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ORIGINAL ARTICLE

Preoperative staging of renal cell carcinoma with multidetector CT

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PURPOSE
To evaluate the diagnostic accuracy of multidetector computed tomography (MDCT) for preoperative staging of renal cell carcinoma (RCC) using the 1997 TNM (tumor, node, metastasis) classification.

MATERIALS AND METHODS
We conducted a retrospective review of MDCT in 57 consecutive patients with RCC performed for tumor staging before radical (n = 51) or partial nephrectomy (n = 6). The scanning protocol of MDCT consisted of unenhanced and biphasic contrast-enhanced scans during corticomedullary and nephrographic phases. MDCT and surgical-histopathologic staging were performed using the 1997 TNM staging system. The results of MDCT were compared with the histopathological results. Agreement between the two staging methods was evaluated using the kappa (κ) statistic.

RESULTS
Consistency between MDCT and histopathologic staging was excellent for T staging (κ = 0.87), fair for N staging (κ = 0.40), and excellent for M staging (κ = 1.00). Fifty-one of 57 tumors were correctly staged, five overstaged and one understaged by MDCT, with an overall accuracy of 89%. MDCT was able to correctly identify and localize the extension of the tumor thrombus in all 10 patients. In the evaluation of nodal involvement, 42 of 57 patients (74%) were correctly staged, 11 (19%) overstaged, and four (7%) understaged.

CONCLUSION
MDCT with a dynamic contrast enhancement protocol is an accurate method for preoperative staging of RCC. MDCT with multiplanar reconstruction capability enables a reliable detection and characterization of the tumor, but the involvement of lymph nodes by tumor is still difficult to predict because it is based on node size criterion only.

Key words: • *renal cell carcinoma* • *neoplasm staging* • *multidetector computed tomography*

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Renal cell carcinoma (RCC) is the most common malignant tumor of the kidney, accounting for 85–90% of adult renal malignancies, and 1–2% of all malignancies (1). Although radical surgery remains the only efficient and curative treatment both in localized and advanced RCC, surgical techniques have evolved over the years. Currently, less-invasive surgical techniques, such as laparoscopic and nephron-sparing surgery are used in the treatment of renal tumors (2). Therefore, detailed preoperative imaging and exact renal tumor staging are important for planning the surgical approach and strategy, and for providing accurate prognostic information for the patient. In preoperative staging of RCC, the aim of any imaging study is to adequately evaluate tumor size, localization, and organ involvement, to reliably predict the presence and extent of any thrombus of the inferior vena cava, and to identify invasion of adjacent organs or lymph nodes, or distant metastases.

For many years, spiral computed tomography (CT) represented the modality of choice for assessment of tumor extension due to its high accuracy (3). The evolution of CT technology and the introduction of multidetector computed tomography (MDCT) have provided higher spatial resolution and faster acquisition. Three-dimensional reformatting techniques enable easy performance of multiplanar reconstructions, which improves the staging capabilities for RCC (4). Tumor stage is the most important factor affecting the prognosis and survival of patients, and has an important bearing on planning treatment. The commonly used staging classifications for renal cell carcinoma include the Robson's and the TNM (tumor, node, metastasis) classification. Although the Robson's classification is simpler and the most widely used in the imaging literature, TNM classification has more subgroups, and thus, defines the anatomic extent of the tumor more precisely. TNM classification correlates more closely with potential curability and prognosis, and has gained wide acceptance (5, 6).

The purpose of the present study was to evaluate the accuracy of MDCT for preoperative staging of RCC using the 1997 TNM classification, by taking surgical and histopathologic staging as the reference method.

Materials and methods

Patients

We retrospectively reviewed the MDCT examinations of 57 consecutive patients (23 women and 34 men; age range, 24–83 years; mean age, 56 years) with 57 histologically verified RCCs, performed between February 2006 and May 2008. In accordance with the guidelines of our institutional review board for retrospective studies, informed consent and formal approval were not obtained. The interval between preoperative MDCT and histological examination ranged from two to 21 days.

MDCT technique

All MDCT examinations were performed using a 16-slice MDCT scanner (GE Lightspeed Ultra, General Electrical Medical Systems, Milwaukee, Wisconsin, USA) with a 0.5 second gantry rotation speed, a tube voltage of 120 kV, and a tube current of 200–240 mAs. The scanning protocol consisted of unenhanced and biphasic contrast-enhanced scans during corticomedullary and nephrographic phases. The unenhanced scan was extended from the diaphragm to the biacetabular line. In all patients, 120 ml of iodinated contrast agent (Iodixanol, Visipaque 320 mgI/ml, GE Healthcare Bio-Sciences, Milwaukee, Wisconsin, USA) was injected at a flow rate of 3 ml/s through an 18 Gauge cannula positioned in an antecubital vein. The start delay was 30 seconds for the corticomedullary phase, and 120 seconds for the nephrographic phase. Scans during corticomedullary and nephrographic phases were taken from the diaphragm to the lower pole of the kidneys or the caudal tumor border. The reconstructed slice thickness was 5 mm for the unenhanced scan, 1.25 mm for the corticomedullary phase, and 2.5 mm for the nephrographic phase. Reconstructed data were transferred to a separate computer workstation (Advanced workstation 4.2, GE Healthcare, Milwaukee, Wisconsin, USA).

Image evaluation

Axial and reformatted images were evaluated by two experienced radiologists, who were aware of the patients' clinical histories, but unaware of the surgical and histopathologic results, with the final diagnosis reached by consensus. All tumors were staged according to the 1997 TNM staging system (Table 1). Tumor staging included identification and characterization of the tumors. The tumor diameter was measured in three planes (craniocaudal, anteroposterior, and transverse), and the largest of three was chosen to represent the tumor size. A tumor was staged T1 when the diameter was ≤7 cm and no infiltration into perinephric fat was seen; T2 with a diameter >7 cm and no infiltration into perinephric fat; T3a with infiltration of the perinephric fat (determined by the presence of perinephric stranding and soft tissue nodules surrounding the lesion) or infiltration of the adrenal gland; T3b with tumor thrombus in renal vein or inferior vena cava extending below the diaphragm; T3c with tumor thrombus extending above the diaphragm; and T4 with invasion of Gerota's fascia or adjacent organs. Renal hilar, paraaortic, and paracaval lymph nodes measuring >1 cm in short-axis diameter were considered to be metastatic. A tumor was staged N1 with lymph nodes >1 cm in one nodal region; and N2 with lymph nodes >1 cm in more than one nodal region.

