The Incidental Renal Mass

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Incidental renal masses are extremely common.1,2 Although most represent benign renal cysts, not all incidental renal masses are benign.2 Most renal cell carcinomas are discovered incidentally when an imaging examination is performed to evaluate a nonrenal complaint.3–6 Therefore, differentiating incidental benign renal masses from those that are potentially malignant is important. There are well-established, time-tested, image-based criteria that can be used to diagnose most renal masses definitively.7–33 However, some renal masses remain indeterminate even after a thorough evaluation with imaging. This article discusses the evaluation, diagnosis, and treatment options of the incidental renal mass.

RENAL PSEUDOTUMORS: CONFIRMATION OF AN ABNORMAL FINDING

When encountering any renal mass, it is necessary to first determine whether the detected abnormality represents a pseudotumor, a masslike finding that mimics a neoplasm. Renal pseudotumors are caused by a variety of conditions including congenital anomalies (prominent renal columns of Bertin, dromedary humps), inflammatory masses (focal pyelonephritis, chronic renal abscess, autoimmune disease), vascular structures (renal artery aneurysm or arteriovenous fistula), or abnormalities relating to trauma or hemorrhage. Although some renal pseudotumors require treatment, they are treated differently from neoplasms and therefore their recognition is important to ensure proper management. If they are not first excluded when evaluating a renal masslike finding, the application of image-based criteria used to evaluate renal masses could lead to an incorrect diagnosis. For example, enhancement is often used to support the diagnosis of a neoplasm, but enhancement can be found in infectious and other inflammatory conditions, aneurysms, and vascular malformations. Key radiologic features to support an inflammatory cause include ill-defined margins and perinephric stranding (Fig. 1). Aneurysms and vascular malformations enhance similarly to nearby vasculature; in the case of a vascular malformation, hypertrophy of the ipsilateral renal artery and arteriovenous shunting may be present. In most cases, careful evaluation of computed tomography (CT) or magnetic resonance (MR) imaging, combined with the clinical presentation and a familiarity with this group of masses, should reveal the correct diagnosis.

CLINICAL HISTORY AND DEMOGRAPHIC INFORMATION

Clinical history and demographic patient information are noncontributory in diagnosing an incidental renal mass in most cases. Most patients with renal cell carcinoma are asymptomatic and the tumor is serendipitously found on an imaging study performed for a nonrenal complaint.3–6 History can be helpful in differentiating a masslike inflammatory process of the kidney (pseudotumor) from a renal neoplasm. A history of flank pain, fever, and pyuria are supportive of pyelonephritis, and not a neoplasm.
However, these signs and symptoms do not exclude the diagnosis of a neoplasm. Patient demographics and a specific imaging appearance may be helpful in interpreting some renal masses and suggesting appropriate management. For instance, angiomyolipoma with minimal fat and multilocular cystic nephroma, both discussed in detail later, are more common in women and have typical imaging characteristics, but cannot be diagnosed with certainty using imaging alone.

ENHANCEMENT OF RENAL MASSES

Once pseudotumors are excluded, mass enhancement indicates a neoplasm. Renal mass enhancement is affected by multiple factors: the amount and rate of the contrast material injected, scan delay, and the vascularity of the mass. Highly vascular tumors show marked enhancement, whereas hypovascular tumors show minimal enhancement. Enhancement is assessed on CT imaging by comparing the attenuation of the mass, measured in Hounsfield units (HU), before and after intravenous (IV) contrast material administration. There is no universally agreed specific value that can be used as a cutoff for differentiating nonenhancing fluid from enhancing soft tissue. We use a threshold of 20 HU to indicate definitive enhancement within a renal mass, values of 10 to 19 HU as equivocal for enhancement, and values of less than 10 HU as indicating no enhancement.7

The accuracy of attenuation values are dependent on multiple factors, including patient size, renal mass size, size and placement of the region of interest, CT technique, partial volume averaging, and CT scanner type and manufacturer.8–11 In our opinion, these are time-tested values and ranges and represent a practical approach to determining enhancement.

There is no unanimously accepted way of determining renal mass enhancement with MR imaging. Methods currently used include image subtraction,12 calculating percent enhancement using arbitrary signal intensity units,12,13 and subjective comparison of unenhanced and contrast-enhanced images. Although a subjective comparison of unenhanced and contrast-enhanced images may be useful in cases of obvious enhancement in hypervascular tumors, enhancement may be difficult (or impossible) to detect in hypovascular tumors and in masses that are hyperintense on unenhanced T1-weighted images.

