Renal Adenocarcinoma:
CT Staging of 100 Tumors

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The preoperative CT scans of 100 pathologically proven renal adenocarcinomas were retrospectively reviewed to assess the accuracy of CT for staging the tumor. Regardless of tumor stage, perinephric extension was assessed with a sensitivity of 46% and a specificity of 98%. The sensitivity of CT in detecting venous invasion (either venous enlargement or thrombus) was 78%, with a specificity of 96%. For detection of metastatic adenopathy, CT had a sensitivity of 83% and specificity of 88%. Adjacent organ invasion was correctly identified in 60% of patients, with a specificity of 100%. Overall, CT correctly staged 91% of patients. If errors associated with perinephric invasion were excluded, CT staging accuracy improved to 96%. CT is useful in staging renal adenocarcinoma. If the renal vein is not well seen, angiography or sonography may be necessary to determine the presence of venous tumor extension.

CT of the abdomen is widely used for the preoperative staging of renal adenocarcinoma. Early reports on the use of CT to stage renal cancer suggested a high accuracy rate but limited value in showing venous invasion [1–7]. This is the largest study yet that evaluates the accuracy of CT in staging renal adenocarcinoma.

Materials and Methods

All patients with pathologically proven renal adenocarcinoma who had a CT examination between October 1980 and October 1985 were included in the study. A total of 100 tumors were present in 97 patients. There were 60 men and 37 women, ranging in age from 24 to 81 years. Final diagnosis was established at surgery (79 tumors) or by biopsy of distant metastases (21 cases). The medical records and pathology reports of all patients were reviewed and compared to the CT examination.

All CT examinations were performed on a GE 8800 (71 tumors) or GE 9800 (29 tumors) scanner. Scan sections were performed by using 10-mm slice thickness at 10-mm intervals, with additional images obtained when judged necessary by the supervising radiologist. IV contrast was given to evaluate all but 18 tumors. Noncontrast studies were performed in patients with a contrast allergy or an elevated creatinine. A 100 ml IV bolus of contrast medium was routinely given, followed by a rapid drip of an additional 100 ml during the course of the CT examination.

The CT examinations were retrospectively reviewed to assess tumor extension into the perinephric tissues; involvement of the renal vein and inferior vena cava; and the presence of regional lymphadenopathy, adjacent organ invasion, and distant metastases. These findings were compared with actual pathologic staging.

Criteria for perinephric invasion required a soft-tissue mass at least 1 cm in diameter in the perinephric space. Perinephric soft-tissue stranding was not considered evidence of tumor invasion. Venous invasion was considered to be present if there was either enlargement (based on the reviewer's estimation rather than on actual measurement) or identifiable thrombus in the renal vein or inferior vena cava. Regional lymph nodes were considered to be involved with tumor if they were at least 1 cm in diameter. Adjacent organ invasion was diagnosed only if there was enlargement and/or a density change in the adjacent structure. The loss of a fat plane between the tumor and adjacent organ was not considered tumor invasion.

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Staging of renal tumors was done according to the Robson classification [8]. Stage I consists of tumor confined within the renal capsule, stage II of perinephric extension (yet contained by Gerota's fascia), stage IIIA of venous invasion (renal vein that may extend into the inferior vena cava), and stage IIIB of regional lymph node metastases. Stage IV tumors have either adjacent organ involvement (excluding ipsilateral adrenal invasion) or distant metastases.

Results

Seventy-nine tumors were removed surgically, providing the basis for pathologic comparison to CT scans for each staging category. Adequate information from the pathology reports was available for analysis of perinephric extension in 71 tumors, venous extension in 74 tumors, regional lymph nodes in 63 tumors, and adjacent organ invasion in 58 tumors. The remaining 21 tumors had pathologic confirmation of distant metastases by percutaneous biopsy. Since a large number of these advanced tumors were not surgically removed, selection bias may be present. We have therefore included a percentage range (best case–worst case) for the sensitivity and specificity in each of the following areas.

Perinephric Extension

Perinephric extension was correctly identified, regardless of overall tumor staging, in 11 (46%) of 24 tumors (range, 58–23%) by a soft-tissue mass at least 1 cm in diameter. The remaining 13 tumors had perinephric soft-tissue stranding or normal fat at CT.

Forty-six (98%) of 47 tumors (range, 98–83%) with proven normal perinephric tissues were correctly evaluated by CT. In one patient an enlarged perinephric vessel supplying the tumor was misdiagnosed as representing tumor extension (Table 1). Seventeen (50%) of 34 stage I tumors also had identifiable soft-tissue stranding at CT (Fig. 1).

