Rectal Cancer - MR staging - 3.0- 2025

A Norouzi
Board certified Radiologist
Fellowship of CT & MRI

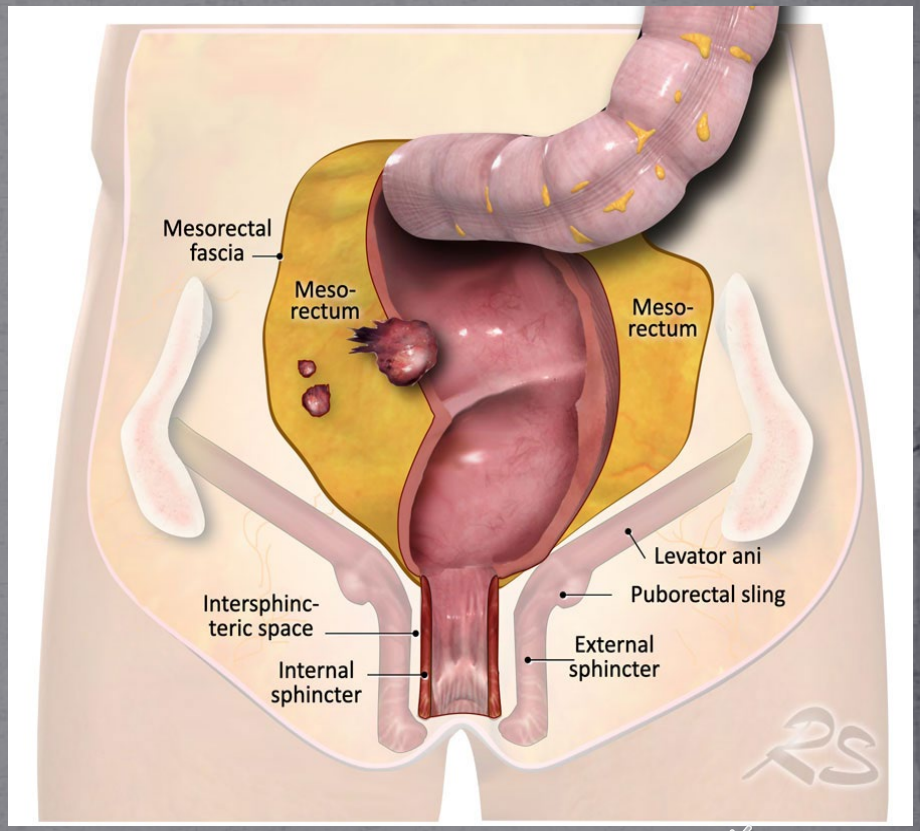


- The two major advancements in the treatment of rectal cancer are total mesorectal excision (TME), and neoadjuvant radiotherapy and chemotherapy .
- Both have dramatically changed the local recurrence and survival rates.
- The decision whether a patient with rectal cancer is a candidate for TME only or neoadjuvant therapy followed by TME, is made on the findings on MRI & EUS.

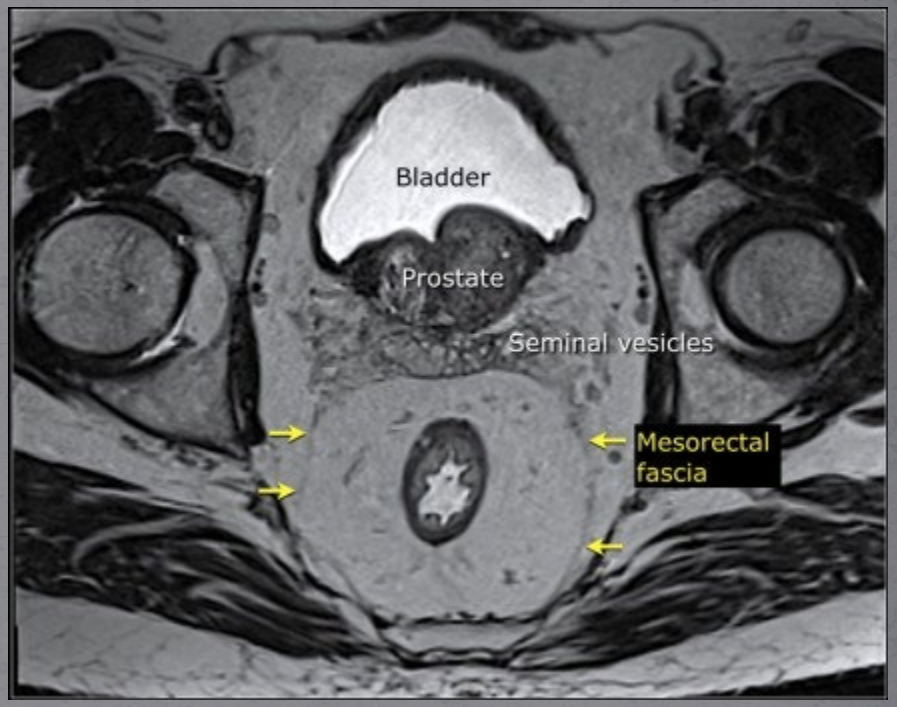


Total mesorectal excision

- In TME the entire mesorectal compartment including the rectum, surrounding mesorectal fat, perirectal lymph nodes and its envelope, the mesorectal fascia (MRF), is completely removed by precise dissection along anatomical planes



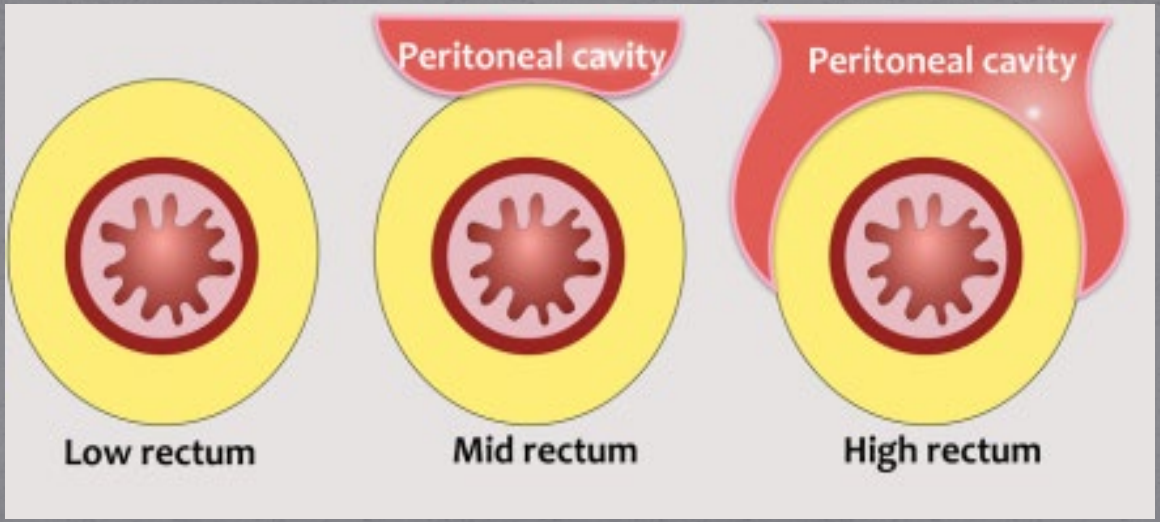
- The mesorectal fascia (MRF) plays a crucial role in the treatment plannnig.
- In TME the mesorectal fascia is the resection plane and it has to be tumor-free.
- A distance of the tumor to the mesorectal fascia of ⩽1 mm is regarded as not suitable for TME and is called an *involved MRF.*
- This means that the tumor has to be downstaged before TME is possible.



