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Imaging and management of the incidentally discovered renal mass

Jonathon Willatt and Isaac R. Francis

University of Michigan Hospitals, Ann Arbor, MI, USA

Corresponding address: Isaac R. Francis, Department of Radiology, 1500 E. Medical Center Drive, Ann Arbor, MI 48109-0030, USA.
Email: ifrancis@umich.edu

Abstract

Improvements in imaging technology and the expanding use of imaging have led to a rapid increase in the discovery of incidental renal lesions. These can present both the radiologist and the referring clinician with diagnostic dilemmas. This article addresses the most frequently encountered lesions and provides a framework for the diagnostic and management pathways for both solid and cystic lesions.

Keywords: *Incidental renal masses; simple cysts; solid renal masses; malignant causes; oncocytomas; angiomyolipomas.*

Introduction

Incidental renal masses are very common. Cross-sectional imaging identifies renal masses in more than half of patients over the age of 50 years[1,2]. Most of these masses are benign[3,4]. However, some incidental masses cannot be accurately characterized as to their nature as they are too small or do not demonstrate typical features.

Imaging modalities and techniques

Computed tomography (CT) and magnetic resonance imaging (MRI) are the two techniques most often used to evaluate renal masses; focused renal ultrasonography is used in some select instances. For the evaluation of small masses and to optimize their characterization, it is important to use thin-section multiphase CT or MR scanning techniques (3–5 mm) both before and after the administration of intravenous contrast material. [4–7]. MRI should be considered in young patients, in women of child-bearing age, and in those requiring multiple follow-up examinations, such as those with genetic syndromes like von Hippel–Lindau disease, in order to limit radiation exposure. In addition, one should consider using MRI instead of CT for renal masses measuring less than 2 cm.

Incidental solid renal masses

Incidentally discovered solid renal masses can be of benign and malignant etiologies. Benign entities include oncocytomas, angiomyolipomas, and rarely metanephric adenomas and leiomyomas[8,9]. If there is a history of a known extrarenal primary malignancy, both solid benign renal masses and renal cell carcinomas should still be considered as possibilities in addition to metastatic disease[10]. This is because only between 50 and 85% of solid renal masses in patients with a history of extrarenal primary malignancy will prove to be metastases[11,12].

In a study of 2770 resected renal masses, 12.8% were benign. The majority of these masses were oncocyotmas and angiomyolipomas. When stratified according to size, the proportion of benign masses increased from 25% for masses <3 cm to 40% for masses <1 cm[13].

The recent increase in the incidence of detection of incidental renal carcinomas is related to an increase in the use of cross-sectional imaging modalities for a variety of clinical indications[14]. Most incidentally discovered renal cell carcinomas are small low stage tumors[14–16]. In addition, it seems that the smaller cancers (<1 cm in size) exhibit less aggressive clinical behaviors[13,17–19], although this remains controversial. Some studies show that some small cancers can be aggressive[20–22]. Despite the increase in detection of small renal cancers and their

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early resection, the mortality rate from renal carcinomas has not declined. This is explained in part by the fact that although smaller incidental cancers are being detected and treated, the rate of discovery of large aggressive cancers has not declined and it is these which contribute to the high mortality rates[23].

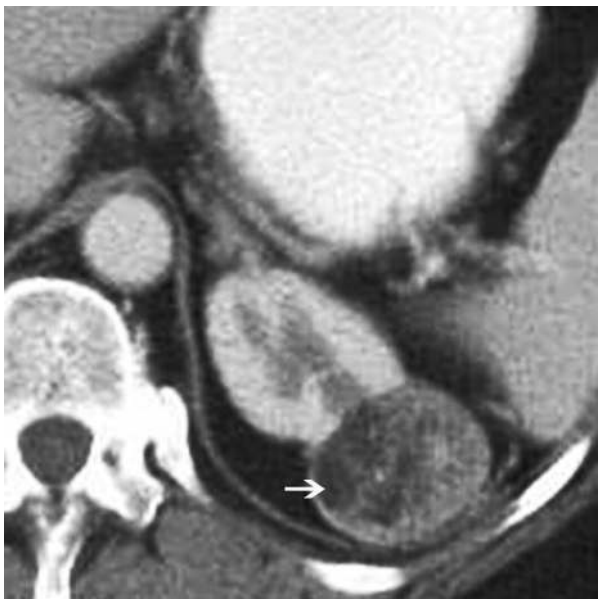

Figure 1 **Angiomyolipoma. Contrast-enhanced axial image shows fat-containing mass consistent with an angiomyolipoma (arrow).**

