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Role of Magnetic Resonance Imaging in Patients with Rectal Cancer

Tsvetelina Teneva, Aleksandar Zlatarov and Rozen Grigorov

Abstract

In a chapter about rectal cancer there is content about rectal anatomy in relation to magnet-resonanse imaging and TME- surgery (total mesorectal excision). Secondly there is content about imaging methods used in diagnosis and follow-up of rectal cancer. Very important topic is concerning the novel imaging strategies in surgical and radiotherapy planning in the era of individual oncologic approach to the patient. At last there is detailed desction and metaanalysis of imaging strategies concerning neoadjuvant and adjuvant radiotherapy and chemotherapy for rectal cancer patients. All imaging markers correspond to substantial oncologic parameters such as survival rates. The connecting bridge is magnet-resonance imaging.

Keywords: rectal cancer, imaging, magnet-resonance imaging, tumor response, tumor regression grade, neoadjuvant therapy

1. Introduction

The purpose of this chapter is to provide the reader with detailed information about imaging of rectal cancer in the context of standardized and novel therapy options of rectal cancer. It is essential to put the rectal cancer in the correct stage group based on different imaging markers- local invasion (T-stage), local infiltration of mesorectum, intra- and extravascular invasion, lymph node spreading. Another important imaging biomarker is the tumor regression grade visualized on magnet-resonance imaging after neoadjuvant therapy. All markers correspond to substantial oncologic parameters such as survival rates. The connecting bridge is magnet-resonance imaging.

2. Rectal cancer imaging

Imaging of rectal cancer is more specific than imaging of the other colonic cancers. Rectal cancer staging is based on two principles. The first is an anatomic definition of the tumor and the second is prognostic stage grouping. Both are achieved by magnet-resonance imaging. Additional imaging modalities such as ultrasound US, computed tomography CT and positron emission tomography PET are discussed later on.

2.1 Anatomic definition of rectum

Knowing the anatomy, especially the anatomy on MR studies is the key to the right treatment of rectal cancer. Important anatomical landmarks are sigmoid take-off (transition rectum-sigma), mesorectal fascia MRF and mesorectum, presacral fascia, anterior peritoneal reflection, retrorectal space, anorectal sling (m. levator ani) and anal verge, shown on the pictures below.

The rectum is the most distal part of the gastrointestinal tract, located before the anal canal. There are different definitions of the distal and proximal borders of the rectum – distal border is linea dentata ani, and proximal part is the sigmoid colon and the transitional part called sigmoid take-off. It is a radiological reference point used to identify the connection of the sigmoid mesocolon with the mesorectum and therefore the connection of the sigmoid colon with the rectum (**Figure 1**).

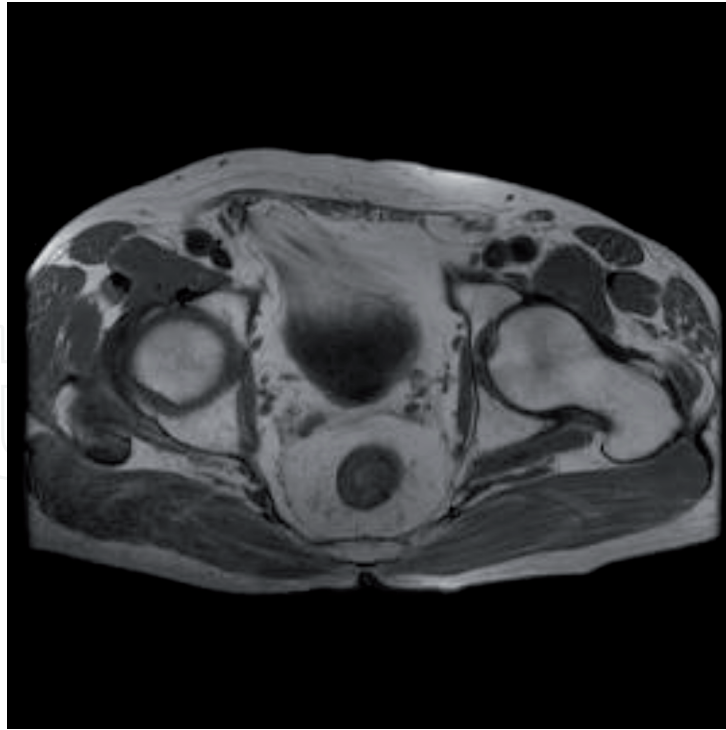#### 2.1.1 Mesorectum and mesorectal fascia MRF

It is a hypointense line that surrounds the mesorectum. Above this layer it connects with the mesorectal fascia, which lies above the levator muscles and, respectively, connects with the peritoneal reflection forward and with the parietal fascia backward (**Figure 2**).

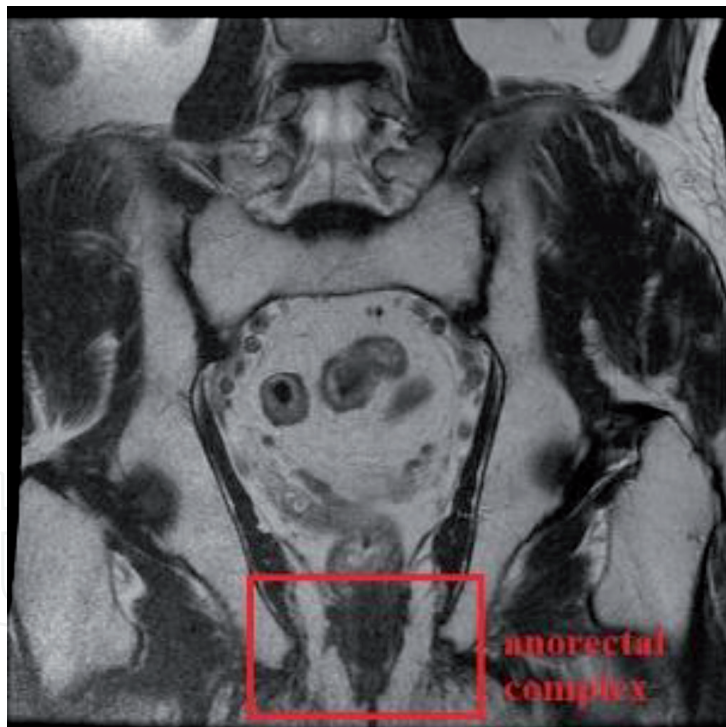#### 2.1.2 Anorectal sling (m. levator ani) and anal verge

