MR imaging findings and staging criteria of cervical carcinoma

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Learning objectives

We review the role of magnetic resonance (MR) in the imaging of malignant neoplasms of the uterine cervix and describe its importance in staging and treatment planning.
Background

Cervical carcinoma is the third most common gynecologic malignancy and is typically seen in younger women, often with serious consequences. In developed countries it is the third most common gynaecological malignancy with an estimated annual incidence of 10.4 per 100000 women in the UK and 8 per 100000 women in the USA. The peak incidence is between 35 and 50 years. In the last 10 years, there has been a decreasing incidence due to national screening programmes for cervical cancer and for cervical intraepithelial neoplasia (CIN), its precursor. Aetiological factors implicated in the pathogenesis of CIN and cervical cancers are multiple and include smoking, immunosuppression, and sexual activity with exposure to certain types of human papilloma virus.

Histopathology
Approximately 90% of cervical carcinomas are of squamous cell origin, the remainder being adenocarcinomas or adenosquamous carcinomas. There is some evidence that adenocarcinoma is increasing in frequency. Other cervical malignancies include malignant melanoma, sarcoma, lymphoma and small cell carcinoma. Squamous carcinomas usually arise from the squamo-columnar junction whose position varies with age. Before puberty and after the menopause it is situated inside the endocervical canal. At puberty, oestrogen influenced cervical eversion occurs, followed by squamous cell metaplasia, which has the potential to de-differentiate into squamous cell carcinoma. Adenocarcinomas arise within the endocervical canal and are more likely to remain occult, delaying clinical presentation.
Fig.

Imaging findings OR Procedure details

MR imaging is the preferred and recommended diagnostic method for the assessment of cervical carcinoma, especially for pre-treatment staging of local tumour extent in patients with histologically proven International Federation of Gynaecology and Obstetrics (FIGO) stage IB or greater cervical cancer. It is the method of choice for local tumour staging: assessing the depth of infiltration, tumour volume, and involvement of adjacent structures. MRI is the most accurate imaging modality (90%) for distinguishing cancer confined to the cervix from cancer with parametrial infiltration (stage IB from IIB). MRI is considered the best method for planning radiochemotherapy and for following up tumour response to therapy. This technique also is useful in the evaluation of lymph node metastases.

Imaging Technique

A brief gynecologic history should be obtained prior to the MRI examination. As the morphologic appearance of the uterus varies with the patient's hormonal status, information on the phase of the menstrual cycle or postmenopause as well as on hormone therapy should be gathered. Moreover, the history should comprise information on pregnancies and cesarean sections as well as on invasive diagnostic procedures such as cervical conization or curettage. In patients undergoing follow-up MRI, information on earlier pelvic surgery or radiochemotherapy is important. The radiologist needs these data to correctly interpret the morphologic MR appearance. MRI is performed with the patient in the supine position. Fasting is not necessary prior to the examination, on the contrary, patients should have a light meal. Moderate bladder filling will straighten an anteflexed uterus. Too much bladder filling may lead to restlessness during the course of the examination or may even make it necessary to discontinue the examination. For an optimal image quality, artifacts caused by intestinal peristalsis should be minimized, in general by administration of a spasmylytic agent (butylscopolamine bromide, glucagon) at the beginning of the examination. Technically, motion artifacts can be reduced by rapid image acquisition. A high signal-to-noise ratio and a high spatial resolution are important for optimal pelvic evaluation by MRI. For this reason, body phased-array surface coils are preferred. The resolution can also be improved by use of a small field of view (FOV), for instance 20 × 20 cm, in combination with phase oversampling to prevent wrap-around artifacts (aliasing). The MRI examination begins with a localizer scan in transverse, sagittal and coronal orientation, followed by T2-weighted imaging in two planes. T2-weighted sequences have the highest soft-tissue contrast and thus provide most of the information on the localization and extent of a cervical carcinoma. The first T2-weighted sequence should be acquired in the sagittal plane and covers the uterus and vagina to the pelvic floor. This sequence should be acquired with a high resolution using thin slices and a small FOV,
i.e., a 512 matrix, a phase resolution of at least 75%, and a slice thickness of 4-5 mm. The sagittal T2-weighted images may serve to plan the transverse angulated T2-weighted sequence. The transverse sequence should be angulated for alignment perpendicular to the axis of the cervical canal. As with the sagittal sequence, the imaging field in transverse orientation extends from the fundus uteri to the pelvic floor. Images should be acquired with a slice thickness of 4-5 mm, a 512 matrix, and a phase-resolution of at least 75%. In cases of vaginal involvement with the risk of parametrial infiltration through the paravaginal tissue from below, additional angulation perpendicular to the vagina is useful. For optimal evaluation of vaginal infiltration, the vagina may be distended with ultrasound gel. Involvement of the pelvic floor muscles in advanced tumours is evaluated on coronal T2-weighted images, which is especially suited for evaluation of the levator ani muscle. Information on muscle involvement is important for planning the surgical procedure.