Statistical analysis

The results from MDCT assessment of tumor staging were compared with the results from the surgical and histopathological evaluation, which served as the reference standard. Agreement between the two staging systems was determined using the kappa (κ) statistic (0.00–0.20, poor; 0.20–0.40, fair; 0.40–0.60, moderate; 0.60–0.80, good; and 0.80–1.00, excellent). Additionally, the results of intraoperative ultrasonography were compared with the MDCT findings with regard to the detection of multifocal lesions and liver metastases.

Table 1. 1997 TNM (tumor, node, metastasis) staging classification of renal cell carcinoma

Classification	Description
T1	Tumor confined to renal capsule, diameter ≤7 cm
T2	Tumor confined to renal capsule, diameter >7 cm
T3a	Invasion of perinephric fat or adrenal gland
T3b	Venous tumor thrombus in renal vein or infradiaphragmatic inferior vena cava
T3c	Venous tumor thrombus in supradiaphragmatic inferior vena cava
T4	Invasion of Gerota's fascia or adjacent organs
N1	Regional lymph node metastasis, in one regional lymph node
N2	Regional lymph node metastasis, in more than one regional lymph node
M0	Distant metastasis, absent
M1	Distant metastasis, present

Results

Surgical findings

Fifty-one patients underwent unilateral radical nephrectomy, and six patients unilateral partial nephrectomy. Intraoperative ultrasound evaluation of the kidney was performed during all partial nephrectomy procedures. Fifty-seven renal cell carcinomas were seen in 57 patients. Twenty-two tumors were in the right kidney, and 35 in the left. Histopathology was evaluated in all 57 patients with renal cell carcinoma, revealing the following tumor cell types: clear cell (n = 48), papillary (n = 6), chromophobe (n = 2), and unclassified (n = 1). The mean tumor size was 7.6 cm (range, 2–18.5 cm). The mean size of T1 tumors was 4.7 cm (range, 2–7 cm); of T2 tumors, 10.4 cm (range, 7.5–15 cm); of T3a tumors, 9.6 cm (range 4.4–15 cm); of T3b tumors 10.7 cm (range 6–18.5 cm); of one T3c tumor 8 cm, and of T4 tumors 9.3 cm (range 8–10 cm). In 37 patients (65%), tumor was confined within the renal capsule (stages T1 and T2) and there was no infiltration into perinephric fat. Involvement of adrenal glands was detected in six patients (10%). Renal vein or inferior vena cava thrombosis was detected in 10 patients (17%) (seven at stage T3b, one at stage T3c and two at stage T4). In one patient with infradiaphragmatic inferior vena cava thrombus, the wall of the inferior vena cava was invaded by tumor thrombus. In one patient, direct invasion of the spleen by left renal tumor (10 cm) was detected. Lymph node involvement (renal hilar, paraaortic, or paracaval lymph nodes) was found in 12 (21%) patients (nine at stage N1 and three at stage N2). Seven metastatic lesions in the liver were detected on intraoperative sonography in three patients (5%). These metastases were biopsied during surgery.

All tumors were staged according to 1997 TNM staging system. Histopathologic examination of the surgical specimens revealed that 26 tumors were stage T1 (46%), 11 were stage T2 (19%),

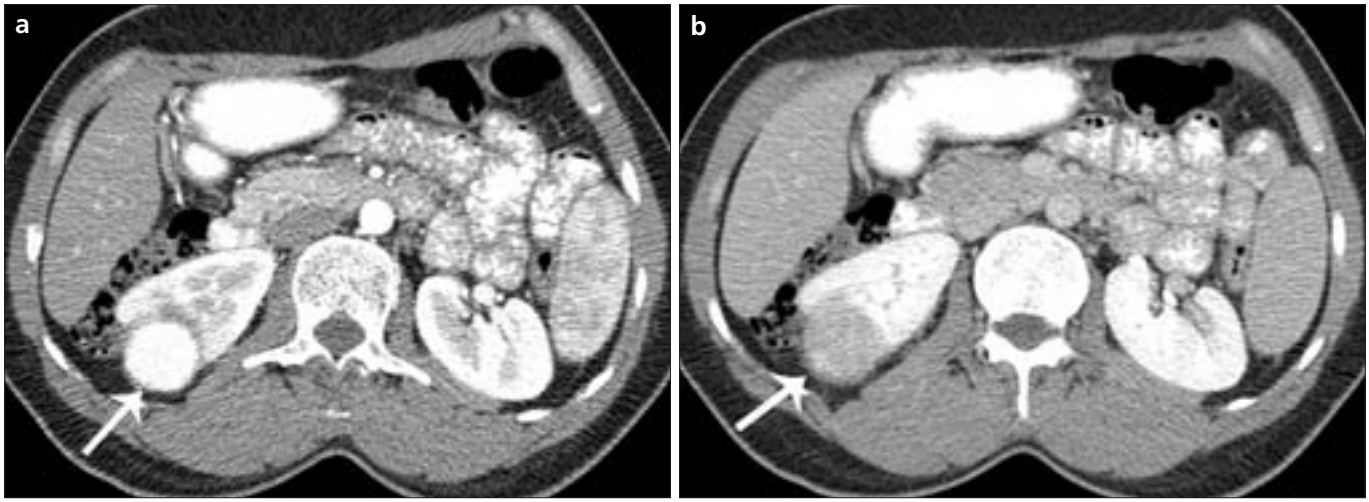

Figure 1. a, b. Stage T1N0M0 renal cell carcinoma in the right kidney of a 40-year-old woman. Contrast-enhanced axial CT images obtained during the corticomedullary **(a)** and nephrographic phases **(b)** show a 3.2 cm homogeneously enhancing mass *(arrows)* in the lower polar region of the right kidney. The patient underwent partial nephrectomy.