Anatomically, the anal canal is at the level at which the anorectal sling envelops the rectum and creates the anorectal transition (**Figure 3**).
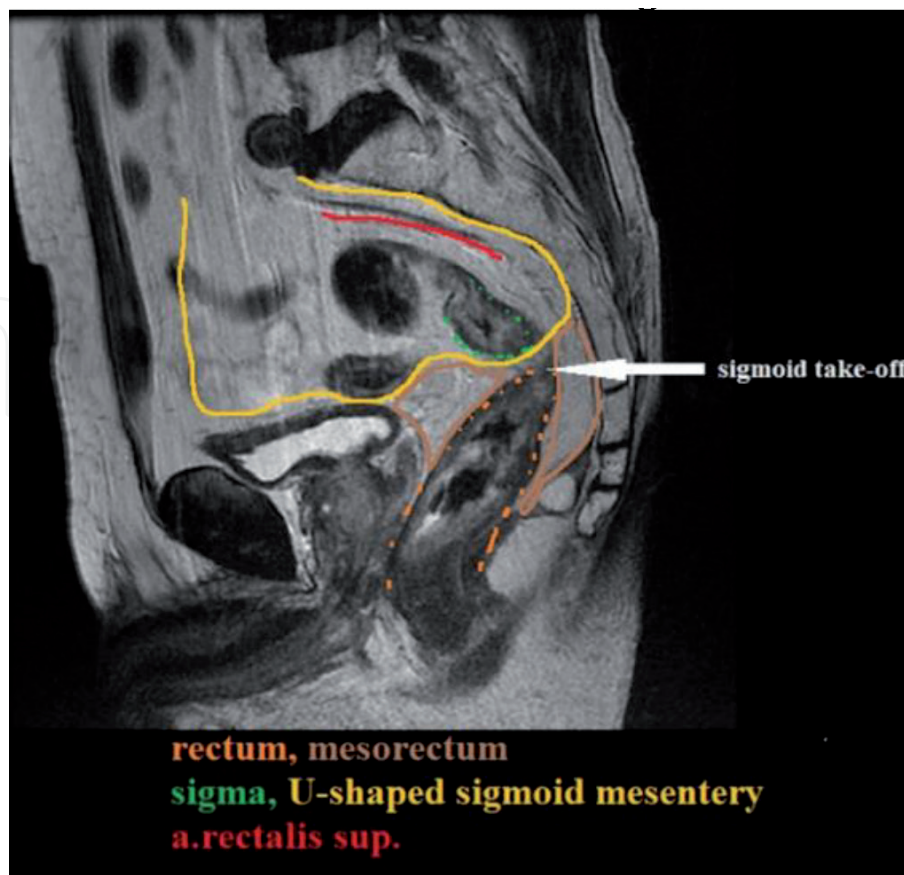
Figure 1.
Anatomical presence of sigmoid take-off (sagittal T2 weighted MR image).

Figure 2.
Mesorectum and mesorectal fascia MRF (axial T2 weighted MR image).
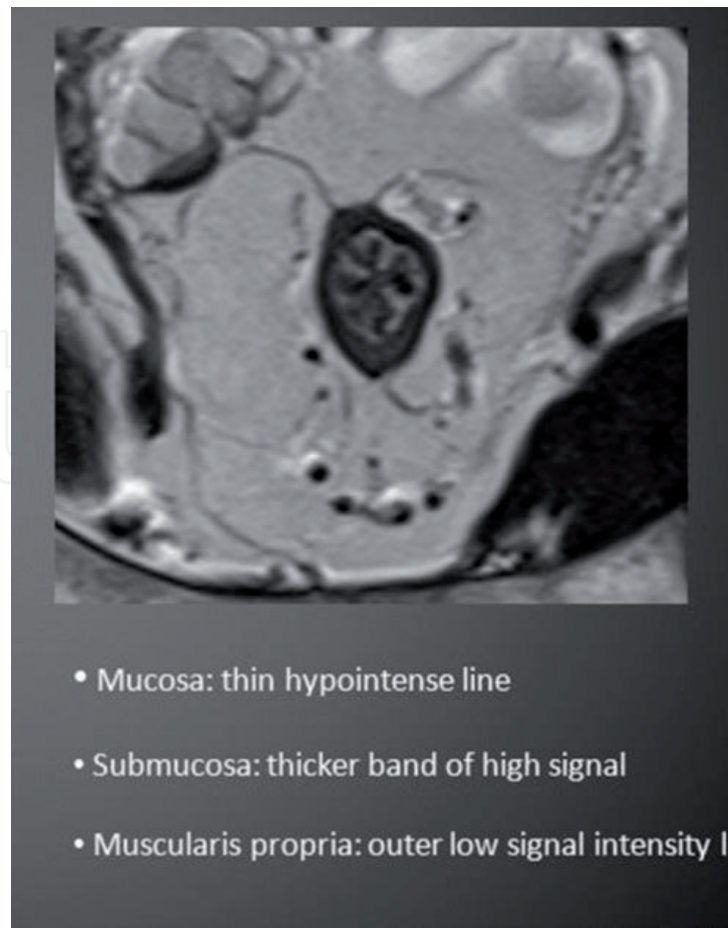

Figure 3.
Anorectal complex (coronal T2 weighted MR image).

2.1.3 Anterior peritoneal reflection

It is a thickened parietal fascia that covers the terminal veins and adipose tissue in the proximal part of rectum.

2.2 Mucosal layers of rectal wall

Another anatomical landmark is differentiating the mucosal layers (**Figure 4**) in relation to the TNM classification of the rectal cancer.

- Mucosa: thin hypointense line
- Submucosa: thicker band of high signal
- Muscularis propria: outer low signal intensity li

Figure 4.
Mucosal layers of rectal wall (axial T2 weigted MR image).

T1- submucosal invasion.

T2- invasion of muscularis propria.

T3- through the muscularis propria to the submucosa.

T4- perforation of the visceral peritoneum or direct invasion of the peritoneum.

Important fact is that T3 and T4 tumors are associated with extramural invasion. The more pronounced penetration of the mesorectum is associated with a worse prognosis and a higher probability of local recurrence. Many tumors are staged as pT3, but there is actually a heterogeneous T3 group, which is why a subclassification of T3 has been created:

T3a - minimal invasion <1 mm by muscularis propria.

T3b- light-walled invasion 1-5 mm from muscularis propria.

T3c- moderate invasion 5-15 mm from muscularis propria.

T3d- extensive invasion>15 mm by muscularis propria.