- On MRI the mesorectal fat has high signal intensity on both T1- and T2-weighted images.
- The mesorectal fat is surrounded by the mesorectal fascia, which is seen as a fine line of low signal intensity .
- High resolution T2-images are needed to clearly identify the MRF



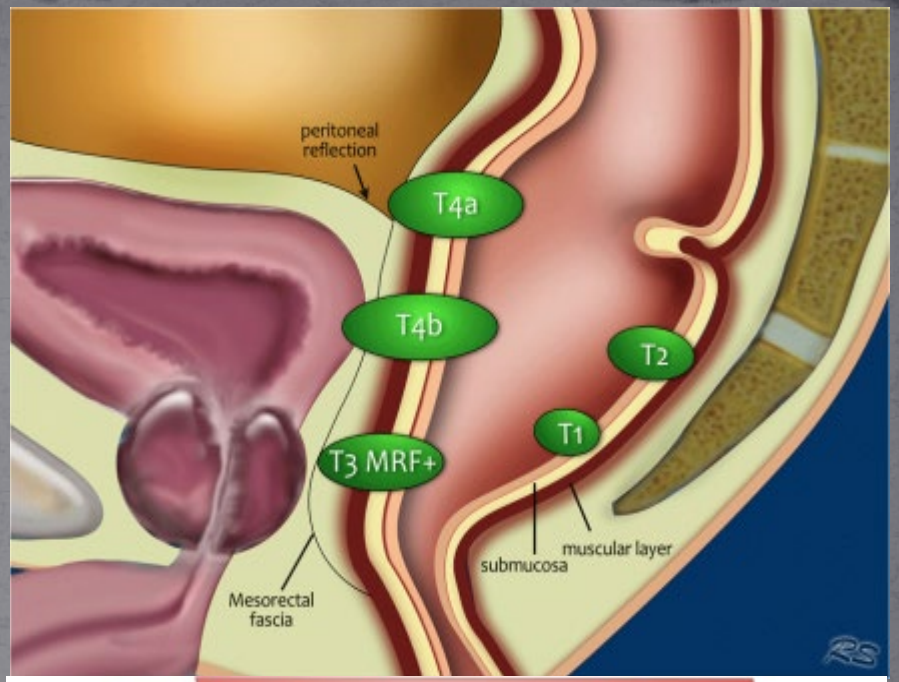
- The MRF is only circumferential in the low-rectum below the anterior peritoneal reflection.
- The MRF does not apply to the anterior peritonealized surface of the anterior mid- and high rectum.

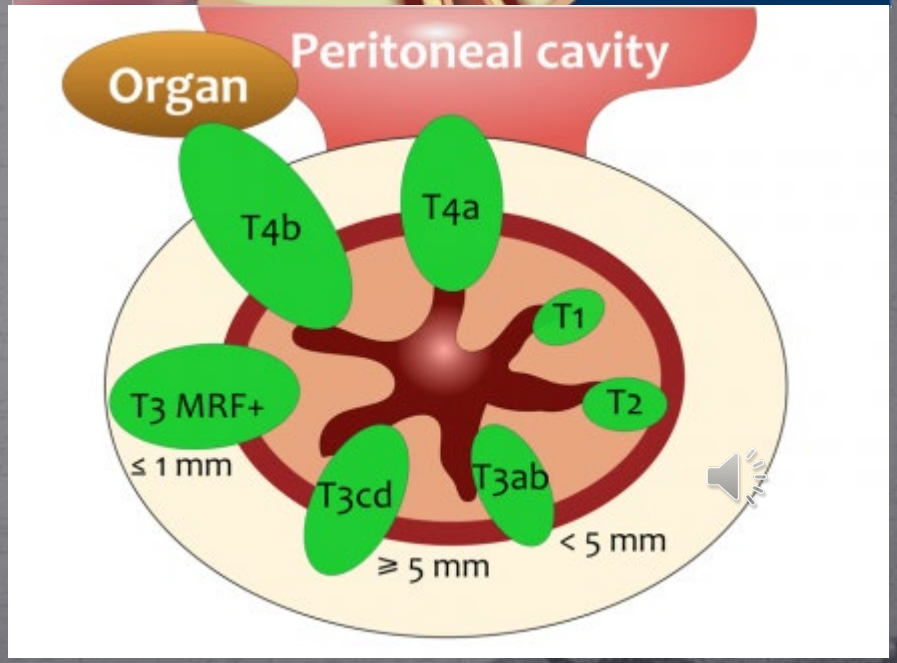


- **TNM-stage**
- The treatment of a patient with rectal cancer depends on the TNM-stage and whether the MRF is involved.



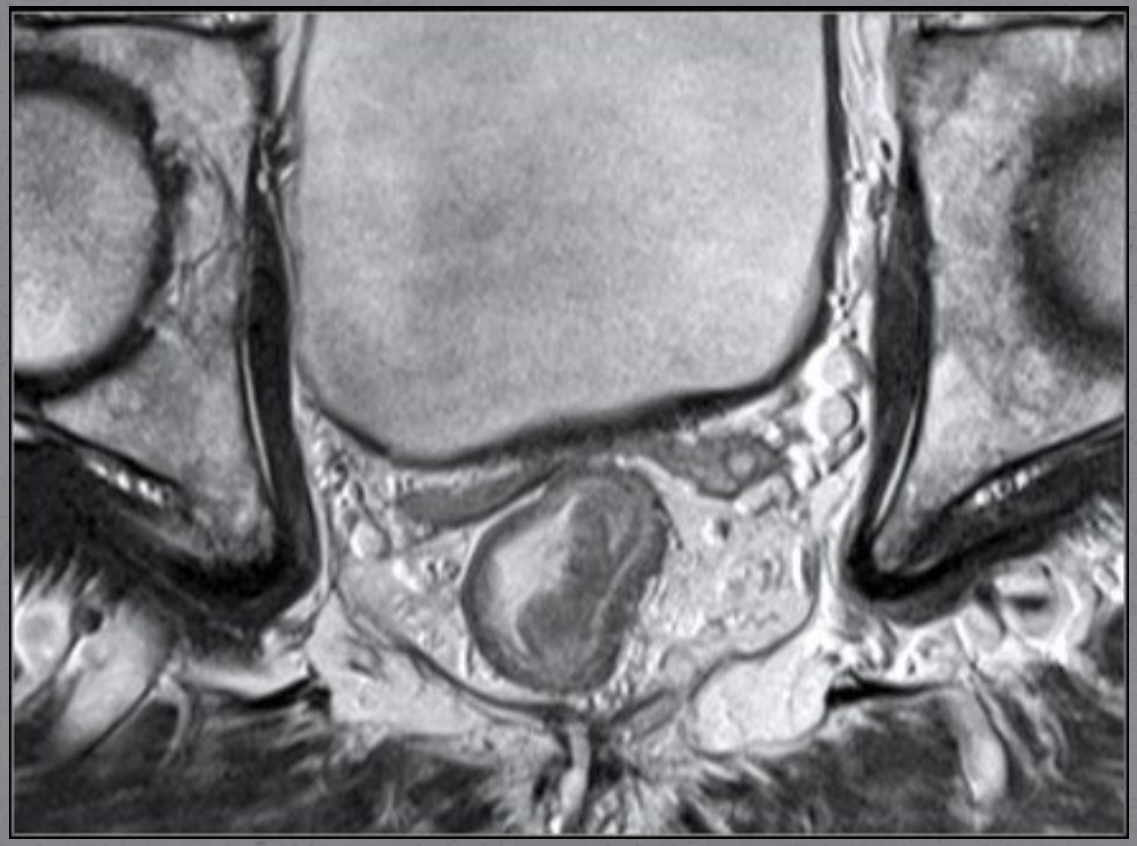
- **T-staging**
- T1 and T2 tumors are limited to the bowel wall.
  T3 tumors grow through the bowel wall and infiltrate the mesorectal fat.
  They are further differentiated in:
  - T3a : < 1 mm extension beyond muscularis propria
  - T3b : 1-5 mm extension beyond muscularis propria
  - T3c : 5 - 15 mm extension beyond muscularis propria
  - T3d: > 15 mm
  - T3 MRF+ tumor within 1mm of MRF
  - MRF- no tumor within 1 mm of MRF





- **T1 and T2**
- T1 and T2 tumors are limited to the bowel wall and have a good prognosis.
- MR imaging is unable to distinguish between tumor extension into the mucosa, submucosa and muscularis propria and therefore can not differentiate between Tis (in situ), T1 and T2 tumors.
- Endorectal ultrasound is more accurate for this purpose.
- Tumors that remain limited to the rectal wall are therefore typically grouped as cT1-2 on MRI.
- Although T1 tumors could be treated with local excision, the treatment of choice in both T1 and T2 tumors is TME.