CYSTIC RENAL MASSES

Cystic renal masses are the most common masses in the kidney, with most being benign simple cysts.2 Simple cysts are defined as having a hairline-thin wall, no septa or calcification, and being filled with simple fluid that measures 0 to 20 HU. There are no soft tissue components within simple cysts, they do not enhance after the administration of IV contrast, and they are considered benign.14 When a cystic renal mass contains material that is higher in attenuation than simple fluid (>20 HU), 1 or more septa, calcifications, thickened walls or septa, or enhancing soft tissue components, it cannot be considered a simple cyst. The Bosniak renal cyst classification system has been used worldwide in evaluating cystic renal masses for the past 25 years.14–18 Cystic renal masses are classified into 5 groups based on CT findings: categories I, II, IIF, III, and IV.19–22

Category I masses are simple cysts using the criteria listed earlier and are always benign. Category II masses are minimally complicated cysts that can be reliably considered as benign. They may contain a few (generally 1 or 2) hairline-thin septa in which perceived (not measurable) enhancement may be appreciated. The wall or septa may contain fine calcifications or a short segment of slightly thickened smooth calcification (Fig. 2).

Hyperdense or hyperattenuating cysts are also included in category II. These masses were initially described as containing attenuations greater than renal parenchyma (typically 40–90 HU), but the attenuation criterion has been expanded to

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Fig. 1. A 48-year-old man with fever and flank pain. Axial contrast-enhanced CT image shows a 2.3-cm mass in the left kidney. The mass has ill-defined margins with the kidney and there is mild perinephric stranding (arrow). Combined with the clinical history of fever and flank pain, the findings are consistent with focal pyelonephritis. The patient was successfully treated with antibiotics. Follow-up CT scan (not shown) showed complete resolution.
include masses with attenuations greater than 20 HU. To diagnose a hyperattenuating cyst with confidence, the mass must be small (≤3 cm), well circumscribed, homogeneously hyperattenuating (even on a narrow window setting), and must not enhance (Fig. 3). Homogeneity is an important feature; high-attenuation fluid within a renal mass can mask small regions of enhancement. Therefore, it is important to obtain multiple attenuation measurements of varying sizes throughout the lesion to ensure that the mass is homogeneous, and that no portion of the mass enhances. To our knowledge, there is only a single case report in the literature that fulfills the criteria for a hyperattenuating cyst and was subsequently proved to represent a renal cell carcinoma. At pathology, the mass was cystic and contained only a single layer of neoplastic cells in its wall. Nonetheless, it is our opinion that small (≤3 cm) homogeneously high-attenuation nonenhancing cystic renal masses, are reliably considered benign and do not need further evaluation. Hyperattenuating cysts may be diagnosed by unenhanced CT alone; a recent study showed

Fig. 2. A 63-year-old woman with a Bosniak category II renal cyst. Unenhanced (A) and contrast-enhanced (B) axial CT images show a cystic left renal mass that contains a few hairline-thin septa in which thin curvilinear calcification is present (arrow). There is no measurable enhancement within the mass and its wall is hairline thin. The mass is consistent with a category II mass (benign). Note the slight puckering in of the wall of the mass at the point where septa insert on the wall. This puckering should not be mistaken for enhancing soft tissue components within the mass.

Fig. 3. A 45-year-old man with a high-attenuation cyst. Unenhanced (A) and contrast-enhanced (B) axial CT images show a 1.3-cm nonenhancing hyperattenuating homogeneous mass in the left kidney that measures 74 HU on the unenhanced examination. This mass is consistent with a hyperattenuating cyst (Bosniak category II). Note the other small low-attenuation lesions in the kidney that are likely a cluster of benign cysts.
that a renal mass with homogeneous attenuation greater than 70 HU on an unenhanced CT had a greater than 99% probability of being benign (Fig. 3).²⁴ Although additional studies are necessary, it seems that some high-attenuation cysts can be diagnosed as benign without additional imaging or contrast material administration.

Overall, Bosniak category II renal masses are reliably considered benign. The clinical significance of case reports of category II masses that were found to be malignant,¹⁶,²³,²⁵,³⁴ some with only a single microscopic focus of malignant cells in the wall,²³ is unclear. Some of the reports did not describe the imaging findings, and it is possible that the lesions were incorrectly categorized. Even if they were appropriately categorized, the number of malignant category II renal masses is extremely small compared with the number of benign category II masses. It is likely that those masses described in the cases reports were low-grade (Fuhrman grade I) renal cell carcinomas. Therefore, a medically appropriate and practical approach is to consider all category II masses benign.