T3a and T3b are associated with better outcome for the patient compared with T3c and T3d stages, suggested they are T4 tumors because of worse outcome and poor prognosis [1].

When talking about staging it is important to notice that low rectal cancer is a separate subgroup again due to different anatomical features- the anorectal sling:

Staging of low rectal cancer with MRI (recently validated in the prospective study Mercury II: Low Rectal Cancer study [2].

stage 1 - the tumor is visualized in the rectal wall, but not throughout its thickness (preserved outer muscle layer).

stage 2- the tumor displaces the muscle layer without crossing the intersphincteric line.

stage 3- the tumor invades the intersphincteric line or is 1 mm from the levator ani.

stage 4- the tumor invades the external anal sphincter and infiltrates the levator ani and/or invades neighboring organs.

2.3 Pathways of spreading

For understanding of the neoplastic behavior of rectal cancer it is of great importance to analyze the pathways of spreading of tumorous tissue. They are:

1. direct invasion in the rectal wall,

2. involvement of local lymph vessels and lymph node metastases,

3. venous invasion (intra- and extramural venous invasion- EMVI) and

4. tumor deposits.

Demonstration of any invasion both histologically and by MRI [3] is always associated with a poor prognosis. The detection of EMVI is associated with the presence of synchronous distant metastases. Involvement of extramural venous vessels is more closely associated with poor prognosis, as well as invasion of larger veins. This leads to the conclusion, that detection of EMVI on MRI is of great prognostic importance and it is explained in details below.

2.4 Surgery of rectal cancer

Explaining the anatomy by the radiologists helps the surgeons plan the surgical procedure. Surgeons have 3 options:

1. TEM- Transanal Endoscopic Microsurgery in T1 stage

2. TME- Total Mesorectal Excision is the universally established standard for optimal oncological surgery in rectal cancer [4]. TME is an independent predictor of local recurrence. TME includes excision of the rectum and surrounding adipose tissue, the lymphovascular cuff, the mesorectum, in which the locoregional lymph nodes are located. The outermost border of the mesorectum, the mesorectal fascia, plays the role of an oncological barrier. Thus, if the surgical principles for TME are followed, the prognostic effect of regional lymph nodes may be neglected [5], as they themselves are removed en block in TME.

3. Deferral of surgery or Watch and Wait strategy- novel strategy based on organ preservation if complete clinical response is achieved by neoadjuvant therapy (references on EURECCA (European Registration of Cancer Care [6] and TRIGGER) [7].

4. No surgery and stoma placement in locally advanced and unresectable T4b tumors.

2.5 Treatment options

Before discussing the imaging of rectal cancer one should understand the treatment options for the disease. The ideal prognostic stage allows selection of the

patient according to the risk of local and/or systemic recurrence. This leads to three main treatment options:

- Surgery alone,

- neoadjuvant therapy before surgery and

- palliative pharmacotherapy/radiotherapy alone.

Planning and decision making are listed in the European [8] and Nord-American guidelines [9].

Main goal is to achieve downstaging and downsizing of the tumor and therefore optimal mesorectal excision. This is possible with neoadjuvant therapy and it has a leading role in treatment of rectal cancer. Synchronous to better therapeutical options many imaging markers for response measurement are found out.

In order to objectively measure the rate of tumor response to this therapy, several systems called histopathological tumor regression grades (pTRG) have been developed, the most commonly used being those of Dworak [10] and Mandard [11] Both systems determine the response to treatment based on the residual/residual cells in the fibrous stroma, and the gradation is between "no response" to "complete response". A pathological complete response (pCR) is defined as "no residual tumor cells in the material". A novel radiological method for tumor response has been developed based on pCR - magnetic resonance imaging of the tumor response tumor regression grade (mrTRG) [7] MRI can be used to predict a favorable response and to assess the extent of subsequent treatment.

Therefore we can use some imaging predictors on pretreatment (primary) MRI-scan and on posttreatment (secondary) MRI-scan. This is how we could reach out to the second principle of rectal cancer staging - prognostic stage grouping.

2.6 MRI of rectal cancer

The main imaging modality for local staging of rectal cancer is magnetic resonance imaging (MRI), as it provides the most accurate information about important prognostic markers that could affect the choice of treatment. In addition, there are many new studies on the role of MRI in assessing the response after neoadjuvant radiation therapy.

Technical parameters for MRI: 1,5 T or 3 T, FOV (160 x 160 mm, 256 x 256 matrix), 0.6 x 0.6 x 3 mm, high-resolution image (1 mm 3 voxel size), sequences: first series - T2-weighted sagittal, turbo spin-echo sequences for tumor identification, second series – axial T2 to the whole pelvis, third series - T2-weighted thin-section axial through the neoplasia, and they should be perpendicular to the long axis of the rectum and to the level of the neoplasm (3-mm slices). Addition: for low rectal cancer there is a fourth series - high resolution, coronary images for the levators, the sphincter complex, the intersphincter axis and the relationship to the rectal wall. Follow-up MRI after treatment follows the same protocol.

Diffusion-weighted imaging (DWI) images of magnetic resonance show the random movement of water molecules in the body. The degree of water restriction in biological tissues is directly proportional to the tissue cellularity and integrity of the cell membrane. Therefore, the contrast of tissues at D The apparent diffusion coefficient (ADC) is recalculated by the DWI, using these two techniques to compare different tissue compartments depending on the cell composition. Evaluates the response to treatment. DWI could be useful in the primary detection of rectal cancer and lymph nodes, but not for follow-up assessment or measurement of tumor regression, incl. mrTRG.

Gadolinium-enhanced MRI is not recommended.

