Perirenal fat invasion on renal cell carcinoma: evaluation with multidetector CT

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Purpose

Renal cell carcinoma (RCC) represents the commonest primary malignancy of the kidney, accounting for about 2% of adult malignancies [1,2]. The American Cancer Society estimates that in 2012 there will be 64,770 new cases of renal cancer, including 92% RCCs, with an estimated 13,570 deaths due to this disease [3]. With the wide-spread use of cross-sectional imaging studies as many as half of RCCs are found incidentally, usually diagnosed at an early stage. This may allow a more limited surgical resection of the neoplasms, such as laparoscopic or nephron-sparing partial nephrectomy [1].

The Tumor-Node-Metastasis (TNM) classification system defines advanced stage RCC within Gerota's fascia as T3 (Table 1) [4]. According to the 2010 American Joint Committee on Cancer, RCCs with extension into the renal vein or its segmental branches and invasion of the perinephric (PN) fat and/or renal sinus (RS) fat are all staged as T3a tumors. Among the differences of the new TNM staging system when compared to the previous editions was to include invasion of the renal sinus fat and/or perinephric fat in T3a stage [4].

Table 1. New TMN staging for renal cell carcinoma (Ref. 4).

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tx</td>
<td>Primary tumor cannot be assessed</td>
</tr>
<tr>
<td>T0</td>
<td>No evidence of primary tumor</td>
</tr>
<tr>
<td>T1</td>
<td>Tumor ≤ 7 cm in greatest dimension, limited to kidney</td>
</tr>
<tr>
<td>T1a</td>
<td>Tumor ≤ 4 cm in greatest dimension, limited to kidney</td>
</tr>
<tr>
<td>T1b</td>
<td>Tumor &gt; 4 cm but ≤ 7 cm in greatest dimension, limited to kidney</td>
</tr>
<tr>
<td>T2</td>
<td>Tumor &gt; 7 cm in greatest dimension, limited to kidney</td>
</tr>
<tr>
<td>T2a</td>
<td></td>
</tr>
<tr>
<td>T2b</td>
<td>Tumor &gt; 7 cm but ( \leq 10 ) cm in greatest dimension, limited to kidney</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>T3</td>
<td>Tumor &gt; 10 cm in greatest dimension, limited to kidney</td>
</tr>
<tr>
<td>T3a</td>
<td>Tumor extends into major veins or perinephric tissues but not into the ipsilateral adrenal gland and not beyond Gerota fascia</td>
</tr>
<tr>
<td>T3b</td>
<td>Tumor grossly extends into the renal vein or its segmental branches, or tumor invades perirenal and/or renal sinus fat but not beyond Gerota’s fascia</td>
</tr>
<tr>
<td>T3c</td>
<td>Tumor grossly extends into the vena cava below the diaphragm</td>
</tr>
<tr>
<td>T4</td>
<td>Tumor grossly extends into the vena cava above the diaphragm or invades the wall of the vena cava</td>
</tr>
<tr>
<td>N0</td>
<td>Tumor invades beyond Gerota’s fascia (including contiguous extension into the ipsilateral adrenal gland)</td>
</tr>
<tr>
<td>M0</td>
<td>Regional nodes cannot be assessed</td>
</tr>
<tr>
<td>M1</td>
<td>No regional lymph nodes metastases</td>
</tr>
<tr>
<td></td>
<td>Metastases in regional lymph node(s)</td>
</tr>
<tr>
<td></td>
<td>No distant metastases</td>
</tr>
<tr>
<td></td>
<td>Distant metastases</td>
</tr>
</tbody>
</table>
Several reports have highlighted that RCCs invading the perinephric fat and/or the renal sinus fat are associated with an unfavorable prognosis [8-14]. Infiltration of the perirenal fat tissue should also modify surgical approach from conservative to radical nephrectomy [1,2].

CT remains the most effective cross-sectional imaging modality for the detection and staging of RCC, with a staging accuracy up to 91% [1,2,15-28]. Advances in multidetector CT technology have greatly improved the diagnostic performance of the technique in patients with renal malignancies [1,2,18-28]. However, spread of RCC into the perirenal fat and differentiation between T1/T2 and T3a stages based on CT findings, is not always feasible [1,2,15,16].

