Abdom Imaging 20:365–367 (1995)

Abdominal Imaging

Transitional cell carcinoma of the upper urinary tract: staging by MRI

S. M. Weeks,[1] E. D. Brown,[1] J. J. Brown,[2] M. K. Adamis,[3] L. B. Eisenberg,[1] R. C. Semelka[1]

[1]Department of Radiology, University of North Carolina, Chapel Hill, NC 27599-7510, USA
[2]Department of Radiology, Mallinckrodt Institute of Radiology, Washington University, St. Louis, MO 63110, USA
[3]Department of Radiology, Beth Israel Hospital, Boston, MA 02215, USA

Received: 23 August 1994/Accepted after revision: 6 January 1995

Abstract

Background: This study evaluates the ability of MRI to stage transitional cell carcinoma of the upper urinary tract.

Methods: Nine patients who had transitional cell carcinoma of the upper urinary tract detected by other imaging modalities underwent MRI examination at 1.5 T. Imaging included pre- and postgadolinium-DTPA T1-weighted images (9 patients) pre- and postgadolinium chelate T1-weighted fat-suppressed spin echo (7 patients). Postcontrast images were acquired prior to the presence of gadolinium within the collecting system (<2 min postcontrast), intermediate (2.5–8 min), and late (>10 min) postcontrast. Images were prospectively interpreted and lesion staging was determined. Correlation with histopathology was obtained in all cases.

Results: Transitional cell cancers were demonstrated in 9/9 patients, and tumors ranged in size from 2 to 8 cm (mean = 3.8 cm) in one dimension. Correct tumor staging was performed in 8/9 patients. The staging error in one case occurred because direct tumor extension into the renal parenchyma was not detected.

Conclusions: The results of this preliminary study show that MRI stages transitional cell cancers relatively well; however, MRI is not able to detect superficial invasion of renal parenchyma.

Key words: Kidney, MR, 81.1214—Kidney, neoplasm, 81.31, 81.21—Magnetic resonance (MR), contrast enhancement.

Malignancies of the kidney and ureter are uncommon, accounting for 2–3% of all neoplasms [1]. Transitional cell carcinoma (TCCA) of the upper urinary tract is rare, accounting for approximately 8% of all renal tumors, and yet it is the second most common renal malignancy [2]. TCCA is diagnostically challenging because it is often multifocal at presentation and is frequently metachronous. On gross specimens, tumors may be rounded masses, superficial spreading lesions, or infiltrating renal masses. Recognition of the variety of appearances is necessary to detect and stage tumors accurately.

TCCA of the bladder has been extensively described in the CT and MRI literature [3–6]. The rarity of upper urinary tract TCCA accounts for the paucity of descriptions in the CT literature [7–10]. To our knowledge, no series reports exist in the MRI literature. The purpose of this study was to evaluate the ability of MRI to stage upper urinary tract TCCA.

Methods

Patients

Nine patients (7 males, 2 female; age range, 50–85 years; mean = 70.7 years) were entered into the study on the basis of detection of lesions arising from the urothelium on CT (6 patients), retrograde pyelography (2 patients), or both (1 patient). All patients underwent resection of tumors within 1 month of MRI.

MRI

All 9 patients underwent MRI examination on a 1.5 T MR imager (63SP or SP4000, Siemens, Iselin, NJ). Image acquisition included breath-held T1-weighted FLASH images (TR = 130–150 ms, TE = 4.5 ms, flip angle = 60–80°) in 9 patients, and T1-weighted fat-suppressed spin echo (T1FS, TR = 500 ms, TE = 15 ms) in 7 patients. Gadolinium-DTPA (Magnevist, Berlex USA, Wayne, NJ) was in-

Correspondence to: R. C. Semelka

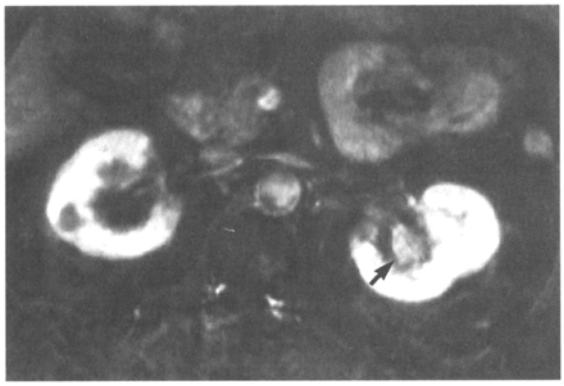

Fig. 1. Stage II transitional cell cancer on gadolinium-DTPA-enhanced T1FS image of a 51-year-old man. The tumor is identified in the upper aspect of the left renal pelvis and enhances with gadolinium-DTPA (*arrow*).

jected in a dosage of 0.1 ml/kg as a rapid i.v. bolus, and postcontrast images were acquired prior to the presence of gadolinium in the collecting system (<2 min), intermediate (3.5–8 min), and late (>10 min) postcontrast.