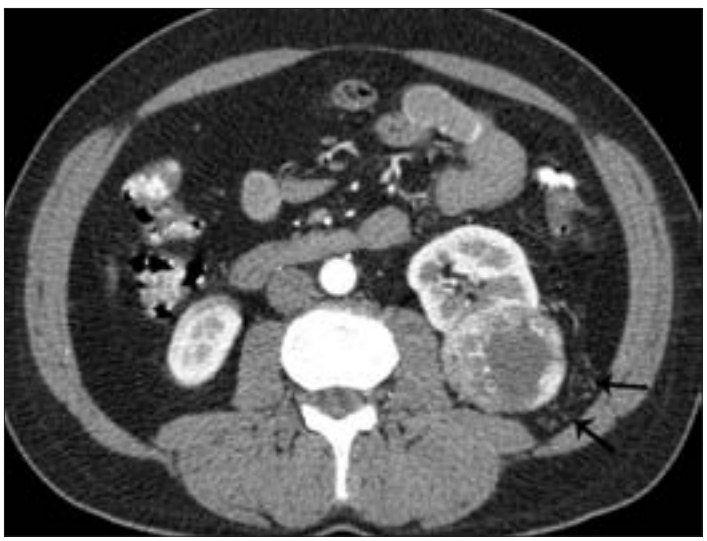

Figure 2. Stage T1N0M0 renal cell carcinoma in the left kidney of a 44-year-old man. Contrast-enhanced axial CT image obtained during the corticomedullary phase shows a 6.5 cm heterogeneously enhancing mass in the left kidney, with perinepric fat stranding *(arrows)* that was staged as T3a by MDCT. Pathologic examination revealed that the tumor did not extend into perinephric space and that this stranding is associated with previous inflammation.

Table 2. Histopathologic and multidetector computed tomography (MDCT) staging of tumor (T)

	Histopathology						
MDCT	T1	T2	T3a	T3b	T3c	T4	Total
T1	25		1				26
T2		7	4				11
T3a			9				9
T3b				7			7
T3c					1		1
T4				1		2	3
Total	25	7	14	8	1	2	57

nine were stage T3a (16%), seven were stage T3b (12%), one was stage T3c (2%), and three were stage T4 (5%). In the evaluation of lymph node involvement and distant metastases, 45 tumors (79%) were stage N0, nine were stage N1 (16%), and three were stage N2 (5%), 54 were stage M0 (95%), and three were stage M1 (5%).

MDCT findings

T staging: In retrospective image analysis, all 57 tumors were identified with MDCT. Assessment of the MDCT images revealed 25 of 57 renal cell carcinomas (44%) were stage T1, seven were stage T2 (12%), 14 were stage T3a (24%), eight were stage T3b (14%), one was stage T3c (2%), and two were stage T4 (4%). Fifty-one of 57 tumors were correctly staged by MDCT, with an overall accuracy of 89% (Table 2). Five tumors (one stage T1 and four stage T2) were overstaged and one tumor (stage T4) was understaged with MDCT.

Twenty-five of 26 T1 tumors were correctly staged by MDCT with an overall accuracy of 96%. In six patients with T1 tumor diameter of less than 4 cm (size range, 2–3.6 cm; mean size, 2.7 cm) and located in the cortical and polar region (Fig. 1), partial nephrectomy was performed. The tumors of all six patients who underwent partial nephrectomy were correctly staged as T1 by MDCT. Thirty-two of 37 patients with tumor confined within the renal capsule (stages T1 and T2) were correctly staged. One T1 tumor (size, 6.5 cm) and four T2 tumors (mean size,

