Approach to Renal Cystic Masses and the Role of Radiology

Andrew D. Smith, MD, PhD*, Asser Abou Elkassem, MD

KEYWORDS

- Bosniak classification system • Renal cysts • Cystic renal masses

KEY POINTS

- The first step in evaluation of a renal mass is to determine if it is cystic or solid and apply the Bosniak classification system version 2019.
- The need for additional characterization depends on the initial imaging modality and the imaging features that can be used for Bosniak classification.
- The Bosniak classification should not be applied to cystic appearing infectious, inflammatory, or vascular etiologies; for all other renal cystic masses with imaging that allows for a complete characterization, the Bosniak classification should be applied.

IS IT A RENAL CYST?

The first step in the evaluation of a renal mass is to determine if it is cystic or solid.[1] Completing this task is critical for management, and the imaging modality is important. The Bosniak classification system version 2019 considers a renal lesion with less than 25% enhancing tissue as cystic, but multiple other definitions for defining a renal cyst now apply and are described elsewhere in this article.[1] In general, the use of colloquial terms that lack standard definitions, such as "complicated cyst" or "complex cyst," should be avoided, although these terms are common in clinical practice for indeterminate renal cysts that require further characterization by renal computed tomography (CT) scan or MR imaging or renal ultrasound examination.

One of the most commonly encountered renal lesions on CT scan are those that are considered too small to characterize (TSTC) owing to problems with volume averaging when attempting to assess the attenuation.[1–4] Homogeneous low-attenuating renal lesions that are TSTC are now considered benign cystic masses.[1] By comparison, a heterogenous renal lesion that is TSTC by CT scan is rarely encountered, but is indeterminate and cannot be assumed to represent a renal cyst, because some of these lesions may represent solid renal neoplasms (**Fig. 1**).[1,2]

To characterize a larger renal lesion on CT scan, a region of interest is used to assess the attenuation in Hounsfield units (HU). If the attenuation of 75% or more of a renal lesion on noncontrast or contrast-enhanced CT scanning measures as fluid attenuation (-9 to 20 HU), it can be considered cystic.[1,2,5–7] The cystic component of a renal cyst may not measure fluid in attenuation, and enhancement is key to differentiating a hyperdense renal cyst from a solid renal neoplasm. Renal masses with less than 25% enhancing tissue are considered cystic, with enhancement on CT scans defined as an increase of 20 HU or more between noncontrast and contrast-enhanced images, most commonly from dedicated renal protocol CT acquisition.[1,8] In addition, homogeneous hyperattenuating ($\geq$70 HU) renal

Department of Radiology, University of Alabama at Birmingham, JTN 452, 619 19th Street South, Birmingham, AL 35249-6830, USA
* Corresponding author.
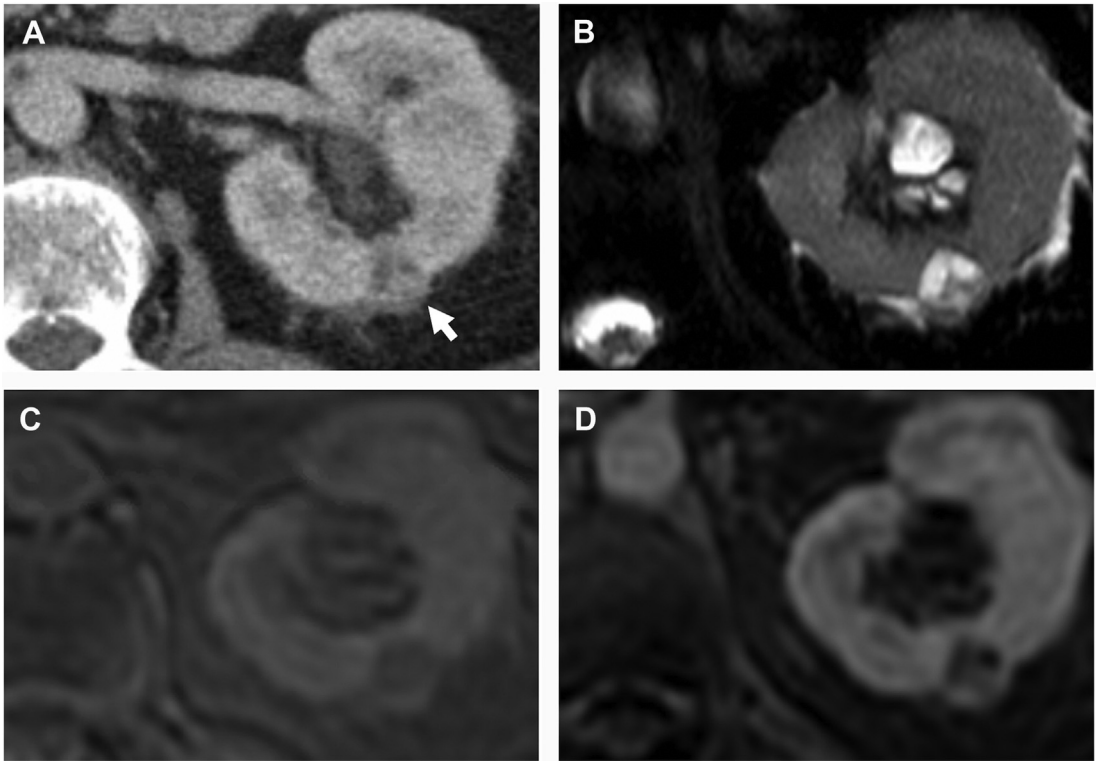E-mail address: andrewdennissmith@uabmc.edu

