Imaging Management of Incidentally Detected Small Renal Masses

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Abstract

Both imaging and intervention play an increasingly important role in the management of renal masses in general and renal cancer in particular. Indeed, radiologists are often the first to detect and diagnose renal cancer, and now with the burgeoning role of percutaneous ablation, they are often the treating physicians. Renal mass management begins with imaging, and although most can be diagnosed with a high degree of certainty using imaging, some remain indeterminate and require biopsy or observation, now referred to as active surveillance. Although active surveillance strategies have been employed for indeterminate renal masses that have a reasonable chance of being benign, recent data suggest that some renal cancers can undergo active surveillance safely. This article reviews the current imaging-based diagnostic evaluation of incidentally detected small renal masses, the burgeoning role of percutaneous biopsy, and how both imaging and biopsy are used to help select which patients need treatment and which can undergo active surveillance.

Keywords

- renal mass
- renal cell carcinoma
- imaging
- biopsy
- surveillance

Objectives: Upon completion of this article, the reader will be able to identify the role of imaging and intervention in the management of the incidentally detected small renal mass.

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The incidence of small renal masses and renal cell carcinoma has increased in recent times.¹ This is primarily attributable to the increased use of cross-sectional imaging, particularly computed tomography (CT) and magnetic reso-

nance (MR) imaging. In addition, technological advances have improved the spatial, contrast, and temporal resolution of these modalities allowing for higher rates of detection.

Approximately half of patients older than 50 years have at least one renal mass.² The majority of these small renal masses are identified in patients who report no symptoms that can be ascribed to the mass, and therefore the mass is incidental. The incidence of small incidental renal masses provides a challenge for the medical community in both diagnosis and management. The radiologist is at the forefront of this clinical quandary and is primarily responsible for not only rendering an accurate diagnosis but also suggesting a management plan. Fortunately, most small renal masses represent benign cysts and can be diagnosed confidently using cross-sectional imaging.³ Some small renal masses are solid; of these, only angiomyolipomas that contain fat by imaging can be reliably diagnosed as benign.⁴ Other angiomyolipomas and indeed all other small solid neoplasms cannot be diagnosed with certainty using imaging alone.⁵ Although almost all solid renal masses were once thought to

be renal cancers, it is now known that a substantial number are benign, either fat poor angiomyolipomas, oncocytomas, or other benign entities particularly when they are small.⁶⁻⁸ As a result, when a small solid renal mass is encountered, options include active surveillance (with imaging), percutaneous biopsy, treatment with surgery (in which case a diagnosis will be rendered), or ablation that generally follows a biopsy.

In the literature, small renal masses have been classically defined as those that are 3 cm or smaller.¹⁻⁵ However, some authors consider small renal masses as those that are 4 cm or smaller; this latter definition complies with the TNM classification.⁹ T1a masses are 4 cm or smaller and T1b masses are between 4 and 7 cm; these terms are best used to describe renal cancers. In this overview, the authors classify small renal masses into two broad groups, cystic and solid, as each group prompts a unique approach to their evaluation and management.⁵

Small Cystic Renal Masses

Cystic renal masses are composed predominantly of fluid. Their appearance can be variable and can range from simple cyst-appearing masses containing almost exclusively fluid with a surrounding pencil-thin margin to complicated masses with thick septa, thick walls, and enhancing nodular components. The Bosniak Classification, first described in 1986 and subsequently modified and updated,¹⁰ is well established and widely used.^{3,5} The original classification assigned cystic renal masses to one of four categories based on their CT appearance; each category related to a certain probability of malignancy ranging from virtually 0% for Category I masses to almost 100% for Category IV masses.^{11,12} Cystic renal masses can be small or large, and in fact size is not a feature of the Bosniak classification. Small cystic masses may be malignant, and large ones benign. However, cystic renal masses smaller than 1 cm with homogenous low attenuation and no septa, nodularity, or calcification are statistically likely to be benign.^{5,13}

