrapelvic ureter.

Urinary Bladder

To evaluate the urinary bladder:

1. Keep the transducer positioned in long axis to the animal, and move it caudal to a level between the last 2 mammary chains.
2. Evaluate the urinary bladder in long axis and short axis.
3. Be sure to examine the trigone region carefully, particularly as it extends caudally into the urethra in cats and female dogs or the prostate gland in male dogs.

Urethra

To evaluate the proximal urethra or, in male dogs, the prostatic urethra:

1. Place the transducer in a long-axis sagittal position at the level of the urinary bladder.
2. Move the transducer caudally until the trigone region is identified.
3. When the transducer cannot move any farther caudally due to the presence of the pubic bone, angle the transducer footprint in a caudal direction.

Measuring Urinary Bladder Wall Thickness in Dogs

Urinary bladder wall thickness in dogs can be calculated based on the degree of bladder distension:[1]

- If the bladder is **minimally distended** (0.5 mL/kg), bladder wall thickness is 2.3 ± 0.43 mm.
- If the bladder is **mildly distended** (2 mL/kg), bladder wall thickness is 1.6 ± 0.29 mm.
- If the bladder is **moderately distended** (4 mL/kg), bladder wall thickness is 1.4 ± 0.28 mm.

If urinary bladder wall thickness is suspected, differential diagnoses include cystitis and urinary bladder neoplasia.

NORMAL ULTRASONOGRAPHIC FEATURES

Urinary Bladder

Bladder Wall Thickness

Normal bladder wall thickness in dogs is 1 mm, with thickness increasing mildly as body weight increases (see **Measuring Urinary Bladder Wall Thickness in Dogs**, page 61). In cats, urinary bladder wall thickness ranges from 1.3 to 1.7 mm.

The urinary bladder has irregular folds, which can be mistaken for abnormally thickened bladder walls when the bladder is relatively empty. If an abnormality of the urinary bladder wall (eg, cystitis) is suspected, wall thickness may be confirmed by:

- Re-examining the bladder at the end of the abdominal US examination
- Administering maintenance intravenous fluid or furosemide at low doses
- Placing a urinary catheter to fill the bladder with sterile isotonic saline as needed.

Evaluation of Bladder Structures

The urinary bladder should be evaluated in long axis and short axis, from the apex to the level of the urethra at the ureterovesicular junction (**Figure 1**). In male dogs, the prostate gland is immediately caudal to the urinary bladder. In females, the urethra should be followed for several centimeters beyond the urinary bladder to evaluate for any abnormal urethral thickening or mineralization.

The distal ureters (if seen) can be evaluated as they enter at the ureteral papillae, which are located along the dorsal urinary bladder wall adjacent to the cranial aspect of the trigone (**Figure 2**). Occasionally, echogenic ureteral jets may be seen entering the urinary bladder lumen at the level of the ureteral papillae secondary to ureteral peristalsis.[2,3]

The histologic layers of the urinary bladder are difficult to define using US in a moderately distended urinary bladder. If the layers are evident, they will consist of the following (**Figure 2**):

- Outer serosal layer (hyperechoic)
- Three smooth muscle layers (hypoechoic)
- Lamina propria submucosal layer (hyperechoic), which parallels the inner mucosal layer (hypoechoic).

Evaluation of Adjacent Structures

The urinary bladder serves as a good acoustic window for adjacent structures, such as the colon, uterus (intact females), and iliac lymph nodes. Anatomically, the urinary bladder is the most ventral structure in the caudal abdomen, followed by the

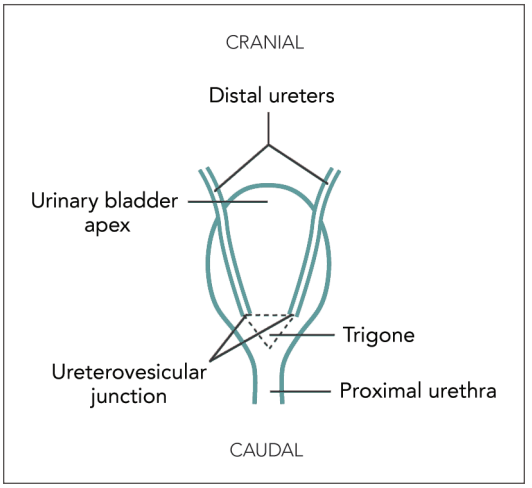

FIGURE 1. Dorsal view of the distal ureters, urinary bladder, and proximal urethra.

