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Seminars in ULTRASOUND CT and MRI

CT Imaging of Emergent Renal Conditions

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The kidneys are paired intra-abdominal organs which provide essential functions and maintain homeostasis throughout the human body. Numerous disease processes affect the kidneys and cause acute renal dysfunction or other potentially catastrophic complications. These conditions can be broadly categorized into obstructive, infectious, hemorrhagic, traumatic, and vascular diseases. Imaging plays a vital role in the work-up and diagnosis of acute and emergent renal conditions. Evaluation of emergent renal conditions with a focus on CT imaging is discussed.
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Role of Imaging

The kidneys are susceptible to many disease processes, many of which are chronic. These include systemic disorders such as diabetes, hypertension, lupus, and congestive heart failure. Inflammatory disorders which can specifically involve the kidneys include nephrotic syndrome, Goodpasture's disease, and various glomerulonephritides. Imaging is of little use in evaluating renal involvement in these diseases, other than to exclude obstruction and to gauge the extent of kidney damage by estimation of size and parenchymal atrophy. Imaging also plays little role in the overwhelming majority of urinary tract infections, as most are confined to the lower urinary tract and treated with antibiotics.

The role of imaging, however, is critical in the work-up and diagnosis of acute and emergent renal conditions. Ultrasound can be initially utilized as it is readily available, quickly performed, and free of ionizing radiation. Ultrasound is the initial modality of choice for pregnant and pediatric patients. Strengths of ultrasound include diagnosing hydronephrosis and stone disease. However, it has poor sensitivity for the diagnosis of pyelonephritis and hemorrhage.

Cross-sectional imaging quickly and accurately diagnoses abnormalities such as obstruction, stone disease, infection and abscess, hemorrhage, and active bleeding. Computed tomography (CT) is the imaging modality of choice in the emergent setting, with magnetic resonance imaging (MRI) often reserved as a problem-solving modality. This article will discuss acute and emergent renal conditions with a focus on CT imaging; MR and ultrasound findings will be discussed when pertinent.

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Obstructive Uropathy

Urolithiasis

Urolithiasis (Fig. 1) is the most common cause of obstructive uropathy and affects approximately 1.2 million Americans per year, with a recurrence rate of up to 75% within 20 years.[1] Unenhanced Multidetector CT (MDCT) is the imaging modality of choice for the evaluation for urolithiasis given its high sensitivity (95%-98%) and specificity (96%-100%).[2] For pregnant and pediatric patients, ultrasound may be utilized as an initial modality given no ionizing radiation; however, sensitivity in detecting renal calculi is significantly lower, reported to be 26% for calculi between 3 and 7 mm and 71% for calculi >7 mm.[3] The use of color Doppler and "twinkling artifact" improves the sonographic sensitivity of ultrasound to 90%, compared with 11%-24% using gray-scale ultrasound alone.

Management of urolithiasis is governed by patient symptomatology and calculi size, location, and composition. In asymptomatic patients, nonobstructing renal calculi smaller than 10 mm are observed, while patients with or without symptoms with larger calculi may undergo an intervention such as shock wave lithotripsy, ureterorenoscopy, or percutaneous nephrolithotomy.[1,4] Calculi smaller than 6 mm have an excellent probability of spontaneous passage. CT findings which have been consistently associated with the need for urologic intervention include large stone size and proximal

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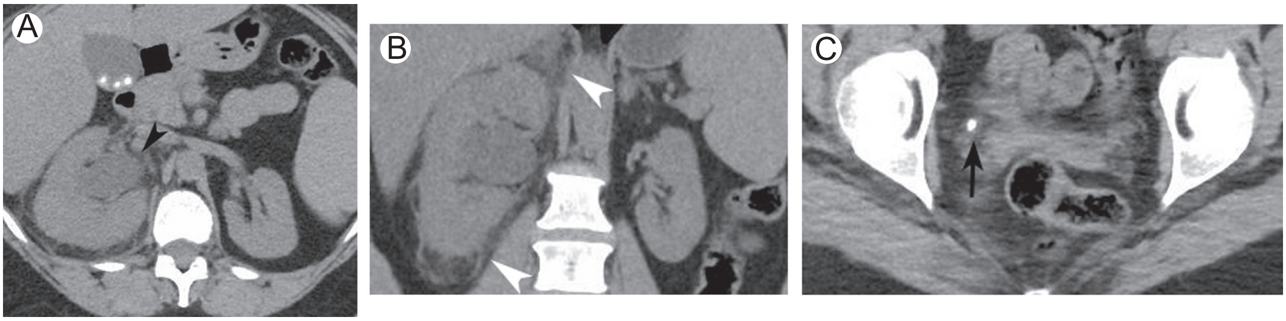