Category I cystic renal masses are simple cysts that contain only homogeneous fluid attenuation (0–20 Hounsfield units [HU]) and no more than a pencil-thin wall. They contain no septa, enhancing nodules, or calcifications. Simple cysts are diagnosed confidently as benign, and if asymptomatic can be ignored. Category II cystic renal masses are called benign complicated cysts, and have features such as few, thin septa or thin, border-forming calcification. The septa can be minimally thickened with enhancement that is perceived but not measurable. Well-marginated, nonenhancing, homogeneously hyperattenuating renal masses measuring 3 cm in diameter or smaller are also classified as Category II masses. All Category II masses are reliably considered benign and can also be ignored if asymptomatic. Cystic masses with more than a few septa, or those that are homogeneously hyperattenuating and nonenhancing but larger than 3 cm, are classified as Category IIF masses. These masses are likely benign but not reliably enough to ignore them.^{10,14} Observation (or active surveillance) is recommended to confirm their benignity. Category III cystic renal masses contain thick or irregular walls or septa in which enhancement can be measured. Category III masses

are considered indeterminate because they may be benign or malignant; the rate of malignancy varies but is generally thought to be more than 50%, and thus these masses are considered surgical lesions.^{15,16} In patients with comorbidities, percutaneous biopsy can be used to provide data that can help determine how to manage them.¹⁷ Category IV cystic renal masses contain enhancing nodular components distinct from the wall or septa, and such masses are almost always malignant^{15,16} and thus are typically resected surgically.

Imaging Evaluation

Of the cross-sectional imaging modalities, ultrasound (US) is the least sensitive for detecting renal masses.¹⁸ US is widely available, uses no ionizing radiation, is relatively inexpensive and quick to perform, but is operator dependent and static images from a dynamic examination can be difficult to evaluate and compare with other modalities. Large patient body habitus can limit visualization of portions of the kidneys. In addition, hemorrhagic cysts may be difficult to differentiate from solid neoplasms. This limitation may be addressed with contrast-enhanced US¹⁹; however, this technology is not currently widely available in the United States. Despite these relative disadvantages, US plays an important role in allowing the confident diagnosis of Category I masses that appear as well-defined anechoic structures with posterior acoustic enhancement and no septa, calcification, or wall thickening. US may also play a significant role in patients with renal insufficiency who cannot receive intravenous contrast material or in patients with a contraindication to MR imaging.

CT is considered the first-line imaging modality for evaluating renal masses that are detected with US or some other modality that cannot be used to diagnose them confidently. The CT protocol at the authors' institution consists of imaging the kidneys before 100 seconds and 8 minutes after a 30- to 42-g iodine dose of intravenous contrast material. The unenhanced scan is necessary to determine a native appearance and attenuation value of the mass. In addition to providing an attenuation value from which to determine enhancement, the unenhanced appearance alone can be used to evaluate a renal mass. Indeed, some patients are examined with only unenhanced CT and the management of renal masses needs to be derived from unenhanced CT alone. If the renal mass has a homogenous attenuation of 20 HU or less, and has no other features such as wall thickening, septa, or calcifications, it is almost certainly a benign cyst.²⁰⁻²² If a renal mass has a homogenous attenuation greater than 70 HU, it is almost certainly a benign proteinaceous cyst.²³ Unenhanced attenuation values between 20 and 70 HU are indeterminate and may represent hemorrhagic or proteinaceous cysts but could also represent neoplasms.²¹ Discrimination between hemorrhagic or proteinaceous cysts and neoplasms is predicated largely on detecting enhancement which is best detected on nephrographic phase images of a renal mass protocol CT. Enhancement is considered unequivocal when the mass's attenuation increases by at least 20 HU,^{5,24} and is deemed equivocal if the increase in CT attenuation is between 10 and 20 HU. A mass does not enhance if the attenuation increases by less than 10 HU.

Recent advances in CT technology have allowed for techniques to be implemented that result in reduction in radiation doses. These include iterative reconstruction techniques, low kVp imaging, and dual energy CT.^{25–28} Dual energy CT has the ability to differentiate different material types and allows for iodine to be “removed” from contrast-enhanced dual energy scans, producing virtual unenhanced images. These virtual unenhanced images could obviate the need for an unenhanced scan (hence reducing radiation exposure); however, the accuracy of attenuation values on virtual unenhanced scans has been questioned.²⁹ In addition, the spatial resolution may not be sufficient to detect small amounts of fat, an important step in the evaluation of any renal mass. As a result, virtual unenhanced images from dual energy CT require further validation before being used in clinical practice.²⁹