Fig. 1. A 58-year-old woman with a 1.1-cm heterogeneous left renal mass on a portal venous CT scan that is TSTC (*arrow, A*). This lesion was indeterminate owing to heterogeneity and further evaluated by renal MR imaging and found to be hyperintense with septations on T2-weighted imaging (*B*), hypointense on pre-contrast T1-weighted fat-saturated images (*C*), and had enhancing septations on post-contrast T1-weighted fat-saturated images (*D*). The lesion was characterized as a Bosniak type IIF renal cystic mass.

lesions at noncontrast CT scanning and homogenous renal lesions measuring −9 to 30 HU at portal venous phase CT scanning are considered benign cystic masses.[1,3,9–13] By comparison, all heterogeneous masses at noncontrast CT scanning are considered indeterminate and could be cystic or solid in nature.[1,2]

The role and reliability of dual energy CT scanning for characterizing renal masses is under investigation in research studies and not yet incorporated into the Bosniak classification system.[14,15] More validation is needed in this area of research. Given the decreased importance of renal enhancement in the Bosniak classification system version 2019, characterization and Bosniak classification of many well-defined renal cysts on dual energy CT images may be possible, especially if 75% or more of the renal mass measures fluid attenuation (−9 to 20 HU) at 120 kV imaging.

On MR imaging, a renal cyst is defined as a renal mass with less than 25% enhancing tissue, with enhancement defined as an increase of 15% or more in signal intensity between contrast-enhanced and noncontrast images or as definitive visual enhancement on high-quality subtraction images.[1,16] On noncontrast MR imaging, homogeneous masses markedly hyperintense at T2-weighted imaging (similar to cerebrospinal fluid) and homogeneous masses markedly hyperintense at fat-saturated T1-weighted imaging (approximately 2.5 times normal renal parenchymal signal intensity) are considered benign cystic masses (Bosniak type II).[1,17–19] Conversely, homogeneous renal masses with mild to moderate intensity at T1- or T2-weighted imaging or heterogenous masses on noncontrast MR imaging are indeterminate and cannot be classified as cystic without further characterization.[1] Furthermore, heterogeneously hyperintense renal masses at fat-saturated T2-weighted imaging cannot be classified as cysts, because some represent necrotic papillary cancers.[1]

On ultrasound examination, a renal cyst is anechoic or hypoechoic with posterior acoustic enhancement (or increased through-transmission).[1] The posterior acoustic enhancement is a key feature, as some solid masses can be hypoechoic but lack posterior acoustic enhancement. Additional features such as debris, wall thickening, color flow, and number, thickness, and nodularity

of septations can also be evaluated and should be used to assist with characterization.[1] On contrast-enhanced ultrasound examination, a renal cyst is defined as a renal lesion with less than 25% enhancing tissue.[1]

DOES THIS RENAL MASS NEED FURTHER CHARACTERIZATION?

The need for additional characterization of a renal mass depends on the initial imaging modality and the imaging features that can be used for Bosniak classification (**Table 1**).[1] With the exception of homogeneous renal lesions that are TSTC, if a renal lesion is not well-defined or not clearly cystic, further characterization by imaging is needed.[1–4] Most renal lesions are detecting on noncontrast or portal venous CT examinations that are obtained for other purposes, and the Bosniak 2019 classification leads to confident characterization as benign cystic lesion, although for a minority of cases the Bosniak rules cannot be applied completely without additional imaging.[1] A review of renal masses requiring further characterization by additional imaging is presented in **Table 2**.

Notable changes in the Bosniak classification system are that the presence or absence of contrast enhancement and extent of calcifications are less important, whereas wall and septation thickness and protrusions are now key features.[1] Even a simple cyst may have wall enhancement in version 2019. Given this change, the Bosniak classification system can be applied to the majority of well-defined renal cysts that lack thickened walls and are identified on portal venous CT scans (**Fig. 2**).

Many renal lesions that are incompletely characterized on CT scans are considered low risk and do not need additional characterization. For example, homogeneous low-attenuating renal lesions that are TSTC on CT images are Bosniak II renal masses and do not require further imaging or workup.[1–4,8] Despite the limitations of noncontrast CT imaging, several types of cystic lesions are considered low risk and do require additional imaging or follow-up. Homogeneous hyperattenuating (≥70 HU) renal masses on noncontrast CT scans are considered Bosniak II renal cystic masses and do not require additional imaging or follow-up.[1,3,9,10] Furthermore, homogeneous fluid attenuating (−9 to 20 HU) renal masses on noncontrast CT scans are considered Bosniak type II renal cystic masses and do not need additional imaging or follow-up.[1–4,8] Importantly, the term "simple cyst" does not apply to noncontrast CT scans and should only apply to contrast-enhanced CT scans, because contrast enhancement is needed

to confirm the absence of wall thickening or septations that are needed to classify a Bosniak type I renal cyst.[1]

Several renal lesions identified on noncontrast CT scans need further characterization with imaging, including any renal lesion with a heterogeneous appearance or any lesion measuring soft tissue in attenuation (>20 to <70 HU).[1,2,8] The rarely encountered heterogenous renal lesion that is TSTC on noncontrast or contrast-enhanced CT scanning (see **Fig. 1**) should be further characterized by renal MR imaging to determine if the heterogeneous appearance is due to septations in a cystic renal mass or indicative of a solid renal mass, although this distinction can often be made 6 to 12 months after the initial discovery owing to the small size.[1,2,8] The homogeneous soft tissue attenuating (21–69 HU) renal mass on a noncontrast CT scan is typically evaluated by ultrasound imaging to determine if it is a hyperdense cyst or solid renal mass (**Fig. 3**); however, larger patients may be best evaluated with a renal CT scan or MR imaging owing to suboptimal ultrasound penetration related to attenuation by large amounts of body fat.[1,2,8]

