CT and MRI Findings in Renal Cancer

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Fotios D. Laspas

77.1 Introduction

Renal masses are very common and in some cases may represent a challenging diagnostic and clinical problem. With the expanding use of imaging methods in the abdomen, the vast majority of renal masses are discovered incidentally. Fortunately, most of these are cysts that do not require any further management. However, if a renal mass is not obviously a simple cyst, it becomes critical to differentiate between a complex but probably benign lesion, which can be observed, and a potentially malignant lesion, which require surgical intervention. Therefore, the proper evaluation of these masses is key to appropriate management.

77.2 Detecting and Characterization

With recent advances in imaging technology the diagnosis of most renal lesions is usually straightforward and renal cell carcinoma (RCC) can be diagnosed with high accuracy (better than 95 %) [1]. Multidetector CT remains the most widely available and primary imaging modality for detecting and characterization of renal lesions. The optimal scanning protocol should include unenhanced CT through the kidneys followed by imaging during the corticomedullary through the liver and kidneys and nephrographic phases of the entire abdomen. Excretory phase is occasionally helpful. The nephrographic phase is the most sensitive for detecting renal masses (almost all renal masses have lower attenuation than the homogeneously enhancing surrounding normal renal tissue) [2]. The role of MRI in the evaluation of renal masses is ever increasing. The use of advanced MRI techniques such as diffusion-weighted imaging and ADC measurements has increased the diagnostic capability of the method in assessing renal masses [3]. Therefore, MRI can be used when the CT findings are nondiagnostic. Furthermore, MRI can be used when optimal CT cannot be performed, as in the case of compromised renal function, severe iodinated contrast allergy or pregnancy where radiation exposure is a problem.

Renal masses can be broadly categorized into cystic or solid appearing lesions. The most important feature which differentiates a solid mass from a cystic lesion is the presence of enhancement after intravenous contrast agent (Fig. 77.1). A change of >20 HU is definite enhancement, while a difference of <10 HU between pre- and postcontrast CT scan is regarded as insignificant and a renal mass that enhances between 10 and 20 HU is indeterminate and needs further assessment for definitive characterization. The presence of enhancement

F. D. Laspas (✉)
CT&MRI Department, "Hygeia" Hospital,
4, Erythrou Stavrou Str. & Kifisias Av,
15123 Athens, Attica, Greece
e-mail: fotisdimi@yahoo.gr

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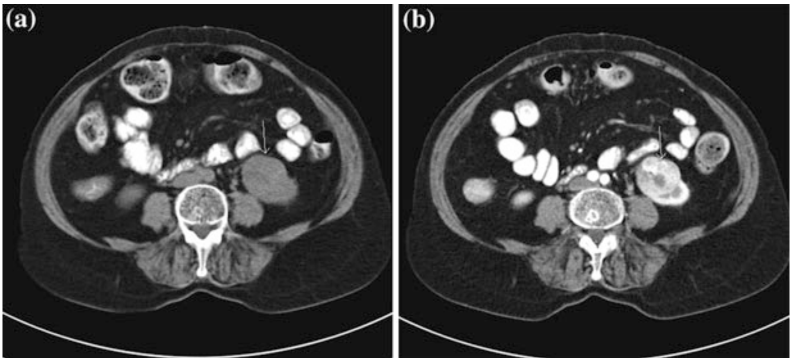

Fig. 77.1 Axial CT scans *before* (**a**) and *after* (**b**) intravenous contrast agent administration in a 54-year-old patient show a 2.8 cm enhancing mass in the left kidney. The lesion is found to be a renal cell carcinoma

at MRI cannot be measured easily and usually is assessed subjectively.

Cystic renal masses are composed predominantly of spaces filled with fluid. At imaging, these fluid-filled spaces have the characteristics of fluid (low-attenuation between 0 and 20 HU on CT and hyperintensity on T2W sequences similar to cerebral spinal fluid) and do not enhance after contrast agent administration. The Bosniak renal cyst classification is a worldwide and useful guide to the diagnosis and management of cystic renal masses (Fig. 77.2). This classification system was developed and based on only CT findings; nevertheless it is recently used in MRI interpretation (although cyst wall calcification is not well appreciated on MR images).

