Renal Ultrasound

Joel P. Thompson, MD, MPH*, Shweta Bhatt, MD

KEYWORDS

• Ultrasound • Renal cyst • Renal pseudotumor • Renal pathology • Renal tumor
• Renovascular hypertension • Renovascular pathology

KEY POINTS

- Familiarization with the appearance of common renal congenital variants and renal pseudotumors is key in differentiating these mimics from renal neoplasms.
- Hydronephrosis may be obstructive or nonobstructive in etiology. Urolithiasis is the most common obstructive cause, demonstrated as foci of well-defined echogenicity with sharp posterior shadowing and posterior twinkle artifact on Doppler.
- Renal cystic disease may be caused by both inherited and noninherited causes. The differential diagnosis may be narrowed based on the presence of nephromegaly, discrete cysts versus numerous microcysts, and the identification of multiorgan involvement.
- Renal neoplasms may be detected on renal ultrasound, which is particularly good at demonstrating renal vein involvement. Although CT and MR imaging are often used to characterize lesions, contrast-enhanced ultrasound is emerging as an alternative imaging modality.
- Spectral Doppler ultrasound is useful in the setting of suspected renovascular hypertension, with direct signs including visualization of the stenosis, increased peak systolic velocity greater than 200 cm/s, and increased renal-to-aorta peak systolic velocity greater than 3.5. Indirect signs include tardus parvus waveform distal to the stenosis.

INTRODUCTION

Ultrasonography may be used for the detection, characterization, and follow-up of a wide variety of acute and chronic renal pathology. The sonographic evaluation of adults may detect congenital abnormalities or be used to further characterize abnormalities on other imaging modalities. Ultrasound is often the initial imaging modality in the emergency department for evaluation for suspected obstructive nephropathy. Although CT or MR imaging is often the gold standard, renal masses and pseudotumors may be further characterized and followed using ultrasound. Color and spectral Doppler imaging is useful for the detection of a variety of vascular and nonvascular pathologies.

The objective of this article is to provide an overview of renal pathology with emphasis on the role of ultrasound in their diagnosis and follow-up evaluation.

RENAL ANATOMY

The kidneys are paired retroperitoneal structures on either side of the vertebral column at the level of T12-L3 vertebrae. Each kidney is approximately 10 to 12 cm in length, 4 to 5 cm in width, and 2.5 to 3 cm in thickness.[1] At the medial aspect of each kidney is the concave-shaped renal hilum, which contains the renal artery, renal vein, renal pelvis, and renal sinus fat.

Renal pyramids and their overlying cortex form a lobulated contour. Between each pyramid is an extension of renal cortex, termed *column of Bertin*. The renal cortex contains glomeruli and the renal pyramids comprise collecting tubules. At the tip of each medullary pyramid is a renal papilla, from

Department of Imaging Sciences, University of Rochester School of Medicine and Dentistry, 601 Elmwood Avenue, Box 648, Rochester, NY 14642, USA
* Corresponding author.
E-mail address: Joel_Thompson@urmc.rochester.edu

Ultrasound Clin 9 (2014) 653–681
http://dx.doi.org/10.1016/j.cult.2014.07.011
1556-858X/14/$ – see front matter

which urine empties into a minor calyx. Two to 3 minor calyces empty into a major calyx; 2 to 3 major calyces then empty into the renal pelvis, which is continuous with the ureter.

SONOGRAPHIC TECHNIQUE

Sonographic evaluation of the kidneys is best performed with a low frequency transducer, usually 2 to 5 MHz, depending on a patient's body habitus.[2] Lower frequencies provide deeper tissue penetration; higher frequencies provide improved image resolution. Visualization of the right kidney is often best performed using the liver as an acoustic window via an anterior oblique approach. The left kidney is located more superiorly than the right kidney, and its upper pole can be visualized using the spleen as an acoustic window via an intercostal approach. A subcostal approach may also be used to evaluate the upper poles during a maximum inspiration breath-hold. The lower poles of both kidneys may be targeted using a posterior approach. Decubitus, prone, or upright positioning may, however, enable optimal imaging, particularly of the left kidney, due to adjacent stomach and air-filled bowel.[2]

Both long-axis and transverse views of the kidneys should be obtained, along with evaluation of the renal hilum. The right kidney should be hypoechoic to the liver, whereas the left kidney should be isoechoic or hypoechoic to the spleen (**Fig. 1**). A long-axis measurement of renal length should be recorded for each kidney; a length discrepancy of 2 cm or greater is considered significant and should be further evaluated for a possible cause for the discrepant sizes.