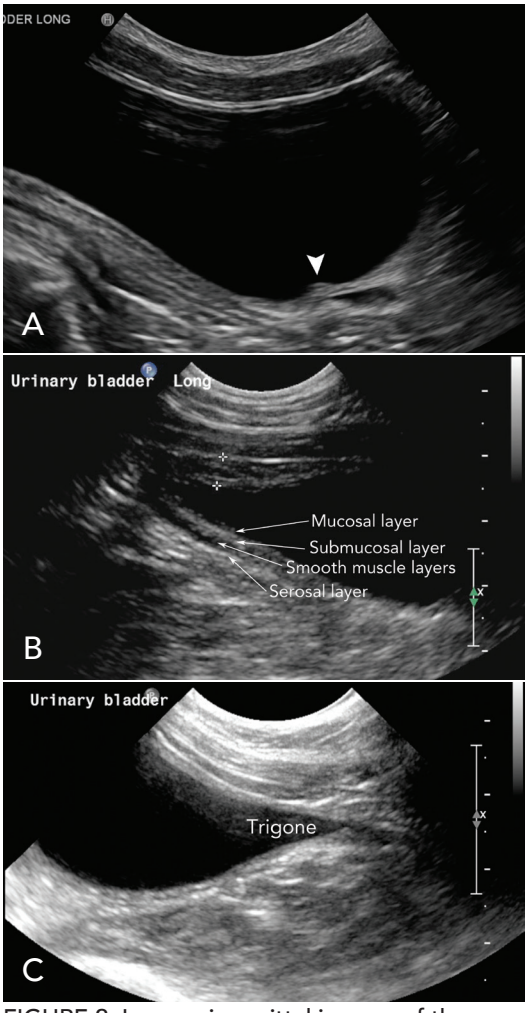

FIGURE 2. Long-axis sagittal images of the ureteral papilla (**arrowhead in A**), normal wall layering (**B**), and trigone region (**C**) of the urinary bladder in a dog.

uterus (intact females), colon, and iliac lymph nodes dorsally (far field).

Evaluation of Urine & Artifacts

Urine in the urinary bladder is normally anechoic; however, echogenic urine is not specific for urinary tract disease.

Other US artifacts of the urinary bladder include side-lobe or grating-lobe artifacts. Side-lobe artifacts, or *pseudosludge*, are caused by mismapped reflections of the secondary US beam into anechoic regions, resulting in echogenic areas within the urinary bladder lumen that can be mistaken easily for sedimentation (**Figure 3**).

Angling the transducer can sometimes decrease the severity of the artifact and, thus, rule out sedimentation in the urinary bladder. Alternatively, the patient can be imaged in a standing position to assess for gravity dependence, which would be characteristic of true sludge.

Urethra

The proximal urethra (prostatic urethra in male dogs) can be visualized as a tubular hypoechoic structure continuing caudal to the trigone region of the urinary bladder and extending to the level of the pubic bone. The membranous urethra cannot be visualized due to its location within the pelvis.

Assessment of the penile urethra within the ventrally located urethral groove of the os penis may be performed in male dogs but is typically not included in a normal abdominal US examination. Indications for a penile urethral US examination include suspicion of a distal urethral obstruction.