On a contrast-enhanced CT scan, a simple renal cyst does not require additional imaging or workup and is defined as a renal cyst with a well-defined, thin (≤2 mm), smooth wall that may enhance, homogeneous simple fluid (−9 to 20 HU), and no septa or calcifications.[1] In the past, homogenous renal lesions measuring 21 HU or more on portal venous CT scans required additional workup to differentiate solid from cystic components.[1,2,5–8] Recent evidence suggests that well-defined homogeneous masses measuring 40 HU or more on portal venous CT scans are likely benign cysts, but the optimal attenuation threshold is unclear, and the Bosniak classification system now considers renal masses that measure −9 to 30 HU on portal venous CT scans as a benign Bosniak type II renal mass that do not need further characterization or follow-up.[1,11–13]

Conversely, any mass on a portal venous CT scan with an attenuation of greater than 30 HU should be further evaluated, because it could represent a solid renal mass.[1] Again, ultrasound imaging is typically used to differentiate solid from cystic renal masses, although larger patients may be best evaluated by renal CT scans or MR imaging.[1,2,8]

A well-defined cystic renal mass on a portal venous CT scan with 75% or more of the lesion measuring fluid attenuation, does not necessarily need additional characterization if the walls and septations are clearly delineated (see **Fig. 2**), because the Bosniak classification system can be applied to these renal masses.[1] Heterogeneous

Table 1
Bosniak classification system version 2019 of cystic renal masses

Class	CT Scan[a]	MR Imaging[a]	Ultrasound Examination[c]
I	Well-defined cyst with thin (<2 mm) smooth wall; homogeneous simple fluid (−9 to 20 HU); no septa or calcifications; the wall may enhance	Well-defined cyst, thin (≤2 mm) smooth wall; homogeneous simple fluid (signal intensity similar to CSF); no septa or calcifications; the wall may enhance	Well-defined cyst (anechoic with posterior acoustic enhancement), thin (≤2 mm) smooth wall; no septa or calcifications
II	Well-defined cyst with thin (<2 mm) smooth walls: 1. Cystic masses with thin (<2 mm) and few (1–3) septa; septa and wall may enhance; may have calcification of any type[b] 2. Homogeneous hyperattenuating (>70 HU) masses at noncontrast CT scan 3. Homogeneous nonenhancing masses >20 HU at renal mass protocol CT scan, may have calcification of any type[b] 4. Homogeneous masses −9 to 20 HU at noncontrast CT scan 5. Homogeneous masses 21–30 HU at portal venous phase CT scan 6. Homogeneous low-attenuation masses that are TSTC	Well-defined cyst with thin (≤2 mm) smooth walls: 1. Cystic masses with thin (≤2 mm) and few (1–3) enhancing septa; any nonenhancing septa; may have calcification of any type[b] 2. Homogeneous masses markedly hyperintense at T2-weighted imaging (similar to cerebrospinal fluid) at noncontrast MR imaging 3. Homogeneous masses markedly hyperintense at T1-weighted imaging (approximately 2.5 times normal parenchymal signal intensity) at noncontrast MR imaging	Well-defined cyst with thin (≤2 mm) smooth walls: 1. Cystic masses that are anechoic or hypoechoic and contain thin (≤2 mm) and few (1–3) septa; septa and wall may have color flow; may have well-defined calcification that does not obstruct other imaging features 2. Cystic masses that are hypoechoic or that contain debris; no septations, may have well-defined calcification that does not obstruct other imaging features
IIF	Cystic masses with a smooth minimally thickened (3 mm) enhancing wall, or smooth minimal thickening (3 mm) of ≥1 enhancing septa, or many (>4) smooth thin (<2 mm) enhancing septa	1. Cystic masses with a smooth minimally thickened (3 mm) enhancing wall, or smooth minimal thickening (3 mm) of ≥1 enhancing septa, or many (≥4) smooth thin (≤2 mm) enhancing septa 2. Cystic masses that are heterogeneously hyperintense at unenhanced fat-saturated T1-weighted imaging	Cystic masses with a smooth minimally thickened (3 mm) wall that may have color flow, or smooth minimal thickening (3 mm) of ≥1 septa that may have color flow, or many (≥4) smooth thin (≤2 mm) septa that may have color flow; may have well-defined calcification that does not obstruct other imaging features
III	≥1 enhancing thick (>4 mm width) or enhancing irregular (displaying <3-mm obtusely margined convex protrusion[s]) walls or septa	≥1 enhancing thick (≥4 mm width) or enhancing irregular (displaying ≤3-mm obtusely margined convex protrusion[s]) walls or septa	Not applicable to routine renal ultrasound examination[c]

(*continued on next page*)

Table 1 (continued)			
Class	CT Scan[a]	MR Imaging[a]	Ultrasound Examination[c]
IV	≥1 enhancing nodule(s) (>4-mm convex protrusion with obtuse margins, or a convex protrusion of any size that has acute margins)	≥1 enhancing nodule(s) (≥4-mm convex protrusion with obtuse margins, or a convex protrusion of any size that has acute margins)	Not applicable to routine renal ultrasound examination[c]

Abbreviation: CSF, cerebrospinal fluid.

[a] The Bosniak classification is intended for cystic renal masses after infectious, inflammatory, or vascular etiologies and necrotic solid masses are excluded. If a cystic mass has features described in >1 Bosniak class, the highest Bosniak class is assigned. In rare cases, a mass may have an unusual combination of features (undefined, not fitting a specific Bosniak class) that may warrant inclusion into Bosniak type IIF. Other than for the diagnosis of Bosniak type I simple cysts, the role of ultrasound examination with or without contrast material in assigning a Bosniak class is uncertain.

