Cervical cancer staging through Magnetic Resonance Imaging (MRI): What the radiologist needs to know

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Learning objectives

Cervical carcinoma is one of the most common cancers in developing countries, accounting for 6% of all malignancies in women and is associated with a high mortality (1). The International Federation of Gynecology and Obstetrics (FIGO) staging system, updated in 2009, is commonly used for treatment planning but is inadequate in the evaluation of prognostic factors like tumor volume and nodal status. Magnetic Resonance Imaging (MRI) is the preferred imaging modality because of its ability to assess soft tissue in detail, permitting thereby better identification of stromal and parametrial invasion. MRI tells us the exact volume, shape, local extent of the disease, and nodal status accurately, which helps the clinician in treatment planning. Therefore, MRI is now widely accepted as optimal for evaluation of the main prognostic factors and selection of therapeutic strategy.

The current exhibit aims to:

- To demonstrate diagnostic strategy of Uterine Cervix Cancer (UCCa) by using MR techniques.

- To illustrate a systematic approach to staging UCC based on MRI.

Background

Cervical cancer is the worldwide leading cause of cancer-related death of women, especially in developing countries (2). The International Federation of Gynecology and Obstetrics (FIGO) staging system is the most widely accepted method for staging cervical cancers. The first FIGO staging system was created in 1958. It was updated in 1988 and was most recently revised in 2009 (3). Cancer staging is fundamentally important in treating patients with cancer and must be reliable, reproducible, and practical.

The FIGO staging system recommends staging during surgery; however, surgical-pathologic staging would not be feasible in cases of more advanced cancers. Generally, in these cases, the staging is performed by means of clinical and gynecological examination and basic imaging studies. However, such an approach fails to demonstrate the actual extent of the disease, and does not include significant prognostic factors such as tumor volume, stromal invasion and lymph node involvement.
The revised FIGO staging system acknowledges the benefits of staging on the basis of MR imaging findings. In fact, MRI has proved its efficiency in cervical cancer staging, since at early stages of the disease its performance may be compared to intraoperative findings and, at advanced stages, it shows to be superior to the clinical evaluation (3). Additionally, MRI presents an excellent imaging resolution for the different densities of pelvic structures, does not require ionizing radiation, improves the staging, and allows the early detection of recurrence and the identification of reliable prognostic factors, which contribute to the therapeutic decision making process and results prediction with an excellent cost-effectiveness.

We aim to demonstrate the MR imaging protocol for the detection and staging of UCCa, as well as the MR imaging findings on each stage of UCCa -with respect to the revised FIGO staging system- and their effect on determining prognosis and treatment strategies.

**Findings and procedure details**

I- MRI protocol:

The basic gynecologic pelvic MR imaging protocol includes acquiring axial, sagittal, and coronal T2-weighted images. Oblique axial T2-weighted images planned perpendicular to the long axis of cervix give more accurate assessment of stromal involvement and parametrial invasion. Fat-suppressed sequences can be useful for the evaluation of parametrial involvement (4). Axial spin-echo T1- or T2-weighted images of the abdomen and pelvis are used to depict enlarged lymph nodes, hydronephrosis, and bone marrow abnormalities (3).

Use of intravenous contrast medium does not improve depiction of disease extent in patients with cervical carcinoma because of the variable enhancement of cervical tumors; therefore, contrast medium is not routinely used in cervical cancer staging protocols. However, it can be useful to identify bladder and rectal wall invasion, fistulas, and in the detection of recurrent tumor. The European Society of Urogenital Radiology (ESUR) guidelines for staging cervical carcinomas recommend considering the use of intravenous contrast medium or diffusion-weighted imaging (DWI) in patients with small lesions, which are not well depicted on T2-weighted images, and those who underwent treatment (3). Dynamic images are obtained in axial, coronal, and sagittal planes, 30-60 seconds after gadolinium injection, as they show increased early contrast enhancement relative to the cervical stroma (5).