As to our knowledge, there are a few published reports in the English-language literature on the accuracy of multidetector CT in diagnosing perirenal fat invasion in patients with RCC and no reports on the diagnostic performance of the technique in evaluating renal sinus fat infiltration. The purpose of this study was to assess the accuracy of multidetector CT in the diagnosis of perinephric and/or renal sinus fat invasion in patients with RCC, with reference to the CT findings predictive for the diagnosis of invasion.

Methods and Materials

Study Patients :

The records of 47 patients (30 men and 17 women) with 48 histologically proven RCCs were retrospectively analyzed. One patient presented with two synchronous RCCs in the same kidney. The mean age of patient population was 60 years, with a range of 31-84 years. The mean interval between CT examinations and surgery was less than two weeks. Radical nephrectomy was performed in all cases.

Approval of this retrospective study was obtained from our institutional review board. This study was complied with the Health Insurance Portability and Accountability Act.

Computed Tomographic examination :

All CT examinations were performed on a 16-row CT scanner with 24-mm scanning span per rotation. Patient’s preparation included the administration of 1,000 ml of water, given orally 30 minutes prior to the examinations. In all patients, unenhanced scanning and three contrast-enhanced series, including arterial phase (scan delay: 25 seconds), portal phase (scan delay: 70 seconds) and a combined nephrographic-excretory phase (scan delay: 4 minutes) were performed. CT images were obtained in a craniocaudal direction, covering the area of the kidneys (unenhanced scan and arterial phase), the area from the diaphragm to the iliac crests (portal phase) and the area from the upper pole of the kidneys to the symphysis pubis (nephrographic-excretory phase). For the acquisition
of all images, a slice thickness of 0.8 mm, a tube voltage of 120 kV, a rotation time of 0.5 sec and a pitch of 1.2 were used. A detector collimation of 16 x 1.5 mm and 16 x 0.75 mm was used for unenhanced and contrast-enhanced series, respectively. Images were reconstructed at 5 mm and 0.5 mm intervals, for unenhanced and post-contrast enhanced scans, respectively. Both dose modulation (DOM) and automatic current settings (DoseRight) were used, and the mean mAs per rotation for each scan was calculated at 115. Contrast-enhanced images were obtained after the intravenous administration of 150 ml of non-ionic iodinated contrast medium, administered at a flow rate of 3 mL/sec, via mechanical injector.

**CT data interpretation:**

Image interpretation was performed on a workstation. The CT data were assessed by two reviewers in consensus, blinded to clinical and histopathologic data. Transverse unenhanced CT images and multiplanar reformations in the transverse, coronal and sagittal planes, separately for each contrast-enhanced series (arterial, portal and nephrographic-excretory phase) were used for data interpretation. Reformatted images were of 5 mm thickness, with 0.5 mm slice intervals. Both soft-tissue (W: 350, L: 50) and wide window (W: 1500, L: 500) settings were used to assess the data of the nephrographic-excretory phase. Wide window settings have been reported to improve the conspicuity of pelvicaliceal details [29].