[b] Renal masses that at CT scan have abundant thick or nodular calcifications; are hyperattenuating, homogeneous, nonenhancing, and >3 cm; or are heterogeneous (including but not limited to many [≥4] nonenhancing septa or ≥3 mm nonenhancing septa or wall) might best be visualized at MR imaging before the assignment of a Bosniak class to determine if there are occult enhancing elements that might affect classification.

[c] Ultrasound criteria were not specifically discussed in the Bosniak classification system version 2019 table, but are inferred from the text.[1] Cystic renal masses with thickened walls (>4 mm width) or thickened or irregular septations without or with color flow should be further evaluated by renal CT scan or MR imaging. Many radiology practices choose to follow Bosniak type IIF renal cysts by ultrasound examination, but it is unclear if this is sufficient to identify changes in complexity that are associated with a higher malignancy rate.

renal masses that are not clearly cystic, that have ill-defined features on portal venous CT scans, or that are evaluated on another contrast-enhanced phase (eg, arterial phase) need further characterization by renal CT scans or MR imaging.[1,2,8] In cases where the renal mass is not clearly cystic, renal ultrasound examination may be of benefit; however a renal CT scan or MR imaging may be needed if the patient is too large for a high-quality ultrasound examination to be obtained or if the entire lesion is cannot be fully characterized using ultrasound examination, or the if walls are thickened (≥4 mm) on ultrasound imaging.[1,2,8]

In the past, there were few guidelines on how to characterize a renal mass as cystic on noncontrast MR imaging. The Bosniak classification system version 2019 provides new and important information. Homogeneous renal masses that are markedly hyperintense at T2-weighted imaging (similar to cerebrospinal fluid) on noncontrast MR imaging are considered Bosniak II renal cystic masses (**Fig. 4**). Lesions meeting this criteria are commonly encountered on abdominal and spinal noncontrast MR imaging and no longer need further characterization.[1,19] In addition, homogeneous renal masses that are hyperintense at T1-weighted imaging (approximately 2.5 times normal parenchymal signal intensity) at noncontrast MR imaging are also considered benign Bosniak II renal masses and do not need further characterization.[1,17,18] By comparison, renal masses with low to intermediate signal on T1- or T2-weighted intensity on noncontrast MR imaging are

indeterminate and require further characterization by renal CT scans or MR imaging without and with intravenous contrast.[1,8]

The most widely accepted use of renal ultrasound examination for the characterization of renal masses is to differentiate a solid from a cystic renal mass identified on CT scan or MR imaging.[1,2,8] In addition, cystic renal masses are frequently first identified on a routine renal ultrasound examination, and many radiologists choose to characterize the renal cystic masses using inferences from the Bosniak classification system, as in **Table 1**. Simple cysts that are anechoic with well-defined smooth borders and posterior acoustic enhancement do not require further characterization.[1] In addition, an anechoic or hypoechoic well-defined cystic renal mass with thin (≤2 mm) smooth walls and few (1–3) septa does not require further characterization. However, if the cystic renal mass cannot be fully characterized on ultrasound examination or has thickened or irregular walls or septations, many (≥4) septations, or nodularity in the septations or walls, then further CT scans or MR imaging characterization is needed.[1]

SHOULD THE BOSNIAK CLASSIFICATION SYSTEM BE APPLIED?

The Bosniak classification system stratifies the risk of malignancy of cystic renal masses and is designed to be applied to definitive cystic renal masses and incompletely characterized lesions that are highly likely to be benign cystic renal

Table 2
Renal masses requiring further characterization before the Bosniak classification system can be applied

Modality	Renal Mass Finding(s)	Recommendation for Further Characterization
CT scan	Heterogeneous and TSTC	Renal MR imaging at 6–12 mo to differentiate solid from cystic and better characterize; renal CT scan may be suitable in some cases
	Heterogeneous on noncontrast CT scan	Renal CT scan or MR imaging to differentiate solid from cystic and better characterize
	Indeterminate potentially cystic lesion on dual energy CT scan	Renal CT scan or MR imaging to better characterize
	Solid appearing (21–69 HU) on noncontrast CT scan	Renal ultrasound or multiphasic renal CT scan or MR imaging in larger patients to differentiate solid vs cystic
	Potentially solid (≥31 HU) on portal venous CT scan	Renal CT scan or MR imaging to better characterize and differentiate enhancement or calcification in a solid renal neoplasm vs hyperdense (hemorrhagic or proteinaceous) renal cyst
	Heterogeneous or not well-defined on contrast-enhanced CT scan	Renal CT scan or MR imaging to better characterize
	Cystic mass with thickened walls (≥4 mm)	Renal CT scan or MR imaging to better characterize and differentiate higher category Bosniak renal cysts
MR imaging	Low to intermediate T1- or T2-weighted signal intensity on noncontrast MR imaging	Renal CT scan or MR imaging to better characterize
	Heterogeneous T1- or T2-weighted signal intensity on noncontrast MR imaging	Renal CT scan or MR imaging to better characterize and differentiate a necrotic papillary malignancy from a renal cystic mass[1]
	Not well-defined owing motion artifact on multiphasic MR imaging	Renal CT scan to reduce motion artifact; may consider renal MR imaging
Ultrasound examination	Not well-defined on ultrasound examination	Renal CT scan or MR imaging to better characterize
	Thickened walls	Renal CT scan or MR imaging to better characterize
	Many septations	Renal CT scan or MR imaging to better characterize
	Nodular areas or protrusions	Renal CT scan or MR imaging to better characterize

A renal CT scan or MR imaging acquisition is assumed to be a multiphasic examination without and with intravenous contrast. An indeterminate renal mass with contraindications to both renal CT scan and MR imaging should be evaluated by contrast-enhanced ultrasound examination.