Figure 1 Acute renal obstruction due to ureteral stone. A 54-year-old woman with right flank pain. (A) Axial noncontrast CT image demonstrates right hydronephrosis (black arrowhead). (B) Coronal noncontrast CT image demonstrates right hydronephrosis and significant stranding of the perinephric fat (white arrowhead). (C) Axial noncontrast CT image demonstrates a 4-mm calculus (black arrow) obstructing the distal ureter adjacent to the UVJ.

ureteral location. For example, Massaro et al found that the risk of intervention increased 2.2-fold for every millimeter increase in stone diameter and with proximally located stones.[5] Lotan et al showed a trend toward intervention in larger (average size 6.5 mm in diameter) and more dense stones (average density of 910 HU), as well as proximal ureteral location. Denser stones are known to be more resistant to lithotripsy, and therefore may need treatment with ureteroscopy and laser fragmentation.[6] Interestingly, both of these studies failed to find a significant association with the degree of hydronephrosis on CT and intervention. Following lithotripsy, passage of small calculi fragments in the form of "Steinstrasse" (German for "stone street"), which refers to stone fragments lining the distal ureter, may occur and usually resolves spontaneously (Fig. 2).[7]

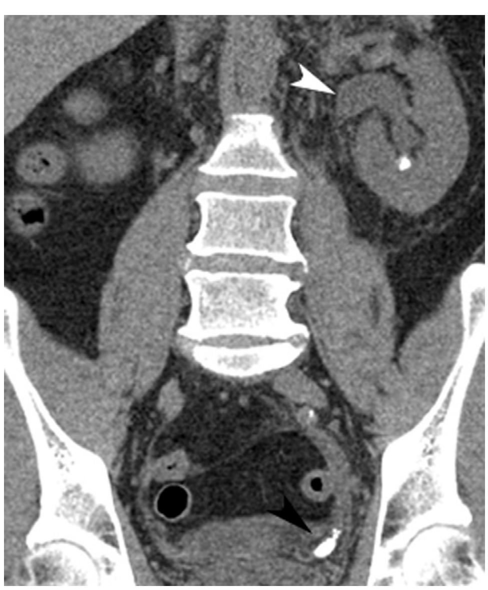

Figure 2 Steinstrasse. A 56-year-old man status post extracorporeal shock wave lithotripsy (ESWL) 10 days prior presented with left flank pain. Coronal unenhanced CT shows left-sided hydroureteronephrosis (white arrowhead) with multiple calculi in the distal ureter (black arrowhead). This is a known complication after stone fragmentation from ESWL and is termed "Steinstrasse" (German for "stone street").

Neoplasm

Obstruction of the urinary tract from a neoplasm can occur at the level of the renal pelvis, ureter, bladder, or urethra. Obstruction can be related to an intrinsic process such as a primary urothelial neoplasm (Fig. 3) or an extrinsic process such as encasement of the ureter by metastatic disease or primary tumor of the pelvis/retroperitoneum (Fig. 4).

Visualization of an obstructive neoplastic process is aided by utilization of CT Urography. CT Urography is a multiphase study which provides a comprehensive assessment of the renal parenchyma, urinary collecting system, bladder, and surrounding structures. Unenhanced CT is first obtained to detect calculi, evaluate masses for fat/calcium, reveal unenhanced masses throughout the urinary tract, and provide a baseline attenuation to assess for enhancement of masses and other abnormalities.[8] Enhanced imaging is then obtained during a nephrographic phase (when the renal cortex and medulla are uniformly enhanced) which occurs at approximately 100-120 seconds after intravenous contrast administration. Subsequently, excretory phase imaging is obtained in order to evaluate the urothelium.[8] The goal of this technique is to

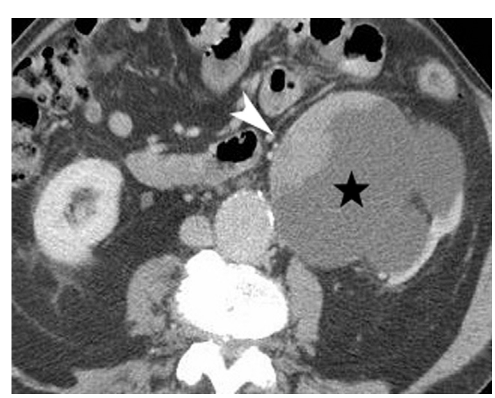

Figure 3 Obstructive uropathy secondary to urothelial cancer. An 83-year-old man who underwent imaging for abnormal renal function. Axial contrast-enhanced CT image demonstrates massive left hydronephrosis (black star) secondary to a large obstructing soft tissue mass in the left renal pelvis (white arrowhead). Transitional cell carcinoma was diagnosed on pathological analysis.