The number and size of RCCs were assessed and compared with the intraoperative and histopathologic findings. CT criteria used for the diagnosis of perinephric fat invasion included perinephric soft-tissue stranding, peritumoral vascularity, increased density of the perinephric fat, tumoral margins and presence of contrast-enhancing soft-tissue nodules in the perinephric space (Fig. 1 on page 6, Fig. 2 on page 7, Fig. 3 on page 8, Fig. 4 on page 9, Fig. 5 on page 10, Fig. 6 on page 11, Fig. 7 on page 12, Fig. 8 on page 13). Stranding of the perinephric fat was defined as linear areas of soft tissue attenuation, corresponding to the bridging septa of the perinephric space (Fig. 9 on page 14) [30,31]. The bridging septa of the perinephric space of the contralateral kidney were used as the standard of reference (Fig. 10 on page 15, Fig. 11 on page 16). Presence of peritumoral vascularity was defined as asymmetrically enlarged, often irregular vessels adjacent to the neoplasm, within the perinephric space (Fig. 6 on page 11, Fig. 12 on page 17) [21]. The CT density of the perinephric fat was measured by placing a circular region of interest (ROI), as large as possible within the perirenal space, close to RCC. The CT density of the perinephric fat of the normal contralateral kidney, measured at the area of the lower pole was used as the standard of reference (Fig. 3 on page 8, Fig. 4 on page 9, Fig. 5 on page 10, Fig. 6 on page 11, Fig. 7 on page 12, Fig. 8 on page 13). Three measurements were obtained and averaged. Tumoral margins were evaluated and characterized as sharp or ill-defined. A sharply-demarcated tumor was characterized as confined within the kidney (Fig. 10 on page 15, Fig. 11 on page 16, Fig. 12 on page 17) and ill-defined margins as suggestive of neoplastic invasion of the PN fat (Fig. 1 on page 6, Fig. 2 on page 7, Fig. 6 on page 11, Fig. 7 on page 12, Fig. 8 on page 13).
CT signs suggestive of neoplastic infiltration of renal sinus fat included tumor extension into the renal sinus, proximity to the pelvicaliceal system and invasion of the pelvicaliceal system (Fig. 5 on page 10, Fig. 8 on page 13). The final histopathologic diagnosis was used as the standard of reference.

**Histopathologic data analysis**

Histopathologic data used for the analysis was TNM stage, histologic subtype, Fuhrman nuclear grade, tumor size and presence or absence of perinephric fat and/or renal sinus fat invasion. The penetration of the renal capsule or the presence of neoplastic cells in direct contact with the perinephric fat was defined as PN fat invasion. Direct contact of neoplastic cells with the renal sinus stroma or fat cells was defined as RS fat invasion. Tumors infiltrating the pelvicaliceal system were characterized as infiltrating RS fat [10].

**Statistical analysis:**

Statistical analyses were performed using the IBM SPSS statistics, version 20 and a two tailed value of $p < 0.05$ was considered statistically significant. The normality of distribution of the CT density values of the perinephric fat was assessed using the Kolmogorov-Smirnov test. Paired Samples T-test was used to assess whether the mean values of the CT density of the perinephric fat of the kidney with RCC and the normal contralateral kidney were statistically different from each other. Independent samples T-test was used to study the differences between the mean CT density values of the perinephric fat of the diseased kidney in the presence or absence of PN fat invasion, as confirmed on histopathology.

The Chi-square 2 way test was used to determine the significance of association between the various CT findings used to diagnose perinephric and/or renal sinus fat invasion. Related descriptive statistical measures, including accuracy, sensitivity and specificity for each CT finding were also calculated.

Binary multiple logistic regression analysis (multi-step backward selection) was used to assess independent predictors of perinephric and/or renal sinus fat invasion among the various CT findings. Logistic regression analysis included coefficients, standard errors (SEs), adjusted odds ratios, 95% confidence intervals (CIs), and the likelihood ratio chi-squared test for parameters in the final model obtained by maximum likelihood estimation. Model fit was evaluated by the Hosmer-Lemeshow goodness-of-fit statistics.