A basic imaging protocol should include axial T1-weighted spin-echo images with a large field of view and T2-weighted FSE images in the axial and sagittal planes with a small field of view. Axial T2-weighted FSE imaging with fat saturation can be helpful in the evaluation of parametrial invasion, especially in younger women who have a prominent pericervical or vaginal plexus. Axial TI-weighted images of the abdomen are also included to identify enlarged abdominal lymph nodes.

**Staging**

**General MR Appearance**

The basis of the radiologic evaluation of cervical cancer is T2-weighted MRI sequences, which provide a high soft-tissue contrast for optimal differentiation of tumour from normal cervical stroma and adjacent organs. Cervical cancer is characterized by a higher signal intensity and is thus delineated against the cervical stroma, which has a lower signal intensity. Cervical cancer typically develops as a circumscribed focal lesion arising from the mucosal layer of the cervix. It may grow superficially in a circular pattern and increases in depth with invasion of the cervical stroma. Sagittal and transverse T2-weighted sequences serve to determine the localization and size of the tumour as well as the depth of cervical stroma infiltration. These sequences are also crucial for excluding extracervical extension and infiltration of the parametria, vagina, bladder, and rectum. The two critical issues - depth of infiltration and parametrial involvement - can be assessed most reliably on transverse images angulated perpendicular to the cervical axis.

**Local Staging**
Stages 0 and 1a
The precursor lesions of cervical cancer, cervical intraepithelial neoplasia/CIN and carcinoma in situ (stage 0), and the earliest cancer stage, microinvasive cervical cancer (stage 1a), are not amenable to clinical evaluation, nor are they detected by MRI because they do not alter the normal morphologic MR appearance of the cervix. The normal endocervix is depicted on T2-weighted images with a hyperintense, continuous mucosal layer surrounded by hypointense cervical stroma, which consists of connective tissue and smooth muscle. The normal cervix is 3 cm long and has a diameter of 2-2.5 cm. Colposcopy and conization is the method of choice for evaluating these early forms of cervical carcinoma.

Fig.: 1
References: Radiology, Hospital São Marcos - Braga/PT

Stage 0 and 1
Stage 1b
Stage 1b cervical carcinoma has a depth of more than 5 mm and a diameter of more than 7 mm or is visible clinically. The tumour is still confined to the cervix but is characterized by invasive local growth. This is the earliest stage that can be demonstrated by MRI. The average MRI detection rate is 95%. Stage 1b1 (diameter <4 cm) and stage 1b2 (diameter>4 cm) are distinguished on the basis of their size. Stage 1b2 cervical cancer has a poorer prognosis and may be treated by neoadjuvant radiochemotherapy prior to surgery. Transverse and sagittal T2-weighted images depict cervical carcinoma as a high-signal-intensity lesion within the low-signal-intensity oval cervical stroma.
Fig.: 3

References: Radiology, Hospital São Marcos - Braga/PT

Stage 2
Stage 2a

In stage 2a cervical cancer, infiltration involves up to two-thirds of the proximal vagina while sparing the lower third. On T2-weighted MR images, vaginal involvement is seen as a hyperintense segmental disruption or lesion in the otherwise low-signal-intensity vaginal wall. Infiltration of the anterior and posterior fornix and of the wall is best seen in sagittal orientation. The radiologist interpreting the images must be aware that a large exophytic cervical cancer may lead to widening of the fornix and thus mimic vaginal infiltration. In such cases, opacification and distention of the vagina can be helpful.

Fig.: 4

Stage 2b cervical cancer is characterized by parametrial infiltration but without extension to the pelvic sidewall. Parametrial infiltration has important implications for the therapeutic approach. MRI is the only noninvasive modality that allows adequate evaluation of parametrial infiltration. The accuracy of MRI in the evaluation of parametrial invasion is up to 90%. Sagittal and transverse T2-weighted images angulated perpendicular to the cervical canal are most suitable to evaluate parametrial infiltration. It is indicated by a disruption of the low-signal-intensity cervical stroma. Visualization of an uninterrupted rim of cervical stroma reliably excludes parametrial infiltration, except for the rare cases of diffusely infiltrating adenocarcinoma.

Early microscopic parametrial infiltration must be suggested if high-signal-intensity tumour tissue shows irregular and unsharp margins and is disrupting the hypointense cervical stroma with no normal cervical stroma left that separates the tumour from the parametria. The most reliable MRI criterion of
parametrial infiltration is the direct visualization of a tumour mass extending into the parametria.

