ABSTRACT

Objectives. To assess magnetic resonance imaging (MRI) combined with artificial erection for local staging of penile cancer.

Methods. We compared local clinical, MRI plus artificial erection, and pathologic staging in 9 cases of penile cancer. Erection was obtained by injecting 10 μg prostaglandin E1 into the corpora cavernosa. T1-weighted and T2-weighted MRI with and without contrast was obtained using a phased array coil. Local treatment was based on tumor location and extent, as defined by the clinical and MRI findings.

Results. The histologic diagnosis was squamous cell carcinoma in 8 patients and sarcoma in 1. The MRI and pathologic staging coincided in 8 of 9 patients. MRI, clinical, and pathologic staging coincided in 5 patients: 4 had Stage T2 and 1 had Stage T1 disease. In 2 patients, the MRI and pathologic stage was T2, but the clinical stage differed. Another patient had Stage T2 clinically but T3 by MRI and pathologic staging. In the last patient, none of the stages coincided (clinical Stage T1, MRI Stage T0, and pathologic Stage Tis). The only complication during the procedure was that 1 patient developed priapism after prostaglandin injection, which was relieved by evacuation of the corpora cavernosa.

Conclusions. To our knowledge, this is the first study to use artificial erection with MRI to stage local penile cancer. The method appears promising for local staging of penile cancer, but additional studies are necessary to confirm its utility.

Cancer of the penis is rare in Western countries, constituting less than 1% of male cancers. However, the cancer occurs in all races and is more common in South American, Asian, and African countries, where it may account for up to 20% of male cancers. The local disease extent has a major influence on treatment, which can be organ sparing (external beam radiotherapy, brachytherapy, cryotherapy, Mohs microscopic surgery laser surgery, or excision) or nonconservative with partial or complete penectomy. Psychosexual morbidity and functional loss are mainly associated with nonconservative therapy. The accurate assessment of the clinical stage and depth of lesion penetration are fundamental for planning optimal treatment.

Physical examination, urethrography, cavernosography, and ultrasonography may achieve these aims. However, we know of no study that has assessed the clinical stage of penile cancer using magnetic resonance imaging (MRI) in combination with artificial erection. MRI affords multiplanar visualization and high tissue contrast to give an excellent view of the penile anatomy. When used in conjunction with artificial erection, MRI provides optimal imaging of all anatomic components of the penis, particularly the corpora cavernosa, tunica albuginea, and corpus spongiosum and their anatomic boundaries. This is particularly evident on T2-weighted (rather than T1-weighted) images, in which the thin tunica albuginea (collagen tissue enveloping the corpora cavernosa and corpus spongiosum) has a low signal intensity, and the corpora cavernosa have high signal intensity. We report on 9 patients with pathologically confirmed penile cancer after biopsy, in whom MRI with artificial erection was used for staging. We
compared the MRI stage with the clinical and final pathologic stage of the disease.

**MATERIAL AND METHODS**

An initial 10 cases of penile cancer were staged and treated at the Division of Urology of the European Institute of Oncology (Milan, Italy) from 2001 to 2003. One case was excluded from this study because the cancer was recurrent. Patients underwent physical examination to determine the clinical stage and MRI with artificial erection to determine the MRI stage. Erection was obtained by injecting 10 μg of prostaglandin E1 into the corpus cavernosum. MRI was performed with a 1T machine (Signa Horizon LX, General Electric, Milwaukee, Wis) using a four-channel phased-array coil with the patient in the supine position. In all cases, spin-echo T1-weighted (TR 380 to 450 ms, TE 14 ms) and fast spin-echo T2-weighted (TR 3500 to 4500 ms, TE 104 ms) sequences were obtained in the axial and sagittal or coronal planes, with a 3 to 4-mm slice thickness, 0.3 to 0.4-mm gap, and 3 to 5 averages after erection. Use of the phased-array coil allowed a 24-cm field of view with a 320 × 224 matrix. After intravenous gadolinium injection (0.2 mL/kg), additional T1-weighted images were obtained in the axial and sagittal or coronal planes.

We used the TNM classification of the American Joint Committee on Cancer staging system of 2002. The study was exempt from ethical approval. All patients provided previous written informed consent. Treatment was decided on the basis of the tumor location and extent, as defined by the clinical examination and MRI findings. Patients with Stage T1 disease were treated with laser resection, those with Stage T2 and T3 underwent partial or total penectomy.

