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Management of the Incidental Renal Mass¹

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Despite substantial advances in the imaging-based diagnosis of renal masses, the increased detection of incidental renal masses with cross-sectional imaging poses problems to the radiologist and referring physician. Most incidental renal masses can be diagnosed with confidence and either ignored or treated without further testing. However, some renal masses, particularly small ones, remain indeterminate and require a management strategy that is both medically appropriate and practical. In this article, the literature will be reviewed and an approach to the diagnosis and management of the incidental renal mass will be suggested. Management recommendations, derived from data regarding the probability of malignancy in cystic and solid renal masses, are provided for two types of patients, those in the general population and those with limited life expectancy or co-morbidity. The Bosniak classification is used to guide the management of cystic masses, with observation reserved for selected patients, and the presumption of benignity recommended for simple-appearing cystic masses smaller than 1 cm. Among solid renal masses, a more aggressive overall approach is taken. However, additional imaging, and in selected patients, percutaneous biopsy, is recommended to diagnose benign neoplasms. Although additional studies are needed to establish risks and benefits, observation of solid masses may be considered in selected patients. Minimally invasive treatments of renal cancer (including percutaneous ablation) show promise but at the same time challenge the radiologist to review the approach to the incidental renal mass.

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ncidental findings are those that cannot be related to the patient's presenting complaint or past medical history. Incidental findings in the kidneys are common; most of them are renal masses. Upon the detection of an incidental renal mass, there are two questions inherent in the decision-making process and the radiologist is faced with two tasks. The first task is to analyze the imaging appearance of the mass to determine the likely diagnosis; the second is to formulate a recommendation regarding how the mass might be managed. The first task, we believe, is a

Essentials

- Cross-sectional imaging can be used to render a confident diagnosis of most incidental renal masses.
- Although most cystic renal masses may be diagnosed and managed by using the Bosniak classification, some remain difficult to diagnose, but these can be managed in such a way that maximizes the chance of detecting cancerous masses and minimizes the chance of unnecessarily treating benign ones.
- Although there are no specific data regarding how to manage very small (<1 cm) cystic masses, on the basis of our experience, we believe that it is medically prudent to consider them benign cysts.
- When a solid renal mass is detected incidentally, in general, an evaluation that aggressively pursues a diagnosis of renal cancer is recommended, but when the mass is small (≤3 cm), a benign diagnosis is more likely than when a larger mass is encountered, and therefore, less aggressive approaches may be considered, such as percutaneous biopsy, in selected patients.
- In patients with limited life expectancy or co-morbidities that might increase the risk of treatment, less aggressive approaches to the diagnosis and treatment of an incidental renal mass may be considered, including percutaneous ablation and observation.

sine qua non of the radiology report, including information regarding probability of disease. The second task is somewhat optional; management decisions typically are the primary responsibility of the referring physician (in close consultation with the radiologist, and ultimately the patient) and often depend on factors not known to the radiologist. However, management recommendations, offered by the interpreting radiologist acting in his or her role as a consultant, are often helpful and can be based on knowledge of the patient's clinical presentation and the information made available at the time of the radiologic examination. Management recommendations from the radiologist are particularly important in patients with incidental renal masses because the probability of malignancy is determined to a large extent on the radiologic assessment of imaging findings.

Incidental renal masses are ubiquitous. It has been estimated that over half of patients over the age of 50 years harbor at least one renal mass, and often several are found during one radiologic examination such as ultrasonography (US), computed tomography (CT), or magnetic resonance (MR) imaging (1,2). Fortunately, the overwhelming majority of incidental renal masses are benign simple cysts and most can be confidently diagnosed as benign on the basis of crosssectional imaging alone (3). However, some cannot, and therefore the radiologist is charged with expressing the likelihood of the mass being a malignant neoplasm or other clinically important disease and offering a management recommendation. In general, management options for possible malignant neoplasms include leaving the mass alone, observation (with close follow-up), imaging with another modality, percutaneous biopsy, or treatment that typically includes surgery or ablation.

This article will summarize our approach to the incidental renal mass; it is complex and dependent on many factors (4). To our knowledge, there are no published data specifically addressing this problem. We will focus on the first task and summarize the radiologic approach to the incidental renal mass that is based

on imaging data. We will identify what we believe to be knowledge gaps in the literature that limit our ability to provide definitive diagnoses and make definitive recommendations. Then, using both the literature and our personal experience, we will provide an overall framework for the radiologist to address management recommendations for renal masses that are detected incidentally.

Confirmation of an Abnormal Finding

The approach to a renal mass first begins with an image analysis to be sure that the finding is indeed a true renal mass. Conditions that mimic a renal mass (sometimes known as pseudotumors), including hypertrophied parenchyma adjacent to scarred parenchyma and congenital anomalies such as a prominent column of Bertin or lobar dysmorphism, should be excluded. Vascular anomalies and aneurysms are other renal lesions that can mimic an enhancing solid neoplasm. Trauma, infarction, hemorrhage, and infection may be incidental; they each can cause masslike enlargement of a portion of the kidney and mimic a solid or cystic neoplasm (Fig 1). However, each is usually associated with some clinical history that will enable an accurate diagnosis; these entities should be excluded also before considering a neoplastic process (5,6). Once a mass is determined to be a neoplastic process, management depends first on the probability that the renal mass is malignant, and second, on factors related to the patient, such as age, life expectancy, co-morbid disease, and patient preference.

Use of Clinical History and Demographic Information

Most patients with renal cell carcinoma are asymptomatic and the tumor is diagnosed as a result of an incidental discov-

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ery of a renal mass at a cross-sectional imaging examination of the abdomen performed for a nonrenal complaint (7-10). Flank pain and hematuria may be contributory in determining that a renal mass is clinically important. However, lack of signs and symptoms of renal cancer should not dissuade the radiologist from considering that a mass is malignant. Demographic information (eg, age, sex) may help also in diagnosing the cause of a renal mass. For example, renal cell carcinoma is unusual in young patients; angiomyolipomas and multilocular cystic nephromas are more common in women. However, demographic information cannot be used alone to diagnose the cause of a renal mass.