MR imaging is performed in patients with an allergy to iodinated contrast material, when radiation exposure needs to be limited (e.g., young patients), and to problem solve following CT. Indeed, MR imaging has been shown to be as diagnostic as CT and can provide more information.^{5,30} The authors dedicated renal mass protocol consists of T1-weighted imaging with an axial breath-hold spoiled gradient-echo dual-echo in-phase and out-of-phase sequence. T2-weighted imaging is obtained in the axial and coronal planes using a single shot fast spin echo sequence and a fast recovery fast spin echo sequence. Diffusion-weighted imaging is obtained using three *b* values (0, 500, and 1,000 s/mm²). Intravenous gadolinium is administered if there are no contraindications, with a volume determined by weight. Breath-hold serial axial and coronal T1-weighted three-dimensional spoiled gradient-echo fat-suppressed images are acquired before intravenous contrast medium administration and during the contrast-enhanced corticomedullary, nephrographic, and excretory phases. Postprocessing involves production of an apparent diffusion coefficient (ADC) map and subtraction images for each contrast-enhanced phase.

T2-weighted imaging is particularly useful in confirming the cystic nature of masses. This is particularly true of small cysts in which it may be difficult to obtain an accurate HU measurement on CT. The T2 signal of simple cysts is that of fluid, typically similar to CSF, and they have a thin wall and no septa or nodules. When hemorrhagic, cysts are typically T1-hyperintense and T2-hypointense. Proteinaceous cysts, generally thought to be the sequela of hemorrhage, may also be T1-hyperintense.³¹ Contrast-enhanced T1-weighted imaging is needed to classify fully all Bosniak cystic masses; these images add to both T1- and T2-weighted images in identifying a thickened wall, septae, and solid nodules.³² Subtraction images can aid in evaluating for enhancement, especially in T1-hyperintense masses that can mimic enhancement on enhanced images. Diffusion-weighted imaging sequences evaluate the diffusion of water molecules within tissue. Diffusion-weighted sequences can be assessed qualitatively or assessed quantitatively by obtaining ADC values. The higher the ADC value, the lower the restriction of water molecules within the tissue. Although rarely diagnostic alone, these sequences may add useful information especially for patients in whom intravenous contrast material cannot be

administered. Simple cysts tend to have the highest ADC values, while hemorrhagic and proteinaceous cysts have lower values signifying restricted diffusion but not as low as solid neoplasms. Septa and solid nodules with cystic masses may demonstrate areas of more pronounced diffusion restriction.^{33–35}

Caution should be taken when using intravenous gadolinium for MR imaging in patients with renal insufficiency given the association with nephrogenic systemic fibrosis (NSF).³⁶ NSF is a systemic disorder that results in fibrosis of the skin, internal organs, eye, and joints, potentially resulting in significant morbidity and death.³⁷ Patients at risk include those on dialysis, those with severe or end-stage chronic kidney disease (estimated glomerular filtration rate less than 30 mL/min/1.73 m²), estimated glomerular filtration rate 30 to 40 mL/min/1.73 m² without dialysis, and with acute kidney disease.³⁸ Ideally in these groups, an alternative examination, such as US, noncontrast-enhanced CT, or noncontrast-enhanced MR imaging should be performed. If no alternative exists, a full discussion regarding risks and benefits should take place and a gadolinium agent with few, if any, unfounded cases of NSF should be used.³⁸

Role of Percutaneous Biopsy

Renal mass biopsy is now well established. Most current indications relate to solid renal masses.^{39,40} The role of biopsy of cystic masses is somewhat controversial. Biopsy can be used to confirm a cystic mass is infectious or inflammatory; this is an important indication, as these benign processes are sometimes mistaken for neoplasms (►Fig. 1). Biopsy of a Bosniak Category IV mass in a patient with comorbid disease or limited life expectancy may be helpful in being sure of the diagnosis before surgery is undertaken. Biopsy of Bosniak Category III renal masses can be undertaken also, particularly in a patient with high surgical comorbidities. The biopsy result may help justify surgery in a high-risk candidate or support observation of the mass.¹⁷ Percutaneous biopsy of Bosniak Category III renal masses is controversial for the following reasons. First, obtaining a specific biopsy diagnosis can be challenging given its cystic composition, leading to a high false-negative rate.⁴¹ When possible, noncystic components such as the cyst wall or thick septa should be targeted for biopsy (►Fig. 2). Second, the absence of malignant cells does not infer a benign diagnosis. Retrieving hemorrhagic aspirates or atypical cells can be seen in both benign and malignant masses.⁴² For a renal mass to be reliably considered benign on the basis of the biopsy alone, a specific diagnosis such as a cystic nephroma or mixed epithelial and stromal tumor should be made. These benign causes of a Category III mass can be indistinguishable from cystic renal cell carcinoma by imaging alone.^{43,44}