DWI has an increasingly accepted role in routine cervical carcinoma staging because it increases tumor conspicuity and aids in image interpretation. Diffusion-weighted images
are acquired in the sagittal and axial oblique planes, perpendicular to the cervical canal (3).

II- Appearances at MR Imaging:

MRI anatomy of the cervix is best delineated on T2-weighted image as it outlines the major zones of cervix. The normal cervix demonstrates a trilaminar pattern of signal intensity, with high-signal-intensity endocervical mucosal glands surrounded by low-signal-intensity stroma and a rim of intermediate-signal-intensity smooth muscle (3, 5).

On T2-weighted images, cervical carcinoma appears as an intermediate- to high-signal-intensity mass that replaces the low-signal-intensity cervical stroma. Enhancement of cervical cancer varies on dynamic multiphase contrast-enhanced T1-weighted images, with small tumors enhancing earlier than adjacent cervical stroma and larger tumors demonstrating a variable degree of enhancement (4, 6).

On diffusion-weighted imaging, tumor typically demonstrates restricted diffusion with an area of hypointensity on apparent diffusion coefficient (ADC) maps (2).

III- Effect of imaging on risk stratification and disease management:

The revised FIGO staging system recommends now performing MR imaging.

There is no role for MR imaging in patients with stage IA disease because it is, by definition, microscopic and, therefore, not visible at MR imaging. However, treatment of patients with early stage disease (stages IIA1 and IB1) comprises surgery, including trachelectomy and radical hysterectomy. Therefore, it is crucial that tumor extension beyond the cervix be identified preoperatively on MRI (7).

Besides, MR imaging helps exclude parametrial invasion with a negative predictive value of 94%-100%, enabling identification of patients who are suitable for radical surgery, which is contraindicated in patients with parametrial invasion (8). In addition, MR imaging assessment of patients' suitability to undergo trachelectomy is essential. Ideally, trachelectomy requires that tumors be smaller than 2 cm, the cervix be longer than 2 cm, and the distance from the internal cervical os be more than 1 cm (9).

MR imaging may also exclude local invasion into the bladder and rectum with a negative predictive value of 100% (10). It is a sensitive and specific tool for depicting lymph node metastases, which are associated with a poorer prognosis.
Furthermore, distant metastases, including liver and bone metastases, which are not apparent at clinical assessment, may be depicted at MR imaging.

**IV- Revised FIGO Staging:**

In the new FIGO staging system, three changes were made: First, the use of diagnostic imaging, including CT and MR imaging, to stage cervical tumors is recommended but remains nonmandatory. Second, stage IIA was subdivided according to size into stages IIA1 (tumors 4 cm or smaller) and IIA2 (tumors larger than 4 cm). Third, examinations performed with anesthesia, including cystoscopy and proctoscopy, are optional and no longer mandatory (11).

The revised FIGO staging system acknowledges the benefits of staging based on MR imaging findings (Figure 1). In particular, imaging provides accurate information about important prognostic factors, such as tumor size, parametrial and pelvic sidewall invasion, and lymphadenopathy.

**1- Stage I:**

In stage I, the tumor is limited to cervix. Stage IA is a microscopic disease and is not visible on MRI. A visible tumor clinically stages the patient as IB or higher. Stage IB tumors are further subdivided by size: Stage IB1 tumors are smaller than 4 cm, and Stage IB2 tumors are 4 cm or larger.

On T2-weighted images, stage IB tumors typically demonstrate intermediate to high signal intensity compared with the cervical stroma; but peripheral T2-hypointense stroma is maintained (12) (Figure 2).

**2- Stage II:**

In stage II, tumors extend beyond the cervix and involve the upper two-thirds of the vagina, but do not extend to the pelvic sidewall or the lower one-third of the vagina. Stage II is further subdivided according to the absence (stage IIA) or presence (stage IIB) of parametrial invasion.