**Images for this section:**
**Fig. 1:** 70-year old man with clear cell RCC of the right kidney, invading both the perinephric and renal sinus fat (stage: pT3a; grade: II). Coronal reformation on arterial phase depicts an ill-defined mass of the right kidney, strongly and heterogeneously enhancing after contrast material administration. CT reveals thickening of the renal fascia (arrowhead), thickening of the diaphragms of the perinephric space and presence of peritumoral vessels. There are multiple nodules (small arrow) in the perinephric space, inhomogeneously enhancing, with a pattern similar to that of the primary neoplasm, a finding strongly suggestive of perinephric spread of the tumor, as proved on pathology. The neoplasm also invades the liver (long arrow).
Fig. 2: Same patient as in figure 1. Transverse reformation during the arterial phase shows a moderate amount of ascites with multiple, heterogeneously enhancing peritoneal masses (arrows)suggestive of peritoneal carcinomatosis. Peritoneal metastases from RCC are very uncommon.
Fig. 3: 70-year old man with papillary RCC of the left kidney, invading both the PN and RS fat (stage: pT3a; grade: II). Coronal reformatted image during the portal phase depicts a large multicystic mass of the left kidney, with solid components (arrowhead), enhancing after contrast material administration. CT revealed perinephric stranding, increased density of the perinephric fat (the mean CT density of the perinephric fat close to RCC was -55 HU, when compared to the CT density of the normal contralateral perinephric fat, with a mean value of -100 HU). Metastatic retroperitoneal lymphadenopathy is also seen (long arrow).
Fig. 4: Same patient as in figure 3. Sagittal reformation on portal phase demonstrates small nodules in the perinephric space (arrow) suggestive of neoplastic invasion, and this was proved on histology.
Fig. 5: Same patient as in figures 3,4. Sagittal reformation during the nephrographic-excretory phase (wide window settings) depicts invasion of the major upper calyx of the left kidney (arrowhead), resulting in dilatation of the minor calyces. Pathology reported neoplastic infiltration of RS fat.
Fig. 6: 62-year old man with clear cell RCC of the left kidney, invading both the PN and RS fat (stage: pT3a; grade: III). Sagittal reformation on portal phase shows a large inhomogeneously enhancing tumor of the left kidney, with ill-defined margins. CT revealed perinephric stranding, increased density of the perinephric fat (mean CT density of the right and left perinephric fat: -80 HU and -25 HU, respectively) and tumor nodules (arrowhead) in the perinephric space.
Fig. 7: Same patient as in figure 6. Coronal reformatted image on portal phase depicts the entire left renal vein dilated and filled with heterogeneously enhancing thrombus (arrow), indicating tumoral thrombus, subsequently proved on histology.
Fig. 8: Same patient as in figures 6,7. Sagittal reformation during the nephrographic-excretory phase (soft-tissue window settings) depicts tumor extending into the renal sinus, with invasion of the pelvicaliceal system (arrowhead). Large peritumoral vessels are also seen in the left perinephric space (arrow).
**Fig. 9:** 36-year old man with clear cell RCC of the right kidney (stage: pT1a; grade: II). Transverse reformation (portal phase) demonstrates right renal hypervascular neoplasm. A thickened bridging septum (arrowhead) is clearly delineated close to the tumor, paralleling the tumor surface. At nephrectomy, the mass did not extend into the PN fat.
**Fig. 10:** 82-year old man with chromophobe RCC of the left kidney (stage: pT1a; grade: II). Coronal reformation during portal phase show a sharply-demarcated hypervascular tumor (arrow) in the lower pole of the left kidney. Bridging septa in the perinephric space are clearly seen bilaterally, although they are more numerous and thickened in the left perirenal space. Histology, reported RCC confined within the kidney. Small renal cysts (asterisk).
Fig. 11: Same patient as in figure 10. Bridging septa in the perinephric space are clearly seen bilaterally, although they are more numerous and thickened in the left perirenal space.
Fig. 12: 56-year old woman with clear cell RCC of the left kidney (stage: pT1b; grade: II). Coronal reformation on portal phase depicts large peritumoral vessels (arrow) in the left perinephric space. Renal tumor is sharply delineated. Histopathology reported RCC confined within the kidney. Small liver cysts (arrowheads).
**Results**

The histologic subtypes of RCCs included clear cell RCC (n=33), papillary RCC (n=2), chromophobe RCC (n=5), mixed RCC (clear cell and chromophobe, n=1), collecting duct carcinoma (n=1), unclassified RCC (n=2), multicystic RCC (n=3) and clear cell RCC, with sarcomatoid differentiation (n=1). Tumor grading included grade I in 3 (6%) tumors, grade II in 26 (55%) tumors, grade III in 15 (31%) tumors and grade IV in four (8%) neoplasms. Pathologic analysis revealed stage T1a in 17 (36%) tumors, stage T1b in 13 (27%) tumors, stage T3a in 16 (33%) neoplasms, stage T3b in one (2%) case and stage T4 in one (2%) tumor. Tumor size ranged from 1.2 to 15 cm, with a mean maximal diameter of 5.1 cm; 44% (21 out of 48) of neoplasms measured equal or less than 4 cm, on histopathology.

