Role of Multi - Detector CT in The Assessment of Renal Masses

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Abstract: This study was performed for evaluation and assessment of solid renal masses by multi detector CT scan. Thirty patients with different solid renal masses were examined by multiphasic CT studies of both kidneys in cortico-medullary, nephrographic and excretory phases. Calculation of attenuation values of all masses throughout the different phases was done. The advent of multi detector CT scan has enabled us to delineate the mass, detect and map the extent of venous spread, lymph nodal enlargement and diagnose local or distant spread. Accordingly, differentiation between benign and malignant masses and accurate staging of malignant ones was obtained. In our multiphasic study, the radiation dose was relatively high as we had to collect three series of images by three exposures in addition to the preliminary non contrast study. However, our study used a non invasive procedure, replaces conventional angiography, CT and IVP, necessitates single dose of IV contrast injection and is performed in short time. Since accurate staging at the time of diagnosis is essential to determine prognosis and formulate a therapeutic plan, we believe that multi detector CT is the single most effective imaging modality for the diagnosis, characterization and staging of solid renal masses in pre operative assessment.
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1. Introduction

Because any cell type found in the kidney or renal capsule has the potential to become neoplastic; there are many types of renal tumors. Benign renal processes, including cystic disease, renal infection, and benign tumors may simulate malignant renal tumors, and could be defined correctly by CT. [7]

Improvement in imaging modalities continues to have a large impact on the diagnosis and treatment of renal masses. As many as 30-40% of renal tumors are discovered incidentally during evaluation of unrelated or unspecific symptoms, and many lesions can be appropriately treated with local excision and maximal preservations of the surrounding unaffected parenchyma. [5]

Multi–detector row helical computed tomography (CT) offers considerable advantages in evaluation of the urinary tract. It has the potential to become the single imaging modality used for comprehensive evaluation and treatment planning of most conditions affecting the kidneys and urinary tract, making conventional diagnostic techniques such as intravenous urography and angiography nearly obsolete [22]

CT is widely accepted as the preferred imaging technique for suspected renal tumors, and also has an important role in tumor staging. Early detection and surgical excision of renal cell carcinomas are critical for patient survival because it has been shown that small tumors grow in size and metastasize. Although most lesions are discovered on a sonographic examination, contrast-enhanced multiphasic CT remains the standard for the diagnosis of small renal cell carcinoma due to its ready availability and its image quality. Its importance has increased conspicuity for detection and characterization of small renal masses. [20]

2. Aim of the work

The aim of this study is to investigate the role of multiphasic CT in the demonstration of anatomy and characterization of nature of solid renal masses.

3. Patients & Methods

The present study included 30 patients, included 18 males and 12 females. Two of them were children (0-16 years old) and the other 28 patients were older than 16 years old.

These patients were referred to the Radiology department in Damanhur Oncology Center for radiological evaluation of their clinical problems with suspected kidney masses.

These patients were primarily investigated by ultrasonography before their referral for multiphasic CT study.

They had full clinical data (including the complaint of abdominal swellings, hematuria, dysuria, pyuria, weight loss or fever) and through physical

examination (general and local abdominal examinations).

All patients underwent multiphasic CT scanning for the kidneys and urinary tract following a preset scanning protocol that included unenhanced phase, corticomedullary phase, nephrogenic phase and excretory phase scanning.

The examination was performed in the craniocaudal direction with a sixteen section multidetector CT scanner (GE Medical Systems).

Patients were lying supine in feet first position at complete rest. Hands were placed behind head. All instructions were given to the patient about table movements, voice messages, sensation of contrast injection, timing and manner of breath holding.

Unenhanced CT of the abdomen and pelvis was performed first from D11 vertebra cranially till the ischio-rectal fossae caudally by using 5-mm section thickness. No oral contrast material was administered.

Scanning was initially performed in the arterial cortico-medullary phase (CMP) using "sure start" technique in the GE machine.

Automatic pump was used and connected to the machines. Approximately 90-100 ml of a nonionic contrast material was injected through a cannula placed in an antecubital vein, the range of scanning from D11 vertebra till the aortic bifurcation. The entire range was scanned during breath holding.

Nephrogenic phase (NP) was then obtained 70-80 seconds post contrast injection with breath holding with range of scanning from D11 vertebra till the ischio-rectal fossae.

Excretory phase (EP) was then obtained 8-10 minutes post contrast injection with range of scanning from D11 vertebra till the ischio-rectal fossae.

All images obtained throughout the different phases of the examination were then sent to remote workstation via local network connections.

A certain region of interest (ROI) was determined within the mass in condition not to include calcifications or areas of cystic degenerations which may result into false high or low attenuation values. We kept the sizes and locations of the regions of interest the same for each patient's images from the three scanning phases.

