CASE STUDY

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A case study on cervical cancer: the role of MRI in staging and management

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Summary

Cervical cancer is the fourth most common cancer in women worldwide, primarily caused by persistent HPV infection, particularly types 16 and 18. In Croatia, 268 new cases of cervical cancer were reported in 2021, along with 109 cervical cancer-related deaths reported in 2022.

Accurate staging, utilizing the 2018 FIGO or TNM classifications, is essential for treatment planning and prognosis. In 2018, the FIGO system incorporated imaging and pathology findings, such as lymph node status, into the staging criteria, enhancing treatment precision.

Magnetic Resonance Imaging (MRI) is the preferred imaging modality for local staging, assessing eligibility for fertility-sparing surgery, evaluating treatment response, and detecting recurrence of cervical cancer. This case study discusses a 61-year-old woman diagnosed with stage IIB/IIIC1 cervical cancer in January 2023. After completing chemotherapy, external beam radiation therapy, and brachytherapy, MRI confirmed tumor regression, achieving a complete response by October 2023.

The case highlights the critical role of pelvic MRI in cervical cancer staging and its integration into the FIGO system. Ongoing advancements in imaging techniques, such as functional MRI, hybrid imaging, and radiomics, are promising to enhance the understanding of disease spread and support personalized clinical decision-making.

KEYWORDS: *FIGO 2018; magnetic resonance imaging; neoplasm staging; uterine cervical neoplasms*

INTRODUCTION

Cervical cancer is the fourth most common cancer among women worldwide, caused by a persistent infection with specific carcinogenic types of human papillomavirus (HPV), particularly types 16 and 18(1–4). In Croatia, 268 new cases of cervical cancer were reported in 2021, along with 109 cervical cancer-related deaths reported in 2022(5–7). Treatment and prognosis depend on clinical staging, determined by the International Federation of Gynecology and Obstetrics (FIGO) 2018 or TNM (T-primary Tumour, N-regional lymph Node, M-distant Metastasis) classifications(3,8,9). Until 2018, cervical cancer was the only gynecological malignancy that was staged primarily on clinical findings, including gynecologic examinations and, when needed, cystoscopy, proctoscopy, colposcopy, and biopsy(10). Imaging methods and pathologic findings, including lymph node status, were implemented into the novel FIGO staging system, which significantly impacted treatment and prognosis assess-

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ment(11,12). Magnetic Resonance Imaging (MRI) is the preferred method for pretreatment locoregional staging, assessing eligibility for fertility-sparing (FS) surgery, evaluating treatment response, and detecting disease recurrence(11,13,14).

CASE REPORT

A 61-year-old woman was admitted to the hospital in December 2022 due to postmenopausal bleeding. She had not had a gynecological exam in over 30 years and had an intrauterine device (IUD) for 40 years, which was removed upon admission. Cytological analysis showed malignant squamous epithelial cells, and a biopsy confirmed the diagnosis of squamous cell carcinoma of the cervix in January 2023. Initially, no extra cervical spread of the disease was found on Multislice Computed Tomography (MSCT) of the thorax, abdomen, and pelvis (MSCT TAP). For locoregional staging, an MRI of the pelvis was performed. The initial MRI describes the tumor-infiltrating the parametrium, uterus, and upper third of the vagina without rectal or bladder involvement. Enlarged lymph nodes of smaller diameter up to 10 mm were detected in the inguinal and iliac regions (Figure 1,2,3). The cancer has been classified as stage IIB/IIIC1 according to the 2018 FIGO classification system.The patient was presented to the multidisciplinary team for gynecological cancers and referred to an oncologist to begin treatment. In March 2023, she received six cycles of neoadjuvant chemotherapy according to the wPC protocol (weekly application of paclitaxel and carboplatin). Follow-up MRI after chemotherapy in April 2023 showed a reduction in tumor size, with residual parametrial infiltration. The patient underwent external beam radiation therapy (EBRT) of the pelvis, inguinum, and vagina from May to July 2023. Preceding brachytherapy, during July 2023, a follow-up MRI of the pelvis showed a significant reduction in tumor size. There was no invasion of the myometrium or vagina, only residual parametrium infiltration. In August 2023, the patient underwent interstitial HDR brachytherapy with an additional radiation boost with a multichannel cylinder in September 2023.

