Rectal Cancer MRI: A step by step approach to staging

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Learning objectives

- Understand advanced MRI techniques and sequences for high resolution rectal imaging
- Identify and understand key anatomical structures for accurate staging - including rectum, mesorectal fascia and sphincter complex
- Recognize the pitfalls of MRI staging

Introduction

- Colorectal cancer is the 3rd most common cancer in United States.
- 44,180 new cases of rectal cancer are estimated by the American Cancer Society in the United States for 2019.
- MRI, with the development of dedicated methodology, is the imaging modality of choice for local staging and treatment planning (surgery vs chemoradiation or both).
- High spatial resolution and higher signal to noise ratio of MRI allows better delineation of the rectal anatomy and surrounding structures.

MRI technique

- 3T scanning allows better spatial resolution, faster scans and high signal to noise ratio. 1.5 T can also provide similar imaging information as 3T.
- T2 weighted imaging (T2WI) is the key sequence to assess the rectum and surrounding structures.
- High resolution images allow detailed evaluation of the sphincter complex, intersphincteric plane, & levator ani muscle in low rectal cancers.
- Diffusion weighted imaging (DWI) plays an important role in tumor detection, lymph node localization, and assessing viability of tumor post treatment.

MRI technique

- Although not routinely used at many institutions, rectal gel and an endorectal coil can be useful for smaller or polypoid lesions.

- IV contrast is not used in initial staging, but can be useful in assessing extramural vascular invasion and viability in post treatment.