Angiomyolipomas

Almost all renal masses containing macroscopic fat are angiomyolipomas. These can be diagnosed with CT (Fig. 1) or MRI[24]. When MRI is used the India ink artifact at the interface of the fatty components of the angiomyolipoma and the non-fatty components of the renal parenchyma on T1-weighted chemical shift imaging indicates the presence of macroscopic fat[25] (Fig. 2). A diagnosis of angiomyolipoma should be not be made only on the basis of loss of signal intensity of the internal components on out-of-phase imaging as clear cell renal carcinomas can also lose signal intensity by virtue of their intracellular lipid content[26] (Fig. 3). Very rarely renal cell carcinomas contain macrosopic fat, thereby mimicking an angiomyolipoma. These prove to be a diagnostic problem but most fat-containing renal cell carcinomas also contain calcium[27–30], a feature that is rare in angiomyolipomas.

Approximately 5% of angiomyolipomas contain little or no fat and these also pose a diagnostic challenge as they mimic other solid renal masses including renal cell carcinoma[31,32]. MRI may be useful in this circumstance. Angiomyolipomas contain smooth muscle which is typically hypointense on T2-weighted images[31,33], in contrast to clear cell carcinoma which is usually hyperintense on T2-weighted images[34–36]. However, papillary renal carcinomas are also typically hypointense on T2-weighted images and therefore can be similar in appearance to atypical angiomyolipomas containing little or no fat[35,37–38]. In these cases a biopsy is required to

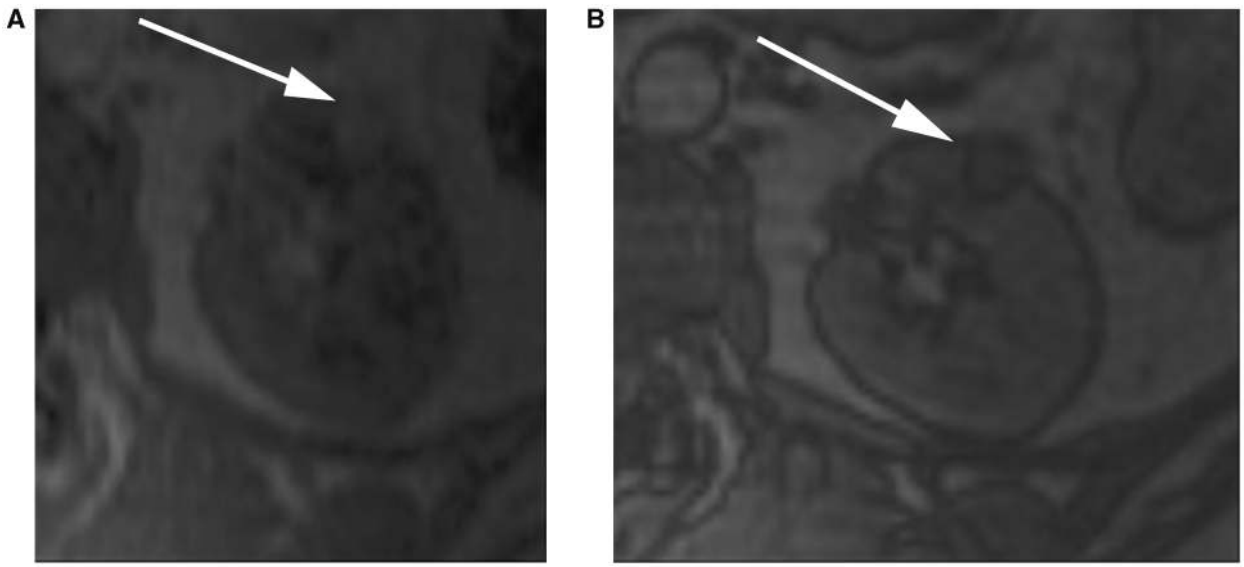

Figure 2 **Angiomyolipoma. In-phase (A) and out-of-phase (B) axial images demonstrate loss of signal intensity within the mass indicating the presence of intracellular lipid. In addition, at the interface of the angiomyolipoma and the renal parenchyma there is an India Ink artifact (arrow) indicating that the lesion contains macroscopic fat, diagnostic of an angiomyolipoma.**