Category IIF masses (F for follow-up)²⁰,²¹,²⁶,²⁷ have more features than those defined for a category II mass. Category IIF lesions are likely benign but require follow-up imaging to show stability. These masses may contain multiple hairline-thin septa and a slightly thickened smooth wall or septum in which perceived enhancement (not measurable enhancement) is present (see Fig. 4). Category IIF renal masses may contain thick or nodular calcification, but there should not be any enhancing soft tissue elements.²¹ Category IIF includes nonenhancing hyperattenuating renal masses that measure greater than 3 cm or are completely intrarenal. Category IIF masses should be followed for morphologic changes, such as development of septa or wall thickening. Growth is not a useful determinant of malignancy because simple benign cysts may grow and renal cell carcinomas may not.²⁰,³⁵–³⁹ Therefore, growth is not a feature of the Bosniak renal cyst classification. Morphologic changes, such as septa or wall thickening or new areas of enhancement, suggest malignancy. Because lack of morphologic change with time suggests a benign diagnosis, following category IIF masses is appropriate. In a study of 42 patients with category IIF masses, only 2 patients’ masses showed progressive septal thickening on follow-up examinations and were diagnosed as renal cell carcinoma 1.5 and 3 years after the initial CT scan.²⁰ The recommended interval for follow-up examinations is to obtain a CT scan or MR imaging examination at 6 and 12 months, followed by yearly examinations for a minimum of 5 years.²⁰ However, there is no known time interval of stability that can be used to diagnose a renal mass as benign with complete certainty. However, if a Bosniak category IIF lesion

Fig. 4. A 54-year-old woman with a benign complicated renal cyst. (A) Contrast-enhanced CT image shows a 2.5-cm cystic right renal mass that contains multiple thin septa (arrows), consistent with a Bosniak category IIF cyst. There are no solid enhancing components. (B) Contrast-enhanced CT image obtained 3 years after the examination in (A) shows that the mass may be slightly larger but that there are no other morphologic changes in the appearance of the mass, suggesting a benign cause. Further follow-up examinations will be performed to ensure benignity.
has not significantly changed morphologically in a period of 5 years, it is likely benign.\textsuperscript{20}

Category III cysts are truly indeterminate masses because they have a reasonable probability of being benign or malignant. Imaging features include a thickened wall or septa that show measurable enhancement (Figs. 5 and 6).\textsuperscript{19,28} Benign masses in this category include acute and chronically infected cysts, hemorrhagic cysts (often secondary to trauma), benign multilocular cysts, benign multiseptated cysts, and cystic neoplasms such as multilocular cystic nephroma. Malignant masses in this category include cystic renal cell carcinoma. Initially, it was estimated that approximately half of category III masses were benign and the other half were malignant. Recent studies have shown a wide range (31\%–100\%) of these masses to be malignant.\textsuperscript{15,40} This wide variation may be attributed to radiologists’ experience in interpreting renal mass imaging and the philosophy and practice of referring urologists caring for the patient. Since category IIIF was introduced, we believe that most category III renal masses have been malignant; benign category III masses that previously were operated on are now being followed (category IIIF) with a subsequent greater percentage of malignant category III masses remaining.

Most category III masses are treated by surgical resection to ensure that a malignancy is not missed. This approach leads to some benign lesions unnecessarily being removed. The number of benign category III masses that are removed can be reduced by always considering benign diagnoses that can be treated nonsurgically, such as renal abscesses and some hemorrhagic cysts. Percutaneous biopsy is of limited value, but may be helpful in patients who have comorbidities that place them at risk for surgery.\textsuperscript{40,41} If a malignant result is achieved; this allows the surgery to proceed with confidence. If a definitive diagnosis of a benign entity is obtained, surgery can be avoided. However, unless a specific benign result is obtained, other negative results (eg, nonspecific biopsy specimens containing inflammatory cells) should be viewed with skepticism.\textsuperscript{29} Biopsy can be difficult because Bosniak category III masses typically contain no soft tissue nodules; there is less tumor to sample, and hence the possibility of sampling error. Therefore, it should be emphasized to the patient and referring physician that a negative biopsy result may not be definitive.\textsuperscript{29}

Category IV cysts are malignant masses until proved otherwise and therefore require surgical removal. Imaging features include those described in category III with the presence of nodular enhancement within the mass or adjacent to its wall (Fig. 7). The probability of such a mass being malignant is close to 100\%.