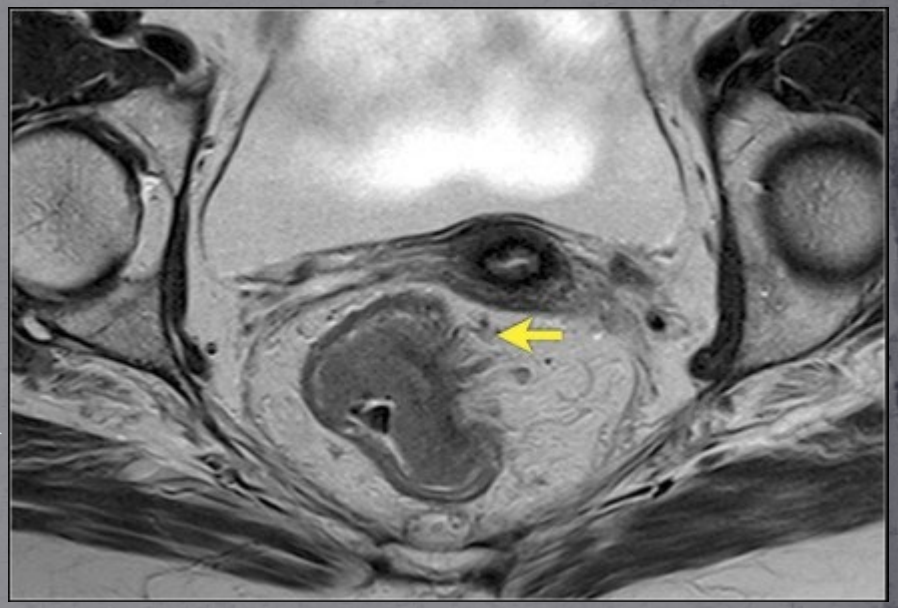
- Key finding in T1 and T2 rectal tumors is an intact external muscularis layer, which is identified as a hypointense thin line surrounding the rectum



- T3
- T3-tumors grow through the external muscularis into the surrounding mesorectum.
- As the rectum does not contain a serosal layer, tumor invades directly into the mesorectal fat and can spread to lymph nodes and beyond.
- Spread into the mesorectum can be depicted as spicules of low signal intensity in the hyperintense mesorectal fat or distortion of the hypointense muscularis propria.



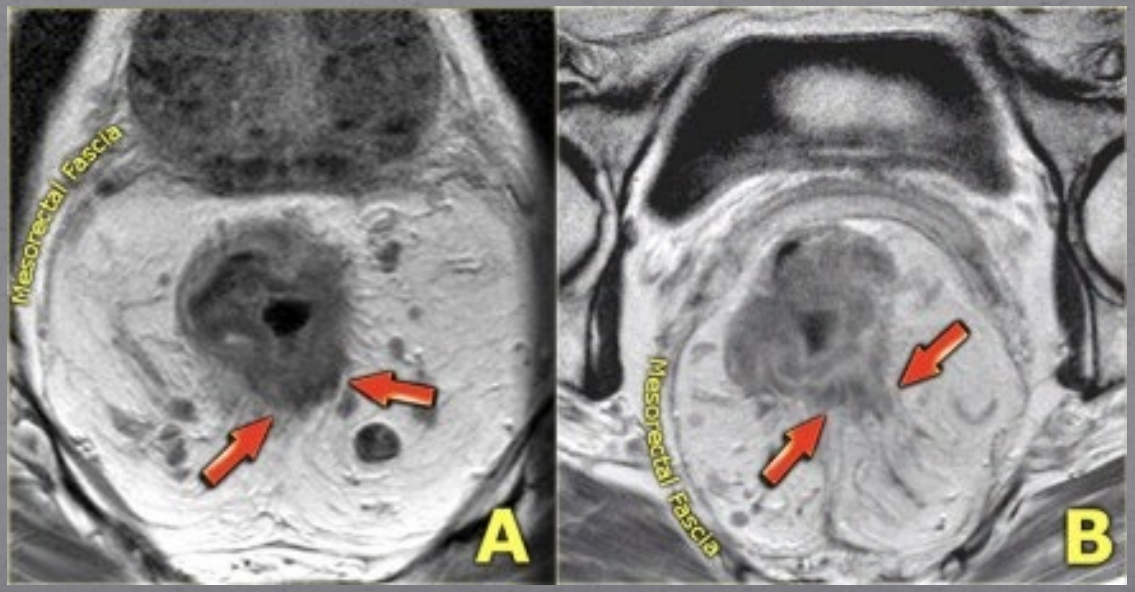
- T3-tumors are further differentiated in:
  - T3a: tumor extends <1 mm beyond muscularis propria
  - T3b: tumor extends 1-5 mm beyond muscularis propria
  - T3c: tumor extends 5-15 mm beyond muscularis propria
  - T3d: tumor extends > 15 mm beyond muscularis propria
  - MRF- no tumor within 1mm of MRF
  - MRF+ tumor within 1mm of MRF



- **Perirectal stranding**
- Difficulty in distinguising true mesorectal tumor invasion from desmoplastic reaction, is the main cause of overstaging.
- However, to prevent understaging, it is recommended to stage a tumor as T3 when stranding is present.



- Here we see two tumors with a similar MR-appearance.
  In A there was perirectal tumor invasion.
  In B the tumor was limited to the bowel wall, i.e. a T2-tumor.
  The perirectal stranding in the latter case was the result of a desmoplastic reaction.



- **T3 with MRF involvement**
- In the description of T3-tumors, the report should include the shortest distance between the tumor margin and the MRF.
- Involvement of the MRF results in an increased risk for local recurrence.
- The MRF is considered *involved* when the distance between the tumor margin and MRF is less than 1 mm.
- Although a positive margin due to a suspicious lymphnode should be assessed and reported, this is not regarded as a determination factor in defining MRF involvement.

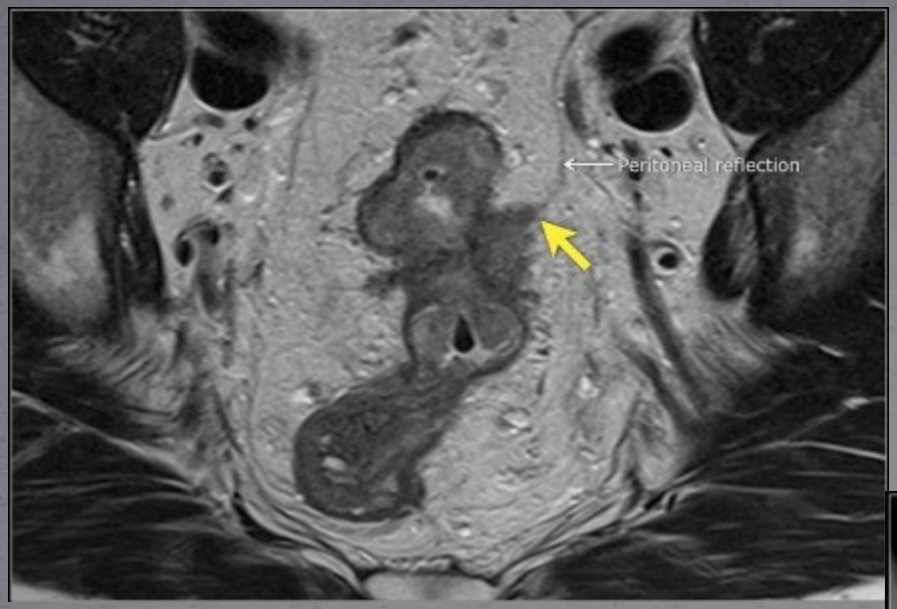


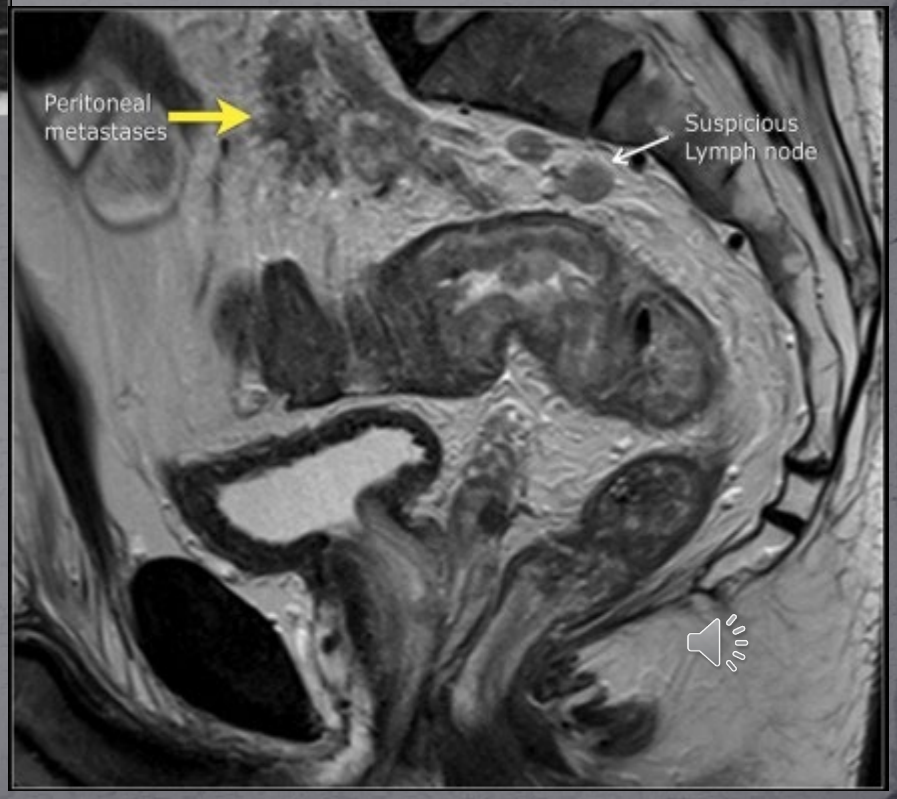
- The image shows a tumor that infiltrates the mesorectal fat with involvement of the resection margin on the posterior side (arrow).
- This tumor is classified as T3 MRF+.
  This patient will be treated with chemotherapy and a long course of radiotherapy.



