UDK :61 ISSN 1857-5587

PHYSIOACTA

Journal of Macedonian Association of Physiologists and Anthropologists

Vol 12 No 3
2018

Physioacta

Journal of Macedonian Association of Physiologists and Anthropologists

Publisher

Medical faculty, Ss Cyril and Methodius University Skopje, R. Macedonia

CONTENTS

UDK:616.351-006.6-073.763.5

PREOPERTIVE STAGING OF RECTAL CARNCER WITH MRI

Lazarova A, *Karagjozov A,*

1. University Clinic for Surgical Diseases " St.Naum Ohridski , Skopje
2. University Clinic for Digestive Surgery, Medical faculty, Skopje

Abstract

Introduction: Rectal cancer is the third most common malignant disease worldwide with a high mortality rate in developed countries. .
The magnetic resonance imaging method plays a crucial role in the pre-operational staging of the rectal cancer. MR is a modality of choice for rectal cancer staging, which assists the surgeon in achieving negative resection margins.
In fact, MR assists the surgeon in the planning of the type of surgical treatment, and also helps to predict the response to treatment and disease detection.
Material and Methods: 61 patients with colonoscopy proven rectal cancer have been treated treated with pre-operative 1.5 T MRI of small pelvis in standard planes and pulse sequences (SAG T2, AX T1, T2, DWI, COR STIR)
Results: A tabular presentation of the results is given witch correlated the pre-operative MR T staging with the pathohistological finding. The comparison was made in T1, T2, T3 and T4 MR stadium with the acquired pathohistological stadium. The second table showing a percentage view of the difference between MR preoperative stadium and pathohistological results. Also a tabular presentation with general information for patients is given ; gender , nationality and age.
Conclusion: MR as an ideal imaging method for preoperative staging for a local or advanced stage of rectal cancer. MR allows evaluation of extramural spreading, determines the mesorectal involvement and involves the margin of resection.

Key words: Rectal carcinoma, MR, preoperative staging, pathohistological findings.

ПРЕОПЕРАТИВЕНА ПРОЦЕНА НА СТАДИУМ СО МАГНЕТНА РЕЗОНАНЦА КАЈ РЕКТАЛЕН КАРЦИНОМ

Абстракт

Вовед: Ректалниот карцином е трета по честота малигна болест ширум светот со висока стапка на морталитет во развиените земји . Преоперативната процена на стадиумот со магнетна резонанца (МР) е метода која игра круцијална улога во предоперативната процена на стадиумот на ректален карцином. МР е метод на избор при проценатa на стадиумот на ректалнот карцином , која му помага на хирургот во постигнување на негативни маргини на ресекција. Всушност МР асистира на хирургот во планирањето на видот на хируршкиот третман , воедно помага во предикција на одговорот на третманот и детекција на болеста.

Материјал и методи: Обработени се 61 пациенти со колоноскопски докажан ректален карцином, кај кои предоперативно е направен 1.5 Т МР на мала

карлица во стандардни рамнини и пулс секвенци (SAGT2 , AXT1 , T2 , DWI , CORSTIR) .
Резултати. Даден е табеларен приказ на резултатите со корелација на предоперативниот Т стеџинг со МР со патохистолошкиот наод. Компарацијата е направена во Т1 , Т2 , Т3 и Т4 МР стадиум со добиениот патохистолошкиот стадиум. Дадена е и табела со процентуален приказ во разликата помеѓу МР предоперативниот стадиум и патохистолошки добиените резултати. Даден е табеларен приказ со општи податоци за пациентите пол , националност и возраст
Заклучок: МР како идеална имиџинг метода за предоперативен стеџинг за локален односно напреднат стадиум на ректален карцином. МР овозможува евалуација на екстрамуралното ширење, го одредува мезоректалното зафаќање и зафаќање на маргините на ресекција.

Клучни зборови: Ректален карцином, МР , предоперативен стеџинг , патохистолошки наод.