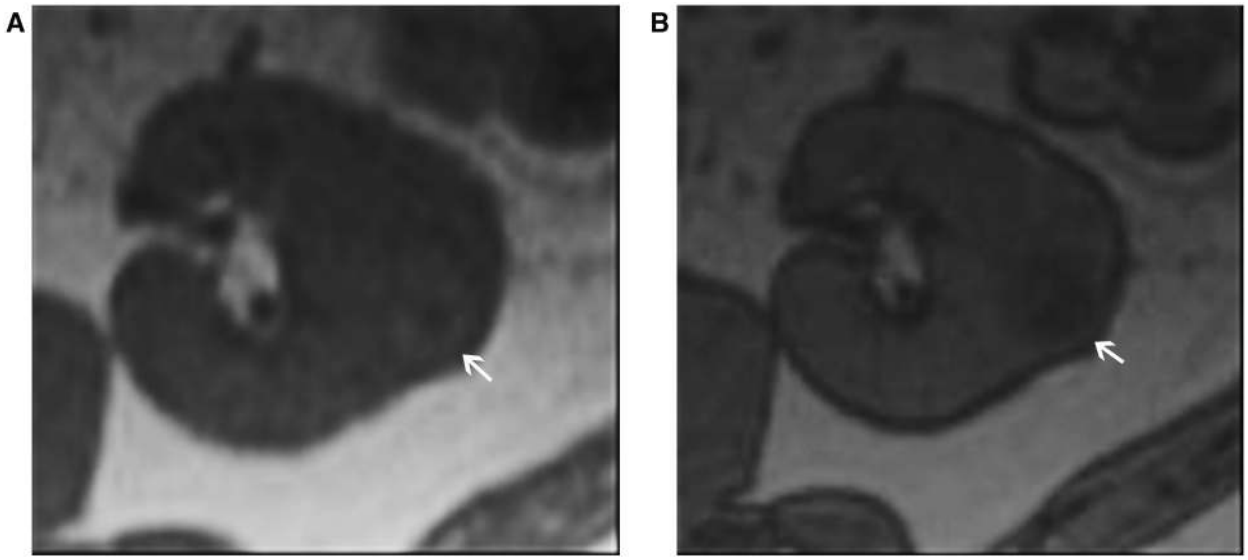

Figure 3 **Clear cell renal carcinoma. In-phase (A) and out-of-phase (B) axial MR images show a mass in the left kidney (arrows) with loss of signal intensity on out-of-phase images. There is no India Ink artifact at the interface of the mass and the renal parenchyma.**