There were 12 (25%) RCCs with peripheral perinephric fat invasion and 11 (23%) tumors with renal sinus fat invasion, proved on pathologic analysis. Among them, seven (14.6%) neoplasms presented with PN fat invasion only, six (12.5%) neoplasms with RS fat invasion only, and five (10.4%) cases with infiltration of both PN and RS fat. The size range of these RCCs varied from 2.4-15 cm, and the mean size was 7.6 cm; 16 (89%) out of 18 neoplasms were larger than 4 cm in diameter. Histologically, 11 (61.5%) RCCs with PN and/or RS fat invasion were of clear cell histology, two (11%) of the papillary type, two (11%) chromophobe RCCs, one (5.5%) collective duct carcinoma, one (5.5%) unclassified RCC and one (5.5%) multicystic RCC. A low grade (grade II) was reported in 8 (44.5%) out of these 18 tumors and a high histologic grade was seen in 10 (55.5%) tumors (grade III, n=7; grade IV, n=3).

Tumor's maximal diameter at CT varied from 1.4 to 15 cm, with a mean diameter of 5.5 cm, and this was in accordance with the pathology report. Paired samples T-test showed a significant difference (p < 0.001) between the CT values of the perinephric fat in the vicinity of RCC (n=46), compared to the CT density of the perinephric fat of the normal contralateral kidney (n=46). The mean and standard deviation (SD) of the CT density of the perinephric fat of the diseased kidney and the contralateral kidney was \(-73 \pm 21\) HU and \(-90 \pm 11\) HU, respectively. Independent samples T-test showed that the mean CT density values of the perinephric fat close to RCC were significantly different (p =0.023) in cases of histologically proven PN fat infiltration (n= 12, mean CT density measurement and SD: \(-61 \pm 18\) HU) when compared to tumors without perinephric spread (n=34, mean CT density measurement and SD: \(-77 \pm 21\) HU). Two patients were excluded from CT density measurement analysis, one case treated with radical nephrectomy for RCC years ago, and another case with synchronous bilateral RCCs, treated with radical nephrectomy and partial nephrectomy of the contralateral kidney.

The results of the Chi-square 2 way test in assessing the significance of association between the CT findings used to diagnose perinephric and/or renal sinus fat invasion are presented on Table 2.
Table 2. Results of the Chi-square 2 way test in assessing the association of CT findings with PN and RS fat invasion in patients with RCC (df: degrees of freedom).

<table>
<thead>
<tr>
<th>CT findings</th>
<th>Chi-square value</th>
<th>df</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perinephric fat invasion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>perinephric stranding</td>
<td>3.361</td>
<td>1</td>
<td>0.067</td>
</tr>
<tr>
<td>peritumoral vessels</td>
<td>3.367</td>
<td>1</td>
<td>0.067</td>
</tr>
<tr>
<td>perinephric nodules</td>
<td>16.111</td>
<td>1</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>tumoral margins</td>
<td>16.456</td>
<td>1</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Renal sinus fat invasion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>extension into renal sinus</td>
<td>2.039</td>
<td>1</td>
<td>0.153</td>
</tr>
<tr>
<td>proximity to pelvicaliceal system</td>
<td>2.436</td>
<td>1</td>
<td>0.119</td>
</tr>
<tr>
<td>invasion of the pelvicaliceal system</td>
<td>33.061</td>
<td>1</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

The diagnostic performance of each CT finding in the detection of neoplastic infiltration of the PN and/or RS fat is illustrated on Table 3.

Table 3. Diagnostic performance of various CT findings in assessing PN and RS fat invasion in RCC.

