REVIEW ARTICLE

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Imaging of Cystic and Solid Renal Mass and the Role of MRI

With the introduction of cross sectional imaging, the diagnostic approach to evaluation of renal masses has been completely changed. Multiple authors have reported cases of small renal cysts and neoplasms being missed by urography and linear tomography, and therefore, it has been suggested that computed tomography (CT) should be performed in any patient in whom a renal mass is suspected regardless of the urographic findings. CT remains to be the single most important technique in the detection and diagnosis of renal masses. In addition, current imaging techniques, especially CT and MR imaging, make accurate preoperative staging of renal cell carcinoma possible. [1-2] Because in most institutions, surgery is considered the only effective therapy for such tumor and because survival depends on local extent and distant metastasis, precise staging of renal cell carcinoma is critical for preoperative planning and prognosis. Alternative to surgery are radiofrequency (RF) or Cryoablation, the role of both continue to expand. From the radiological point of view, evaluation of renal masses will include three different categories: Detection, Diagnosis, and Staging.

A. Detection of Renal Masses

One of the greatest contributions of cross sectional imaging of the abdomen is detection of renal neoplasms far before advanced stages when it will cause clinical symptoms. This has affected the cure rate of renal cell carcinoma since it has been shown that the prognosis of patients with this tumor discovered incidentally is far better than when patients present with symptoms. In addition, early detection will have effect on treatment planning and approach since some of these small renal neoplasms will be treated with percutaneous ablation instead of wedge resection or partial nephrectomy. [3] CT, MRI and ultrasound have also increased the detection rate of other renal masses such as small renal cysts, abscesses and benign tumors such as oncocytoma.

Smith et al. in 1989 evaluated the rate of detection of renal tumors during the 70s when such patients were examined by conventional urography and tomography and compared the result to the 80s when CT scan became the primary modality in the evaluation of renal tumors.[4]

They demonstrated that there was a five-fold increase in the percentage of renal cell carcinoma (3 cm or smaller) detected and diagnosed in the 80s compared to the 70s. Today, almost as many new renal cell carcinomas are being detected incidentally as are being found in patients investigated because of hematuria or flank pain. [5] Ultrasound also played a major role in routine imaging of such patients. These two diagnostic modalities are more sensitive than urography in detecting small tumors and more kidneys are imaged in the general population because of the general use of these techniques in the diagnosis of a wide range of

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abdominal diseases.

MRI which has entered into the clinical practice during the past two decades, occasionally detects a renal mass in abdominal evaluation for other causes. It may be used as the primary diagnostic modality in patients allergic to iodine or in those that because of the body habitus, sonography cannot be performed. Otherwise, it is probably most important in staging of renal neoplasm. [6, 7] MRI is very helpful for further differential diagnosis of lesions, which are equivocal on CT, especially in differentiating between complicated cysts and cystic or hypovascular renal cell carcinoma. [8]

B. Diagnosis of renal masses

Intravenous urography (IVP) used to be the primary screening modality in the diagnostic work-up of a suspected renal mass. However, it has been proven that a normal urogram does not rule out a renal neoplasm. When an excretory urogram reveals a mass, to define the nature of the lesion, a further cross-sectional imaging method, either sonography, CT or MRI is pursued. Also, if the patient is clinically suspected to have a renal mass, it is probably preferable to do a computed tomography as the primary diagnostic work-up. CT or MRI will provide the diagnosis and often will give clues as to the nature of the mass, whether benign or malignant, and also provide information for staging. [7, 8]

In order to make a diagnosis of renal cell carcinoma, one must exclude the possibility of other masses which may often not require surgery. Therefore, a diagnosis of renal cell carcinoma is dependent on showing that a renal mass is not a benign cyst, not a pseudo neoplasm such as a normal anatomic variation, hematoma or abscess, and is not a tumor of different histology such as metastatic neoplasm, angiomyolipoma or lymphoma.

Renal Cysts

The most common mass in the kidney is simple renal cyst. They are usually one of the easiest conditions to diagnose accurately with sonography using criteria such as anechoic mass with a sharply marginated smooth wall and good through transmission.

These criteria generally apply to simple, uncomplicated cysts, however, complicated cystic lesions can create considerable difficulty in diagnosis and can lead to a difference of opinion concerning the proper diagnostic and therapeutic approach. Clinical status of the patient, availability and quality of the equipment and experience of radiologists and urologists are major factors involved in decision making regarding management of individual patient. Rarely, the renal cysts are symptomatic and the majority remain to be found during imaging study particularly sonography of the abdomen for other reasons. However, any deviation from ultrasonic criteria should lead to additional study such as CT scanning.