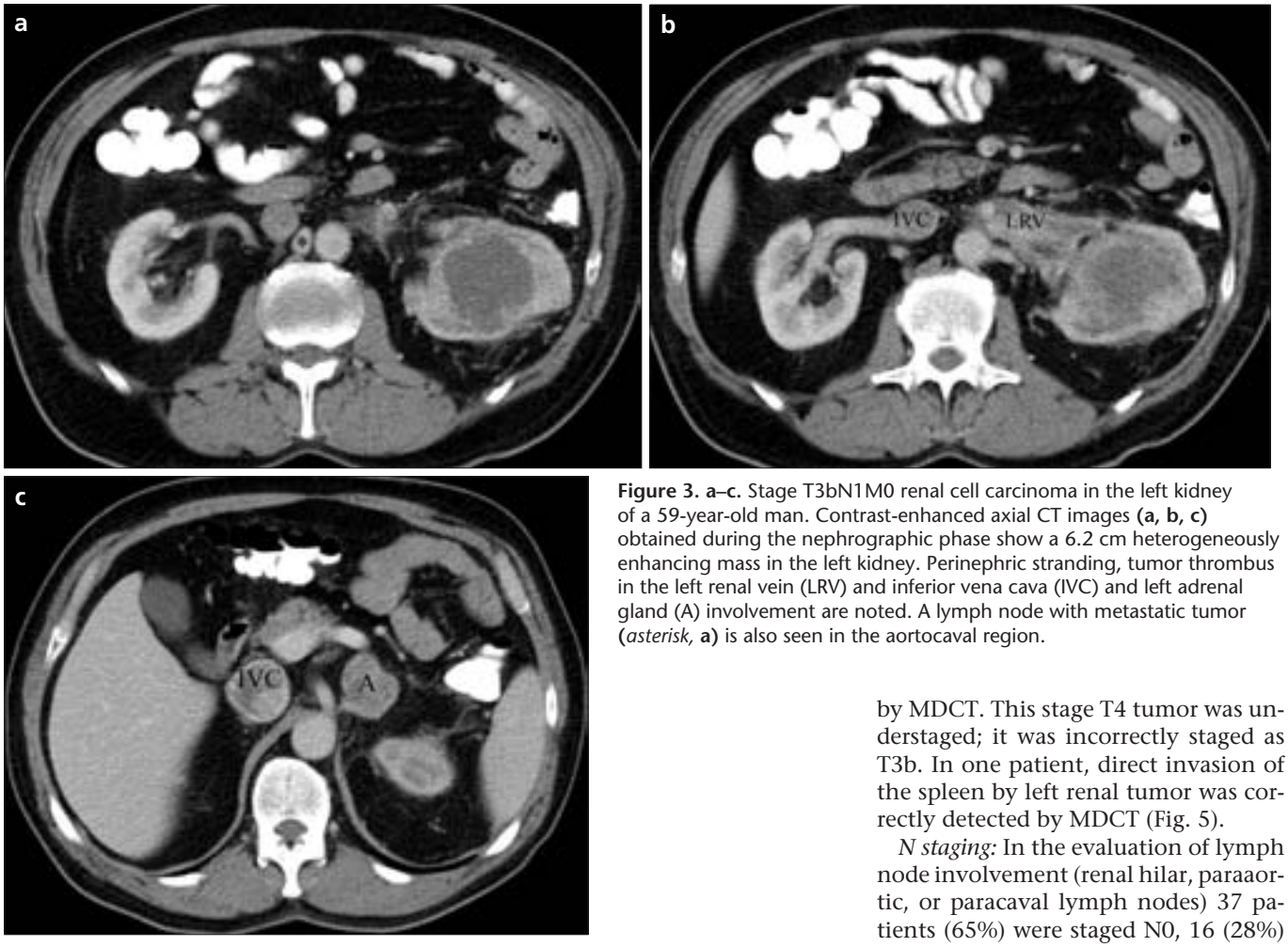

Figure 3. a–c. Stage T3bN1M0 renal cell carcinoma in the left kidney of a 59-year-old man. Contrast-enhanced axial CT images **(a, b, c)** obtained during the nephrographic phase show a 6.2 cm heterogeneously enhancing mass in the left kidney. Perinephric stranding, tumor thrombus in the left renal vein (LRV) and inferior vena cava (IVC) and left adrenal gland (A) involvement are noted. A lymph node with metastatic tumor **(***asterisk,* **a)** is also seen in the aortocaval region.

11.2 cm) were overstaged as T3a (Fig. 2). In these patients, MDCT showed evidence of perinephric spread, but no infiltration of tumor cells was seen on pathology. Pathologic findings of these cases were associated with previous inflammation in four cases (one of T1 tumor), organizing perinephric hematoma in one case, and perinephric fat necrosis in one case. Six patients with adrenal gland involvement were correctly diagnosed by MDCT (Fig. 3).

MDCT was able to identify correctly and localize the extension of the tumor thrombus in all of ten patients with 100% diagnostic accuracy (Figs. 3–5). Direct continuity with the renal tumor, and enhancement after administration of contrast medium were considered features of tumor thrombus. In one patient who had thrombus in the right renal vein and infradiaphragmatic inferior vena cava, invasion of the wall of the inferior vena cava was not detected by MDCT. This stage T4 tumor was understaged; it was incorrectly staged as T3b. In one patient, direct invasion of the spleen by left renal tumor was correctly detected by MDCT (Fig. 5).

N staging: In the evaluation of lymph node involvement (renal hilar, paraaortic, or paracaval lymph nodes) 37 patients (65%) were staged N0, 16 (28%) were staged N1 and four (7%) were staged N2 by MDCT (Table 3). Forty-two of 57 patients (74%) were correctly staged (Figs. 3, 5, 6), 11 patients (19%) were overstaged (Fig. 7), and four patients (7%) were understaged. In 11 patients with false-positive diagnoses of metastatic lymph node involvement by MDCT, the lymph nodes were larger than 1 cm but were characterized as reactive hyperplasia on pathology. In three of four patients with false-negative diagnoses, pathology detected microscopic foci of metastatic disease in lymph nodes with a diameter of less than 1 cm. A fourth patient with stage N2 disease was understaged as N1 because lymph nodes with a diameter greater than 1 cm in the renal hilus were not identified separately from the large renal tumor.

M staging: Only three patients (5%) had metastatic disease, and all of them were correctly staged by MDCT. MDCT detected all seven lesions, with two detected only in the corticomedullary phase, and five detected in both phases.

Table 3. Histopathologic and multidetector computed tomography (MDCT) staging of nodes (N)

	Histopathology			
MDCT	N0	N1	N2	Total
N0	34	9	2	45
N1	3	6		9
N2		1	2	3
Total	37	16	4	57