In October 2023, a follow-up MRI of the pelvis was performed, showing complete tumor regression, confirmed by another follow-up MRI in May (Figure 4) and MSCT TAP in January 2024, as well as a Pap smear, which showed no signs of malignancy. The last check-up with an oncologist was in August 2024, where, considering all expected findings, an excellent response to the treatment was observed.

DISCUSSION

Optimal imaging modalities in cervical cancer

The International Federation of Gynaecology and Obstetrics (FIGO) classification system is the primary standard for staging cervical tumors and correlates well with the most recent TNM staging criteria(15). Clinical assessment is the first and essential step for tumor detection. Pelvic examination and biopsy, and/or colposcopy performed by a trained gynecologist, is vital to diagnose cervical cancer(16). According to the 2023 guidelines established by the European Society of Gynecological Oncology (ESGO), the European Society for Radiotherapy and Oncology (ESTRO), and the European Society of Pathology (ESP), MRI is recommended as the gold standard for the initial assessment of pelvic tumor extent and pelvic lymph node enlargement for staging(17–19). Nevertheless, FIGO 2018 permits the use of any imaging modality in the given resources(12,20). Ultrasound (US), including endovaginal, transrectal, and abdominal approaches, is a low-cost, easily accessible, and well-tolerated imaging method with promising diagnostic potential in the gynecologic oncology field, especially with the development of endovaginal high-resolution probes and three-dimensional US(13). The international SENTIX study reported equal sensitivity of MRI and US in assessing the clinically relevant staging factors, such as tumor size, parametrial involvement, and lymph node involvement(21).

However, US limitations are operator dependency, questionable inter-observer reproducibility, and data storage(22). In the case study presented in this report, a CT scan of the thorax, abdomen, and pelvis (CT-TAP) was initially performed. However, it was inadequate for assessing disease spread. In the presented case, pelvic MRI scan was the method of choice for locoregional staging. Due to its excellent contrast in soft tissue imaging, high spatial resolution, and absence of ionizing radiation, CT remains inferior to MRI scan for local tumor size and extension(13,14,18,23–25). MRI and