CONGENITAL NORMAL VARIANTS

The adult kidneys are formed from the metanephros, which develops at week 5 of gestation and begins to function at approximately week 9.[3] The metanephros contains the ureteric bud, which forms the calices and ureters, and the metanephrogenic blastema, which forms the renal parenchyma. The kidneys are formed within the pelvis at approximately week 5 of gestation, then ascend and rotate medially approximately 90° until the hila are directed medially. The kidneys attain their normal adult location by the ninth week of gestation.[1]

Renal pseudotumors, or tumor mimics, are often developmental variants resulting from abnormal renal growth. A common pseudotumor is *persistent fetal lobulation* (**Fig. 2**), which is seen when normal fetal lobulations fail to diminish at the end of the fetal period. The indentation between prominent lobules overlies columns of Bertin, which differentiates fetal lobulations from scarring (which overlies renal pyramids).

Prominent columns of Bertin are intrusions of hypertrophied cortical tissue found between medullary pyramids. Prominent columns of Bertin are most often located at the junction between the upper and middle thirds of the kidney and more frequently in the left kidney (left-to-right ratio 2:1).[4] The ultrasound appearance is of a soft tissue mass isoechoic to renal cortex that extends into the hyperechoic renal sinus, usually oriented perpendicular to the renal cortex (**Fig. 3**). The overlying renal contour is usually normal. Occasionally, prominent columns of Bertin may appear more echogenic than overlying cortex due to anisotropic effect.[3,5]

A *dromedary hump* is a focal bulge along the superolateral margin of the left kidney, formed due to impression by the adjacent spleen (**Fig. 4**). Because a dromedary hump comprises cortical tissue, it may be differentiated from a

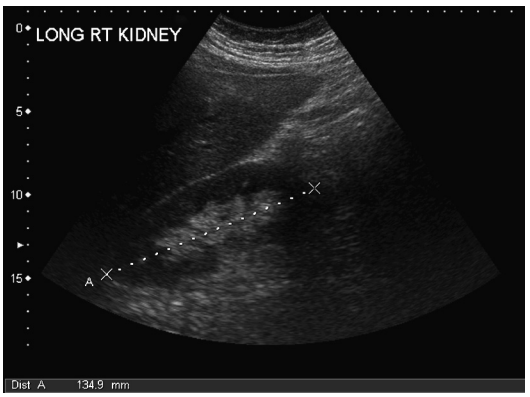

Fig. 1. Normal ultrasound appearance of the right kidney. The liver is used as an acoustic window and is isoechoic to the kidney.

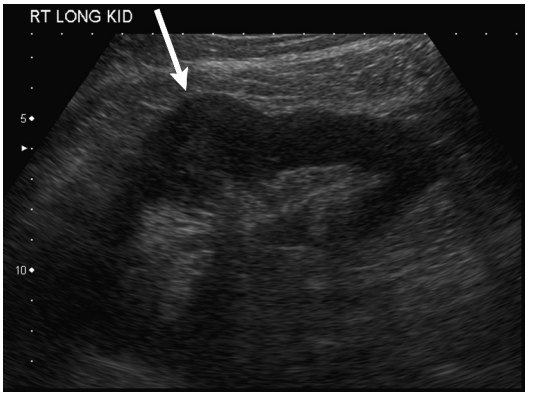

Fig. 2. Persistent fetal lobulation. Longitudinal ultrasound image of the right kidney demonstrates a lobular pseudotumor (*arrow*) comprised of renal cortex, with lateral margins overlying columns of Bertin.