**Fig.: 6**

**References:** Radiology, Hospital São Marcos - Braga/PT

**Stage 3**
Stage 3a tumour is established when there is involvement of the lower third of the vagina. As with stage IIA tumour, sagittal and oblique transverse T2-weighted sequences are most suitable to evaluate vaginal infiltration. Tumour infiltration is indicated by a hyperintense disruption and continuous or discontinuous thickening of the vaginal wall that extends to the lower third of the vagina. This stage is also associated with an increased risk of metastatic spread to the superficial inguinal lymph nodes, which must be taken into account in the diagnostic evaluation.
Stage 3b
Cervical cancer with invasion of the pelvic sidewall corresponds to stage 3b. Cervical cancer can reach the pelvic sidewall by continuous lateral growth through the parametrial tissue and the sacral bone and through posterior extension along the sacrouterine ligament. T2-weighted images depict tumor infiltration as hyperintense lesions in the intermediate signal intensity of the muscle, or low signal intensity of the cortical bone, or as thickening of the vascular wall. T1-weighted imaging allows evaluation of the extent of advanced parametrial infiltration and possible extension to the pelvic sidewall with good delineation of the hypointense tumour mass from the lateral parametrial tissue and the intermediate-signal-intensity muscle tissue. Ureteral infiltration and obstruction with hydronephrosis is also classified as stage IIIIB disease. The ureter is typically infiltrated by lateral tumour growth through the parametria. A thickening of the ureteral wall or hydronephrosis is seen. In patients with a tumour mass in the parametria, the kidneys and urinary tract should be included in the imaging volume in order to confirm or exclude ureteral obstruction and hydronephrosis.
Fig.: 9

References: Radiology, Hospital São Marcos - Braga/PT

Stage 4
Stage 4a cervical cancer is characterized by infiltration of the mucosa of the rectum or urinary bladder. The FIGO classification is based on mucosal infiltration of these organs because the outer wall layers are not amenable to evaluation by endoscopy and biopsy. MRI already identifies infiltration of the outer muscular layer of the bladder and rectum. Sagittal and transverse T2-weighted MR images depict infiltration as segmental disruption of the hypointense muscular layer of the wall of the bladder or rectum by hyperintense tumour. Contrast-enhanced T1-weighted images often enable a more reliable identification of segmental disruption because of stronger enhancement of the tumour as compared with the muscular layer. Infiltration of the wall of the bladder and/or the rectum as well as contiguity of cervical cancer with either of these organs has important therapeutic implications.
Stage 4b
Distant metastases are characteristic of stage 4b cervical cancer. In the FIGO classification, metastases of the para-aortic lymph nodes count as distant metastases. Hematogenous dissemination occurs late in cervical cancer or typically in patients with local tumor recurrence. Organ metastases most commonly affect the lungs and are less frequent in the liver, peritoneum, and skeleton.
Fig.: 12

References: Radiology, Hospital São Marcos - Braga/PT

Lymph node staging
Fig.: 13

The most widely used staging system is the FIGO classification, which distinguishes four stages of cervical cancer. This staging system was introduced before the advent of modern imaging modalities and hence differs from all other classifications of gynecologic tumors in that it is still based on the results of bimanual palpation. The radiographic modalities include intravenous pyelography, barium enema, and X-ray examinations of the lungs and skeleton. The invasive diagnostic procedures for assessing tumor extent consist of cystoscopy and proctoscopy. Findings obtained with MR, CT, ultrasound, scintigraphy, and laparoscopy are not taken into consideration in determining the FIGO stage, which is regarded as a drawback of this staging system. The vaginal extent of cervical cancer can be determined with a high degree of accuracy by means of rectovaginal examination and colposcopy while the clinical examination is less accurate in determining tumor size and parametrial involvement. Studies comparing FIGO stages with surgical stages found an error rate of about 30% for stage IB and of up to 70% for advanced tumors of stages II-IV. Clinical symptoms such as fever or reactive parametrial inflammation often lead to overstaging. The nodal status is not considered,
although it is crucial for the patient’s prognosis and survival. For these reasons, more and more examiners prefer surgical and histopathologic staging according to the TNM classification from the American Joint Committee on Cancer (AJCC) and the UICC (United International Cancer Congress) criteria (Table). These criteria correlate much better with the prognosis. According to the FIGO and TNM classification, MRI and CT are optional modalities in perioperative staging. Surgical lymph node staging is often performed as a supplementary procedure to determine operability or prior to neoadjuvant therapy, primary radiotherapy. In patients with positive para-aortic lymph nodes, additional biopsies should be obtained from scalene lymph nodes.

Tumor markers have a poor sensitivity and specificity and are therefore not routinely determined as part of the diagnostic work-up and follow-up of patients with cervical cancer.

![Staging of cervical cancer according to UICC and TNM criteria](image)

**Fig.: 15**

Conclusion

Evaluation of prognostic factors MR imaging is a valuable non-invasive diagnostic modality for evaluation and staging of cervical carcinoma, identifying its main prognostic factors and facilitating selection of therapeutic strategy.
Personal Information

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Fig. 0: 3

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**Stage T2b.** Sagittal (A), axial (B), and coronal (C) T2 images show cervical cancer (asterisk) involving both anterior and posterior lips of cervix and involving the upper third of the vagina. Tumor invades fibrocervical stroma bilaterally, as shown by loss of low-signal-intensity ring with right parametrial extension (arrow).

**Fig. 0: 6**

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Fig. 0: 9

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