**CYSTIC RENAL MASS SIZE AS A FACTOR**

Size is not a good predictor of malignancy in cystic renal masses because small cystic masses may be malignant and large ones can be benign. In our experience, the smaller the cystic lesion, the more likely it is benign, and very small (<1 cm) cystic renal mass are almost always benign. This finding is important because subcentimeter cystic masses

![Fig. 5. A 47-year-old man with a Bosniak category III renal mass. Axial contrast-enhanced CT image shows a 3.3-cm mass in the left kidney that contains a thickened wall in which measurable enhancement could be measured (arrow). The mass is consistent with a Bosniak category III mass. The patient underwent partial nephrectomy and a renal cell carcinoma was diagnosed at pathology.](image-url)
are more difficult to characterize compared with larger cystic masses, because their morphologic features are not as evident. With the technological advances in CT during the past 20 years, more cystic-appearing masses measuring less than 1 cm are being detected in the kidneys. Many of these masses cannot be characterized accurately because of their small size. However, the probability of a small cystic lesion being benign is extremely high. Therefore, as Bosniak recommended in the

Fig. 6. A 33-year-old woman with a category III cystic renal mass. Unenhanced fat-suppressed T1-weighted image (A) and postcontrast fat-suppressed T1-weighted image (subtraction image obtained by subtracting the unenhanced image in (A) from a contrast-enhanced image [not shown]) (B) shows a 4.5-cm cystic mass with irregular and thickened enhancing septa (arrows), consistent with a Bosniak category III mass. Renal cell carcinoma was diagnosed at pathology.

Fig. 7. A 74-year-old man with a complex cystic renal mass. Unenhanced (A) and contrast-enhanced (B) axial CT images show a 1.7-cm cystic mass in the right kidney that contains a solid enhancing nodule along its wall (arrow). This is consistent with a Bosniak category IV mass, a renal cell carcinoma was diagnosed at pathology.
past, we believe that a small (<1 cm) cystic-appearing mass that is homogeneously low in attenuation and without septa, nodularity, or calcification can be diagnosed as a benign cyst.30,42

**SOLID RENAL MASSES**

A solid renal mass is best defined as a mass with little or no fluid components, and usually consists predominantly of enhancing soft tissue. As detailed earlier, after excluding pseudotumors, such as inflammatory causes, and vascular anomalies and aneurysms, a solid renal mass should be considered a renal neoplasm. Most solid renal neoplasms in adults are renal cell carcinoma and surgery is recommended. However, many small (≤3 cm) solid renal masses are benign.43 Benign diagnoses typically encountered at surgery for what was believed to be renal carcinoma include oncocytomas and angiomyolipomas. Oncocytomas are benign tumors that historically have been resected because they could not be distinguished from renal cell carcinoma with confidence. As a result, most are still resected; however, percutaneous biopsy can be used to render a confident diagnosis in some cases, and this is discussed later.29 Most angiomyolipomas can be diagnosed by showing with CT or MR imaging the presence of fat in a noncalcified renal mass. As a result, angiomyolipomas that are resected today are typically those that contain little or no fat.

It is also necessary to diagnose those malignant renal neoplasms that do not require surgery (eg, lymphoma and metastatic disease). A combination of clinical history and the imaging findings may allow these masses to be diagnosed. However, in some cases percutaneous biopsy may be required. In the setting of an extrarenal malignancy that is known to metastasize to the kidney, the mass may represent a primary renal malignancy or metastatic disease. In patients with a history of extrarenal malignancy, 50% to 85% of solitary solid renal masses are metastatic.34,45 Therefore, a metastasis cannot be diagnosed presumptively, and other benign and malignant primary renal neoplasms need to be considered.51 In patients with widespread metastatic disease, this differentiation may not be necessary clinically but, in patients with an extrarenal neoplasm without metastatic disease, percutaneous biopsy may help diagnose the mass.29,51

When multiple non–fat-containing solid renal masses are identified in a patient without a history of extrarenal malignancy, the most likely diagnoses are multifocal renal cell carcinoma or multiple oncocytomas (which may or may not be part of a hereditary syndrome).48–48 In these cases, renal mass biopsy is usually performed for diagnosis before making management decisions because patients with multifocal renal cell carcinoma are typically treated more aggressively than those with multiple oncocytomas.32,33,42 In patients with a history of an extrarenal malignancy (especially lung cancer and lymphoma) who are found to have multiple solid renal masses, metastatic disease (in addition to multifocal renal cell carcinoma and multiple oncocytomas) needs to be considered and renal mass biopsy is suggested for differentiation.