Cystic Renal Masses

Renal masses may be subdivided into cystic and solid masses. Cystic renal masses are composed predominantly of spaces filled with fluid; at imaging, these fluid-filled spaces have the characteristics of fluid, in that fluid does not enhance. When a cystic mass is composed entirely of low-attenuation (0-20 HU) fluid surrounded by a hairline-thin smooth wall and does not enhance, the mass is benign (11). We consider attenuations between 0 and 20 HU to represent simple fluid attenuation (3,5,11). Although there is no universally agreed upon number that can be used to identify unequivocal enhancement, we use a threshold of 20 HU to indicate enhancement, and values of 10-20 HU as equivocal for enhancement and needing further assessment (5). We recognize that the accuracy of attenuation values is dependent on numerous factors, including patient size, mass size, the size of the region examined, CT technique, image noise, partial volume averaging, pseudoenhancement, and the CT scanner type and manufacturer (12-15). The CT attenuation values and ranges presented herein are, in our opinion, time tested and represent a practical approach to the evaluation of the renal mass. When a cystic mass contains fluid that is of higher attenuation than simple fluid, has calcification within its walls or

septa, has a thickened wall or septa, or contains an enhancing soft-tissue component, the mass may be benign or malignant depending on the degree of thickness and irregularity of the wall or septa and its enhancement characteristics. Cystic lesions containing enhancing soft-tissue components independent of the wall are malignant (11). The Bosniak classification, introduced 20 years ago, is a practical and useful guide to the diagnosis and management of cystic renal masses (11). In its current form, there are five categories of cystic renal masses, ordered in increasing probability of malignancy (3,11,16,17).

Bosniak Classification

Category I masses are benign, simple cysts; these lesions represent the most common renal mass detected with imaging (2). Simple cysts contain lowattenuation (0-20 HU) fluid and a hairline-thin smooth wall and do not contain septations, calcifications, or enhancing nodular soft tissue (Fig 2). To our knowledge, when characterized by using a properly performed CT or MR examination, masses with these features are always benign. Category II masses are benign, minimally complicated cysts; these masses may contain a few hairline-thin septa in which perceived (not measurable) enhancement may be appreciated when unenhanced and enhanced CT or MR images are compared side by side (Fig 3). Fine calcification or a short segment of slightly thickened calcification may be present in the wall or septa.

Category II masses also include hyperattenuating cysts. Hyperattenuating cysts are cysts containing fluid higher than water attenuation (ie, over 20 HU) (Fig 4). Originally they were described as cysts that had a



Figure 1: Renal abscess mimicking a cystic neoplasm in a 43-year-old man. Transverse contrast material—enhanced CT scan shows 4.6-cm cystic mass (arrow) with a thickened, enhancing wall and surrounding stranding in the adjacent fat. In preparation for ablation, biopsy was performed and a renal abscess was drained percutaneously.



Figure 2: Bosniak category I renal cyst in a 55-year-old woman. Transverse (a) unenhanced and (b) contrast-enhanced CT scans show a 2-cm mass (arrow) in the upper pole of the right kidney. The mass is homogeneous and low attenuation (8 HU), does not enhance or contain septa or calcification, and fulfills the criteria for a benign, simple cyst; no follow-up is necessary. Two additional very small (<1 cm) low-attenuation lesions are also likely benign cysts.

higher attenuation than renal parenchyma (typically 40-90 HU) on an unenhanced CT scan, but now it is generally accepted that a cyst measuring higher than water attenuation on an unenhanced CT scan is considered high attenuation if it has sharp, smooth margins and does not enhance with contrast media (3,5,11). Because

of the high-attenuation fluid in the cyst (and since the thickness of the wall cannot be evaluated in high-attenuating cysts), it must be certain that the lesion is completely homogeneous (even when viewed with a narrow window setting). It is helpful to obtain multiple region-of-interest measurements throughout the lesion to be cer-



a.

Figure 3: Bosniak category II renal cyst in a 42-year-old man. Transverse (a) unenhanced and (b) contrastenhanced CT scans show a 4-cm cystic left renal mass that contains few, hairline-thin septa, some of which contain hairline-thin calcification (arrows). There is no measurable enhancement within the mass. Findings are diagnostic of a benign complicated renal cyst; no follow-up is necessary.

Figure 4



a.

Figure 4: Bosniak category II renal cyst in a 51-year-old woman. Transverse (a) unenhanced and (b) contrast-enhanced CT scans show a 1-cm exophytic, homogeneous right renal mass (arrow) that measures 74 HU on **a** and does not enhance. The findings are diagnostic of a benign, hyperattenuating renal cyst; no follow-up is necessary.

b.

hances (5). In general, cysts that measure between 20 and 40 HU are proteinaceous cysts and will show findings of a simple cyst at US; those with attenuations over 40-50 HU are likely to be hemorrhagic cysts and will be complex at US (18). One mass that fulfilled these criteria for a hyperattenuating cyst has been reported to be malignant (19). The wall of the cystic lesion contained a single layer of neoplastic cells. This case report notwithstanding, a small (≤ 3 cm) homogeneously hyperattenuating, nonenhancing cystic mass (Bosniak II) is reliably considered benign and need not be evaluated further. Moreover, a recent study (20) suggested that when a hyperattenuating renal mass was encountered on an unenhanced CT scan, the probability of the mass being benign was over 99% as long as the attenuation was 70 HU or higher and the mass was homogeneous. Although more confirmatory studies are needed, these data raise the possibility of presumptively diagnosing such masses as hyperattenuating cysts rather than reexamining them with a CT or MR examination, with and without contrast material, to be sure that the mass does not enhance (16).

tain that no portion of the lesion en-

Overall, all category II renal masses are reliably considered benign. There are reports in the literature of rare renal masses that were classified as category II and were found to be malignant or potentially malignant at histologic evaluation (19,21-23). Some of these masses (19) contained microscopic foci of renal cell carcinoma in their walls. However, it is difficult to interpret the meaning of these reports. The features of the masses are not always fully described; therefore, the masses may not have been categorized correctly. Furthermore, these are small series with select populations that do not represent the true prevalence of category II masses. Finally, the natural history of these lesions is not known. Although it is indeed likely that there are extremely rare cases of renal cell carcinoma in the walls of otherwise benign category II cysts, they are so rare that, in our opinFigure 5

ion, it is more practical to consider these masses benign than to subject many patients to surgery.