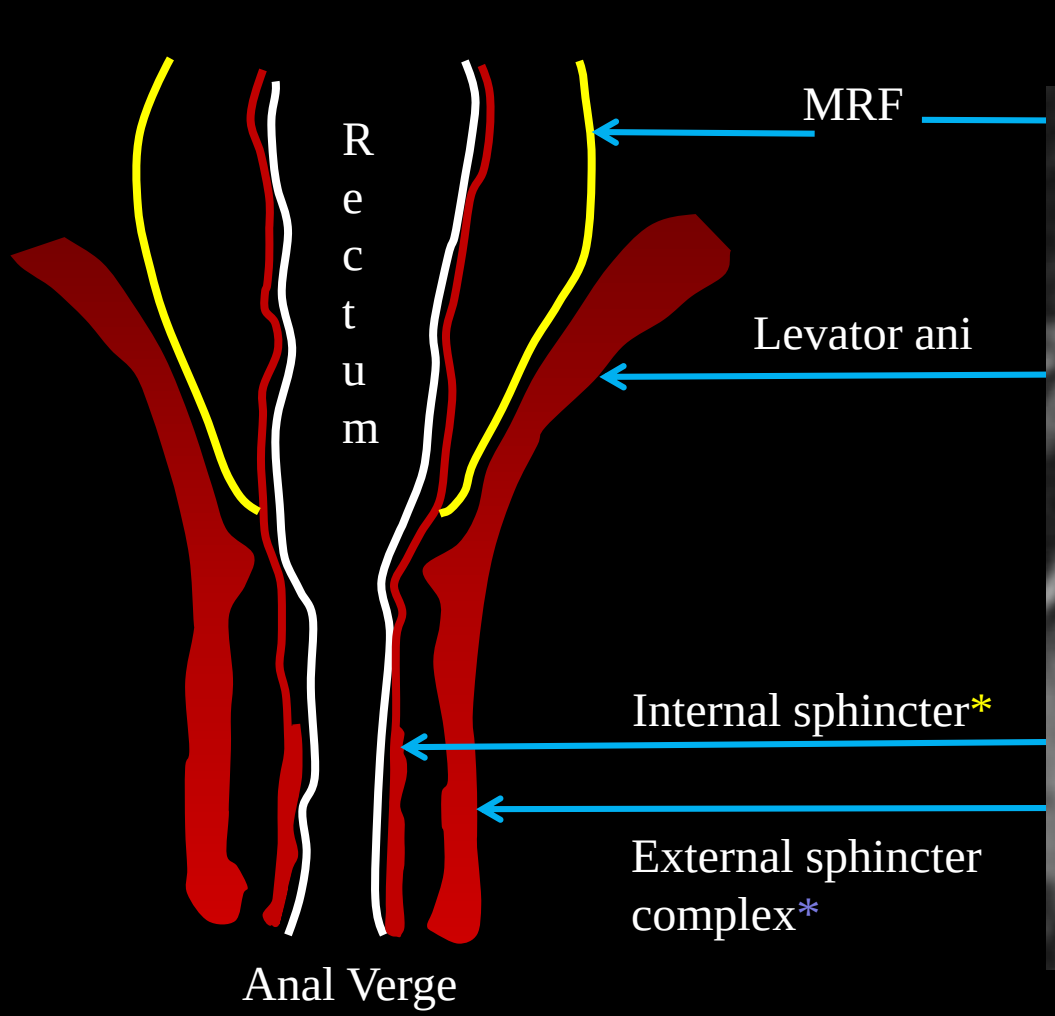
MRI technique

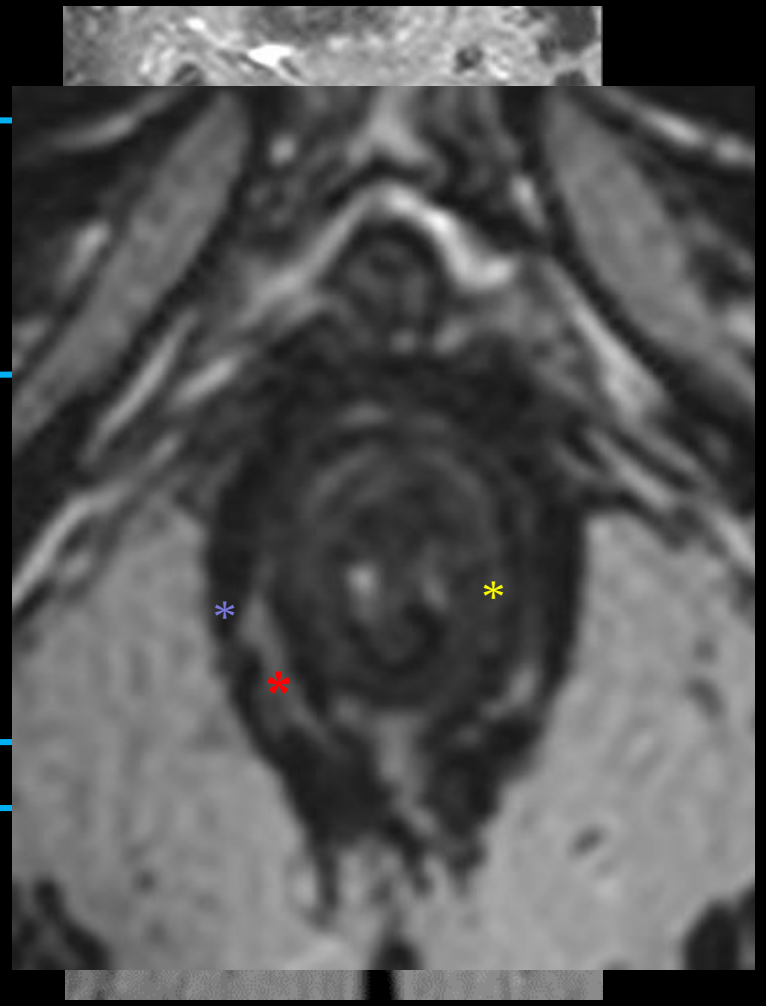
- The following MRI sequences are performed at our institution:
  - 3T scanner, phased array coil over the pelvis with patient in supine position
  - No bowel preparation or rectal distension with air or gel
  - Glucagon 1mg IM to decrease bowel movement related artifact
  - Localizer images in three planes
  - Coronal T2- weighted Fast spin echo/Turbo spin echo sequence*
  - Diffusion weighted imaging, B=150 and B=1000 in the axial plane
  - Sagittal and axial 3mm small field of view T2-WI
  - Axial 3mm small field of view T2-WI perpendicular to long axis of tumor
  - High resolution sagittal T2 SPACE**
- Estimated time for scanning: approximately 45 min