**RESULTS**

The clinical, MRI, and pathologic stages in the 9 patients are presented in Table 1, together with patient age, lesion localization, and treatment. Patient age ranged from 47 to 68 years (mean 55.1). In 3 patients, the lesion was in the glans; in 2, the glans and prepuce; in 2, the coronal sulcus; in 1, the prepuce; and in 1, the shaft. The histologic diagnosis was squamous cell carcinoma in 8 patients and penile sarcoma in 1 (patient 3, Table 1).

In 5 cases, the clinical, MRI, and pathologic stages coincided: 4 were Stage T2 (patients 3, 4, 5, and 7) and 1 was Stage T1 (patient 2). Treatment was total penectomy (in patient 3 with a shaft lesion), partial penectomy (patients 4, 5, and 7), and laser resection (patient 2). In three other cases (patients 1, 8, and 9), the MRI and pathologic stage coincided but the clinical stage differed. Patient 8 had clinical Stage T2 but the MRI and pathologic stage was T3. The other 2 cases were Stage T2 pathologically and by MRI, but T1 clinically. All 3 patients underwent partial penectomy. The remaining case, patient 6, had Stage T1 clinically and T0 by MRI, but the pathologic examination revealed in situ carcinoma.

One complication occurred during the MRI procedures. Patient 2 developed priapism secondary to prostaglandin injection, which was relieved by evacuation of the corpora cavernosa.

**COMMENT**

The definition of the standard protocols for evaluating and treating penile cancer is rendered difficult by the rarity of the disease in Western countries. Depending on the stage of the primary lesion, conservative management may be possible, thereby avoiding the psychosexual morbidity and functional loss associated with non-organ-sparing treatment. Clinical examination is unable to assess the tumor extent accurately, and ultrasonography and MRI may be used to stage the primary lesion in penile cancer. In a study of 16 patients, Horenblas et al. used ultrasonography to assess the extent of penile lesions and invasion into the corpora cavernosa. They found that ultrasonography was useful for staging this cancer, except when located on the glans, because the tunica albuginea was not easily identifiable, and Stage T1 and T2 could not be distinguished. Ultrasonography was also used on 59 Indian patients in a study by Agrawal et al. All 59 patients had Stage T2 disease clinically. In 4 patients, ultrasonography changed the clinical stage. However, the study was concerned with assessing tumor extent, not with comparing the stage. The investigators concluded that ultrasonography was more accurate than clinical

<table>
<thead>
<tr>
<th>Pt. No.</th>
<th>Age (yr)</th>
<th>Site</th>
<th>Clinical Stage</th>
<th>MRI Stage</th>
<th>Pathologic Stage</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>68</td>
<td>Glans and prepuce</td>
<td>T1</td>
<td>T2</td>
<td>T2</td>
<td>Partial penectomy</td>
</tr>
<tr>
<td>2</td>
<td>48</td>
<td>Glans</td>
<td>T1</td>
<td>T1</td>
<td>T1</td>
<td>Laser resection</td>
</tr>
<tr>
<td>3</td>
<td>63</td>
<td>Shaft</td>
<td>T2</td>
<td>T2</td>
<td>T2</td>
<td>Total penectomy</td>
</tr>
<tr>
<td>4</td>
<td>57</td>
<td>Prepuce</td>
<td>T2</td>
<td>T2</td>
<td>T2</td>
<td>Partial penectomy</td>
</tr>
<tr>
<td>5</td>
<td>54</td>
<td>Coronal sulcus</td>
<td>T2</td>
<td>T2</td>
<td>T2</td>
<td>Partial penectomy</td>
</tr>
<tr>
<td>6</td>
<td>47</td>
<td>Coronal sulcus</td>
<td>T1</td>
<td>T0</td>
<td>Tis</td>
<td>Laser resection</td>
</tr>
<tr>
<td>7</td>
<td>55</td>
<td>Glans and prepuce</td>
<td>T2</td>
<td>T2</td>
<td>T2</td>
<td>Partial penectomy</td>
</tr>
<tr>
<td>8</td>
<td>50</td>
<td>Glans</td>
<td>T2</td>
<td>T3</td>
<td>T3</td>
<td>Partial penectomy</td>
</tr>
<tr>
<td>9</td>
<td>54</td>
<td>Glans</td>
<td>T1</td>
<td>T2</td>
<td>T2</td>
<td>Partial penectomy</td>
</tr>
</tbody>
</table>