<table>
<thead>
<tr>
<th>CT findings</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perinephric fat invasion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>perinephric stranding</td>
<td>91.6</td>
<td>36.1</td>
<td>50.0</td>
</tr>
<tr>
<td>peritumoral vessels</td>
<td>75.0</td>
<td>55.5</td>
<td>60.4</td>
</tr>
<tr>
<td>perinephric nodules</td>
<td>50</td>
<td>97.2</td>
<td>85.4</td>
</tr>
<tr>
<td></td>
<td>58.3</td>
<td>94.4</td>
<td>85.4</td>
</tr>
</tbody>
</table>
tumoral margins

**Renal sinus fat invasion**

<table>
<thead>
<tr>
<th></th>
<th>100</th>
<th>16.2</th>
<th>35.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>extension into renal sinus</td>
<td>100</td>
<td>18.9</td>
<td>37.5</td>
</tr>
<tr>
<td>proximity to pelvicaliceal system</td>
<td>90.9</td>
<td>94.6</td>
<td>93.7</td>
</tr>
</tbody>
</table>

The presence of contrast-enhancing nodules in the perinephric fat (Fig. 1 on page , Fig. 2 on page , Fig. 3 on page , Fig. 4 on page , Fig. 5 on page , Fig. 6 on page , Fig. 7 on page , Fig. 8 on page ) proved accurate in 41 (85.4%) out of 48 RCCs in diagnosing the presence or absence of PN fat invasion, with a significant difference. In one false-positive, an enhancing nodule was detected in the perinephric space close to RCC, although the neoplasm was reported as confined within the kidney on the pathology report (Fig. 13 on page 22 , Fig. 14 on page 23 ). Absence of perinephric nodules resulted in understaging of six RCCs in this report.

Tumoral margins proved accurate in 41 (85.4%) out of 48 cases in diagnosing extension of RCC into the perinephric space, with a significant difference. More specifically, seven ill-defined RCCs proved histologically to infiltrate the PN fat (Fig. 1 on page , Fig. 2 on page , Fig. 6 on page , Fig. 7 on page , Fig. 8 on page ), and 34 sharply-demarcated tumors (Fig. 10 on page , Fig. 11 on page , Fig. 12 on page ) found confined within the kidney on pathology. In two false-positives, RCCs with ill-defined margins reported negative for neoplastic infiltration of the PN fat on histology and in five false-negatives, well-demarcated RCCs found to invade the perirenal fat histologically (Fig. 15 on page 24).

Perinephric stranding and presence of peritumoral vessels enabled the diagnosis of PN fat invasion in 24 (50%) and 29 (60.4%) out of 48 tumors, respectively, and this was not proved significant. Both CT findings although sensitive in diagnosing neoplastic infiltration of the perinephric fat, had low specificities (36.1% and 55.5%, respectively). Twenty-three RCCs with thickened bridging septa in the perinephric fat and 16 tumors with peritumoral vessels were overstaged as T3a disease in the present study (Fig. 9 on page , Fig. 10 on page , Fig. 11 on page , Fig. 12 on page ). Absence of perinephric stranding and collateral vessels resulted in understaging of one and three tumors, respectively.

Invasion of the pelvicaliceal system proved accurate in 45 (93.7%) out of 48 RCCs in detecting the presence or absence of neoplastic involvement of renal sinus fat, and this was proved significant (Fig. 5 on page , Fig. 8 on page ). Extension of RCC into the renal sinus and proximity of the tumor to the pelvicaliceal system, although sensitive in
diagnosing infiltration of RS fat, proved of low specificity (16.2% and 18.9%, respectively, Fig. 14 on page 23).

Table 4 shows the results of multiple logistic regression analysis of CT criteria used to diagnose PN and/or RS fat invasion. The most significant CT predictors in detecting perinephric fat invasion were the presence of contrast-enhancing nodules in the perinephric fat and tumoral margins. Invasion of the pelvicaliceal system was the most significant predictor in the diagnosis of renal sinus fat invasion.

Table 4. Results of multivariate logistic regression analysis: independent predictors of CT findings in diagnosing perinephric and/or renal sinus fat invasion (PVC: pelvicaliceal system).