Image Interpretation

MR images were interpreted prospectively, and interpreters were blinded to the results of other imaging techniques. The tumors were staged using the American Joint Committee on Cancer criteria as follows [12]:

stage I: limited to uroepithelial mucosa and lamina propria;
stage II: invasion to, but not beyond, pelvic/ureteral muscularis;
stage III: invasion beyond muscularis into adventitial fat or renal parenchyma;
stage IV: distant metastasis.

Correlation of tumor staging was performed with histopathology in all cases: 8 patients by surgical resection and 1 case of stage IV disease by biopsy.

Results

MRI demonstrated tumors arising from the urothelium in all 9 patients. Tumors measured >2 cm in at least one dimension (range, 2–8 cm, mean = 3.8). Five patients had solitary focal mass lesions in one kidney (Fig. 1); 3 had superficial spreading tumors, including one of the renal pelvis, one of the upper ureter, and one extending from renal pelvis along upper ureter (Fig. 2), and 1 had bilateral tumors with diffuse infiltration of both kidneys.

MRI correctly staged 8/9 patients including 2/2 stage I/II tumors, 4/5 stage III tumors, and 2/2 stage IV tumors. One patient with stage IV TCCA had liver metastases, which were low in SI on postcontrast images. One patient with stage III cancer was incorrectly staged as stage II because superficial invasion of renal parenchyma was not detected on MR images.

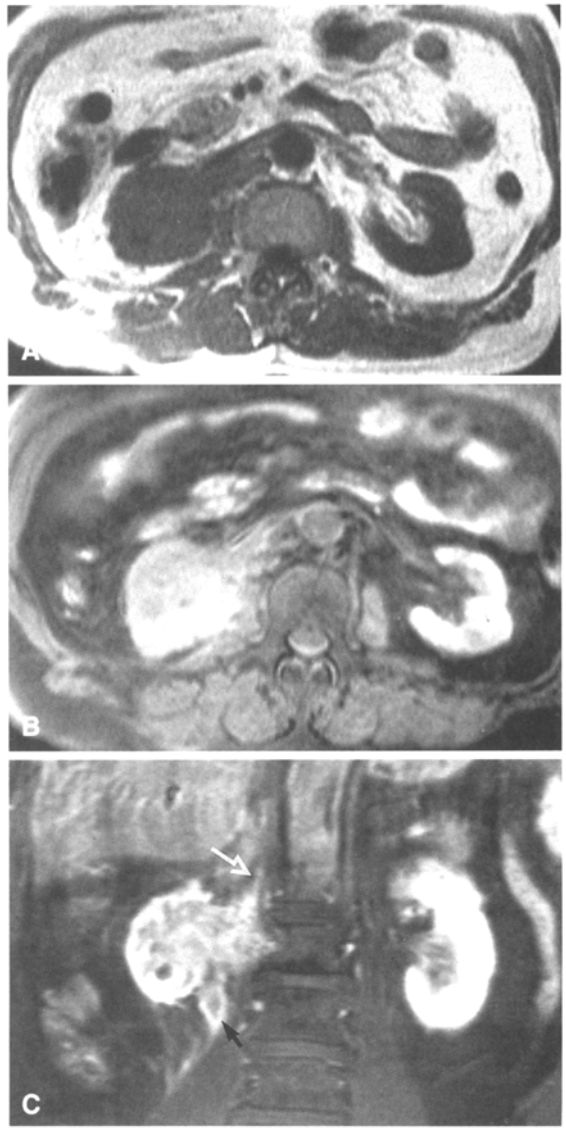

Fig. 2. Stage IV transitional cell cancer on T1-FLASH (**A**), T1FS (**B**), and gadolinium-DTPA-enhancer T1FS coronal (**C**) images of a 74-year-old man. The tumor demonstrates extension beyond the right renal pelvis. The extent of involvement is best demonstrated on the coronal image, in which the tumor is shown to extend along the ureter and psoas muscle (C, *black arrow*) and superiorly along the IVC (C, *white arrow*).

Appreciable tumor enhancement was observed in all tumors. On postcontrast MR images obtained prior to gadolinium appearance in the collecting system, tumors were intermediate in SI adjacent to signal-void urine. On intermediate postcontrast images, tumors were intermediate in SI adjacent to signal-void concentrated gadolinium-containing urine. On late postcontrast images, tumors were intermediate in SI adjacent to high SI dilute gadolinium-containing urine.

Discussion

TCCA of the upper urinary collecting system >2 cm in one dimension are well shown when using state-of-the-art MR imaging techniques that employ sequences which avoid respiratory artifact (breath-hold FLASH) or diminish artifact (fat-suppressed spin echo) [13, 14]. To facilitate demonstration of TCCA, we employed postcontrast techniques that exploit the variable appearances of urine following gadolinium injection, including early postcontrast signal-void urine (gadolinium-free urine), intermediate postcontrast (concentrated gadolinium-containing urine), and late postcontrast high SI urine (dilute gadolinium-containing urine). The differing contrast relationship between tumor and urine may increase the ability to demonstrate and stage TCCA. Interestingly, although TCCA is a hypovascular tumor, those neoplasms all showed moderate enhancement following gadolinium administration, which presumably reflects the high sensitivity of MRI for the presence of gadolinium [13–16].