Solid renal masses consist predominantly of enhancing tissue. Although any solid mass in the kidney should be considered a RCC, benign lesions also may enhance. The presence of fat in a solid mass is of great importance, as its presence has long been considered diagnostic for angiomyolipoma (Fig. 77.3). Intralesional fat can be easily detected by CT using density measurement and by MRI using fat-suppression techniques. However, approximately 4.5 % of angiomyolipomas are fat-poor (no demonstrable fat on CT or MRI) and the imaging differentiation from RCC is impossible [2]. Moreover, there have been a few cases of fat-containing renal lesions that appeared to be RCC; most of them also contained calcifications [4]. Since angiomyolipomas rarely contain calcification, the presence of calcification in a lesion (even if macroscopic fat is seen on unenhanced images) indicates that RCC must be considered likely. In such cases, because the accuracy of MRI in detecting calcifications is relatively low, it is important always to assess CT examination of the patient (which will likely has been performed in most cases). Oncocytoma is the most common benign, solid, non-fat-containing renal

Fig. 77.2 Coronal multiplanar reconstruction (*MPR*) contrast-enhanced CT image shows a large cystic right renal lesion that contains distinct enhancing soft-tissue components (*arrows*), a finding consistent with a category IV cystic mass

mass. Although some imaging characteristics (homogeneous enhancement and central scar at CT or MR) are suggestive of oncocytoma, they may also be seen in RCC, and therefore the two entities are indistinguishable by imaging alone and a tissue diagnosis is needed. Silverman et al. [5] support that there is a direct relationship between malignancy and the size of the mass (the smaller the renal mass, the greater the incidence of benign lesions) and this must be taken into account when considering treatment options. Therefore, they support that it is reasonable to observe a solid mass less than 1 cm in diameter (which is usually difficult to be characterized) with CT or MR at 3–6 months and 12 months followed by yearly examinations.

Fig. 77.3 Axial contrast-enhanced CT image shows fat attenuation within the renal lesion (*arrow*), a finding indicative of an angiomyolipoma

77.3 Staging

Since RCC is relatively resistant to both radiotherapy and chemotherapy and the only curative treatment remains complete surgical excision of the tumor, preoperative imaging is critical for appropriate treatment decisions providing important anatomic information to the surgeon. Staging is usually performed using multidetector CT, although MRI is equally accurate in staging of the primary tumor. MRI may be helpful when questions related to the staging of RCC are left unanswered at CT and also is used in patients who cannot undergo CT scanning with intravenous iodinated contrast agent.

Evaluation of perinephric tumor extension is the most common cause of imaging staging errors, as it is difficult to discriminate from nonspecific perinephric stranding from edema or previous inflammation. Moreover, both CT and MRI cannot reliably detect microscopic invasion of the perinephric fat. The reported sensitivity and specificity for predicting extension of tumor into the perinephric fat are 84 and 95 %, respectively [2]. Diagnosis of perinephric extension does not affect management, when the patient is candidate for radical nephrectomy (en block resection of all the contents of Gerota's fascia), but this is a key point if partial nephrectomy is considered (currently recommended for management of T1 renal masses). Moreover, due to increasing application of modern imaging modalities, the number of small incidentally detected renal tumors (at an earlier stage) is increasing and nephron-sparing surgical techniques have been advocated. Three-dimensional CT helps in preoperative evaluation of patients for partial nephrectomy defining the precise location of the renal mass, the depth of renal parenchymal invasion, and relationship of the tumor to the collecting system and the renal vessels.

Evaluation of the venous invasion, which is very important for the surgical approach, is well appreciated on cross-sectional imaging modalities (Fig. 77.4). For differentiation between clot and tumor thrombus, postcontrast images are required (the tumor thrombus enhances). Moreover, invasion of the inferior vena cava wall is important information for the surgeon. MRI is considered to be superior to CT in the assessment of the inferior vena cava wall invasion, although the accuracy of MRI has not yet been well documented [4].

Evaluation of ipsilateral adrenal gland invasion is important because the current trend is to spare the ipsilateral adrenal gland when it is assessed as normal at the preoperative imaging investigation. Direct RCC invasion outside the

Fig. 77.4 Coronal multiplanar reconstruction (*MPR*) contrast-enhanced CT image in a 61-year-old woman shows a right renal lesion (asterisk). Moreover, a small filling defect (*arrow*) is seen within the right renal vein, a finding consistent with venous invasion

Gerota fascia into adjacent organs is well shown (focal change in attenuation or signal intensity within a neighboring organ), but it may not be possible to be proven (loss of fat planes between the tumor and surrounding organs raise the possibility of direct infiltration, but not always is confirmed surgically).