As mentioned earlier, although solitary solid renal masses are frequently renal cell carcinoma, many also represent benign masses (angiomyolipoma and oncocytoma), particularly when they are small. Most angiomyolipomas can be diagnosed with CT or MR imaging by showing regions of fat within a mass.49 Some angiomyolipomas contain very small quantities of fat that can be overlooked if the mass is not carefully evaluated (Fig. 8).50,51

Metastatic evaluation of all solid renal masses for the presence of fat is imperative to avoid recommending surgical excision of an angiomyolipoma. When a small amount of fat is suspected in a renal mass, an unenhanced CT scan with thin sections combined with a pixel analysis is the most sensitive test to confirm this.50–52 MR imaging using T1-weighted sequences with and without frequency-selective fat suppression or chemical shift imaging can also be used.53 Approximately 5% of angiomyolipomas do not contain fat that can be seen at imaging, and the differentiation from other renal neoplasms is not possible with CT or MR imaging. These masses, referred to as angiomyolipoma with minimal fat,51 are often small, hyperattenuating on an unenhanced CT examination (attenuation > unenhanced renal tissue) and homogeneously enhance with contrast material (Fig. 9).51,54 However, these findings are not specific enough to make a confident diagnosis of an angiomyolipoma, and other tumors, such as papillary renal cell carcinoma, metanephric adenoma, oncocytoma and leiomyoma, may have a similar appearance.33,55,56

MR imaging may be useful when an angiomyolipoma with minimal fat is suspected on CT. Angiomyolipomas with minimal fat contain a lot of smooth muscle and are therefore typically hypointense on T2-weighted images51,57 compared with clear cell renal cell carcinoma (the most common subtype of renal cell carcinoma), which is typically hyperintense on T2-weighted images.58–61 Therefore, if a solid renal mass shows high attenuation on an unenhanced CT scan, homogeneously enhances, and is hypointense on T2-weighted images, an angiomyolipoma with minimal fat is a possible diagnosis, especially if the patient is
a woman. However, this is not diagnostic because other renal masses may have similar appearances. Specifically, papillary renal cell carcinoma may also enhance homogeneously and is typically hypointense on T2-weighted sequences. Therefore, when imaging suggests the diagnosis of angiomyolipoma with minimal fat but cannot exclude papillary renal cell carcinoma, renal mass biopsy is suggested to differentiate between these 2 entities.29

Oncocytoma is a benign solid renal mass that cannot be differentiated from renal cell carcinoma by imaging. Although a central scar and homogeneous enhancement at CT or MR imaging are
suggestive of oncocytoma, these findings are not specific and a tissue diagnosis is necessary to differentiate oncocytoma from renal cell carcinomas that have also been reported to display these findings. Percutaneous biopsy has recently been used to diagnose small oncocytomas; the appearance of an oncocytoma on biopsy specimens can be characteristic and the diagnosis further corroborated using special immunocytochemical stains. However, biopsy is not definitive in all cases, because some renal cell carcinomas have oncocytic features, and surgical resection may be needed to make a definitive diagnosis. 29,63

SOLID RENAL MASS SIZE AS A FACTOR

A study of 2770 surgically removed solid renal masses showed that 12.8% of the masses were benign, of which almost all were oncocytomas and angiomyolipomas. 43 When all renal masses were stratified according to size, 46% of masses less than 1 cm were benign, as were 22% of those that were between 1 and 2.9 cm, and 20% of those that were between 3 and 3.9 cm. Smaller solid renal masses are therefore more likely to be benign than larger masses. Although there are limited data regarding the natural history of small (<3 cm) solid renal masses, they are usually low grade with a slow growth rate. Similar growth rates have been shown for both benign and malignant small solid renal masses. 5,64–68 Some small solid renal masses may not grow at all. In one meta-analysis, 30% of small (<3 cm) solid renal masses did not grow during a 23- to 39-month observation interval. 56 Another study showed that the chance of malignancy in a renal mass that is stable in size was approximately the same as an enlarging mass, 83% versus 89%, respectively. 38 However, some small renal cell carcinomas can be histologically aggressive, 69 grow quickly, 66 and metastasize early. Therefore, it is difficult to predict the clinical behavior of a renal mass based on size or histology alone.