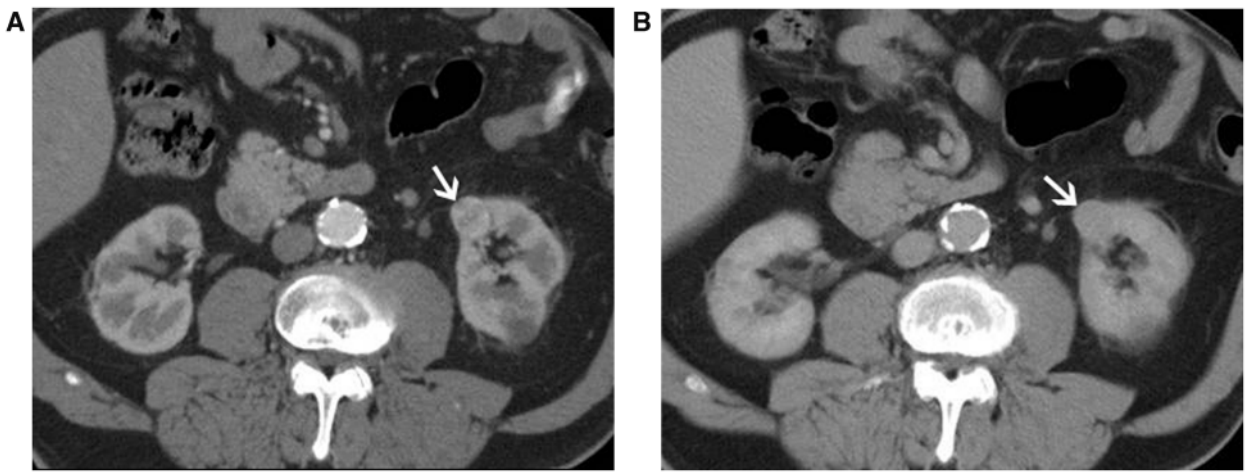

Figure 4 **Oncocytoma. Axial contrast-enhanced CT images demonstrate an enhancing mass (arrow) in the corticomedullary phase (a) and nephrographic phase (b) which cannot be distinguished from renal cell carcinoma.**

distinguish the two. The development of stains specific for smooth muscle and melanosyme-associated protein HMB-45 has led to improved accuracy in the diagnosis of angiomyolipomas[39]. Cytokeratin is also absent in angiomyolipomas but seen often in renal cancers.

Oncocytomas

These benign tumors may demonstrate some features, such as the presence of a central scar and homogeneous brisk enhancement following intravenous contrast administration (Figs. 4 and 5) that can be used to suggest the diagnosis[40–42]. However, none of these signs are diagnostic, and therefore historically these tumors have undergone surgical resection for definitive diagnosis and treatment. Oncocytomas and some renal cancers contain oncocytes and tissue aspiration biopsy has in the past been unreliable in differentiating between these two entities[43–48]. However, recent advances in histopathology and immunohistochemistry have led to improvements and the use of a combination of Hale's colloidal iron stain and cytokeratin 7 stains leads to confident diagnosis in most cases[39,43].

Incidental cystic renal masses

The Bosniak classification has been used as a clinical guide in the diagnosis and management of renal cystic

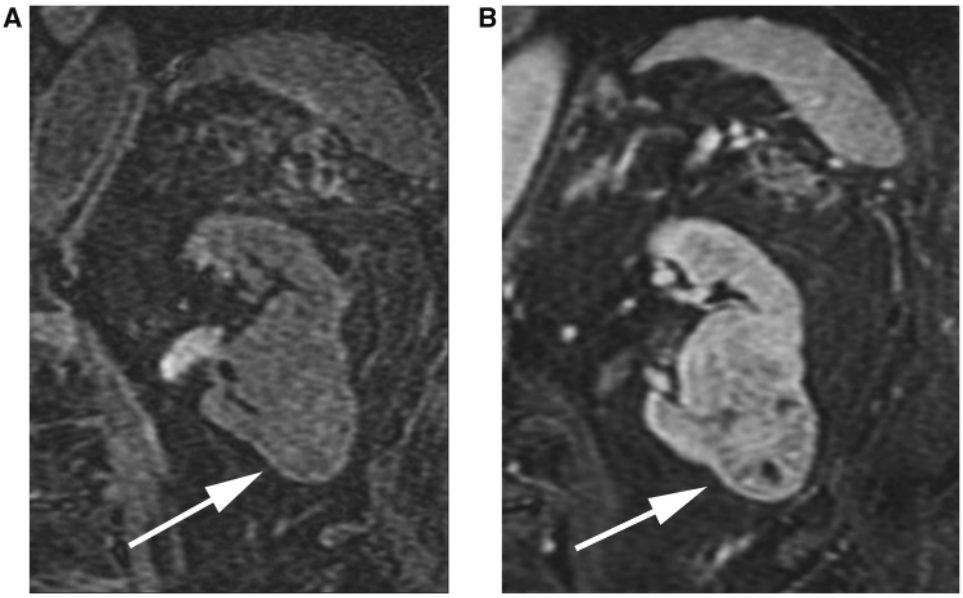

Figure 5 **Oncocytoma. Coronal pre- (a) and post-contrast (b) enhanced T1-weighted images shows an enhancing mass (arrows) which has a non-specific appearance.**