Venous Extension

Venous extension, defined as either enlargement of and/or thrombus within the renal vein or inferior vena cava, was correctly identified in 14 (78%) of 18 tumors (range, 86–42%) regardless of tumor stage. In eight (44%) of 18 tumors only venous enlargement was seen, while the remaining six tumors (33%) had identifiable tumor thrombus. The four false negatives were due to motion artifact (one), poor visualization of the right renal vein owing to a large right renal tumor (two), and a tumor thrombus that occurred in only a branch renal vein (one).

Normal renal veins were correctly identified in 54 (96%) of 56 tumors (range, 97–80%). The two false-positive studies were due to enlarged renal veins from increased blood flow through the hypervascular tumor, which did not contain thrombus (Fig. 2).

Table 1: Proven Renal Adenocarcinoma[a]

	Sensitivity (%)	Specificity (%)
Perinephric extension	11/24 (46)	46/47 (98)
Venous invasion	14/18 (78)	54/56 (96)
Metastatic adenopathy	10/12 (83)	45/51 (88)
Adjacent organ invasion	3/5 (60)	53/53 (100)

[a] All stages included.

Adenopathy

Lymph nodes at least 1 cm in diameter containing tumor were correctly identified in 10 (83%) of 12 tumors (range, 93–32%). Four (33%) of 12 nodes were 1–2 cm in diameter, while six (50%) of 12 nodes were larger than 2 cm. Two patients had tumor within normal-sized lymph nodes.

Forty-five (88%) of 51 tumors (range, 91–65%) had normal-sized lymph nodes that did not contain tumor. Three false-

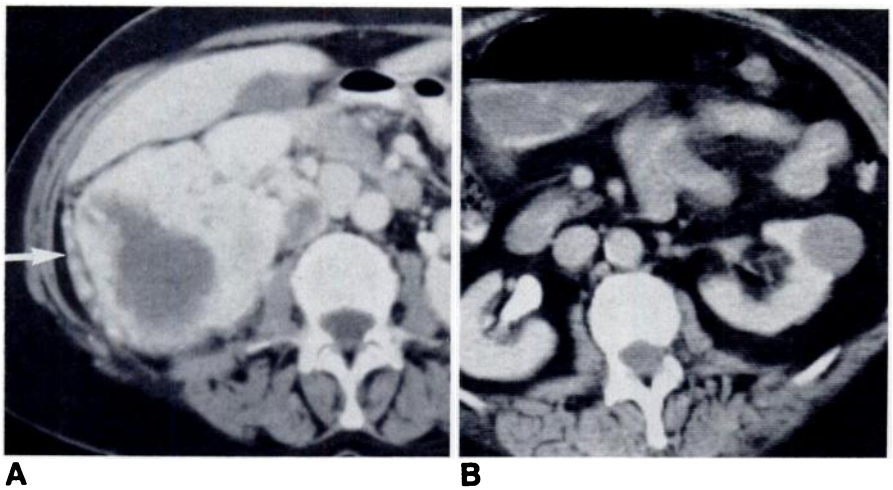

Fig. 1.—Perinephric extension.
***A*, Large right-sided renal adenocarcinoma with enhancing surgically proven tumor in perinephric tissues (*arrow*). Also note paracaval lymphadenopathy.**
***B*, Small left-sided renal adenocarcinoma with normal-appearing perirenal fat (CT stage I). Pathologically, microscopic perinephric invasion had occurred (pathologic stage II).**

positive studies occurred in nodes 1–2 cm in diameter that were histologically hyperplastic, but did not contain tumor (Fig. 3).

Adjacent Organ Invasion

Adjacent organ invasion was correctly identified in three (60%) of five proven tumors (range, 77–7%), with either enlargement and/or a density change in the affected organ. Two false-negative studies showed obliteration of the fat plane between tumor and adjacent organ, but no other sign of invasion.

All 53 tumors (100%) (range, 100–93%) without adjacent organ invasion showed either a preserved fat plane between tumor and adjacent organ or a lost fat plane without other signs of invasion (increased adjacent organ size or density change). Forty-five (85%) of these 53 tumors without adjacent organ invasion showed a preserved fat plane, while the other eight (15%) had loss of the intervening fat plane (Fig. 4).

Overall Staging

Overall staging results were better than the sensitivity reported for each separate category. Thirty-four (97%) of 35 stage I, four (44%) of nine stage II, 14 (88%) of 16 stage III, and 39 (98%) of 40 stage IV tumors were correctly staged by CT when compared with pathologic staging (Table 2).

Nine CT staging errors occurred, for an overall accuracy of 91%. Only one error was an overstaging error. This patient had an enlarged lymph node identified by CT (CT stage IIIB) not commented on at pathologic examination (surgical stage I). The remaining eight errors were understaged by CT. Five errors were due to microscopic perinephric extension that did not appear as a discrete 1-cm mass on CT. Two stage III errors were due to large right-sided tumors in which the involved renal vein could not be identified by CT. Motion artifact and a poor bolus of contrast material also contributed to these errors. The ninth error was due to posterior body-wall invasion, not identified by CT because enlargement or density change of the affected body wall was not present.