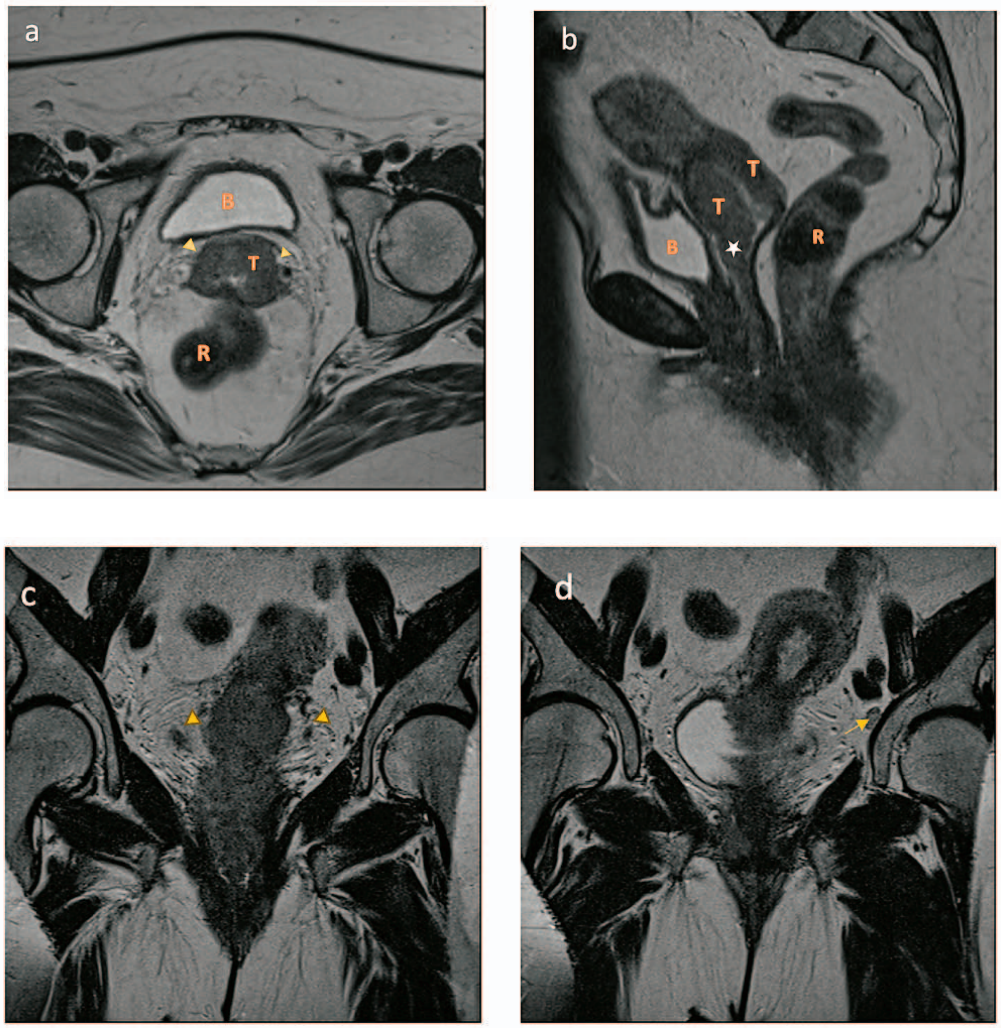

*Figure 1. Pretreatment MRI pelvic scan in a 61-year-old patient. On T2-weighted imaging (WI) in the axial oblique (**a**) and sagittal (**b**) plane, the tumor (T) is seen as an intermediate T2 signal intensity (SI) mass that infiltrates the whole cervix circumferentially and spreads into the corpus of the uterus. No bladder (B) or rectal (R) wall invasion is seen (**a,b**). Fornix and the cranial third of the vagina are also infiltrated by the tumor (**b**, star sign). The tumor (T) disrupts the hypointense cervical stroma bilaterally, characteristic of parametrial invasion (PMI) (**a**, arrowheads). In the T2-WI MRI oblique coronal plane, PMI is observed (**c**, arrowhead) and iliac region lymph node enlargement (**d**, arrow).*

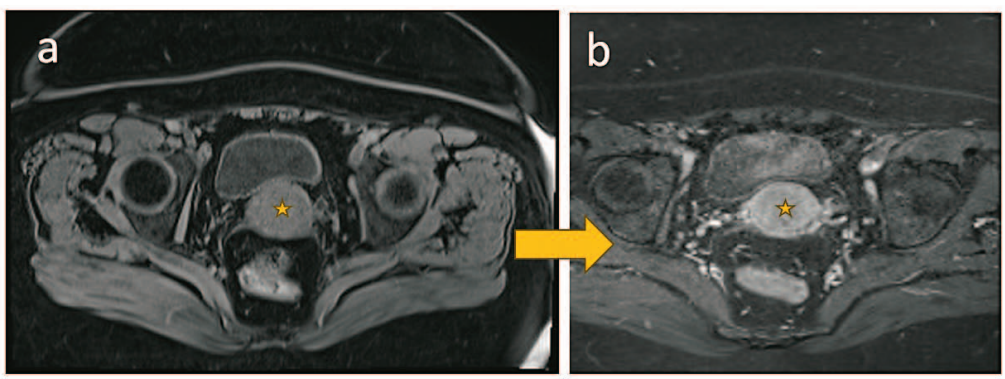

*Figure 2. T1-WI axial image obtained before contrast (**a**) and after contrast application (**b**), heterogeneous contrast enhancement is seen in tumor tissue (marked with a star).*

CT have limited accuracy in detecting metastatic lymph nodes, making Fluorodeoxyglucose Positron Emission Tomography (FDG-PET)/CT the preferred option. However, its sensitivity decreases for microscopic metastases, and negative results don't rule out occult lymph node involvement. Therefore, surgical staging is recommended in some instances(17,26).

