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Evaluation of Cystic Renal Masses: Comparison of CT and MR Imaging by Using the Bosniak Classification System[1]

PURPOSE: To compare computed tomography (CT) and magnetic resonance (MR) imaging in the evaluation of cystic renal masses by using the Bosniak classification system.

MATERIALS AND METHODS: Images of 69 renal masses in 59 patients (38 men, 21 women; mean age, 60.4 years; range, 30–86 years), who had undergone both CT and MR imaging examinations within 1 year (average, 60.5 days; range, 0–356 days), were retrospectively analyzed by two radiologists in consensus. For each lesion, images were compared for thickness of wall and septa, number of septa, and presence of enhancement. Each mass was categorized (Bosniak classification) first on CT images and then on MR images, and results were compared. Pathologic correlation was available in 25 lesions.

RESULTS: On CT images, there were 15 category I, 16 category II, 10 category IIF, 19 category III, and nine category IV lesions. Findings on CT and MR images were similar in 56 (81%) lesions; in 13 (19%) lesions, there were differences. In eight (12%) lesions, MR imaging depicted more septa than did CT, which resulted in an upgrade of the classification at MR imaging in two cases. In seven (10%) lesions, MR imaging depicted increased wall and/or septa thickness compared with CT, resulting in a classification upgrade in six cases. Three lesions had both increased numbers of septa and thickening of the wall and/or septa. In two (3%) lesions, enhancement characteristics at CT and MR imaging were different. One of these lesions also had an increased number of septa. Overall, MR imaging results led to a cyst classification upgrade of seven lesions, from category II to IIF ($n = 2$), IIF to III ($n = 3$), or III to IV ($n = 2$). Pathologic correlation in 25 lesions revealed 20 malignant and five benign lesions.

CONCLUSION: CT and MR imaging findings were similar in the majority of cystic renal masses. In some cases, however, MR images may depict additional septa, thickening of the wall and/or septa, or enhancement, which may lead to an upgraded Bosniak cyst classification and can affect case management.

The Bosniak classification of renal cysts, introduced in 1986, has been used to help evaluate cystic renal masses and decide clinical management (1–4). It has been accepted and used by urologists and radiologists as an effective way to assess these lesions, and there has been general interobserver agreement in most instances (4–7). Although this classification scheme is based on computed tomographic (CT) criteria, the same approach may provide a useful framework for evaluation with magnetic resonance (MR) imaging (8). However, MR imaging may demonstrate some findings that are not depicted at CT, and there may not always be a clear correlation between the findings at MR imaging and those at CT. To our knowledge, this comparison has not yet been published. The purpose of our study was to compare the findings at CT and MR imaging in the evaluation of cystic renal masses by using the Bosniak classification system.

MATERIALS AND METHODS

Patients

A computerized database was retrospectively searched from January 1, 1996, through December 31, 2002, for all cases of patients referred for MR imaging evaluation of the kidneys in which the term "cyst" or "cystic neoplasm" (not necrotic neoplasm) appeared in the physician's final assessment of the images. This group of patients was cross-referenced with the radiology information system at our institution to determine which patients had also undergone a dedicated CT examination of the kidneys (before and after administration of intravenous contrast medium) within 1 year of MR imaging. This search yielded a total of 45 patients with 55 masses. Four lesions in four patients showed indeterminate CT enhancement (10–20 HU), and MR imaging was performed to determine whether the lesions were cystic or solid; the lesions were diagnosed as simple cysts at MR imaging, and these patients were excluded from this study. To the remaining 41 patients were added eight patients (eight masses) in whom MR imaging was performed at our institution and CT was performed at outside institutions within 1 year of MR imaging. Also added were 10 patients (10 masses) who were referred to us for consultation and who underwent both CT and MR imaging examinations within 1 year of each other at outside institutions. This yielded records of a total of 69 cystic renal masses in 59 patients. The average interval between the CT and MR imaging examinations was 60.5 days (range, 0–356 days). In 66 cystic renal masses (56 patients), the CT examination preceded the MR imaging examination, and in the remaining three masses (three patients), MR imaging preceded CT. There were 38 men (mean age, 62.1 years; age range, 31–86 years) and 21 women (mean age, 55.8 years; age range, 30–86 years); the overall mean age was 60.4 years (range, 30–86 years). Our study was approved by the Institutional Board of Research Associates (at our institution), with a waiver of patient informed consent.

