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Accuracy of multidetector CT scans in staging of renal carcinoma

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ABSTRACT

Objective: The aim of this study is to determine the diagnostic accuracy of multidetector-row computed tomography (MDCT) compared to histopathological findings in tumor staging of renal cell carcinoma, with the focus on tumor size and stage, renal vein involvement, and peri-renal infiltration.
Materials and methods: In a retrospective study, a total of 98 consecutive patients with renal cell carcinoma were preoperatively assessed for tumor staging using multidetector-row CT. Triphasic CT imaging (i.e., noncontrast, arterial, and parenchymal phase) was performed using multidetector-row CT with the slice thickness of 5 mm and using multi planar reconstructions to define the tumor characteristics. A single blinded reader evaluated the CT scans independently who reviewed the scan on multi planar reconstructions. The results were then correlated with the histopathological results.
Results: A total of 98 renal cell carcinomas were proven on histopathology. There was a significant (p 0.05) difference in the mean maximum radiological and maximum pathological diameter of the tumor with radiological diameter being greater. Twenty seven tumors were down staged and only 1 was up staged. The specificity of CT for capsular invasion, nodal disease and adrenal involvement was 85, 82 and 98% respectively. The specificity was over 97% for tumor thrombus in renal vein and IVC.
Conclusions: The multi planar reconstruction capability of multidetector-row CT allowed good specificity in predicting renal vein, IVC involvement, capsular invasion and nodal disease.

1. Introduction

Renal cell carcinoma is the seventh most common malignancy affecting adults in United States and had an estimated 54390 new cases and 13310 deaths in 2008[1] With the advancement and widespread use of imaging techniques such as CT, MRI and sonography, the proportion of incidentally discovered tumors in asymptomatic individuals has risen steadily.[2] The proportions of incidentally discovered tumors were only 10% in early 1970s which has risen to 60% in 1990s.[3]

The aims of imaging techniques are not only to detect but also to correctly stage the primary tumor with regard to tumor size, location, organ confinement, presence and extent of tumor thrombus in vena cava and to identify lymph node and or visceral metastasis.[4]CT scan is now the main imaging technique for the evaluation of the intra abdominal component of renal tumors.[5]

Surgery is considered to be the main form of curative treatment of both localized and advanced renal cell carcinoma. For the patient counseling and planning of surgical approach and strategy, therefore preoperative imaging has a vital role.[6] Many variables have been regarded as prognostic indicators in RCC, the most important of which being tumor size, stage and histological types. RCC can be histo pathologically classified into clear cell RCC (CCRCC), papillary RCC (PRCC), chromophobe (Ch RCC), collecting duct (Cd RCC) and unclassified tumors.[7]

MDCT has been a major advancement in imaging, with very thin slice collimation, high speed of acquisition and allowing reformatting of imaging in any planes which can provide excellent anatomical details.[8,9]

The aim of this present study is to compare the predictability of MDCT scan findings with the histopathological results in providing the anatomical information to properly stage the RCC in subset of patients who were treated with open radical nephrectomy at a single centre.

2. Materials and methods

This is a retrospective analysis of data over a period of 2 1/2 years from January 2007–October 2009. The radiological, clinical and pathological data of all patients who were treated by open radical nephrectomy for RCC were reviewed. All adult patients with proven RCC by histopathological examination for which surgery was done at our institute who had triphasic enhanced MDCT scan done preoperatively within 2 weeks prior to surgery were included. Patients with renal tumor other than adenocarcinoma, whose surgery was done in an outside hospital, those with

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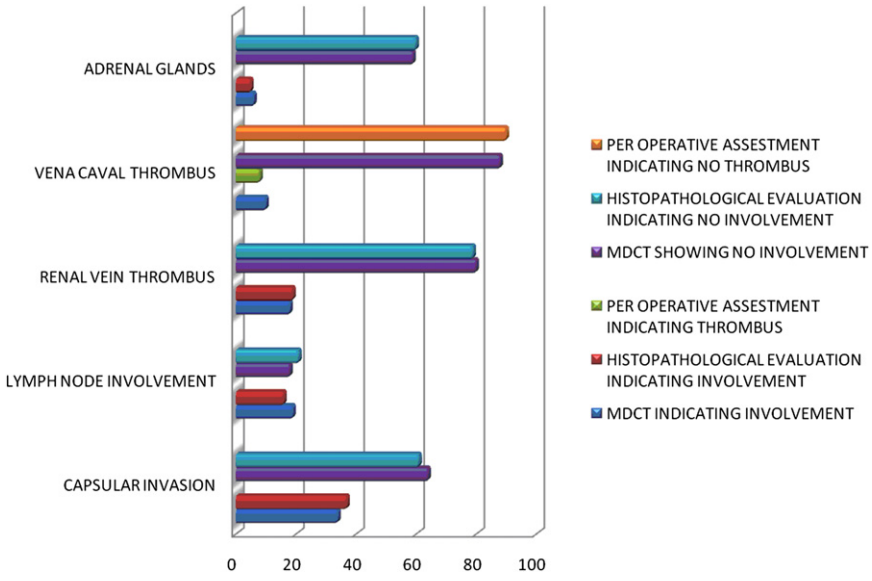