On CT scanning, the criteria for the diagnosis of a simple cyst include sharp margination and demarcation from surrounding renal parenchyma, smooth thin imperceptible wall, water density content with Hounsfield units ranging from 0 to 20 without enhancement following intravenous administration of contrast material. The CT attenuation values of the fluid in renal cysts vary considerably from cyst to cyst, depending mainly on the protein content, the presence of blood-breakdown products and possibly calcium content. Therefore, if the value measures above 20 HU but it is clearly cyst according to sonography, that diagnosis is accepted and no further evaluation is needed. On the other hand, if sonography cannot establish a clear diagnosis of cyst, then repeat CT scanning with and without contrast is indicated to establish possible enhancement of the lesion. If the lesion enhances over 10 HU, from the baseline density the diagnosis of tumor or abscess should be suspected. If the lesion does not enhance, then correlation with sonographic findings is necessary and a decision is made concerning if follow up is adequate or a further approach should be taken.

Bosniak classifies renal cysts and cystic masses of kidneys into four categories based on their imaging appearance. [9]

Category 1: lesions are by far the most common and are uncomplicated simple benign cysts of the kidney.

Category 2: minimally complicated cysts which are benign but have some radiologic findings that cause concern. These include septated cysts, minimally calcified cysts, infected cysts and high density cysts. The goal is to avoid surgery in these lesions and to separate them from Category 3 which requires surgical

exploration.

Category 3: more complicated cystic lesions which exhibit some findings seen in malignant tumors. Radiologically, they cannot confidentially be distinguished from malignant neoplasms. Some of these lesions such as multi-locular cystic nephroma, complex septated cysts, multi-loculated cysts, hemorrhagic cysts, chronically infected or calcified cysts maybe benign. However, they often should be explored surgically, In this category, radiologic findings do not allow clear distinction between benign and malignant cases and the surgical options can be affected by the radiologist's evaluation of whether the lesion is more likely to be benign or more likely to be malignant.

Category 4: lesions are clearly malignant lesions with large cystic components. These lesions show irregularity of margins and have solid vascular elements; while they are cyst-like lesions, they are clearly malignant and should be explored.

Pseudotumors

On CT or sonography, conditions such as normal fetal lobulation, compensatory hypertrophy and columns of Bertin should not be mistaken with renal neoplasms. Other benign conditions such as abscesses, hamartoma, vascular malformation and infarction may also mimic renal tumors. Clinical history is able to help distinguish these conditions from neoplasm and it may become necessary to obtain a close follow-up study or to perform other examinations such as radionuclide study or aspiration biopsy for differentiation.

Other Renal Tumors

Other than renal cell carcinoma, infiltrated processes such as lymphoma, and metastasis can involve the kidney and also benign neoplasms such as oncocytoma and angiomyolipoma may be present within the kidney and should be differentiated from renal cell carcinoma. Renal sarcoma is extremely rare and the kidney may be secondarily infiltrated by retroperitoneal sarcoma.

Renal lymphoma is often seen in patients with known diagnosis of such condition. However, in patients without lymphoma, diagnosis can be more difficult. [10] Lymphomatous involvement of the kidneys may be present and distinct from other lymphomatous masses in the body. Renal involvement may be seen as discrete lymphomatous masses either single or multiple, unilateral, bilateral or diffuse. Also lymphoma may directly extend in the kidney from the retroperitoneum.

The CT characteristics of lymphomatous tissue are that the lesions are generally homogeneous on unenhanced and on enhanced CT studies. The lymphomatous tissue is similar in attenuation to renal tissue and may enhance minimally with intravenous contrast media. Sonographically, the tissue is usually homogeneous and often hypoechoic, occasionally mimicking a cyst. [11]

Renal metastasis has an incidence between 2 and 20%, however, only recently the radiologists have to come to recognize such lesions probably as a result of several factors including greater reliance on CT and sonography for staging and follow up of cancer patients. Metastatic neoplasm to the kidney is not uncommon and by far the most common tumor that metastasizes to the kidney is primary lung carcinoma but metastasis from any other site may occur. In fact, one report describes that in patients with a history of malignancy, renal metastasis outnumbered renal cell carcinoma by approximately 4 to 1. [12]

Renal metastasis generally are detected late in the course of the malignancy and patients are often without symptoms referable to the kidney. Urinalysis may be normal but the patients could have microscopic or gross hematuria. The lesions may be multifocal but it has been reported that those arising from lung, breast and colon carcinoma can sometimes be large, solitary and otherwise indistinguishable from primary renal cell carcinoma. If a history of primary neoplasm is known, then aspiration biopsy should be performed to determine the histology and etiology of the tumor so that the correct therapy can be initiated.

