Imaging of Solid Renal Masses

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KEYWORDS

• Renal cell carcinoma • Lymphoma • Angiomyolipoma • Renal oncocytoma • Ultrasonography • X-ray computed tomography • MR imaging • Image-guided biopsy

KEY POINTS

- Solid renal masses include various types of malignant and benign histologic diagnoses.
- Noninvasive lesion characterization is achievable in a substantial number of cases, with the use of state-of-the-art imaging techniques and evidence-based interpretation criteria.
- Cross-sectional imaging has the potential to improve patients' outcomes by reducing the number of unnecessary biopsies and/or surgical procedures.

INTRODUCTION

The incidence of renal cancer increased from 7.1 to 10.8 cases per 100,000 patients between 1983 and 2002, with most primary tumors initially diagnosed as incidental small renal masses (ie, measuring $\leq$4 cm) on imaging studies performed for other clinical reasons.[1] Paradoxically, this increase in diagnosis has not been associated with better clinical outcomes, with a reported increase in mortality from 1.5 to 6.5 deaths per 100,000 patients within the same time interval.[1] Furthermore, most incidentally detected tumors either grow slowly[2] or do not show detectable growth over time.[3,4] Therefore, cost-effective strategies are necessary to identify clinically significant renal masses that could evolve into life-threatening disease, while avoiding the unnecessary morbidity and financial costs associated with overtreatment of benign or more indolent malignant conditions.

The first step in the workup of incidentally found renal lesions is to differentiate benign cysts from solid masses.[5,6] Solid renal masses contain little or no fluid and are composed predominantly of vascularized tissue (ie, elements enhancing with the administration of exogenous contrast agents).[6] Despite their lower prevalence compared with cystic lesions, up to 90% of solid masses are malignant.[7–9] The risk of malignancy is influenced by size, occurring in approximately 50% for lesions smaller than 1 cm and more than 90% for masses greater than or equal to 7 cm.[7]

Solid malignant masses most frequently encountered in clinical practice are renal cell carcinoma (RCC), urothelial carcinoma, lymphoma, and metastasis, whereas the most frequently encountered benign solid renal masses are angiomyolipoma (AML), oncocytoma, and inflammatory pseudotumors or pseudolesions. This article provides a comprehensive imaging approach to common malignant and benign solid renal masses on state-of-the-art ultrasonography (US), computed tomography (CT), and multiparametric magnetic resonance (MR) imaging, proposing strategies to

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differentiate benign from malignant lesions and to distinguish RCC subtypes.

Malignant Lesions

Cancer arising in the kidney and renal pelvis accounts for 5% of all malignancies in men and 3% of malignancies in women.[10] RCC is more common among men (1.6:1, M:F). Patients with localized disease have a reported 93% 5-year survival, whereas this rate decreases to 66% and 12% for those with regional and distant metastasis, respectively.[10]

Renal cell carcinoma

The World Health Organization classification subdivides RCC into different histologic groups,[11] with clear cell RCC (ccRCC) accounting for 70% to 75%, papillary RCC (pRCC) accounting for 10% to 21%, and chromophobe RCC (chrRCC) accounting for 5% of all RCC cases.[11,12] Survival heavily depends on staging, histologic grade (ie, Furhman/International Society of Urological Pathology), presence of sarcomatoid features, and necrosis. In addition, ccRCC is associated with worse prognosis than pRCC and chrRCC.[11,13] Different histopathologic subtypes have distinct features on imaging studies, and these are discussed later.

Urothelial carcinoma

Urothelial carcinoma originates from the epithelium of calyces and renal pelvis and may comprise up to 15% of all renal tumors.[14] Median age at diagnosis is more than 60 years, with an approximately 2:1 M/F ratio, and hematuria is the most frequent symptom at presentation.[14,15] Synchronous and metachronous involvement of the urinary tract may occur in 24% and 11% of patients with renal urothelial carcinoma, respectively.[15] Differentiation of upper-tract urothelial carcinoma from RCC and other solid renal masses is simpler during earlier stages, when the presentation is characterized by wall thickening of the urothelial tract or filling defects in the collecting system. Infiltrative masses in the renal sinus or parenchyma are features of advanced disease, in which distinction from aggressive forms of RCC is difficult.[16]

Lymphoma

Lymphomatous involvement of the kidneys is most frequently the result of secondary spread of non-Hodgkin disease, with prevalence at autopsy reaching 50% in this population.[17] Renal lymphoma may present as multiple masses, solitary lesions simulating RCC, retroperitoneal/perirenal disease, and infiltrative renal disease. A pattern of multiple renal masses is encountered in up to 60% of the patients, typically ranging from 1 to 3 cm, with homogeneous attenuation (CT) or signal intensity (MR imaging), and low-level postcontrast enhancement compared with background parenchyma (Fig. 1).[18] Contiguous involvement of the kidneys by bulky retroperitoneal disease is another common presentation of lymphoma on imaging.[18] Solitary lesions occur in 10% to 20% of the patients, and although differentiation from ccRCC may be possible because of the characteristic homogeneous signal/attenuation and low-grade enhancement of lymphoma, biopsy may be needed to discriminate from non-ccRCC subtypes, especially papillary tumors.

Metastases

The reported prevalence of metastatic disease to the kidneys in oncologic patients differs depending on the method of assessment, varying from 20% on autopsy studies to less than 1% in clinicopathologic studies.[19] Commonly, the primary tumor is already known or diagnosed at the same time as the renal lesion, with more than half of the cases occurring in patients older than 60 years.[19] The most common primary sites are lung, breast, female genital tract, head and neck, colon, and prostate. Bilateral or multiple masses are found in 23% and 30% of the patients, respectively.[19] Renal metastases occur more commonly at the junction of the renal cortex and medulla, often showing ill-defined borders and low-level enhancement, except in the case of hypervascular primary tumors (eg, RCC, thyroid, choriocarcinoma). These features may help to suggest the diagnosis and differ from the most common well-defined appearance of cortical-based RCCs, although a definitive diagnosis may require a biopsy.

Benign Lesions

The reported prevalence of benign histology is 13% to 16% of all surgically resected renal masses.[7,9] The likelihood of benign histology in small solid renal masses is influenced by size, with a prevalence of up to 40% in lesions less than 1 cm in diameter.[20] AMLs and oncocytomas comprise most of the benign solid masses, representing 44% and 35%, respectively.[9]

Angiomyolipoma

AMLs are benign neoplasms, consisting of aberrant blood vessels, smooth muscle, and mature adipose tissue,[21] representing 2% to 6% of all resected tumors in surgical series.[22,23] Most of these neoplasms are found incidentally on imaging (eg, 0.1%–0.2% of US examinations), with a female preponderance (1:2, M/F).[24] AMLs can