Pelvic Adenopathy in Prostatic and Urinary Bladder Carcinoma: MR Imaging with a Three-Dimensional T1-Weighted Magnetization-Prepared–Rapid Gradient-Echo Sequence

OBJECTIVE. The purpose of this study was to evaluate a magnetization-prepared–rapid gradient-echo (MP-RAGE) sequence as a three-dimensional (3D) T1-weighted MR imaging technique to reveal lymph node metastases from carcinoma of the bladder and the prostate.

SUBJECTS AND METHODS. Using a 3D T1-weighted MP-RAGE sequence, MR images of 134 consecutive patients with prostate carcinoma (n = 63) or urinary bladder carcinoma (n = 71) who were scheduled for radical prostatectomy or radical cystectomy were correlated with histopathologic findings after fine-needle aspiration biopsy (FNAB) (n = 6), open or laparoscopic pelvic lymph node dissection (n = 127), or autopsy (n = 1). MR imaging was used 10 times to guide FNAB in nine patients.

RESULTS. The sensitivity, specificity, accuracy, and positive predictive value of the technique were 75%, 98%, 90%, and 94%, respectively. Thin-slice (1.2-mm) multiplanar reconstructed images correctly revealed diseased nodes in 33 patients. However, MR imaging failed to reveal microscopic metastatic deposits in normally sized nodes in 11 patients. Two other patients had enlarged nodes without metastasis. Furthermore, FNAB guided by MR imaging revealed metastases in six of nine patients.

CONCLUSION. MR imaging with a 3D MP-RAGE sequence was accurate in revealing nodal metastases from carcinoma of the prostate and bladder. This imaging technique can be used to select patients for biopsy or laparoscopic pelvic lymph node dissection.
received 0.5 mg of glucagon IV before the examination. To reduce respiratory motion, an adjustable belt was wrapped around the abdomen to induce slight compression. In the 3D MP-RAGE implementation, T1-weighting was obtained with a 180° inversion pulse for magnitude preparation. For each of the phase-encoding steps in the second dimension, the inversion preparation was applied and then the rapid gradient-echo data acquisition was obtained; the latter step extended into the phase encoding for the third dimension. The sequence parameters were 10/4 (TR/TE); inversion time, 500 msec; flip angle, 10°; matrix size, 192 × 256; field of view, 25 cm; two acquisitions; and voxel size, 1.0 × 1.3 × 1.6 mm. A total of 128 contiguous images were obtained in 9 min. From this image set, off-line multiplanar reconstruction of images in specific planes was performed depending on the preference of the investigator. A plane parallel to the external iliac vessels was always included. In patients with urinary bladder carcinoma, the 3D MP-RAGE sequence was part of local staging [2].

Histologic examination after laparoscopic lymph node dissection revealed metastatic deposits. Reconstructed 3D MP-RAGE image in slightly angulated coronal plane reveals enlarged lymph nodes (arrow).
MR imaging revealed lymph node metastases in 33 of 44 patients. MR imaging failed to depict metastases in 11 patients with unenlarged nodes. No metastatic disease was found in two patients with enlarged nodes.

The MR technique proved to have a sensitivity of 77%, a specificity of 94%, an accuracy of 98%, and a positive predictive value of 95%.

Prostatic Carcinoma

The MR pelvic lymph node findings in 63 patients with prostatic carcinoma are correlated with the results of pathologic examination in Table 1. Metastases were revealed by MR imaging in nine patients. In these patients, 15 enlarged lymph nodes were shown with a mean diameter of 11 mm (range, 8–18 mm). In three of these patients, lymph node metastases were present in round nodes with a diameter of 8 or 9 mm. In six patients, lymph node metastases were present in normally sized nodes. The diameter of the largest false-negative node was 6 mm (Fig. 5). In the one patient with a false-positive lymph node, we measured a diameter of 10 mm on reconstructed MR images.

Urinary Bladder Carcinoma

The MR pelvic lymph node findings in 71 patients with invasive urinary bladder carcinoma are correlated with pathologic examination in Table 2. Metastases were predicted correctly in 24 patients. In these 24 patients, 39 enlarged lymph nodes were detected. The mean axial diameter was 12 mm (range, 9–18 mm). Metastases in five patients were predicted correctly because they were round. The diameter of the involved nodes was 9–10 mm. In one patient with false-positive nodes, the minimal axial diameter of the largest node was 15 mm. However, this node did not contain metastatic disease.

In nine patients with enlarged nodes, MR imaging was used to guide FNAB. All patients appeared to have metastases. In four patients, insufficient aspirated material precluded diagnosis. These cases were classified as false-negative. In one patient the procedure was repeated, and enough material was aspirated for diagnosis. In six patients tumor cells were seen after FNAB guided by MR imaging. All failures occurred in the first five procedures, suggesting a learning curve for this procedure.