Introduction

Rectal cancer is the third most common malignant disease worldwide with a high mortality rate in developed countries. Rectal cancer has somewhat greater predisposition to the male sex (20% - 30% higher in men compared to women), and the percentage of the disease is higher over 50 years of age. However, although the frequency of the disease has increased. the mortality rate has been reduced due to several significant factors.[1,2]
The rates of 5 year survival vary depending on the stage of the disease.It is important to mention that both adenomatous polyps considered to be pre-cancerous lesions are detected by colonoscopy and can be removed. [3] Also, the preoperative staging of rectal cancer with MR plays a significant role in further neoadjuvant and surgical treatment, which affects the reduction of extensive surgical treatment, an increase in the rate of 5 year survival. [4]
As risk factors include familial predisposition, smoking, increased consumption of red meat and aspirin. Rectal carcinoma is primarily developed from adenomatous polyps for a period of 10-15 years, known as an adenoma-carcinoma sequence. The incidence of polyps increases with age and the risk of malignant transformation of the polyps increases with increasing their diameter. The malignant transformation rate of polyps under 1 cm in diameter are less than 1% but over 10% for those larger.[4,5]
Around 50% of colorectal cancer is localized in the rectum. Rectal cancer is defined as a tumor whose upper margin is measured by a rigid rectoscope at 16cm or slightly less than the anocutaneous line. The highest percentage of rectal cancef belongs to adenocarcinoma (98%). The remaining rectal tumors are relatively less common, the carcinoid (0.1%), the lymphomas around 1% and the GIT, less than 1%.[6,7]
The prognosis of rectal cancer has been significantly improved over the past decade and this is mainly due to progression in preoperative staging, which has been reflected in a therapeutic approach, where significant change has been made from simple surgical treatment to multimodal treatment.[5,7]

This reduced the local recurrence rate by 11% and increased the 5-year survival rate by 58%. Surgical treatment of rectal cancer is a challenge to achieve a balance between minimizing the risk of local recurrence and preserving the anorectal and genitourinary function.[8,9]

Total mesorectal excision is the removal of the tumor, rectum and surrounding mesorectal fat and mesorectal fascia. Today Total Mesorectal Excision is a surgical choice for the treatment of rectal cancer. The introduction of this surgical technique reduces the rate of mortality from rectal cancer from 16% to 9%.[9]

Mesorectal fascia is a significant anatomical indicator for the diagnostic evaluation of the local tumor spread. Fascia is a connective tissue that surrounds the rectum and mesorectal fat weaving, including lymph nodules and lymph vessels to the pelvic floor, and is actually a natural barrier to tumor spread. [10]

The ability to visualize the mesorectal fascia of CT was described more than 25 years ago, but magnetic resonance is the best tool for visualizing the tumor and its staging.

The next advance in the treatment of rectal cancer is a transition from adjuvant to neoadjuvant chemoradiotherapy, which resulted in an increase in the percentage of five-year survival and a decrease in the recurrence rate, decreases the percentage of multivisecular and post-extensible resections in the surgical treatment of the rectal cancer.[11]

The significance is whether a patient with a rectal cancer is a candidate for TME or a preoperative radio-chemotherapy followed by TME. MR can give an answer to this question because it is the most important tool in rectal cancer staging.[12]

The magnetic resonance imaging method plays a crucial role in the pre-operational staging of the RC. MR is a modality of choice for RC staging, which assists the surgeon in achieving negative resection margins.[12,13,14]

The prognosis of rectal cancer has been significantly improved over the past decade, and this is mainly due to progress in preoperative staging, which reflected in the therapeutic approach, where significant change was made from simple surgical treatment to multimodal treatment. This reduced the local recurrence rate by 11% and increased the 5-year survival rate by 58%.[15,16]

The goal of neoadjuvant therapy is to reduce the size and stage of advanced rectal cancer, to minimize the risk of distant metastases and to allow less extensive surgical therapy and, preferably, a sphincter preservative technique.[17,18]

There are differences in the treatment of rectal cancer in certain countries and between certain institutions.[19] But it is generally accepted that total mesorectal excision is the best approach for all rectal carcinoma where the resection margins are unavailable. In most Western European countries, a short cycle of 5x5 Gray radiotherapy in combination with chemotherapy has been applied before total mesorectal excision is performed because its benefits have been proven.[20,21]

It is a question whether a patient with a rectal cancer is a candidate for TME alone or a preoperative chemoradiotherapy followed by TME. Preoperative staging with MR may be the answer to this question because it is the most important tool in the staging of rectal cancer[22].

The magnetic resonance imaging method plays a crucial role in the preoperative staging of the rectal cancer. MR is a modality of choice for rectal cancer staging, which assists the surgeon in achieving negative resection margins.In fact, MR assists the surgeon in planning the type of surgical treatment, and helps predict the response to treatment and disease detection[23].