URINARY TRACT ABNORMALITIES

Congenital Abnormalities: Urinary Bladder & Ureter

Ureterocele

Ureterocele is a rare congenital ureteral malformation that can be associated with ectopic ureters. An intravesicular ureterocele is characterized by focal cystic dilation of the distal submucosal portion of the ureter that protrudes into the urinary bladder lumen. A thin-walled, round structure containing anechoic fluid can be seen within the neck of the urinary bladder (**Figure 4**).[4]

Urachal Remnants

In the fetus, the urachus connects the apex of the urinary bladder with the allantoic sac through the umbilical cord. Before birth, this structure normally atrophies. Incomplete closure of the urachus may result in patent urachus, urachal diverticulum, or urachal cyst.

Patent urachus is uncommon in dogs and cats. Ultrasonographically, it is seen as a tubular structure extending from the apex of the urinary bladder to the umbilicus.

Urachal diverticulum results when the caudal segment of the urachus fails to close. It appears as a fluid-filled, rounded, thin-walled, well-defined structure extending from the urinary bladder lumen at any location (**Figure 5**, page 64).[5] The urachal diverticulum disappears in an empty urinary bladder.

Urachal cysts form when secretions continue in an isolated section of urachal epithelium while the remainder of the urachus undergoes fibrosis. Ultrasonographically, a urachal cyst appears as a thin-walled, anechoic structure cranial to the urinary bladder.[5]

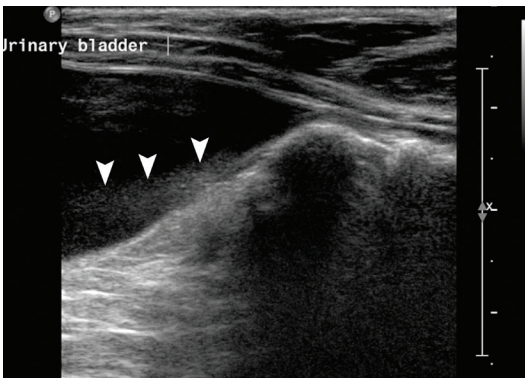

FIGURE 3. Long-axis sagittal image of the trigone region of the urinary bladder showing a side-lobe artifact (**arrowheads**).

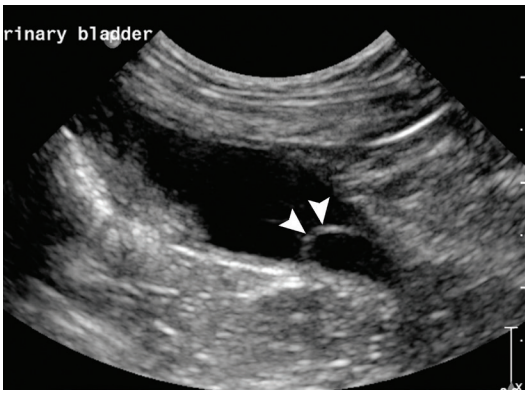

FIGURE 4. Long-axis sagittal image of the trigone region of the urinary bladder in a Tibetan terrier. Note the minimally to moderately distended urinary bladder with a hyperechoic, thin-walled structure (**arrowheads**) with anechoic fluid centrally located in the trigone and urinary bladder neck. This is consistent with a ureterocele.

Acquired Abnormalities: Bladder

Ruptured Urinary Bladder

In ruptured urinary bladder, small mural defects may not be seen and discontinuity of the wall may be falsely suspected due to echo dropout from a curved urinary bladder wall (**Figure 6**). A ruptured urinary bladder is best diagnosed using positive-contrast cystography and identifying contrast material within the peritoneum.[5]

Cystic Calculi

Cystic calculi appear as a variable-sized, spheric, and hyperechoic curvilinear interface with distal acoustic shadowing collecting in the dependent portion of the urinary bladder (**Figure 7**), but cystic calculi can adhere to a severely inflamed urinary bladder wall. If the gas in the adjacent descending colon makes the cystic calculi difficult to detect, the patient can be scanned while standing, using the benefits of gravity to mobilize the calculi away from the dorsal urinary bladder wall.