- **T4a - Invasion peritoneal reflection**
- The low rectum is totally covered by the mesorectal fascia.
- In the mid-rectum it is covered by the mesorectal fascia on the posterior and lateral side, but on the anterior side it is covered by the visceral peritoneum.
- Growth into the visceral peritoneum means spread to the peritoneal cavity.



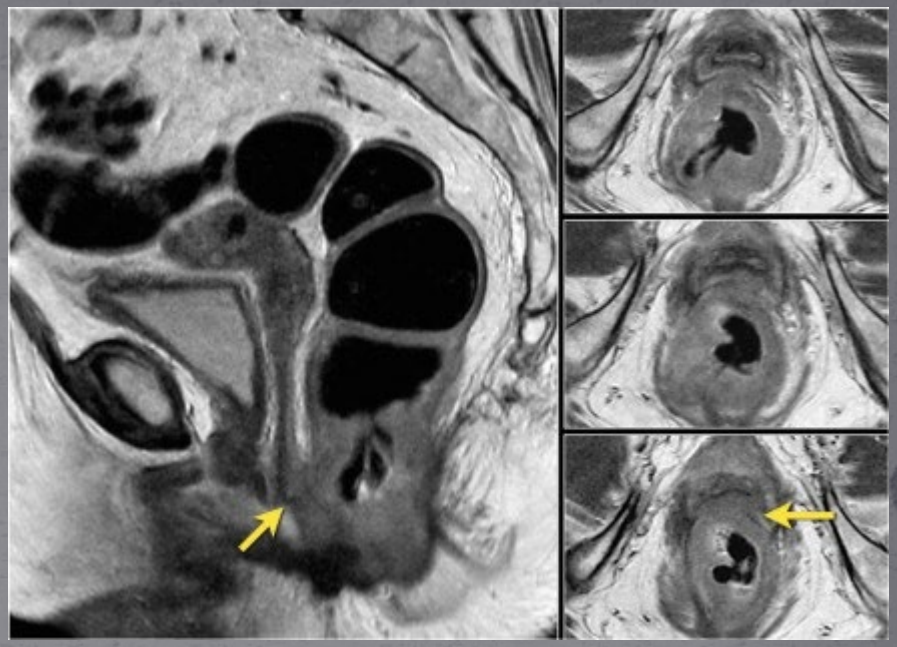

Peritoneal reflection

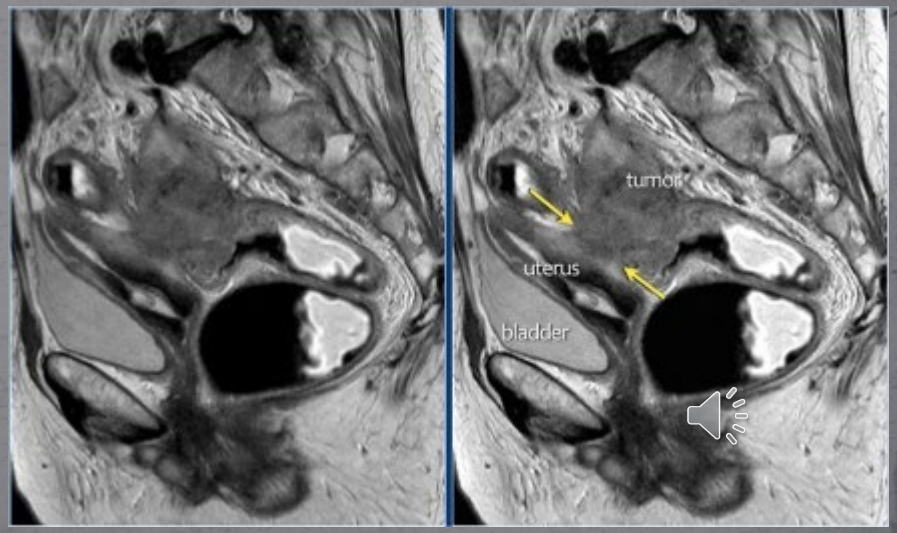

Peritoneal
metastases
Suspicious
Lymph node

- **T4b - Invasion surrounding organs**
- A T4b-tumor invades the surrounding structures such as pelvic wall, vagina, prostate, bladder or seminal vesicles.
- Tumor invasion is defined as loss of the intervening fat plane *and* corresponding T2 signal abnormality within the involved surrounding structure.



- On the sagittal T2W-image there is loss of fat plane between the rectum and the posterior wall of the vagina.
- On axial images the relatively low signal intensity of the tumor is seen to extend into the posterior wall of the vagina

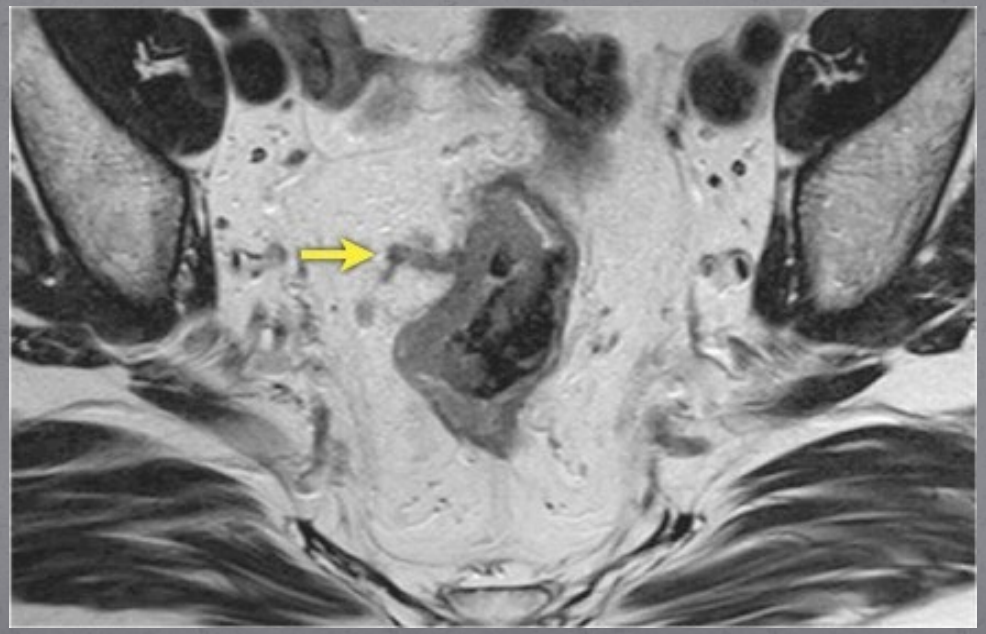




T-stage of Rectal Cancer

T1-2	Confined to the rectal wall	- T1 invade submucosa - T2 invade muscularis propria (the outer layer of the rectal wall)
T3	Extend beyond the bowel wall into the mesorectal fat. Note: low riskT3: T3ab MRF- high risk T3: T3cd and/or MRF+	- T3a: < 1 mm extension of infiltration - T3b: 1-5 mm extension - T3c: 5-15 mm extension - T3d: > 15 mm extension
T4a	invade the peritoneum or peritoneal reflection	
T4b	invade other organs or structures outside the meso-rectum: - pelvic organs (incl. uterus, ovaries, vagina, prostate, seminal vesicles, bladder) - bone - striated/skeletal muscle (incl. external anal sphincter, puborectalis and levator ani, obturator, piriformis, and ischiococcygeus) - ureters and urethra - sciatic or sacral nerves - sacrospinous/sacrotuberous ligaments - any vessel outside the mesorectal compartment - any loop of small or large bowel in the pelvis (separate from the primary site from which the tumor originates) - any fat in an anatomical compartment outside the mesorectal compartment (i.e. obturator, para-iliac or ischiorectal space	