Active Surveillance

Active surveillance of cystic renal masses primarily refers to Bosniak Category IIF masses (►Fig. 3). Category I and II masses are considered benign and require no follow-up. Category III and IV masses have high rates of malignancy and are generally resected.^{15,16} However, Bosniak Category III

Figure 1 Patient with history of carcinoid tumor with a renal abscess in the interpolar region of the left kidney mimicking a cystic neoplasm. (A) Transverse postcontrast computed tomography (CT) image shows a thick-walled cystic mass (arrow). (B) Following aspiration of purulent material during a percutaneous biopsy, CT-guided percutaneous drainage was performed. Transverse CT image shows a catheter tip coiled within the abscess (arrow).

and IV masses may undergo active surveillance in patients with comorbidities or limited life expectancy.⁴⁵

Follow-up of Bosniak Category IIF masses is typically performed with CT or MR imaging. An initial interval of 6 months is recommended followed by yearly imaging.¹⁰ The optimal duration and frequency of imaging follow-up is not known; however, if the mass demonstrates no change in morphological features (other than overall growth) in 5 years, it is likely benign.¹⁰

Small Solid Renal Masses

Solid renal masses are defined as masses composed primarily of enhancing soft tissue. The most commonly encountered malignant solid mass is renal cell carcinoma, but other malignant neoplasms such as lymphoma, urothelial carcinoma, and metastases can occur. Benign neoplasms such as

angiomyolipoma, oncocytoma, metanephric adenoma, and capsular leiomyoma can be indistinguishable from renal cell carcinoma. Therefore, size is now used as a general indicator of whether the mass is benign or malignant; the smaller the solid renal mass, the more likely it is benign. In a large study of 2,770 resected masses, approximately 44% of masses smaller than 1 cm, 30% of masses smaller than 2 cm, and 25% of masses smaller than 3 cm were benign.⁶ In addition, there is evidence to suggest that the smaller the renal cell carcinoma, the less aggressive the behavior.^{6,7} Both these observations are expanding the utilization of percutaneous biopsy in clinical practice as well as the research of imaging techniques to differentiate benign from malignant solid renal masses.

Imaging Evaluation

The imaging appearance of solid renal masses on US is relatively nonspecific.⁴⁶ Renal cell carcinoma usually appears as a hypoechoic mass. Cystic components may represent hemorrhage or necrosis, but these are rare in small tumors.⁴⁷ Doppler US may be useful to demonstrate thrombus in the renal vein and inferior vena cava (IVC).⁴⁸ Angiomyolipomas may be suspected by detecting a hyperechoic mass with echogenicity similar to renal sinus fat.⁴⁹ Renal cell carcinoma, however, can appear hyperechoic and have similar imaging features.⁴⁷ In fact, a third of small renal cell carcinomas are hyperechoic, and may sometimes be as hyperechoic as the renal sinus.^{50,51} Therefore, hyperechoic renal masses cannot be diagnosed as angiomyolipomas with US alone; CT or MR imaging would be needed to provide a definitive diagnosis.

Unenhanced CT provides the ability to detect fat and calcification. Identifying regions of fat in a noncalcified solid mass is virtually diagnostic of angiomyolipoma.⁵² Cases of calcified^{53,54} and noncalcified⁵⁵ renal cell carcinoma with fat have been described; however, these are extremely rare.

Some masses are hyperattenuating and when not enhancing are hemorrhagic or proteinaceous cysts. The differential diagnosis of hyperattenuating enhancing renal masses includes fat-poor angiomyolipoma, renal cell carcinoma (typically papillary subtype), oncocytoma, lymphoma, leiomyoma, and metanephric adenoma.⁵⁶ Fat-poor angiomyolipomas account for approximately 5% of angiomyolipomas and do not contain enough fat to be diagnosed with confidence on unenhanced CT.⁵⁷ Although features such as unenhanced attenuation, enhancement pattern, and the presence of intratumoral vessels have been used to differentiate fat-poor angiomyolipoma from renal cell carcinoma, these two entities are difficult to diagnose with certainty by CT.^{58,59} In this scenario, unenhanced CT or MR imaging may be useful to detect small amounts of fat.

