

Magnetic Resonance Imaging of Rectal Cancer - the Surgeon Principles

Toman D^{1,2*}, Vavra P^{1,2}, Ihnat P^{1,2}, Foltys A^{1,2} and Roman J^{1,2}

¹The Department of Surgery, Faculty of Medicine, Ostrava University, The Czech Republic

²The Department of Surgery, University Hospital Ostrava, The Czech Republic

***Corresponding Author:** Toman D, The Department of Surgery, Faculty of Medicine, Ostrava University and The Department of Surgery, University Hospital Ostrava, The Czech Republic.

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Abstract

Background: Rectal cancer as a part of colorectal cancers is one of the most common human malignancies. The incidence of colorectal cancer rose dramatically following economic development and industrialization. The clinical manifestation is based on the anatomical localization of the rectum in the pelvis. Rectal bleeding, the discomfort in the sense of tenesm or pain, blood and mucus spotting on underwear or the changes in defecation habits are the most common symptoms.

Methods: We searched from the PubMed, Google Scholar and Research gate database and looked for keywords rectal cancer, MRI, extramural venous invasion, total mesorecta excision, transrectal ultrasonography.

Results: The diagnostic methods should be aimed at determining the extent of tumour involvement, eventual fixation of the tumour or its ingrowth into surrounding organs or structures, the distance of the tumour from the an cutaneous line, also like the potential of metastatic spreading. Magnetic resonance imaging (MRI) in rectal cancer was first investigated in 1999 and now is essential in treatment planning. MRI has a high accuracy in predicting circumferential resection margin involvement and is used to plan the treatment strategy.

Conclusions: Radical surgical removal of the tumour is accompanied by other therapeutic modalities, including chemotherapy, radiotherapy and, in cases of metastases, targeted biological therapy as well. All of these modalities are based on multi-disciplinary meetings that selects the most appropriate treatment for patients with rectal cancer. In this review article, we will focus on the use of magnetic resonance imaging in the treatment of rectal cancer from a surgeon perspective.

Keywords: Rectal Cancer; MRI, Extramural Venous Invasion; Total Mesorectal Excision; Transrectal Ultrasonography

Abbreviations

CRM: Circumferential Radial Margin; CT: Computed Tomography; DRM: Distal Resection Margin; EMVI: Extramural Venous Invasion; MRI: Magnetic Resonance Imaging; PET: Positron Emission Tomography; RC: Rectal Cancer; Tame: Total Mesorectal Excision Via Transanal Route; TRUS: Transrectal Ultrasonography

Introduction

Rectal cancer (RC) as a part of colorectal cancers is one of the most common human malignancies [1]. The incidence of colorectal cancer rose following economic development and industrialization and it is higher in Western nations than in Asian and African countries. By the The American Cancer Society from 2006 to 2015, incidence rates increased by 1.8% annually also among those younger than age 55 [2]. The incidence of rectal malignancy is a bit higher in males than in females, yielding a male-female ratio of 1.30:1. Mortality rates were also higher in males 16.9 per 100,000, than in females 11.9 per 100,000 in 2012 - 2016 [3]. There are several external risk factors like high red meat consumption, high animal fat content, low fibre content in the diet, insufficient physical activity, sedentary lifestyle, increase in BMI, insufficient intake

of calcium, vitamine D, folic acid and trace elements and high alcohol consumption. The most common hereditary and familial risk factors are Familial adenomatous polyposis, Turcot syndrome or Lynch syndrome I and II.

Search strategy and selection criteria

We searched from the PubMed, Google Scholar and Research gate database and looked for keywords rectal cancer, MRI, extramural venous invasion, total mesorecta excision, transrectal ultrasonography.