The attenuation (HU) in each ROI was calculated automatically using DICOM image viewer. All values were collected and tabulated aiming to obtain certain pattern of enhancement for each group of pathology.

After confirmation of the presence or absence of solid renal mass, certain information was then fulfilled. They include their positions, locations, extensions, relation to collecting system, peri-nephric spread, local infiltrations, venous involvement, renal vascular anatomy, regional lymph nodes and distant metastasis.

4. Results

This study included 30 patients with solid renal masses. Multiphasic study by multi detector row CT machine was done followed by pathological evaluation for every patient.

The cases included in this study were 18 males and 12 females. Their age ranged from 7 months to 68 years old with mean age ± standard deviation 45.07 ± 17.73 years.

There were 2 cases showed bilateral renal masses and 28 cases had unilateral renal masses.

Patients were categorized in 2 different groups according to their radiological findings:

- Malignant renal masses (22 cases).
- Benign renal masses mimicking malignancy (8 cases).

Out of the 22 cases diagnosed radiologically as malignant renal masses, 20 cases were proved to be malignant by pathological examination and 2 cases were diagnosed pathologically as benign renal masses. While out of 8 cases diagnosed radiologically as benign renal masses, 7 cases were proved pathologically to be benign and one case revealed as malignant renal mass.

According to these results the accuracy of the multiphasic study by multi detector row CT machine in detection of malignant renal masses is 90 %, the sensitivity is 95.24 % and the specificity is 77.78 %.

Patients proved to have malignant renal masses in this study (21 cases) included:

- RCC (17 cases).
- Wilms tumor (2 cases).
- Collecting duct carcinoma (1 case).
- Metastatic carcinoma (1case).

Patients proved to have benign renal masses in this study (9 cases) included:

- Angiolipoma (2 cases).
- Xanthogranulomatous pyelonephritis (2 cases).
- Hematoma (2 cases).
- Chronic abscess (1 case).
- Focal nephritis with perinephric abscess formation (1 case).
- Oncocytoma (1 case).

Out of 21 patients diagnosed to have malignant renal masses 9 patients revealed to have lymph node metastasis, 2 patients revealed to have renal vein invasion, 3 patients revealed to have renal pelvis invasion and 4 patients revealed to have distant metastasis.

5. Discussion

Improvement in imaging modalities continues to have a large impact on the diagnosis and treatment of solid renal masses. As many as 30-40% of renal tumours are discovered incidentally during evaluation of unrelated or unspecific symptoms, and many lesions can be appropriately treated with local excision and maximal preservations of the surrounding unaffected parenchyma [28].

Recent advances in US, CT and magnetic resonance imaging (MRI) techniques have enabled us to detect incidentally renal cell carcinomas. In our institute, most renal parenchymal neoplasms were first suspected by physicians to be RCCs. Multiphasic CT was performed and confirmed the diagnosis as RCC before the surgical treatment because CT has been the most readily available method for diagnosis of RCC, including its types. [18].

Early detection and surgical excision of renal cell carcinomas are critical for patient survival because it has been shown that small tumors grow in size and metastasize. Although most lesions are discovered on a sonographic examination, contrast-enhanced multiphasic CT remains the standard for the diagnosis of small renal cell carcinoma because of its ready availability and its image quality. Its importance has increased for detection and characterization of small renal masses [13].

Multi detector CT remains the single most effective imaging modality for the diagnosis and staging of renal cell carcinoma. In the majority of patients, it is the only imaging test needed prior to surgical management. Advances in data acquisition and display, including three-dimensional volume rendering techniques, provide unparalleled capabilities for the detection, staging, and management of primary renal cell carcinoma.

Accurate staging at the time of diagnosis is essential to determine prognosis and formulate a therapeutic plan. With a reported accuracy of 91%, CT remains the most widely available and single most effective modality for staging renal cell carcinoma.

Numerous studies have shown that the anatomic extent of the tumour at the time of diagnosis is the single most important factor in determining prognosis. The 5-year survival rate of 60%–90% among patients with organ-confined disease falls to 5%–10% among those with distant metastases.

Treatment decisions hinge on the extent and stage of the tumour. Since the only curative treatment for renal cell carcinoma remains complete surgical excision, the goals of preoperative CT are to delineate the primary tumour, detect and map the extent of venous spread, and diagnose local or distant metastases [28].