All this could lead to a reduction in the number of extensive surgeries, and increase the number of sphincter-preserving surgical procedures. This implies standardization of the MRI procedure, which would improve the diagnostics and radicality of the overall treatment in the rectal cancer.[24]
Appropriate preoperative diagnostic treatment of rectal cancer is esentional for appropriate treatment and management of the disease. Response to these questions gives the Magnetic Resonance.[25]
Apart from the different views and discussions on this issue, MR remains the gold standard in the pre-operative staging of rectal cancer.[24]
The main role in the preoperative staging of rectal cancer in our country with MR is the evaluation of tumors by stages.

Surgical treatment with negative resection margins (no tumor presence within 1mm of resection margins, seen on histopathology) is the only standard for treatment.
Positive postoperative margins often result in relapse of the tumor, the possibility of the disease being incurable, poor quality of life, and a recurrent rate of 5-year-survival. The initial preoperative staging is aimed at selecting patients requiring chemoradiotherapy.
In patients with rectal cancer, local relapse is difficult to treat; it can cause a variety of symptoms, and most often has a fatal outcome[26,27].

Preoperative staging of rectal carcinoma with MR allows patients,usually in T1, T2 and T3a stage,to benefit from only TME without preoperative neoadjuvant therapy, , in contrast tothose patients with extrarectal spread that might benefit from a preoperative radio chemotherapy, in order to reduce the tumor[28,29].
World literature shows sensitivity and specificity of 83% and 93% for the T3 stage and 82% and 98% for the T4 stage.[30]

All tumors in the T4 stage and tumors with involvement of the resection margins, as well as tumors with suspected malignant lymph nodes around the margins of resection are first subjected to high dose of hemoradiation. In case of tumor over the mesorectal fascia, this would mean less extensive resection.[31]
Recent studies performed on 3T MR showed no significant difference in the differentiation of the T2 stage and early T3 stage. The latest views in the literature show that both 1.5 T and 3 T are equally useful in the preoperativ staging of rectal cancer with MR.[27]

The aim of this study is to show the importance for a preoperative stagingprotocol of the rectal carcinoma in our country based on the world standardsand protocols.

Material and methods

The study is prospective and includes 61 hospital patients with previously proven rectal cancer, who have been operated at the Department of Abdominal Surgery.

- Inclusion criteria for participation in the study are: Patients in whom previously colonoscopic has been proven rectal cancer and scheduled surgery.
- Patients excluded from the study are those who have a body weight greater than 120 kg, patients who have implanted metal parts and patients who can not withstand the examination due to claustrophobia.

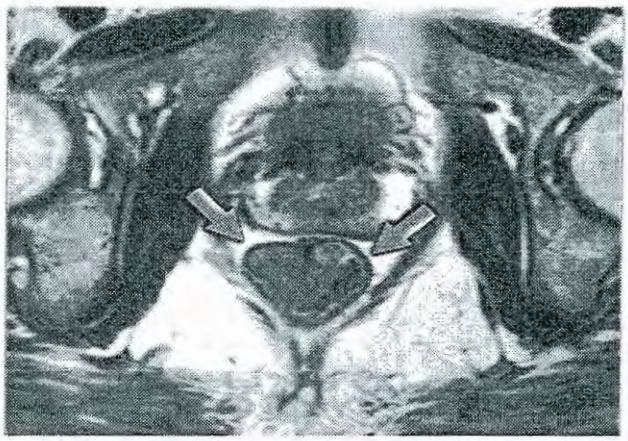
The following parameters were considered: Sex(Males and Females) Age (range from 45years to 90 years old patient) , Localization of the tumor (low, middle, high) rectum, and T stages determined by MR.
A correlation was then made with the results obtained from the histopathological finding.
MRI should determine the following:

1. Localization of the tumor - is a high or low rectal tumor and what size is, as well as the way of its growth.
2. T staging - T1, T2, T3 and T4
3. The distance of the tumor to the mesorectal fascia
4. Tumoral growth or the existence of lymph nodules up to 1mm from the margin of resection
5. The presence of lymph nodules mesorectally
6. The presence of extra murular vascular invasion (EMVI positively or negatively)