masses.[1] However, the Bosniak classification should not be applied to cystic-appearing infectious, inflammatory, or vascular etiologies.[1,2,8] A common mistake encountered in the emergency radiology setting is to incorrectly apply the Bosniak classification system to a cystic-appearing renal mass in a patient with a urinary tract infection, with the cystic-appearing renal mass later identified as a renal abscess (**Fig. 5**). Some aneurysms can also seem to be cystic on grayscale ultrasound
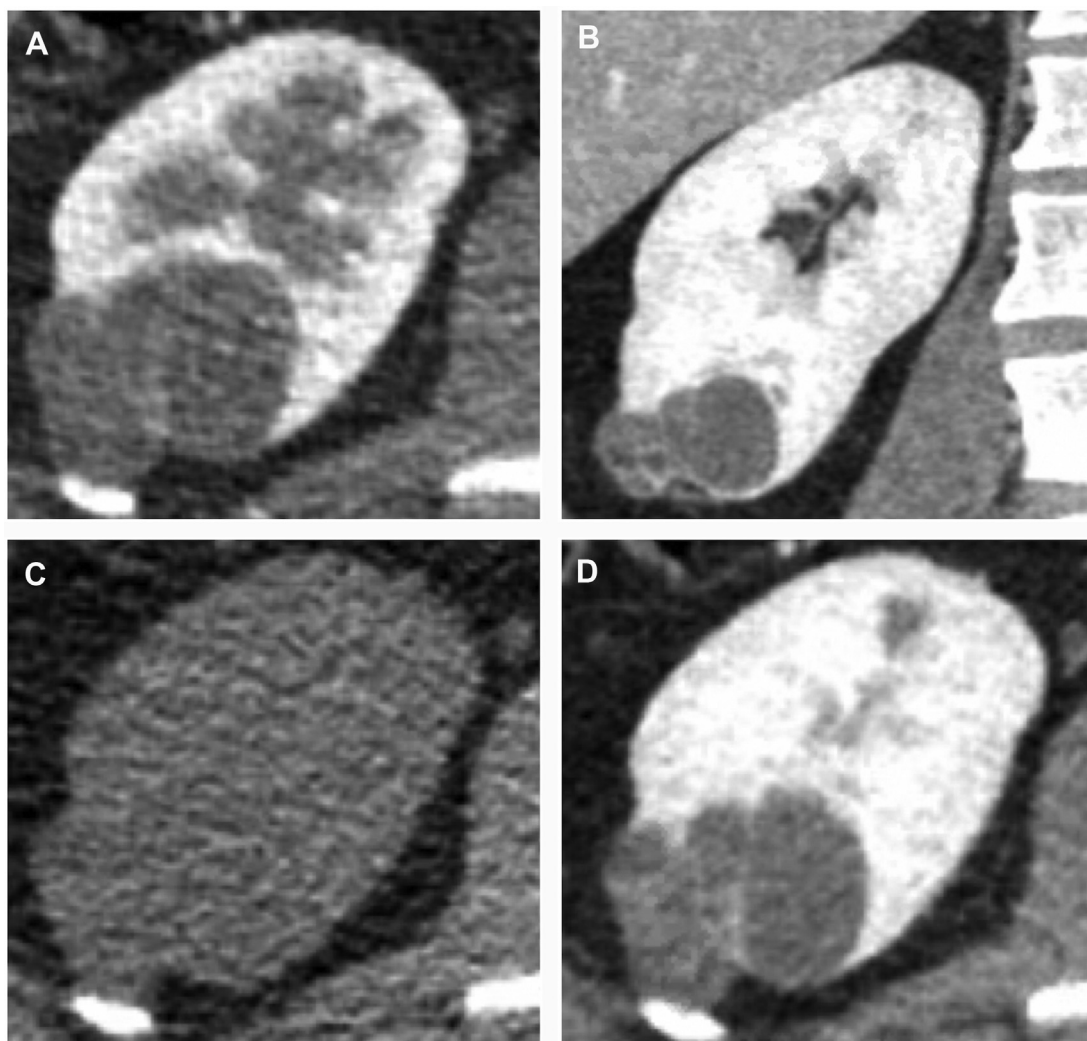
Fig. 2. A 63-year-old man with incidental discovery of a well-defined right renal mass on axial (*A*) and coronal (*B*) portal venous CT images. The hypoattenuating component of the mass measures fluid in attenuation and comprises 75% or more of the mass, indicating that it is cystic. Multiple thin internal septations are seen with probable enhancement. This mass could be classified as a Bosniak type IIF renal cystic mass based on these features, but a subsequent renal CT scan was ordered. Axial noncontrast (*C*) and axial corticomedullary phase (*D*) images from the renal CT scan confirm the presence of multiple thin enhancing septations, and this was correctly classified as a Bosniak type IIF renal cystic mass.

examination or noncontrast CT scans, but can be easily differentiated from a cystic mass on color flow ultrasound imaging (by visualizing the internal vascular flow) or on contrast-enhanced CT scans (with enhancement that matches the aorta). One additional special case is the calyceal diverticulum. Most calyceal diverticuli appear as cystic renal masses and cannot be prospectively identified as non-neoplastic, but the radiologist should look for layering stones as a clue that a calyceal diverticulum may be present (**Fig. 6**). If it is unclear whether calcifications represent layering stones versus wall calcifications, then a CT urogram could be performed, because a calyceal diverticulum should fill with contrast on the excretory phase, and the Bosniak classification system would not apply.

