ORIGINAL ARTICLE

ACCURACY OF MULTIPHASE HELICAL TOMOGRAPHY IN DETECTION AND CHARACTERISATION OF SUSPECTED RENAL MASSES USING HISTOPATHOLOGICAL FINDINGS AS GOLD STANDARD

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Background: The introduction of multiphase helical computed tomography has created many important advances in the detection and characterisation of renal masses. Renal cell carcinoma (RCC) is the seventh most common cancer and makes up 80–85% of all primary renal cancer in adults. If it is found and treated early, the chances of survival from kidney cancer are high. This **c**ross-sectional comparative was carried out at department of CMH/MH Rawalpindi from 1st February 2007 to 25 March 2008 to evaluate accuracy of multiphase helical tomography in detection and characterisation of suspected renal masses using histopathological findings as gold standard. **Methods:** Thirty patients with suspicion of having renal masses were scanned with multiphase CT scanning and 5 mm thick contiguous section were obtained from kidneys before and after injection of intravenous contrast material. The corticomedullary phase images were obtained after a delay of 25 seconds and nephrographic phase images, after a delay of 120 seconds after initiation of contrast medium injection. The numbers of lesions detected in all three phases were determined. The mass was then characterised by evaluation of its features and by its degree of contrast enhancement. Results of CT scan were compared with histopathology. **Results:** At review of unenhanced, corticomedullary and nephrographic phase images, 26, 29 and 30 lesions, respectively, were identified. One malignant lesion was not identified and 3 malignant lesions falsely appeared benign in the corticomedullary phase. All lesions were detected in the nephrographic phase and only 1 malignant lesion falsely appeared benign. The corticomedullary phase had a sensitivity of 86.2% and nephrographic phase 96.6% in malignant lesion detection. **Conclusion:** Enhancement of renal neoplasm is time dependent and is better in nephrographic phase. Small, hypovascular tumours and those placed in medulla may be missed or inadequately characterised if nephrographic phase scanning is not done.

Keywords: Computed tomography, renal masses, corticomedullary phase, nephrographic phase

INTRODUCTION

The introduction of helical CT has created many important advances in the detection and characterisation of disease throughout the body. Helical CT is widely accepted as the state of the art technology for the evaluation of abdomen.[1] It is considered as the preferred imaging technique for the suspected renal tumour, tumour surgery and detecting metastasis, as it is low in cost, has high accuracy and ready accessibility.

Helical CT has many advantages as compared with conventional, axial CT for the evaluation of renal diseases. It has high speed of image acquisition and thus allows for more rapid scanning and acquisition of scans exclusively during peak level of contrast enhancement and reconstruction of scans at overlapping intervals.[2] Omission of portions of an organ which occur with axial scanning, because of respiratory misregistrations, does not occur in helical scanning performed during a single breath hold. This ensures that the entire lesion is imaged and maximises the chance of identifying small enhancing lesions. Volumetric data acquisition during a single breath hold allows a comparison of identical levels on scans obtained before and after contrast medium administration. With helical CT partial volume averaging is maximised, when overlapping sections are reconstructed. Reconstruction of raw data, obtained by helical CT, can be done at any level. Thus improving the accuracy of region of interest measurements and the ability to characterise a lesion.

The challenges of renal imaging for tumours include not only reliable differentiation between benign and malignant lesions but also accurate delineation of the extent of the disease to ensure optimal treatment planning. Spiral computed tomography (CT) has significantly improved imaging of renal masses. The role of multiphase imaging of the kidneys has been explored. Investigators have shown that the helical CT scan of 5 mm thick collimation obtained during the corticomedullary phase (CMP) of renal enhancement, depict fewer renal masses than scans obtained during either the homogenous nephrographic phase (NP) or the delayed excretory phase.[3] It is necessary to obtain contrast enhanced images during the nephrographic phase of enhancement because renal mass detection is maximised in this phase.[4] The degree of enhancement is the most valuable parameter in differentiating among

the types of renal cell carcinoma and the pattern of enhancement may play an additional role in characterisation.[5]

This study has not been carried out in our set up before. The purpose of my study was to compare thin section, helical CMP and NP images of the kidneys, in our set up, to determine whether one technique is superior to the other in the detection and characterization of renal masses.

MATERIAL AND METHODS

All patients referred from 1st February 2007 to 25 March 2008 to Radiology Department CMH/MH Rawalpindi with suspicion of having renal tumour were included in the study. Informed consent of selected patients was obtained. Patients with suspected renal masses detected on ultrasonography and referred from medical/surgical OPD's were scanned with Toshiba Asteion 4MD helical computed tomography scanning machines. A multiphase imaging protocol was applied comprising the plain pre contrast, corticomedullary and finally the nephrographic phase scans. Prior to scanning 2–4% water soluble oral contrast medium was given to all patients. For acquisition of all images, a tube voltage of 120 kVp, a tube current of 240 mA, slice thickness of 5 mm and a pitch of 1.5:1.0 was used. In all patients, initial scanning was done before administration of contrast medium. Patients than received 2 ml/Kg body weight of low osmolar non-ionic contrast medium (Ultravist 300 mg/ml) with a 20 gauge plastic venous cannula into the antecubital vein at the rate of 3 ml/s. The CMP images were obtained after a delay of 25 seconds after initiation of injection of contrast material. The NP images were obtained after a delay of 120 seconds after initiation of contrast medium injection. Area scanned was from the level of diaphragm to symphysis pubis. However in NP, scanning, area scan was from the diaphragm to the lower pole of right kidney.