Manifestations of RC

The clinical manifestation is based on the anatomical localization of the rectum in the pelvis. The most common reason for patients coming for examination is rectal bleeding. Blood and mucus spotting on underwear or spontaneous evacuation of gas, mucus or stool are also common symptoms. The discomfort in the sense of tenesm or pain, which may be dull or searing and is rather a symptom of a more advanced stage of the disease with a below placed rectal tumour, is also characteristic. Other warning symptoms are changes in defecation habits, alternation of diarrhoea and consti-

pation. Possible manifestation is also a raised temperature caused by the disintegration of tumour masses or infection, sometimes under the image of the Fournier's gangrene of the perineum. Other symptoms such as rectovaginal fistula is possible, depending on the extent of involvement or ingrowth of the tumour into the surrounding organs.

Diagnostic methods of the RC

At the beginning of the whole diagnostic process, in addition to the most detailed medical history of the problems, a surgical examination should be performed, especially per rectum examination. The examination should be aimed at determining the extent of tumour involvement, eventual fixation of the tumour or its ingrowth into surrounding organs or structures, and the distance of the tumour from the an cutaneous line, which is particularly important for determining the strategy for further surgical therapy. The anoscopic or rectoscopic examination with the collection of a valid histological sample is also mandatory. The colonoscopy examination has only an indicative value in relation to tumour placement but is all the more important in detecting the possible occurrence of synchronous carcinoma in 5% or adenoma in 35%. These examinations should be directed to a complete anorectum and colon examination. To complement the overall diagnosis of rectal tumour involvement, the occurrence of possible nodal and distant metastases should be determined in order to determine the stage of the disease. The chest, abdomen and pelvic computed tomography (CT) scan are considered to be basic to routine examinations that aim to display distant organ metastases. The transrectal ultrasonography (TRUS) and magnetic resonance imaging (MRI) as the gold standard are particularly important for the local range of RC. The Positron emission tomography (PET) /CT or PET/MRI examination is reserved rather for unclear findings in individual cases such as relapsing disease.

TRUS is beneficial especially in case of less advanced findings in T1 and T2 stage, where it helps us to distinguish the anatomical layers of the rectum and possibly also nodal involvement. It is also not as economically demanding as MRI. It is used more preferably where tumours do not have an exophytic ally growing intraluminal component.

Magnetic resonance imaging in rectal cancer

The main advantage of MRI is the excellent contrast of soft tissue, which is important for distinguishing normal tissue from pathologically altered tissue and the absence of ionizing radiation is also not negligible. Prior to examination, the patient is also not required to have any previous preparation, the rectum is not filled and expanded and the measured distance of the tumour from the an cutaneous line corresponds most to the physiological state. It is normally performed at two weighted times T1 and T2. At T1 weighted times, differentiating postoperative changes from normal pelvic tissue is beneficial, and T2 sequences help to differentiate postoperative fibrosis from tumour relapse [4]. MRI is used mainly for evaluation of Dukes but mainly TNM classification. The most important anatomical structure in this classification is