Image Analysis

Hard-copy images for each case were retrospectively analyzed by two of the authors in consensus (G.M.I. and M.A.B., with 8 and 25 years of experience in interpreting cross-sectional images, respectively). The CT images for each patient were reviewed first, and their review was immediately followed by review of the MR images obtained in the same patient. MR images obtained in all planes were used for image interpretation. Each cystic mass was categorized at CT by using the Bosniak cyst classification (1,9,10), and this categorization was then compared with categorization at MR imaging by using the same classification system.

Each lesion was assigned to a Bosniak cyst category on the basis of the following criteria:

Category I lesions are benign simple cysts with hairline-thin walls. These cysts contain no septa, calcifications, or solid components and do not show enhancement after intravenous contrast material administration.

Category II masses are benign cystic lesions that may contain hairline-thin septa. Fine calcification in the walls or septa of such lesions, or a short segment of slightly thickened calcification, may be present. Minimal perceived (not measurable) enhancement of a hairline-thin smooth septum or wall is sometimes present. Lesions with uniformly high attenuation (high-attenuation cysts) that are less than 3 cm in diameter and do not enhance are included in this category.

Category IIF (the "F" indicates need for follow-up imaging) lesions are more complex cysts that cannot be neatly classified as category II or III lesions. These cysts may contain an increased number of hairline-thin septa or have minimal but smooth thickening of the wall or septa. The wall and/or septa may contain calcifications, which may be thick and nodular, without obvious enhancement. Like category II cysts, these lesions may demonstrate minimal perceived enhancement of a hairline-thin smooth septum or wall; however, there are no enhancing soft-tissue components. Nonenhancing high-attenuation lesions (high-attenuation cysts) that are completely intrarenal and are 3 cm or larger are also included in this category.

Category III lesions are indeterminate masses, and it usually cannot be determined at imaging whether they are benign or malignant. They have thickened irregular walls or septa, in which enhancement can be demonstrated.

Category IV lesions are malignant cystic masses. They may have findings similar to those seen in Category III masses but also have enhancing soft-tissue components adjacent to, but independent of, the wall or septum.

For each lesion, the numbers of septa were determined on the CT and MR images, and the lesions were categorized on this basis into one of four groups as follows: group 1, no septa; group 2, between one and four septa; group 3, between five and nine septa; and group 4, more than nine septa. The thickness of the wall and/or septa of each lesion was subjectively determined to be hairline thin (category I [wall only] or II), minimally thickened (category IIF), or grossly thickened and irregular (categories III and IV). If a single septum or the wall of a lesion was determined to be slightly or grossly thickened, this finding was recorded as slightly or grossly thickened septa and/or wall for the entire lesion. Contrast enhancement at CT was determined by using multiple region-of-interest measurements in areas that appeared enhanced; for those CT examinations performed at our institution, measurement was performed at the time of examination. The size of the region of interest was determined by the size of the area to be evaluated and was similar for the unenhanced and contrast material–enhanced examinations. For the CT examinations performed at outside institutions, we used region-of-interest measurements that were available on the images. Contrast enhancement on MR images obtained at our institution was determined by using voxel-by-voxel subtraction of unenhanced images from contrast-enhanced images; subtraction was performed by using a satellite console. Any signal above the background noise on the subtracted images was considered enhancement. For MR imaging performed at outside institutions, a direct comparison between the unenhanced and contrast-enhanced images was performed.

Imaging Techniques

The CT examinations that took place at our institution were performed by using one of three CT scanners (HiSpeed Advantage or CT/i [GE Medical Systems, Milwaukee, Wis] or Volume Zoom [Siemens Medical Systems, Forchheim, Germany]). Unenhanced images were acquired first, and then contrast-enhanced images were acquired. The section thickness was 2.5–5.0 mm. All patients received 150 mL of intravenous contrast material, and at least one contrast-enhanced acquisition was obtained after a scanning delay of 90 seconds.