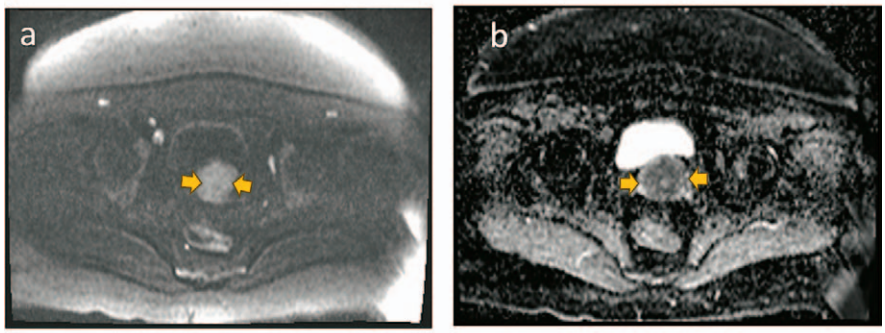

*Figure 3. Axial diffusion-weighted image (DWI) (**a**), with the corresponding slice on the ADC map (**b**). The tumor is shown as a hyperintense mass (**a**, arrows toward tumor), corresponding to a hypointense mass on the ADC map (**b**, arrows toward tumor), a sign of proper diffusion restriction.*

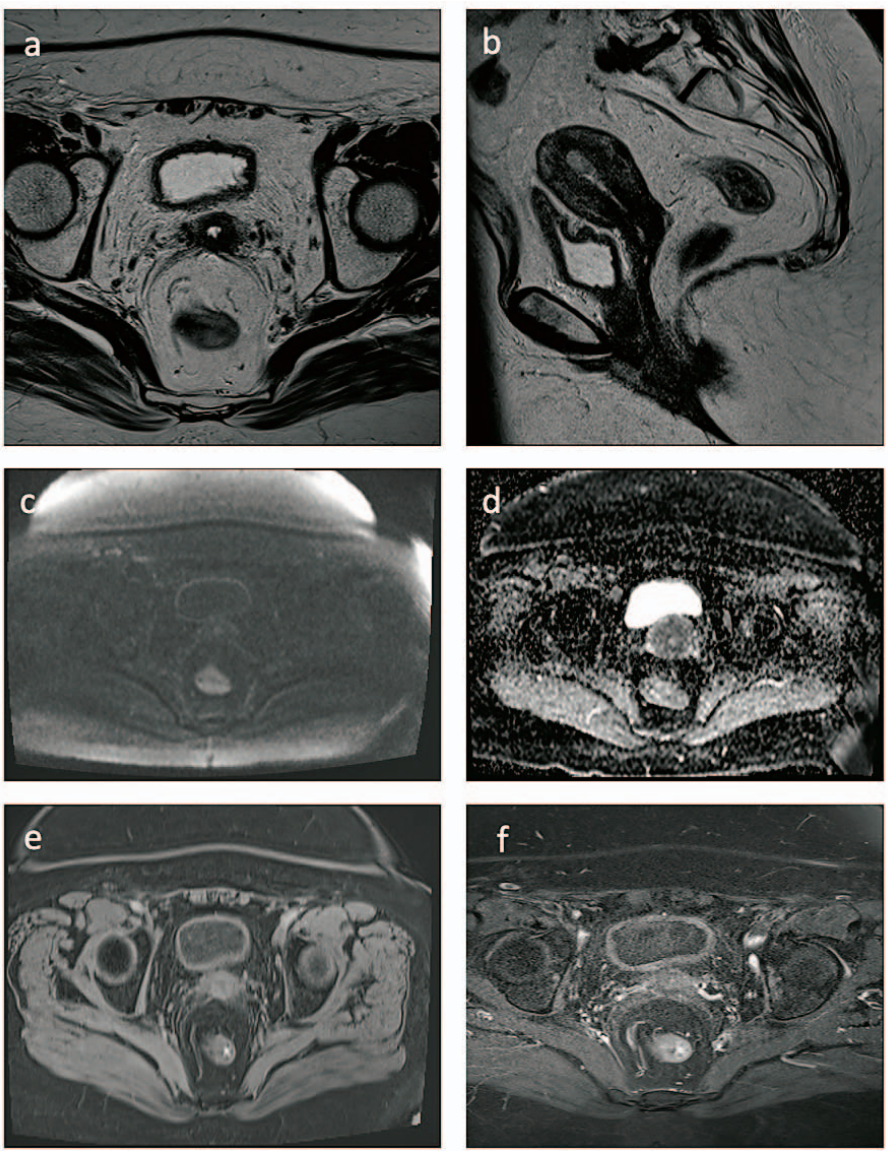

*Figure 4. Post-treatment MRI scan: T2-weighted images in the oblique axial (**a**) and sagittal (**b**) planes show tumor regression. The intact hypointense stromal ring indicates regression of the parametrial invasion (PMI). Additionally, on DWI (**c**) and ADC map (**d**), no diffusion restriction is observed, corresponding to no pathological contrast enhancement on post-contrast T1-WI (**e, f**).*