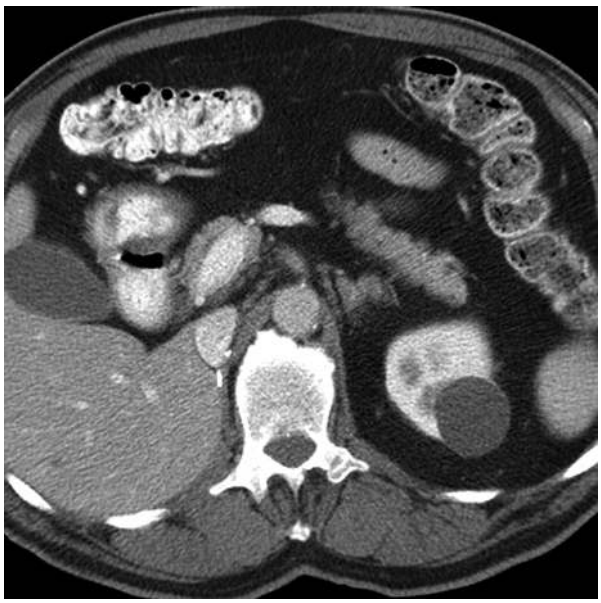

Figure 6 **Simple renal cyst, Bosniak category I. Axial contrast-enhanced CT shows a smooth homogeneous simple cyst in the left kidney with no septations and an imperceptible wall.**

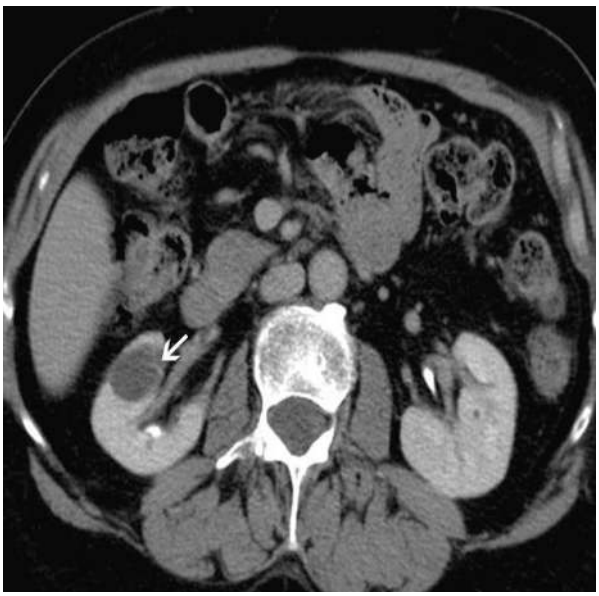

Figure 7 **Minimally complicated cyst Bosniak category II. Axial contrast-enhanced CT shows a right renal cyst with a thin septation (arrow).**

lesions[4]. If a lesion measures less than 20 HU on CT, does not contain septations, mural nodules or calcification and has an imperceptible wall, it fulfills the criteria of a simple cyst and is designated as a category I lesion (Fig. 6). Category II lesions are also benign lesions and appear as minimally complicated cysts that contain a few hairline-thin septa in which perceived enhancement may be seen (Fig. 7). Fine calcifications or a short segment of thickened calcification may be present in either the wall or septa. Hyperdense cysts are also included as category II lesions. These usually measure greater than 20 HU on unenhanced images, are homogeneous and show no enhancement following intravenous contrast administration (Fig. 8). Hyperdense cysts measuring ≤ 3 cm in size and fulfilling these criteria can be considered as benign and do not require follow-up. Category II F[49,50] lesions require a period of follow-up before making a decision as