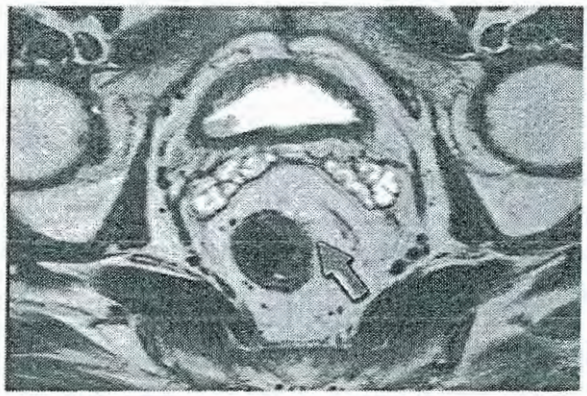
The MR protocol includes the SAG T2 pulse sequence that starts the scan. The cranial boundary of the scanning field is the level of the vertebrae L5, and the caudal is below the anal duct. This pulse sequencegives a longitudinal diameter of the tumor, providing insight into its length and the way of its growth. On this pulse sequence, the distance from the anorectal junction to the lower edge of the tumor is measured to determine the localization of the tumor in the rectum. Based on the sagittal pulse sequence, the axial pulse sequences (AX T1, AX T2, AX DWI) are planned to be directed perpendicularly to the axial and distally localized tumors in parallel to the anal canal. A coronal tumor is obtained by COR STIR pulse sequence.The distance between two sequences is 2mm

The localization of the tumor: the rectum extends from the anorectal blend to the sigma in the length of aproximately 15 cm. Rectal cancer can be: low rectal carcinoma (at a distance of 5 cm from the surgical ano-rectal joint), middle rectal carcinoma (at a distance of 5 to 10 cm from the ano-rectal joint) and high localization of rectal carcinoma (10 to 15 cm) .

Once the exact localization of the tumor is determined, the determination of T staging is next. An MR can not distinguish a tumor that grows in submucosis or invades muscular external, which can not differentiate between T1 and T2.
In the T3 stage, the tumor penetrates all walls and grows into peri -rectal fat. In this stage, it is important to determine whether the mesorectal fascia is involved. MR showed a sensitivity of 82% in the detection of peri-rectal invasion.

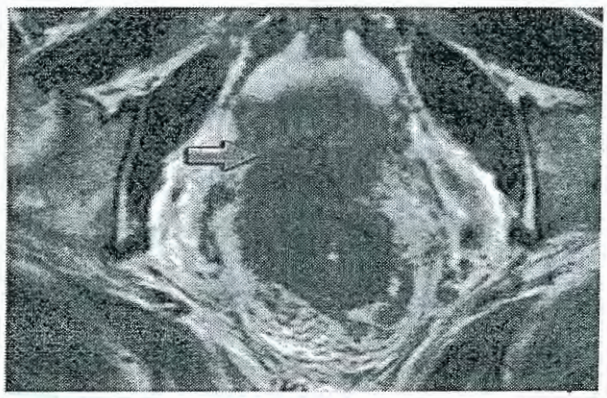


Picture 1 Rectal tumor without invasion of muscularis propria T1/T2 stadium



Picture 2 Rectal cancer in T3 stadium with invasion of muscularis propria

If the tumor infiltrates the visceral peritoneum and adjacent organs(prostate and seminal vesicules at males and vagina ,cervix , uterus at females)is a T4 stage. Thus, an appropriate interpretation of peritoneal reflection is crucial for an appropriate MR



Picture 3 Tumor in T4 stadium with infiltration of prostate

The existence of lymph nodules and N staging is a significant prognostic indicator and determines the rate of recurrence. If the lymph nodes are larger in diameter than 5mm have irregular shape and heterosignal appearance, the likelihood that they contain metastatic deposits is high.

Extramural vascular invasion (EMVI) is the extension of the rectal tumor in the veins under musculature, and can be detected by MR. Suspicion for EMVI exists when the veins near the tumor are irregular or dilated. EMVI was accepted as an independent prognosis indicator in the rectal cancer that is associated with a higher incidence of metastases, local relapse, a weaker response to preoperative chemo-radio therapy, and a lower survival rate.
It has recently been demonstrated that the rate of distant MS deposits and the response to preoperative chemo-radiotherapy is strongly related to the size of the involved vessels.
Statistical data analysis was performed in the statistical program SPSS for windows 17.0. Two different statistical methods were used for the results : Analysis of variance (ANOVA) and Correlation.

Results

Graphic 1 shows the patients in preoperative MR evaluation of rectal cancer stging in comparison with the patohistology results after the operation , showing the different in each T stage.