Category IIF (the "F" means to follow) is a category of cystic renal masses that cannot be considered benign without some period of observation (17, 24). These masses are slightly more complicated than masses in category II (Fig 5). These cysts have a hairline-thin wall and may contain multiple, hairline-thin septa that demonstrate perceived (not measurable) enhancement. There may be minimal smooth thickening of the wall or septa. They may contain thick, irregular or nodular calcification. There are no enhancing soft-tissue components. Hyperattenuating renal masses that exhibit all of the features of hyperattenuating cysts but are larger than 3 cm and are completely intrarenal are included also in this category (17).

Cystic renal masses in category IIF require follow-up CT or MR examination; stability over time suggests that they are benign. Observation of these masses has been shown to be safe and, in one series, prevented unnecessary surgery in 95% (40 of 42) of patients (17). In two patients, renal cell carcinoma was diagnosed at 1.5 and 3 years after the initial CT scan when imaging findings progressed on follow-up studies. The recommended interval for follow-up studies is to perform an initial CT or MR examination at 6 months, followed by yearly studies for a minimum of 5 years (17).

This is a rational approach; however, there is no known interval of time that can be used to definitively diagnose renal masses as benign (17,25). Indeed, some small solid cancers grow slowly or not at all (26-29). Nevertheless, a category IIF mass that exhibits no growth or morphologic change after 5 years is likely benign (17). It should be emphasized that growth rate is not a feature of the Bosniak cyst classification. Benign renal cysts grow, sometimes rapidly; conversely, malignant lesions may grow slowly (25). For this reason, when following cystic renal lesions, the radiologist should examine the lesion for morphologic change (eg, septa becoming thicker or more nodular); overall



Figure 5: Bosniak category IIF cystic mass in a 66-year-old man. Transverse (a) unenhanced and (b) contrast-enhanced CT scans demonstrate a cystic mass in the lateral aspect of the left kidney that contains thick and irregular calcifications in its wall. There is high-attenuation material (arrow) within the mass that does not enhance. The mass was observed for 9 years and has not changed. There is a simple cyst in the anteromedial aspect of the left kidney.



Figure 6: Bosniak category III cystic mass in a 68-year-old woman. Transverse (a) unenhanced and (b) contrast-enhanced CT scans show a 3.8-cm cystic left renal mass that contains multiple thickened septa (arrows) in which measurable enhancement could be demonstrated. Features of category III cystic renal masses cannot be used reliably to distinguish benign from malignant causes. A benign multiseptated cyst was diagnosed at surgical pathologic evaluation.

growth and lesion size are less important.

Category III lesions are truly indeterminate renal masses; imaging cannot be used to diagnose them as benign or malignant with confidence (Figs 6, 7). Category III cystic masses contain thickened walls or septa in which measurable enhancement is present (3, 16, 30, 31). These lesions have been found to be multilocular cysts (in which the walls have fibrous lining), hemorrhagic or infected cysts, multilocular cystic nephroma (containing blastemal elements), or cystic renal cell carcinoma. Category III cystic renal masses have a reasonable chance of being benign or malignant. In two series (22,32), approximately half were benign and half were malignant. Category III cystic renal masses are considered "surgical lesions" because they have a reasonable probability of being malignant (22,31,32). Surgical removal of all category III lesions ensures that cancers are not missed. However, the prevalence of malignancy among resected category III masses has ranged from 31% to 100% (30,33). Although this practice ensures that cancers are not missed, up







Figure 8: Bosniak category IV cystic mass in a 55-year-old man. Transverse (a) unenhanced and (b) contrast-enhanced CT scans show a 2.8-cm peripherally calcified cystic left renal mass (arrow) containing a solid enhancing nodule that is adjacent to the wall. Renal cell carcinoma was diagnosed at surgical pathologic evaluation.

to 69% of patients undergo surgery unnecessarily. However, with the introduction of category IIF, benign lesions that were previously considered category III (eg, cystic renal mass that contains a thick calcification as its only nonsimple cyst feature) are now classified as category IIF and are followed up. As a result, we believe that today a greater percentage of category III lesions are malignant. However, it should be realized that there is a wide variation of reported series in the literature as to what percentage of category III lesions are benign or malignant. Reported percentages depend on how the radiologist categorized the lesion and the philosophy and practice preference of the urologist treating the patient with these indeterminate lesions (34).

Recently, some authors have posited that percutaneous biopsy can be helpful in identifying patients with benign causes of indeterminate cystic renal masses, obviating surgery in these patients (33,35). If an infectious etiology is considered, needle aspiration is indicated. However, in distinguishing benign from malignant neoplastic processes, we view with skepticism studies that promote biopsy of indeterminate cystic renal masses as being definitive (36). The principal problem is that there is less tumor bulk to sample. Biopsy may be helpful in selected circumstances, such as in patients who have co-morbidities that increase the risk of surgical exploration. In these patients, biopsy results serve as additional data that can be combined with imaging data to render a probable clinical diagnosis. However, it should be emphasized to the patient and referring physician that biopsy results, particularly in the absence of malignant cells, may not be definitive (36).

Category IV lesions may contain some or all of the features of category III lesions, but they also contain enhancing soft-tissue components adjacent to or separate from the wall or septa (Fig 8). Cystic renal lesions in this category are renal cancer until proved otherwise and are surgically removed. They are almost always malignant.