Nephron-sparing surgery for renal neoplasms is performed using open or laparoscopic partial nephrectomy, cryoablation, or radiofrequency ablation and is the main treatment option for patients with bilateral tumours, a solitary kidney, or any condition causing renal insufficiency. This surgery has also been shown to be an effective therapeutic option for patients with small, low-stage, low-grade tumours and is the procedure of choice at some institutions. The increased use of CT for diagnostic imaging has led to the identification of many small incidental renal neoplasms. Most of these tumours are small, low stage, and low grade, and therefore, patients with such tumours are ideal candidates for nephron-sparing surgery [13].

Our study included non contrast study of the urinary tract followed by post IV contrast administration multiphasic technique resulting in obtaining multiple sets of images in CMP, NP and EP. All sets were sent to workstations to obtain coronal and saggital serial images.

Multi detector CT has replaced preoperative angiography in almost all cases. It provides all the information required for preoperative and intra operative planning in nephron-sparing surgery in a single test. It allows the surgeon to readily appreciate the pertinent findings and has also proved highly useful to urologists for both preoperative and intra operative surgical planning.

Complete and extensive information about the renal mass is needed by the clinician to determine the appropriate treatment modality. That means extensions of the mass as well as relations with adjacent structures such as vessels and ureters. Furthermore, renal vascularisation shows variation and must be clarified before any surgical approach. These variations include renal artery duplications, accessory renal artery and retro aortic renal vein. Thus, without performing an angiography, a single imaging modality performed preoperatively could provide sufficient information about the accompanying vascular abnormalities, thus granting the opportunity to minimize the unexpected hemorrhagic complications associated with vascular variations. [28].

We provided in our study rotation of the kidney image in different positions and facilitated obtaining cut planes; hence, the relationship of the mass with the renal tissue and adjacent organs was demonstrated better and the masses were defined to their finest detail. Identification of the relationship of the mass with adjacent vessels both affected the treatment procedure and decreased possible operative complications. Additionally, determining the collecting system invasion had important contributions to the treatment protocol both in benign and malignant masses.

Acquiring a set of images with the entire pelvicalyceal systems and ureters fully opacified is a challenge. As has been the case with IVU, the entirety of both ureters and collecting systems is rarely opacified on a single image obtained after intravenous injection of a bolus of contrast material. For this reason, IVU protocols have historically used multiple image acquisitions, abdominal compression, and, occasionally, prone positioning to depict all segments. A multiple-acquisition approach is not feasible with CT because of the high radiation dose that would result [23].

In our work we investigated the effect of altering patient position and supplementally infusing normal saline after injecting contrast medium. The rationale for saline infusion was as follows: First, normal saline increases the amount of fluid presented to the collecting systems and ureters and improves distension, similar to drip-infusion pyelography, during which diluted contrast material is used to opacify the urinary system without compression devices. Second, because CT easily depicts the high attenuation produced by contrast material, diluting the contrast material does not substantially affect perceived opacification. Third, normal saline is well tolerated by patients.

In our multiphasic study we had to collect three series of images by three exposures. So the radiation dose was relatively high. However, our study replaces conventional angiography, CT and IVP which if performed each separately the patient will receive higher dose of radiation. On the other hand we had to inject IV contrast once while each of the previous modality necessitates IV contrast injection during the study.

Dedicated renal CT performed for the diagnosis and staging of renal cell carcinoma must include a combination of image data acquisitions, despite the added radiation exposure and cost. Better detection and characterization of renal masses, as well as more accurate staging, are possible when the scanning protocol includes a combination of unenhanced CT and imaging in the corticomedullary and nephrographic phases [20].

Patient sex distribution in our study is in agreement with [24] proving that RCC had a male predominance.

Multiple renal cell carcinomas can be sporadic in 4 %–15 % cases but are much more common in patients with hereditary renal cell carcinoma. In these patients, renal cell carcinomas are often bilateral, multifocal, and manifest at a younger age [29].

Of 198 lesions, 177 (89 %) were malignant and 21 (11 %) were benign. Of the 177 malignant lesions 172 (97 %) were RCC and five (3 %) were classified as "other malignant," including three tumors with multiple histologic findings, one metastatic colorectal adenocarcinoma, and one Wilms tumour. The 21 benign lesions included 14 oncocytomas (67 %), 6 angiomyolipomas (29 %), and one leiomyoma (5 %) [31].

Our work included 30 cases, 21 (70%) were malignant and 9 (30%) were benign. Of the 21 malignant masses 17 (80.95%) were RCC, 2 (9.52%) Wilms tumours, 1 (4.76%) collecting duct carcinoma and 1 (4.76%) metastatic. The 9 benign masses included 2 angiomyolipomas (22.22%), 4 inflammatory masses (44.44%), 1 (11.11%) oncocytoma and 2 (22.22%) hematomas.