MRI protocol

According to European Society of Urogenital Radiology (ESUR) guidelines, fast spin-echo (FSE) T2-WI aligned with the uterine axis (axial, sagittal, and coronal oblique planes) is the key sequence for assessing cervical tumors. Axial plane T1-WI without and with fat saturation, along with a large field of view (FOV) axial T1– and T2-WI from renal hila to pubic symphysis, is recommended to evaluate retroperitoneal lymph node spread and kidney involvement(14,27,28). Functional sequences are also added to the MRI protocol in addition to the morphological sequences. Diffusion-weighted imaging (DWI)-MRI measures water movement within tissues, which is restricted in malignant lesions due to differences in cellular microstructure. This restriction is quantified by the apparent diffusion coefficient (ADC)(13,14,27,29,30).

Dynamic contrast-enhanced (DCE) MRI is an imaging technique that uses an intravenous bolus of gadolinium-based contrast agent. Tumor tissues typically exhibit rapid enhancement and early contrast washout compared to normal cervical tissue(13,18). In premenopausal women, DWI and DCE-MRI improve tumor visualization during menstrual cycles, where T2-weighted images may show similar signal intensities between the cervix and myometrium(31–33). In our Department, the standard protocol, including T1– and T2– WI in three planes and DCE sequences after intravenous paramagnetic contrast media application, was acquired(Figures 1,2,3).

Integrating MRI Findings to FIGO (2018) Staging

A step-by-step approach is recommended to evaluate the MRI pelvic scan and assign an appropriate stage according to the FIGO 2018 classification that further guides treatment. The summary of the 2018 FIGO Staging System for cervical cancer and its relation to the adjacent MRI findings and treatment options is summed up in Table 1(3,17).

Cervical tumors typically present as an iso-or hyperintense T2-weighted signal mass surrounded by normal hypointense cervical fibrous stroma(34,35). The tumor presents as a hyperintense signal on a DWI-MRI scan and complementary hypointense on the ADC maps(30).

The FIGO stage I includes tumors limited to the cervix. This stage is divided into two groups: stage IA, with microscopic findings, and stage IB, recognized clinically and radiologically(36). With the new 2018 FIGO staging system, stage IB is now divided into three, instead of two subgroups, depending on tumor size as IB1 (≤ 2 cm), IB2 (> 2 cm and ≤ 4 cm), and IB3 (> 4 cm), respectively. These changes are essential because tumor size ≤ 2 cm is the cut-off value for fertility-sparing (FS) management; moreover, tumor size > 4 cm is treated by concurrent chemoradiotherapy (CCRT) rather than surgery(14). The third step is to evaluate tumor extension. FIGO Stage II indicates that the tumor has invaded beyond the uterus. In stage IIA, the tumor is limited to the upper two-thirds of the vagina without the involvement of the parametrial tissue (PMI). On MRI T2-WI, vaginal tumor infiltration is seen as a hyperintense disruption of the hypointense vaginal wall and a rapid uptake of contrast on DCE images at the site(32,33,37). The MRI accuracy for detecting vaginal involvement is reported to be 86-93%, respectively(29). If PMI is present, stage IIB is assigned, indicating an advanced stage that requires a different treatment approach compared to lower stages(14). Full-thickness cervical stromal invasion (CSI) and MRI T2-WI findings, such as nodular tumor at the parametrial interface, spiculation, and periuterine vasculature encasement, are essential to diagnose PMI (38,39). On oblique axial MRI T2-WI, a hypointense intact stromal ring excludes parametrial invasion with a high negative predictive value (94-100%)(38,40,41).

Moreover, adding DWI sequences increases sensitivity and specificity from 72% and 91%, respectively, to 82% and 97%(41).

Stage III in the 2018 FIGO classification consists of involvement of the lower third of the vagina (IIIA), pelvic wall involvement, and/or renal complications (IIIB). The novel staging system introduced Stage IIIC to emphasize the importance of lymph node involvement. Based on the Lymph Node Metastasis (LNM) site, stage IIIC is subdivided into two categories: pelvic lymph node involvement (IIIC1), reported in 30-50%, and paraaortic lymph node involvement (IIIC2), reported in 10-25% of patients with locally advanced disease, respectively(42–44). Studies have demonstrated that paraaortic LNM is associated with a significantly worse prognosis, with a 5-year survival rate of less than 20–30%, compared to 50%

Table 1.