* **FSE/TSE: HASTE (Siemens), SSFSE (GE), Single-shot TSE (Philips), ADA (Hitachi), FASE (Toshiba)**

** 3D Fast/Turbo Spin Echo: **SPACE (Siemens), CUBE (GE), VISTA (Philips), isoFSE (Hitachi), mVox (Toshiba)**

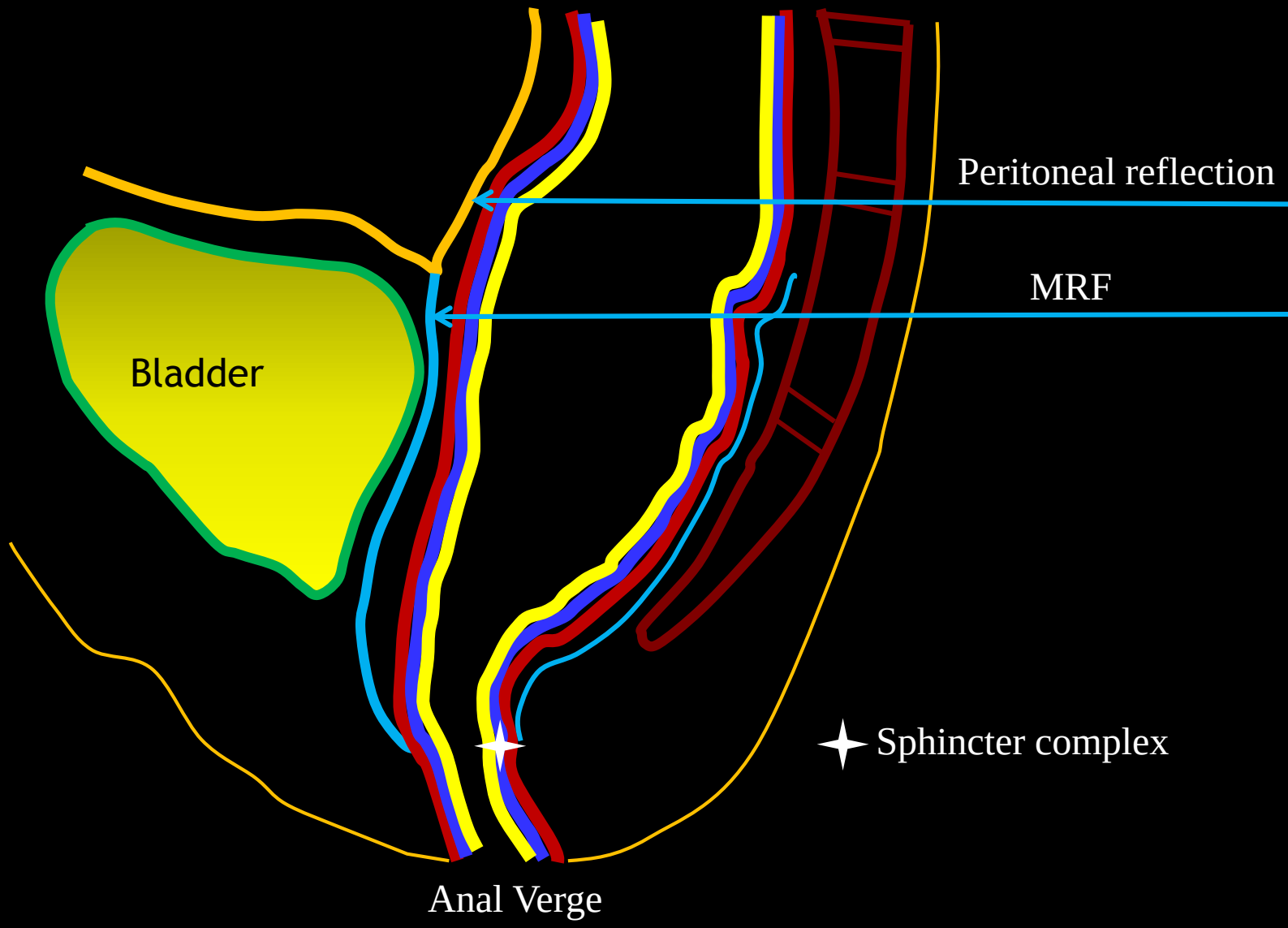
Rectal anatomy and surrounding structures