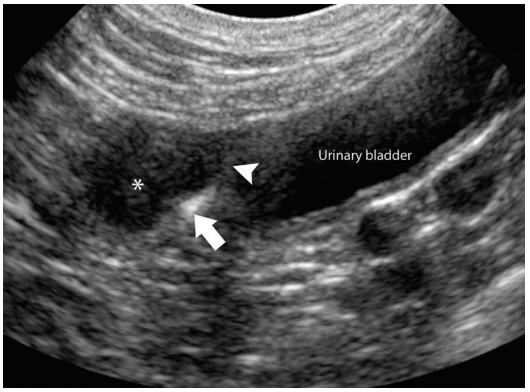

FIGURE 5. Short-axis transverse image of the urinary bladder in a Bedlington terrier. There is a thin-walled (**arrowhead**), well-defined, anechoic focus (**asterisk**) located immediately cranial to the urinary bladder containing a small, gravity-dependent calculus (**arrow**). This is consistent with urachal diverticulum.

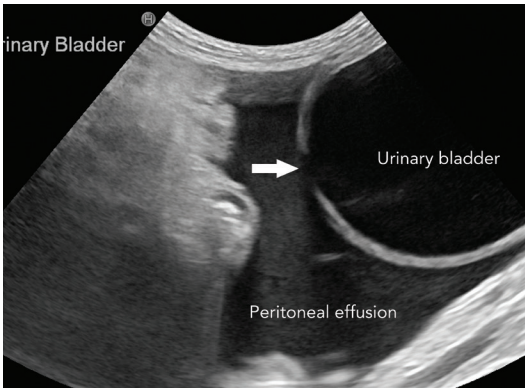

FIGURE 6. Long-axis sagittal image of the urinary bladder in a bichon frise with a moderate to severe amount of echogenic peritoneal effusion. There is a refraction artifact located in the cranial border of the urinary bladder (**arrow**). This is often confused with discontinuity of the urinary bladder wall.

Blood Clots & Hematomas

Blood clots may form secondary to trauma, bleeding disorders, infection, or neoplasia. They are commonly hyperechoic without distal acoustic shadowing (**Figure 8**), irregularly shaped, and often gravity dependent.[6,7]

Cystitis

Chronic cystitis causes urinary bladder wall thickening and mucosal surface irregularity that is

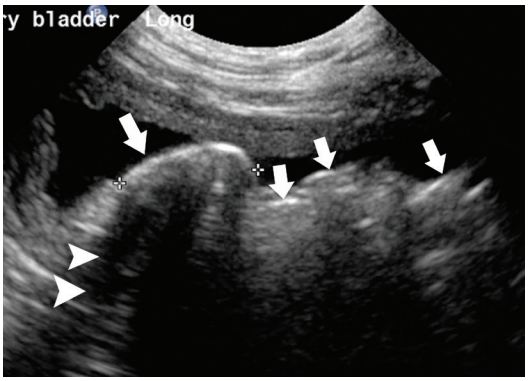

FIGURE 7. Long-axis sagittal image of the urinary bladder in a Cavalier King Charles spaniel. There are multiple hyperechoic, rounded structures (**arrows**) with distal acoustic shadowing (**arrowheads**) within the urinary bladder lumen. This is consistent with multiple cystic calculi.

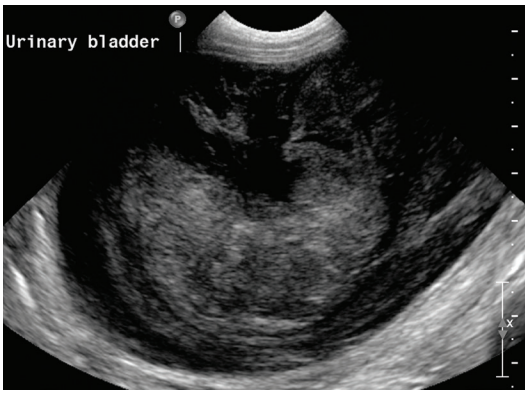

FIGURE 8. Long-axis sagittal image of the urinary bladder in a mixed-breed dog. The bladder is distended with heterogeneous, echogenic, formed material consistent with a large blood clot.

most pronounced cranioventrally (**Figure 9**). Severe cystitis can be generalized.[8]