Fig. 1. Comparison of result of MDCT with per operative findings and histopathological assessment of capsular invasion, adrenal gland involvement, renal vein thrombus, and vena cava thrombus and lymph node involvement.

incomplete/missing medical records and failure to follow were excluded. The total numbers of radical, partial and cyto-reductive nephrectomies done during this period at our institute were 126, however using the criteria, the final study population consisted of 98 patients.

All CT examinations were performed on Aquilion 64, Toshiba™. CT scans were obtained with renal protocol i.e. un-enhanced sections through the renal area, arterial phase and parenchymal (cortico medullary) phase. The following parameters were used; slice thickness0.5 mm, collimation0.5 mm, reconstruction interval 5×5 mm and gantry rotation 0.5 s 80–100 ml of intravenous contrast was given to all patients through peripheral venous access at a rate of 1.5 ml/s with a start delay of 40 s. Multi planar reconstruction was done in standard abdomen algorithm provided by the Toshiba™ as default setting to evaluate the tumor and its relationships with the adjacent organs and structures. CT scan examinations were re-reviewed in a purposeful manner, by a single investigator on a working station (Vitrea 2, Vital connect, Toshiba™) who was not aware of histopathological report, to assess tumor invasion beyond the capsule into the perinephric fat, maximum radiological diameter (MRD), involvement of adrenal gland by tumor or tumor thrombus involving the renal vein and IVC (Fig. 1). By using the diameter of at least 1 cm as well as contrast enhancement, the hilar lymph nodes were commented on whether involved by tumor or not radiologically. The routine practice at our institute in open radical nephrectomy is to remove only hilar lymph nodes without any extensive lymph node dissection.

The operative notes were reviewed from medical records and Pathology reports including both gross and microscopic description were analyzed and where necessary, slides were re-reviewed with histo-pathologist. Tumor size was recorded as maximum pathological diameter (MPD). The histological type of RCC and its grade were also noted according to Fuhrman grading. The radiological findings were compared with operative and pathological findings. All tumor were staged both radiologically and pathologically using TNM staging system (TNM-UICC 2002[10]) as follows: T1a, less than 4 cm; T1b, 4 cm or more but less than 7 cm; and T2, larger than 7 cm. The percentage reduction/increase in tumor size (TSR) was determined by using formula 1-(MPD/MRD) and either down staging or upstaging of tumor was determined by comparing the radiographic stage and pathological stage.[11] All clinical, radiological and histopathological data were collected and analyzed on Statistical Package for Social Sciences (SPSS) version 16 and on Epi Info. Qualitative variables were compared using Pearson Chi square test and 2×2 test and Student t test was used to compare quantitative variables. $P < 0.05$ was considered statistically significant in all analyses. The sensitivity, specificity, (positive and negative predictive values) PPV and NPV of CT scan for variables studied were determined from histopathological and per operative findings.

3. Results

The mean age of the population was 57.6 ± 12.7 (22–81 years). There were 34% women and 66% men. The mean age between men and women were $57.8 + 13$ and $55.6 + 12.5$ years respectively which was not statistically different ($p = 0.415$). The surgical approaches were flank in 73 (74%), midline in 14 (14%), Chevron in 3 (3%) and Hemi-chevron in 8 (8%) patients. The Fuhrman grading indicates that 11, 61 and 28% of tumors had grade I, II and III respectively.

Majority of RCC were clear cell 74 (75.5%) type, papillary were 14 (14.3%), 6 (6%) chromophobe and 2 (2%) each of collecting duct and unclassified type. The mean MRD for all tumors was $7.51 + 2.8$ (2.6–16.0) cm and mean MPD was $7.13 + 2.0$ (2.0–18.0) cm, and the difference in sizes was statistically significant (p 0.005). The average MRD was 7.74, 6.25, 7.43, 7.3 and 8.35 cm for CCRCC, PRCC, ChRCC, CdRCC and unclassified RCC respectively. The corresponding values for average MPD were 7.29, 5.82, 7.88, 7.5 and 8.0 cm. Overall 61 (61.2%) tumors showed lesser size on pathological assessment compared to radiological assessment (Table 1).