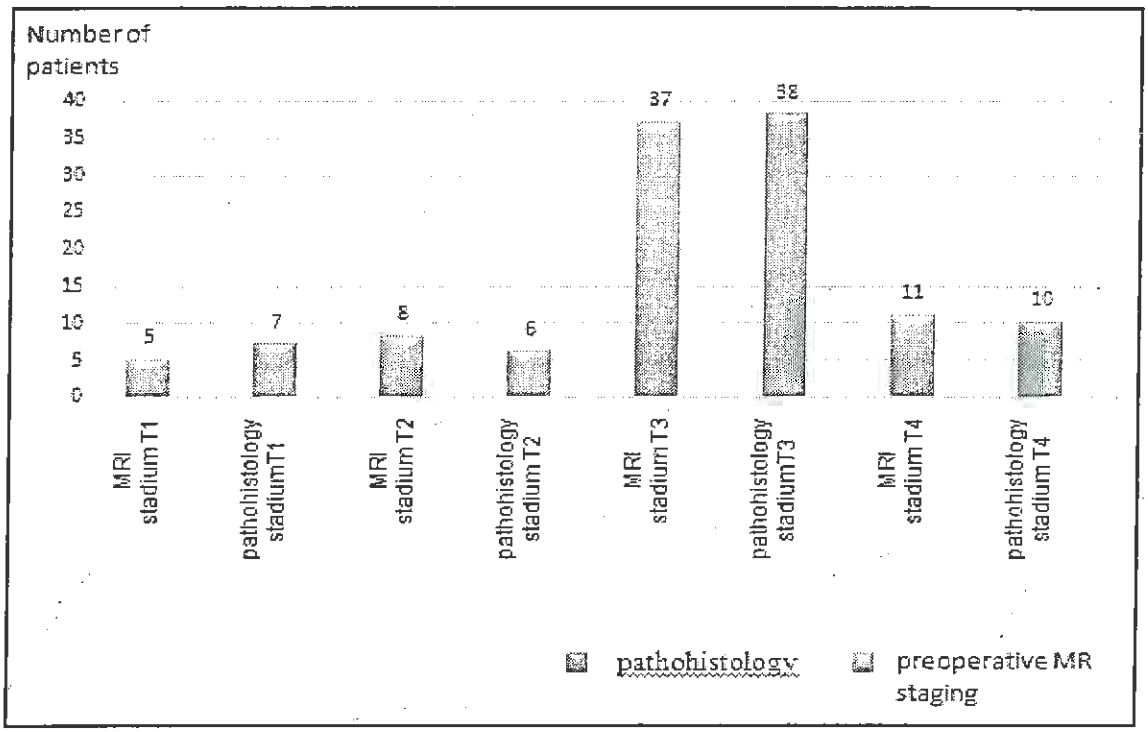


Figure 1 Correlation of MR staging with pathohistology staging

MRI staging versus pathohistology staging given in percentages for T1 , T2 , T3 , T4 stages and summery for all stadiums.
The higher percentage different are in T1 and T2 stadium MR versus pathohistology but this different is little in T3 and T4 stadium MR versus pathohistology witch in summery for all stadiums is not more than 10 % showing the high sensitivity of MR preoperative staging.

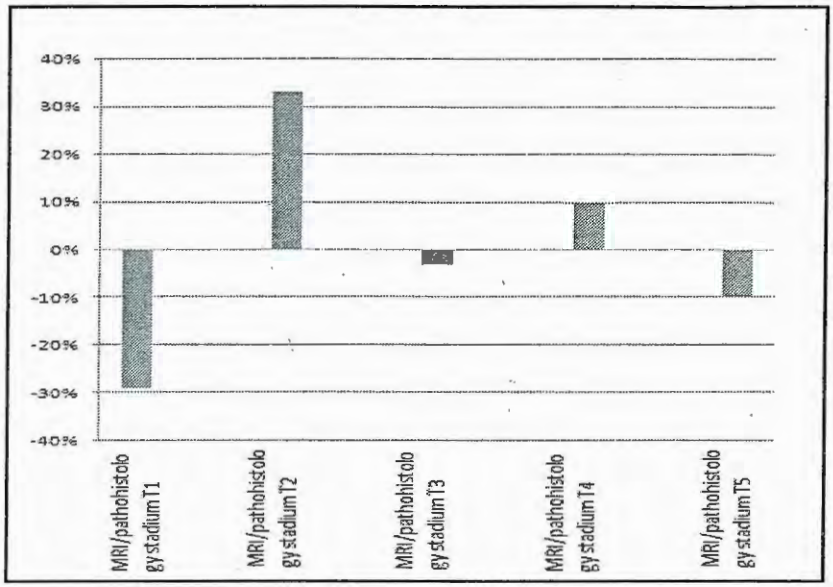


Figure 2 Different between preoperative MR staging and postoperative pathohistology staging given in percentages