Cystic Renal Mass Size as a Factor

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Size is not an important feature of the Bosniak classification; small cystic masses may be malignant and large ones may be benign. However, in our experience, small cystic renal masses are more likely benign, but large ones are not necessarily more likely malignant. Benign cysts may grow to be large. Therefore, a radiologist can use small size to lower the probability of a cystic renal mass being malignant but cannot use large size to increase the probability of a cystic renal mass being malignant. Since small cystic lesions (particularly ones smaller than 1-2 cm) are more likely benign, size can be used to conclude that a small cystic lesion that exhibits no other features other than low attenuation is likely benign (except in patients with a genetic predisposition to developing renal cancer). These lesions used to be problematic because they could not be imaged well enough to assess their features, such as presence of enhancement, septa, and wall thickness (3). Today, particularly with use of multidetector CT and protocols with thin $(\leq 2.5 \text{ mm})$ collimation, cysts as small as 5 mm can be characterized with more confidence than in the past as simple cysts by using 3-mm sections with a 50% overlap (37). As a corollary to this concept, the smaller the mass, the more likely it is benign. As a result, the probability of malignancy in a cystic renal mass less than 1 cm ("very small" cystic renal lesion) is extremely low. Bosniak has recommended that in otherwise healthy individuals all lesions (cystic and solid) 1.0 cm or larger should be evaluated, but lesions under 1 cm that appear to be simple cysts, that is, a low-attenuation (0-20)HU) mass containing no septations, nodularity, calcifications, or enhancement, can be presumed to be benign and need not be pursued further (38).

Solid Renal Masses

Solid masses contain little or no fluid components and usually consist predominantly of enhancing tissue. As noted above, a masslike abnormality in the kidney with these features could be the result of infection, infarction, or trauma. Clinical history is typically indicative of these conditions. Abundant stranding in the ipsilateral perinephric fat should raise the suspicion for one of these processes. A vascular abnormality such as an aneurysm or an arteriovenous malformation may also present as an enhancing masslike structure. Observing that a masslike structure enhances to the same degree as the vasculature is a clue in making the diagnosis of a vascular anomaly. In the case of arteriovenous malformations, the ipsilateral renal artery is frequently enlarged; arteriovenous shunting may be detected also. Excluding inflammatory and vascular abnormalities and pseudotumors, an enhancing renal mass should be considered neoplastic.

With regard to the management of solid renal neoplasms, it is important to know whether there is a known primary malignancy. When there is a history of an extrarenal primary tumor, only 50%-85% of solitary renal masses are metastatic (39,40). Therefore, if a solid renal mass is detected in a patient with a known primary malignancy (eg, lung cancer, lymphoma), a metastasis should not be necessarily diagnosed presumptively; both a second primary (renal cell carcinoma) and a benign neoplasm should be considered (41). Percutaneous biopsy has been shown to be helpful in this clinical setting (36,41).

If multiple renal masses are discovered incidentally in the absence of a known primary malignancy, metastatic disease is less likely. Lymphoma is possible but rarely presents only in the kidney without other evidence of lymphoma. The two most likely diagnoses are multifocal renal cell carcinoma and multiple oncocytomas. These typically occur as part of hereditary syndromes that manifest as multiple, bilateral renal cell carcinomas, oncocytomas, or both (42-44). Percutaneous biopsy may be helpful in distinguishing these possibilities and dictating management (45,46). Patients with a genetic predisposition to renal cell carcinoma, or a family history of renal cell carcinoma who present with a mass that cannot be fully characterized, or who are unable to be treated

Figure 9



Figure 9: Incidental angiomyolipoma in a 61-year-old woman. Transverse unenhanced CT scan shows a 1.4-cm left mass (arrow) nearly entirely composed of regions of low attenuation (-90 HU); the findings are diagnostic of renal angiomyolipoma.

because of co-morbidities need to be followed aggressively. One could argue that lesions detected in these patients are not truly incidental; however, these patients may present without a family history of renal cancer. A 6-month examination followed by annual examinations has been suggested by some (26,47); others have suggested a more aggressive regimen that includes imaging patients every 3 to 6 months, depending on the size of the masses and the syndrome (48).

In adults, most solitary solid renal neoplasms found at imaging that do not contain fat are renal cell carcinoma. However, a substantial fraction of solid renal masses are benign. When encountering an incidental solid renal mass, angiomyolipoma should be excluded. These are benign neoplasms that, particularly when small, warrant no treatment. Most angiomyolipomas can be diagnosed by identifying regions of fat within a noncalcified renal mass at unenhanced CT (49) (Fig 9). However, calcified (50-53) and noncalcified (54) fat-containing renal masses have been reported to be renal cell carcinoma. Thin-section CT may be needed for small angiomyolipomas and those angiomyolipomas that contain only small amounts of fat. Chemical shift MR imaging may be used also to diagnose an angiomyolipoma that contains fat cells by demonstrating the India ink artifact at the interface of the fatty components of the angiomyolipoma with the nonfatty components of the kidney (55). However, a renal mass cannot be diagnosed as an angiomyolipoma solely on the basis of signal intensity loss on out-of-phase MR images. Clear cell subtype of renal cell carcinoma may also lose signal intensity on out-of-phase images because the cells of this tumor, like fat cells, may also contain intracellular lipid (56).

Although most angiomyolipomas contain fat and can be diagnosed with unenhanced CT alone, approximately 5% of angiomyolipomas contain little or no fat and appear as small, hyperattenuating (at unenhanced CT), homogeneously enhancing masses (57,58) (Fig 10). As a result, they are indistinguishable from a small renal cell carcinoma at CT (57,59). In one series, six (3%) of 175 resected solid tumors were found to be angiomyolipomas with little or no fat

(57); all of them were hyperattenuating (more attenuating than renal parenchyma) and homogeneously enhancing. In this series, 2% of the resected renal cell carcinomas were hyperattenuating and homogeneously enhancing. Therefore, when encountering a small (≤ 3 cm), hyperattenuating (at unenhanced CT), homogeneously enhancing renal mass, there is a strong possibility that the mass is benign. Rather than presume the mass is renal cell carcinoma and proceed directly to treatment, we recommend evaluating it further with MR imaging, and if necessary, percutaneous biopsy (36,46).