With respect to size of primary tumor, among 74 CCRCC, 10 were stage T1a, 34 stage T1b and 30 were T2 by pathological staging Fig. 2 and when radiological and pathological stages were compared 21 tumor were down staged (8 from stage T1b to T1a and 13 from stage T2 to T1b) and only one tumor up staged from T1a to Tlb. Similarly 3 tumors from PRCC showed down staging while ChRCC, CdRCC or unclassified RCC did not show any down staging or upstaging. (Table 2)

Adequate information from pathology reports was available for analysis of capsular invasion in all 98 tumors. The sensitivity, specificity, PPV and NPV of CT scan for capsular invasion were 68%, 85%, 76% and 81% respectively. The hilar lymph nodes were available in histopathological specimen of 37 (38%) patients. CT scan had sensitivity, specificity, PPV and NPV for hilar lymph nodes of 77%, 82%, 67% and 88.2% respectively.

Adrenal glands were present in 65 (66%) specimens, excluding 33 patients who had adrenal sparing radical nephrectomy and sensitivity, specificity, PPV and NPV of CT scan were 100%, 98.33%, 83.33% and 100% respectively for adrenal involvement on CT and pathology. Renal vein invasion and IVC tumor thrombus status was determined on histopathology and per operatively in all 98 patients. CT scan sensitivities, specificities, PPVs and NPVs were 84.2%, 97.5%, 89% and 96.3% for renal vein invasion and 100%, 97.77%, 80% and 100% for IVC tumor thrombi respectively. (Table 3)

Table 1
Tumor size reduction of each histological type of renal cell carcinoma.

Malignant histological type	Tumors (N)	Average MRD(cm)	Average MPD (cm)	Reduced in size tumors (N)	Average TSR (%)
CCRCC	74	7.74	7.29	48 (64.8%)	5.81%
PRCC	14	6.25	5.82	9 (64.3%)	6.9%
Ch RCC	6	7.43	7.83	3 (50%)	−5.4%
Cd RCC	2	7.3	7.5	0 (0%)	−2.74%
UNCLASSIFIED RCC	2	8.35	8.0	2 (100%)	4.2%
TOTAL	98	7.51	7.13	61 (62.24%)	5.0%

MRD = mean radiologic diameter, MPD = mean pathologic diameter, TSR = tumor size reduction = 1- (MPD/MRD).

Table 2
Radiologic and pathologic stage difference of renal tumors.

Histological type	Tumors by radiologic stage (N)	Tumors by pathologic stage (N)	Down staged tumors (N)	Upstaged tumors (N)
CCRCC	T1a 3 T1b 28 T2 43	T1a 10 T1b 34 T2 30	T1b–T1a = 8 T2–T1b = 13	T1a–T1b = 1 T1b–T2 = 0
PRCC	T1a 2 T1b 8 T2 4	T1a 3 T1b 7 T2 4	T1b–T1a = 2 T2–T1b = 1	T1a–T1b = 1 T1b–T2 = 1
ChRCC	T1a 1 T1b 1 T2 4	T1a 1 T1b 1 T2 4	T1b–T1a = 0 T2–T1b = 0	T1a–T1b = 0 T1b–T2 = 0
CdRCC	T1a –– T1b 1 T2 1	T1a –– T1b 1 T2 1	T1b–T1a = 0 T2–T1b = 0	T1a–T1b = 0 T1b–T2 = 0
UNCLASSIFIED RCC	T1a –– T1b 1 T2 1	T1a –– T1b 1 T2 1	T1b–T1a = 0 T2–T1b = 0	T1a–T1b = –– T1b–T2 = ––
TOTAL	T1a 6 T1b 39 T2 53	T1a 14 T1b 44 T2 40	T1b–T1a = 10 T2–T1b = 14 –	T1a–T1b = 2 T1b–T2 = 1

4. Discussion

In the current work, we examined the reliability and accuracy of CT scan for giving staging information in patients with RCC, keeping final pathology report as a point of reference. CT scan is regarded as a highly accurate measure (sensitivity 100%, specificity 95%) for detection of renal masses using the proper technique and protocol.[12] There are studies that have demonstrated the accuracy of CT scan for detection and staging of renal masses to be up to 91% making it the imaging modality of choice.[6]