IMAGING MODALITIES AND TECHNIQUES

It is common to find incidental renal masses when imaging the abdomen, and most are simple cysts. If the mass does not seem to represent a simple cyst, a CT or MR imaging examination designed to evaluate renal masses is usually necessary. Exceptions include masses that can be characterized on the initial study, such as obvious renal cell carcinoma, angiomyolipomas that show fat, and some benign complicated renal cysts (Bosniak category II). The imaging modality used to characterize a renal mass is dependent on the preference and experience of the radiologist and urologist. In some cases, ultrasound can be used to characterize a renal mass. Ultrasound is best used to characterize simple cysts; benign, minimally complicated cysts that are well imaged with ultrasound may not need additional imaging. CT and MR imaging are the most frequently used modalities to characterize a known renal mass. Although this article does not review the CT and MR imaging techniques used to characterize renal masses in detail, it is necessary to perform both examinations with 3- to 5-mm sections before and after the administration of IV contrast material.

Follow-up imaging can be used as part of an observational strategy of renal masses, most recently referred to as active surveillance. It is frequently used in patients with renal masses that would have been surgical removed, but who are not surgical candidates because of surgical comorbidities or limited life expectancy. Follow-up imaging is used to determine interval growth of the mass. Any imaging modality that can be used to show the mass clearly enough to obtain accurate measurements is suitable. Unenhanced imaging may be adequate in follow-up imaging. In cases of Bosniak category IIF cysts, follow-up imaging with and without contrast is necessary because morphologic characteristics and enhancement of the mass is needed in addition to lesion size. Therefore, protocols used to characterize a renal mass (CT or MR imaging with and without IV contrast material) should be used when following Bosniak category IIF masses.

MANAGEMENT RECOMMENDATIONS

Management decisions are dependent on many factors, including imaging findings, patient age, life expectancy, comorbidities, available treatment options, and patient preference. A 3-cm non–fat-containing solid mass that would typically be surgically removed in the general population would require an alternate management strategy, such as follow-up imaging or ablation, in a patient at high surgical risk. Because each patient is unique, it is impossible to develop management schemes that would be appropriate for all patients. The management of each patient needs to be individualized, and appropriate management should consider imaging findings in addition to clinical factors.

RECOMMENDATIONS IN PATIENTS WITH CYSTIC RENAL MASSES

General Population

The Bosniak renal cyst classification is recommended as the guideline for management in the general population (Table 1). Although renal
<table>
<thead>
<tr>
<th>Bosniak Category</th>
<th>Imaging Features</th>
<th>Appearance</th>
<th>Recommendation</th>
<th>General Population</th>
<th>Comorbidities or Limited Life Expectancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ia</td>
<td>Hairline-thin wall; no septa, calcifications, or solid components; water attenuation; no enhancement</td>
<td></td>
<td>Ignore</td>
<td>Ignore</td>
<td></td>
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<td>II</td>
<td>Few hairline-thin septa with or without perceived (not measurable) enhancement; fine calcification or short segment of slightly thickened calcification in the wall or septa; homogeneously high-attenuating masses (≤3 cm) that are sharply marginated and do not enhance</td>
<td></td>
<td>Ignore</td>
<td>Ignore</td>
<td></td>
</tr>
<tr>
<td>IIIF</td>
<td>Multiple hairline-thin septa with or without perceived (not measurable) enhancement, minimal smooth thickening of wall or septa that may show perceived (not measurable) enhancement, calcification may be thick and nodular but no measurable enhancement present; no enhancing soft tissue components; intrarenal nonenhancing high-attenuation renal masses (&gt;3 cm)</td>
<td></td>
<td>Observe&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>Observe&lt;sup&gt;b&lt;/sup&gt; or ignore&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
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<tr>
<td>III</td>
<td>Thickened irregular or smooth walls or septa, with measurable enhancement</td>
<td></td>
<td>Surgery&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Surgery&lt;sup&gt;e&lt;/sup&gt; or observe&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
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<tr>
<td>IV</td>
<td>Criteria of category III but also containing enhancing soft tissue components adjacent to or separate from the wall or septa</td>
<td></td>
<td>Surgery&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Surgery&lt;sup&gt;e&lt;/sup&gt; or observe&lt;sup&gt;b&lt;/sup&gt;</td>
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Note: These recommendations are to be followed only if nonneoplastic causes of a renal mass (eg, infections) have been excluded; see text for details. The recommendations are offered as general guidelines and do not necessarily apply to all patients.

<sup>a</sup> When a mass smaller than 1 cm has the appearance of a simple cyst, further work-up is not likely to yield useful information.

<sup>b</sup> CT or MR imaging at 6 and 12 months, then yearly for 5 years; interval and duration of observation may be varied (eg, longer intervals may be chosen if the mass is unchanged; longer duration may be chosen for greater assurance).