lamina muscularis propria. In the T1 stage of the tumour we are talking about mucosa and submucosa involvement. The T2 stage of the tumour leads to invasion of the lamina muscularis propria. Evaluation of stage T3 represents a very heterogeneous group. These are tumours that overlap lamina muscularis propria very discreetly, but this group also includes tumours that extend to the mesorecta fascia area and there is no detailed division of this very broad group of T3 stage tumours. The T4 group includes tumours that grow into the surrounding organs and reach the peritoneum. Another important structure that can be visualized on MRI in particular in T3 tumours is the so-called fascia recti, which represent the relationship of tumour tissue to perirectal soft tissues and can express the distance of the tumour to this fascia as well as differentiation of individual anatomical layers affected by tumour. Mesorecta fascia is the visceral layer of the endopelvic fascia that contains the rectum, mesorecta fat, lymph nodes and lymphatic vessels and forms a separate anatomical unit. Its ventral leaf coalesces cranially with the peritoneum leaf and the dorsal leaf coalesces with the presacral fascia. Thus, it is possible to determine relatively clearly the given T stage of the tumour, especially in the T3 stage, where the tumour grows through serosa's into the adjacent mesorecta fat. In tumours of the middle and oral rectum at a distance of 5 - 15 cm from the anus, we distinguish another four subgroups in the T3 stages according to the depth of invasion into the perirectal fat and the ingrowth into mesorecta fascia or distance from it less than 1 mm. These individual T3a, T3b, T3c, and T3d subgroups have great prognostic significance - tumours in the T3a and T3b subgroups have significantly better prognosis than T3c and T3d tumours. T3 stage tumours are more likely to have extramural vascular invasion, as well as a higher predictive factor of local relapse and poor prognosis of survival [5]. The significance of MRI also consists in determining the distance to the circumferential radial margin (CRM) in millimetres. At a safe distance, 1 mm or more, a local relapse risk of 12% is reported, compared to a 28% local relapse risk at a smaller distance [6]. Another unquestionably great advantage, especially in terms of prognosis, is the invasion into the blood vessels, assessed as extramural venous invasion (EMVI). This means the presence of malignant cells outside of the muscularis propria. A worse prognosis with a higher risk of metastatic process, especially in the liver area, is described with positive detection of venous invasion. There is also a scoring system for the evaluation of EMVI using MRI, where four indicators are evaluated, i.e. the location and boundary of the tumour, the location of the tumour in relation to the vessels, the width of the vessel and its boundary. With all characteristics present, the score is 4 and is associated with a higher incidence of metastases, local relapses with a worse response to neoadjuvant therapy and hence overall lower survival [5,7]. The evaluation of the tumour process invasion into lymph nodes by MRI is not always unambiguous, because even the size of the node itself does not necessarily indicate the presence or absence of metastases. The general size criterion is the affected node width of 5 mm, although, according to some studies, up to 30% of the metastases in the nodes are smaller than 5 mm. Therefore, the shape of the node is also important, and rather a blurred contour and a heterogeneous MRI signal points to metastatic involvement [8]. The staging evaluation of

MRI after neoadjuvant treatment called restaging is important for patient prognosis. The determination of the degree of regression following neoadjuvant therapy based on histopathological evaluation has been shown to be an independent predictive factor of total survival time and overall asymptomatic survival of patients [9]. However, the accuracy of the examination itself is questionable, mainly because of the ambiguous distinction of the fibrotic scar reaction. There is both an overestimation and an underestimation of MRI findings compared to the finding in a definitive histological preparation after intestinal resection or rectum amputation, both in the T stage of the extent of tumour involvement of the rectal layers and in the N stage of lymph nodes [8]. For tumours of the distal rectum, MRI is important to assess infiltration of musculus levator ani, external and internal sphincter infiltration, and the intersphincteric complex, i.e. for complete muscle complex ensuring faeces continence. The individual anatomical layers closely adhere to each other, and therefore local staging differs from tumours placed more proximally [7].

Treatment

In the case of a rectal tumour without metastasis, we always consider whether treatment by pre-operative tumour chemotherapy or radiation with chemotherapy will be included prior to surgical treatment. MRI examination is absolutely necessary to assess this treatment procedure correctly. The rectal cancer therapy should be individualized on the basis of a decision of the multidisciplinary cancer committee on behalf of an oncologist, radiologist, pathologist and, last but not least, a surgeon, as surgical treatment is for now the only treatment option that will give the patient a chance to cure. The decision on this treatment procedure should be consensual with the best benefit for the patient. The aim of surgical, i.e. oncosurgical treatment, is R0 resection without leaving a microscopic residue of malignant cells. This can be achieved by following Mason's and Tunball's principles, i.e. by completely removing the tumour, removing regional lymphatic pathways and nodes, and preventing the spread of tumour cells. It is also important to maintain a sufficient distal resection margin (DRM) between the resection margin and the lower border of the tumour. For upper rectal tumours, a minimum distance of 5 cm is recommended. For middle rectal tumours, a minimum distance is 2 cm, and a minimum distance of 1 cm is accepted for lower rectal tumours. DRM is considered a distal principle of oncosurgical radicality. Another necessity of oncosurgical radicality is sufficient CRM for resection. This is the distance of the tumour on the radial section from the fascia recti. This distance is measurable only on the preoperative MRI and on the definitive histological specimen. For R0 resection, the distance of tumour infiltration must be greater than 1 mm from fascia recti. During surgical resection, the surgeon attempts to remove a precisely defined part of the rectum with the tumour and all adipose tissue with nodes and intact fascia recti that encircles the rectum, referred to as total mesorecta excision. Mesorecta resection statistically significantly reduces locoregional relapses. CRM along with total mesorecta excision fall under the lateral principle of nonsurgical radicality. In resection, we try to avoid injuring the visceral nerves around the rectum by using electrocoagulation,