MRI has the ability to distinguish each individual layer of mucosa and muscle due to their different signaling characteristics. For this purpose, the T2 sequence is used:

- Mucosa - fine hypointense line

- Submucosa - thicker hyperintense layer

- Muscularis propria - a double layer of inner circular and outer longitudinal layer, the latter having an irregular appearance due to the passing vessels

- Perirectal adipose tissue/mesorectum - high signal tissue

- Mesorectal fascia - a thin hypointense band surrounding all of the above (**Figure 5**)

Patients with rectal cancer will receive a series of MRIs during the course of their treatment:

- the initial (primary) MRI will guide whether neoadjuvant therapy is needed, will guide the operative plan, and factors such as mrEMVI will determine the type of neoadjuvant therapy

- the secondary MRI follows the neoadjuvant therapy, and the response is assessed by mrTRG. In patients with a good mrTRG response [1, 2], it is possible to wait with surgery or reduce the volume of the operation or continue with radical surgery. The first two options potentially lead to the preservation of the integrity of the rectum, but additional MR examinations are needed. In case of a weak response (mrTRG4–5) it is possible to choose surgery or
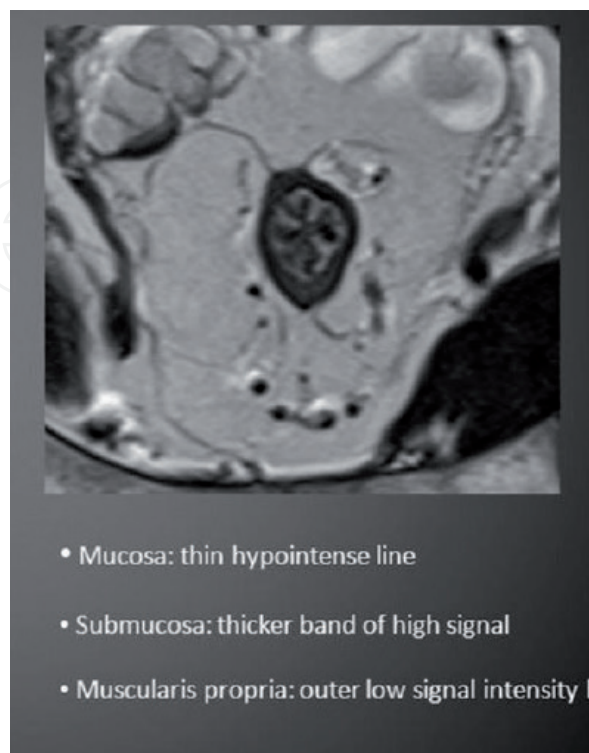
Figure 5.
Mucosal layers of rectal wall (axial T2 weigted MR image).

continuation with chemotherapy with intensification and/or experimental pharmacotherapy and change of mrTRG to a prognostically better group.

- the third MRI is for the group waiting for surgery and MRI is used to monitor recurrence.

As already mentioned, we have to separate some imaging markers on the pre- and posttreatment studies that are essential for predicting response and outcome from the disease.

In the first group is the pretreatment MRI and the imaging features for predicting the tumor response:

- Tumor height - low rectal cancer is more likely to have a bad response;

- T stage- T1, T2, T3a, T3b are more likely to have a good response;

- EMVI - the presence of mrEMVI is associated with a worse prognosis.

In the second groups is the posttreatment MRI and evaluation of the post-therapeutic response (used prefix "y"- after neoadjuvant therapy):

- Tumor height from the intersphincteric line to the distal TME line

- mrTRG (tumor regression)

- EMVI- ymrEMVI

- CRM (circumferential resection margin)

- ymrT (depth of invasion)

- ymrN (nodal status).

2.6.1 Assessing tumor high

Rectal cancer can be divided (**Figure 6**) into:
Low rectal cancer:
Distal border is 0–5 cm from the anorectal angle.
Mid rectal cancer:
Distal border is 5–10 cm from the anorectal angle.
High rectal cancer:
Distal border is 10–15 cm from the anorectal angle.
Involvement of the intersphincteric plane, external sphincter and levator musculature should be assessed. Low cancer localization increases the risk of CRM engagement.

2.6.2 Assessing T-stage

Determination of the T-stage (**Figure 7**) depends on the correct visualization of each individual layer in compliance with the MR-protocol. T category is characterized by the depth of tumor penetration into the rectal wall and extramural spread into the mesorectum and adjacent structures.
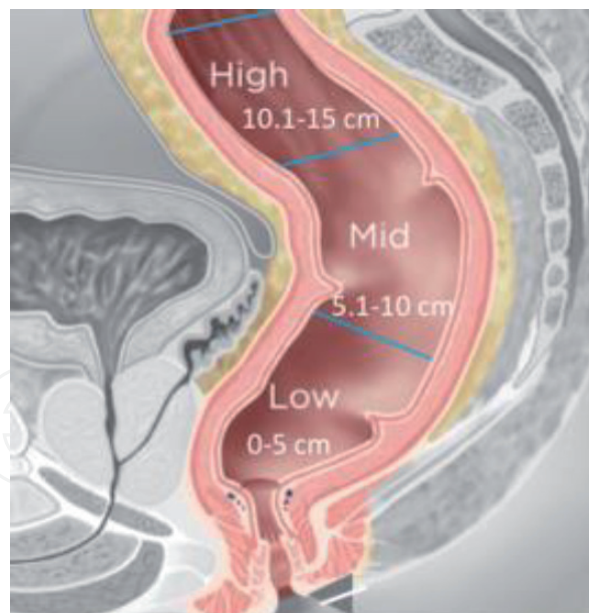
Figure 6.
Rectal tumor high. Source: MRI of Rectal Cancer: Tumor Staging, Imaging Techniques, and Management",
Horvat et al. [12].
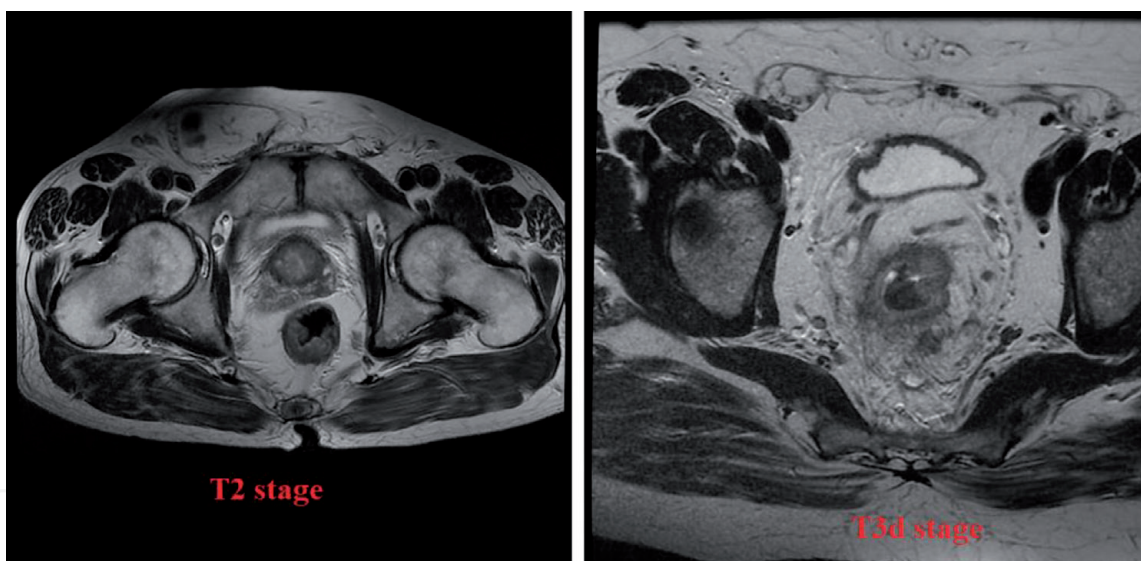
Figure 7.
Different T stages of rectal cancer: T2 rectal cancer (left) and T3d rectal cancer (right) (axial T2 weighted MR
images).

in T1 and T2 rectal tumors is an intact external muscularis layer, which is identi-
fied as a hypointense thin line surrounding the rectum. T3-tumors grow through
the external muscularis into the surrounding mesorectum, important is to classify
T3 to T3a, b, c, d.

