Kidneys
Survey abdominal radiographs (Figures 1 and 2) offer important information on kidney number, size, shape, symmetry, and location, as well as the presence of any mineralized opacities (eg, calcified tissue, nephroliths). The utility of abdominal radiographs is decreased in patients with abdominal fluid or lack of abdominal fat (eg, young or emaciated patients) because of lack of contrast. Excretory urography (IV pyelography), although more invasive, can augment survey radiographs and provide information about renal parenchymal architecture (eg, filling defects associated with cysts or infiltrative disease), the renal pelvis, and ureters as well as a qualitative assessment of global and individual renal excretory function (Figure 3, next page).

Similar to survey radiography, ultrasonography can document the number, size, shape, and location of kidneys. An enlarged left kidney with an irregular shape (arrows) is noted on the VD view of a dog with renal adenocarcinoma. The left kidney measured 4.5 times the length of L2; normal kidney length in the dog is 2.5 to 3.5 times the length of L2.

The left kidney (arrows) is decreased in size compared to the right kidney on the VD view of a cat. The left kidney measured 1.5 times the length of L2; normal kidney length in the cat is 2 to 3 times the length of L2. Both kidneys are normal in shape and opacity.
of the kidneys as well as the presence of mineralized tissue and nephroliths. In contrast to radiography, abdominal fluid or lack of abdominal fat does not limit the utility of ultrasound. The major advantage of ultrasound for evaluating kidney disease is its ability to assess the internal renal architecture and perirenal tissues. Both focal and diffuse lesions are recognized. Focal lesions may be solid, either homogenous or heterogenous, or fluid in nature. Diffuse lesions (Figures 4-8, next page) may uniformly affect the parenchyma or be heterogenous. The renal cortex, medulla, or both regions may be affected depending on the disease process.

Renal pelvic dilation (pyelectasia) and proximal ureteral dilation are readily observed with ultrasound and renomegaly may be seen on radiographs if dilation is severe (Figures 9 and 10, page 88). Ultrasound can also be used to guide fine-needle aspiration and tissue biopsies of the kidney and fluid aspiration from a dilated renal pelvis. The major limitation of ultrasonographic evaluation of the kidneys is operator experience and expertise.

Ureters
Normal ureters cannot be visualized with survey radiography or ultrasonography, but normal and abnormal ureters are readily visualized with excretory urography. The location of a ureteral obstruction or rupture as well as the presence of an ectopic ureter (especially when combined with pneumocystography) can be documented with excretory urography (Figure 11, page 88). A dilated ureter (hydroureter) can be observed with ultrasonography (Figure 12, page 89). Pyelocentesis (for cytology and culture) and antegrade pyelography (nephropyelography) (Figure 13, page 89) to document obstruction or leakage can be conducted via ultrasound guidance with heavy sedation or anesthesia. Ultrasonography can also be used to visualize retroperitoneal fluid
accumulation, which may occur with a ureteral rupture, hemorrhage, or infectious or neoplastic disease. Whereas ureteroliths without hydroureter may be missed on ultrasonography, radiopaque ureteroliths can be observed on survey radiography (Figure 14, page 89). Survey radiographic visualization of radiopaque ureteroliths may be facilitated by enemas to empty the colon of fecal material and/or use of a radiolucent paddle to apply regional compression over the ureter to separate adjacent organs (eg, loops of bowel) (Figure 15, page 89). Aged cats with chronic kidney disease (CKD) frequently have calcium oxalate nephroliths; in some cases, these nephroliths will migrate into the ureters. Survey radiographs should be employed to rule out ureterolithiasis, especially in cats with acute decompensation of their CKD (Figure 16, page 90).

**Urinary Bladder**

Survey radiographs of the urinary bladder are helpful for evaluation of size and location and for detection of radiopaque calculi. Urinary bladder distention is readily detected (Figure 17, page 90). Radiographs are of limited value in evaluating mural disease because the bladder wall cannot be differentiated from the fluid contained within the bladder. Bladder wall...
thickening (e.g., bacterial inflammation, polypoid cystitis, neoplasia) is best evaluated by ultrasonography or double-contrast cystography (Figure 18, page 90). It should be noted that the degree of bladder filling can affect bladder wall thickness. For example, a small, mildly distended bladder may appear to have a thickened bladder wall on ultrasound compared with a moderately or severely distended bladder (Figure 19, page 90). This potential disadvantage can often be overcome by reevaluating the bladder several hours after preventing voiding.
Double-contrast cystography can be an excellent tool to evaluate bladder wall thickness and any irregularities of the bladder mucosal surface and to rule out the presence of radiolucent cystouroliths (Figure 20, next page). Although double-contrast cystography is more invasive because of the need for urethral catheterization, artifactual bladder wall thickening is usually not an issue because the degree of bladder distention can be controlled.

Positive-contrast cystography is useful when evaluation of urinary bladder location or integrity is questioned (Figures 21 and 22, page 91).

The major advantage to survey radiography of the urinary bladder is the detection of radiopaque cystouroliths. In many cases, the radiodensity, size, and shape of the uroliths aid in determining urolith type, which is not possible with ultrasonography.