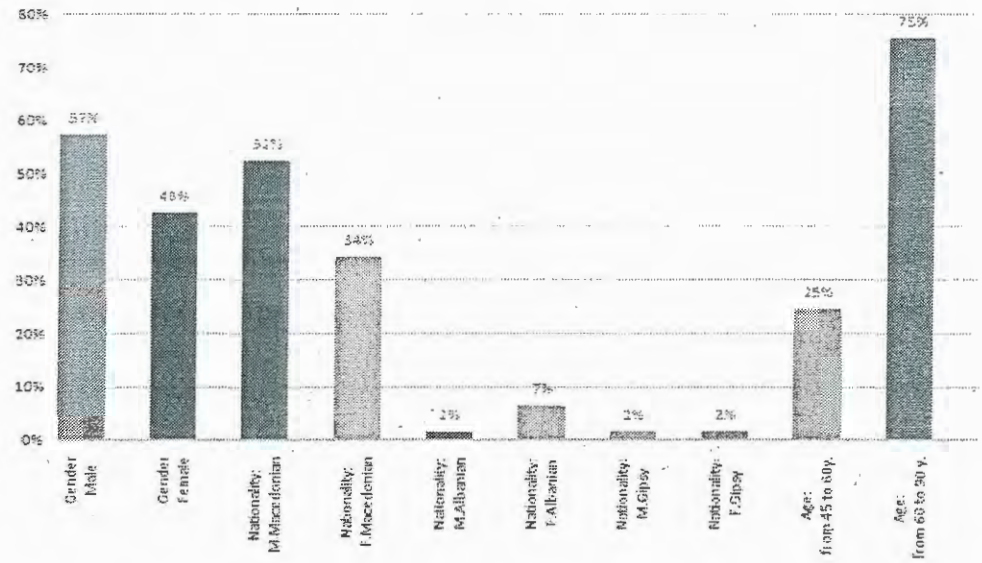


Figure 2 General information about patients given in percentages

Grafic gives the general information about patients Gender, Nationality and Age.
Male predisposition for rectal cancer is slightly higher than female.Most of the patients are Macedonian nationality.The peak age for rectal cancer is over 60ty years old

Discussion

This study shows that MR is a tool with high accuracy for the prediction of transmural tumor invasion, the invasion of mesorectal fascia, and the local organs.
From Chart 1, the differences between the MRT T1 and T2 stage with the pathohistological T1 and T2 stages where the MR is accurate is 70% (due to the weaker differentiation between the T1 and T2 stages), in contrast to the higher accuracy in the T3 and T4 stages where is accurate to 97%.
The difference between the T1 and T2 stadium is visualized with rectal ultrasound.[5]
For treatment of rectal cancer does not matter if it is T1 or T2 stadium..[3]
It is significant in the evaluation of the T3 stadium and the tumor's distance from mesorectal fascia.
For therapeutic purposes, it is not important to determine whether T2 or a T3 stage where the circum resection margins is not affected. The T3 stage has its own specificities with respect to the division, it is a heterogeneous group that depends on the depth of the tumor invasion in the mesorectal fat weaving . Its division into T3a, (<5mm) T3b (= 5mm), T3c (> 5mm) is a significant prognostic indicator. [8]
Knowing these factors is essential in the treatment of rectal cancer.

Male gender has slight high predisposition for suffering from rectal cancer , this correlate with the data from the world literature. The age of the patients shows that the majority of patients suffering from rectal cancer is over the age of sixty.[2]
MR is a standard procedure in the diagnosis of rectal cancer in developed countries. In addition, there are no exact criteria for performing this imaging technique in our country , which are essential for determining the preoperative stage of the disease, isolation of patients who are candidates for neoadjuvant therapy and multimodal treatment with additional performance of lower rectal UC.[7,8 ,9]
All this could lead to a reduction in the number of extensive surgeries, and increase the number of sphincter-preserving surgical procedures. This implies completion of the MRI procedure, supplemented with lower rectal UZ (for better differentiation between the T1 and T2 stages), which would improve the diagnostics and radicality of the overall treatment in rectal cancer.[10 ,11]
MR as an ideal imaging method for preoperative staging for a local or advanced stage of rectal cancer. MR allows evaluation of extramural spread, determines the mesorectal involvement and involves the margins of resection.[12]
The purpose of the rectal tumor staging of the MR imaging method is to identify patients in the T3 stage in potentially involving the resection margins in order to benefit from radiation and radio chemotherapy.[13]
This is significant for multimodal treatment of rectal carcinoma leading to neoadjuvant therapy, which could lead to a reduction in the size of the tumor and the stage, thereby avoiding extensive multivessel resection. All this will affect the overall survival period as well as lower comorbidity and less extensive surgical procedures.[15,16,17]

