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Analysis of the accuracy of dynamic contrast-enhanced magnetic resonance imaging in assessing lymph node metastasis and prognosis in cervical cancer patients

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► ***Original article***

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ABSTRACT

Background: To assess the accuracy, specificity, and sensitivity of dynamic contrast-enhanced magnetic resonance imaging (MRI) in assessing lymph node metastasis (LNM) and prognosis after cervical cancer surgery. ***Materials and Methods:*** Fifty cervical cancer patients admitted to our hospital from April 2022 to April 2023 were selected. 27 patients were in stage I-IIA and processed radical hysterectomy combined with pelvic lymph node dissection. Twenty-three patients were in stage IIB and beyond and underwent laparotomy with key site biopsy combined with pelvic lymph node biopsy. Postoperative pathological diagnosis was used as the gold standard for diagnosis. All patients underwent MRI scanning, including conventional MRI scanning such as DWI, T2WI, and T1WI of the pelvic cavity. Gadolinium-diethylene triamine pentaacetate (Gd-DTPA) was injected for dynamic contrast-enhanced scanning. The data of postoperative pathological staging, MRI staging, LNM, deep muscle layer invasion, and postoperative recurrence were analyzed. ***Results:*** There was no marked difference between MRI staging and postoperative pathological staging (P>0.05). When comparing preoperative clinical staging and MRI staging with postoperative pathological staging as the control group, there was no significant difference in accuracy. Both postoperative pathological diagnosis and MRI diagnosis had high specificity and sensitivity in assessing LNM and deep muscle layer invasion, but the differences were not significant (P>0.05). ***Conclusion:*** Dynamic contrast-enhanced MRI examination has high accuracy in assessing lymph node metastasis for cervical cancer patients. It has high sensitivity and specificity in assessing parametrial invasion, LNM, deep muscle layer invasion, and vaginal involvement, as well as has good prognostic value in assessing postoperative recurrence.

INTRODUCTION

Cervical cancer is one of the prevalent malignant gynecological tumors, boasting the highest mortality rate among female reproductive system diseases [1, 2]. This poses a significant threat to women's health and profoundly impacts their quality of life. A crucial factor influencing the clinical prognosis of cervical cancer patients is the occurrence of pelvic lymph node metastasis [3]. Notably, patients with lymph node metastasis exhibit a considerably low survival rate, and an increasing number of metastatic lymph nodes correlates with a further decline in the survival rate [4]. Early diagnosis and treatment are imperative in cervical cancer management, encompassing surgical intervention, radiotherapy, and chemotherapy [5]. While early detection and treatment yield favorable outcomes, the early diagnosis rate in China remains low, often resulting in a delayed diagnosis until the later stages when symptoms become apparent [6]. Therefore, enhancing the early clinical diagnosis rate is paramount in diagnosing cervical cancer promptly and improving patient prognosis.

Magnetic Resonance Imaging (MRI) is a frequently utilized modality for examining cervical cancer, owing to its superior soft tissue resolution, capability for multi-directional and multi-sequence imaging, and ability to produce clear images [7, 8]. The use of dynamic contrast-enhanced MRI significantly enhances the clarity of MRI, enabling a more precise visualization of tumor development [9]. Furthermore, dynamic scanning broadens the scope of MRI observation, offering a more comprehensive view [10]. In this study, we collected 50 cases of patients with cervical cancer. This study not only focuses solely on DCE-MRI but also integrates the comprehensive application of conventional MRI scanning techniques, such as DWI, T2WI, and T1WI, to conduct a comprehensive assessment of multiple prognostic

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factors in cervical cancer patients, including LNM, deep muscular layer invasion, and postoperative recurrence. This multi-parametric comprehensive assessment approach enhances the accuracy and comprehensiveness of diagnosis, providing a more reliable basis for clinical prognosis prediction.