<sup>c</sup> In selected patients, (eg, young) early surgical intervention may be considered, particularly if a minimally invasive approach (eg, laparoscopic partial nephrectomy) can be used.

<sup>d</sup> Cystic masses 1.5 cm or smaller that are not clearly simple cysts, or that cannot be characterized completely, may not require further evaluation in patients with comorbidities and in patients with limited life expectancy.

<sup>e</sup> Surgical options include open or laparoscopic nephrectomy and partial nephrectomy; each provides a tissue diagnosis. Open, laparoscopic, and percutaneous ablation may be considered where available, but biopsy would be needed to achieve a tissue diagnosis. Long-term (5- or 10-year) results of ablation are not yet known.
mass size is generally not a part of the Bosniak classification, renal masses that measure less than 1 cm and seem to represent simple cysts (low attenuating without septa, nodularity, calcification, or enhancement), can be presumed to be benign and do not need to be further evaluated. Although the true nature of these masses is unclear, it is reasonable to report that they are too small to diagnose definitively, but are statistically likely to represent benign renal cysts.

**Patients with Limited Life Expectancy or Significant Comorbidity**

Similarly to cystic masses in the general population, the Bosniak classification can be used, but with a less aggressive approach (see Table 1). In addition, incidental indeterminate renal masses measuring up to 1.5 cm when they are first discovered need not be further evaluated in patients with comorbidities that limit life expectancy. This is based on the idea that most of these masses will be benign cysts or slow-growing neoplasms.

**RECOMMENDATIONS IN PATIENTS WITH SOLID RENAL MASSES**

**General Population**

Solid renal masses are more likely to be malignant than cystic masses and a more aggressive approach is recommended (Table 2). With the exception of angiomyolipoma, benign and malignant solid renal masses cannot be differentiated with imaging, and histologic diagnosis is suggested. Similarly to cystic masses, masses smaller than 1 cm that seem solid are challenging from a management perspective. Despite state-of-the-art CT and MR imaging techniques, correctly diagnosing the mass as solid is difficult, given their small size. Even if the mass can be correctly characterized as solid, there is as much as a 46% chance that the mass would be benign. Therefore, when a mass in the kidney measures less than 1 cm and has features that suggest it is solid, it is reasonable to follow the mass with serial imaging (initially 3–6 months and then yearly), until the mass reaches 1 cm in size. At this time, the mass should be of sufficient size to be able to be further characterized.

**Patients with Limited Life Expectancy or Comorbidities**

In patients with limited life expectancy or comorbidities, a less aggressive approach may be used from that of the general population (Table 3), especially for small (<3 cm) renal masses because they are more likely to be benign and are less aggressive than larger masses. These masses can be observed with serial imaging in lieu of surgery. In the past, Bosniak has suggested observation in patients with solid masses smaller than 1.5 cm because most small renal cell carcinomas grow

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**Table 2**

<table>
<thead>
<tr>
<th>Mass Size (cm)</th>
<th>Probable Diagnosis</th>
<th>Recommendation</th>
<th>Comment</th>
</tr>
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<tbody>
<tr>
<td>Large (&gt;3)</td>
<td>Renal cell carcinoma&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Surgery&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Angiomyolipoma with minimal fat, oncocyctoma, other benign neoplasms may be found at surgery</td>
</tr>
<tr>
<td>Small (1–3)</td>
<td>Renal cell carcinoma&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Surgery&lt;sup&gt;b&lt;/sup&gt;</td>
<td>If hyperattenuating, and homogeneously enhancing, consider MR imaging and percutaneous biopsy to diagnose angiomyolipoma with minimal fat</td>
</tr>
<tr>
<td>Very small (&lt;1)</td>
<td>Renal cell carcinoma, oncocyctoma, angiomyolipoma&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Observe until 1 cm&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Thin (&lt;3 mm) sections help confirm enhancement</td>
</tr>
</tbody>
</table>

Note: These recommendations are best followed after nonneoplastic causes of a renal mass (eg, infections) have been excluded; see text for details. The recommendations are offered as general guidelines and do not necessarily apply to all patients.

<sup>a</sup> Provided there is no detectable fat by CT or MR imaging using protocols designed to evaluate renal masses.

<sup>b</sup> Surgical options include open or laparoscopic nephrectomy and partial nephrectomy; both provide a tissue diagnosis. Open, laparoscopic, and percutaneous ablation may be considered where available, but biopsy would be needed to achieve a tissue diagnosis. Long-term (5- or 10-year) results of ablation are not yet known.