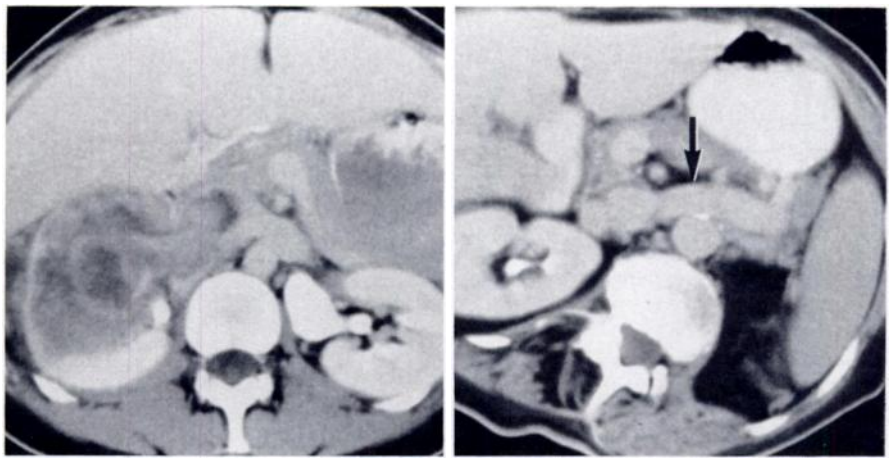

Fig. 2.—Venous extension.
***A*, Large right-sided renal adenocarcinoma with proven renal vein and inferior vena caval extension.**
***B*, Enlarged left renal vein (*arrow*) arising from left-sided renal adenocarcinoma (seen on lower section). No tumor thrombus found pathologically. Venous enlargement secondary to high-volume blood flow through hypervascular tumor.**

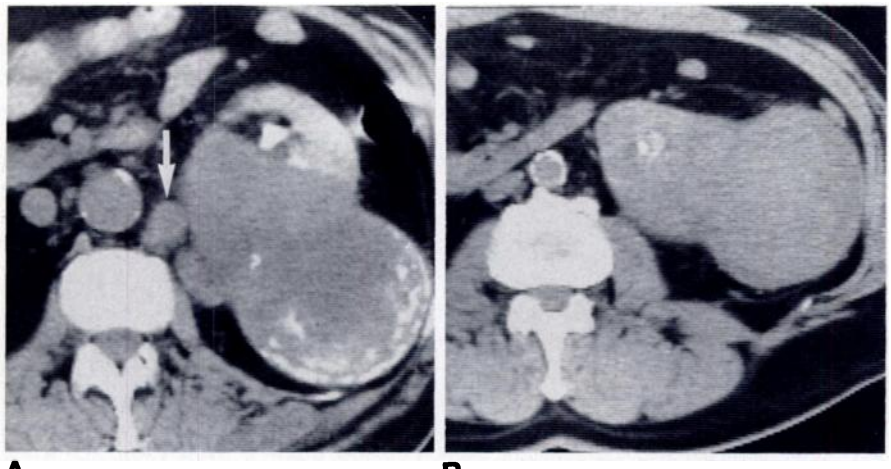

Fig. 3.—Regional lymphadenopathy.
***A*, Large, calcified left-sided renal adenocarcinoma with enlarged paraaortic lymph nodes (*arrow*). Pathologically metastatic regional lymphadenopathy was present.**
***B*, Left-sided renal adenocarcinoma with several normal-sized paraaortic lymph nodes. Pathologically, these lymph nodes contained metastatic tumor.**

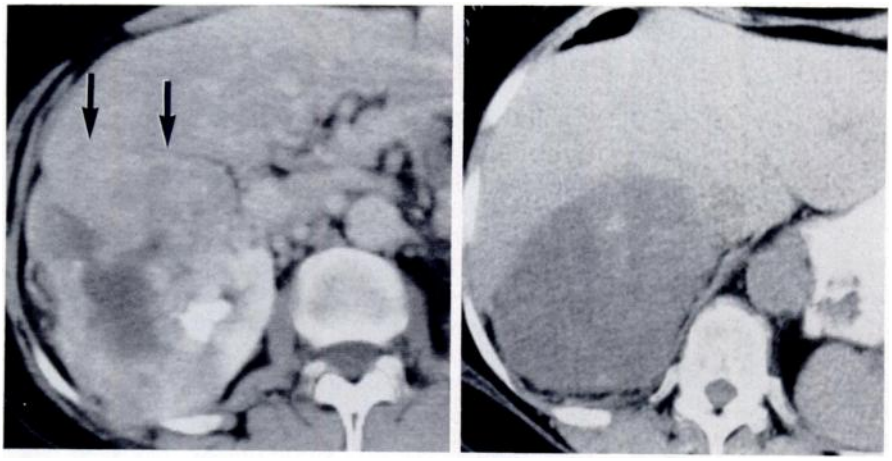

Fig. 4.—Adjacent organ invasion.
***A*, Large right-sided renal adenocarcinoma with loss of fat plane between the tumor and adjacent liver (*arrows*). No other signs of liver invasion visible, but at surgery hepatic invasion was present.**
***B*, Large right-sided renal adenocarcinoma with obliteration of fat plane between tumor and liver. No hepatic invasion was present at surgery.**