In the case of angiomyolipomas that contain sufficient amounts of fat to be imaged, the fat may be identified by detecting linear signal drop ("India ink" artifact) at the interface between macroscopic fat and adjacent water-containing renal parenchyma on spoiled gradient-echo out-of-phase MR imaging.⁶⁰ This sign should be interpreted with caution because a similar signal drop can be identified in the clear cell subtype of renal cell carcinoma secondary to intracytoplasmic lipid.⁶¹

Figure 2 A 79-year-old woman status postcolectomy for ulcerative colitis, with a Bosniak Category IIF cystic mass in the interpolar region of the left kidney. (A) Transverse postcontrast computed tomography (CT) image shows a 1 cm cystic mass (arrow) with subtle wall thickening and few, thin septa. (B) Transverse postcontrast CT image 6 months later demonstrates an anterior nodule (arrow) and growth of the mass to 1.6 cm. (C) Transverse postcontrast CT image 6 months later demonstrates growth of both the nodule (arrow) and mass to 2.4 cm. (D) CT-guided percutaneous biopsy (arrow) revealed clear cell renal cell carcinoma.

Renal mass signal on T2-weighted sequences may be helpful in characterizing a solid renal mass. Fat-poor angiomyolipoma is hypointense due to its smooth muscle content, whereas clear cell renal cell carcinoma is usually T2-iso- or hyperintense, thereby allowing for differentiation between these two neoplasms.^{57,61} Papillary renal cell carcinoma, however, is also typically T2-hypointense^{62,63} and therefore T2-weighted imaging cannot be used to differentiate papillary renal cell carcinoma from a fat-poor angiomyolipoma. As a consequence, if a T2-hypointense solid renal mass is visualized, biopsy is the only nonsurgical way to diagnose them confidently (►Fig. 4).

Oncocytoma is another benign neoplasm that is important to diagnose to prevent unnecessary surgical resection or ablation. Typical imaging features of oncocytoma include

intense homogenous enhancement, a central scar, and an arterial spoke-wheel pattern of enhancement.^{64,65} These findings, however, are neither sensitive nor specific enough to render a diagnosis with a high degree of accuracy.⁶⁶ Recently, it has been described that many small (< 4 cm) oncocytomas exhibit “segmental inversion enhancement” on CT. This sign is the presence of two distinct regions of enhancement of a renal mass in the corticomedullary phase in which the degree of enhancement reverses in the nephrographic phase.^{67,68} Although this finding could be used to express the probability of an oncocytoma, a percutaneous biopsy would be needed to be fully confident of the diagnosis.

Diffusion-weighted imaging of solid renal masses has several potential applications that have shown promising results in predicting the likelihood of malignancy and the

Figure 3 A 66-year-old woman with a Bosniak Category IIF cystic mass in the lower pole of the right kidney and prior partial nephrectomy for clear cell renal cell carcinoma. (A) Transverse postcontrast computed tomography (CT) image demonstrates a 1 cm cystic mass (arrow) with few thin septa. (B) Transverse postcontrast CT image 1 year later shows more prominent septa and growth of mass to 1.6 cm (arrow). (C) CT-guided percutaneous biopsy (arrow) revealed clear cell renal cell carcinoma. (D) CT-guided percutaneous cryoablation of the mass was performed in the same session as the biopsy.

subtype of renal cancer.^{33–35,69,70} Currently, percutaneous biopsy is necessary to garner this information before rendering decisions regarding surgical resection, ablation, or active surveillance. The advent of new molecular targeted therapies in metastatic renal cell carcinoma has also generated a need to subtype renal cell carcinoma before treatment; different subtypes respond differently to different therapies.^{71,72} ADC values of benign solid masses have been shown to be significantly higher than those of malignant solid masses.^{33,35} More variability is seen with ADC values of different renal cell carcinoma subtypes. In general, papillary renal cell carcinoma tends to have lower ADC values than nonpapillary cancers^{34,35,70}; however, this is not absolute.³³ Currently, diffusion-weighted imaging does not have the necessary sensitivity and specificity to replace percutaneous biopsy, but as the technique becomes more advanced it may be useful clinically. At present, it provides an additional data point that can be used before intervention, and is particularly useful in patients who cannot receive intravenous contrast material.