Polypoid Cystitis

Polypoid cystitis appears ultrasonographically as wall thickening and multiple small masses (usually located cranioventrally) that project into the urinary bladder lumen (**Figure 10**). Large polyps can appear pedunculated at their attachment site.[9,10]

Emphysematous Cystitis

Gas-producing micro-organisms (eg, *Escherichia coli, Aerobacter, Proteus, Clostridium*) accumulate within the urinary bladder wall, lumen, and ligaments. These micro-organisms ferment glucose, with gas as a by-product. As a result, in patients with glucosuria secondary to diabetes mellitus, gas can be present in the urinary bladder wall.

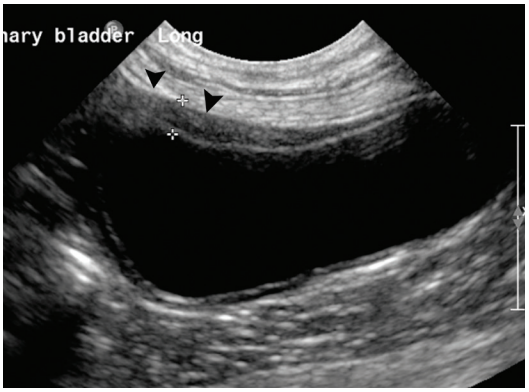

Figure 9. Long-axis sagittal image of the urinary bladder in a Scottish terrier. The cranioventral aspect of the bladder wall is focally thickened (**arrowheads**), consistent with chronic cystitis.

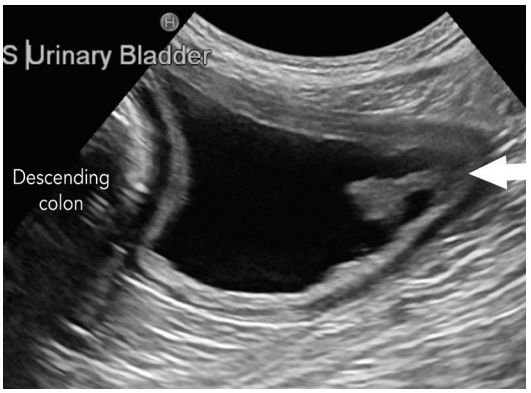

FIGURE 10. Short-axis transverse image of the urinary bladder in a border collie. The urinary bladder mucosa is irregularly marginated and contains a pedunculated, echogenic structure extending into the lumen (**arrow**). This is consistent with polypoid cystitis.

Ultrasonographically, the urinary bladder wall is irregularly marginated and hyperechoic, with acoustic shadowing and reverberation produced by the gas (**Figure 11**).[11,12] The position of the gas in the wall can help differentiate emphysematous cystitis from a normal colon containing gas within its lumen; in emphysematous cystitis the position of the gas does not change with the position of the patient.

Urinary Bladder Neoplasms

Transitional cell carcinoma (TCC) is the most common neoplasm of the urinary bladder (**Figure 12**). It is typically an irregular urinary bladder wall mass with a broad-based attachment projecting into the urinary bladder lumen in the trigone region.

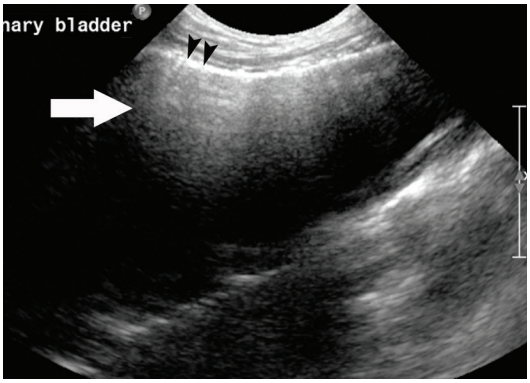

Figure 11. Long-axis sagittal image of the urinary bladder in a Rhodesian ridgeback with emphysematous cystitis. Throughout the urinary bladder wall, there is a hyperechoic interface (**arrowheads**) and a large amount of distal reverberation artifact (**arrow**).