or by the thermal effect of high-energy instruments, because of the intact sexual and urological functions. The last, i.e. the third, proximal principle of oncosurgical radicality is the removal of the lymph nodes in the proximal direction, lymphadenectomy, in a sufficient number in the definitive histological preparation. The range corresponds to the ligation of inferior mesenteric artery at a distance of 1 cm from the aortic distance, thus protecting important visceral nerves for pelvic organs.

In the case of distal rectal carcinoma, only the abdominoperineal excision/rectum amputation has been considered the only surgical method for a long time, including substantial complications in the form of impotence or another urological dysfunction [10]. This variant of the surgical treatment is indicated for patients in whom we are not able to provide a sufficient distal resection margin of at least 1 cm oncosurgically and in patients with tumour infiltration of external sphincter and musculus levator ani as well as in already incontinent patients.

With the development of the stapler technique and the reduction of the safe distance of the distal resection margin to 1 cm, the number of sphincter-preserving resections has also increased [11]. As a method of choice, low anterior resection is modified here according to Dixon and is the most commonly indicated surgery. The introduction of preoperative radio chemotherapy and the possibility of intersphincteric resections was also another beneficial factor [12]. The aim of neoadjuvant therapy is to maximize the downstaging rate with the consequent possibility of complete resection with negative resection margins. Another variant of surgical treatment, especially in the case of a tumour of the lower, i.e. early stage, is a trans anal surgery. The surgery can be performed either in the form of trans anal microsurgical endoscopy, which removes only the affected area with a protective margin of the tissue, or as a novelty in recent years by performing trans anal total mesorecta excision via trans anal route (TaTME). After tumour resection, adjuvant chemotherapy is indicated on the basis of histological examination. Its aim is to destroy the remaining tumour cells and thus prevent the relapse of the disease. The adjuvant therapy is given either in the form of radiotherapy or more often as a combination of radiotherapy with concomitant chemotherapy.

Discussion

The main benefit of preoperative local staging by MR is in the assessment of gentle sphincter surgery performance in patients with low placed rectal tumour, where the difference in tumour distance from an cutaneous fold and anal canal length in preoperative diagnosis may change the type of surgery performed. The accurate MR topography will also evaluate the relation of rectal tumour and mesorecta fascia, which is removed in tumours in the middle and distal third of the rectum, and therefore, the radicality of the surgical solution can be determined even before surgery. For the patient, measuring the length of the anal canal and placing the tumour is an indication of whether he is undergoing extensive abdominoperineal amputation with permanent stool derivation by ostomy, or based on the outcome of the MRI examination, the pa-

tient will be offered a gentle sphincter surgery performance while maintaining stool derivation per vias naturales. The evaluation of local staging within the TNM classification has essential effect on prognosis and is crucial for eventual neoadjuvant treatment. The aim of surgical, i.e. nonsurgical treatment in the sense of intestinal resection with mesorecta excision is radical curative removal of the tumour, preservation of sphincters and their function, preservation of sexual functions and bladder function. However, even the best surgical treatment would be less successful without good diagnosis, quality histology and effective oncological treatment.

Conflict of Interest Statement

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