HEMATURIA IN SMALL ANIMALS: IS ULTRASONOGRAPHY USEFUL?
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Introduction
Hematuria is a common presenting complaint and can have numerous causes. Hematuria can be confirmed with identification of red blood cells on urine sediment examination. When present, it indicates disease affecting the urogenital system. In this presentation, we will discuss only hematuria of upper (kidneys and ureters) and lower (bladder and urethra) urinary tract origin. Ultrasonography plays a key role in detecting the site of origin of hematuria, unless it is located within the pelvic cavity. The active bleeding site may be challenging to diagnose if there is no significant morphological change or numerous lesions are identified.

Kidneys disorders
Numerous renal disorders may be associated with hematuria. Using clinical cases, the key features of renal changes seen in acute versus chronic nephritis/pyelonephritis, as well as the presence of nephrolithiasis will be presented. Acute tubular and glomerular nephritis and pyelonephritis can be associated with hematuria, and their sonographic features may be increased cortical echogenicity, with or without decreased corticomedullary distinction, and pyelectasia. Anomalies distorting the renal architecture can be encountered in pathologies such as polycystic renal disease (PKD), telangiectasia, and tumors; their features will be discussed. PDK is an autosomal-dominant disease resulting in the formation of numerous variable size cysts deforming the renal contours. Telangiectasia (Welsh Corgi) appears as an inhomogeneous nodule/mass distorting part of the kidney. This appearance can easily be confused with tumor. Renal nodules or masses can be benign or malignant. Benign deforming lesions can be cystadenoma, fibro-epithelial polyp. Renal tumors include adenocarcinoma, nephroblastoma, hemangioma/sarcoma, metastases, disseminated/multicentric tumors such as lymphoma, histiocytic sarcoma.

Any of these disorders may affect the collecting system and result in hematuria/blood clot formation.

Ureter disorders
With inflammation or infection, the ureters can be affected along with the kidneys and/or the bladder. This may result in dilation, thickening of the wall, and change in peristaltic activity. The contents may become more echogenic and ureteroliths appear as mineralized structures associated with shadowing. In rare occasions, ureteral nodule or mass can be identified.

Clinical cases will outline the key features of these different disorders.

Bladder disorders
It is important that the bladder be sufficiently distended to evaluate its thickness. If the normal urinary bladder is insufficiently distended by urine, the wall appears thickened with an irregular mucosal surface.
This can mimic a wall lesion. If needed, sterile saline should be instilled via a urinary catheter to distend the bladder and to distinguish between true thickening and artifact. Bladder disorders can affect the wall and/or the contents. 

**Wall abnormalities** can appear as focal or diffuse thickening, mural nodules or masses and are encountered in case of cystitis and neoplasia. **Content abnormalities** include calculi, gas, blood clots, sediment, and foreign bodies. Calculi and mineralized sediment are found in the dependent portion of the bladder/urethra and appear as hyperechoic interfaces most commonly associated with shadowing, whereas gas is found in the nondependent portion of the bladder and is associated with "dirty" shadowing/reverberation. Blood clots are often amorphous, mildly echogenic and heterogeneous, without acoustic shadowing. They may move with repositioning of the animal, or be adherent to the bladder wall. 

**Cystitis** can result in irregular and variably extensive thickening of the urinary bladder wall, usually more pronounced at the cranio-ventral aspect of the urinary bladder. 

**Polypoid cystitis** is an uncommon form of cystitis reported in dogs. It may appear as pedunculated, variably echogenic nodules projecting from the bladder wall mucosal surface into the lumen. Such forms of polypoid cystitis share ultrasound features with bladder neoplasia and tissue sampling is recommended for final diagnosis. 

**Pseudomembranous cystitis** is due to bacterial or mycoplasma infection and results in severe diffuse ulceration, necrosis, hemorrhage and sloughing of the bladder wall along with intraluminal fibrinous, hemorrhagic and necrotic tags and debris. The ultrasound features include thickening of the wall with irregular mucosal surface associated with hyperechoic bands (sloughing mucosa) and luminal septations. Detached tags and debris can predispose to urethral obstruction. 

**Emphysematous cystitis** can be diagnosed by the presence of gas-forming bacteria within the bladder wall that appear as hyperechoic foci associated with reverberation artifact. This condition is seen most commonly in diabetic animals with glycosuria. Discrimination between intramural gas and free luminal gas (due to catheterization) can be achieved by changing patient positions. 

**Bladder tumors:** **Transitional cell carcinoma** (TCC) is the most common neoplasm of the urinary bladder. It appears typically as an irregular urinary bladder wall mass with a broad-based attachment. The echogenicity is often mixed with variable amount of mineralized foci. The masses are most commonly located at the bladder trigone region and dorsal bladder wall. Due to the location of the ureteral papillae in this region, unilateral or bilateral hydrourerter can occur. It is common for the tumor to extend into the proximal urethra. Color flow Doppler examination commonly reveals the presence of vessels inside the mass. 

Other **bladder tumor types** including epithelial (squamous cell carcinoma) and mesenchymal tumors (botryoid rhabdomyosarcoma, chemodectoma, leiomyosarcoma, leiomyoma, fibroma, fibrosarcoma, hemangioma, hemangiosarcoma, lymphoma, mast cell tumor) can be encountered. Ultrasonographic differentiation of tumor type and differentiating from non-neoplastic disease is often impossible without a biopsy. However, a mass with a smooth luminal surface is more likely to have a mesenchymal origin. Uncommonly, bladder tumors can diffusely invade the bladder wall.
Urethral disorders

Urethritis can occur as an extension of cystitis or ascending inflammation. Thickening of the wall with possibly the presence of calculi or sediment may be detected. The most common urethral tumors in dogs include transitional cell carcinoma, squamous cell carcinoma or adenocarcinoma. Proximal urethral neoplasms are often the result of local spread of bladder or prostatic neoplasms. Urethral transitional cell carcinoma has a markedly hyperechoic non-shadowing mucosal line and may be associated with hypoechoic thickening of the urethral wall.

Enlargement of the medial iliac, hypogastric, sacral or superficial inguinal lymph nodes is not specific to bladder or urethral disease however they should be located and measured to aid the staging of a suspected neoplastic disease.

Interventional procedures

Fine-needle aspirate or core biopsy of focal or diffuse renal change can be performed safely with ultrasound guidance. A free-hand or guide-assisted technique can be used depending on the operator experience and availability of the guide for the transducer. Percutaneous cystocentesis is routinely performed with ultrasound guidance. A small gauge needle (22) is preferred. Suction biopsies of bladder and urethral lesions can be obtained using a red-rubber urinary catheter. This technique is preferred when neoplasia especially TCC of the bladder or urethra is suspected, as it avoids the risk of tumor seeding along the needle track. However, needle-track seeding is rare in small animals, and therefore trans-abdominal fine needle aspiration (FNA) should still be considered when the urethra cannot be catheterized.