Oncocytoma is a benign renal tumor with the incidence reported to be about 3-6% of all renal neoplasms. They arise from the proximal tubular epithelial cells of the kidney and on gross pathology they are brown in color similar to renal tissue, being well encapsulated and usually homogeneous in appearance with the exception of occasional central scar. [13] They only can be diagnosed by pathologists and usually only when the entire tumor is available for examina-

tion. Radiologically, one can suspect presence of oncocytoma on CT or angiography however, it would not be possible to make a definitive diagnosis. Even cytologist may have many difficulties to differentiate such neoplasms because well differentiated renal cell carcinomas may have portions with oncocytic features.

Angiomyolipoma (hamartoma) are benign tumors of the kidney which their name describes their tissue makeup. However, these tumors may contain only two tissue elements and therefore being called angiolipoma, angiomyoma, or myolipoma. Fat in the tumor is in a variable amount and considered to be a unique feature that enables a definitive preoperative diagnosis. [14] However, on rare occasion when there is no mature fat in the tumor and therefore the diagnosis would be difficult.

Angiomyolipoma can occur in the kidney, in a number of clinical settings including an association with tuberous sclerosis (usually multiple and bilateral), in association with lymphangio- myomatosis or as an incidental finding during cross sectional scanning. Occasionally the patients present with clinical symptoms such as pain and hemorrhage due to bleeding from the tumor.

Renal sarcoma is rare often originating from the renal capsule. The two most common types are leiomyosarcoma and liposarcoma. [15] The tumors are bulky and often exophytic.

Renal Cell Carcinoma

Two percent of adult malignancies are renal neoplasms and the vast majority (80-85% are renal cell carcinoma. It is the fifth most common cancer in men. This neoplasm occurs in patients over the age of 40, the peak incidence noted in the sixth and seventh decade of life and has been reported to be more common in male than female with a ratio of 2 to 1. [5]

Any renal mass which does not contain adipose tissue and particularly if enhances with intravenous contrast should be considered renal cell carcinoma until proven otherwise. This tumor has many varied appearances on CT ranging from a small homogeneous enhancing mass to a large cystic or solid heterogeneous tumor extending to the adjacent organs. The goal of radiologists is to separate renal cell carcinoma from other renal masses so such diagnosis can be established with total confidence. This means that renal cell carcinoma should be differentiated from other conditions such as complicated cysts, hamartoma, infarcts, inflammatory pseudotumors, abscesses, angiomyolipomas, metastasis to the kidney and lymphoma. Clinical history and CT findings play the two major roles in such differentiation. [2]

On the unenhanced CT, a solid renal cell carcinoma may have attenuation values similar to or occasionally higher or even lower than that of the normal kidney. However, as the tumor becomes larger, there are often areas of necrosis seen on enhanced CT as regions of low attenuation close to fluid density within the mass. [16] For cystic masses, accurate Bosniak classification requires adequate renal CT. Curry et al. [17] analyzed 116 cystic renal lesions, 82 of which were resected and 34 were followed for up to 10 years. They were 100% accurate in category I and II where the cysts were benign. Also 100% of those in category IV were malignant. However, 59% of those in category III were malignant and 41% were benign.

C. Staging of Renal Cell Carcinoma

The most important role of radiologists after detection and diagnosis of a renal cell carcinoma, is to stage the tumor and determine whether or not the neoplasm is resectable. Imaging is extremely important in determining the type of treatment undertaken in patients with proven renal cell carcinoma. The overall accuracy of CT for staging this tumor is reported to vary from 61% to 91% but can be as high as 96%. [5,7,16]

Non-resectable tumors are indicated by showing presence of metastases in distant structures such as liver, bone or lungs or extension into adjacent organs such as colon. Also involvement of lymph nodes on the contralateral side of the great vessels indicated non resectability. Localized lymphadenopathy in or near the hilum of the involved kidney can be considered resectable.

