Imaging of incidental renal masses

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Introduction
The incidental finding of a renal mass is very common. The incidence of this is increasing with the widespread use of cross-sectional imaging in the investigation of patients. The majority of the incidental lesions are renal cysts, which can be safely ignored. Benign or simple renal cysts are very common, affecting around half of the population over the age of 50. However, the detection of complex cystic and solid lesions requires further investigations and management. A solid renal mass is generally regarded as a renal cell carcinoma unless specific imaging features suggest otherwise. 5-15% of renal cell carcinoma has been shown to be cystic on imaging.\(^1\)\(^,\)\(^2\) 25-40% of all renal tumours are detected incidentally and at an earlier stage.\(^3\) The detection at an earlier and less aggressive stage than symptomatic tumour has led to better patient survival and decreased recurrence.\(^4\)

Imaging techniques
Ultrasound scan is the initial investigation of choice for renal imaging as it is readily available and lacks ionising radiation. It is good for differentiating cystic and solid lesions. However, US is poor at detecting small renal lesions, radiation. It is good for differentiating cystic and solid renal imaging as it is readily available and lacks ionising radiation. Ultrasound scan is the initial investigation of choice for the incidental finding of a renal mass. The kidneys are best imaged with a 3 to 5 MHz curvilinear probe. Harmonic imaging may be helpful in defining cystic components. US allows the detection of complex cysts for which CT scanning is required for further assessment.

CT scanning plays an important role in the accurate assessment of complex cystic or solid lesions. In order to evaluate the enhancement in the lesion, an unenhanced scan should be performed followed by a scan in the nephrographic phase (80-120s delay). The nephrographic phase is the optimum phase to characterise renal masses. As there is maximal and homogeneous renal parenchymal enhancement, this allows detection of renal masses that normally do not enhance to the same degree. The mean attenuation value of the lesion should be obtained on the unenhanced and post-contrast scan. A lesion is regarded as enhancing if there is an increase of 20 or more Hounsfield units (HU) between the pre- and post-contrast scans. An increase of 10-20 HU should be regarded as indeterminate and further imaging is required for accurate evaluation. Following a diagnosis of renal cell carcinoma, CT scan has been shown to be accurate in up to 91% of patients in the staging of these patients.\(^5\) It is useful for assessing renal venous invasion and to assess for distant metastases. The introduction of multidetector CT scanning has also led to the ability to perform multiplanar reconstruction. This is a useful tool for accurate staging and planning for surgery, in particular in nephron-sparing surgery. CT scan, however, has been shown to be poor at detecting lesions under 1cm.\(^6\)

MRI plays a role in the imaging of indeterminate renal lesions. It has been shown to have similar diagnostic accuracy as CT scan. In some cases, MRI may depict additional septa, thickening in the wall or enhancement in the assessment of complex cystic lesions leading to a change in management.\(^7\) It also has the advantage of a lack of ionising radiation and may be useful in patients who cannot undergo contrast enhanced CT scan due to iodine allergy. MRI has been shown to have similar accuracy to CT scan in the diagnosis and staging of renal cell carcinoma.\(^8\)\(^,\)\(^9\)

Cystic renal masses
Accurate characterisation of cystic renal masses determines the management of these lesions. The publication of the Bosniak classification has enabled a more accurate assessment of cystic renal masses – see table 1.\(^10\) The Bosniak classification was developed for CT but can be applied to US or MRI. The Bosniak classification is based on the following features as seen on CT: Wall and septal thickness, enhancement, calcification and the position of the mass within the kidney.

The diagnosis of Bosniak categories I and IV lesions are usually straightforward. A Bosniak category I cyst is a simple cyst and seen as an anechoic lesion with a sharply defined posterior wall on ultrasound scan (US) and posterior acoustic enhancement. A Bosniak category II cyst is slightly more complex with one or more thin septa (figure 1) and may be seen incidentally on US. These two categories are shown similarly on CT scan with no enhancement seen within the wall or septations. These lesions do not require further follow-up. The finding of more complex features on US, such as nodularity, calcification, multiple septations, septal or wall thickening, would warrant a CT scan for a more accurate assessment of the lesion. This would include a pre-contrast and nephrographic phase scan to evaluate for enhancement. The presence of enhancing soft tissue component in a lesion would make it a Bosniak category IV cyst (figures 2a and 2b) which is malignant and surgical intervention is required.

The difficulty in categorising complex cysts lies in accurately differentiating between Bosniak II and III cysts. Accurate characterisation is important as it makes the distinction between further follow-up imaging and surgical management. A Bosniak IIF cyst is more complex than a Bosniak II cyst with more thin septa with minimal enhancement of the septa or wall. Calcification may be seen and can appear slightly thick and nodular.

Follow-up is recommended for Bosniak IIF lesions. Bosniak category III cysts are those with thickened septa or wall demonstrating enhancement which is measurable by a region of interest cursor. These are referred for consideration of surgery as studies have shown malignancy rates of 59 to 81.8%.\(^11\)\(^,\)\(^12\) As mentioned before, MR may be useful in depicting additional septa, wall or septal thickening, or enhancement which may upgrade a complex cystic lesion.