<sup>c</sup> Benign entities are more likely in small renal masses than large ones.

<sup>d</sup> CT or MR imaging at 3 to 6 months, and 12 months, then yearly; interval and duration of observation may be varied (eg, shorter intervals if the mass is enlarging).
slowly. An expert panel commission of the American College of Radiology also supports a wait-and-see approach for renal masses of 1.5 cm or less in the elderly. Because solid renal masses represent renal cell carcinoma in most cases, and are only curable when they are confined to the kidney, a decision to observe should be made carefully.

Options for the treatment of renal masses are increasing. Historically, radical nephrectomy was the standard of care for patients with renal cell carcinoma, both solid and cystic types. Partial nephrectomy is now recommended for T1a masses (organ-confined masses ≤ 4 cm). Minimally invasive techniques, including laparoscopic partial nephrectomy and laparoscopic and percutaneous ablation, may be considered, particularly for patients with comorbidities.

**SUMMARY**

Incidental renal masses are extremely common. Although most have benign causes, some are renal cell carcinoma. The guidelines we recommend are an attempt to optimize the use of imaging to differentiate benign from malignant causes. Not all masses can be diagnosed with confidence with imaging alone. Because it is not feasible to follow every incidental renal mass, some need to be presumed benign. However, some physicians may be unwilling to accept any diagnostic uncertainty in diagnosis, even though the chance of serious disease is very low. Nevertheless, we believe that the guidelines presented here are practical and medically sound. We emphasize that the guidelines and recommendations included in this review do not necessarily apply to all patients. Each patient’s renal mass should be managed individually taking into consideration patient factors and the preferences, capabilities, and expertise of all physicians caring for the patient. As with any set of guidelines aimed to summarize a complicated medical management issue, deviation from the guidelines is inevitable in some patients. With advances in state-of-the-art imaging, diagnosis, and treatment of renal masses, it is expected that

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**Table 3**

Management recommendations for an incidental solid renal mass in patients with limited life expectancy or comorbidities that increase the risk of treatment

<table>
<thead>
<tr>
<th>Mass Size (cm)</th>
<th>Probable Diagnosis</th>
<th>Recommendation</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large (&gt;3)</td>
<td>Renal cell carcinoma&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Surgery&lt;sup&gt;b&lt;/sup&gt; or observe</td>
<td>Angiomyolipoma with minimal fat, oncocytoma, other benign neoplasms may be found at surgery; Biopsy can be used preoperatively to confirm renal cell carcinoma</td>
</tr>
<tr>
<td>Small (1–3)</td>
<td>Renal cell carcinoma&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Surgery&lt;sup&gt;b&lt;/sup&gt; or observe</td>
<td>If hyperattenuating, and homogeneously enhancing, consider MR imaging and percutaneous biopsy to diagnose angiomyolipoma with minimal fat</td>
</tr>
<tr>
<td>Very small (&lt;1)</td>
<td>Renal cell carcinoma, oncocytoma, angiomyolipomac</td>
<td>Observe until 1.5 cm&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Thin (&lt;3 mm) sections help confirm enhancement</td>
</tr>
</tbody>
</table>

Note: These recommendations are best followed after nonneoplastic causes of a renal mass (eg, infections) have been excluded; see text for details. The recommendations are offered as general guidelines and do not necessarily apply to all patients.

<sup>a</sup> Provided there is no detectable fat by CT or MR imaging using protocols designed to evaluate renal masses.

<sup>b</sup> Surgical options include open or laparoscopic nephrectomy and partial nephrectomy; both provide a tissue diagnosis. Open, laparoscopic, and percutaneous ablation may be considered where available, but biopsy would be needed to achieve a tissue diagnosis. Long-term (5- or 10-year) results of ablation are not yet known.

<sup>c</sup> Benign entities are more likely in small renal masses than large ones.

<sup>d</sup> CT or MR imaging at 3 to 6 months, and 12 months, then yearly; interval of observation may be varied (eg, shorter intervals if the mass is enlarging); duration of observation may be individualized. Observation may be considered for a solid renal mass of any size in a patient with limited life expectancy, or comorbidities that increase the risk of treatment, particularly when the mass is small. It may be safe to observe a solid renal mass beyond 1.5 cm; however, there are insufficient data to provide definitive recommendations on the risks and benefits of observation.
the guidelines for the management of incidental renal masses will also evolve.

REFERENCES