The evaluation of renal vein thrombosis is crucial for treatment planning; in fact, if tumour thrombus spreads into the inferior vena cava, the exact extent of the thrombus is essential for planning the correct surgical approach: an abdominal incision is performed if the thrombus is infra hepatic, whereas a thoraco-abdominal incision is needed if the thrombus extends more cranially [28].

Two patients in this study with the diagnosis of renal cell carcinoma had renal vein invasion.

Involvement of the perirenal fat tissue represents a key point in treatment planning. In fact, the infiltration of the perirenal fat tissue modifies the surgical approach from conservative to radical nephrectomy.

Under- and over staging of perinephric invasion are the most common staging errors at CT. The most specific finding of stage T3a disease, the presence of an enhancing nodule in the perinephric space, is highly specific but only 46% sensitive. Spread of tumoral tissue within the perinephric fat cannot always be reliably diagnosed, and differentiation between stage T2 and T3a tumors is problematic. This limitation of CT does have prognostic implications but does not affect case management, since patients with stage T3a disease are candidates for radical nephrectomy or nephron-sparing nephrectomy [9]

In our study, out of 21 malignant masses, perinephric extension was seen in 14 renal masses as follow: 13 from RCC and 1 from Wilms tumours.

Among all renal cortical tumours detected, approximately 20% are benign lesions and 25% are relatively indolent papillary or chromophobe carcinomas. It appears that although 80% of renal cortical tumours are malignant, not all malignant tumours undergo substantial active growth. Without tumour growth, the risk of metastasis may be limited as well. Thus, treatment strategy may differ according to the patient's age, general medical condition, and renal function status, as well as the aggressiveness of the detected renal tumour. Since different subtypes of renal tumours are associated with different clinical

implications, it is clinically important to differentiate these lesions preoperatively [31].

The results of previous studies reported that certain imaging features may be associated with specific subtypes of renal cortical tumour. The degree of enhancement was the most valuable parameter for differentiation of RCC subtypes, as clear cell RCCs enhance to a greater degree than other subtypes of malignant lesions, especially papillary RCCs. [28].

In our study we included solid renal masses of different aetiologies: malignant, benign tumours, traumatic and inflammatory masses. Pathologically proven cases of RCC clear cell type in our study showed intense enhancement in the early CMP (110 - 150 HU) and rapid wash out of contrast in the following NP (65 – 90 HU) respectively.

Our study results showed that the presence of neovascularity was mildly associated with a more aggressive tumour and that smooth contour was associated with a less aggressive tumour.

Despite its complexity, the TNM classification, which defines the anatomic extent of the tumour more precisely, has gained wide acceptance. [28]

In our study, 4 cases of RCC were early stage as follow: 3 cases T1 (17.65%) and 1 case T2 (5.88%) out of 17 cases of RCC. Despite the generally small sizes of these lesions, their characterization based on imaging features and degree of enhancement could be achieved.

The rest of our RCC cases had more advanced stages as 11 cases were staged T3 (64.71%) and 2 cases T4 (11.76%) with total of 13 cases.

A limitation of our study was that the percentage of malignant lesions (64.5 %) may have been slightly higher than that in the general population, since our institution is a tertiary referral centre. However, even in the general population the incidence of malignant renal lesions is much higher than that of benign lesions.

6. Conclusion

In conclusion, multi detector row CT has led to better detection and earlier diagnosis of solid renal masses and differentiation between malignant lesions and benign lesions that mimic the malignant criteria.

Our study was performed to establish a routine, non invasive, accurate and reliable technique for assessment of solid renal masses using multidetector row CT. The chosen technique consists of multiphasic study of the kidneys using intravenous contrast injection. This technique by itself provides valuable data about the nature, regional features, extent and spread of the mass. It also fulfills information about vascular supply, venous thrombosis, excretory function and state of the pelvicalyceal system whether invaded, compressed or obstructed.

Achieving proper examination and precise phases relied mainly on the timing of contrast injection and images acquisition. The performance of the technique was not difficult and processing of images on workstations was easy and quick. We were able to detect a certain pattern of enhancement in the RCC.

We believe that this technique can be used as single-step study procedure for renal masses detection, characterization and staging.

We recommend this technique in case of suspicion or diagnosis of solid renal mass by imaging modality other than CT. We also invite surgeons to depend on it confidently in pre operative evaluation as it can replace a number of routinely needed procedures prior to surgical intervention saving time and unnecessary repetitive IV contrast injection.

With the continuing advances being made in CT imaging equipment, it is expected that imaging techniques will change and the effect of some imaging findings on patient care will need to be redefined as we gain further experience with these modalities. In any event, accurate imaging diagnosis will still be dependent on the radiologist to perform high-quality imaging examinations, to correlate these imaging findings with clinical and pathological results so that the proper management options can be instituted.

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