The MR imaging examinations that took place at our institution were performed by using a 1.5-T system (Vision or Symphony; Siemens Medical Systems, Erlangen, Germany) and a torso phased-array coil. All patients underwent

Comparison of Discrepant CT and MR Imaging Findings in Cystic Renal Masses

Patient	Examination Interval (d)	Category		Thickness of Septa/Wall		No. of Septa*		Outcome
		CT	MR Imaging	CT	MR Imaging	CT	MR Imaging	
1	117	II	IIF	Hairline	Minimal	2	4	4-year stability
2	46	II	IIF	Hairline	Minimal	2	2	3-year stability
3†	2	IIF	III	Hairline	Minimal	3	4	1-year stability
4‡	36	IIF	III	Minimal	Gross	3	3	Progression
5	1	IIF	III	Minimal	Gross	1	1	Benign
6§	15	III	IV	Gross	Gross	1	2	Malignant
7‖	17	III	IV	Hairline	Hairline	1	1	Malignant
8	7	III	III	Gross	Gross	1	4	Benign
9	32	III	III	Gross	Gross	2	3	Malignant
10	27	IIF	IIF	Minimal	Minimal	2	3	1-year stability
11	3	IV	IV	Gross	Gross	3	4	Malignant
12	24	II	II	Hairline	Hairline	3	4	Presumed benign
13	17	III	III	Gross	Gross	1	1	Lost to follow-up

* Number of septa by group: group 1, no septa; group 2, one to four septa; group 3, five to nine septa; and group 4, more than nine septa.

† A 75-year-old man who refused surgery; lesion is stable after 1 year of follow-up.

‡ At follow-up imaging, lesion has become more complex and is believed to be renal cell carcinoma; patient has refused surgery.

§ Lesion showed further thickening and enhancement of the wall and septa at MR imaging; lesion upgraded to category IV at MR imaging.

‖ Enhancement of a mural nodule in a cystic renal mass was indeterminate at CT but definitive at MR imaging; lesion upgraded to category IV at MR imaging.

transverse breath-hold T1-weighted MR imaging with a two-dimensional gradient-echo sequence and transverse or coronal breath-hold T2-weighted MR imaging with a half-Fourier single-shot turbo spin-echo sequence. Imaging parameters for the T1-weighted gradient-echo sequence were as follows: 151–200/2.0–5.3 (repetition time msec/echo time msec); flip angle, 70°–90°; matrix, 80–118 × 256; section thickness, 5–8 mm; intersection gap, 0.6–2.0 mm; and field of view, 200–263 × 320–375. The T2-weighted sequences were performed with the following parameters: ∞/62–67; flip angle, 120°–180°; matrix, 180–256 × 256; section thickness, 5–8 mm; intersection gap, 0–0.8 mm; and field of view, 200–263 × 320–375.

A three-dimensional fat-suppressed T1-weighted interpolated spoiled gradient-echo sequence (volumetric interpolated breath-hold examination, or VIBE [11]) was performed both prior to and 3–5 minutes after intravenous administration of 20 mL of gadopentetate dimeglumine (Magnevist; Berlex Laboratories, Wayne, NJ). This sequence was performed in the transverse or coronal plane, and parameters were as follows: 3.4–4.5/1.4–1.9; flip angle, 12°; matrix, 83–167 × 256; field of view, 203–350 × 350–400; and interpolated section thickness, 1.0–2.4 mm. All acquisition times were less than 30 seconds to facilitate breath holding at end expiration.

The CT (n = 18) and MR imaging (n = 10) examinations that took place at outside institutions were performed with a variety of CT scanners and MR imagers (MR imaging performed at 1.5 T in eight patients and 1.0 T in two patients). At CT, the section collimation ranged from 3 to 7 mm. At MR imaging, a variety of T1- and T2-weighted sequences were performed with spin-echo, fast spin-echo, and gradient-echo techniques. All CT and MR imaging examinations performed at outside institutions were considered adequate for inclusion in this study because they were performed prior to and after intravenous contrast material administration and the images were of sufficient diagnostic quality.

Pathologic Correlation and Follow-up

In patients who underwent surgery, correlation was made by two authors (G.M.I. and M.A.B.) between the imaging findings and the pathologic examination reports. In those cases in which the findings at CT and MR imaging were not in agreement and in which there was no pathologic correlation, and for those lesions categorized as category IIF, a review of all available cross-sectional images was performed by the same two authors in consensus to evaluate for any interval change.

RESULTS

Categories

The 69 lesions in this series were characterized at CT as follows: category I (n = 15), category II (n = 16), category IIF (n = 10), category III (n = 19), and category IV (n = 9).

Overall, in 56 lesions (81%), the CT and MR images demonstrated equivalent findings, while in 13 lesions (19%), there were differences in the findings (Table). This resulted in a higher classification of seven lesions (10%) at MR imaging compared with classification at CT with the Bosniak system. There were two lesions upgraded from category II to IIF (patients 1 and 2), three from category IIF to III (patients 3–5), and two from category III to IV (Table, patients 6 and 7). In six lesions, the differences did not affect classification (Fig 1; Table, patients 8–13).