Role of Percutaneous Biopsy

Several indications exist for the biopsy of small solid renal masses, and these masses make up the majority of the renal masses that are biopsied.^{39,40} Renal mass biopsy is a safe procedure. Hemorrhage, if it occurs, is usually subclinical and needle tract seeding is exceedingly rare.⁴⁰ Advances in cytological techniques such as immunocytochemistry and cytogenetics have allowed for the accurate diagnosis of both benign and malignant neoplasms.^{73,74} As a consequence, the authors typically begin with fine needles aspirates (19G or thinner) to obtain a preliminary assessment of adequacy. If adequacy cannot be confirmed, then large needles (18G typically) are used for aspiration. Test characteristics are good overall; however, as biopsy is being used to triage patients into different management strategies, there is a need for subtyping and Fuhrman grading. Large needles are more likely to yield subtype and grade.^{75–77}

Including patients with Category III cysts, there are currently multiple indications for renal mass biopsy.^{39,40} First,

Figure 4 A 28-year-old woman with a solid renal mass in the interpolar region pole of the left kidney. (A) Transverse unenhanced computed tomography (CT) image demonstrates a 1.4-cm hyperattenuating mass with no evidence of fat (arrow). (B) Transverse postcontrast CT image shows enhancement of the mass (arrow). (C) Transverse T2-weighted MR image demonstrates the hypointense mass (arrow). (D) CT-guided percutaneous biopsy using 25-gauge needles placed coaxially via a 20-gauge needle (arrow) revealed fat-poor angiomyolipoma.

biopsy is indicated in patients with an extrarenal carcinoma who develop a new small renal mass. Both renal cell carcinoma and a metastasis are possible. Radiological findings may be suggestive but are rarely diagnostic. For example, metastases usually present as solid renal masses and not as cystic masses.⁴¹ In addition, a renal metastasis is unusual in the absence of other sites of metastatic disease.⁷⁸ As a result, a percutaneous biopsy is indicated to determine further management; a primary renal cell carcinoma would undergo surgical resection or ablation, whereas a metastasis would typically require medical treatment. Second, biopsy can be used to provide a pathologic diagnosis of masses in patients with a renal mass and imaging findings suggestive of unresectable renal cancer. Third, biopsy can add confidence to the preoperative diagnosis of renal masses in patients with surgical comorbidities. Fourth, the biopsy diagnosis of masses that could be inflammatory prevents the possibility of these masses inadvertently being resected. Fifth, biopsy is indicated before percutaneous ablation to confirm that the mass represents renal cell carcinoma. Unlike surgical resection where a specimen is available for pathological analysis, percutane-

ous ablation destroys the tissue in situ and the only opportunity to make a pathological diagnosis is at the time of a preprocedural biopsy.⁷⁹ Sixth, percutaneous biopsy has also been suggested when multiple, bilateral solid masses are encountered. In addition to metastases and lymphoma, hereditary conditions can result in multiple bilateral renal cell carcinomas⁸⁰ and benign neoplasms such as multiple oncocytomas.⁸¹ Percutaneous biopsy is sometimes required on both sides to render a diagnosis and plan the treatment.

Finally, as discussed above, it has been suggested³⁹ that small, hyperattenuating enhancing masses be biopsied because they may be benign or malignant.^{56,57,62} The hyperattenuating subset of solid renal masses was suggested to be biopsied because most fat-poor angiomyolipomas have this appearance, while renal cell carcinoma rarely does.⁵⁷ However, because a substantial fraction of resected small solid renal masses are benign,⁶ biopsy is being used more frequently to diagnose all small solid renal masses preoperatively. A confident diagnosis of a benign neoplasm obviates the need for treatment and avoids unnecessary surgery. A diagnosis of a malignant lesion would prompt a discussion as to what is an

Figure 5 A 62-year-old woman with a hyperattenuating enhancing mass in the lower pole of the left kidney. (A) Transverse unenhanced CT image reveals a 1.2-cm hyperattenuating mass with no evidence of fat (arrow). (B) Transverse postcontrast CT image shows enhancement of the mass (arrow). (C) Transverse T2-weighted MR image shows that the mass is hypointense (arrow). (D) CT-guided percutaneous biopsy was performed using 25-gauge needles placed coaxially via a 20-gauge needle (arrow). The final diagnosis was papillary renal cell carcinoma, Fuhrman grade III.

appropriate form of treatment or whether an active surveillance approach can be used instead. However, when renal cell carcinoma is diagnosed with biopsy, a treatment decision depends in part on obtaining the renal cell carcinoma subtype and grade from the biopsy.^{75-77,82} Obtaining the renal cell carcinoma subtype is easier than determining the grade; accurate subtyping⁷⁵⁻⁷⁷ occurs in 86 to 98% of cases, whereas correct grading⁷⁶ may occur only in up to 63.5% of cases.