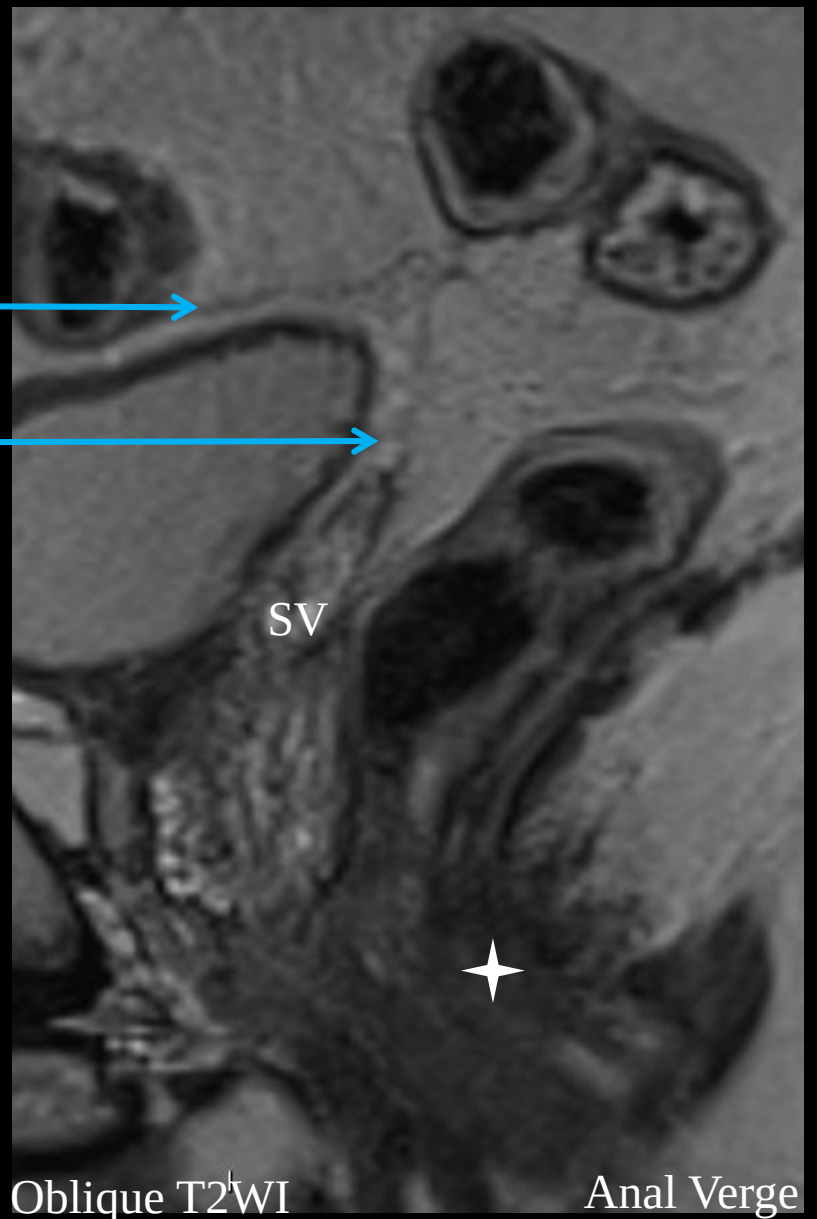




Internal sphincteric plane *

Rectal anatomy and surrounding structures





Rectal anatomy and surrounding structures

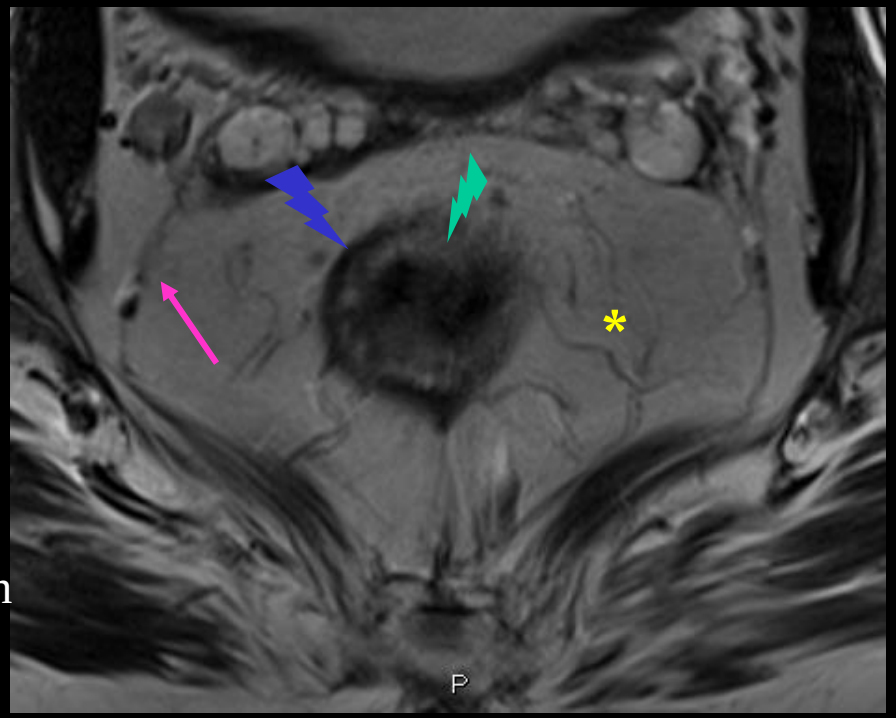
On axial T2WI

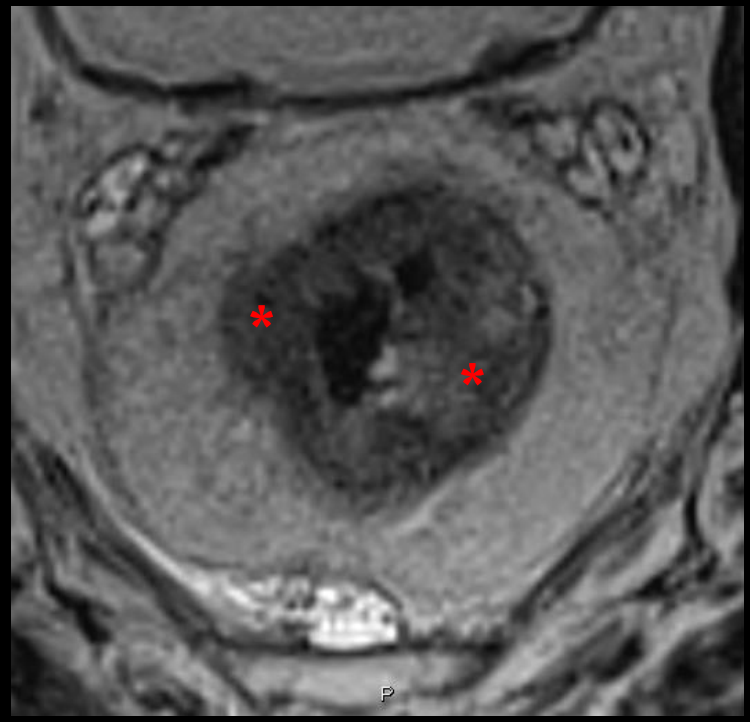
Submucosa is hyperintense