Number of Septa

The numbers of septa present on CT and MR images were equivalent in 61 lesions (88%), which included 33 lesions in group 1 (no septa), 16 lesions in group 2 (one to four septa), five lesions in group 3 (five to nine septa), and seven lesions in group 4 (more than nine septa). In eight lesions (12%), MR images depicted more septa than did CT images (Table), which led to lesion upgrading from group 1 to group 2 (patient 6), group 1 to group 4 (patient 8), group 2 to group 3 (patients 9 and 10), group 2 to group 4 (patient 1), and group 3 to group 4 (patients 3, 11, and 12). This resulted in an upgrading of classification at MR imaging compared with that at CT in two lesions as follows (Table): from category II to IIF in patient 1 (Fig 2) and from category IIF to III in patient 3 (Fig 3).

Thickness of Septa and Wall

The thickness of the septa and wall of the lesion was equivalent at CT and at MR imaging in 62 lesions (90%), which included lesions with septa and/or walls that were hairline thin (n = 34), minimally thickened (n = 8), or grossly thickened and irregular (n = 20). In seven lesions (10%), depiction with MR imaging caused the characterization of septa and/or wall to be upgraded from hairline thin to minimally thickened (patients 1–3), or from minimally thickened to grossly thickened and irregular (patients 4 and 5), or (in two lesions with a grossly thickened and irregular wall at CT) indicated greater thickening and enhance-

ment than were apparent at CT (patients 6 and 13). This resulted in a higher cyst classification at MR imaging than at CT in six lesions as follows: category II to IIF (Fig 2) in two lesions (patients 1 and 2); category IIF to III (Fig 3) in three lesions (patients 3–5); and category III to IV (Fig 4) in one lesion (patient 6). Three of these six lesions (patients 1, 3, and 6) demonstrated both increased numbers of septa and increased thickening of the wall and/or septa on MR images compared with CT images.

Enhancement Characteristics

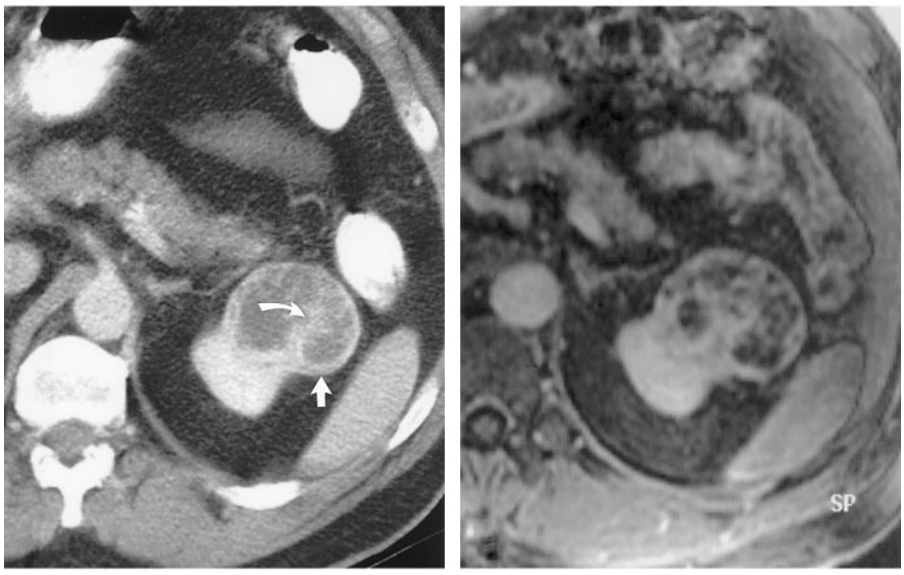
In two lesions (3%), enhancement characteristics at CT and MR imaging were different. The first was a cyst that contained a mural nodule, which enhanced 13 HU at CT after intravenous contrast material administration (patient 7). Although it was believed that this lesion represented a hypovascular neoplasm at CT, MR imaging showed definitive enhancement in the mural nodule, a finding that supported a diagnosis of malignancy. The second lesion was characterized as category IIF at CT and had a thick calcified wall (patient 5; Fig 5). At MR imaging, the wall of the lesion appeared thicker and more irregular, was enhanced, and was characterized as category III. The calcification could not be evaluated on the MR images. This lesion proved to be a hemorrhagic cyst at pathologic examination.