Key: Pt. No. = patient number; MRI = magnetic resonance imaging.
examination in estimating the extent of the primary lesion. Hricak et al. studied abnormal penile conditions by MRI without intravenous contrast injection and concluded that the technique could inform surgical decision-making in patients with penile neoplasms. In 1994, Kawada et al. reported the use of MRI to evaluate tumor extent in 2 patients. In both cases, the MRI stage coincided with the histologic stage, and they recommended MRI for evaluating penile cancer and determining treatment, especially when invasive cancer was suspected. de Kerviler et al. investigated the role of contrast-enhanced MRI without artificial penile erection to stage primary or recurrent penile cancer using a round surface coil in 9 patients. (Their was the largest series we found in the literature.) Clinical evaluation correctly determined the stage in 6 patients, MRI in 7 patients, and both modalities combined in 8. They concluded that MRI was valuable for evaluating invasive penile cancer, but had limitations for the evaluation of Stage T1 disease. They also noted that recurrent lesions should be assessed carefully, because fibrosis could be misdiagnosed as malignancy. They recommended that the MRI study should include T2-weighted and contrast-enhanced T1-weighted sequences, because they provide optimal contrast between the tumor and surrounding tissues.

Unlike other studies, we used artificial erection combined with MRI to achieve optimal revelation of the penile anatomy (Fig. 1). The contrast between the tunica albuginea and corpora cavernosa was better on the T2-weighted than on the T1-weighted images, including T1-weighted images with contrast (Figs. 2 to 4). Generally, the corpora cavernosa were characterized by high signal intensity on T2-weighted images, but sometimes presented with low signal intensity owing to fibrosis or transiently decreased blood flow secondary to psychologic or somatic factors. The signal intensity of the corpora cavernosa changes markedly with increased blood flow. Erection has the advantage, in MRI, not only of increasing the image size, but also of increasing the signal intensity of both corpora cavernosa as a result of increased blood flow. In the flaccid penis, the tunica albuginea has low signal intensity on MRI. During erection, it becomes thinner, yet the signal intensity increases, often allowing determination of its exact limits in relation to the corpora cavernosa (Fig. 1). We found that lesion location did not influence the ability of MRI to stage the lesion.

We found that MRI plus erection correctly staged the disease of 8 of the 9 patients in our series. The failure was in patient 6, in whom no lesion was found on MRI but the clinical assessment indicated that the superficial lesion should be removed. After laser resection, the histologic examination revealed carcinoma in situ, which is difficult to identify with any diagnostic method. Thus, laser resection decided on the basis of the clinical findings, was adequate.

The treatment was changed as a result of the MRI findings in patients 1 and 9. Both had Stage T1 by
clinical evaluation and would normally have undergone laser resection. In both, however, MRI demonstrated corpus spongiosum involvement (Stage T2), and they underwent partial penectomy instead. In these cases, MRI with artificial erection was more accurate than clinical staging and resulted in more aggressive treatment. Laser resection would have been undertreatment. Finally, the organ-sparing treatment for patient 2, which was decided on the basis of the MRI and clinical findings, was adequate in view of the Stage T1 disease found on the histologic examination.

CONCLUSIONS

The results of our study showed that pharmacologic erection in combination with MRI is a promising method for staging primary penile cancer.

FIGURE 2. Axial MRI of Stage T1 penile cancer after erection. (A) T2-weighted image. Lack of infiltration is more clearly evident than in (B) T1-weighted image with contrast. Tunica albuginea is line of low-signal intensity (white arrow) not infiltrated by tumor (black arrow).

FIGURE 3. Coronal MRI of penis with artificial erection showing T1 cancer. (A) T2-weighted image. Lack of infiltration is more clearly evident than in (B) T1-weighted image with contrast. Tunica albuginea is line of low-signal intensity (white arrow) not infiltrated by tumor (black arrow).
Gadolinium injection did not help to determine the lesion margins. However, additional comparative studies are necessary to confirm these initial results.

REFERENCES