- **Extramural vascular invasion (EMVI)**
- Vascular invasion is a risk factor for recurrent disease and is to be included in standardized MR reporting.
  EMVI is associated with T3- and T4 tumors.
- EMVI is suspected if a vascular structure in close proximity to the tumor is expanded, irregular or infiltrated by tumor signal intensity



N staging

- Lymph node involvement is an important factor for the treatment and the prognosis of the patient.
- MR has proven to have a low diagnostic accuracy for distinguishing positive or negative lymph nodes when characterization is based on size criteria alone.
- Nodes larger than 9 mm are always regarded as suspicious.
- Smaller lymph nodes need additional malignant characteristics to be considered suspicious.
- Prediction of nodal involvement is improved by using the border contour and signal intensity characteristics of lymph nodes

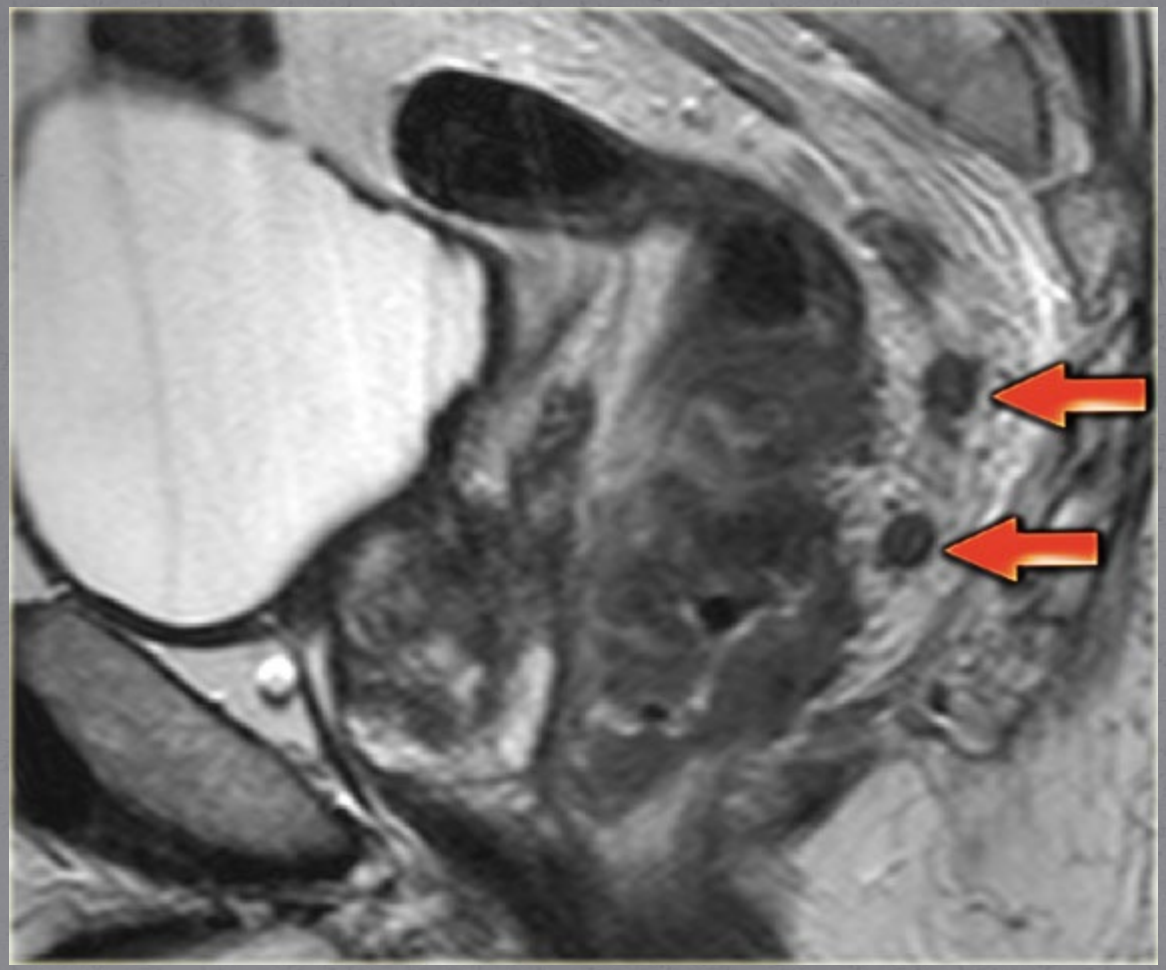


N-staging

N-stage - suspicious nodes	
Malignant characteristics	Indistinct  Heterogeneous  Round 
Short axis	- < 5mm : needs 3 malignant characteristics - 5 -9mm : needs 2 malignant characteristic - > 9mm : always suspicious
cN-stage	- N0 : ***no*** *suspicious* lymph nodes - N1 : 1-3 *suspicious* lymph nodes - N2 : ≥ 4 *suspicious* lymph nodes

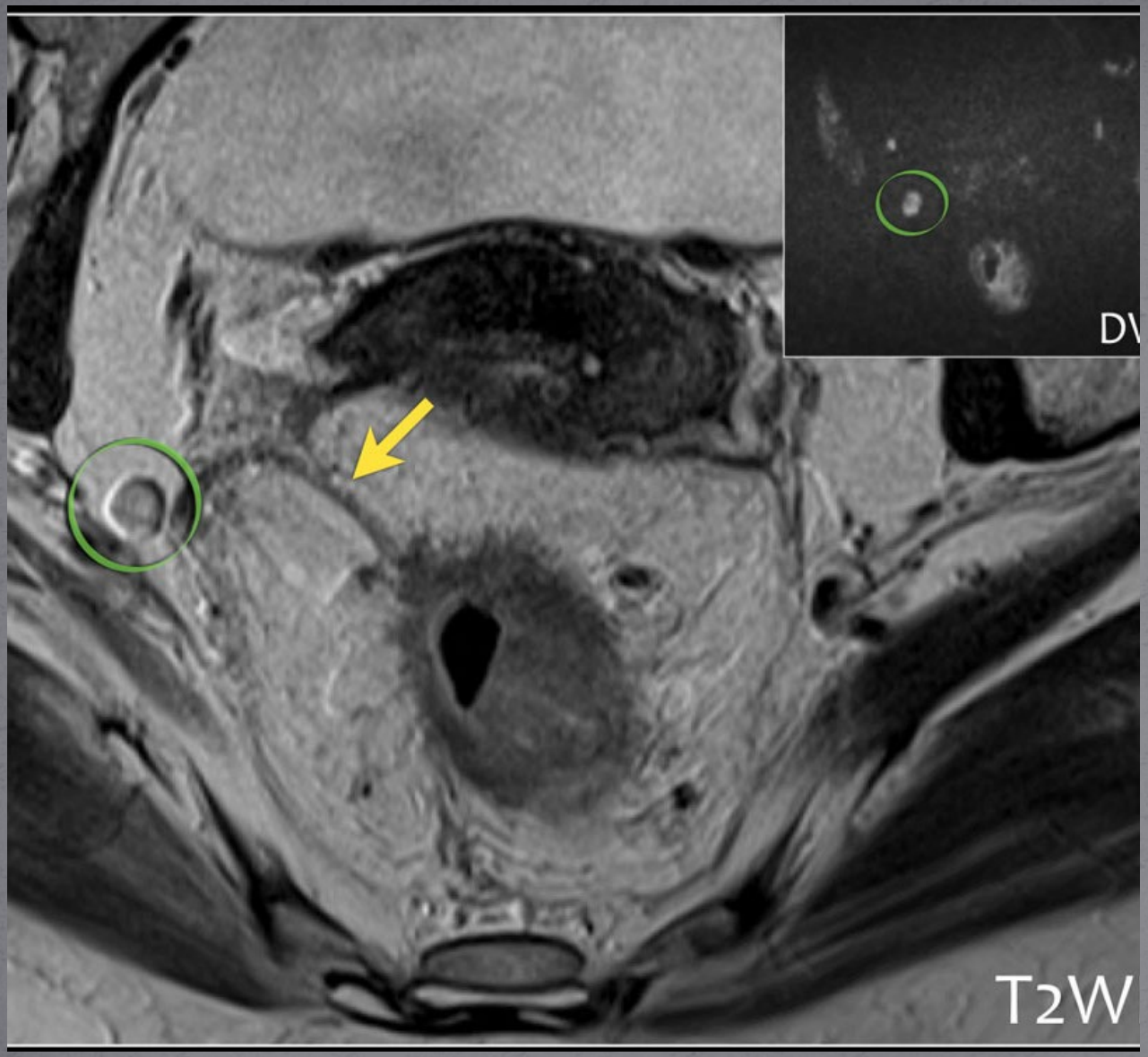
- When in doubt, a borderline suspicious lymph node should not be considered as suspicious.
- Consequently, a lesser N-stage should be assigned.