Consistency between MRI and histopathology in determining the T-stage was
initially studied by Brown et al. [3], who found a 94% match between MRI and pT-
stage. The MERCURY multicentre study directly compared the extramural depth of
invasion as measured by MRI and histopathology.

Numerous histopathological studies have shown the importance of the T-stage.
The T3 subclassification was developed because the majority of patients have a T3
tumor, but the heterogeneity in survival values is high:

- pT3 with>5 mm tumor invasion have a worse 5-year survival (disease-free survival (DFS)) than tumors with an invasion below 5 mm (pT3b); and this regardless of the nodal status.

- T3a tumors, with an invasion below 1 mm, have a very good prognosis

- The values for local recurrence and overall survival of T2 and T3a are identical

- The palpable difference in DFS between T3b and T3c shows that their differentiation is of greater clinical significance than the distinction between T2 and T3.

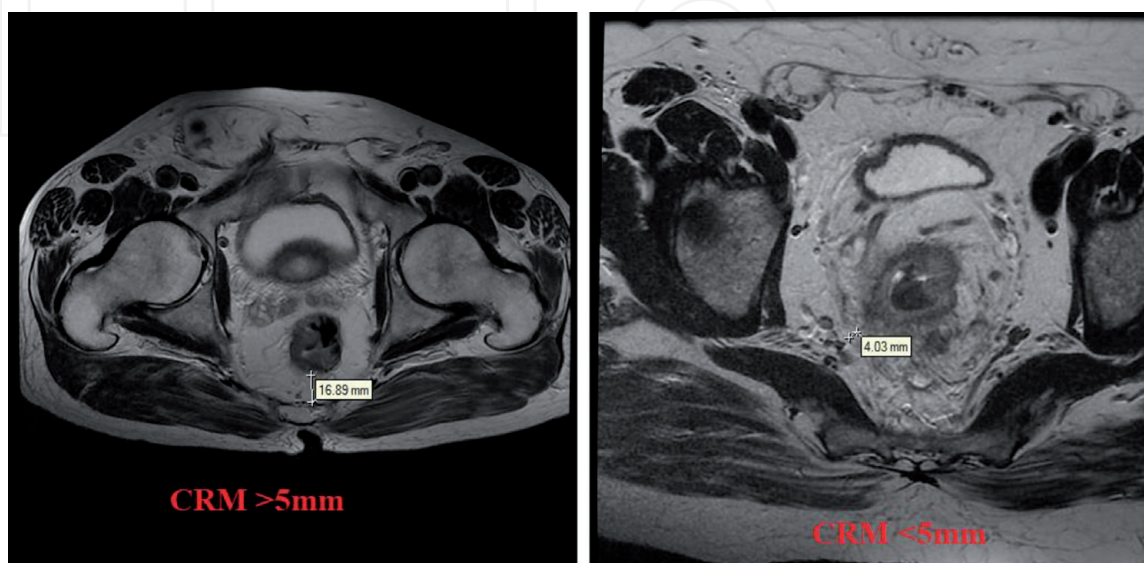*2.6.3 Assessing CRM- circumferential resection margin*

CRM is the surface of the nonperitonealized part of the rectum that is resected during surgery. In the description of T3-tumors, the report should include the shortest distance between the tumor margin and the mesorectal fascia MRF because of increased risk for local recurrence. MRF often refers to CRM. CRM > 5 mm measured by MRI is sufficient to predict microscopically clear resection lines (**Figure 8**).

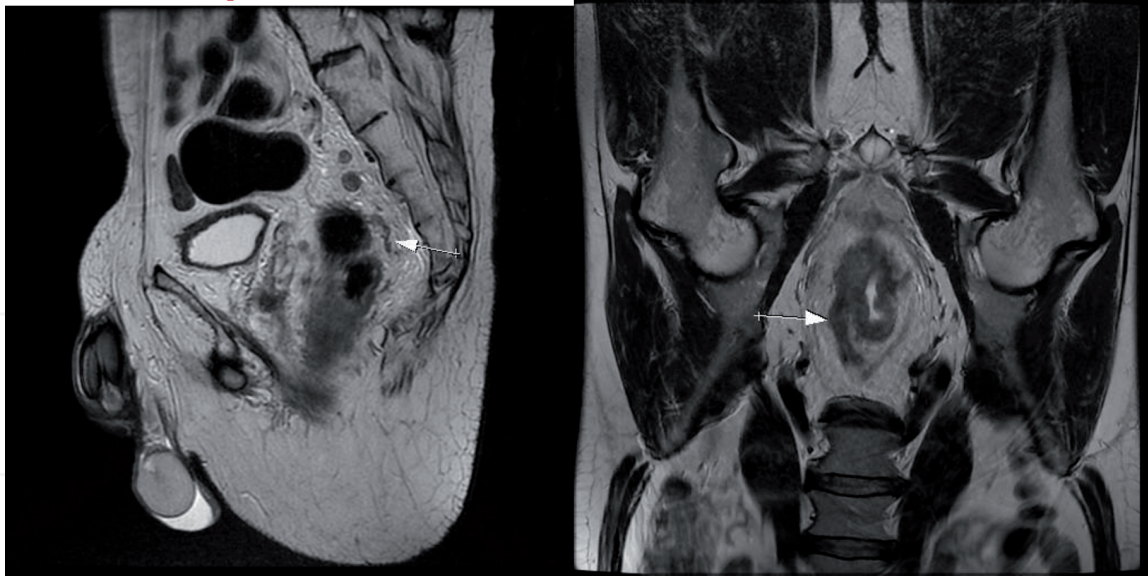*2.6.4 Assessing EMVI: extramural venous/vascular invasion*

Extramural vascular invasion is defined as the presence of tumor cells in vessels outside the lamina muscularis propria (**Figure 9**, arrows).
Positive mrEMVI is associated with low survival rates. The 3-year survival in mrEMVI-positive patients was 35% compared to 74% in mrEMVI-negative patients. mrEMVI-positive patients have a fourfold increased risk of developing distant metastases.
The radiological characteristics of EMVI observed on MRI are described in detail -The veins around the rectum are recognized on the T2 sequence as serpiginous or curved linear structures; in the tubular structures considered to be blood vessels, in addition to changes in the contour, there is a weakening of the signal.