Conclusion

MR as an ideal imaging method for preoperative staging for a local or advanced stage of rectal cancer. MR allows evaluation of extramural spread, determines mesorectal involvement and involves the margin of resection
The purpose of the rectal tumor staging of the MR imaging method is to identify patients in the T3 stage in potentially involving the resection margins in order to benefit from radiation and radio chemotherapy
This is significant for multimodal treatment of rectal carcinoma leading to neoadjuvant therapy, which could lead to a reduction in the size of the tumor and the stage, thereby avoiding extensive multivisceral resection. All this will affect the overall survival period as well as lower comorbidity and less extensive surgical procedures.

References

1. Kang H, O'Connell JB, Leonardi MJ, Maggard MA, McGory ML, Ko CY. Rare tumors of the colon and rectum: a national review. *Int J Colorectal Dis* 2007; 22:183–189
2. Adam IJ, Mohamdee MO, Martin IG, et al. Role of circumferential margin involvement in the local recurrence of rectal cancer. *Lancet* 1994; 344:707–711
3. Kelly SB, Mills SJ, Bradburn DM, Ratcliffe AA, Borowski DW; Northern Region Colorectal Cancer Audit Group. Effect of the circumferential resection margin on survival following rectal cancer surgery. *Br J Surg* 2011; 98:573–581
4. Heald RJ, Moran BJ, Ryall RD, Sexton R, MacFarlane JK. Rectal cancer: the Basingstoke experience of total mesorectal excision, 1978–1997. *Arch Surg* 1998; 133:894–899
5. Kosinski L, Habr-Gama A, Ludwig K, Perez R. Shifting concepts in rectal cancer management: a review of contemporary primary rectal cancer treatment strategies. *CA Cancer J Clin* 2012; 62:173–202
6. Bipat S, Glas AS, Slors FJ, Zwinderman AH, Bossuyt PM, Stoker J. Rectal cancer: local staging and assessment of lymph node involvement with endoluminal US, CT, and MR imaging—a meta-analysis. *Radiology* 2004; 232:773–783
7. Beets-Tan RG, Lambregts DM, Maas M, et al. Magnetic resonance imaging for the clinical management of rectal cancer patients: recommendations from the 2012 European Society of Gastrointestinal and Abdominal Radiology (ESGAR) consensus meeting. *Eur Radiol* 2013; 23:2522–2531
8. Fernandez-Esparrach G, Ayuso-Colella JR, Sendino O, et al. EUS and magnetic resonance imaging in the staging of rectal cancer: a prospective and comparative study. *Gastrointest Endosc* 2011; 74:347–354
9. Intven M, Reerink O, Philippens ME. Diffusion-weighted MRI in locally advanced rectal cancer: pathological response prediction after neo-adjuvant radiochemotherapy. *Strahlenther Onkol* 2013; 189:117–122
10. Jung SH, Heo SH, Kim JW, et al. Predicting response to neoadjuvant chemoradiation therapy in locally advanced rectal cancer: diffusion-weighted 3 Tesla MR imaging. *J Magn Reson Imaging* 2012; 35:110–116