In this ultrasound image, the ureter (between arrows) was distended and could be followed to an accumulation of hyperechoic structures (arrowheads) with distal acoustic shadowing, consistent with multiple ureteroliths.

Bilateral antegrade pyelography was performed in a cat with bilateral pyelectasia, in which a cause was not identified on ultrasound. Both renal pelves and ureters are dilated. There is a radiopaque ureterolith (arrow) that was not seen on survey radiographs (most likely because of colonic superimposition); ureteral contrast did not extend beyond the ureterolith. Ideally, the colon would be evacuated before the study.

Multiple mineral opaque ureteroliths (arrows) and a nephrolith (arrowhead) are seen in this lateral abdominal radiograph of a dog.

Compression radiography helped isolate the small left kidney (arrows) and localize the left ureterolith (arrowhead) in the ventrodorsal image of a cat. There is also a nephrolith present in the right kidney.
but type of urolith cannot be definitively determined with radiography. Ultrasonography has the advantage of detecting radiolucent cystouroliths (Figure 25, next page). Emphysematous cystitis can be observed on both survey radiography and ultrasonography (Figure 26, page 92). Standing the patient may be useful when trying to determine if a bladder abnormality is within or adhered to the wall or free within the lumen (hematoma or calculi) (Figure 27, page 92). Ultrasonography has the advantage of allowing evaluation of sublumbar lymph nodes and other perivesicular structures as well as enabling cystocentesis when the bladder is small and minimally distended. Extension of neoplasia to the spine, as with transitional cell carcinoma of the bladder, is more easily identified with radiography.

(Figures 23 and 24, next page),
Two large soft-tissue opaque masses were noted on survey radiographs in a dog. After positive-contrast cystography, the more cranial structure (arrows) was identified as the urinary bladder. The caudal soft tissue mass (arrowheads) was diagnosed as a uterine leiomyoma.

Multiple round, smooth, mineral opaque calculi are present in the central urinary bladder in this dog with struvite uroliths.

A positive-contrast cystogram was performed in this dog that was hit by a car and had reduced serosal detail and pelvic fractures. There is a triangular region (arrow) of contrast extravasation from the ventral bladder wall and contrast within the peritoneal cavity consistent with a bladder wall tear and uroabdomen.

A solitary urolith with a stellate appearance is centrally located in the urinary bladder of this dog. Calcium oxalate urolith was diagnosed on stone analysis.

Small cystoliths, which were not seen with radiography, were identified on ultrasound. On the ultrasound image, the calculi are gravity-dependent and the 2 larger calculi (arrows) demonstrate distal acoustic shadowing.
Urethra

The normal urethra of dogs and cats is difficult to visualize on survey radiography and ultrasonography. Radiopaque urethroliths can be observed on survey radiographs, and therefore the entire urethra should always be included in the field of view (Figure 28). In male dogs, it is useful to pull the hindlimbs forward to assess the urethra between the pelvis and os penis (Figure 29, next page). The prostate gland and proximal urethra, before entering the pelvic canal, can be visualized with ultrasonography, especially if there is urethral distention. In male dogs, the urethra at the proximal os penis can be evaluated with ultrasonography to assess for urethroliths, which commonly lodge in this location. Positive-contrast retrograde urethrography is the best tool for diagnosis of intraluminal, intramural,
A standard abdominal view (A) in a dog with cystourethroliths. There is mineral within the bladder (arrow) and multiple urethroliths (arrowheads). On the perineal view (B), additional urethroliths are present (arrowheads). Additional urethroliths are seen because the hindlimbs were pulled forward; otherwise, they might have been blocked from view by the femurs.

A urethrogram in this male dog defines a mural lesion that appears as a filling defect within the contrast (arrows). This area repeatedly did not fill with contrast and was diagnosed as transitional cell carcinoma. Proximal to this lesion, there are multiple small circular filling defects that are consistent with gas bubbles (arrowheads).

Prostate Gland
Survey radiography can be used to evaluate the size, shape, and opacity of the prostate gland (Figures 31 and 32). Ultrasonography has the advantage of providing tissue-architecture information. Prostatic abscesses, internal cysts, and paraprostatic cysts are readily visualized on ultrasonography. Ultrasonography can also aid in diagnosing benign prostatic hyperplasia (homogenous echotexture with intact capsule) and prostatic neoplasia (heterogenous with course echotexture and irregular margins) (Figure 33, next page) and with identifying any potential source of excess androgen production (eg, adrenal...
glands, retained testes) in cases of suspected squamous metaplasia of the prostate gland. Mineralization of the prostate in a neutered dog is suggestive of neoplasia and can be detected by both survey radiography and ultrasonography. Sublumbar lymph nodes can also be evaluated by ultrasonography, whereas radiography is best for evaluating the adjacent lumbar spine (Figures 34 and 35).

**Conclusion**
Radiography and ultrasonography have distinct advantages and weaknesses in the evaluation of urinary tract disorders in dogs and cats. Combining these 2 imaging modalities will almost always provide improved diagnostic information compared with the use of 1 modality alone.

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**Suggested Reading**