Pathologic Correlation

Pathologic correlation, which was available for 25 lesions, revealed 20 malignant and five benign lesions. In 18 (90%) of the malignant lesions, CT and MR images showed similar findings (category III, $n = 12$; category IV, $n = 6$). The remaining two malignant lesions were characterized at CT as category III (patients 6 and 7) and were upgraded to category IV at MR imaging. In four (80%) of the five benign lesions, CT and MR images showed similar findings (category III, $n = 3$; category I, $n = 1$). The category I lesion was a 15-cm simple cyst that obstructed the collecting system and was surgically removed. The remaining benign lesion (patient 5) was peripherally calcified and was discussed in the previous paragraph.

In seven patients in whom CT and MR images showed different findings, there was no pathologic correlation available. Four patients (patients 1–3, 10) underwent periodic follow-up examinations over an average of 1.8 years (range, 1–4 years), and their lesions showed no interval change. One lesion (patient 4) showed progression at follow-up examinations and was presumed to be malignant, but the patient refused surgery. One lesion (patient 12) was classified as a category II cyst on both CT and MR images and was presumed benign. One patient (patient 13) was lost to follow-up.

The results at CT and MR imaging were equivalent in the remaining 37 lesions. This included 14 category I and 13 cate-

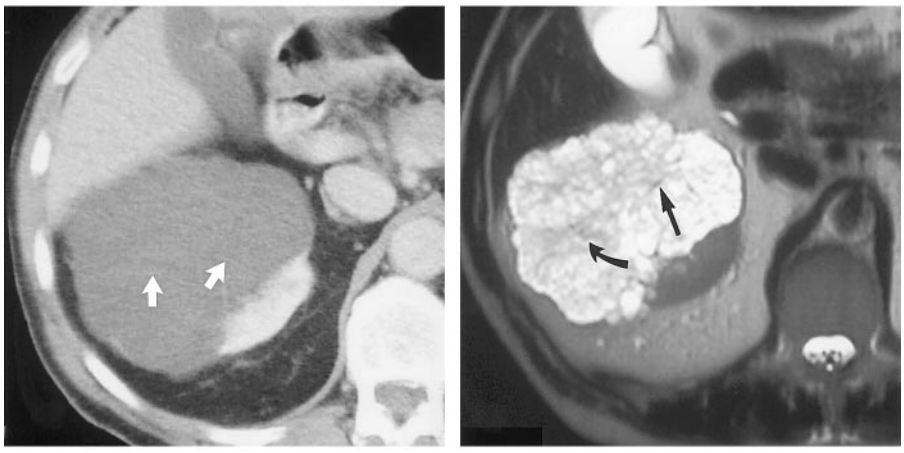


a. b.

Figure 1. Transverse images in a 56-year-old woman (patient 11) with a Bosniak category IV cystic lesion in the left kidney. **(a)** Contrast-enhanced CT scan shows a complex cystic mass that contains a grossly thickened and enhancing wall (straight arrow) and enhancing soft-tissue components (curved arrow). **(b)** Gadolinium-enhanced fat-suppressed T1-weighted MR image (3.4/1.4; 12° flip angle) demonstrates similar findings when compared with the CT image. However, more septa are apparent within the mass at MR imaging. This lesion was surgically removed and determined to be a renal cell carcinoma.

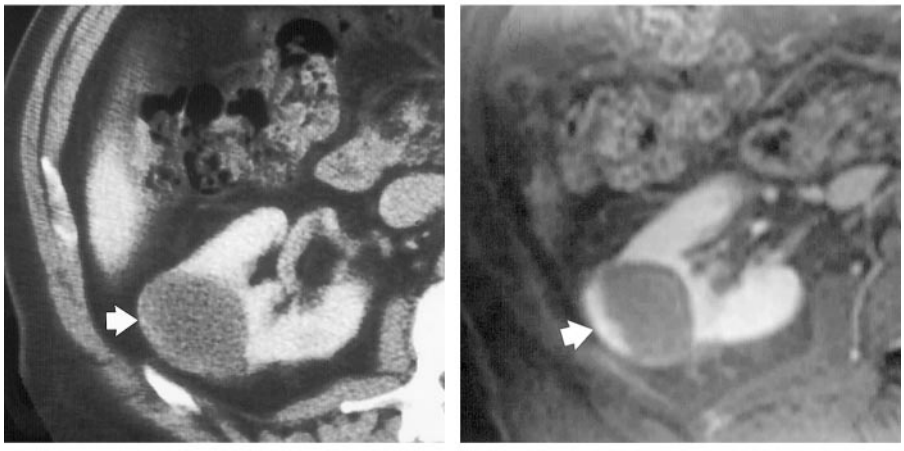
a. b.