The MR imaging appearance of clear cell renal cell carcinoma is typically different from that of angiomyolipoma with minimal fat. Because of the smooth muscle content, angiomyolipoma with minimal fat is typically hypointense on T2-weighted MR images (57,60). On the other hand, clear cell renal cell carcinoma is typically hyperintense on T2-weighted images (61-64). Therefore, if an enhancing, hyperattenuating renal mass is also hyperin-

(effective): 90° flip angle) shows that the mass (ar-

row) is hypointense. Percutaneous biopsy revealed

angiomyolipoma with minimal fat.



tense on T2-weighted images, clear cell renal cell carcinoma is more likely than an angiomyolipoma with minimal fat. However, papillary renal cell carcinoma is also typically hypointense on T2weighted images (62,65). Therefore, a homogeneously enhancing renal mass that is both hyperattenuating at unenhanced CT and hypointense at T2weighted MR imaging could represent either angiomyolipoma with minimal fat or papillary renal cell carcinoma. Percutaneous biopsy is the only way to distinguish them, short of surgical resection. Biopsy can be used to diagnose angiomyolipoma with minimal fat and papillary renal cell carcinoma (36). Hyperattenuating, enhancing renal masses may represent other benign tumors that include metanephric adenoma, oncocytoma, and leiomyoma (66,67).

Oncocytoma is another benign renal tumor that may be found incidentally (68). In a patient with a known oncocytoma, a conservative approach such as leaving the mass alone, observation, or a minimally invasive form of treatment such as open partial nephrectomy, laparoscopic partial nephrectomy, or ablation may be indicated. Although there are some imagebased features that can be used to raise the possibility of oncocytoma (eg, homogeneous enhancement, central scar at CT or MR), none is sufficiently diagnostic and a tissue diagnosis is needed. Historically, surgical resection has been indicated both to obtain a definitive tissue diagnosis and to treat the lesion. There is an ongoing debate concerning the natural history of this tumor and the extent of surgery (or whether removal is necessary). Although oncocytomas are considered benign, some demonstrate invasive features such as lymphovascular and renal capsular involvement (68). Since oncocytoma can be diagnosed now with reasonable certainty by using percutaneous biopsy, the role of biopsy in the diagnosis of oncocytoma is emerging (36,69). However, biopsy results may not be definitive since some renal cell carcinomas have oncocytic features and it has not been established which, if any, of these

C.

masses should undergo biopsy. Nevertheless, the fact that biopsy can be used to reach a probable diagnosis is helpful in patients with masses that have suggestive features of oncocytoma and in whom surgery would carry above-average risk.

Although MR imaging and percutaneous biopsy can be used to help diagnose small, hyperattenuating (at unenhanced CT), homogeneously enhancing renal masses, the roles of MR and biopsy have not been established fully, particularly when a renal mass is discovered incidentally at an imaging test performed for a nonrenal complaint. More studies will be needed to establish fully the role of MR imaging and percutaneous biopsy in these masses. Nevertheless, we have found both techniques to be helpful adjuncts to US and CT when a small (≤ 3 cm), homogeneously enhancing, hyperattenuating (at unenhanced CT) renal mass is encountered incidentally. Patients with these masses have been referred to radiologists for percutaneous ablation; MR imaging and biopsy have been found to be particularly useful in preventing benign masses from being inadvertently ablated (70).

Solid Renal Mass Size as a Factor

A study of 2 770 resections of solid renal masses found that 12.8% were benign; almost all were oncocytomas and angiomyolipomas (71). However, when stratified according to size, the proportion of benign masses was 25% among masses smaller than 3 cm, 30% among masses less than 2 cm, and 44% among masses smaller than 1 cm (71). Hence, there was a direct relationship between malignancy and the size of the mass: the smaller the renal mass, the greater the percentage of benign causes. To our knowledge, there are limited data regarding the natural history of small renal cell carcinoma. However, data derived from the active surveillance of renal masses in the elderly are emerging (28,29,72-74). Most incidentally discovered renal cell carcinomas are low stage (9,75,76). In addition, it appears that the smaller the cancer, the less aggressive the clinical behavior (26,27,

71,77), particularly in masses smaller than 3 cm (78). Some have debated this point and have claimed that small cancers may be aggressive (79-81). A meta-analysis of the literature reviewed 234 small (mean diameter, 2.6 cm) solid masses (of which only approximately one-half were pathology-proved renal cancers) that were followed up. Lesion size at presentation did not predict growth rate. Approximately 1% of patients (three masses) developed metastases during follow-up (79); each mass demonstrated interval growth during observation. In a recent series (28), one patient developed metastases during observation, but the mass had grown to 8 cm. The authors concluded that although all renal cancers managed with observation alone have the potential to metastasize, currently available data suggest that the risk of developing metastases during observation is low, particularly if there is no observed interval growth (28). Observation of small renal masses is supported further by data that demonstrate that, concomitant with the increasing incidence of renal cancer over the past decades, the mortality rate from kidney cancer has also increased (82). This is explained, at least in part, by the fact that the increased incidence of renal cell carcinoma is due to the increased detection of small renal cancers; these small cancers are being cured. However, the number of detected large, lethal renal masses has not diminished and their treatment not changed (82). It is these masses that contribute to renal cancer mortality. Since the detection and treatment of small cancers have not diminished renal cancer mortality, it has been suggested that at least some of them could be observed instead of treated. However, data regarding the watchful waiting approach are sparse and typically derived from retrospective studies that include selection bias, inherent errors in the measurements of renal masses, and short interval follow-up. Most important, virtually all series have focused on enhancing renal masses that were presumptively diagnosed as renal cancers. Since small enhancing renal masses may be benign (71), these data likely included a small percentage of benign masses and may underestimate the risk of observing renal cancers.

