Emergent urinary tract conditions require timely diagnosis and treatment to ensure a favorable clinical outcome and to prevent morbidity and mortality. This has become even more important with the advent of interventional procedures in veterinary medicine, such as urethral/ureteral stenting or Subcutaneous Ureteral Bypass (SUB), which require an early and accurate diagnosis in order to salvage renal function and urine output. Medical emergencies include acute kidney injury and pyelonephritis. Surgical emergencies of the urinary tract fall in one of three categories, including uncontrolled renal hemorrhage, accumulation of urine within the peritoneal cavity or retroperitoneal space, and obstruction to urine outflow.

ACUTE KIDNEY INJURY / PYELONEPHRITIS / PYELONEPHROSIS

Acute kidney injury (AKI) is characterized by an abrupt, sustained decrease in renal function and loss of the kidneys’ ability to excrete wastes, regulate acid-base and electrolyte balance, and concentrate urine and was previously referred to as ‘acute renal failure’. Acute azotemia can have pre-renal (dehydration, systemic hypotension…), renal (toxic, infectious, other) or post-renal origins (ureteral, urethral obstructions, see below). Imaging is useful in trying to determine in which of these three groups the patient with AKI falls. Ultrasound is very useful to identify renal structural changes suggestive of a renal origin of AKI. In addition to renomegaly (usually bilateral), cortical hyperechogenicity may be seen causing an increased contrast between the cortex and medulla (interstitial and glomerulonephritis, toxic acute tubular necrosis [e.g. ethylene glycol toxicity, grapes in dogs, lily in cats…]). In some cases, both cortex and medulla can become hyperechoic (e.g. leptospirosis), thereby reducing the corticomedullary border distinction. Perirenal effusion is often seen in these acute nephropathies. A medullary rim sign can be seen in a variety of disease processes such as acute tubular necrosis, nephrocalcinosis, leptospirosis and FIP but is also possibly seen in normal dogs and cats. In acute-on-chronic renal disease, imaging features of chronicity may be identified, including more diffuse hyperechogenicity, irregular shape, small to normal size, architecture distortion, with linear or patchy dystrophic mineralization.

Pyelonephritis is an interstitial inflammation most severe in the renal pelvis and adjacent medullary tissue. It may cause variable degree of pyelectasia. In the acute form, the shape of the pelvic cavity and pelvic diverticula is usually preserved with anechoic fluid in the dilated pelvic cavity. Mild dilation of the proximal ureter with periureteral hyperechoic fat may be seen. The renal lymph nodes caudal to the kidneys should be scrutinized for signs of enlargement. Note that fluid renal pelvic dilation should be interpreted with caution, as chronic renal disease can also lead to variable degrees of pyelectasia; ultrasound abnormalities need to be interpreted in light of findings on other clinical and laboratory tests.

When pyelonephritis leads to obstruction of the renal collecting system, or when obstructive hydronephrosis is accompanied by an ascending infection, pyonephrosis may occurs: it is a collection of sloughed urothelium and inflammatory cells in a dilated renal collecting system and is a serious complication that can lead to loss of renal function and septic shock. On ultrasound, hyperechoic contents completely fill the dilated renal pelvis, or a fluid-debris level can be observed. Hyperechoic perirenal fat, and peritoneal and retroperitoneal effusion, are common.

RENOAL HEMORRHAGE

Uncontrolled renal hemorrhage can occur as a result of blunt or penetrating abdominal trauma. Clinically, patients may present with acute gross hematuria, microscopic hematuria or systemic hypotension. Traumatic renal injuries include bruising/ecchymosis, hematomata, fissure/laceration and rupture of the vascular pedicle. Ultrasound and CT are certainly the best and fastest methods to diagnose traumatic
renal hematomas. A mass of irregular shape and structure altering the renal parenchyma and capsule is usually seen, with variable amounts of perirenal fluid. At CT, intrarenal hematomas may result in hypoattenuating foci in the renal cortex on contrast-enhanced images. Subcapsular hematomas may appear as a hypoattenuating collection conforming to the outer renal capsule and highlighted by the contrast enhanced renal parenchyma. If laceration is present, hemorrhage may extend to the retroperitoneal space: the “sentinel clot sign” could be used to identify acute bleeding, corresponding to freshly clotted blood close to the source of bleeding that appears hyperattenuating on pre-contrast images because of a greater density and hemoglobin content compared to lower attenuating unclotted blood located further from the source. In cases of pedicle avulsion, disruption or disconnection of the collecting system and renal vasculature is present and contrast may extravasate while renal parenchymal enhancement is poor.

UROPERITONEUM AND URORETROPERITONEUM
Extravasation of urine into the retroperitoneal space or peritoneal cavity can occur as a result of blunt or penetrating abdominal or pelvic trauma. Uroabdomen can also occur as a complication of abdominal surgery, catheterization of the urethra or bladder, diagnostic cystoscopy, rupture of the bladder secondary to urethral obstruction, vigorous manual expression of the bladder, and bladder/urethral neoplasia. Radiographic findings of uroperitoneum are non-specific as seen with any kind of peritoneal effusion. Retrograde positive contrast cystography is the test of choice to diagnose lower urinary tract tears and leakage; CT may be more sensitive to detect small volumes of contrast leakage; imaging the patient in both dorsal and ventral recumbency may be sometimes required to detect the region of bladder rupture. Ultrasound can also be used to identify bladder tear using agitated saline and urethral catheter injection; the bladder is imaged while the agitated saline is injected into it, and the microbubbles leaking into the peritoneal space can be imaged in real time.