MATERIALS AND METHODS

General data

Fifty patients who received cervical cancer examination in our hospital from April 2022 to April 2023, aged 23 to 84 years, with an average age of (45.37±3.63) years. All 50 patients presented with varying degrees of irregular vaginal bleeding, including postmenopausal vaginal bleeding and menstrual disorders with irregular bleeding among premenopausal women. Additionally, they exhibited excessive vaginal discharge, and B-ultrasound (WED9618-CII, Wyard, Guangdong, China) imaging revealed cervical enlargement. Among these patients, 27 with stages I to IIA underwent radical hysterectomy combined with pelvic lymph node dissection, while 23 patients with stage IIB and above received laparotomy with pelvic lymph node dissection. All patient care was conducted in strict adherence to the ethical principles outlined in the World Medical Association's Declaration of Helsinki. The research study was granted approval by the Ethical Committee of Women's Hospital, School of Medicine, Zhejiang University (ethical approval number 2022-ZU-16).

***Inclusion criteria*:** (1) no systemic serious organic diseases; (2) good clinical compliance; (3) no blood system diseases or coagulation disorders.

***Exclusion criteria*:** (1) serious mental disorder or cognitive dysfunction; (2) the expected survival period is less than 3 months; (3) those who do not agree with the research plan or have not signed the informed consent.

Methods of MRI detection

Patients were required to fast and retain urine on an empty stomach, lying flat on the examination table. The scanning area extended from the superior pelvic margin to the horizontal line of the symphysis pubis. The scanning sequence commenced with cross-sectional Fast Spin Echo and T2-weighted imaging (T2WI), followed by sagittal T2WI and cross-sectional fat suppression sequences. Coronal T2WI and cross-sectional T1-weighted imaging (T1WI) were also included. Prior to the scan, 0.1 mmol/kg of the Gd-DTPA (#HY-107353, MedChemExpress, USA) was administered intravenously at an injection rate of 3 mL/s. Subsequently, 25 consecutive dynamic enhancement images were captured, commencing with 20-second scans during the venous phase, 40-second scans during the venous phase, and 60-second scans during the parenchymal phase.

Clinical staging

Cervical cancer staging, as defined by The International Federation of Gynecologyand Obstetrics (FIGO), comprises: (1) Stage I: Cancer confined to the uterus, with IA ⩽3-5mm interstitial infiltration and IB ⩽4cm cervical lesion. (2) Stage II: Cancer extends beyond uterus but not to pelvic wall or lower 1/3 vagina; IIA without, IIB with paracentral infiltration. (3) Stage III: Involves pelvic wall or lower 1/3 vagina; IIIA in vagina only, IIIB extends to pelvic wall/ hydronephrosis. (4) Stage IV: Invades bladder/ rectum mucosa, extends to pelvis, or metastasizes [11].

MRI staging

T1W1, T2W2 axial plane, coronal plane and sagittal plane scans were performed first. Specific scanning parameters were as follows: The layer distance and thickness were 1.0mm, the field of view was 16 cm × 16 cm, the matrix was 256 × 256, the repetition firing time was 25 ms, the echo time was 6.0 ms, and the acquisition time is 270 s. After obtaining the corresponding image data, the image is reconstructed by using the maximum density projection method. The specific staging criteria are as follows: (1) Stage I: Cervical cancer is confined to the uterus. Cervical cancer lesions limited to intrauterine and uninvaded cervix was stage IA; Confined to the cervix stage IB; (2) Stage II: Cervical cancer downward invasion and upper two-thirds of the vagina. There was no clear sign of paracentral invasion for stage IIA; Lateral paracentric invasion with poorly defined boundary with the posterior wall of the bladder without obvious signs of involvement was stage IIB; (3) Stage III: Cervical cancer involves 1/3 of the lower vagina, accompanied by paracentral invasion. Stage IIIA involved the lower 1/3 of the vagina but did not see obvious signs of invasion of the pelvic wall; Cervical cancer involving pelvic wall was IIIB stage. (4) Stage V: Cervical cancer has invaded the anterior wall of the rectum, the bladder wall, or metastasized to the distal end.