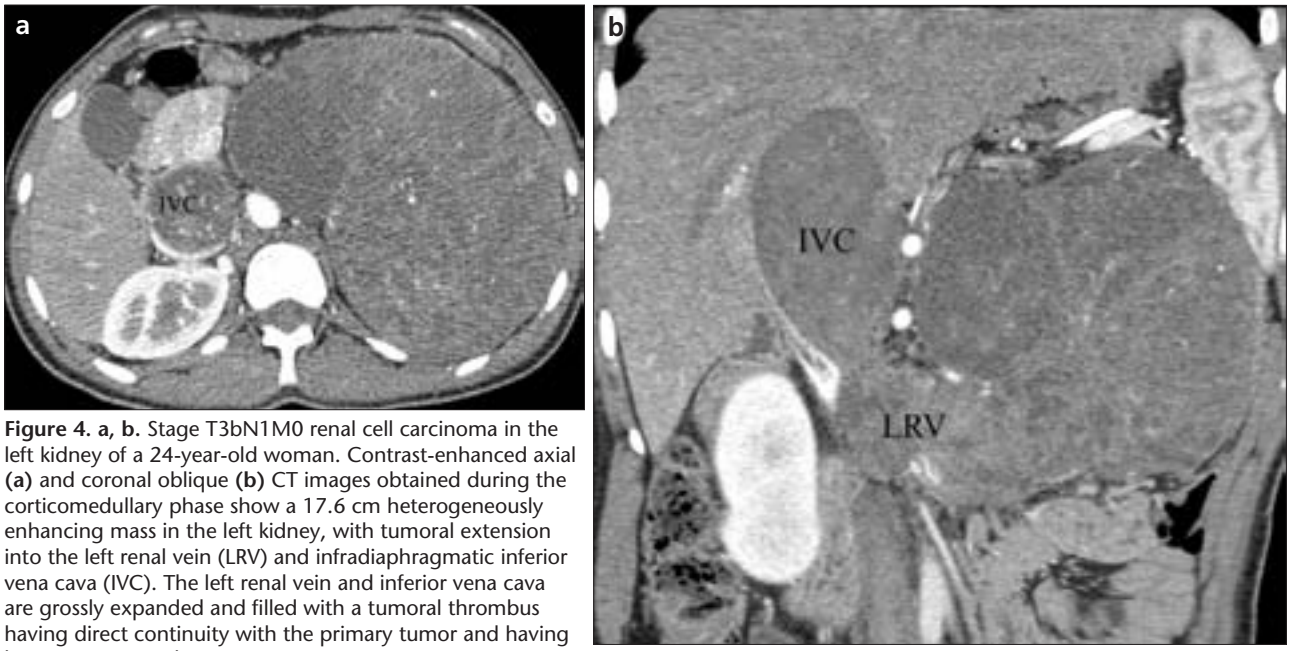

Figure 4. a, b. Stage T3bN1M0 renal cell carcinoma in the left kidney of a 24-year-old woman. Contrast-enhanced axial **(a)** and coronal oblique **(b)** CT images obtained during the corticomedullary phase show a 17.6 cm heterogeneously enhancing mass in the left kidney, with tumoral extension into the left renal vein (LRV) and infradiaphragmatic inferior vena cava (IVC). The left renal vein and inferior vena cava are grossly expanded and filled with a tumoral thrombus having direct continuity with the primary tumor and having heterogeneous enhancement.

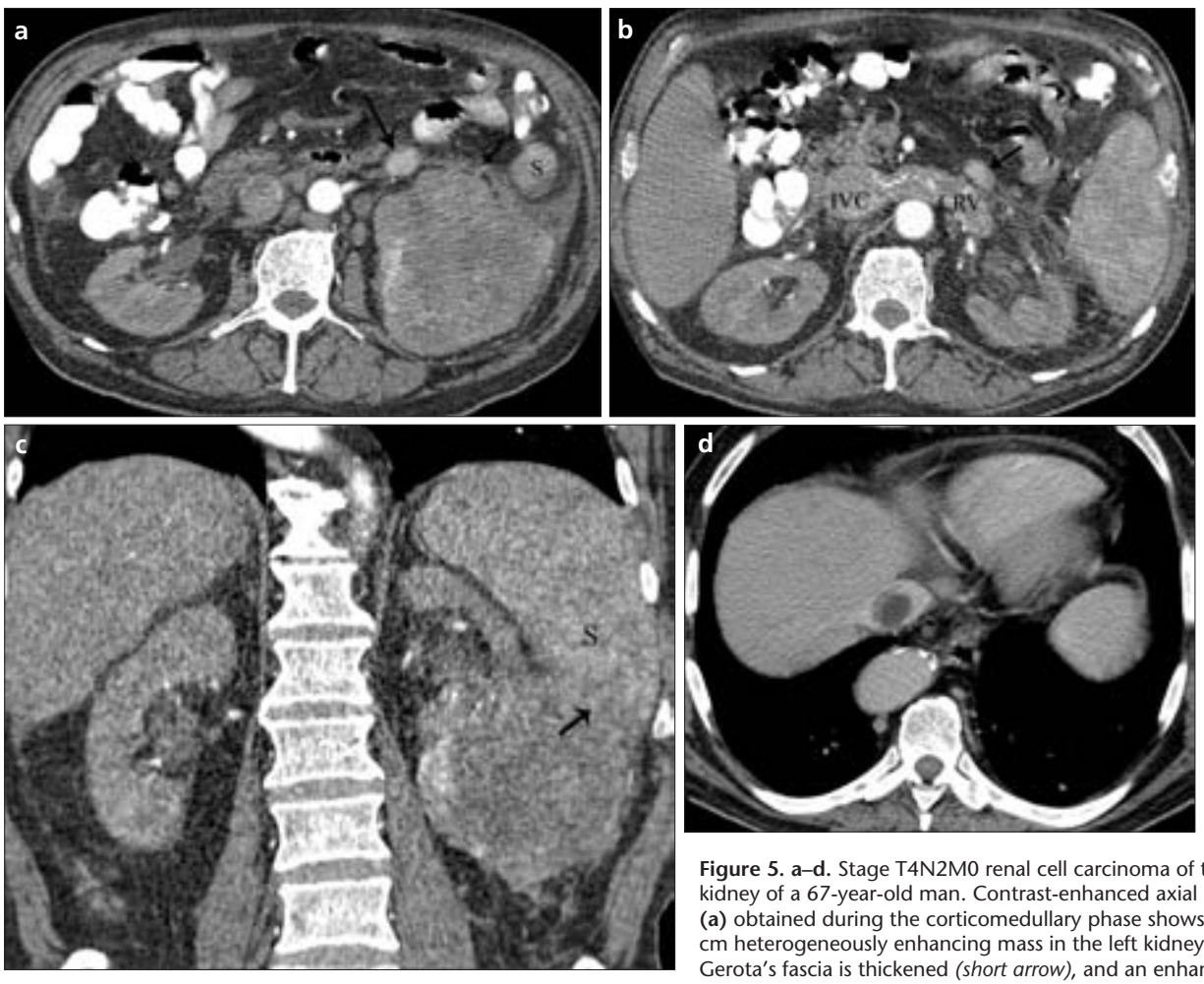

Figure 5. a–d. Stage T4N2M0 renal cell carcinoma of the left kidney of a 67-year-old man. Contrast-enhanced axial CT image **(a)** obtained during the corticomedullary phase shows a 10 cm heterogeneously enhancing mass in the left kidney. The left Gerota's fascia is thickened *(short arrow)*, and an enhancing tumor node *(long arrow)* is seen in the anterior pararenal space. Multiple enlarged lymph nodes are present in the left hilar, paraortic, and aortacaval spaces (S: spleen). Axial CT image **(b)** obtained during the corticomedullary phase shows that the left renal vein (LRV) and inferior vena cava (IVC) are dilated and filled with enhanced thrombus. An enhancing tumor node *(arrow)* is also seen. Coronal CT image **(c)** shows the absence of the tissue plane *(arrow)* between the mass and the spleen (S). At surgery, tumor was observed to have invaded the spleen. Axial CT image **(d)** obtained during the nephrographic phase shows a tumor thrombus at the supradiaphragmatic inferior vena cava.