11. Barbaro B, Vitale R, Valentini V, et al. Diffusion-weighted magnetic resonance imaging in monitoring rectal cancer response to neoadjuvant chemoradiotherapy. *Int J Radiat Oncol Biol Phys* 2012; 83:594–599
12. Lambregts DM, Vandecaveye V, Barbaro B, et al. Diffusion-weighted MRI for selection of complete responders after chemoradiation for locally advanced rectal cancer: a multicenter study. *Ann Surg Oncol* 2011; 18:2224–2231
13. Kim SH, Lee JM, Hong SH, et al. Locally advanced rectal cancer: added value of diffusion-weighted MR imaging in the evaluation of tumor response to neoadjuvant chemo- and radiation therapy. *Radiology* 2009; 253:116–125
14. DeVries AF, Piringer G, Kremser C, et al. Pre-treatment evaluation of microcirculation by dynamic contrast-enhanced magnetic resonance imaging predicts survival in primary rectal cancer patients. *Int J Radiat Oncol Biol Phys* 2014; 90:1161–1167
15. Lim JS, Kim D, Baek SE, et al. Perfusion MRI for the prediction of treatment response after preoperative chemoradiotherapy in locally advanced rectal cancer. *Eur Radiol* 2012; 22:1693–1700
16. Oberholzer K, Menig M, Pohlmann A, et al. Rectal cancer: assessment of response to neoadjuvant chemoradiation by dynamic contrast-enhanced MRI. *J Magn Reson Imaging* 2013; 38:119–126
17. Intven M, Reerink O, Philippens ME. Dynamic contrast enhanced MR imaging for rectal cancer response assessment after neo-adjuvant chemoradiation. *J Magn Reson Imaging* 2014 Aug 14 [Epub ahead of print]
18. Kim SH, Lee JM, Gupta SN, Han JK, Choi BI. Dynamic contrast-enhanced MRI to evaluate the therapeutic response to neoadjuvant chemoradiation therapy in locally advanced rectal cancer. *J Magn Reson Imaging* 2014; 40:730–737
19. Gollub MJ, Gultekin DH, Akin O, et al. Dynamic contrast enhanced-MRI for the detection of pathological complete response to neoadjuvant chemotherapy for locally advanced rectal cancer. *Eur Radiol* 2012; 22:821–831
20. Ozis SE, Soydal C, Akyol C, et al. The role of ^{18}F-fluorodeoxyglucose positron emission tomography/computed tomography in the primary staging of rectal cancer. *World J Surg Oncol* 2014; 12:26
21. Maas M, Lambregts DM, Lahaye MJ, et al. T-staging of rectal cancer: accuracy of 3.0 Tesla MRI compared with 1.5 Tesla. *Abdom Imaging* 2012; 37:475–481 [Crossref] [Medline] [Google Scholar]
22. Donmez FY, Tunaci M, Yekeler E, Balik E, Tunaci A, Acunas G. Effect of using endorectal coil in pre-operative staging of rectal carcinomas by pelvic MR imaging. *Eur J Radiol* 2008; 67:139–145
23. Slater A, Halligan S, Taylor SA, Marshall M. Distance between the rectal wall and mesorectal fascia measured by MRI: effect of rectal distension and implications for preoperative prediction of a tumour-free circumferential resection margin. *Clin Radiol* 2006; 61:65–70
24. Furey E, Jhaveri KS. Magnetic resonance imaging in rectal cancer. *Magn Reson Imaging Clin N Am* 2014; 22:165–190, v–vi
25. Suzuki C, Torkzad MR, Tanaka S, et al. The importance of rectal cancer MRI protocols on interpretation accuracy. *World J Surg Oncol* 2008; 6:89

26. Mir N, Sohaib SA, Collins D, Koh DM. Fusion of high b-value diffusion-weighted and T2-weighted MR images improves identification of lymph nodes in the pelvis. *J Med Imaging Radiat Oncol* 2010; 54:358–364
27. Cong GN, Qin MW, You H, et al. Diffusion weighted imaging combined with magnetic resonance conventional sequences for the diagnosis of rectal cancer [in Chinese]. *Zhongguo Yi Xue Ke Xue Yuan Xue Bao* 2009; 31:200–205
28. Alberda WJ, Dassen HP, Dwarkasing RS, et al. Prediction of tumor stage and lymph node involvement with dynamic contrast-enhanced MRI after chemoradiotherapy for locally advanced rectal cancer. *Int J Colorectal Dis* 2013; 28:573–580
29. Heijnen LA, Lambregts DM, Martens MH, et al. Performance of gadofosveset-enhanced MRI for staging rectal cancer nodes: can the initial promising results be reproduced? *Eur Radiol* 2014; 24:371–379
30. Rudisch A, Kremser C, Judmaier W, Zunterer H, DeVries AF. Dynamic contrast-enhanced magnetic resonance imaging: a non-invasive method to evaluate significant differences between malignant and normal tissue. *Eur J Radiol* 2005; 53:514–519
31. Tamakawa M, Kawaai Y, Shirase R, et al. Gadolinium-enhanced dynamic magnetic resonance imaging with endorectal coil for local staging of rectal cancer. *Jpn J Radiol* 2010; 28:290–298