A summary of FIGO Staging, MR Imaging, and preferred treatment according to stage is demonstrated(3,17) (CCRT – concurrent chemoradiotherapy; LNM – lymph node metastasis; SI – signal intensity on MRI; T2-WI – T2 weighted image)

FIGO Staging		Description	MRI Imaging Finding	Treatment
I	Confined to the cervix			Surgery (cervical conisation)
	IA	**Invasion < 5 mm**	No tumor visible	
	IA1	Stromal invasion ≤3 mm		
	IA2	>3 mm and ≤5 mm depth of stromal invasion	Small enhancing tumor may be seen	Surgery (if < 4 cm); Surgery and adjuvant radiation therapy or CCRT (if > 4 cm)
	IB	**Invasion >5 mm**	T2-WI intermediate SI mass with intact stromal ring surrounding the tumour	
	IB1	≤2 cm maximum diameter		
	IB2	2 cm and ≤4 cm maximum diameter		
	IB3	>4 cm maximum diameter		
II	Beyond the uterus, not involving the lower third of the vagina or pelvic sidewall			
	IIA	Upper two thirds of vagina	Disruption of low SI vaginal wall	
	IIA1	≤4 cm maximum diameter		
	IIA2	>4 cm maximum diameter		
	IIB	Parametrial invasion	Complete disruption of hypointense stromal ring with tumour extension into parametrium	Concurrent chemoradiotherapy (CCRT)
III	Lower third of vagina,pelvic sidewall, hydronephrosis, nonfunctioning kidney, pelvic and/or para-aortic lymph node metastasis (LNM)			
	IIIA	Lower one-third of the vagina	Invasion of lower one-third of vagina	
	IIIB	Pelvic sidewall and/or hydronephrosis	Tumor tissue within 3 mm of pelvic muscles, vasculature, dilateted urether	
	IIIC	Pelvic and para-aortic LNM irrespective of tumor size	LN size ≥ 1.0 cm, round, spiculated, heterogenic, necrotic center; (FDG-PET/CT is recommended)	
	IIIC1	Pelvic LNM only		
	IIIC2	Para-aortic LNM		
IV	Beyond the true pelvis, involving of bladder or rectal mucosa			
	IVA	Rectum or bladder mucosa involvement	Loss of signal intensity of bladder or rectal wall	
	IVB	Distant metastases	Supraclavicular LN enlargement; bone or lung metastasis	CCRT/Systemic therapy

for pelvic lymph node involvement(45). On MRI, lymph nodes measuring ≥ 1.0 cm on the short axis that are round, spiculated, asymmetrical, and have heterogeneity of signal or necrosis are considered LNM, with moderate sensitivity and high specificity(37,46). Moderate sensitivity for LNM is due to the fact that lymph nodes are typically reported as potentially metastatic only when they are enlarged. However, they may be normal-sized in the early stages of the disease(47). According to some studies, DWI-MR with a high *b* value detects LNM as high signal intensity foci and decreased ADC value, which allows for the detection of LNM smaller than 1 cm(14,48,49). However, FDG-PET/CT remains the most accurate imaging approach to identify lymph node metastases, with a pooled sensitivity of 72% and a pooled specificity of 96%, respectively(14). In the presented case, the tumor was extensive and involved the entire circumference of the cervix, disrupting its normal shape and spreading into the parametria on both sides (Figure 1). The disease extended toward the uterine body and the vaginal fornix, initially placing it in FIGO stage IIB. However, since enlarged inguinal and iliac lymph nodes with a short-axis diameter of up to 1 cm were found, the stage was updated to IIIC1. No additional FDG-PET/CT was performed for initial staging in the clinical setting.

The last stage (IV) in FIGO 2018 classification is characterized by biopsy-proven invasion of

bladder or rectal mucosa (IVA) and distant metastases, including LNM beyond the pelvic and para-aortic regions (IVB). MRI signs of bladder invasion are nodular bladder wall, lumen protrusion, vesicovaginal fistula, and hyperintense anterior aspect of the posterior bladder wall(50).