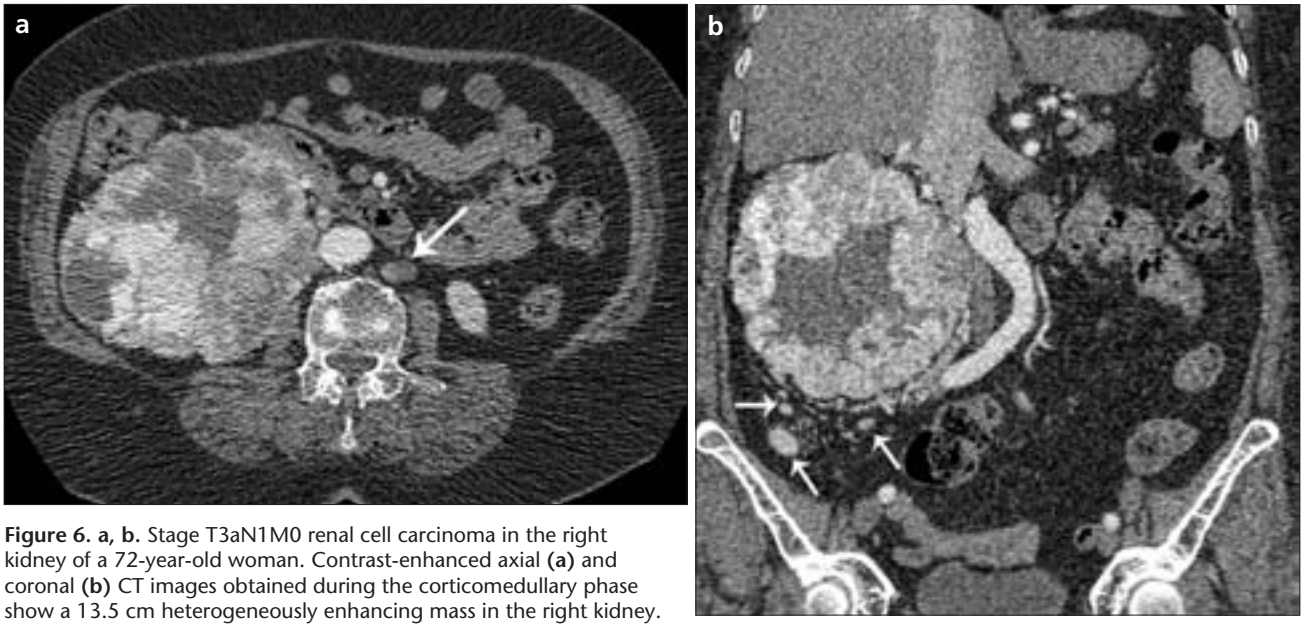

Figure 6. a, b. Stage T3aN1M0 renal cell carcinoma in the right kidney of a 72-year-old woman. Contrast-enhanced axial **(a)** and coronal **(b)** CT images obtained during the corticomedullary phase show a 13.5 cm heterogeneously enhancing mass in the right kidney. A lymph node with metastatic tumor is present in the paraaortic region **(***long arrow,* **a)**. Several enhancing tumor nodules and soft tissue stranding are seen in the right perinephric space **(***short arrows,* **b)**. The inferior vena cava was compressed by the tumor.

MDCT and histopathologic staging

Agreement between MDCT and surgical-histopathologic staging was excellent for T staging ($\kappa = 0.87$), fair for N staging ($\kappa = 0.40$), and excellent for M staging ($\kappa = 1.00$).

Discussion

The T component of the TNM classification for staging of RCC is the most important variable in predicting prognosis and survival. It is determined primarily by the size and extent of the tumor, and the presence and extent of venous involvement. Evaluating the spread of the tumor into perinephric fat, and differentiation between T1/T2 and T3a stages is the most difficult aspect of T staging of RCC with spiral CT (7, 8). Various criteria have been used to describe the appearance of infiltration of perinephric fat. Perinephric stranding does not reliably indicate tumoral spread, and is found in about 50% of patients with localized T1 and T2 tumors. It is caused by edema, vascular engorgement, or previous inflammation (8). The presence of an enhancing nodule in the perinephric fat, considered the most reliable finding of perinephric invasion, has high specificity (98%) but low sensitivity (46%) (7). Sheth et al. (9) and Hallscheidt et al. (10) suggested that evaluation of renal tumor extension into perinephric fat remains a difficult task, even with three-dimensional and MDCT technology, leading to reduced accuracy in staging RCC. Hallscheidt et al. reported that the overall accuracy of triphasic MDCT (noncontrast, arteriographic, and nephrographic phases with reconstructed slice thicknesses of 2 and 5 mm) for assessment of T staging is only 64% (10). However, Catalano et al. reported that the accuracy of high resolution MDCT (1-mm slices were obtained during the arteriographic, nephrographic, and urographic phases) in the assessment of perinephric fat infiltration of Robson stage 1 tumors was 95%, with 96% sensitivity, and 93% specificity (4). In their study, only one case of understaging occurred, and there were no false-positive findings. In our study, 86% of patients with tumor confined within the renal capsule were correctly staged, but one T1 (6.5 cm) and four T2 tumors (mean, 11.2 cm) were overstaged. In these overstaged cases, imaging evidence of perinephric spread was present, but was not confirmed by tumoral infiltration on pathology. Pathologic findings of these cases were associated with previous inflammation, organizing perinephric hematoma, and perinephric fat necrosis. We conclude that the assessment of perinephric fat infiltration continues to be a problem, even with MDCT.