The findings of each computed tomographic scan were substantiated by opinion of consultant radiologist. The numbers of lesions detected during multiphase study were determined. The mass was then characterized by evaluation of its features and by its degree of contrast enhancement. The enhancement of all lesions was determined by the region of interest technique. All solid lesions with ill defined lobulated margins, heterogeneous attenuation/enhancement, enhancement more than 20 HU or with infiltration of surrounding tissues were classified as malignant. For characterisation of cystic renal lesions Bosniak criteria was used. All patients suspected of having malignant renal masses or complicated category III and IV cyst were subjected to surgery/fine needle aspiration cytology and their specimens were sent to Armed Forces Institute of Pathology, Rawalpindi for histopathology. Results of CT scans and histopathology were compared and all data was collected on performa.

RESULTS

Total of 30 patients, 22 (73.3%) males and 8 (26.7%) females (Male:Female= 2.75:1) with suspected renal masses were examined. The mean age was 57.03±13.95 (ranging from 20–85) years. Total 34 lesions were detected in 30 patients. Majority of the patients were of age groups 40–59 years (40%) and 60–79 years (43.3%). Irregular lesion margins were seen in 21 (70%) patients while in 9 (30%) patients, margins of lesions were seen smooth. Invasion of surrounding structures were found in 17 (56.7%) patients. Complicated renal cysts were found in 6 (20%).

The number of lesions detected with un-enhanced phase, with combined un-enhanced and CMP images, and un-enhanced, CMP and NP images were determined. In phase-1 of unenhanced CT, 20 (22.7%) patients were found malignant, 6 (20%) were benign but lesions in 4 (13.3%) patients could not be detected for renal masses. In phase-2 in which unenhanced+CMP were employed for case detection, lesion in one (3.3%) patient could not be detected however, 25 (83.3%) were found malignant and 4 (13.3%) were benign. In phase-3 in which unenhanced CT with CMP and NP were employed for case detection, lesions in 28 (93.3%) patients were found malignant in this technique while 2 (7.7%) were benign. This data reveals significant number of case detection in phase-2 and phase-3 as compared with phase-1 (Table-1). Also phase-3 had better detection as compared to phase-2.

Table-1: Types of lesions detected between various computed tomographic phases (n=30)

Diagnosis	CT findings		
	Phase-1	Phase-2	Phase-3
Not detected	4 (13.3)	1 (3.3)	0 (0)
Malignant	20 (66.7)	25 (83.3)*	28 (93.3)**
Benign	6 (20.0)	4 (13.3)	2 (6.7)

Significant number of case detection in phase-2 (p=0.043*, and **p=0.001) in phase-3 as compared with phase-1. Case detection in phase-3 is also better as compared to phase-2

Histopathological findings have shown 29 (96.7%) patients with malignant lesions and only one (3.3%) patient with benign lesion.

Histopathological proof of the diagnosis was available in all 30 patients with renal neoplasms. Diagnosis was confirmed in these patients at histopathological review of nephrectomy specimens (29 patients) and percutaneous biopsy (one patient).

Out of 29 confirmed cases of malignant renal masses on histopathology, 25 were true positive on Phase-2, which yielded 86.2% sensitivity in diagnosis of malignant lesions. The one confirmed benign case on histopathology, was also found benign in Phase-2, which yielded 100% specificity (Table-2).

Table-2: Sensitivity of unenhanced + corticomedullary phase computed tomography in diagnosis of malignant lesion (lesion characterisation) (n=30)

Computed tomography	Histopathology (Gold standard)		Total
	Positive	Negative	
Positive	25 (TP)	0 (FP)	25
Negative	4 (FN)	1 (TN)	5
Total	29	1	30

TP=True positive, FP=False positive,
TN=True Negative, FN=False negative

All 30 cases were detected in 3rd phase CT. Of the 29 confirmed cases, 28 were true positive that yielded 96.6% sensitivity of 3rd phase CT in characterization of malignant lesion. The one confirmed benign case on histopathology was also found benign in 3rd phase, which yielded 100% specificity.