<table>
<thead>
<tr>
<th>CT findings</th>
<th>Regression coefficient (SE)</th>
<th>Adjusted odds ratios (95% CI)</th>
<th>Likelihood ratio test</th>
<th>Degrees of freedom</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PN fat invasion</td>
<td>2.65 (1.285)</td>
<td>14.16 (1.141-175.867)</td>
<td>4.255</td>
<td>1</td>
<td>0.039</td>
</tr>
<tr>
<td>neoplastic nodules</td>
<td>-2.382 (1.042)</td>
<td>0.92 (0.012-0.712)</td>
<td>5.223</td>
<td>1</td>
<td>0.022</td>
</tr>
<tr>
<td>tumoral margins</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RS fat invasion</td>
<td>5.165 (1.276)</td>
<td>175 (14.347-2134.534)</td>
<td>16.379</td>
<td>1</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>invasion of PVC</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Images for this section:
Fig. 13: 63-year old woman with sarcomatoid RCC of the right kidney (stage: pT1b; grade: IV). Transverse reformation (portal phase) depicts a sharply-demarcated, heterogeneously enhancing mass (arrow) in the lower pole of the right kidney. A small, contrast-enhancing nodule (arrowhead) was detected in the perinephric space, suggesting neoplastic invasion. PN fat was reported negative for invasion, at histopathology.
**Fig. 14:** Same patient as in figure 13. Coronal reformatted image during the nephrographic-excretory phase shows the tumor was in close proximity to the lower calyces (long arrow) without signs of invasion. RS fat was reported negative for invasion, at histopathology.
**Fig. 15**: 71-year old woman with collecting duct carcinoma of the left kidney (stage: pT3a; grade: IV), with invasion of the PN fat on pathology. Coronal reformation (portal phase) depicts a sharply-delineated mass in the upper pole of the left kidney (arrow). A thick hyperdense halo surrounded the tumor, corresponding to a fibrous pseudocapsule histologically. CT findings were negative for invasion of the PN fat.
Conclusion

Accurate preoperative staging of RCC is important, permitting optimal patient management [1,2]. The T component of the TMN staging classification system is a major factor in predicting prognosis and survival in these patients. Local staging and differentiation between T1/T2 and T3a stages is significant in determining best surgical approach (conservative versus radical nephrectomy and laparoscopic versus open incision) [1,2].

Detection of perinephric fat invasion in RCC represents one of the commonest staging errors at CT examination [1,2,15,16]. Johnson et al in a retrospective study of 100 RCCs using a conventional CT scanner reported 46% sensitivity and 98% specificity in detecting perinephric fat invasion. The presence of a soft-tissue perinephric nodule suggested tumor extension into the PN fat in this study [16]. Kopka et al in a prospective study of 76 RCCs evaluated with a dual-phase helical CT reported 91% overall staging accuracy, with three understaged carcinomas, in which tumor spread to the PN fat tissue was not identified [15]. Catalano et al reported 96% sensitivity, 93% specificity and 95% accuracy in diagnosing PN fat invasion in a prospective study of 42 RCCs, using a multidetector CT scanner. CT criteria used to diagnose neoplastic invasion of the perirenal fat tissue were hyperdense streaks and nodules surrounding RCC in this report [2].

The present study was a retrospective review of 48 histologically proven RCCs, including 18 (37.5%) cases with perinephric and/or renal sinus fat invasion. The diagnostic performance of multiphase multidetector CT with multiplanar reformations in detecting infiltration of the PN and/or RS fat invasion was evaluated. Multiple logistic regression analysis was performed to assess which CT features were more predictive for the diagnosis of invasion.

The results of logistic regression analysis indicated that the presence of contrast-enhancing nodules in the perinephric space and tumoral margins were the two most significant predictors in diagnosing PN fat invasion. Using perinephric nodules and tumoral margins as CT criteria to detect RCC extension into the perinephric fat, we had 85.4% overall accuracy, with a sensitivity of 66.6% and 50%, respectively and a specificity of 94.4% and 97.2% respectively. Contrast-enhancing nodules in the PN fat has been reported as the most specific finding of stage T3a disease, although sensitive in 45-50% of cases [1,2]. This was also proved in this report.

Perinephric stranding and presence of perinephric collateral vessels are not considered as reliable or specific signs in diagnosing neoplastic infiltration of the perirenal fat tissue, and this was seen in this study. Both CT signs had low accuracies (50% and 60.4%, respectively) in detecting tumor extension into the PN fat.