- **Extramesorectal lymph nodes**
- It is important to look beyond the mesorectum for lymph nodes.
- These extramesorectal nodes are important, because they can be a cause of local recurrence, because in a standard TME procedure these extramesorectal lymph nodes will not be resected.
- The finding of malignant extramesorectal lymph nodes entails that at least a more extensive surgical approach is necessary to remove all the cancer deposits or a boost of radiotherapy to the areas of risk.



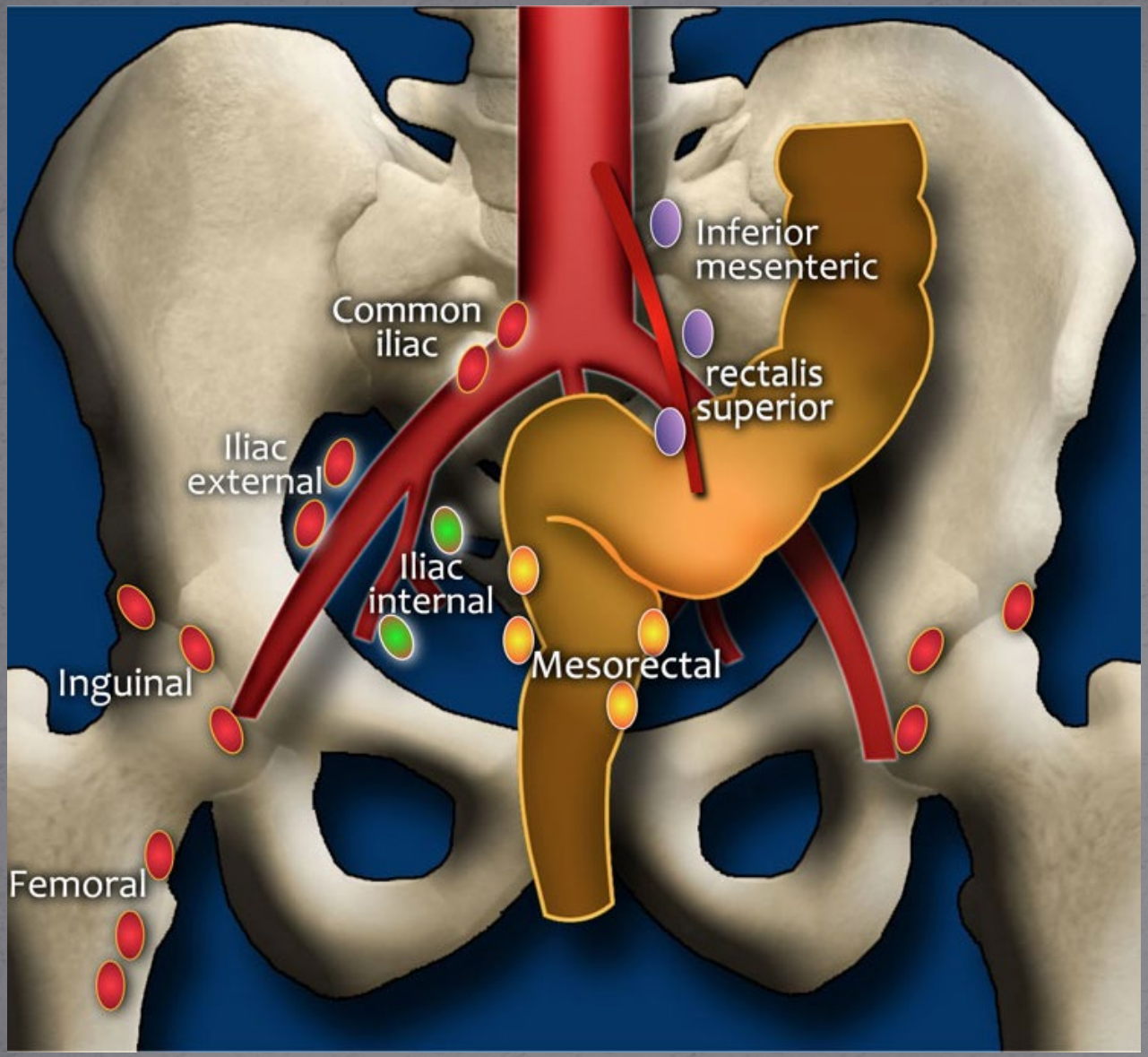


The image shows a circular T3 tumor with extramural vascular invasion (EMVI), bridging to the right extramesorectal space (yellow arrow).

In addition there is a suspicious extramesorectal lymph node (green circle).

- **Regional Lymph nodes**
- Regional lymph nodes are located along the providing vessels of the rectum.
- Note that lymph nodes are potentially suspicious at the level - or proximally of the primary tumor, following the normal lymph drainage





Regional lymph node drainage. The lymph nodes in red are metastatic nodes.

TABLE 2: Staging Systems for Rectal Cancer

Stage	Description
T stage for middle tumors and high tumors[a]	
T1	Tumor invades submucosa
T2	Tumor invades muscularis propria
T3	Tumor invades through muscularis propria to pericolorectal tissues
a	Tumor < 5 mm into the perirectal fat or extramural
b	Tumor 5–10 mm into the perirectal fat or extramural
c	Tumor > 10 mm into the perirectal fat or extramural
T4	Organ invasion
a	Tumor penetrates to surface of visceral peritoneum
b	Tumor directly invades or is adherent to other organs or structures
T stage for low tumors[b]	
T1	Tumor confined to bowel wall but does not extend through full thickness; intact outer muscle coat
T2	Tumor replaces muscle coat but does not extend into intersphincteric plane
T3	Tumor invades intersphincteric plane or lies within 1 mm of levator muscle
T4	Tumor invades external anal sphincter and is within 1 mm and beyond levator muscle with or without invading adjacent organs
N stage	
Nx	Regional lymph nodes cannot be assessed
N0	No regional lymph node metastasis
N1	Metastasis in 1–3 regional lymph nodes
N2	Metastasis in > 3 regional lymph nodes
M stage	
M0	No distant metastasis
M1	Distant metastasis
a	Metastasis confined to 1 organ or 1 site
b	Metastasis in more than 1 organ, 1 site, or peritoneum

Note—[a]Adapted from a Radiological Society of North America (RSNA) Radiology Reporting Template developed at the RSNA by the RSNA Radiology Reporting Committee and its subspecialty subcommittees and provided under license from RSNA [94]: Radiological Society of North America website. Hussain S, et al. MR rectum cancer. www.radreport.org/template/0000068. Published December 1, 2009. Updated July 16, 2012)