A potential advantage of MRI over CT, which has been observed in the evaluation of bladder TCCA, is that the multiplanar imaging capability permits direct image acquisition in the plane of tumor spread [17]. This was helpful in the staging of 1 patient in our study, as coronal images allowed demonstration of superficial spread of tumor from renal pelvis to ureter, which was confirmed at surgery (Fig. 2).

As few MR descriptions of upper urinary tract TCCA exist [11], the comparison of our results with previous analogous CT studies appears warranted. In 1982, Baron et al. [8] reported that, in 22 patients with TCCA, periureteral and intrarenal tumor invasion, as well as distant metastatic disease, were accurately diagnosed in 5/8 patients. In 1992, Nynam et al. [9] reported that CT detected 23/28 urothelial tumors of renal pelvis, but correctly staged 21 cases. Also in 1992, Badalement et al. [10] reported that demonstration of intrarenal or periureteral invasion on CT images in 4/7 patients was a sensitive indicator for advanced disease. These results are consistent with the findings of our study in that tumor demonstration by CT or MRI appears good, whereas tumor staging is less accurate.

Limitations of this study include a small patient population and all patients had a known urothelial lesion prior to MRI. These limitations are difficult to avoid due to the rarity of these tumors. MR images were, however, interpreted blind to the findings of the other imaging modalities. Nonetheless, findings in this study should be considered preliminary.

In conclusion, our preliminary results suggest that MRI performs well at staging upper urinary tract TCCA. Multiplanar imaging and high soft-tissue contrast are advantages of MRI; however, errors in staging occur due to the inability to recognize superficial renal parenchymal invasion.

References

1. McClennan B, Balfe D. Oncologic imaging: kidney and ureter. *Rad Onc Bio Physics* 1983;9:1683–1704
2. Richie JP. Carcinoma of the renal pelvis and ureter. In: Skinner DG, Lieskovsky G, eds. *Diagnosis and management of genitourinary cancer.* Philadelphia: WB Saunders. 1988:323–336
3. Husband JE, Oliff JF, Williams MP, Heron CW, Cherryman GR. Bladder cancer: staging with CT and MRI imaging. *Radiology* 1989;173:435–440
4. Barentsz JO, Ruijs SHJ, Strijk SP. The role of MR imaging in carcinoma of the urinary bladder. *AJR* 1983;160:937–947
5. Neuerburg JM, Bohndorf K, Sohn M, et al. Urinary bladder neoplasms: evaluation with contrast-enhanced MR imaging. *Radiology* 1989;172:739–743
6. Bryan PJ, Butler HE, LiPuma JP, et al. CT and MR imaging in staging of bladder neoplasms. *J Comput Assist Tomogr* 1987;11:96–101
7. Leder RA, Dunnick NR. Transitional cell carcinoma of the pelvicalices and ureter. *AJR* 1990;155:713–722
8. Baron RL, McClennan BL, Lee JKT, Lawson TL. Computed tomography of transitional cell carcinoma of the renal pelvis and ureter. *Radiology* 1982;144:125–130
9. Nyman U, Oldbring J, Aspelin P. CT of carcinoma of the renal pelvis. *Acta Radiol* 1992;33:31–38
10. Badalament RA, Bennett WF, Bova JG, Kenworthy PR, Wise HA, Smith S, Perez J. Computed tomography of primary transitional cell carcinoma upper urinary tracts. *Urology* 1992;40:71–75
11. Leo ME, Petrou SP, Barrett DM. Transitional cell carcinoma of the kidney with vena caval involvement: report of 3 cases and a review of the literature. *J Urol* 1992;148:397–400
12. Bears OH, Henson DE, Hatler RVP, Kennedy BJ, eds. *Manual for staging cancer: American Joint Committee on Cancer,* 4th ed. Philadelphia: JP Lippincott. 1992:205–207
13. Semelka RC, Shoenut JP, Magro CM, Kroeker MA, MacMahon R. Renal cancer staging: comparison of contrast-enhanced CT and gadolinium-enhanced fat-suppressed spin-echo and gradient-echo MR imaging. *JMRI* 1993;3:597–602
14. Semelka RC, Schoenut JP, Kroeker MA, Hricak H, Minuk GV, Yaffe CS, MicFlikier AB. Bile duct disease: prospective comparison of ERCP, CT, and fat-suppressed MRI. *Gastrointest Radiol* 1992;17:347–352
15. Semelka RC, Hricak H, Stevens SK, Finegold R, Tomei E, Carroll PR. Combined gadolinium-enhanced and fat-saturation MR imaging of renal masses. *Radiology* 1991;178:803–809
16. Semelka RC, Shoenut JP, Kroeker MA, McMahon RG, Greenberg HM. Renal lesions: controlled comparison between CT and 1.5 T MR imaging with nonenhanced and gadolinium-enhanced fat-suppressed spin-echo and breath-hold FLASH techniques. *Radiology* 1992;182:425–430
17. Narumi Y, Kadota T, Inone E, et al. Bladder tumors: staging with gadolinium-enhanced oblique MR imaging. *Radiology* 1993;187:145–150