DISCUSSION

Ultrasound and CT scan are widely used now for abdominal surveys and have resulted in an increased rate of detection of both benign and malignant renal masses. In several earlier studies helical CT images were used which were obtained during the CMP of contrast enhancement. In my study the sensitivity of CMP and NP scans is evaluated in detection of renal masses. In addition to detection, accurate characterization of a renal mass or a complex cyst has become an increasingly important CT application. In cases in which ultrasonography cannot tell definitely that the lesion is a simple cyst, a dedicated renal CT is needed. The purpose of enhancement in the lesion is indicative of neovascularity and neoplasm. Comparison of CMP and NP in the characterisation of renal masses was the major part of my study.

Helical CT has a high speed of image acquisition and images of the kidneys are obtained during each of the three phases of contrast enhancement.[6] During the CMP, much of the injected contrast agent resides within the renal vessels, including the renal cortical capillaries, and also in the peritubular spaces, proximal convoluted tubules and columns of Bertin. The CMP of enhancement is between 25 and 80 seconds after initiation of contrast injection. The renal cortex enhances briskly during CMP and medulla enhances only minimally.

In this study patients with complex cystic and solid renal masses were studied on multiphase helical CT scanning. It was found that more masses were identified with NP imaging than with CMP imaging. Smaller lesions and those placed in the medulla were better demonstrated in the NP than in CMP images. A solid mass would have been missed if only un-enhanced and CMP images were obtained. Failure to identify detectable renal carcinoma at a time when the patient can be treated is not acceptable in my opinion.

Herts *et al*[7] observed that hypervascular cortical masses (such as adenocarcinomas) may enhance to the same extent as normal renal cortex and therefore may not be identified on CMP. No such case was identified in my study; this may be because sample was not big.

Previous studies have shown that detection of renal masses is better in the nephrographic phase as compared to the corticomedullary phase.[8–10]

Some previous studies which reported greater sensitivity with CMP helical CT than with excretory phase scanning, in the detection of renal masses, such as the study conducted by Baumgartner *et al*,[11] may have been because of small number of renal lesions in the study and because they did not include many medullary lesions. We therefore do not agree with the results of their study.

Richard *et al*[12] demonstrated that a false positive diagnosis of a renal mass may be made if only CMP images are viewed. This pseudo lesion is normal renal medulla which has not yet enhanced to the same degree as renal cortex. He also found that majority of masses which were more than 10 mm could be characterised with either CMP images (84%) or NP images (98%). If NP images are obtained immediately after CMP images, false positive results may be encountered.

Silverman *et al*[13] used a 100 seconds delay in NP images, in their study and obtained acceptable homogenous enhancement of renal parenchyma. He showed that NP helical CT images effectively demonstrated the key features of small renal masses that helped distinguish between benign and malignant lesions. In my study it was seen that although quiet a number of lesions could be characterised in CMP scans but more lesions were characterised with NP scans.

In our study, the renal parenchyma was homogenous on all NP images obtained 120 seconds after initiation of contrast agent administration. The acquisition of these homogenous NP images effectively reduces the number of false positive diagnoses of masses.

My study results demonstrated more enhancement in NP compared to that in CMP. Normal renal cortex also shows more enhancement in NP compared to CMP. It was evident that renal mass enhancement is time dependent. 29 of 30 lesions (96%) showed progressive enhancement over time, and the mean enhancement over time was significantly greater in the NP than that in the CMP. NP imaging thus proved to be superior to CMP image in the characterisation of renal masses. All neoplasms

demonstrated significant enhancement (more than 20 HU) during the NP, whereas only 20 of 30 neoplasms (66%) enhanced greater than 20 HU during the CMP. Therefore only CMP imaging may be inadequate for characterisation of relatively hypovascular neoplasms.

Our study results were similar to results obtained by Shetty *et al*[14] in their comparative study of different phases in renal mass characterisation.

One mass of relatively smaller size and placed in the renal medulla was not detected in the unenhanced and corticomedullary phases, due to lack of significant enhancement but was picked up when nephrographic phase scans were obtained. Thus small masses, especially those in medulla may be missed if only CMP scans are acquired. Three lesions which were malignant, appeared benign in the CMP as they did not show significant features of malignancy like, irregular margins, invasion of surrounding structures or demonstration of significant enhancement in CMP. These appeared malignant on NP due to marked enhancement seen in this phase, and were confirmed to be malignant on histopathology.

Sensitivity of NP scanning was more as compared to CMP scans in characterisation of a renal mass, in this study. However, specificity was found to be 100%. This finding probably due to a small sample size and a larger sample size would be required for more accurate results.

Few more patients with renal masses would have been included in the study if histopathological examination of their lesions were done. But they were excluded from the study because either they refused biopsy/surgery or their physical condition did not allow them to be candidates for surgery. Thus they were not included in the study.

CONCLUSION

Renal neoplasm enhancement is time dependant and NP imaging is superior to CMP imaging in characterisation of renal masses. Nephrographic phase imaging should be part of all dedicated renal CT characterisation studies. A larger number of renal masses were detected when CT images were obtained in NP rather than CMP of enhancement. The difference is seen in the smaller renal medullary masses.

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