Figure 8.
CRM- circumferential resection margin (axial T2 weighted MR images).

Figure 9.
EMVI- extramural venous/vascular invasion (T2 weighted MR images).

A complete evaluation of mrEMVI should include the following: (entry into small veins may produce a nodular border); location of the tumor relative to the large vessels; vascular caliber (the tumor causes the vessels to dilate and amplify the tumor signal in the lumen) and the vessel boundary.

2.6.5 Assessing N- stage

The N-stage is an important risk factor for local recurrence. The size of the lymph node itself is not indicative, as 15–42% of patients with rectal cancer have small (<5 mm) mesorectal lymph nodes containing tumor cells (**Figure 10**, arrowheads).

Figure 10.
Lymph nodes (arrowheads).

2.6.6 Assessing mrTRG (special focus)

Tumor regression refers to the effect of neoadjuvant radiotherapy or chemotherapy on the tumor. The degree of tumor regression (TRG) is determined by the amount of residual tumor cells and the degree of fibrosis induced by non-adjuvant therapy. High tumor regression correlates with higher survival and lower rate of local recurrence. Several scales have been developed for TRG, such as Mandard and Dworak, but no consensus has been reached on which to use routinely.

After chemoradiotherapy, a number of tissue changes induced by radiation occur. These include swelling, inflammation, necrosis and fibrosis. mrTRG evaluates the changes on MRI after 12 weeks of neoadjuvant chemo-, radiotherapy.

This mrTRG system uses a 5-point scale. The low points [1–3] correspond to a more significant regression, and the high points [4, 6] mean no regression. The system also divides the categories according to the type of answer (complete, good, moderate, poor, none).

mrTRG1- radiologically complete response- linear, eccentric scar of 1–2 mm, limited in the mucosa or submucosa.

mrTRG2- good response- dense fibrosis without visualizing a residual tumor and without suspecting (**Figure 11**).

mrTRG3- incomplete response - over 50% fibrosis or mucin and visible intermediate signal intensity.

mrTRG4- weak response- small areas of fibrosis or mucin among tumor tissue (**Figure 11**).

mrTRG5- no response- intermediate signal intensity, tumor visualization without tumor dynamics or growth.

(Proposed by Bhoday et al) [13].

Many studies show that mrTRG is a prognostic and predictive biomarker-MERCURY trial, EXPERT-C trial [14], GEMCAD study, CORE study [5]. EXPERT – C study shows significant difference in rates of disease-free survival DFS and overall survival OS: mrTRG 1 & 2 (good response), mrTRG3 (medium response) and mrTRG4–5 (poor response) have a 3-year DFS survival of 82, 72 and 61%, respectively. These independent studies show that mrTRG predicts different groups- mrTRG could distinguish between "good" and "poor" responses to chemotherapy ('good' and 'poor' responders). It could be suggested that mrTRG can be used as a biomarker to stratify the choice of treatment for rectal cancer. Good responses (mrTRG1–2) are similar to good pCR, so surgery rejection and intensive follow-up of these patients can be chosen (watch and wait strategy). Poor responses (mrTRG3–5) could be subject to additional chemotherapy in order to improve mrTRG status to a lower grade. This requires the use of MRI to repeat the assessment of mrTRG.
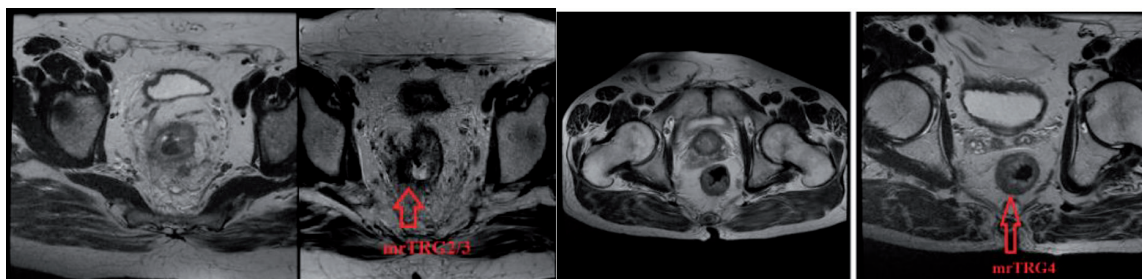
Figure 11.
Tumor regression grade on MRI: First picture T3d rectal cancer before neoadjuvant therapy. Second picture mrTRG 2/3 same patient after neoadjuvant therapy. Third and fourth picture another patient with T3 tumor before (third) and after (fourth) neoadjuvant therapy- mrTRG 4/5.

mrTRG and pTRG were compared in patients with rectal cancer in two clinical trials (EXPERT and EXPERT-C) [14]. The concurrence of the opinions of radiologists and pathologists was assessed with the weighted k test. The Kaplan–Meier method was used to evaluate the results of overall survival. Results: 191 patients were included in the study. The mean time from completion of neoadjuvant treatment to preoperative MRI and surgery was 4.1 weeks (IQR: 3.7–4.7) and 6.6 weeks, respectively (IQR: 5.9–7.6). good agreement was found between mrTRG and pTRG, with regression classified according to standard five-stage systems (kj0.24) or modified three-stage systems (kj0.25). Sensitivity and specificity of mrTRG 1–2 (complete / good radiological regression) for predicting the pathological complete response was 74.4% (95% CI: 58.8–86.5) and 62.8%, respectively (95% CI: 54.5–70.6) Survival outcomes in patients with intermediate pTRG 2 were numerically better if complete/good regression was also observed with mrTRG 1–2, compared with poor regression of mrTRG4–5 (5-year recurrence-free survival 76.9% vs. 65.9%, P00.18; 5-year overall survival 80.6% vs. 68.8%, P0.22).

Conclusions: The coherence between mrTRG and pTRG is low and mrTRG cannot be used as a substitute for pTRG. Further studies are needed to assess the ability of mrTRG to detect patients with a complete response to pTRG and to provide additional prognostic information to pTRG for better risk stratification after surgery.