Table 2: Renal Adenocarcinoma, Overall Staging

CT Staging	Pathological Staging				Total
	I	II	III	IV	
I	34	5	1	0	40
II	0	4	1	0	5
III	1	0	14[a]	1	16
IV	0	0	0	39[b]	39
Total	35	9	16	40	100

[a] Includes two patients with distant metastases identified by CT but not confirmed pathologically.

[b] Includes six patients with proven distant metastases that were outside the region scanned by CT.

Discussion

CT is a reliable and accurate means of preoperatively staging renal adenocarcinoma, with an overall staging accuracy of 91%. These results are comparable to the 90–95% accuracy reported in previous smaller series [3, 6, 7]. Results from CT are important, for nearly all surgeons perform a partial or radical nephrectomy for stage I or stage II disease. Venous thrombus is important information preoperatively, because a more extensive surgical procedure may be required in attempting to clamp distal to intravascular tumor. Debulking of enlarged lymph nodes can also be planned if nodal metastases are identified. Treatment of stage IV disease differs from center to center; some perform a radical nephrectomy in nearly all patients while others do so only in symptomatic patients. In advanced disease, percutaneous biopsy to document a distant metastases is all that may be required before start of chemotherapy.

Perinephric invasion is the most troublesome CT area, accounting for more than half of the staging errors. Perinephric soft-tissue masses at least 1 cm in diameter were seen in only 46% of patients with proven tumor, accounting for this low sensitivity. Perinephric stranding is also very nonspecific, for it was seen in half of patients with stage I tumors. If errors associated with perinephric invasion were excluded, the CT accuracy improved to 98%. This is a legitimate consideration, for both stage I and stage II tumors are usually treated similarly with radical nephrectomy. Of course, perinephric invasion would be important if partial nephrectomy was considered.

The difficulties of detecting venous extension with CT have been previously reported [2, 9]. Half of our false-negative studies were in patients with large right-sided tumors in which the involved renal vein could not be identified. False-positive studies were seen in patients with enlarged renal veins that did not contain tumor. These enlarged renal veins were most likely caused by increased blood flow from a hypervascular tumor. These results may be improved by using bolus, dynamic, and thin-section collimation scanning. A larger contrast bolus with dynamic scanning should eliminate the false-positive studies. Thin sections during a bolus injection may make identification of short, distorted right renal veins easier. Equivocal cases should undergo angiography (either conventional or digital) [10, 11], sonography [12], or MR imaging to more carefully examine for venous thrombus.

Metastatic adenopathy was identified by CT with a sensitivity of 83% and a specificity of 88%. CT was successful in identifying nodal size and location. Errors were due to an inability to differentiate between normal hyperplastic nodes and cancerous nodes. Seven tumors had regional lymph nodes 1–2 cm in diameter, four (57%) contained cancer, and three (43%) were hyperplastic histologically. All nodes greater than 2 cm in diameter contained tumor. Therefore, nodes greater than 2 cm in diameter are highly suspicious for metastases. Nodes 1–2 cm in size are worrisome, but nondiagnostic.

Adjacent organ invasion was assessed in only a small number of tumors, because these patients typically had distant metastases that were more easily biopsied percutaneously without radical nephrectomy. By using the criteria for adjacent organ invasion of enlargement or density change, the sensitivity of CT was 60% with a specificity of 100%. Caution must be exercised when obliteration of the fat plane is observed between tumor and adjacent organ; this was observed in 15% of patients without adjacent organ invasion. Sonography and/or MR might be helpful in some patients

because of their capability to image sagitally and coronally and to provide a different means of tissue characterization.

Conclusion

Preoperative CT staging of renal adenocarcinoma is highly accurate. Perinephric invasion is the most difficult to detect but is of minor importance if radical nephrectomy is planned. Accurate assessment of renal vein invasion may require bolus, dynamic, and thin-collimation scanning, especially in large right-sided tumors in which identification of the short renal vein is most difficult. Lymph nodes larger than 2 cm in diameter were always associated with metastases in our series. Nodes 1–2 cm in diameter are worrisome but not diagnostic of metastases. Identification of a fat plane between tumor and adjacent organs excludes local invasion, but loss of the fat plane can be seen in 15% of patients without local invasion.

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