Imaging Modalities and Techniques

A detailed review of technique is beyond the scope of this treatise. However, many incidental renal masses are detected during a radiologic examination designed to detect extrarenal disease. Therefore, CT or an MR examination using protocols designed to evaluate renal masses may be needed to characterize the mass fully if the initial examination is not diagnostic. Important elements of these protocols include obtaining images before and after contrast material administration and reconstructing sections that are no thicker than 3-5 mm. Incidental renal masses are often small, and the features used to classify them are also small or subtle; the importance of detailed technique was emphasized by Bosniak (3,11) years ago and is still important today. We use the same protocols to observe renal masses as are used to evaluate them initially. CT or MR examination, with and without intravenous contrast material, is recommended when observing renal masses so that subtle morphologic changes may be identified (eg, in the case of a Bosniak IIF mass). It may be appropriate to utilize only postcontrast-enhanced CT or MR examinations in patients with solid renal masses that have been fully characterized and simply need to be observed for growth. Technologic advances in each of the cross-sectional imaging modalities allow radiologists to evaluate (and observe) masses more thoroughly than ever before.

With regard to the modality choice, it should be emphasized that US is often sufficient alone to diagnose most cystic renal masses as benign, particularly those in category I. The remaining masses are often best characterized and observed with multidetector CT performed before and after intravenous contrast material administration and with thin (3–5 mm) sections. MR imaging may be used in lieu of CT, and in particular, in patients with allergy to iodinated contrast material. To limit radiation exposure, MR may be preferable when observing renal masses in young patients. MR may be useful also in characterizing small (1-2 cm) renal masses in which an accurate attenuation measurement cannot always be obtained with CT. When encountering such masses, differentiating a neoplasm from a simple cyst may be difficult, particularly if thin sections are not used. MR can be used to characterize these masses as simple cysts when they are sharply demarcated from renal parenchyma, have a smooth thin wall, do not contain septa, and contain a signal intensity similar to simple fluid (eg. urine or cerebrospinal fluid) on T2-weighted images (83). MR may be helpful also in category IIF and III lesions. MR, particularly by using subtraction techniques, may be used to demonstrate enhancement in heavily calcified cystic masses and in cystic masses with questionable enhancement at CT (84,85). MR also aids the evaluation of the small, hyperattenuating, homogeneously enhancing renal mass as detailed earlier. MR may be helpful in answering questions related to the staging of renal cell carcinoma left unanswered at CT and US.

MR imaging also may be considered in patients with renal insufficiency (85). However, there may be an association between patients with renal insufficiency who receive intravenous gadolinium-based contrast material and the development of nephrogenic systemic fibrosis, a rare potentially fatal dermopathy (86). Until the relationship between intravenous gadolinium-based contrast agents and nephrogenic systemic fibrosis becomes more clear, when evaluating an indeterminate renal mass in a patient with or at risk for renal insufficiency, we recommend that MR imaging with an intravenous gadolinium-based contrast agent be used with caution if the estimated glomerular filtration rate is lower than 60 mL/min/ 1.73 m^2 and perhaps only when MR is considered a medical necessity in a particular patient. However, in our experience, this is rarely the case when evaluating an indeterminate renal mass. An alternative evaluation strategy might be more prudent, such as arriving at a probable diagnosis based on US and CT findings alone and following the mass if the probability of malignancy is low or considering percutaneous biopsy or surgery if the probability of malignancy is high. MR imaging without an intravenous gadolinium-based contrast material could provide contributory information regarding the appearance of a renal mass on T1- and T2-weighted images, but the diagnostic value of this information alone has not been shown. Diffusion-weighted MR imaging may be helpful in the future (87).

Management Recommendations

Herein, our goal is to derive a framework that clinicians, including radiologists, can use to approach the incidental renal mass. Recommendations are based on the probability of disease, patient factors, and whether subsequent imaging is likely to be helpful. For example, very small (<1 cm) cystic renal lesions are highly likely to be benign and difficult to characterize fully. Furthermore, a diagnosis would not likely be made after many years of follow-up imaging if there was no change in size or morphology. In addition, there is the societal perspective; some might argue that the cumulative cost of following these lesions across all populations over a period of several years would far outweigh the benefit of finding a rare cancer.

Recommendations Based on Probability of Disease

On detection of an incidental renal neoplasm, broadly, options include doing nothing, observation, imaging with another modality, percutaneous biopsy, or surgery or ablation. Ignoring the mass is based on the presumption that the mass is benign and clinically unimportant; this is usually reserved for those masses that, based on their imaging appearance, have an extremely high probability of being benign. Observation or watchful waiting is generally recommended for masses that are probably benign; a low probability of malignancy exists, hence, the mass is observed with serial imaging. Biopsy, in general, is performed for a mass that could be either benign or malignant (and that can likely be diagnosed definitively at biopsy). These masses have a higher probability of being malignant than those that would be simply observed but not high enough to subject a patient to invasive treatment such as surgery without obtaining a confirmatory tissue diagnosis. Surgery is recommended for masses that have a high probability of being malignant; the probability of malignancy is so high that a negative test result (eg, percutaneous biopsy) would not change substantially the posttest probability. Percutaneous ablation is a relatively recent treatment method that has the potential to be curative and offers a less-invasive option to the patient with co-morbidity and limited life expectancy (88-98).