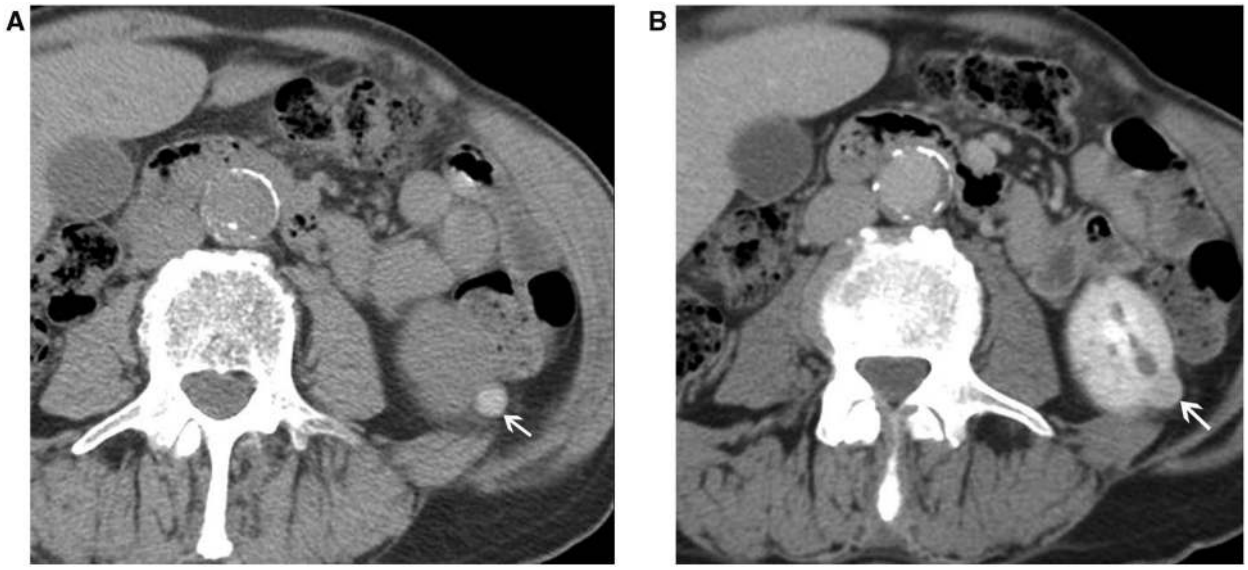

Figure 8 **Hyperdense cyst. Axial unenhanced (A) and enhanced (B) CT images show a small left lower pole mass (arrows) which is hyperdense on unenhanced imaging (a) and which shows no significant post-contrast enhancement.**

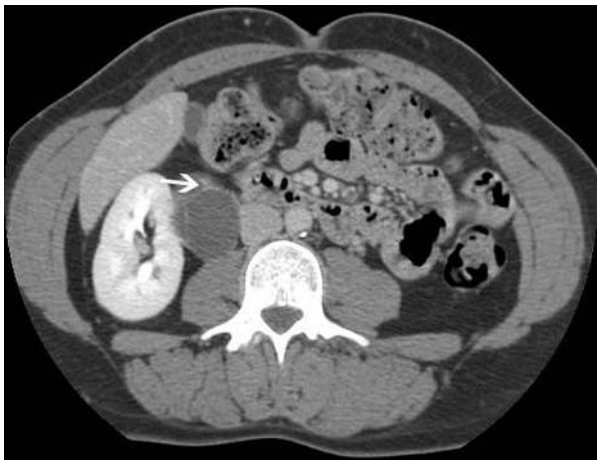

Figure 9 **Cystic RCC, Bosniak category III. Axial contrast-enhanced CT shows a right renal cystic lesion with septations and a mural nodule (arrow).**

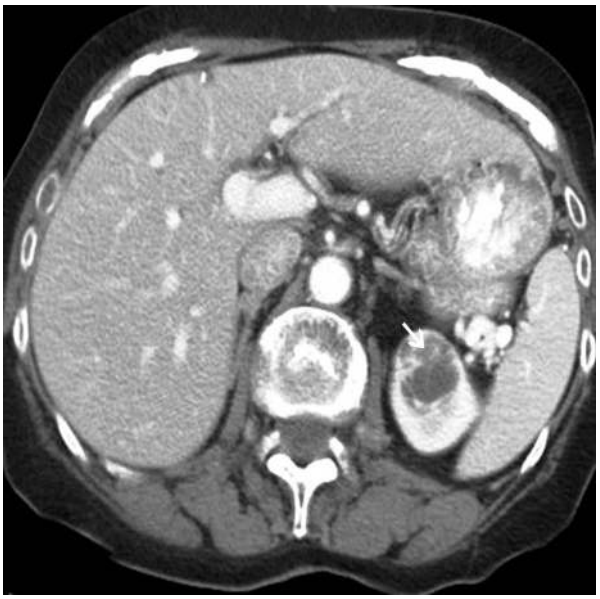

Figure 10 **Renal cell carcinoma with cystic degeneration, Bosniak category IV. Axial contrast-enhanced CT shows a cystic left upper pole lesion with thickened and nodular enhancing septa (arrow).**