Figure 2. Images in a 70-year-old man (patient 1) with a cystic mass at the upper pole of the right kidney. **(a)** Transverse contrast-enhanced CT scan demonstrates a minimally complex cystic mass that contains a few hairline-thin septa (arrows) consistent with a Bosniak category II cyst. **(b)** Coronal T2-weighted MR image (∞/64; 150° flip angle) demonstrates more septa (arrows) within the lesion than are depicted on the CT scan. Note that while septa are hairline-thin at CT, they appear minimally thickened at MR imaging. The increased number and thickness of septa depicted on the MR image caused the lesion to be upgraded to category IIF. The lesion in this patient has been followed up for 4 years and is unchanged.



a. b.

Figure 3. Transverse images in a 75-year-old man (patient 3) with a complex cystic mass in the right kidney. **(a)** Contrast-enhanced CT scan demonstrates a lobulated cystic mass that contains numerous hairline-thin septa (arrows) that are barely visible; findings are consistent with a Bosniak category IIF cyst. **(b)** T2-weighted MR image (∞/64; 160° flip angle) shows many more septa than are seen on the CT scan. Some of the septa are minimally thickened (straight arrow) and others are confluent (curved arrow) and have the gross thickening typical of category III lesions. Because of the lesion's complexity at MR imaging, surgery was suggested as a treatment option; the patient refused surgery, and this lesion has remained unchanged for 1 year.



a. b.

Figure 4. Transverse images in a 65-year-old man (patient 6) with pathologically proved renal cell carcinoma. **(a)** Contrast-enhanced CT scan shows a cystic mass in the right kidney that has an enhancing thickened and irregular wall (arrow), typical of a category III lesion. **(b)** Gadolinium-enhanced fat-suppressed T1-weighted MR image (3.6/1.6; 12° flip angle) shows enhancing soft tissue (arrow) associated with the wall of the cyst, a finding that led to upgrading of the lesion to category IV.

gory II lesions, which were considered benign. Six patients with category IIF lesions underwent follow-up for a mean of 8.3 months (range, 2–12 months). One patient with a category III lesion and one with a category IV lesion were lost to follow-up. One patient with two category IV lesions refused surgery.

DISCUSSION

The Bosniak cyst classification was developed solely on the basis of CT findings. Since MR imaging has proved to be a valuable tool in the evaluation of renal masses, we analyzed and compared the CT and MR imaging findings in 69 cystic renal masses by evaluating the number of septa, the morphology of the septa and wall, and the enhancement characteristics of these lesions.

Number of Septa

The presence and number of septa within a cystic renal mass are important findings for evaluation. On the basis of the number of septa within a lesion, it is possible to upgrade a cystic renal mass by using the Bosniak classification system from category I (no septa) to category II (a few hairline-thin septa) and from category II to category IIF (increased numbers of hairline-thin septa or minimal thickening of septa). It is not possible to upgrade a lesion to category III on the basis of the number of septa alone. In some cases, however, particularly in smaller lesions, there may be so many septa within a lesion that they become confluent and masslike. In this instance, they may appear as thickened or irregular septa, which is typical of category III lesions. In this study, we found that MR imaging demonstrated septa within a lesion with more sensitivity than did CT, and, therefore, it may be expected that MR imaging would cause a lesion to be classified into a higher category than it would be with CT criteria. Overall, in our cohort, MR imaging demonstrated more septa than did CT in eight (12%) of 69 lesions, but this accounted for an upgrade of the Bosniak classification at MR imaging in only two lesions.

Morphology of the Wall and Septa

The morphology of the septa and wall in a cystic renal mass is another important factor in evaluation. The wall of a category I lesion and the wall and/or septa of a category II lesion are hairline thin. Category IIF lesions may contain minimal thickening of the wall or septa. It must be emphasized, however, that the septa or wall thickening that is typical of category IIF lesions is minimal and smooth; it is not the gross and irregular thickening that may be present in category III or IV lesions. In seven (10%) of the 69 lesions in this series, the MR images demonstrated increased thickness of the wall or septa when compared with the CT images, which accounted for a higher classification at MR imaging in six lesions. Three of these six lesions were noteworthy in that the MR imaging findings indicated category III (lesion requiring surgery) but the CT findings suggested category IIF (likely benign, but in need of follow-up imaging).