Post-treatment follow-up

Early-stage cervical cancer (≤ Stages IB2, IIA1) is treated surgically, while large tumors (stage IB3, IIA2) and advanced disease stages (≥ Stage IIB) are treated with concomitant chemoradiotherapy (CCRT)(20,51,52). In patients receiving CCRT, a mid-treatment MRI after 5 weeks of cisplatin chemotherapy and before intra-cavitary brachytherapy aids in adjusting the brachytherapy dose based on residual tumor volume(14). Post-treatment MRI and FDG-PET/CT are recommended 3 to 6 months after CCRT is completed. A complete response is seen as the reappearance of hypointense cervical stroma on T2WI. Still, CCRT-related edema, inflammation, and necrosis may last up to 6 months and mimic residual tumors with a false positive rate of up to 45%(53–55). Post-treatment FDG-PET/CT is a valuable marker for residual disease and risk of recurrence(56–58). According to a systematic review, the median recurrence time ranged from 7 to 36 months after primary treatment; therefore, careful clinical follow-up should be performed in the first two to three years post-treatment(59). Routine imaging is not recommended unless there is a risk of recurrence, which occurs in 30% of cases, most commonly in the pelvis, followed by para-aortic lymph nodes(20,60,61).

The application of DWI-MRI and DCE-MRI for tumor response and prognosis is still being researched. The DWI-MRI is of particular interest for residual tumors, as it successfully differentiates high cellularity (residual tumor) from low cellularity (edema)(54,62).

Future perspective on cervical cancer imaging

New diagnostic imaging methods are emerging and are expected to be integrated into clinical practice. Of particular interest is the hybrid FDG-PET/MRI imaging, which includes high-resolution morphological and functional data from MRI and metabolic data from FDG-PET/CT, which could be used for initial staging, therapy response evaluation, and recurrence analysis(63,64). One must also mention radiomics, which involves quantitative data extraction from radiological images. When combined with clinical variables, this knowledge helps guide personalized treatment options for cervical cancer(65).

CONCLUSION

In conclusion, this case study highlights the advantages and critical role of pelvic MRI in the staging of cervical cancer, providing crucial insight into locoregional tumor spread and lymph node involvement. Integrating MRI findings into the FIGO staging system leads to better clinical decision-making and patient outcomes. Continued research and advancement in imaging techniques, including functional MRI sequences, hybrid imaging, and radiomics, could further improve our understanding of cervical cancer disease spread and lead to personalized clinical decision-making.

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Sažetak

Uloga MRI u određivanju stadija i liječenju raka vrata maternice kroz prikaz slučaja

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Rak vrata maternice četvrti je najčešći karcinom žena u svijetu, uzrokovan kroničnom infekcijom HPV-om, osobito tipovima 16 i 18. U Hrvatskoj je 2021. dijagnosticirano 268 novih slučajeva raka vrata maternice, a 2022. zabilježeno 109 smrtnih ishoda. Točno određivanje stadija bolesti ključno je za planiranje liječenja i predviđanje ishoda, pri čemu se koriste TNM ili FIGO klasifikacije iz 2018. godine, koje obuhvaćaju slikovne i patološke nalaze, poput statusa limfnih čvorova. Magnetska rezonancija (MR) zdjelice postala je glavna slikovna metoda za određivanje regionalnog stadija bolesti, procjenu mogućnosti za poštedne zahvate s ciljem očuvanja plodnosti, evaluaciju terapijskog odgovora te otkrivanje recidiva. U ovom radu prikazan je slučaj 61-godišnje pacijentice kojoj je u siječnju 2023. dijagnosticiran rak vrata maternice stadija IIB/IIIC1. Nakon kemoterapije, vanjskog zračenja i brahiterapije, MR zdjelice je pokazala značajnu regresiju tumora, s potpunim odgovorom postignutim do listopada 2023. Ovaj slučaj naglašava ključnu ulogu MR zdjelice u određivanju stadija raka vrata maternice i njegovu integraciju u FIGO sustav. Razvoj slikovnih tehnika, kao što su funkcionalne MR sekvence, hibridna slikovna dijagnostika i radiomika, mogao bi dodatno unaprijediti razumijevanje širenja bolesti i omogućiti personalizirano donošenje kliničkih odluka.

KLJUČNE RIJEČI: *FIGO 2018, karcinom vrata maternice, magnetska rezonancija, određivanje stadija*