Multidetector CT has the added advantage of better resolution because of thin collimation enabling reconstruction of coronal and sagittal planes in addition to the generation of volumetric images. The reformation was also possible with single detector CT but the resolution for multidetector CT is far superior which makes the evaluation accurate for detection and staging of renal tumors. Multidetector CT also allows better visualization of renal vascular anatomy and involvement of renal vein and IVC by the tumor. The involvement of peri-renal fat and the adrenal gland is also better appreciated by the MDCT as compared to single detector CT.[8,13] MRI has the advantage of superior soft-tissue contrast, which provides a powerful tool in the detection and characterization of renal lesions. Currently 1- to 1.5-T systems are generally used for abdominal imaging, but the advent of 3-T MRI systems brings a twofold increase in the signal-to-noise ratio (SNR). However, although 3-T MRI is promising, only a limited amount of research has been published on 3-T MR imaging for renal lesions, and its value has still to be established.[14] Staging is usually performed using CT. Hallscheidt compared the performance of CT and MRI in the TNM system and found a similar accuracy in the staging of renal cell carcinoma.[15]

Tumor size, stage and histological type are known to be an important prognostic variable for RCC[16,17] Many studies have shown the discrepancy in size of tumor on preoperative imaging compared to post operative pathological specimen size.[11,18,19] These studies have noted down sizing of the tumor on pathological evaluation. The pathological size is an important indicator for prognosis of patients; however, radiological size estimation is an essential component for selecting the appropriate treatment in RCC i.e. radical or partial nephrectomy. Decrease in volume of blood in a highly vascular renal tumor after ligation or occlusion of renal artery has been postulated as a cause for reduction in tumor size on pathological examination.[20] The shrinkage in tumor size can also be a result of 10% buffered Formalin which was used for fixation of pathological specimen in our study. CT scan can accurately predict the tumor size with only 0.5 cm difference compared to pathological size.[18,20] We have similarly found average decreases in size of specimen of RCC of 0.38 cm which was statistically significant (p 0.005). Although we have not analyzed the factors responsible for this significant difference between radiological and pathological sizes, Yaycioglu et al[18] noted that the

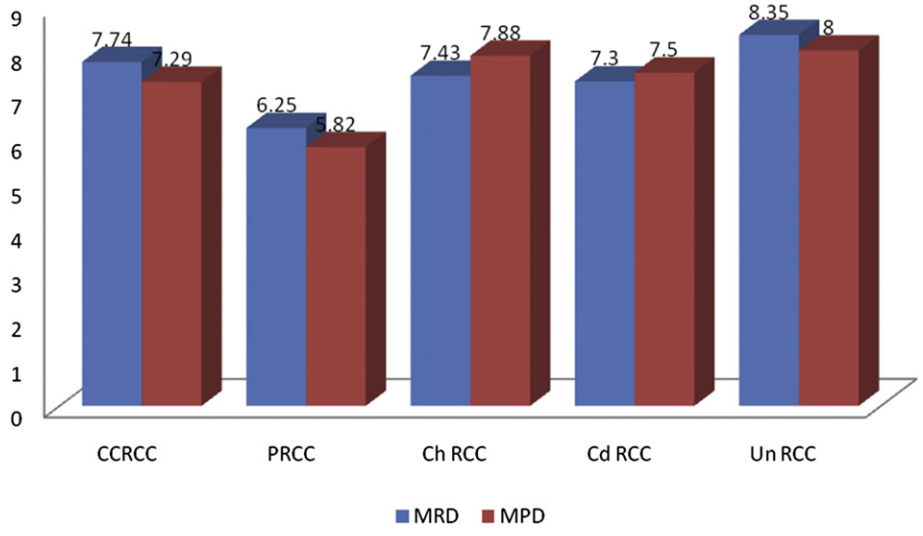

Fig. 2. Reduction/increase in size on pathological staging.

Table 3
Sensitivity, specificity and predictive values of various anatomical parameters of renal cancer on radiologic and pathological evaluation.