Involvement of the upper two-thirds of the vagina is seen on T2-weighted images as a high-signal-intensity lesion disrupting the low-signal-intensity vaginal wall (Figure 3).
According to revised FIGO staging, if the tumor size is smaller than 4 cm, it is stage IIA1 and if it is larger than 4 cm, it is stage IIA2.

In stage IIB, the tumor disrupts the normally seen hypointense peripheral stroma on T2-weighted images and extends in the parametrium (Figure 4). Intact T2-hypointense stroma ring, thicker than 3 mm—a finding known as the "hypointense rim" sign—has a high negative predictive value for parametrial invasion and is between 94% and 100% (13). Confident diagnosis of parametrial invasion is made when one sees the spiculated tumor-parametrial interface, soft tissue mass in parametrium, encasement of periuterine vessels and ureter.

In large tumors, parametrial invasion may be overestimated on T2-weighted images due to the presence of stromal edema, which is caused by compression of the tumor or inflammation (14).

3- Stage III:

In stage IIIA, tumors extend to the lower one-third of the vagina but not the pelvic sidewall (Figure 5). Extension to the pelvic sidewall or involvement of the ureters, which causes hydronephrosis, is classified as stage IIIB. Visualization of tumor within 3 mm of the obturator internus, levator ani, and piriform muscles or the iliac vessels is considered highly suggestive of stage IIIB disease (13).

4- Stage IV:

Presence of bladder or rectal mucosa involvement or distant metastasis upgrades the tumor to stage IV. In stage IVA, bladder and rectal invasion is suggested by the presence of focal or diffuse disruption of the normally seen T2-low signal intensity wall, irregular or nodular wall, and presence of an intraluminal mass (Figure 6, 7). Bullous edema within the bladder causes high-signal-intensity thickening along the superficial internal surface of the bladder, a finding that may mimic tumor involvement (15).

In stage IVB, tumors spread beyond the pelvis, including the para-aortic and inguinal lymph nodes, lung, liver, and bone (16).

IV- Lymph node evaluation:

Lymph node metastasis initially occurs to pelvic nodes, which then subsequently spreads to retroperitoneal and supraclavicular nodes. Paracervical and parametrial nodes are first
to be involved, followed by spread to external iliac nodes by lateral route, internal iliac nodes by hypogastric route, and lateral sacral and sacral promontory nodes by presacral route (14).

Although pelvic lymph node metastasis is not considered in FIGO staging, it is one of the important prognostic factors and presence of a positive node indicates poor prognosis in each stage. Presence of metastatic para-aortic or inguinal node is classified as stage IVB disease. Identification of node involvement on imaging is based on size and morphology. A lymph node having transverse diameter >10 mm is abnormal. Morphological criteria that indicate pathological lymph node are border irregularity, heterogeneity of signal on T2-weighted images, and presence of necrosis (17).