Observation indicators

Postoperative pathological stage of cervical cancer, and MRI staging and clinical staging accuracy of cervical cancer, including six stages of IA, IB, IIA, IIB, IIIA and IIIB.

Statistical analysis

All data were processed by SPSS17.0 software (SPSS, Chicago, IL, USA), and the adoption rate of counting data (%) was expressed by Chi-square test. $P<0.05$ indicated a statistically significant difference.

RESULTS

Postoperative pathological stage of patients with cervical cancer

The pathological staging results of the 50 cervical

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cancer patients were stage IA (2 cases) (4%), stage IB (14 cases) (28%), stage IIA (20 cases) (40%), stage IIB (9 cases) (18%), stage IIIA (3 cases) (6%), and stage IIIB (2 cases) (4%).

Comparison of accuracy of preoperative clinical staging and MRI staging

Taking the postoperative pathological stage as the control group, the accuracy of preoperative MRI stage was 88%, and the accuracy of clinicopathological stage was 84%, with no statistical significance (P>0.05, table 1).

Table 1. Comparison of MRI staging and clinical staging of cervical cancer [n(%)].

Stage	n	IA	IB	IIA	IIB	IIIA	IIIB	accuracy rate (%)
Clinical stage	50	0(0)	12(24)	18(36)	8(16)	1(2)	3(6)	84
MRI stage	50	0(0)	13(26)	20(40)	7(14)	3(6)	1(2)	88
c2		0.000	0.365	1.208	0.930	0.364	1.482	0.761
P		1.000	0.205	0.332	0.548	0.285	0.603	0.872

Comparison of specificity and sensitivity of pathological diagnosis and MRI diagnosis for lymph node metastasis

There was no significant difference between MRI diagnosis and postoperative pathological examination on deep muscle infiltration in patients with cervical cancer (P>0.05). The sensitivity and specificity of MRI were 85.5% and 100.0% respectively. No significant difference was observed between preoperative MRI diagnosis and postoperative pathological examination for vaginal involvement (*P*>0.05). The sensitivity and specificity of MRI were 83.0 % and 88.4%. There was no significant difference in the results of MRI diagnosis and postoperative pathological examination on the intrauterine tissue infiltration (*P*>0.05). The sensitivity and specificity of MRI were 84.0% and 86.2%. Additionally, there was no difference between MRI diagnosis and postoperative pathology in lymph node metastasis (*P*>0.05). MRI diagnosis with (figure 1) or without (figure 2) lymph node metastasis was represented. The sensitivity and specificity of MRI were 86.5% and 92.0% respectively.

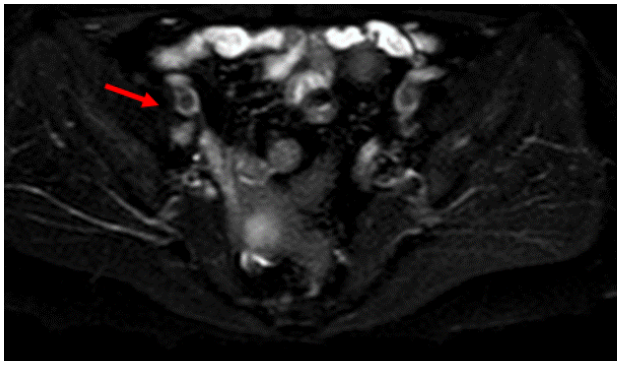


Figure 1. MRI diagnosis with lymph node metastasis. The red arrow precisely pinpoints the metastatic lymph nodes, demonstrating their size, shape, and potential invasion into surrounding tissues.

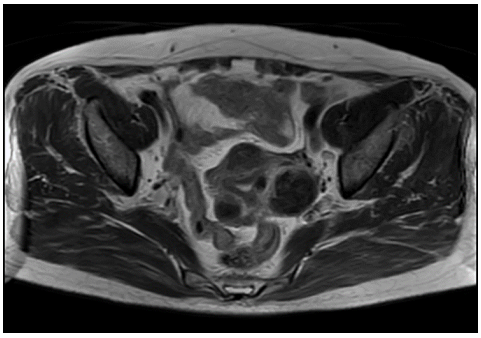


Figure 2. MRI diagnosis without lymph node metastasis. The MRI scan showcases a detailed visualization of the patient's lymphatic system, including lymph nodes and associated vessels. The absence of any abnormal enhancement or morphological changes within the lymph nodes.