to whether they are benign or not, as they may have multiple hairline septa, may contain thick irregular or nodular calcifications and may have smooth thickened walls or septa. Hyperdense homogeneous masses greater than 3 cm in size which are completely surrounded by renal parenchyma also fall into this category. The recommended intervals for follow-up are 6 and 12 months, followed by yearly studies for 5 years. Category III lesions are indeterminate. Imaging cannot reliably distinguish between benign and malignant lesions in this category. Some cases of hemorrhagic or infected cysts, multilocular cystic nephroma and cystic renal cell carcinoma fall into this category. These lesions contain thick walls or septa that demonstrate enhancement (Fig. 9). Category IV lesions contain all or some of the features of category III lesions, but in addition have enhancing soft tissue components (Fig. 10).

Although size alone cannot be used to characterize whether a cystic lesion is benign or malignant, Bosniak recommends that lesions under 1 cm in size that have the imaging features of simple cysts in otherwise healthy subjects can be presumed to be benign[51]. A cystic lesion in the 1–2 cm size range is most likely to be benign

except in a patient with a genetic predisposition to developing renal cancer.

Management of incidental renal masses

Options for the management of incidentally discovered renal masses include the use of other imaging modalities to enable further characterization, observation using follow-up imaging, biopsy, ablative therapy and minimally invasive nephron-sparing or radical surgery[52]. Clinical history and patient demographics have to be taken into consideration when making a decision on the management of the renal mass. Factors such as age, life expectancy, other co-existing morbidities and patient preference all play a major role in management decisions[52].

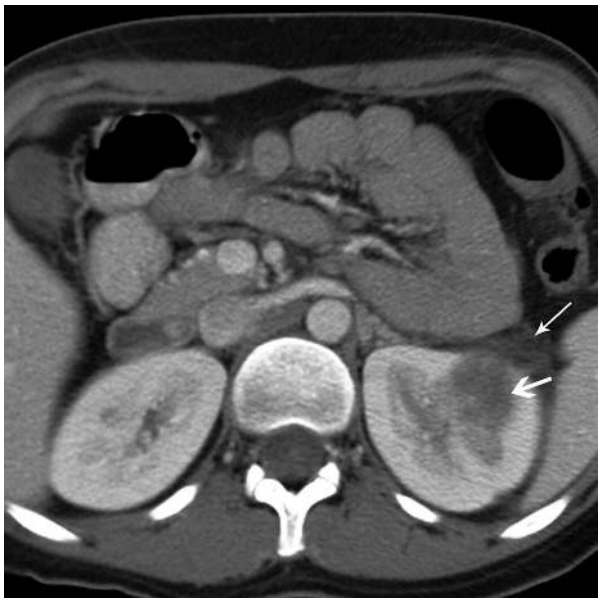

Figure 11 **Renal abscess. Contrast-enhanced axial CT shows an ill-defined left upper pole mass (thick arrow) with perinephric stranding (thin arrow).**

Management strategy for cystic renal lesions

Category I and II lesions can be ignored. Category IIF lesions can be observed with imaging at 6 and 12 months and yearly follow-up for 5 years. Category III and IV lesions are surgical lesions[4], except in patients who have limited life expectancy or comorbidities that would preclude surgery. In these patients observation may be appropriate[52]. Percutaneous ablative therapies may also be considered for category IV lesions in elderly patients or those with comorbidities that preclude surgery[53–56]. In patients who have life-threatening conditions or limited life expectancy, cystic lesions that cannot be characterized and measure under 1.5 cm need not undergo observation with follow-up imaging[51,52].