Both CT and MRI diagnosis of lymph node involvement is based on lymph node size (short-axis diameter larger than 1 cm). Although both methods are very effective in detection of lymph node enlargement, the limitation of using size criteria for detecting lymphatic metastases is well known. High false positive rates have been reported as malignant lymphadenopathy cannot be differentiated from nodal enlargement due to reactive hyperplasia [2]. Except from retroperitoneal lymph node involvement, mediastinal nodal involvement is also a frequent finding in patients with RCC as the lymphatic drainage of the kidneys is highly variable [6].

Distant RCC metastases are generally easy to identify with CT or MRI. Hematogenous metastases most commonly occur to the lungs, liver, bones, and brain, but essentially to any organ. CT is the ideal method for identifying hematogenous spread to lungs. Some authors still recommend that chest radiography can be sufficient for assessment of the lungs in low-risk groups (small tumors, T1) of metastatic disease, despite the fact it is far less sensitive than chest CT [6]. Both CT and MRI are sensitive techniques for the detection of liver metastases. Since RCC metastases are often hypervascular (like the primary tumor), hepatic metastases are most noticeable on scans obtained during the arterial phase. Brain imaging (CT or MRI) and bone scanning are generally performed only in the presence of symptoms and signs suggesting disease at these sites. Concerning cerebral metastases MRI is more sensitive for the detection of smaller lesions than CT. As bone metastases from RCC show variable uptake on bone scintigraphy, it may be limited in detecting the typical osteolytic bone metastases from RCC (the accuracy of bone scintigraphy in RCC varies from 10 to 60 %) [6]. Correlation with CT is helpful. MRI performs better for bone lesion characterization, but it is not used routinely [6].

77.4 Follow-up Evaluation-Response to Therapy

Multiple prognostic factors have been reported in the literature to predict RCC prognosis, however, the stage of the tumor at the time of presentation is the most important determinant of recurrent disease. The intensity of the follow-up program for an individual patient is primarily dependent on disease stage. More intensive surveillance is needed for patients who are at high risk for tumor recurrence. RCC recurrence may occur in the nephrectomy bed (local recurrence) or appears as distant metastases (most commonly in the lungs). CT offers the simplest way to assess RCC recurrence, while MRI is mainly used as a problem solving tool. Local recurrence manifests as an enhancing solid mass at the nephrectomy site (Fig. 77.5) with or without central necrosis. As during staging, brain imaging and bone scintigraphy are generally justified only in the presence of symptoms. The surveillance strategy after

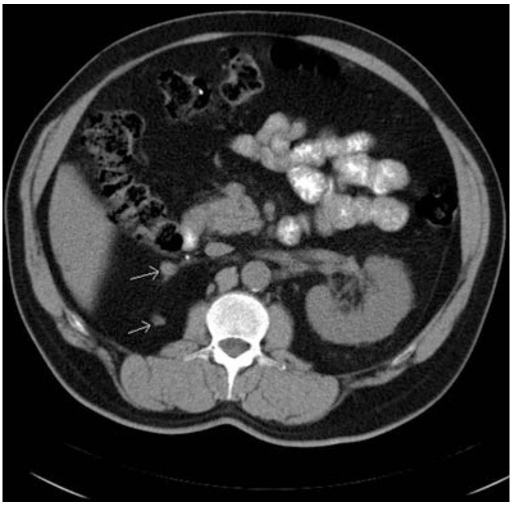

Fig. 77.5 68-year-old man who underwent right nephrectomy for renal carcinoma. Two years later, he developed two enhancing nodules (*arrows*) at the nephrectomy bed. Biopsy revealed recurrent tumor

nephron-sparing surgery is similar, except that greater consideration should particularly be given to the remnant kidney. Careful follow-up is also needed for patients who have undergone ablation treatment. After effective ablation, the tumor shows increased density on the unenhanced studies and does not enhance. The fat halo sign is a common postablation finding surrounding the ablated tumor. Any enhancement within the ablation zone on CT or MRI is a reliable sign of incomplete ablation or recurrence. A change in size is not an indicator of treatment efficacy [7].

Conventional disease response evaluation in patients with metastatic RCC was based on measurements of change in size. However, using size change in response criteria may be inadequate to new antiangiogenic agents, which show clinical benefit without tumor regression. To improve assessment of response to therapy in metastatic RCC, decrease in attenuation and reduced enhancement of target lesions should also be evaluated [7].

77.5 Conclusion

CT remains the mainstay of imaging in the detecting, characterizing, staging, and surveillance of renal lesions. MRI is increasingly used as a problem solving tool. Advanced MRI techniques such as diffusion-weighted imaging are being explored in investigating of renal lesions.

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