For all other cystic renal masses, the Bosniak classification should be applied (see **Table 1**). There are now 6 types of Bosniak II renal cysts identifiable by CT scans, 3 by MR imaging, and 2 by ultrasound examination (see **Table 1**).[1] Most of these can be characterized on single phase CT scans or MR imaging. For example, a well-defined cystic mass with thin (<2 mm) smooth walls, few (1–3) septa, and the presence or absence of calcifications can be identified on a portal venous CT
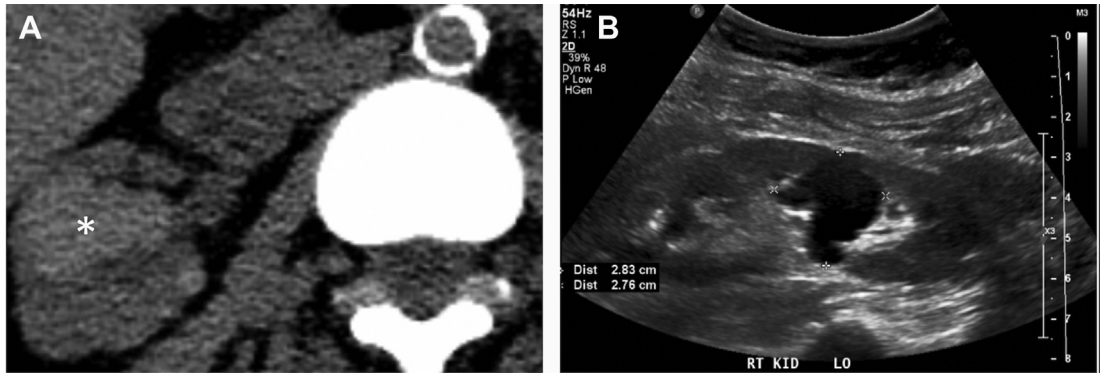
Fig. 3. A 66-year-old man with a 3.2-cm homogeneous right renal mass on noncontrast CT scan (*asterisk*), with a mean attenuation of 42 HU (*A*). A renal ultrasound examination was performed and demonstrated a hypoechoic cystic renal mass with small amounts of internal debris (*B*), most likely representing a hemorrhagic renal cyst and compatible with a Bosniak type II renal cystic mass. Given the size of this renal cystic mass on noncontrast CT scan, renal MR imaging could have been ordered instead of a renal ultrasound examination to look for occult enhancing elements (see footnote in **Table 1**), although that was not done in this case.

scan as a Bosniak type II cystic renal mass that needs no further characterization or follow-up.

The Bosniak classification system cannot be applied to heterogeneous appearing lesions on noncontrast CT scans or MR imaging without further characterization.[1] One notable difference in the Bosniak classification system version 2019 is the lack of a need to differentiate perceivable
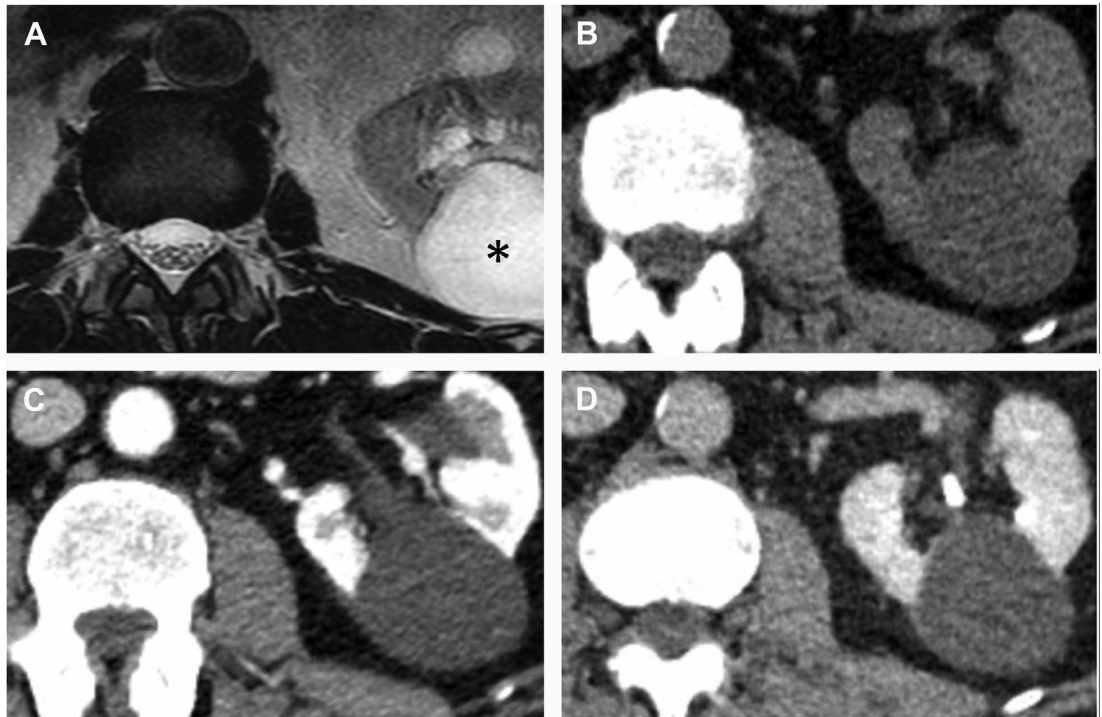