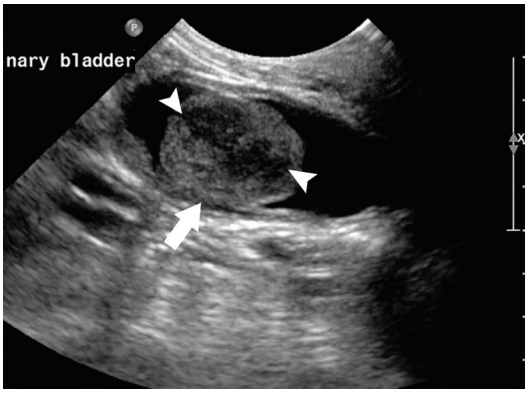

FIGURE 12. Long-axis sagittal image of the urinary bladder in a Maltese. There is a rounded, pedunculated mass extending from the wall and into the urinary bladder lumen (**arrow**). Centrally, there are multifocal areas of hypoechogenicity (**arrowheads**), presumed to be areas of necrosis. This dog was diagnosed with transitional cell carcinoma.

TCC is heterogeneous, and its overall appearance can be hyperechoic, isoechoic, or hypoechoic relative to the bladder wall.[13] TCCs can be extensive, invading the ureters, urethra, and/or prostate, causing lower urinary tract obstruction and hydronephrosis.[14,15] These tumors are typically very vascular and may have areas of dystrophic mineralization.

Squamous cell carcinoma (SCC) is a urinary bladder neoplasm of epithelial origin. Urinary bladder neoplasms of mesenchymal origin include botryoid rhabdomyosarcoma, chemodectoma, leiomyosarcoma, leiomyoma, fibroma, fibrosarcoma, hemangioma, hemangiosarcoma, lymphoma, and mast cell tumor.[16]

Differentiation of urinary bladder neoplasms is not possible ultrasonographically; biopsy or traumatic catheterization is needed for definitive diagnosis.

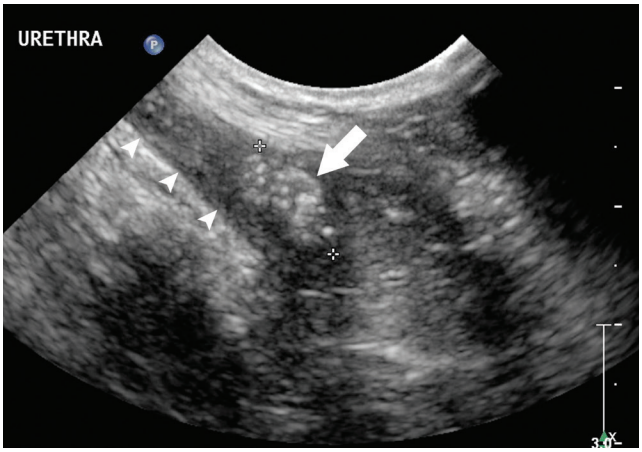

FIGURE 13. Long-axis sagittal image of the proximal urethra in a mixed-breed dog. The proximal urethra (**arrowheads**) is hypoechoic and subjectively, diffusely thickened containing an oval-shaped, hyperechoic structure within its wall (**arrow**). These findings are consistent with a mineralized urethral neoplasm, such as transitional cell carcinoma.

Abnormalities: Urethra

Urethral Calculi

Enlargement of the urinary bladder with dilation of the proximal urethral lumen suggests urethral obstruction. Occasionally, small, curvilinear, hyperechoic foci with distal acoustic shadowing can be seen proximal to the os penis in male dogs.

Urethral Neoplasms

Common urethral neoplasms in dogs include TCC, SCC, and adenocarcinoma. Urethral TCC is associated with a hypoechoic and thickened wall with a hyperechoic mucosal lining (**Figure 13**).[15] SCC is most commonly associated with the distal urethra. Spread of prostatic neoplasia is possible in the proximal urethra and into the urinary bladder.