Roberts et al. stated that when initial classification of T1 tumor by CT was upgraded to T3a on pathological analysis, these patients showed the same recurrence-free survival rate as those with pathologically confirmed T1 tumors (11). Although detection of infiltration into perinephric fat in the preoperative staging of RCC may not be important clinically, the accurate staging of T1 tumors is essential because infiltration into the perinephric fat is a contraindication to elective nephron-sparing surgery. The most appropriate lesion for elective nephron-sparing surgery is small (<4 cm in diameter), is located in the polar region, and is situated cortically, far from the renal hilum and collecting system (2, 12). A clear depiction of the relationship of the tumor to the kidney, renal vasculature, and collecting system is necessary for the surgeon to perform a successful partial nephrectomy (10). In our series, partial nephrectomy was performed in six patients who had a T1 tumor with a diameter of less than 4 cm, localized in the polar region far from the renal hilum and collecting system. The tumors of all six patients who underwent partial nephrectomy were correctly staged as T1 by MDCT.

Accurate preoperative evaluation for the presence and extent of the tumor thrombus in the renal vein and inferior vena cava is important for the surgeon to plan the appropriate surgical approach for thrombectomy, and to minimize the risk of intraoperative tumoral embolism (13). In this con-

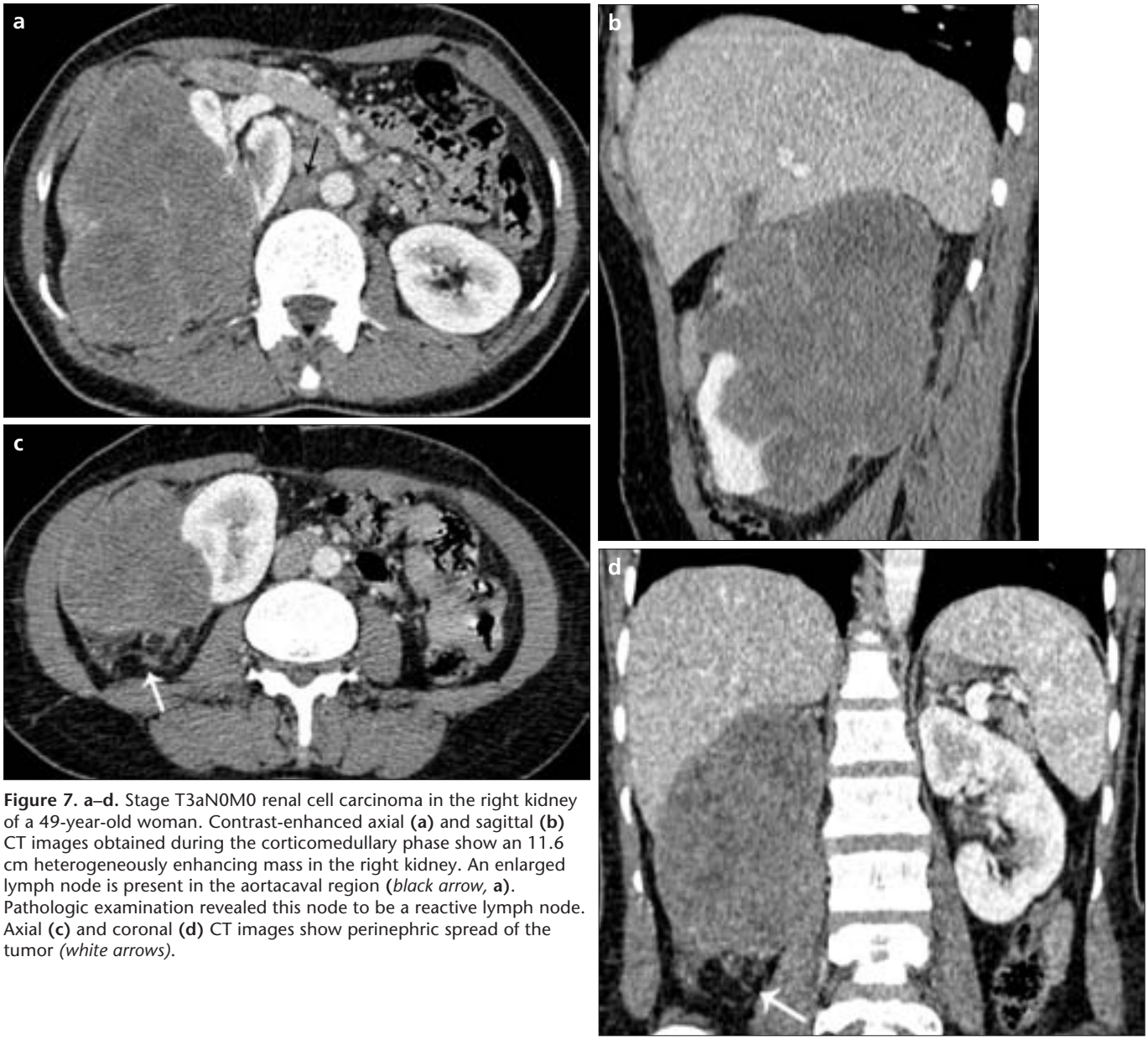

Figure 7. a–d. Stage T3aN0M0 renal cell carcinoma in the right kidney of a 49-year-old woman. Contrast-enhanced axial **(a)** and sagittal **(b)** CT images obtained during the corticomedullary phase show an 11.6 cm heterogeneously enhancing mass in the right kidney. An enlarged lymph node is present in the aortacaval region **(***black arrow,* **a)**. Pathologic examination revealed this node to be a reactive lymph node. Axial **(c)** and coronal **(d)** CT images show perinephric spread of the tumor *(white arrows)*.

text, several studies have evaluated the capability of spiral CT, magnetic resonance imaging (MRI), and MDCT in the accurate detection of cranial extension of tumor thrombi (14–16). Spiral CT detects caval thrombi with sensitivities of 64% to 95% (14, 15). MRI has been reported to have a sensitivity of up to 100% in detecting caval thrombi (16, 17). It has proven to be superior to spiral CT for thrombus detection and staging, and has replaced venacavography as the gold standard (17). MDCT is also effective in delineating the superior extent of inferior vena cava thrombus due to multiplanar reconstruction capability and appropriate timing of the contrast enhanced acquisitions. Hallscheidt et al. reported that MRI and MDCT show similar staging results for the assessment of the extension of tumor thrombus (16). In a recent study, similar data have been provided by Padovan et al., who reported that in 25 of 27 surgically treated patients with RCC (93%), the upper extent of the tumor thrombus was correctly diagnosed by MDCT (18). In their study, two incorrectly diagnosed patients were understaged as T3b, while surgery revealed stage T3c; however, in both cases surgery was performed at least one month after MDCT diagnosis.