Enhancement Characteristics

The most important factor in the evaluation of a renal mass is the presence or absence of enhancement. A cystic renal mass is considered a neoplasm (category IV) if there is enhancing soft tissue within

the lesion. Enhancement of grossly thickened walls or septa in a cystic lesion is seen in category III lesions, which require surgery but may be benign or malignant. Category II and IIF lesions do not enhance with the administration of contrast material. However, minimal enhancement of hairline-thin and smooth septa or wall can often be perceived when unenhanced and contrast-enhanced CT images are compared side by side, and it also may be evident on subtracted MR images. It must be emphasized that since this "enhancement" occurs in the hairline-thin septa and walls, it cannot be measured or quantified. In the past it was thought that hairline-thin septa in benign lesions did not enhance. This was based on early experiences with nonhelical CT scanners. With the advent of helical CT and the ability to obtain thinner sections, combined with the use of power injectors and larger boluses of intravenous contrast material, we have observed minimal enhancement of some of these hairline-thin septa (which are fed by tiny capillaries). It must be emphasized that this applies to hairline-thin smooth septa. Any irregularity or thickness in a septum or wall that enhances makes the lesion category III.

In this series, the enhancement characteristics at CT and MR imaging were different in two (3%) of the 69 lesions. The superior contrast resolution of MR imaging combined with image subtraction is ideal for the further characterization of renal lesions with indeterminate enhancement at CT. This is especially useful in suspected cases of "pseudoenhancement" at CT (12) and in high-attenuation renal cysts in which the internal architecture of the lesion is obscured by the high-attenuation fluid. By using subtraction at MR imaging, it is possible to evaluate for any septa or enhancing components, as well as to assess the inner surface of the wall in these lesions. Subtraction at MR imaging is also of value in evaluating for possible enhancement in cystic lesions with thickened calcified walls. Ultrasonography can also be used to characterize suspected cases of pseudoenhancement at CT and some cases of high-attenuation renal cysts at CT.