Renal cell carcinoma is staged using either Robson category of 1 to 4 stages or TNM classification based on the extent of the tumor and presence or absence of lymphadenopathy or distant metastases. These two different staging approaches are summarized in table 1.

In stage 1, the tumor is confined within the renal capsule. Stage 2, is when there is extension into the perinephric fat but confined by the perirenal fascia, ipsilateral adrenal involvement is possible. It may be difficult to differentiate between stage 1 and 2 on CT or MRI, particularly for exophytic tumors. This difficulty has little impact on therapy since both stages are treated with radical or partial nephrectomy. [18] In the stage 3, the tumor is associated with ipsilateral nodal metastasis, extends into the renal vein and or the IVC. As many as 20% of renal cell carcinoma extend into renal vein and 10% extend into IVC. [19] The surgical implications of venous extension are implicit. Patients with stage IIIA disease, including renal vein involvement only or with IVC and renal vein involvement, with appropriate surgical treatment, can achieve 5-year survival rates equal to stage I patients, and the level of thrombus extension up into the IVC has little effect on survival in localized renal cell carcinoma. [19,20] Surgical planning for these patients acutely depends on accurate preoperative staging. If tumor extends only into the subdiaphragmatic cava, then a flank approach is sufficient; if it extends beyond this, then intraoperative cardiopulmonary bypass with a thoracoabdominal approach often is required. CT scan is approximately 78% accurate in the detection of tumor extension into the renal vein and approximately 96% accurate in the IVC. [5] When there is extension of tumor into the adjacent regional lymph nodes, the neoplasm is considered stage 3B but still it is resectable. In stage 3C, there is involvement of both veins and lymphatic structures.

Stage 4 is when there is extension into the adjacent organs outside of the perirenal fascia (stage 4A) or there is distant metastases (stage 4B). While the sensitivity of CT in stage 4A is only 60%, its specificity is 100%. Treatment of stage 4 is usually palliative, with surgery reserved only for symptomatic relief in selected patients. MRI appears to have a similar overall accuracy to CT [20], whereas ultrasound is less accurate than CT or MRI in the overall staging of tumors. However, ultrasound is often accurate in identifying and localizing the clinically important tumor extension into the intrahepatic vena cava and right atrium and if only a knowledge of venous invasion is necessary, a technically adequate ultrasound examination may suffice. All techniques are unreliable in detecting early perinephric spread.

MRI has proven to be highly valuable in accurate diagnosis of vascular extension of tumor and therefore plays an important role in staging of renal cell carcinoma and determining its respectability. [6,19,20] In patients with renal failure or in those who have severe allergy to iodine, MRI may be used for diagnosis and staging of renal cell carcinoma. In addition, gadolinium-DTPA enhanced MRI is used and plays a significant role in characterization of such neoplasm. [19,21] The value of dynamic CT scanning for staging renal carcinoma was studied prospectively in 28 patients by London et al. and the results compared with those of ultrasonography, arteriography and conventional CT.[16] Arteriography correctly staged 48% of tumors, ultrasonography and conventional CT correctly staged 50% and dynamic CT correctly staged 72%. Dynamic CT staged renal carcinoma more accurately than ultrasonography, conventional CT or arteriogra-

Table 1- Renal cell carcinoma staging systems

Robson Staging	Description	TNM Staging
I	Tumor contained within renal capsule	
	Small tumor (<2.5 cm)	
	Large tumor (>2.5 cm)	T2
II	Tumor spread to perinephric fat	T3a
III-A	Venous tumor thrombus	
	Renal vein tumor thrombus only	T3b
	Infradiaphragmatic caval thrombus	T3c
	Supradiaphragmatic caval thrombus	T4b
III-B	Regional lymph node metastasis	N1-N3
III-C	Venous tumor thrombus & regional lymph node metastasis	
IV-A	Direct invasion of adjacent organs outside Gerota's fascia	T4a
IV-B	Distant metastasis	M1a-d, N4

Data from Robson CJ, Churchill BM, Anderson W: The results of nephrectomy for renal cell carcinoma. J Urol 101:297,1969

phy and it is suggested that arteriography should be restricted to specific indications such as therapeutic renal artery embolization. Mapping of renal arteries for surgical approach particularly when laparoscopic surgery is contemplated can be achieved by CT angiography. [6]

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