Variable Studied (N)	Capsular invasion		Lymph node involvement		Renal vein involvement		IVC involvement		Adrenal gland involvement	
	98		37		98		98		65	
Sensitivity (%)	67.6		77		84.2		100		100	
Specificity (%)	85.2		82		97.5		97.8		98.3	
PPV (%)	75.3		66.7		89		80		83.3	
NPV (%)	81.3		88.2		96.3		100		100	
CT +ve	HP +ve	HP −ve	HP +ve	HP −ve	HP +ve	HP −ve	Op +ve	Op −ve	HP +ve	HP −ve
	25	9	10	9	16	2	8	2	5	1
CT −ve	HP +ve	HP −ve	HP +ve	HP −ve	HP +ve	HP −ve	Op +ve	Op −ve	HP +ve	HP −ve
	12	52	6	12	3	77	0	88	0	59

IVC = Inferior vena cava, HP = Histopathological finding, Op = Per operative finding, CT +ve = reported on CT scan, CT −ve = Not reported on CT.

presence of multi-cystic masses, hemorrhage > 700 mL, pyelonephritis, and tumor invasion into the collecting system and locally advanced RCC, as influencing factors responsible for this reduction in size in the pathological specimen compared to radiological size. Kanofsky et al[11] in their study showed that 59% of CCRCC showed regression after excision and greatest reduction in size was also observed in pts with CCRCC. The reduction in size of tumor was enough to downstage the tumor by TNM system in 16% of specimen with regression. Based on this finding, they have postulated that worsened size/stage stratified disease specific survival is due to this artificial down staging of CCRCC as compare to other subtypes. In our study 65% of CCRCC showed tumor regression however, only 44% of them had down staging of tumor by TNM system. This difference in size of tumor and regression from T2-T1 and T1b- T1a; however, has no impact on surgical strategy and management of patients. The greatest reduction in tumor size was observed with PRCC. Only one tumor (CCRCC) showed upstaging.

In a cross sectional imaging it is difficult to distinct b/w RCC with or without renal capsular invasion.[21] CT scan showed sensitivity of only 67% as compare to histological examination with respect to capsular invasion. Capsular invasion is however very difficult to diagnose as reported in different studies. In a study, half of the patients with stage I (T1-T2) disease were found to have peri-renal stranding and thickening of fascia secondary to perinephric edema, fat necrosis and inflammatory changes owing to previous stone disease or inflammation which can give rise to false positive diagnosis.[22]

Nodal involvement is one of the factors influencing the prognosis of patients with RCC. The extent of lymphadenectomy during radical nephrectomy is not clearly defined in contemporary literature. Extended lymphadenectomy does not improve survival in patients with clinically undetectable lymph nodes and should be restricted to staging purposes in palpable and CT detected enlarged lymph nodes[23] Identification of lymph node metastasis has been a significant problem with the axial CT scans and are still based on size criteria only, limiting the size to 10 mm. Johnson et al showed that CT scan had an accuracy of 83–88% for lymph nodes of at least 1 cm in diameter, which contained tumor on histopathology.[24] Axial CT scan had a false negative rate of about 10% and a false positive rate of up to 58% mainly due to reactive hyperplasia.[25] Catalona et al[6] showed that MDCT with thin collimation and multi-planer reformatting resulted in diagnostic accuracy with false positive rate only 6.3% due to reactive hyperplasia. Our series has shown similar results with sensitivity of 77% and specificity of 82% for lymph node positivity on histopathology.

Nearly 15–25% of patients have venous invasion and tumor thrombus at the time of diagnosis which warrants accurate identification and exact extent of thrombus for planning correct surgical approach. MRI has replaced and is superior to all other invasive and non invasive imaging modalities in identifying the cranial extent of thrombus and differentiating between bland thrombus and tumor thrombus.[4] Our results have shown sensitivity of 84.2% and specificity of 97.5% for renal vein and sensitivity of 100% with specificity of 97.8% for IVC involvement. Out of 2 cases with supra-diaphragmatic involvement of IVC, CT scan missed one.

The current surgical trend is to spare adrenal gland during surgery for RCC because of low incidence (1.2–8.5%) of metastasis to ipsilateral gland. The relationship of adrenal gland to renal neoplasm can be better visualized on MDCT using coronal reformatted images[6] and studies have shown specificity and NPV of this modality to be nearly 10.[26–28] Our data showed similar results with specificity and NPV of 98% and 100% respectively.

In conclusion, CT scan can detect size of renal masses within 0.5 cm of its histopathological size (which determines the stage) however a significant number of tumors were down staged on pathology. CT scan has high specificity for capsular invasion, nodal disease, and renal vein and IVC tumor thrombus but has poor sensitivity for capsular invasion and lymph node involvement by tumor.

Conflict of interest
None to declare.

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None.

Ethical approval
None.

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