IN SUMMARY

Systematic examination of the urinary system is a routine part of a complete abdominal evaluation. A complete US examination of the urinary system is required as abnormalities of the kidneys and ureters are commonly seen in conjunction with urinary bladder lesions.

SCC = squamous cell carcinoma; TCC = transitional cell carcinoma; US = ultrasound

References

1. Geisse AL, Lowry JE, Schaeffer DJ, Smith CW. Sonographic evaluation of urinary bladder wall thickness in normal dogs. *Vet Radiol Ultrasound* 1997; 38:132-137.
2. Lamb CR, Gregory SP. Ultrasonography of the ureterovesicular junction in the dog: A preliminary report. *Vet Rec* 1994; 134:36-38.
3. Lamb CR. Ultrasonography of the ureters. *Vet Clin North Am Small Anim Pract* 1998; 28:823-848.
4. Stiffler KS, Stevenson MM, Mahaffey MB, et al. Intravesical ureterocele

with concurrent renal dysfunction in a dog: A case report and proposed classification system. *JAAHA* 2002; 38:33-39.
5. Nyland TG, Widmer WR, Mattoon JS. Urinary tract. In Mattoon JS, Nyland T (eds): *Small Animal Diagnostic Ultrasound*, 3rd ed. St. Louis: Elsevier Saunders, 2015.
6. Leveille R. Ultrasonography of urinary bladder disorders. *Vet Clin North Am Small Anim Pract* 1998; 28:799-821.
7. Johnston GR, Walter PA, Feeney DA. Radiographic and ultrasonographic features of uroliths and other urinary tract filling defects. *Vet Clin North Am Small Anim Pract* 1986; 16:261-292.
8. Voros K, Wladar S, Marsi A, et al. Ultrasonographic study of feline lower urinary tract diseases: 32 cases. *Acta Vet Hung* 1997; 45:387-395.
9. Martinez I, Mattoon JS, Eaton KA, et al. Polypoid cystitis in 17 dogs (1978-2001). *J Vet Intern Med* 2003; 17:499-509.
10. Takiguchi M, Inaba M. Diagnostic ultrasound of polypoid cystitis in dogs. *J Vet Intern Med Sci* 2005; 67:57-61.
11. Lobetti RG, Goldin JP. Emphysematous cystitis and bladder trigone diverticulum in a dog. *J Small Anim Pract* 1998; 39:144-147.
12. Root CR, Scott RC. Emphysematous cystitis and other radiographic manifestations of diabetes mellitus in dogs and cats. *JAVMA* 1971; 158:721-728.
13. Leveille R, Biller DS, Paugh B, et al. Sonographic investigation of transitional cell carcinoma of the urinary bladder in small animals. *Vet Radiol Ultrasound* 1992; 33(2):103-107.
14. Ticer JW, Spencer CP, Ackerman N. Transitional cell carcinoma of the urethra in four female dogs: Its urethrographic appearance. *Vet Radiol* 1980; 21(1):12-17.
15. Hanson JA, Tidwell AS. Ultrasonographic appearance of urethral transitional cell carcinoma in ten dogs. *Vet Radiol Ultrasound* 1996; 37(4):293-299.
16. Heng HG, Lowry JE, Boston S, et al. Smooth muscle neoplasia of the urinary bladder wall in three dogs. *Vet Radiol Ultrasound* 2005; 47(1):83-86.

ELIZABETH HUYNH

Elizabeth Huynh, DVM, is a diagnostic imaging resident and graduate student at University of Florida College of Veterinary Medicine. Her interests include ultrasonography, cross-sectional imaging, and nuclear medicine. She received her DVM from Ross University, finished her clinical year at Ohio State University, and completed a diagnostic imaging internship at Animal Specialty and Emergency Center in Los Angeles.

CLIFFORD R. BERRY

Clifford R. Berry, DVM, Diplomate ACVR, is a professor of diagnostic imaging at University of Florida College of Veterinary Medicine. His research interests include cross-sectional imaging of the thorax, nuclear medicine, and biomedical applications of imaging. He received his DVM from University of Florida and completed a radiology residency at University of California–Davis.