Recommendations based on probability of disease carry several uncertainties. For example, we do not know the precise probability of disease in a given circumstance. Knowledge regarding the probability of cancer is largely based on case series and not on individual feature analyses that allow us to predict probability of cancer on the basis of every combination of features. The Bosniak classification allows us to group cystic renal masses into five probability ranges (one of the main reasons why this classification has been so useful in clinical practice for so many years). However, we do not know the probability of disease on the basis of several individual features. In particular, among the indeterminate (category III) group, we do not know the precise probability of a cystic renal mass being malignant or benign. Another knowledge gap is how to manage probability; this problem is common to all incidental findings in all organ systems. For example, even if we knew that a mass had a 2% chance of being malignant, the question of appropriate management has social, ethical, and economic considerations.

Recommendations Based on Clinical History

Management of a patient's problem is based on the synthesis of multiple factors that are considered together to render a medical decision. Patient factors such as age, life expectancy, co-morbidity, and patient preference must also be weighed in the management decision. Although there are many patient factors that contribute to management decisions, life expectancy and co-morbidities are two important ones.

The greatest incidence of solid renal masses thought to represent small renal cell carcinomas is in patients older than 70 years in whom multiple co-morbidities may affect management decisions (75). It is difficult to derive general recommendations on the basis of age alone; life expectancy of an otherwise healthy elderly patient may in fact be longer than a younger patient with a medical illness. With regard to co-morbidity, if the risk of treatment is increased as a result of co-morbid illness, observation of a renal mass that otherwise would have been treated might be considered.

Management decisions are often the purview of the primary care physician or a clinical specialist in the field, typically a urologist. Given the fact that there are numerous factors that need to be considered, management guidelines cannot be derived for all patients. Indeed, each patient is unique and deserves an individual synthesis of all factors such that the ultimate decision is appropriate for that patient. For example, follow-up of a category IIF cystic mass is an appropriate approach in general. However, if the same mass was found in a young, otherwise healthy patient who was anxious about the chance (albeit small) of a malignancy, surgical resection may also be appropriate, particularly if a nephron-sparing procedure can be performed. This latter approach would alleviate patient anxiety and eliminate the need for repeated, long-term follow-up examinations. Similarly, while category III lesions are surgical lesions, in a patient who is a poor surgical risk, a watchful waiting approach may be prudent.

Recommendations in Patients in the General Population

Cystic Renal Masses

The Bosniak classification detailed above suggests how cystic renal masses can be diagnosed and managed. Coupled with the size factor, a set of management recommendations can be derived (Table 1). We concur with Bosniak's recommendation that a cystic lesion that is smaller than 1 cm and appears to be simple cyst, that is, a low-attenuation (0-20 HU) mass containing no septations, nodularity, calcifications, or enhancement, can be presumed to be benign and need not be pursued further (38). In the radiology report, we typically state that these lesions are highly likely to be benign renal cysts. If multiple renal cysts are found in a young patient, a cystic nephropathy can be considered.

Solid Renal Masses

Solid masses, in general, are more likely than cystic masses to be malignant and therefore recommendations are overall more aggressive (Table 2). Solid masses that are found inciden-

Table 1

Management Recommendations for Patients with an Incidental Cystic Renal Mass

Bosniak Category	Imaging Features (5)	General Population	Co-morbidities or Limited Life Expectancy
*	Hairline–thin wall; no septa, calcifications, or solid components; water attenuation; no enhancement	Ignore	Ignore
II	Few hairline—thin septa with or without perceived (not measurable) enhancement; fine calcification or a 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	Ignore	Ignore
liF	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 (>3 cm)	Observe ^{†‡}	Observe [†] or ignore [§]
III	Thickened irregular or smooth walls or septa, with measurable enhancement	Surgery [∥]	Surgery [∥] or observe [†]
IV	Criteria of category III, but also containing enhancing soft-tissue components adjacent to or separate from the wall or septa	Surgery [∥]	Surgery [∥] or observe [†]

Note.—These recommendations are to be followed only if non-neoplastic 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.

* When a mass smaller than 1 cm has the appearance of a simple cyst, further work-up is not likely to yield useful information.
[†] CT or MR 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).

⁺ In selected patients (eg, young), early surgical intervention may be considered, particularly if a minimally invasive approach (eg, laparoscopic partial nephrectomy) can be utilized.

[§] 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 co-morbidities and in patients with limited life expectancy.

^{II} 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.

tally may be evaluated as detailed above; inflammatory masses, vascular abnormalities, and angiomyolipomas should be excluded. In the general population, we recommend evaluating the remaining solid masses (depending on their size) fully, with a tissue diagnosis obtained either percutaneously or surgically. Solid masses smaller than 1 cm ("very small" solid masses) are challenging. First, there is a reasonable chance that a very small solid mass is benign. Second, it is often difficult to characterize a mass smaller than 1 cm as solid and enhancing, despite a meticulous technique using state-of-the-art CT and MR imagers. Third, these masses are often too small to biopsy. Therefore, when encountering a mass that is believed to be solid and is less than 1 cm in size, it is reasonable to observe them with an initial examination with CT or MR at 3–6 months followed by yearly examinations. A full work-up could ensue when the mass reaches 1 cm in size.

Recommendations in Patients with Limited Life Expectancy or Comorbidity That Increases the Risk of Treatment

Cystic Renal Masses

Cystic masses can be evaluated as they would in the general population, but with a less aggressive approach for some masses (Table 1). Bosniak has recommended that lesions between 1.0 and 1.5 cm that cannot be characterized completely, that is, they measure higher

Table 2

Management Recommendations for an Incidental Solid Renal Mass in Patients in the General Population

Mass Size	Probable Diagnosis	Recommendation	Comment
Large (>3 cm)	Renal cell carcinoma*	Surgery [†]	Angiomyolipoma with minimal fat, oncocytoma, and other benign neoplasms may be found at surgery
Small (1–3 cm)	Renal cell carcinoma *	Surgery [†]	If hyperattenuating and homogenously enhancing, consider MR and percutaneous biopsy to diagnose angiomyolipoma with minimal fat
Very small (<1 cm)	Renal cell carcinoma, oncocytoma, angiomyolipoma [‡]	Observe until 1 cm $^{\$}$	Thin (\leq 3 mm) sections help confirm enhancement

Note.—These recommendations are best followed after non-neoplastic 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.