Evaluation of the preoperative response to treatment of rectal cancer by MRI is an area of growing importance both in terms of predicting results and in determining the complete response. Clinical use is currently limited. The MERCURY study [13] shows that tumor regression can be assessed by MRT (mrTRG) after preoperative chemotherapy and radiation, using the differences in signal intensity between tumor and fibrous tissue. In this study, the 5-year overall survival (OS) was 27% for poor response (mrTRG4–5) versus 72% (p = 0.007) for good response (mrTRG 1–2), and the 5-year free survival was relapse survival (DFS) resp. 31% vs. 64% (p = 0.007). Nougart et al. [15] reported that volume assessment with MRI in patients receiving preoperative therapy was of prognostic significance. In this study, a reduction in tumor volume of at least 70% was associated with a better DFS value (HR 13.7; 95% CI 3.98–31.93).

Another PAN-EX study [16] by the same study group again demonstrated that mrTRG had greater value for prognostic factors such as relapse-free survival (RFS), long-term relapse-free survival (DFS), and overall survival (OS).

The main advantage of mrTRG is that it is not based on evaluation of resection material. The degree of tumor regression with MRI can be assessed before any surgery. This information provides a potential opportunity to consider other preoperative therapies. Previous analyzes of the PAN-EX study showed that patients who achieved mrTRG 1–2 after completion of CLT had a significantly better prognosis than patients who were assessed as mrTRG 3–5. mrTRG can potentially be used as an imaging parameter for the selection of patients with a good prognosis, in whom a non-operative approach after neoadjuvant treatment may be preferred. mrTRG appears as a dynamic, non-invasive, surrogate method for assessing tumor regression after neoadjuvant treatment and before surgical resection.

Be aware that the classification of patients as good and poor responders on the basis of mrTRG makes it possible not only to predict the outcome of the disease, but also to modulate therapeutic behavior. This means that patients may be advised to delay surgery, modulate chemo-, radiotherapy or choose another approach. The TRIGGER study [17] evaluated mrTRG as a new biomarker for stratification of patients with good and poor response to neoadjuvant therapy for rectal cancer and the inclusion of good responders in a new strategy, namely Watch & Wait.
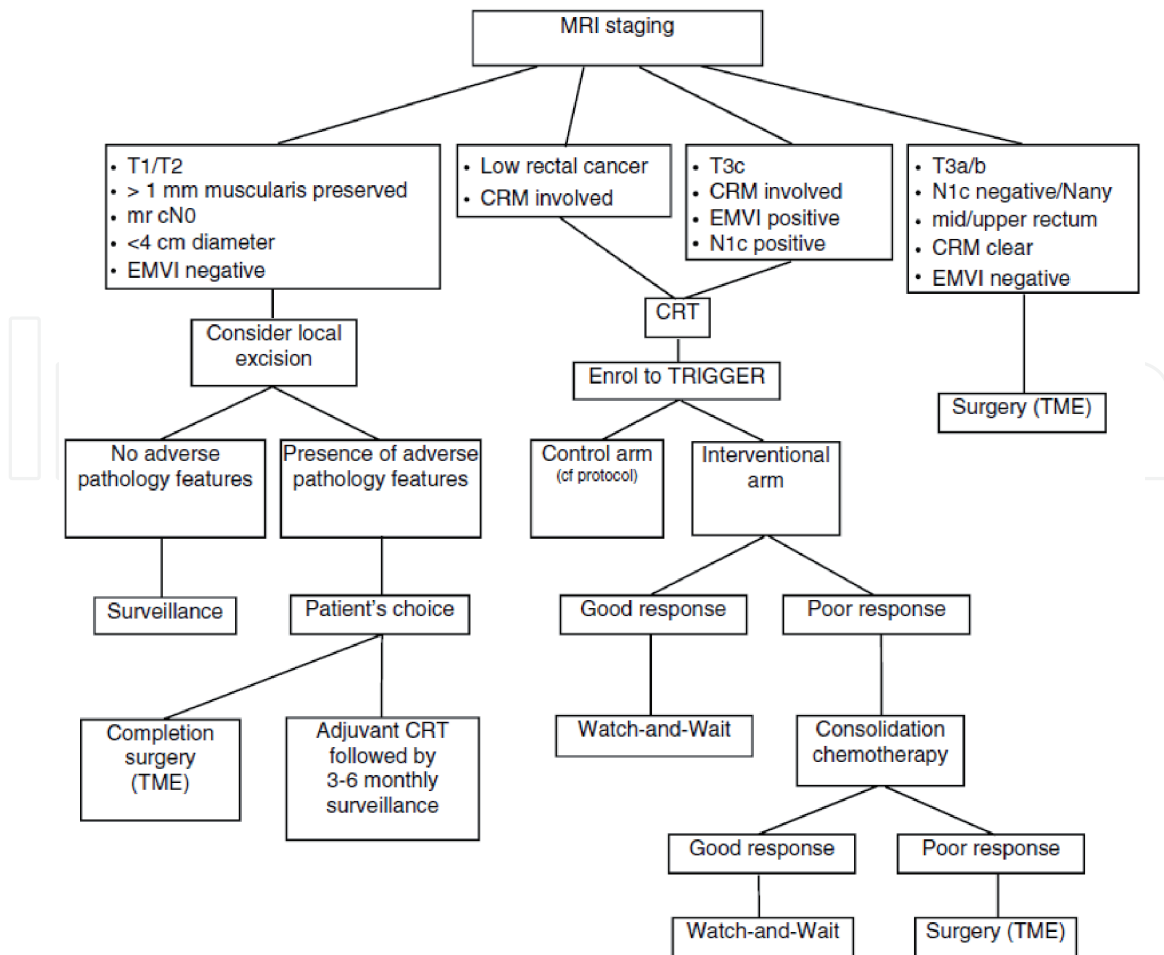
2.7 Additional imaging modalities

Computed tomography, ultrasound and positron-emission tomography are imaging studies that could be complementary to MRI and be incorporated in the management of rectal cancer in some cases. Be aware that MRI is not available imaging tool in some institutions and CT and/or US are the only diagnostic choice for rectal cancer.

2.7.1 Computed tomography CT

Computed tomography CT (**Figure 12**) is not a modality of choice in the staging of rectal cancer due to the low resolution of the method and the inability to distinguish the different layers of the intestinal wall required for T-staging compared to MRI. CT is not applicable for detection of accurate T-stage, CRM- or EMVI involvement, but a method of choice for N- and M-staging and CT is still used in many centers. CT is not recommended for follow-up or for monitoring after therapy.