Fig. 4. A 55-year-old man with an incompletely imaged 4.5-cm homogeneous left renal mass (*asterisk*) that is markedly hyperintense at T2-weighted imaging (similar to cerebrospinal fluid) from a noncontrast spinal MR imaging that was obtained in 2018 (*A*), before the latest updates to the Bosniak classification system. A follow-up renal CT scan demonstrated a mildly hyperdense lesion (25 HU) on unenhanced phase (*B*), and no enhancement on corticomedullary phase (*C*) or nephrographic phase (*D*). This was characterized as a Bosniak type II renal cystic mass. According to the Bosniak classification system version 2019, the noncontrast MR imaging findings are sufficient to classify this as a Bosniak type II renal cystic mass, and no further characterization is needed.
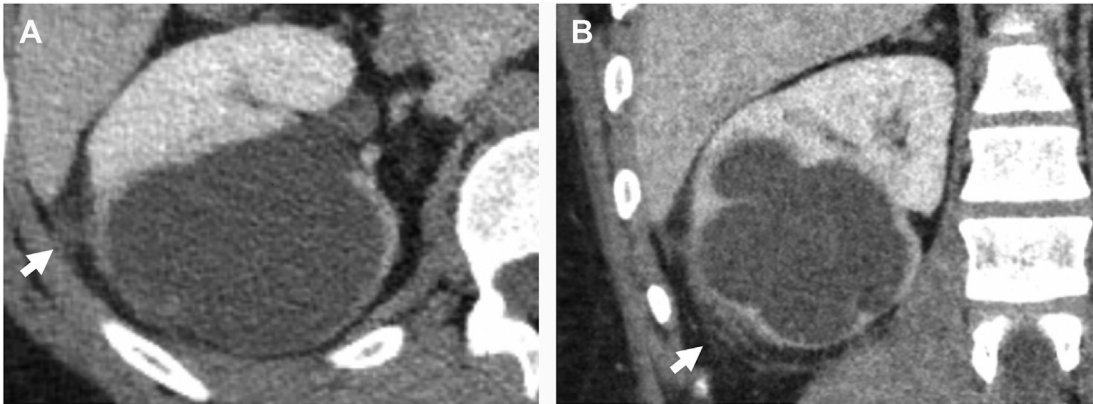
Fig. 5. A 45-year-old woman with abdominal pain, leukocytosis, and lower urinary tract symptoms. On the portal venous CT scan, a cystic-appearing renal mass with thickened walls and multiple thin internal septations is present, along with mild edema (*arrows*) in the surrounding perirenal fat (*A*, *B*). This lesion was correctly identified as a renal abscess, and the Bosniak classification system was not applied. The abscess subsequently resolved on intravenous antibiotic therapy (*B*).

from measurable enhancement.[1] Thereby, if a complex renal cystic mass is well-defined and clearly meets criteria for a cyst on portal venous CT scans (eg, ≥75% with fluid attenuation), it is often possible to fully characterize these renal cystic masses without the need for a dedicated renal CT scan or MR imaging (see **Fig. 2**). A renal mass on a CT scan or MR imaging is needed to fully characterize any renal mass with ill-defined features and to confirm enhancement, because a cystic renal mass with thickened (≥4 mm) or irregular walls that do not enhance would not strictly fall
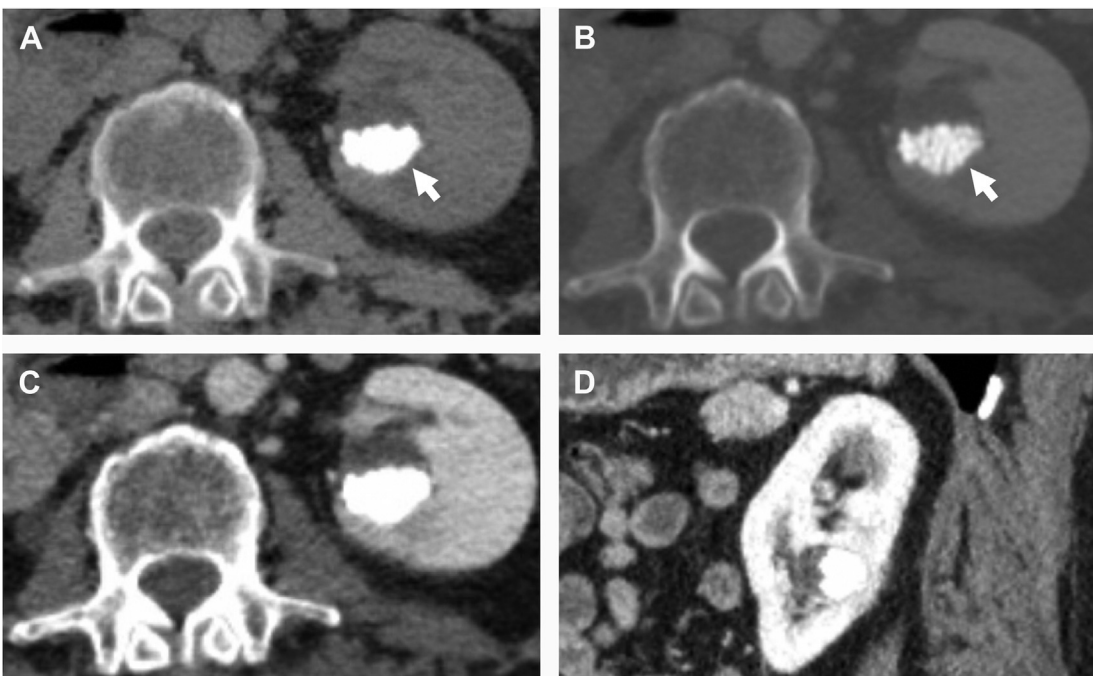

Fig. 6. A 57-year-old man with incidental discovery of a left renal cystic mass on a portal venous dual energy CT scan. The virtual nonenhanced images show multiple layering stones (*arrows*) within the renal cystic mass on soft tissue (*A*) and bone (*B*) windows. The cyst walls are thin, smooth, and enhance on contrast-enhanced axial (*C*) and coronal (*D*) images. This was interpreted as a calyceal diverticulum containing stones. No additional imaging was obtained, and the Bosniak classification system was not applied.

into any particular category and would default into the Bosniak IIF category (see **Table 1** footnote), although this occurrence is likely rare.[1]

The use of noncontrast MR imaging as it applies to the Bosniak classification system has been described elsewhere in this article and is limited to homogenous masses that are markedly hyperintense at T2-weighted imaging or at T1-weighted imaging, both of which are features of Bosniak type II renal cystic masses.[1] Features on contrast-enhanced MR imaging can and should be used to classify renal cystic masses (see **Table 1**).