Perinephric stranding was defined as thickening of the bridging septa of the perinephric space. These septa (Kunin septa) divide the perinephric space into multiple
compartments and are divided into several groups [29,30]. Group I septa arise from the renal capsule and extend to the renal fascia. Group II septa are attached to the renal capsule, paralleling more or less the renal surface. Group III representing the commonest type, connect the anterior and posterior leaves of the renal fascia [29]. A variety of pathologic conditions, including neoplastic and nonneoplastic processes may involve the perirenal space, causing thickening of the bridging septa [29,30]. Perinephric stranding is reported in about half of patients with RCC confined within the kidney, and this was also seen in our study [1,2]. Other causes resulting in thickening of the bridging septa in the vicinity of RCC include edema, vascular engorgement, previous inflammation, perinephric hematoma or perinephric fat necrosis [1,2].

Neoplastic infiltration of the perirenal fat tissue resulted in hyperdensity of the perinephric fat close to RCC in this study. Measurements of the CT density values of PN fat in cases of histologically proven neoplastic invasion had higher values when compared with both the PN fat in the vicinity of RCCs confined within the kidney and the PN fat of the normal contralateral kidney. However, logistic regression analysis indicated that the CT density measurement of the perinephric fat is not a significant predictor for the diagnosis of tumor extension into the perirenal fat tissue.

The renal sinus is a central compartment formed by the extension of the perinephric space into the medial surface of renal parenchyma [32]. The fibrous capsule surrounding the cortex terminates near the renal hilum and does not separate the columns of Bertin from the renal sinus, resulting in absence of any barrier preventing the extension of cancerous cells into the rich network of lymphatics and venules within the renal sinus [32]. Renal sinus fat invasion from RCC was reported to be associated with aggressive neoplasms at risk for dissemination [10-14]. Bertini et al reported that RS fat invasion in clear cell RCC significantly affects cancer specific survival in patients without lymph node or distant metastases [13]. Bonsib et al reported that RS fat invasion was associated with clear cell variant on histopathology, higher nuclear grade and larger tumor size [11]. Thompson et al reported that patients with SF invasion were 63% more likely to die of clear cell RCC compared to those with PN invasion [14]. These were also proved in the present study. Eleven (61.5%) out of 18 RCCs with histologically proven infiltration of the PN and/or RS fat were of clear cell histology, 10 (55.5%) tumors were of high histologic grade and 16 (89%) neoplasms were larger than 4 cm in diameter.

Using a 16-row CT scanner we demonstrated 90.9% sensitivity, 94.6% specificity and 93.7% overall accuracy in the diagnosis of RS fat infiltration. The results of multivariate logistic regression analysis indicated that pelvicaliceal system invasion was the single most significant predictor of RS fat invasion. Results also indicated that neither tumor extension into the renal sinus, nor proximity to the pelvicaliceal system could contribute to the diagnosis of RS fat invasion. Some neoplasms may distort the renal sinus and protrude, without invading the renal sinus complex, and this was seen in this report. The proximity of a tumor to a neighboring structure, as the pelvicaliceal system, does not always correspond to neoplastic infiltration on histopathology, and this was proved in the present study.
The above results confirm the improved diagnostic performance of multidetector CT in the preoperative evaluation of renal cell carcinoma. MDCT with the improvement of spatial resolution and the ability to obtain multiphasic imaging and multiplanar reformations in any desired plane, with excellent anatomic details resulted in satisfactory results when assessing the presence or absence of neoplastic infiltration of the perirenal fat tissue and/or renal sinus fat compartment in patients with RCC.

In concluding, multidetector CT provides satisfactory results in detecting perinephric and/or renal sinus fat invasion in patients with RCC. The presence of contrast-enhancing nodules in the perinephric fat and tumoral margins was the most significant predictors in diagnosing tumor extension into the perinephric fat tissue. Invasion of the pelvicaliceal system was the single most significant predictor in diagnosing neoplastic invasion of the renal sinus fat compartment.

References


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