Biopsy has been used in a recent study of 133 masses to plan management.⁸³ Percutaneous biopsy results were shown to be discordant with surgical pathology from resected specimens in 8% of cases.⁸³ This discordance may result in patients being stratified to an incorrect management plan. For example, the grade of clear cell renal cell carcinoma can be underestimated, leading to active surveillance where in fact definitive treatment should take place.⁸³ Nevertheless, the preliminary data support that biopsy can be helpful in the majority of cases in triaging patients into treatment and observational paradigms (→Fig. 5). Current research is revealing biomarkers that will help define the biology of renal

cell carcinoma and assist in determining which small renal masses are suitable for active surveillance.⁸⁴

Active Surveillance

Over the last few years, active surveillance of small solid renal masses including small renal cell carcinomas has gained popularity as an accepted management paradigm.⁸⁵ Although treatment of small renal cell carcinomas by surgical resection or ablation remains accepted practice, several trials have indicated that active surveillance can be a safe management strategy in certain groups, specifically elderly patients with significant comorbidities or limited life expectancy.⁸⁶ In addition to the fact that most renal masses (including cysts) are benign and should be ignored, the rationale for active surveillance of masses include the following. Many solid renal masses are benign and although the clinical behavior of renal cell carcinoma is variable and unpredictable, most are indolent and many do not limit survival. In fact, on a population basis, renal cell carcinoma is a rare cause of overall mortality.

The justification for active surveillance has been strengthened further by the fact that despite earlier detection and treatment of small renal cell carcinomas, disease-specific mortality has continued to increase.^{87,88} This increase in mortality has been attributable principally to tumors larger than 4 cm in size, suggesting that many smaller tumors have an indolent course and do not require treatment.

Active surveillance also appears to be safe, and longitudinal studies of patients who have undergone active surveillance have demonstrated favorable results. A recent meta-analysis of 18 studies pooled 880 patients with 936 masses with an average mass size of 2.3 cm and average follow-up of 33.5 months.⁸⁶ Of the renal masses undergoing active surveillance, 65 demonstrated no growth and only 18 patients progressed to metastases. Patient age, initial greatest tumor dimension, initial estimated tumor volume, and linear and volumetric growth rates were all significantly greater in patients who progressed. In addition, no difference in overall and cancer-specific survival has been demonstrated in patients with T1a renal masses treated with active surveillance, partial nephrectomy, or radical nephrectomy.⁸⁹ Among the 234 masses in 202 patients that were evaluated, 71 patients underwent active surveillance, 90 patients were treated with partial nephrectomy, and 41 patients underwent radical nephrectomy. Of the masses treated with active surveillance, 53% showed negative or zero growth.

Standardized active surveillance protocols are yet to be established and many questions still remain. These pertain to patient selection, the role of percutaneous renal mass biopsy, the type, timing, and frequency of imaging follow-up, and the growth rate thresholds that would initiate intervention. The American Urological Association has attempted to address some of these issues by publishing clinical guidelines pertaining to percutaneous biopsy and follow-up imaging.⁹⁰

It has been suggested that imaging follow-up take place with CT and MR imaging, and occur initially within 6 months of diagnosis to establish a growth rate.⁹⁰ After this, yearly follow-up is usually adequate unless growth rates increase or the morphology of the mass changes.⁹⁰ Linear growth rates have typically been used, working on the assumption that tumors are spherical and grow equally in all directions.⁹¹ However, volumetric analysis may provide a more accurate method of monitoring growth.⁹² Small renal masses that progress to metastatic disease on active surveillance have shown average linear growth rates of 0.8 cm/year and average volumetric growth rates of 27.1 cm³/year.⁸⁶

Conclusion

Imaging and intervention are utilized throughout the renal mass "care continuum." Imaging is used to detect masses, ignore those that are benign, dictate management for those that are malignant, and select those that need imaging follow-up by active surveillance. With the burgeoning application of active surveillance, imaging will become even more vital in determining which masses need treatment. Moreover, as there is no single clinical or pathologic feature that defines the biologic behavior of a renal neoplasm, future research in

imaging and intervention will hopefully derive the key biomarker that can be used to clearly decide which renal masses need treatment and which do not.

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