Although the role of ultrasound examination has not been fully established in the classification of renal cystic masses, some inferences can be extracted and are permissible by the Bosniak classification system (see **Table 1**).[1] The role of contrast-enhanced ultrasound examination is less clear and cystic renal masses are often assigned a higher Bosniak class compared with renal CT imaging, owing to increased conspicuity of septa and previously undetected enhancement.[1] In addition, contrast-enhanced ultrasound examination is typically a focused examination and is not commonly used to survey for additional contralateral or other occult renal lesions or for coexisting retroperitoneal lymphadenopathy (uncommon with cystic renal masses, but more common with solid renal malignancies). For these reasons, the Bosniak classification system does not currently incorporate contrast-enhanced ultrasound examination as an accepted tool for further evaluating cystic renal masses.[1] However, contrast-enhanced ultrasound examination is an excellent choice when there are contraindications to both contrast-enhanced CT scans and MR imaging.

SUMMARY

Most renal masses are first encountered as incidental findings on abdominal CT scans, MR imaging, and ultrasound examination. The main purpose of this article was to provide a simple approach to evaluation of renal masses that are cystic or potentially cystic. Updates to the Bosniak classification system as captured in version 2019 have improved the radiologist's ability to define a renal cystic mass on multiple different imaging modalities and better determine the need for further characterization by imaging. The Bosniak classification system should be applied to all renal cystic masses that have appropriate high-quality images for complete characterization, except for specific clinical scenarios including cystic-appearing abscesses, aneurysms, or cystic

masses containing stones that are likely to represent calyceal diverticuli.

DISCLOSURE

Nothing to disclose.

REFERENCES

1. Silverman SG, Pedrosa I, Ellis JH, et al. Bosniak classification of cystic renal masses, version 2019: an update proposal and needs assessment. Radiology 2019;292(2):475–88.
2. Bosniak MA. The current radiological approach to renal cysts. Radiology 1986;158(1):1–10.
3. Bosniak MA. The Bosniak renal cyst classification: 25 years later. Radiology 2012;262(3):781–5.
4. Israel GM, Bosniak MA. An update of the Bosniak renal cyst classification system. Urology 2005; 66(3):484–8.
5. Herts BR, Silverman SG, Hindman NM, et al. Management of the incidental renal mass on CT: a white paper of the ACR Incidental Findings Committee. J Am Coll Radiol 2018;15(2):264–73.
6. O'Connor SD, Pickhardt PJ, Kim DH, et al. Incidental finding of renal masses at unenhanced CT: prevalence and analysis of features for guiding management. AJR Am J Roentgenol 2011;197(1):139–45.
7. O'Connor SD, Silverman SG, Ip IK, et al. Simple cyst-appearing renal masses at unenhanced CT: can they be presumed to be benign? Radiology 2013;269(3):793–800.
8. Silverman SG, Israel GM, Herts BR, et al. Management of the incidental renal mass. Radiology 2008; 249(1):16–31.
9. Pooler BD, Pickhardt PJ, O'Connor SD, et al. Renal cell carcinoma: attenuation values on unenhanced CT. AJR Am J Roentgenol 2012;198(5):1115–20.
10. Jonisch AI, Rubinowitz AN, Mutalik PG, et al. Can high-attenuation renal cysts be differentiated from renal cell carcinoma at unenhanced CT? Radiology 2007;243(2):445–50.
11. Agochukwu N, HuberS, Spektor M, et al. Differentiating renal neoplasms from simple cysts on contrast-enhanced CT on the basis of attenuation and homogeneity. AJR Am J Roentgenol 2017; 208(4):801–4.
12. Hu EM, Ellis JH, Silverman SG, et al. Expanding the definition of a benign renal cyst on contrast-enhanced CT: can incidental homogeneous renal masses measuring 21-39 HU be safely ignored? Acad Radiol 2018;25(2):209–12.
13. Corwin MT, Hansra SS, Loehfelm TW, et al. Prevalence of solid tumors in incidentally detected homogeneous renal masses measuring > 20 HU on portal venous phase CT. AJR Am J Roentgenol 2018; 211(3):W173–7.

14. Mileto A, Sofue K, Marin D. Imaging the renal lesion with dual-energy multidetector CT and multi-energy applications in clinical practice: what can it truly do for you? Eur Radiol 2016;26(10):3677–90.

15. Mileto A, Nelson RC, Paulson EK, et al. Dual-energy MDCT for imaging the renal mass. AJR Am J Roentgenol 2015;204(6):W640–7.

16. Ho VB, Allen SF, Hood MN, et al. Renal masses: quantitative assessment of enhancement with dynamic MR imaging. Radiology 2002;224(3): 695–700.

17. Kim CW, Shanbhogue KP, Schreiber-Zinaman J, et al. Visual assessment of the intensity and pattern of T1 hyperintensity on MRI to differentiate hemorrhagic renal cysts from renal cell carcinoma. AJR Am J Roentgenol 2017;208(2): 337–42.

18. Davarpanah AH, Spektor M, Mathur M, et al. Homogeneous T1 hyperintense renal lesions with smooth borders: is contrast-enhanced MR imaging needed? Radiology 2016;280(1):128–36.

19. Nelson SM, Oettel DJ, Lisanti CJ, et al. Incidental renal lesions on lumbar spine MRI: who needs follow-up? AJR Am J Roentgenol 2019;212(1): 130–4.