Discussion

Accuracy of MR Imaging for Nodal Staging

Local and regional lymph nodes are routinely evaluated for metastases in candidates for radical prostatectomy or cystectomy. Surgical PLND is the most invasive and reliable method for establishing metastatic disease in pelvic lymph nodes. However, frozen sectioning has been reported to be false-negative in 33% of patients [6]. Laparoscopic PLND is less invasive and almost as accurate in sampling lymph nodes (90%). However, this method requires more skill and experience, and if no lymph node metastases are found a second operation is performed [7]. Therefore, a noninvasive, reliable method for detecting and staging nodal metastasis would reduce unnecessary surgery.

CT and MR imaging are reported to be the most accurate noninvasive techniques for nodal staging, but accuracy rates vary widely. For CT, the sensitivity varies from 0% to 100%, and the specificity varies from 44% to 100%.
A FNAB-initiated T3 tumor has a 68-93% probability of microscopic metastases [18], radical cystectomy is indicated in a plane that is not perpendicular to its long axis, the size of the node can be overestimated. We used reconstructions in every desired plane, which may explain the relatively low number of false-positive lymph nodes in our series.

**Nodal Staging in Prostatic Carcinoma**

Lymph node metastasis in patients with prostatic carcinoma is highly related to tumor grade and clinical stage. The chance that a patient with a well-differentiated T1a tumor has lymph node metastases is 0% [12, 13], whereas a patient with a poorly differentiated T3 tumor has a 68-93% probability of having nodal metastases [12, 14]. Lymph node metastases can also be assessed by prostate-specific antigen levels [13, 15].

Because of an increasing trend to perform surgery on patients in the early stages of prostatic carcinoma, the incidence of lymph node metastases has decreased to 5-15% [16]. Therefore, routine use of PLND is no longer considered justified in all patients [13]. Also, the diagnostic yield of imaging for nodal staging is considered too low for routine use [13]. Cost-effective analysis performed by Wolf et al. [5] pointed out that imaging should be restricted to patients with a high probability of lymph node metastasis. They stated that when the probability of positive nodes based on prostate-specific antigen level and clinical stage was 32%, the sensitivity of the imaging method must be 36% to be beneficial. When the sensitivity was 25%, as in their series, prior probability should be 45% if FNAB provided a sensitivity of 70%.

We achieved a high sensitivity in our series. Because metastases may occur in normally sized nodes, the sensitivity of imaging cannot be 100%. In a series of 39 lymph node metastases [6], 14 were present in lymph nodes smaller than 1 mm. Of these, seven were not recognized on frozen sections.

In our study, subjects were restricted to those patients whose true disease status was verified by pathologic examination (verification bias). If clinicians' confidence in MR staging increases, the need for pathologic confirmation decreases. A patient with obvious T3c disease (seminal vesicle invasion) and enlarged lymph nodes will no longer undergo FNAB, and the number of true-positive nodes decreases. In addition, the real prevalence of disease affects the reported figures. In our hospital, MR staging is no longer indicated in patients with low-grade tumors (prostate-specific antigen concentration < 10 ng/ml), so we expect a lower number of true-negative results.

**Nodal Staging in Urinary Bladder Carcinoma**

In patients with urinary bladder carcinoma, lymph node metastases is related strongly to tumor stage. Lymph node metastases in patients with superficial tumors (less than T3) are rare, but if the deep muscle layer is involved (T3a) or if extravesical invasion is seen, the incidence of lymph node metastases rises to 20-30% and 50-60%, respectively [17]. Although some authors advocate radical cystectomy even when the patient has microscopic metastases [18], radical cystectomy is not justified if lymph node metastases are detected [19].

The sensitivity of nodal staging in patients with urinary bladder carcinoma was better than that in patients with prostatic carcinoma. The difference between these two groups of patients is also seen in previous reports. For prostatic cancer and urinary bladder cancer, the overall reported sensitivities for nodal staging with MR imaging are 32% [1, 4, 5, 10, 20-25] and 64% [10, 19, 26-32], respectively.

The 3D MP-RAGE sequence in our hospital plays an integral part in staging urinary bladder carcinoma. Therefore, nodal staging does not affect the costs of staging. In patients with urinary bladder carcinoma, laparoscopic PLND is no longer done because of the chances of tumor seeding. In patients with lymph node metastases shown by MR imaging, we use FNAB guided by MR imaging.

**FNAB**

FNAB of pelvic lymph nodes has been performed under sonographic [33], CT [4], or lymphangiographic [34] guidance. The
reported sensitivity varies from 50% to 100% with a mean of 70% [5]. In our preliminary study of FNAB, we achieved a sensitivity of 60% in 10 procedures, obviating the need for radical cystectomy in six of nine patients. False-negative results were obtained in the first patient in whom we performed the procedure. Compared with CT, FNAB has no advantages; it is more time-consuming and expensive. With new MR-imaging-compatible puncture devices and open-configuration, superconducting MR imagers, which allow direct access to the patient during the procedure [35], we expect to overcome some of these problems.

Nodal staging using the 3D MP-RAGE technique is excellent compared with other MR studies and most CT studies. Therefore, local and nodal staging should be integrated into one MR examination. We advise MR staging in all patients with urinary bladder carcinoma with muscle invasion who are considered surgical candidates and in candidates for radical prostatectomy who have a Gleason score of seven or more (moderately dates for radical prostatectomy who have a metastatic disease, an FNAB is advised.

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References