Management strategy for solid renal lesions

Inflammatory masses (Fig. 11), vascular "mass-like" lesions (Fig. 12) and angiomyolipomas should be excluded by appropriate clinical history and follow-up, by imaging or biopsy[53]. Most small solid masses under 1 cm in size are too difficult to biopsy but are probably benign. These can be observed by follow-up imaging studies at between 3 and 6 months initially and then annually until they reach an adequate size suitable for biopsy[52]. Solid masses larger than 3 cm can be removed with nephron-sparing surgery if they have been proven to represent renal cell carcinoma or if the imaging

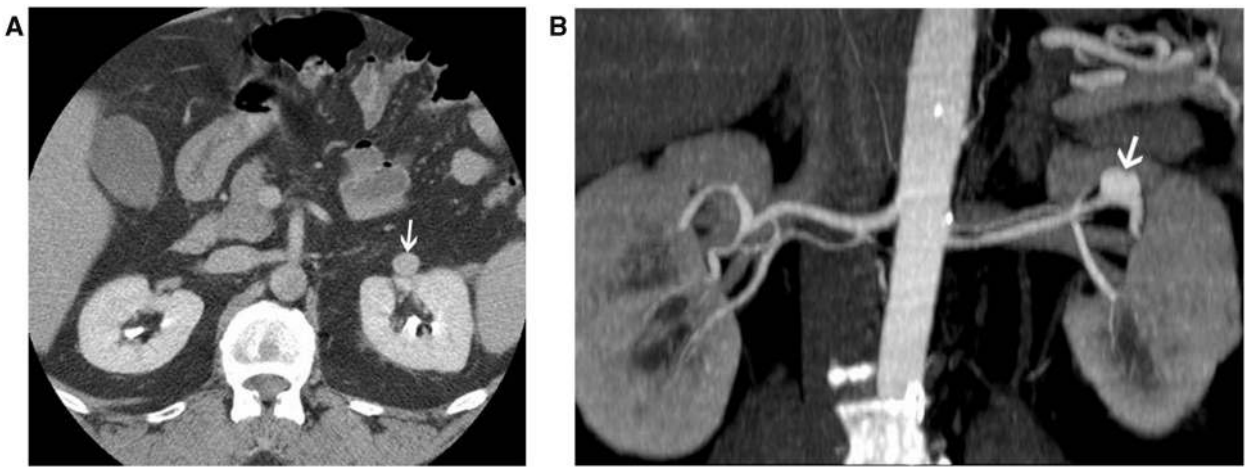

Figure 12 **Contrast-enhanced axial CT during the nephrographic phase (A) showing a homogeneous enhancing mass (arrow) in the left renal hilum. A dedicated CT with arterial phase imaging with reformatted images (B) shows that the lesion is a pseudoaneurysm (arrow).**

features are suggestive of renal carcinoma. Masses measuring 1–3 cm should also be removed surgically unless they have imaging features of atypical angiomyolipomas and oncocytomas, in which case a percutaneous biopsy and immunohistochemical staining should be used to exclude these diagnoses[39,43–48,52]. However, there is a growing trend in the use of ablative techniques for the treatment of solid renal tumors in patients who are poor surgical candidates because of co-existing comorbidities. Recently reported long-term data regarding the effectiveness of these techniques is promising for their use in this subset of patients[53–57].

Role of image-guided biopsy for renal masses

Established indications for renal mass biopsy are: (a) renal mass and known extrarenal malignancy, (b) renal mass with imaging features suggestive of unresectable renal cancer, (c) renal mass that may be due to an infection, (d) renal mass suspicious for malignancy and surgical comorbidity[39]. Expanded indications for biopsy have emerged more recently including: (a) small enhancing masses, (b) masses undergoing thermal ablation[39,58]. Although controversial, some advocate biopsy of indeterminate cystic renal masses (Bosniak category III).

Newer cytological and immunohistochemistry techniques have enhanced the ability to diagnose atypical angiomyolipomas and oncocytomas. The melanosyme-associated protein, HMB-45, is expressed in angiomyolipomas[59,60] but not in renal cell carcinomas. Angiomyolipomas also stain with smooth muscle actin, which is not present in most renal cancers. In the past, oncocytomas could not be distinguished from oncocytic renal carcinomas such as granular cell carcinoma, chromophobe renal carcinoma and the eosinophilic variant of papillary renal carcinoma, as these tumors all contain oncocytes. However, new immunocytochemical techniques now help distinguish oncocytomas from these renal cancers. Oncocytomas and chromophobe renal carcinomas do not stain with vimentin; granular cell carcinomas and the eosinophilic variant of papillary renal carcinomas are positive. Oncocytomas and chromophobe renal carcinomas can be distinguished as the latter stain with Hale colloidal iron stain and oncocytomas do not[39,42–48,58].

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