* Provided there is no detectable fat at CT or MR with protocols designed to evaluate renal masses.

[†] 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.

[‡] Benign entities are more likely in small renal masses than large ones.

§ CT or MR at 3-6 months and 12 months, then yearly; interval and duration of observation may be varied (eg, shorter interval if the mass is enlarging).

Table 3

Management Recommendations for an Incidental Solid Renal Mass in Patients with Limited Life Expectancy or Co-morbidities That Increase the Risk of Treatment

Mass Size	Probable Diagnosis	Recommendation	Comment
Large (>3 cm)	Renal cell carcinoma*	Surgery ^{\dagger} or observe	Angiomyolipoma with minimal fat, oncocytoma, other benign neoplasms may be found at surgery; Biopsy can be utilized preoperatively to confirm renal cell carcinoma
Small (1–3 cm)	Renal cell carcinoma*	Surgery [†] or observe	If hyperattenuating and homogenously enhancing, consider MR and percutaneous biopsy to diagnose angiomyolipoma with minimal fat
Very small (<1 cm)	Renal cell carcinoma, oncocytoma, angiomyolipoma [‡]	Observe until 1.5 $\mathrm{cm}^{\$}$	Thin (\leq 3 mm) sections help confirm enhancement

Note.—These recommendations are best followed after non-neoplastic 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.

* Provided there is no detectable fat at CT or MR with protocols designed to evaluate renal masses

⁺ 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.

[‡] Benign entities are more likely in small renal masses than large ones.

[§] CT or MR at 3–6 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 co-morbidities 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.

than water attenuation at CT or are not clearly cysts at US, need not be evaluated further in patients who are elderly, fragile, or with an underlying lifethreatening disorder (eg, metastatic carcinoma, severe heart disease) that will clearly limit life expectancy (38). This recommendation is based on the fact that most of these lesions will be benign cysts mimicking solid neoplasms or neoplasms with a slow growth rate (26,47,99). Ignoring these lesions is further supported by economic considerations. As discussed above, it is reasonable to observe category III cystic masses in patients with co-morbid conditions.

Solid Renal Masses

Radiology

In patients with limited life expectancy or co-morbidities, solid masses can be evaluated as they would in the general population; however, observation may be appropriate, particularly for small $(\leq 3 \text{ cm})$ renal masses (Table 3). If we accept the tenet that most small (≤ 3 cm) cancers are not as aggressive as large ones, it is tempting to select them for less aggressive management algorithms in patients who have co-morbid disease that either limits their life span or makes a surgical procedure risky. In the past, Bosniak has recommended observation alone in the patients with solid neoplasms smaller than 1.5 cm based on the likelihood that most small renal cell carcinomas grow slowly (25-27) and that "length bias" and "lead bias' are likely factors when a small lesion is discovered incidentally (100). An expert panel commission of the American College of Radiology agrees that a "wait and see" approach for renal masses 1.5 cm or smaller in the elderly is prudent (101). However, renal cell carcinoma is curable when confined to the kidney, and any course of management short of surgical intervention should be chosen carefully.

Most recommendations in the literature to date have been made as if open surgery (and its attendant risks) was the only effective local treatment for renal cancer. Emerging minimally invasive procedures such as laparoscopic partial nephrectomy and percutaneous ablation techniques are less invasive and carry less risk. Laparoscopic partial nephrectomy might allow a more aggressive approach in young healthy patients with an indeterminate mass. Similarly, one might consider ablation of solid masses or category IV cystic masses in the elderly or in patients with co-morbid disease who otherwise would have been observed if surgery were the only option. Treatment effectiveness data following ablation are promising, and its use in these patients is being embraced (88–98). However, 5-year data are only now beginning to appear in the literature; 10-year data will need to be analyzed to understand the effectiveness of the procedure (88-98). Furthermore, a meta-analysis of the literature through 2005 revealed that only 88% of renal masses ablated by using a surgical approach and 59% of masses ablated by using a percutaneous approach underwent biopsy (91). As described above, small renal masses (the ones most amenable to ablation) may be benign, and imaging alone cannot be used to diagnose renal cell carcinoma definitively. Unlike surgery, in which a mass is examined fully at pathologic examination after it is removed, during percutaneous ablation the tumor is treated in situ. Unless biopsy is performed, a tissue diagnosis cannot be obtained. Once a tumor is ablated, the patient needs to be observed as if the lesion was cancerous. Therefore, we recommend that percutaneous ablation be preceded by percutaneous biopsy (in advance of the day of the ablation procedure) to ensure that the mass is malignant and warrants treatment (36,70). Tissue diagnosis is needed for two reasons, to prevent patients from undergoing an unnecessary procedure with its attendant risks (albeit small) and to be sure that the data used ultimately to determine which patients are best treated with ablation do not include benign masses. Nevertheless, on the basis of promising data, ablation may become the standard treatment of small renal cell carcinoma in the future. Data will be needed to determine which patients are suitable. In particular, future study will be needed to determine the cost-effectiveness of ablating small renal cancers in the elderly that otherwise would have been ignored, or observed, if open surgery were the only option (36).

Finally, a discussion of the management of incidental findings would not be complete without acknowledging medicolegal aspects. Follow-up recommendations of indeterminate renal masses are no doubt related in part to a perceived liability of missing a cancer (102). Since renal cell carcinoma is a curable disease when confined to the kidney, it is difficult to refrain from evaluating and following all indeterminate renal masses. Nevertheless, we believe that the guidelines presented here are a practical and medically sound approach to the incidental renal mass. Again, it must be emphasized that these are "guidelines" and the evaluation and treatment of each case must be individualized depending on the imaging findings, the age and condition of the patient, and the diagnostic and treatment options available. In the future, as our ability to detect and characterize renal masses evolves, so too will the recommendations that follow from the discovery of an incidental renal mass.

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