On survey radiographs, uroretroperitoneum causes nonspecific signs of a retroperitoneal mass effect with loss of contrast in the retroperitoneal space obscuring the renal shadows; a wispy/streaky soft tissue pattern summatting with the retroperitoneal fat is often seen. Ventral displacement of the colon and small intestine is common with larger amounts of retroperitoneal leakage. In cases of urinomas (encapsulated accumulation of urine caused by traumatic extravasation), a more focal and well-marginated retroperitoneal mass effect may be seen radiographically. On ultrasound this may appear as a rounded to oval-shaped collection of anechoic fluid. Radiographic or CT intravenous urography can help identifying areas of leakage in the retroperitoneal space.

OBSTRUCTION TO URINE OUTFLOW
In the emergency patient, most cases of obstruction to urine outflow are due to the presence of calculi in the ureters or urethra. Radiopaque calculi (calcium oxalate, calcium phosphate, and struvite) are usually easily diagnosed on survey radiographs where they appear as rounded to spiculated mineral opacities of variable size in the plane of the ureters, urinary bladder and/or urethra. Contrast resolution of modern digital radiography equipment seems to have improved detectability of less opaque and nonopaque calculi (silica, urate, and cystine calculi) compared with previous analog radiography, however in many cases, additional imaging procedures may be needed to identify non-opaque or poorly opaque calculi, especially if they are obscured by overlying pelvic bones. Urinary calculi may become lodged in the urethra and result in partial or complete urethral obstruction. Survey radiographs should be obtained first to rule out opaque calculi. Obtaining standard lateral abdominal view as well as the so-called ‘urethral view’ with the pelvic limbs moved cranially under the abdomen ensures an optimal evaluation of the urethral region. Non-radiopaque calculi located in the intra-abdominal portion of the urethra or in the penile urethra in male dogs, can usually be visualized by means of ultrasonography. Distension of the visible abdominal portion of the urethra and failure to visualize an obstructive lesion on ultrasound necessitate further imaging to rule out an obstruction downstream. Techniques of choice include retrograde positive contrast urethrography or possibly CT. Feline lower urinary tract disease with acute urethral obstruction due to urethral plugs, urolithiasis, urethral stricture or idiopathic obstruction is common. Obstructive opaque urethral stones may be identified on survey radiographs. Ultrasound may provide additional information that can be useful for medical management of the patient; ultrasound abnormalities of the bladder include echogenic urine sediment, bladder wall thickening, pericystic effusion, hyperechoic pericystic fat, and increased...
urinary echoes; reno-ureteral changes include pyelectasia, renomegaly, perirenal effusion, hyperechoic perirenal fat, and ureteral dilation.

Ureteral obstruction is increasingly diagnosed in cats and occasionally seen in dogs. Patients may present with non-specific signs or with renal failure in cases of bilateral obstruction or unilateral obstruction with failing contralateral kidney. Radiographs may reveal mineral opacities in the area of the retroperitoneal space where the ureters are expected to be located. Ipsilateral renomegaly may be seen. Ultrasound is useful to confirm the presence of a ureteral obstruction, with ureteral dilation upstream and variable degrees of hydronephrosis in the ipsilateral kidney. Thickening of the ureteral wall due to concurrent ureteritis may be present. Accurate assessment of the ureters requires high-frequency ultrasound and sedation, or anesthesia of the patient is often necessary to allow for a thorough evaluation of the ureter from the renal pelvis to the trigone. Ultrasound may allow differentiation between ureteral stones and ureteral strictures. Stones appear as hyperechoic structures of variable size and shape. Dependent on size of the calculus and transducer frequency, distal shadowing may be present but may be only faint with ureteral stones, which are usually very small. With a lower-frequency transducer, false negative may happen. In addition, ultrasonographic measurements may overestimate the true size of calculi and should be interpreted with caution whenever the urolith size may influence patient management. Ureteral strictures may appear as focal peri-ureteral hyperechogenicity with dilation of the ureter immediately cranial to this area.

Diagnosis of ureteral obstruction with ultrasound can be challenging. Renal size and the degree of pelvic dilatation are variable in cats with normal renal function, and normal values overlap with values observed in cats with renal disease or urinary obstruction. Studies found that a renal pelvic diameter >13 mm was consistently associated with ureteral obstruction, but the majority of obstructed kidneys have less marked pelvic dilatation, and therefore may appear similar to kidneys affected by chronic kidney disease or pyelonephritis. For these reasons, cats considered equivocal for ureteral obstruction at ultrasonography are candidates for antegrade pyelography, with direct injection of iodinated contrast material into the renal pelvis under ultrasound guidance. Recent studies found that ultrasound may overestimate ureteral obstruction when using antegrade pyelography as the gold standard, however it is also important to note that antegrade pyelography is performed by injecting contrast material in the renal pelvis under pressure, which is likely higher than physiologic ureteral pressure; therefore, clinically significant obstruction may be present that may be relieved during antegrade pyelography.

REFERENCES