Imaging of Cystic Renal Masses

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KEYWORDS

• Renal • Kidney • Bosniak • Classification • Cystic • Complex • Indeterminate

KEY POINTS

- Cystic renal lesions are generally more indolent than solid renal lesions.
- The Bosniak classification system is an imaging framework for differentiating benign and malignant cystic renal masses.
- The key feature that separates malignant from benign Bosniak cystic lesions is that Bosniak 3 and 4 lesions demonstrate enhancement of solid components. Benign lesions do not demonstrate internal solid enhancement.
- Although gray-scale ultrasound is useful for definitive characterization of simple renal cysts, it tends to erroneously upgrade benign renal cysts, which have internal debris, given its high sensitivity to morphology and lack of sensitivity to internal vascularity.
- The Bosniak classification system is a contrast-enhanced CT-defined classification system; however, it has been shown to be equally accurate when applied to contrast-enhanced MR imaging.

INTRODUCTION: DISCUSSION OF PROBLEM/CLINICAL PRESENTATION

Cystic renal masses are a common diagnostic challenge in daily imaging. These lesions are frequently detected incidentally in patients imaged for other reasons, and the optimal management of these lesions can be challenging. Both benign and malignant renal lesions may have a cystic imaging appearance. The imaging definition of "cystic" is a lesion that, on imaging, has a mostly fluid-filled growth pattern with a solid portion occupying a maximum of one-fourth of the tumor volume[1–3] or a mass that is mostly composed of fluid-filled spaces.[4] Cystic renal mass lesions represent only 15% of all renal mass lesions (the other 85% are solid renal masses)[5,6] and malignant cystic renal lesions are associated with a much lower morbidity and mortality rate than malignant solid renal mass lesions.[1,7–11] This more indolent behavior of malignant cystic renal masses than malignant solid renal masses allows greater leeway in surveillance imaging of cystic renal masses, prior to definitive surgical intervention.

The most common benign cystic renal mass is a simple renal cyst, which is estimated to be seen incidentally in up to 17% to 41% of patients imaged for other reasons.[12,13] Typically, these simple renal cysts can be readily diagnosed as benign on the initial imaging study that detected them[14] and appropriately ignored. The diagnostic challenge with cystic renal masses is distinguishing between benign and malignant complex cystic renal masses. The Bosniak classification system, introduced in 1986 by Dr Morton Bosniak, provides a robust imaging approach for the differentiation of benign and malignant cystic renal masses and is widely used in the international urologic and radiologic communities for its utility in assisting with management of these lesions.[15–21]

This article reviews the imaging evaluation of cystic renal masses (through the Bosniak classification), discusses the CT and MR imaging

Disclosure Statement: The author has nothing to disclose.
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Radiol Clin N Am ■ (2016) ■–■
http://dx.doi.org/10.1016/j.rcl.2016.10.004

techniques for evaluation of the cystic renal mass, provides an image-rich differential diagnosis of cystic renal mass lesions (benign and malignant), and reviews current approaches to management of these lesions.

NORMAL ANATOMY AND IMAGING TECHNIQUE: DISCUSSION OF IMPORTANT ANATOMIC CONSIDERATIONS

Most renal masses, including cystic renal masses, are found incidentally at the time of cross-sectional imaging for another reason.[4,16,22,23] Most of these incidental masses are simple renal cysts that can be diagnosed at the time of the initial scan without additional work-up or treatment.[4,22] Incidental solid and complex cystic masses may also be found, however, which need characterization, because some are malignant and need to be surgically excised, and others are benign. Careful attention to proper technique in evaluating these masses is essential to guide appropriate management. If the initial examination that detects the cystic renal mass is inadequate for characterization, then a dedicated renal mass CT or MR imaging can be performed, with gray-scale sonography reserved for the characterization of suspected simple cysts or some proteinaceous cysts. The CT and MR imaging protocols and recommended technique for the analysis of renal masses are presented, with the acknowledgment that these protocols are not extensive (for example, the presurgical work-up of a known malignant renal mass, including arterial, nephrographic, and urographic phases, is not included, for the sake of brevity).

CT TECHNIQUE

For evaluation of a known renal mass, a CT scan must include a noncontrast examination prior to the contrast-enhanced examination, because a noncontrast baseline is essential to determine true enhancement on the postcontrast scan. Nonionic intravenous contrast is given at a weight-based dose (1.5 mL/kg), using a power injector for a rate of 3 mL/s to 4 mL/s to guarantee that a high concentration of intravenous contrast is delivered for uniform opacification of the kidneys postcontrast. By using a multidetector row CT scanner, contrast material–enhanced imaging is routinely performed using a scan delay of 80 seconds to 90 seconds; this should ensure that there is opacification of the renal arteries and that there is a uniform nephrogram in the kidneys. In select cases, a corticomedullary phase at a 40-second delay also is added to the evaluation of the renal mass, particularly if a vascular lesion (pseudoaneurysm) or if a renal pseudotumor (column of Bertin) is suspected. Renal mass lesion should not be characterized on the corticomedullary phase of contrast enhancement, because renal masses may have attenuation similar to that of the renal medulla and are invisible on this phase of contrast. Additionally, hypoenhancing renal lesions, such as papillary neoplasms, may not demonstrate internal enhancement on this phase.

Typically, the data sets are acquired at 0.6 mm and are reconstructed to 4-mm sections, which are sent to a picture archiving and communication system (PACS). If smaller slices are required for analysis of a small renal tumor, then these thinner slices (various multiples of 0.6 mm) are evaluated on the scanner or workstation, without need to rescan the patient (**Table 1**). This data set can then be analyzed on a 3-D workstation to create volume-rendered and 3-D images, for improved analysis of the renal tumor and its relationship to renal vasculature and the hilum.

The Bosniak classification is a CT-defined classification system,[14,24] and imaging performed on a multidetector CT scanner, using the previously described renal mass technique,[25] characterizes most renal cystic lesions. Known challenges in using CT for lesion characterization include the phenomenon of pseudoenhancement (the artifactual increase in attenuation on contrast-enhanced CT images by 10 Hounsfield units [HU] or more, thought to be secondary to beam hardening artifact) and the pitfall of partial volume averaging in small lesions (which occurs when the size of the lesion is less than twice the slice thickness used to scan).[26] Virtual monochromatic imaging in dual-energy multidetector CT may completely eliminate renal cyst pseudoenhancement in cysts larger than 1.5 cm.[27]

MR IMAGING TECHNIQUE

The average renal mass MR exam lasts approximately 30 minutes on the magnet, which can be a long time for a patient who is not adequately prepared for the examination. Therefore, discussion with patients about the length of a scan, the breath-holds required, the placement of phased array coils in contact with the body, and the noises (from gradient coil switching) should be explained; this helps decrease anxiety. At the author's institution, all breath-hold sequences are held during end expiration (because this has been shown to have improved diaphragmatic level reproducibility and thus allows for improved registration on subtraction images).[28]