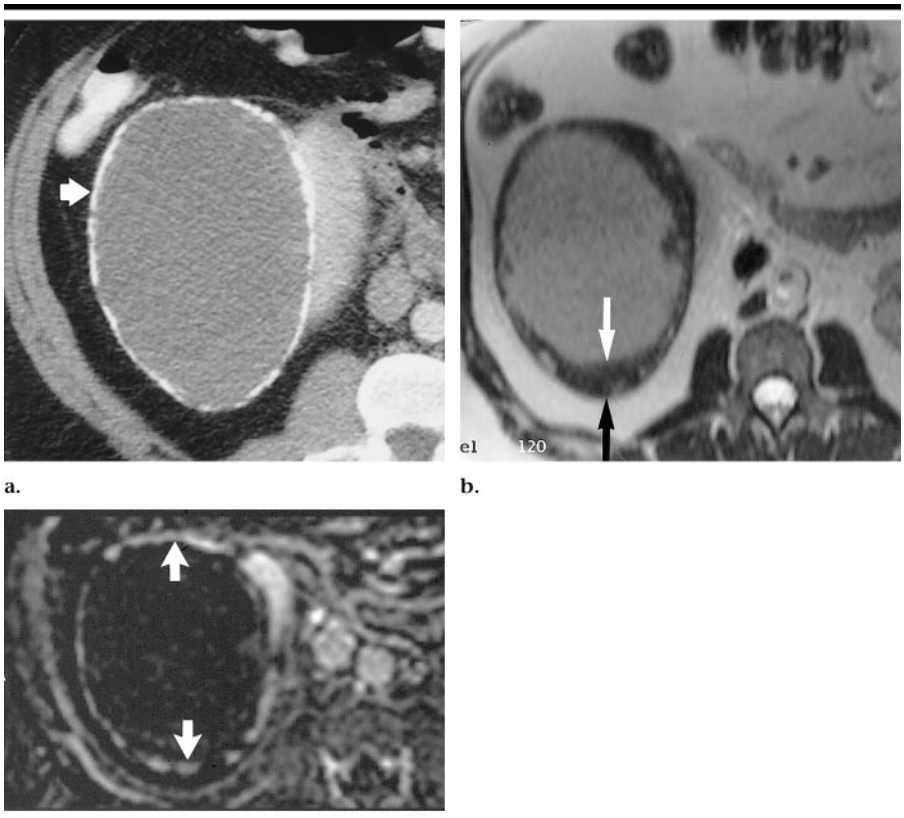


Figure 5. Transverse images in a 44-year-old man (patient 5) with a large peripherally calcified mass in the right kidney. **(a)** Contrast-enhanced CT scan shows a large cystic mass with thick irregular calcification (arrow) in its wall. This lesion did not enhance and is consistent with a category IIF cyst; however, a surgical option was advised because of the young age of the patient and large size of the lesion. **(b)** T2-weighted MR image (∞/64; 160° flip angle) shows gross thickening of the lesion wall (arrows), which cannot be appreciated on the CT scan. Note the calcification depicted on the CT scan cannot be appreciated on the MR image. **(c)** Subtracted multiplanar reformation from a coronal three-dimensional gadolinium-enhanced fat-suppressed T1-weighted MR image (4.5/1.9; 12° flip angle) data set shows enhancement (arrows) within the thickened wall of the cyst, which led to an upgrade of the lesion to category III at MR imaging. At surgery, a benign hemorrhagic cyst was found.

Calcification

The presence of calcification plays only a minor role in the evaluation of cystic renal masses (9). A limitation of MR imaging in the characterization of renal masses is its inability to depict calcification within the lesion. It is theoretically possible that MR imaging could classify a unilocular renal cyst with hairline-thin calcification in its wall (which would be category II at CT) as a category I cyst. However, this is not of concern, as lesions of both categories are benign and do not need further imaging.

Sometimes it is difficult to determine whether enhancement is present in a heavily calcified cystic lesion at CT (9). In such a case, MR imaging should be helpful in characterizing these lesions because the calcification would not be depicted on the MR image, and any enhancement could be better appreciated (9).

An important question is how to handle those cases in which a cystic renal mass appears benign at CT (categories I, II, or IIF [nonsurgical]) yet appears more complex at MR imaging (category III [surgical]). Since the contrast resolution at MR imaging is superior to that at CT, it should not be surprising that, in some cases, MR imaging shows enhancement of structures not depicted at CT. Also, more septa are depicted at MR imaging than at CT. However, since there is more cumulative radiologic experience using CT in the evaluation of cystic renal masses, there may be a tendency to use the CT findings to determine patient care. We believe that, in this scenario, factors such as the size of the lesion or the condition and age of the patient dictates the treatment options.

When performing follow-up imaging examinations, it is not clear which modality, whether MR imaging or CT, should be used. However, it is important that images from the same modality at both initial and follow-up evaluations are compared. This way, any progression

of the lesion that is seen at the follow-up examination will be a real change in the lesion rather than an apparent change caused by use of a different imaging modality at follow-up examination. In younger patients who will undergo multiple follow-up examinations, an early switch to MR imaging is suggested.

There are limitations to our study. The cases in this series were analyzed in consensus, and therefore interobserver variability could not be evaluated. In addition, the MR images were interpreted immediately after the CT images, which may have introduced an observer bias. Another limitation of our study is that the cases were retrospectively collected and included some examinations from outside institutions, factors that may have introduced a case-selection bias. Moreover, the CT and MR imaging protocols were not standardized across all cases because some of the examinations were performed at outside institutions, and a visual assessment of enhancement on MR images acquired with various protocols could be misleading. Also, although the mean interval between the CT and MR imaging examinations was 60.5 days, it could have been as long as 356 days. It is therefore possible that some changes between examinations may have been secondary to evolutionary changes in the lesion and not secondary to differences in the imaging modalities. In addition, the different imaging delays, thinner sections obtained at MR imaging, and the use of subtraction at MR imaging, may account for the improved conspicuity of some septa and walls at MR imaging. It is also possible that septa and lesion morphology may be better depicted on multiplanar MR images than on transverse CT images. The sample size was relatively small, and additional studies with increased numbers of patients and longer follow-up would be important to further evaluate these findings. Another limitation is that pathologic correlation was not available in most cases (many of which involved category I and II lesions).

In conclusion, the evaluation of complex cystic renal masses remains a common and difficult problem in radiologic practice. Although the Bosniak renal cyst classification system was developed on the basis of CT findings alone, CT and MR images show similar findings in the majority of cystic renal masses, and, on the basis of our preliminary experience, we believe that the Bosniak renal cyst classification is appropriate for use with MR imaging in the evaluation of most cystic renal masses. However, it is wise to be cautious when interpreting MR images of complex cystic renal masses that are on the borderline between categories IIF and III without CT correlation, since MR imaging does demonstrate additional septa, wall or septa thickening, or enhancement that may cause a lesion to be upgraded.

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