Images for this section:
### FIGO Staging of Cervical Carcinoma

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Tumor confined to the surface layer (the cell lining) of the cervix; also called carcinoma in situ</td>
</tr>
<tr>
<td>I</td>
<td>Extension deeper into the cervix with no spread beyond (extension to the corpus is disregarded)</td>
</tr>
<tr>
<td>IA</td>
<td>Invasive carcinoma; may only be diagnosed at microscopy</td>
</tr>
<tr>
<td>IA1</td>
<td>Stromal invasion 3.0 mm deep and extension 7.0 mm</td>
</tr>
<tr>
<td>IA2</td>
<td>Stromal invasion &gt;3.0 mm and 5.0 mm with extension ≤7.0 mm</td>
</tr>
<tr>
<td>IB</td>
<td>Clinically visible lesions limited to the cervix uteri or preclinical cancers higher than stage IA</td>
</tr>
<tr>
<td>IB1</td>
<td>Clinically visible lesion 4.0 cm in greatest dimension</td>
</tr>
<tr>
<td>IB2</td>
<td>Clinically visible lesion &gt;4.0 cm in greatest dimension</td>
</tr>
<tr>
<td>II</td>
<td>Cervical carcinoma extends beyond the uterus but not to the pelvic wall or the lower one-third of the vagina</td>
</tr>
<tr>
<td>IIA</td>
<td>No parametrial invasion</td>
</tr>
<tr>
<td>IIA1</td>
<td>Clinically visible lesion 4.0 cm in greatest dimension</td>
</tr>
<tr>
<td>IIA2</td>
<td>Clinically visible lesion &gt;4.0 cm in greatest dimension</td>
</tr>
<tr>
<td>IIB</td>
<td>With obvious parametrial invasion</td>
</tr>
<tr>
<td>III</td>
<td>Extension to the pelvic wall, involvement of lower one-third of the vagina, or hydronephrosis or nonfunctioning kidney</td>
</tr>
<tr>
<td>IIIA</td>
<td>Involvement of lower one-third of the vagina with no extension to the pelvic wall</td>
</tr>
<tr>
<td>IIIB</td>
<td>Extension to the pelvic wall, hydronephrosis, or nonfunctioning kidney</td>
</tr>
<tr>
<td>IV</td>
<td>Extension beyond the true pelvis or involvement of the bladder or rectal mucosa (biopsy proved); bullous edema does not convey stage IV disease</td>
</tr>
<tr>
<td>IVA</td>
<td>Spread to adjacent organs</td>
</tr>
<tr>
<td>IVB</td>
<td>Spread to distant organs</td>
</tr>
</tbody>
</table>

**Fig. 1:** FIGO Staging of Cervical Carcinoma.
**Fig. 2:** Stage IB1 cervical carcinoma. Pelvic MRI: (a) Sagittal and coronal (b) T2-weighted images: mass with high signal intensity within the endo-cervical canal, measuring 15mm. The surrounding low-signal-intensity cervical stroma is intact, excluding parametrial invasion (arrowhead, b).
**Fig. 3:** Stage IIA cervical carcinoma. Pelvic MRI: (a) Sagittal and axial (b) T2- weighted images: tumor with intermediate signal intensity replacing the normal low-signal-intensity cervical stroma, and involving the upper two-thirds of the vagina. There exists an isthmic extension (arrowhead) with hydrometry (a).
Fig. 4: Stage IIB cervical carcinoma. Pelvic MRI: (a) Sagittal and axial oblique (b) T2-weighted images: tumor with high signal intensity replacing the normal low-signal-intensity cervical stroma and involving the anterior vaginal wall, with interruption of the low-signal-intensity cervical stromal ring and extension into the left parametrium (arrowhead, b).
Fig. 5: Stage IIIA cervical carcinoma. Pelvic MRI: Sagittal unenhanced T1-weighted (a) and fat-saturated contrast-enhanced T1-weighted (b) images: cervical tumor with intermediate signal intensity (a), extending to the lower one-third of the vagina and enhancing heterogeneously after injection of Gadolinium (b).
Fig. 6: Stage IVA cervical carcinoma. Pelvic MRI: Sagittal T2-weighted (a) and fatsaturated contrast-enhanced T1-weighted (b) images: cervical tumor with high signal intensity (a), filling the vesico-uterine fornix and infiltrating the posterior bladder wall. Enhancement of the posterior bladder wall identical to tumor enhancement (b).
Fig. 7: Stage IVA cervical carcinoma. Pelvic MRI: (a) Sagittal T2-weighted and (b) axial fat-saturated contrast-enhanced T1-weighted images: cervical tumor with high signal intensity (a), presenting a direct extension to the anterior rectal wall as an irregular thickening. Enhancement of the anterior rectal wall identical to tumor enhancement (b).
Conclusion

MRI is a non-ionizing noninvasive imaging modality, with functional capabilities and potential for diagnosis, local staging, lymph node and vascular assessment and, surgical planning of UCCa. One of the keys roles of the radiologists is to accurately determine staging as this may lead to appropriate management pathway either with surgery or chemo-radiotherapy.

Personal information

References