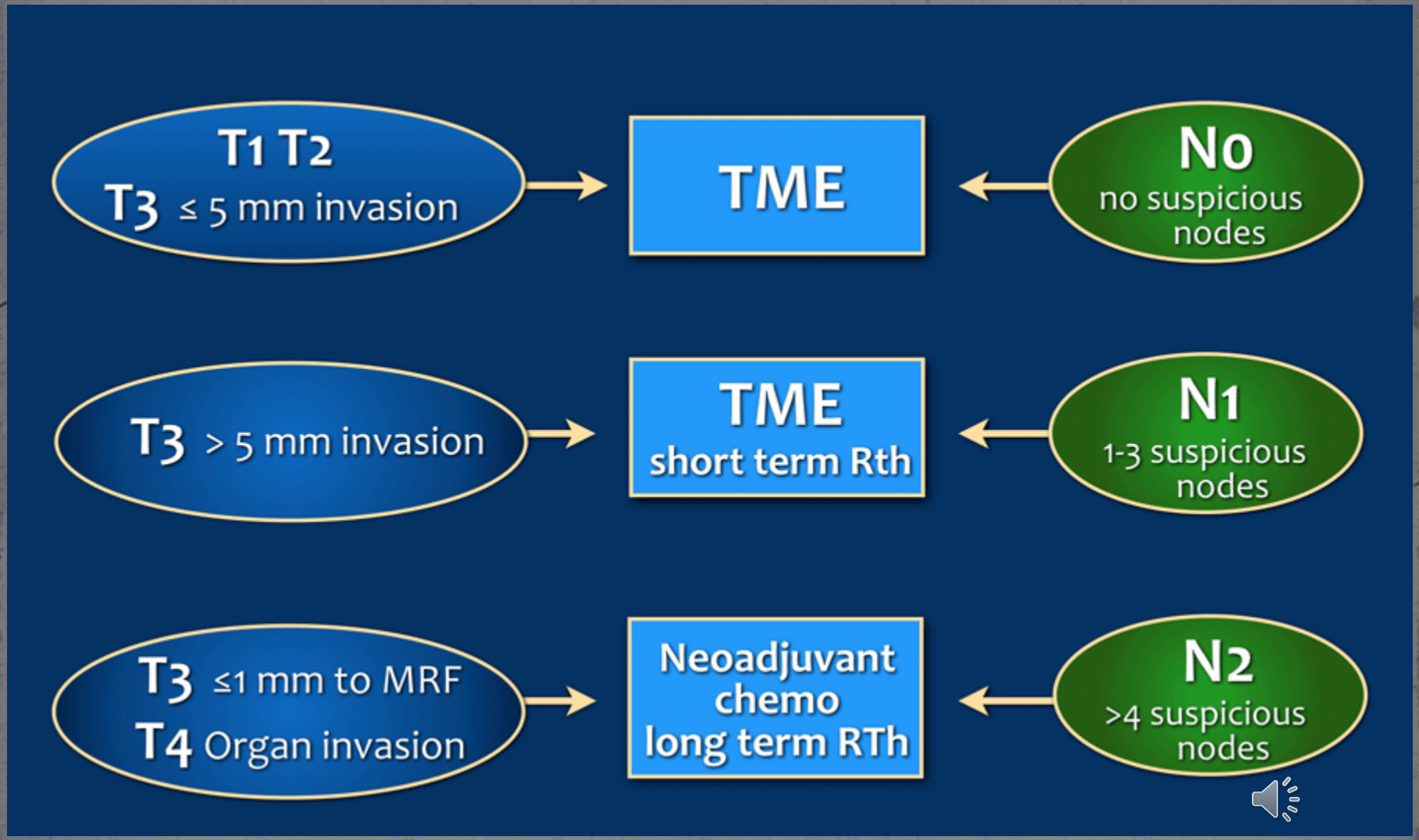
[b]Adapted from [40]: Taylor FG, Swift RI, Blomqvist L, Brown G. A systematic approach to the interpretation of preoperative staging MRI for rectal cancer. *AJR* 2008; 191:1827–1835.

Treatment

- The treatment is based on the clinical or cTNM. The cTNM is based on the results of endoscopy and imaging.
  - *Low risk tumors*
    T1, T2 and borderline T3 without suspicious nodes can directly undergo surgery.
  - *Intermediate risk tumors*
    T3 with >5mm invasion or tumors with 1-3 suspicious nodes - will be treated with short term radiotherapy preoperatively.
  - *High risk tumors*
    T3 with involved MRF or T4 tumors or tumors with 4 or more suspicious nodes will receive neoadjuvant chemotherapy and long term radiation therapy and will be restaged to determine whether TME is possible

Criteria for treatment stratification

Low risk	- cT_{1-2} N_0 or - cT_{3ab} (≤ 5mm invasion) - cN_0 - Distance to MRF > 1mm	Total mesorectal excision or Local excision
Intermediate risk	- cT_{3cd} (> 5mm extramural invasion) - cN_1 - Distance to MRF > 1mm	+ Short course (5x5 Gy) neoadjuvant radiotherapy
High risk	- cT_{3cd} or cT_4 - cN_2 - Distance to MRF ≤ 1mm	+ Long course neoadjuvant treatment (chemoradiotherapy) + restaging


T1 T2
T3 ≤ 5 mm invasion
TME
N0
no suspicious nodes
T3 > 5 mm invasion
TME
short term Rth
N1
1-3 suspicious nodes
T3 ≤1 mm to MRF
T4 Organ invasion
Neoadjuvant chemo
long term RTh
N2
>4 suspicious nodes

Rectal cancer - Treatment

Low RisK	- cT1-2 N0
	- cT3 N0
	  - ≤ 5 mm extramural invasion and
	  - distance to MRF > 1 mm
		TME

Inter-mediate	- cT1-3 N1
	- cT3 N0
	  - > 5 mm extramural invasion and
	  - distance to MRF > 1 mm
		5x5 Gy pre-operative radiotherapy and TME

High Risk	- any cT + N2 - any cT + suspicious extramesorectal nodes - cT3 distance to MRF ≤1 mm - cT4	Neoadjuvant ChemoRadiotherapy Surgery depending on yTN stadium

MR protocol



- The current studies in the literature show that, if the imaging parameters are appropriately adjusted, both 1.5- and 3-T machines can be used with comparable accuracies for staging rectal cancer

http://www.ajronline.org/doi/full/10.2214/AJR.14.14201

- Although endorectal coils provide higher resolution of the rectal wall, they are not in common use because of patient and cost factors.
- Bowel preparation is generally not necessary before the examination, but antispasmodic agents are useful for decreasing bowel peristalsis and resultant motion artifacts and, therefore, are generally advised unless contraindicated.

http://www.ajronline.org/doi/full/10.2214/AJR.14.14201

- Filling of the rectal lumen with gel or contrast material probably facilitates the detection of small tumors.
- However, compression of the mesorectal fat due to rectal distention may critically alter the staging because it leads to underestimation of the distance of the tumor to MRF and possibly to nonvisualization of the mesorectal nodes; therefore, the routine use of endorectal filling is not recommended

http://www.ajronline.org/doi/full/10.2214/AJR.14.14201

- **T2-weighted FSE**
- High resolution 2D T2-weighted fast spin echo sequences in the sagittal, axial and coronal plane are required for state-of-the-art staging of rectal cancer.
- The slice thickness should be 3 mm.

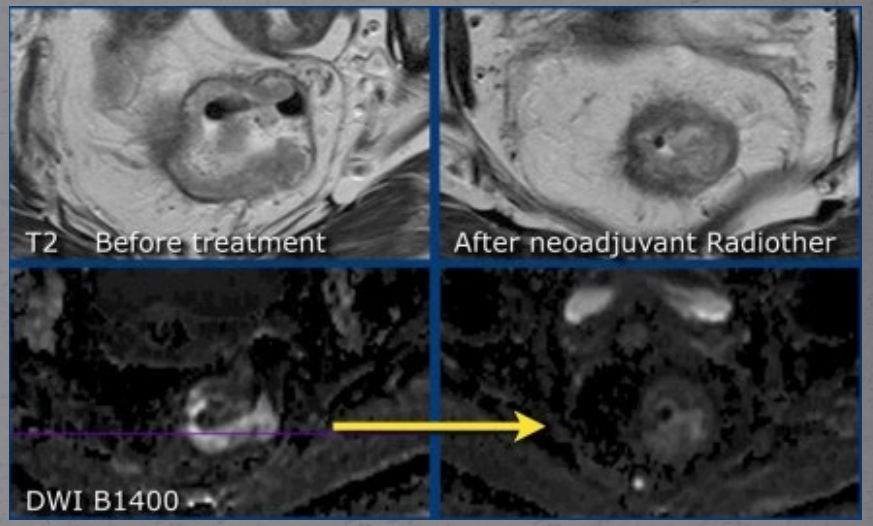


- The use of T1-weighted imaging for rectal cancer staging is recommended mainly for the evaluation of coincidental findings and the pelvic bones.
- DWI may help in the assessment of response to CRT and may improve the accuracy of MRI for the detection of rectal cancers and involved pelvic nodes