A low-attenuation filling defect within the vein seen after injection of contrast material is the most specific CT criterion for venous involvement, although a bland thrombus may mimic tumor thrombus. The presence of bland thrombus in the veins does not alter the tumor stage, but may influence the surgical approach. Direct continuity of the thrombus with the primary tumor, and heterogeneous enhancement of the thrombus with contrast material indicates tumoral thrombus (8). Although the number of patients in our study with renal vein or inferior vena cava thrombosis was limited, MDCT correctly identified and localized the extent of the tumor thrombus in all ten patients. However, in one patient who had thrombus in

the right renal vein and infradiaphragmatic inferior vena cava, invasion of the inferior vena cava wall was not detected by MDCT.

Focal enhancement of the vena cava wall, or infiltration of adjacent soft tissue, indicates vena cava wall invasion on CT (18). Invasion of the inferior vena cava wall will significantly complicate surgical resection because prosthetic reconstruction usually is necessary in this situation (19). Although the extent of tumor thrombus in the inferior vena cava has limited influence on the prognosis, even when the thrombus extends to the right atrium, a significant difference in prognosis exists between patients with tumor invasion of the inferior vena cava wall and those with free-floating tumor thrombus in the inferior vena cava (5). There is a difference in the 5-year survival rate between the two groups, 25% and 69%, respectively (13).

In previous studies using spiral CT scans, identification of lymph node involvement using a threshold of 1 cm remained a significant problem (7). Use of this criterion is neither sensitive nor specific for lymph node involvement. A cutoff value of 1 cm as the upper limit for normal nodes reveals a false-negative finding of 10% because micrometastases can not be identified. Furthermore, false-positive findings vary between 3% and 43%, according to different studies (5, 7, 20). Nodal enlargement may be caused by reactive hyperplasia, which is often associated with extensive tumoral necrosis or venous thrombosis, and may represent a reactive immune response (20). In a study performed by Catalano et al. with MDCT, all patients with synchronous lymphadenopathy at the time of nephrectomy were identified, thereby reducing the false-positive rate due to reactive hyperplasia to 6.3% (4).

In our study, 74% of patients with lymph node involvement were correctly staged, 19% were overstaged, and 7% were understaged by MDCT. In all 11 overstaged cases, overstaging was caused by the presence of reactive nodes larger than 1 cm. In three of four underestimated N stages, microscopic foci of metastatic disease were detected on pathology in lymph nodes with diameters of less than 1 cm. The fourth case, a stage N2 tumor, was underestimated as N1. In this case, there were involved lymph nodes with a diameter of greater than 1 cm in the renal hilus, where they could not be identified separately from the large renal tumor.

Although the superiority of MRI in the detection of lymph node involvement has been documented in early reports (14), Ergen et al. report poor agreement between MRI and surgical-pathologic staging for lymph node involvement (6); however, the role of MDCT and MRI in the assessment of regional lymph node involvement has not been evaluated in large clinical series, so no final recommendations can be made. It has been shown recently that there is no clinical benefit to performing regional lymph node dissection in patients with no suspected adenopathy prior to surgery, or in those patients with lymph nodes smaller than 1 cm (21).

The risk of adrenal involvement is higher among patients with large or advanced stage RCC and tumors that involve the upper pole of the kidney. Assessment of the adrenal gland is important for surgical management because the current trend is to spare the ipsilateral adrenal gland unless an abnormality is suggested by CT (5). In our series, MDCT allowed correct identification in all cases of adrenal involvement. Direct extension of RCC outside Gerota's fascia and into adjacent organs (stage T4) is difficult to diagnose with certainty unless there is a demonstrable focal change in attenuation within the affected organ. Loss of tissue planes and irregular margins between the tumor and neighboring organs raise the possibility of direct infiltration (7). Three-dimensional MDCT displays the tumor and its relationship to the adjacent organs in multiple planes and orientations, and is valuable in difficult cases for increasing diagnostic confidence and helping to plan surgical resection (9). In one patient in our study, direct invasion of the spleen by the left renal tumor was correctly identified by MDCT.

RCC commonly metastasizes to the lungs and mediastinum, bones, and liver (3, 5). Like the primary tumor, metestatic lesions tend to be hypervascular. Liver metastases are noticeable on scans obtained during the hepatic arterial phase. They may become isoattenuating with respect to the liver parenchyma, and may be obscured during the portal venous phase (9). In our study, all seven liver metastates were correctly detected with MDCT; two were detected in only corticomedullary phase, and five were detected in both phases. The detection of visceral metastases is crucial because it has been shown that even patients with metastatic disease might benefit from radical nephrectomy followed by systemic immunotherapy in patients with good performance status, and if the metastases are lymph node and pulmonary metastases only (22).

In conclusion, the multiplanar and three-dimensional reconstruction capability of MDCT provides good delineation and characterization of the RCC tumor, including evaluation of the presence and extent of renal venous involvement. Similar to staging by spiral CT, MDCT staging of tumors, especially differentiation of T2 tumors from T3a tumors, is still limited because of poor visualization of infiltration of the perinephric fat. In addition, involvement of lymph nodes by tumor remains difficult to predict because the criterion of node size >1 cm is neither sensitive nor specific for nodal metastases.

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