DISCUSSION

Cervical cancer is a common prevalent gynecological malignancy, exhibiting a steady rise in incidence rates and a notably high mortality rate, posing a significant threat to women's health. It is imperative to enhance the early diagnosis rate of cervical cancer to facilitate prompt and effective treatment [12, 13].

MRI is a widely employed modality for cervical cancer examination, owing to its high resolution in soft tissue imaging. It enables multi-directional, multi-sequence imaging, resulting in clear and precise visualizations [14]. In cervical cancer tissue, T2WI reveals a slightly elevated signal, while the cervical stroma exhibits a low signal. Sagittal T1WI images effectively demonstrate the extent of invasion into the uterus and vagina. Furthermore, the intactness of the low-signal stromal ring in T1WI cross-sectional scans indicates whether the tumor has breached the serosal layer [15, 16].

Dynamic contrast-enhanced MRI scans significantly enhance the clarity of imaging, allowing for a more precise delineation of the tumor. This dynamic scanning approach also enables a more comprehensive evaluation of MRI observations [17, 18]. As modern science and technology continue to advance, coupled with the constant improvement in medical standards, the utilization of dynamic MRI enhancement scans has increased steadily. Consequently, there is a need for further investigation into the clinical application value of this technique. In this study, 50 cases of cervical cancer in our hospital underwent dynamic MRI enhancement scans. The diagnostic outcomes were found to be consistent with the postoperative pathological staging, demonstrating no significant differences. When compared to the postoperative pathological stage as the control group, the diagnostic accuracy of dynamic MRI enhancement scans and clinicopathologic staging revealed a preoperative MRI staging accuracy of 88% and a clinicopathologic

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staging accuracy of 84%, with no statistical difference. These findings indicate that dynamic MRI enhancement scanning can effectively enhance the clinical diagnostic accuracy, enabling earlier diagnosis and assisting in prompt clinical treatment.

The primary modalities of cervical cancer spread are direct invasion and lymph node metastasis [19]. Due to the lack of restriction posed by the parauterine fascia, cervical cancer tends to invade surrounding structures and lymph nodes, with parasauterine invasion often preceding anteroposterior invasion [20]. MRI boasts excellent soft tissue resolution, serving as the foundation for distinguishing tumors from normal tissue [21]. The accuracy of cervical cancer imaging diagnosis relies on the capability to visually delineate the anatomical structure of pelvic organs, the inter-tissue layers, and the differences between tumor and healthy tissue. It facilitates multi-directional and multi-sequence imaging [22]. When compared to conventional scanning methods, dynamic enhancement scanning is more adept at detecting lesions and delineating their extent, creating a favorable contrast in signal differences and enhancing lesion detection rates [23, 24]. In this study, we compared and analyzed the specificity and sensitivity of postoperative pathological diagnosis and MRI diagnosis for lymph node metastasis. The results revealed that both methods exhibited relatively high specificity and sensitivity for lymph node metastasis, deep muscle infiltration, and intrauterine tissue infiltration, with no significant differences observed.

CONCLUSION

In summary, this study suggested that dynamic enhanced scanning had high accuracy, sensitivity and specificity in the evaluation of lymph node metastasis and deep muscle infiltration in cervical cancer.

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***Competing interests*:** No conflict of interest exits in this manuscript.

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***Author contributions*:** C-Y.Z.; .Conception and design of the research, the analysis and interpretation of the data, and the writing of the first draft. Y-Y.P.; Statistical analysis. Z-Y.Z.; Data acquisition. X-M.Z.; Revision of manuscript for important intellectual content. All authors were involved in manuscript writing and approved final manuscript for publication.

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