DWI in restaging

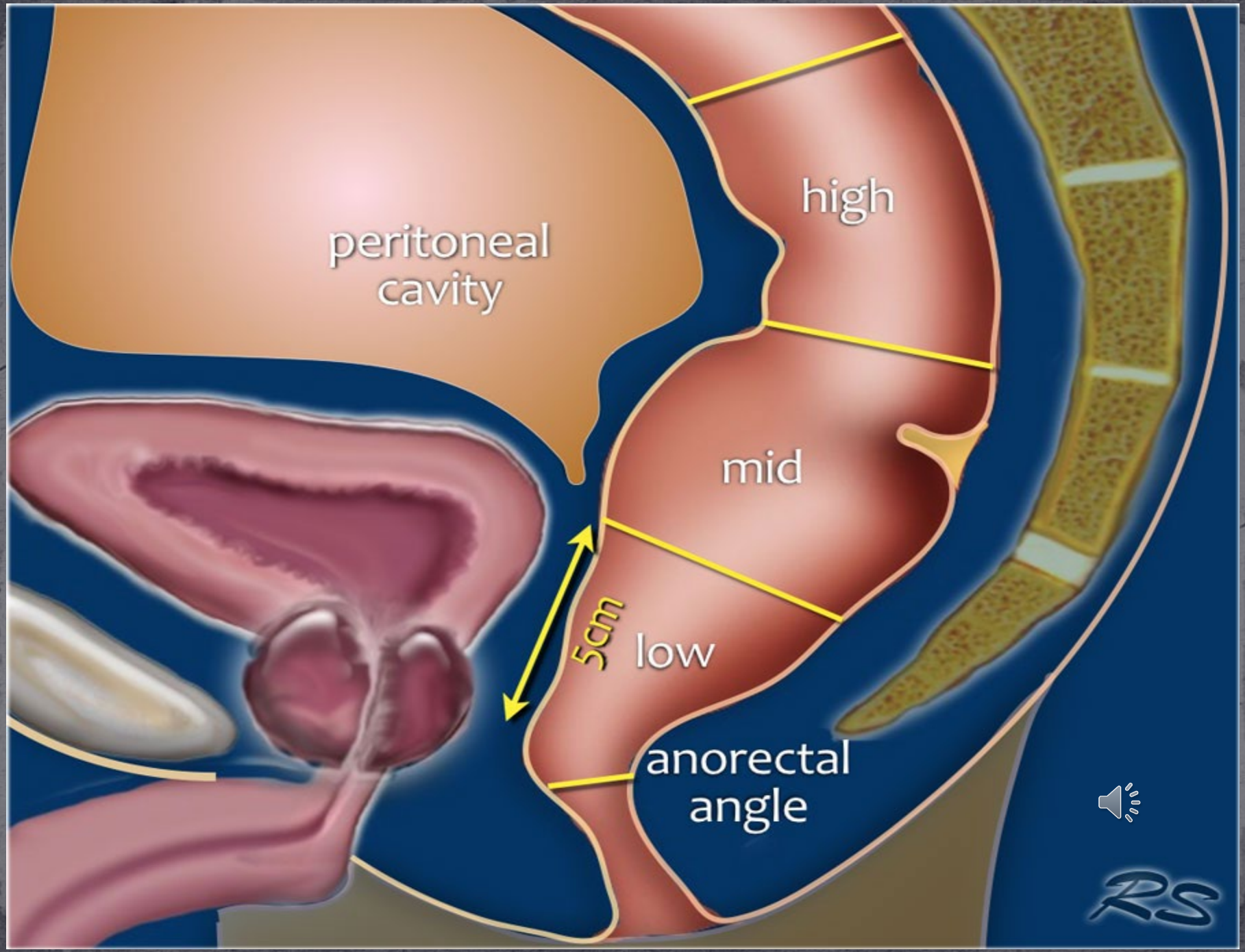
- DWI is very useful in determining the response to chemoradiation.
- In this case there is persistent high signal on images with high B-values, which indicates incomplete response



Location of the tumor

- The rectum extends from the anorectal junction to the sigmoid.
- The rectosigmoid junction is arbitrarily defined as 15 cm above the anorectal angle.
- A tumor more than 15 cm above the anorectal angle is regarded and treated as a sigmoid tumor.
- Rectal cancer can be divided 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




peritoneal cavity
high
mid
low
5cm
anorectal angle
RS

EUS vs Magnetic Resonance Imaging



- ERUS (endorectal ultrasound) and MRI are considered to be the most accurate modalities for determining local tumor stage.
- Two recent meta-analyses have compared EUS, CT and MRI for rectal cancer staging. Bipat et al found that ERUS was the most accurate modality when compared with CT and MRI for the evaluation of the T stage in rectal cancer.
- For lymph node involvement, the results of ERUS, CT and MRI were comparable.
- However, the T-staging system does not discriminate between T3 tumors with close or involved circumferential resection clearance.



Table 2. Statistics of T stagings of the EUS, MRI and MDCT

	Modality								
	EUS (n:50)			MRI (n:50)			MDCT (n:50)		
Statistics (%)	**T2**	**T3**	**T4**	**T2**	**T3**	**T4**	**T2**	**T3**	**T4**
Sensitivity	73	100	90	20	50	45	46	85	63
Specificity	100	82	100	51	67	89	94	66	94
PPV	100	81	100	15	55	55	77	50	77
NPV	89	100	97	60	63	85	80	92	90
Accuracy	92	90	98	72	60	80	64	58	88

EUS: endosonography; MDCT: multidetector computed tomography; MRI: magnetic resonance imaging; PPV: positive predictive value; NPV: negative predictive value

Table 4. Statistics of positive N Stagings of the EUS, MRI and MDCT

	Modality		
	EUS (n:50)	MRI (n:50)	MDCT (n:50)
Statistics (%)	**n (+)**	**n (+)**	**n (+)**
Sensitivity	92	82	75
Specificity	72	54	77
PPV	81	69	80
NPV	88	70	70
Accuracy	84	70	76

EUS: endosonography; MDCT: multidetector computed tomography; MRI: magnetic resonance imaging; PPV: positive predictive value; NPV: negative predictive value

- Its overall accuracy before radiation ranges from 73% to 94% in T staging, and from 70% to 80% in N staging. Comparative studies found EUS very accurate in staging rectal cancer from 80% to 95%, compared to 65% to 75% for CT and 75% to 85% for MRI.
- Recent data suggest that EUS staging of rectal cancer after RT-CT is inaccurate, while MRI seems to be cost-effective in selecting appropriate patients for neoadjuvant therapy and its use is justified for local staging.



- As reported in other studies, at the first staging examination after the diagnosis of rectal cancer, EUS and MRI offer similar accuracies.
- However, if we consider the degree of agreement between the two procedures in rectal cancer, EUS (without lymph node biopsy) and MRI give concordant results in T and N staging only in 64% and 54% of patients. Moreover, they only give concordant results for both T and N stages in one third of patients.



- Therefore, in the modern era of GI-oncology it seems that patients benefit mostly from interdisciplinary approaches.
- In considering the value of a diagnostic technique, based on its ability to influence the therapeutic choices by allowing a better selection of patients, we believe that in this situation these two modalities are complementary.

Structured MR report



- The radiological report should describe the tumor localization and characteristics as listed in the table.
- The circumferential location of the tumor within the wall can be described as lateral, anterior or posterior or in a clockwise manner, i.e. 6-12 o' clock.
- In T3-tumors describe the location and the depth of the perirectal fat infiltration and the exact distance to the mesorectal fascia.



- Description of suspicious nodes should be subdivided into mesorectal - and extramesorectal nodes, as location of the nodes may influence radiation planning and surgical excision (*see section N-stage*).
- The report should conclude with a cTNM.



Rectal cancer MR-report

Morphology	Polyp - Solid tumor - Mucinous tumor
Length	Measure in cm
Level	Distance from anorectal junction to lower border of tumor - low rectum : 0-5cm - mid rectum : 5-10cm - high rectum : 10-15cm
Location	Circumference : … - …o'clock or description
cT-stage	T1 or T2 : limited to bowel wall T3a : <1 mm beyond muscularis propria T3b : 1-5 mm T3c : 5-15 mm T3d : > 15 mm T4a : involvement peritoneal reflection T4b : ingrowth in organ
MRF	Shortest distance to mesorectal fascia - MRF involved : distance ≤ 1mm - MRF not involved : distance > 1mm
cN-stage	N0 : ***no*** *suspicious* lymph nodes N1 : 1-3 *suspicious* lymph nodes N2 : ≥ 4 *suspicious* lymph nodes

Example MR-report

There is a solid tumor with a length of 2 cm in the low-rectum.
The lower border is at 3 cm from the anorectal angle.
At 9 o' clock there is 7 mm ingrowth into the mesorectal fat (T3c).
The shortest distance to the mesorectal fascia is 2mm (not involved).
There are 5 suspicious nodes (see image no….).

Conclusion:
cT3c-N2 tumor with 2mm distance to MRF at 9 o' clock.

- After neoadjuvant treatment the patient is restaged to evaluate the preoperative locoregional status.
- Restaging is done 6 - 8 weeks after completing neoadjuvant therapy.
- Similar to the initial MRI, the level of the residual tumor, length, circumferential location, involvement of the MRF and number of mesorectal and extramesorectal lymphnodes should be reported.
- After neoadjuvant therapy, the stage is reported as yTNM.



- In addition to the conventional T2 weighted assessment, comparing diffusion weighted imaging before and after therapy is crucial to assess residual tumor.
- Diffusion restriction suggests residual tumor. DWI and ADC sequences are also used to interpret residual tumor location and morphology.