Solid renal masses
A solid renal mass should be regarded as a malignant renal lesion until proven otherwise. Of course, not all enhancing solid renal lesions are malignant. The demonstration of macroscopic fat within a renal lesion on CT scan or MRI is diagnostic of an angiomyolipoma.\(^13\) Angiomyolipoma is a benign lesion that contains fat, smooth muscle and blood vessels, and appears hyperechoic on US (figures 3a and 3b). Lesions larger than 4cm are at risk of haemorrhage and intervention should be considered at this size. Approximately 4.5% of angiomyolipoma do not demonstrate macroscopic fat on CT or MRI, otherwise known as minimal fat angiomyolipoma.\(^14\) Although studies have shown these lesions to demonstrate homogeneous high attenuation on unenhanced CT scan “with homogeneous and prolonged enhancement on contrast-enhanced scans,” these findings...
are not specific enough to make a confident diagnosis of angiomyolipoma. The most common solid renal mass is a renal cell carcinoma (RCC) which accounts for approximately 90% of renal masses. An oncocytoma is the commonest solid benign renal tumour, accounting for approximately 5% of renal masses. Although described as having a central stellate scar on CT, this is found only in a small proportion of cases and other tumours cannot be reliably distinguished from renal cell carcinoma on imaging. A solid renal lesion should therefore be considered and managed as a renal cell carcinoma except in the presence of microscopic fat. RCC can have variable appearance on US and may appear hyperechoic, isoechoic or hypoechoic. RCC, like in all solid renal lesions, demonstrates enhancement on contrast-enhanced CT scan and may have cystic components. CT scan is accurate in staging RCC which include assessing for perinephric extension, involvement of the renal vein and inferior vena cava, and distant metastasis. MRI plays a limited role in staging RCC but has been shown to be the most sensitive means of identifying tumour thrombus.

Other tumours of the renal tract may present in an infiltrative pattern. Advanced transitional cell carcinoma of the pelvicalyceal system extends into the renal parenchyma in an infiltrative manner and distorts normal architecture. The kidney may enlarge but retains its reniform shape, unlike RCC. In a patient with known primary malignancy elsewhere, metastasis should be considered if there are multiple bilateral renal masses. These are often poorly defined and infiltrate the renal parenchyma. Non-neoplastic conditions, which include focal pyelonephritis, renal abscesses or infarction, may mimic a cystic or solid neoplasm. An appropriate clinical history will enable a correct diagnosis. In the clinical setting suggestive of an infective process, needle aspiration and percutaneous drainage should be performed.

**Conclusion**

The finding of incidental renal lesions is increasing due to the increasing use of cross-sectional imaging in the investigation of patients. This has led to an earlier detection of malignant lesions with earlier treatment and improved survival. US is useful for differentiating cyst from solid lesions although there are limitations in detecting lesions under 2cm. CT scan has been shown to be accurate in the assessment of complex cystic and solid lesions and for staging patients with renal cell carcinoma. MRI has similar diagnostic accuracy to CT scan, but is generally reserved for lesions that remain indeterminate following a CT scan or for patients who cannot undergo CT scan due to contrast allergy, due to its more limited availability.

**References**


**TABLE 1**

Bosniak classification of renal cysts.

<table>
<thead>
<tr>
<th>Category</th>
<th>Features</th>
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<tbody>
<tr>
<td>I</td>
<td>Simple cyst with a hairline-thin wall that does not contain septa, calcification or solid components. It has water attenuation and does not enhance.</td>
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<tr>
<td>II</td>
<td>Benign cystic lesion that may contain a few hairline-thin septa. Fine calcification or a short segment of slightly thickened calcification may be present in the wall or septa; uniformly high-attenuating lesions (&lt;3 cm) that are sharply margined and do not enhance.</td>
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<tr>
<td>IIF</td>
<td>Cyst may contain multiple hairline-thin septa; perceived (not measurable) enhancement of a hairline-thin smooth septum or wall can be identified at CT. There may be minimal thickening of wall or septa, which may contain calcification that may be thick and nodular, but no measurable contrast enhancement is present. There are no enhancing soft-tissue components. Totally intrarenal nonenhancing high-attenuating renal lesions (&lt;3 cm) are also included.</td>
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<tr>
<td>III</td>
<td>Cystic masses with thickened irregular or smooth walls or septa and in which measurable enhancement is present at CT.</td>
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<tr>
<td>IV</td>
<td>Clearly malignant cystic masses that can have all of the criteria of category III but also contain distinct enhancing soft-tissue components.</td>
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FIGURE 1
CT scan demonstrating a thin walled cyst with minimal calcification in keeping with a Bosniak category II cyst.

FIGURE 2a
US demonstrating a renal cyst with a solid nodule

FIGURE 2b
CT scan shows the cyst with an enhancing nodule in keeping with a Bosniak category IV cyst.

FIGURE 3a
US shows a hyperechoic lesion in a patient with known angiomyolipoma.

FIGURE 3b
Unenhanced CT scan showed macroscopic fat in keeping with an angiomyolipoma.

FIGURE 4
CT scan demonstrating a heterogeneously enhancing mass in the right kidney in keeping with a renal cell carcinoma.