2.7.2 Ultrasound US

Endorectal ultrasound is effective diagnostic modality in the assessment of rectal cancer. Its accuracy in numerous trials is around 80% for T-staging and 70% for N-staging.

ERUS images of the rectal wall comprise three hyperechoic and two hypoechoic layers, which alternate with each other and correspond to anatomic layers. (**Figure 13**).
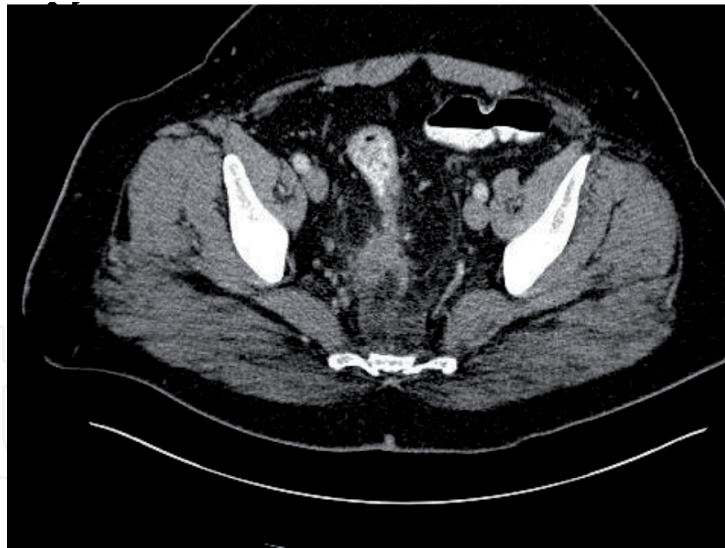
Figure 12.
CECT of rectal cancer, axial view, soft tissue window.
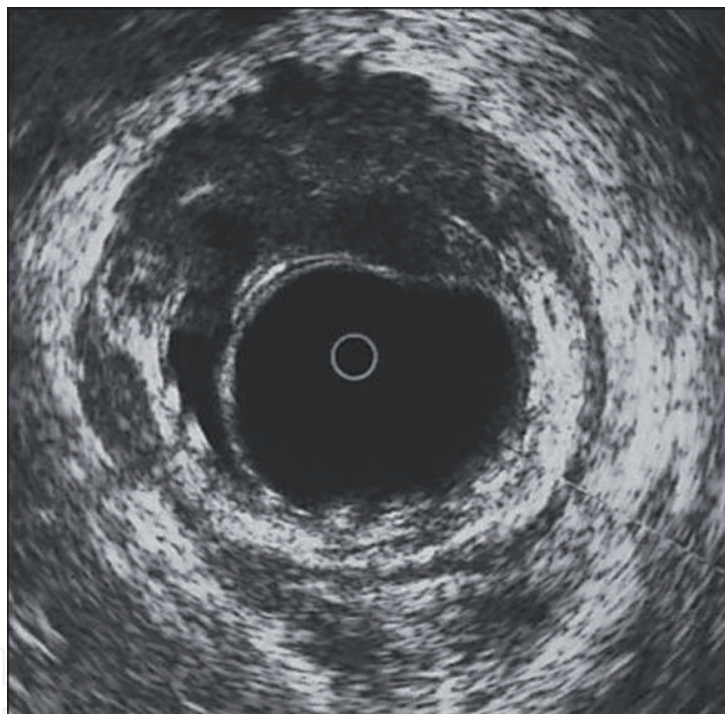
Figure 13.
Endorectal ultrasound illustrating rectal cancer invading beyond the rectal wall into perirectal fat.

On endorectal ultrasound, rectal tumors appear as hypoechoic lesions and are staged according to level of invasion through the rectal wall. Ultrasound stages are labeled with the prefix "u".

ERUS can also be used to monitor for rectal cancer recurrence postoperatively. After surgery, the excision site appears as a pattern of mixed echogenicity, replacing the normal five-layer image.

ERUS is a method of staging rectal cancer which is human dependent. ERUS is less accurate for T staging of stenotic tumors, but the accuracy may still be within acceptable limits. Surgeons use ERUS to adopt a treatment protocol, knowing the risk of under-staging and over-staging of this method. The accuracy of ERUS is higher in diagnosing rectal cancer in stages T1, T2 and with less sensitivity for T3 and T4 tumors.

Figure 14.
PET/CT of rectal cancer.

2.7.3 Positron emission tomography PET

Positron emission tomography PET with computed tomography is an additional method for functional staging by imaging in the following cases: [1] in unconvincing computed tomography and magnetic resonance data for primary tumor or distant visceral metastases with elevated values of tumor markers; [2] for N-staging; 3) for M-staging. Disadvantages are the high cost and low availability of the method. Inaccuracies in the differentiation of changes in the mesorectum and pelvic lymph nodes and inaccuracies in the assessment of mucinous tumors are known. It also cannot stratify patients with complete and incomplete response (**Figure 14**).

3. Conclusion

In this chapter about rectal cancer there is content about rectal anatomy in relation to magnet-resonance imaging and TME- surgery (total mesorectal excision). There is a detailed description of imaging strategies concerning neoadjuvant and adjuvant radiotherapy and chemotherapy for rectal cancer patients. The staging and choice of treatment for rectal cancer are the main goal of any national and international organization in choosing guidelines and resp. guideline. The main guidelines are those of the European Society of Medical Oncology (ESMO), the European Rectal Cancer Consensus Conference (EURECCA-CC2) and the National Comprehensive Cancer Network (NCCN), but they also differ in their recommendations in some aspects of rectal cancer management.

Conflict of interest

The authors declare no conflict of interest.

Notes/Thanks/Other declarations

All figures (except **Figure 6**) are provided by Teneva MD from Department of Imaging Diagnostics, University Hospital St. Marina, Varna, Bulgaria.

Abbreviations

MRI	magnet-resonance imaging
DWI	diffusion-weighted imaging
US	ultrasound
CT	computed tomography
PET	positron emission tomography
MRF	mesorectal fascia
EMVI	extramural venous invasion
CRM	circumferential resection margin
pCR	pathological complete response
mrTRG	magnetic resonance imaging of the tumor response tumor regression grade
pTRG	histopathological tumor regression grades
TEM	transanal endoscopic microsurgery
TME	total mesorectal excision
DFS	disease-free survival
OS	overall survival

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