Muscularis propria (Mp) is hypointense surrounded by

Mesorecal fat which is hyperintense *

Mesorectal fascia is a hypointense thin line

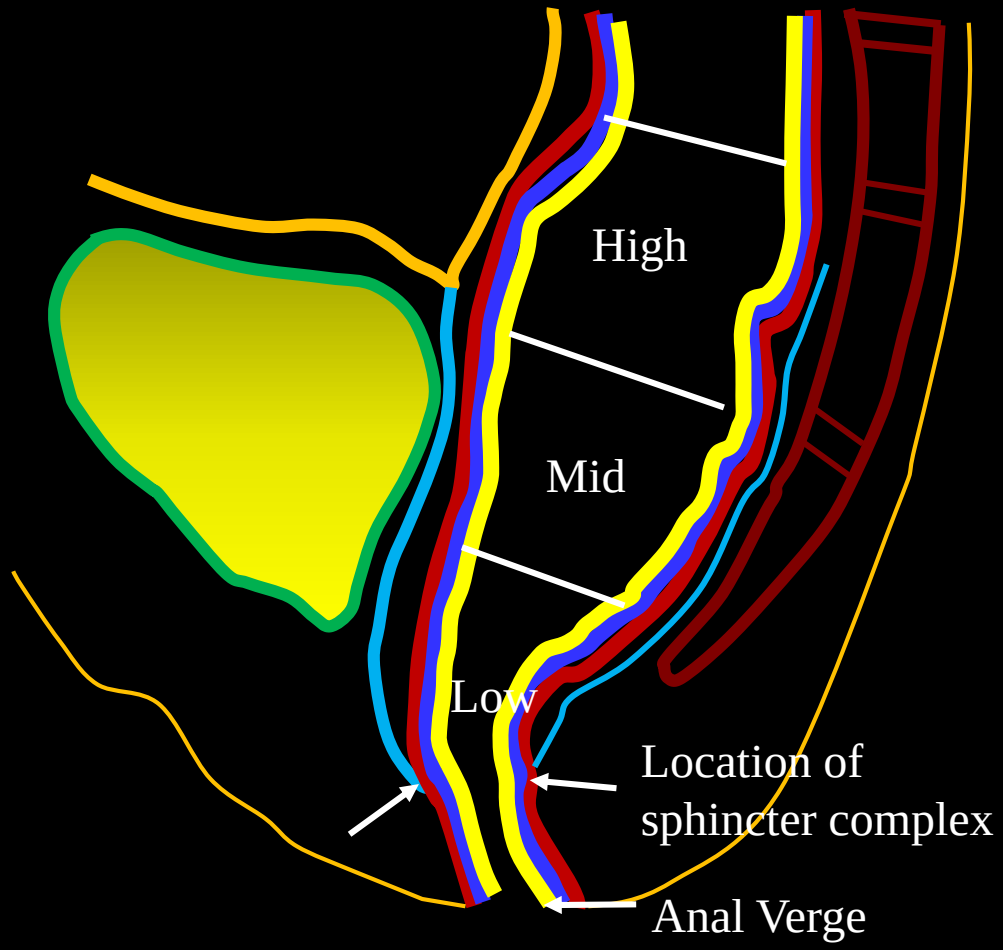




Tumor * is intermediate signal on T2WI relative to submucosa and muscularis propria

Rectal anatomy and surrounding structures

- Rectal cancer is divided into three levels as high, mid and low based on distance between lower margin of the tumor from anal verge



Low rectal cancer: 0-5 cm from the anal verge

Mid rectal cancer: 5-10 cm from the anal verge

High rectal cancer: 10-15 cm from the anal verge

MRI staging

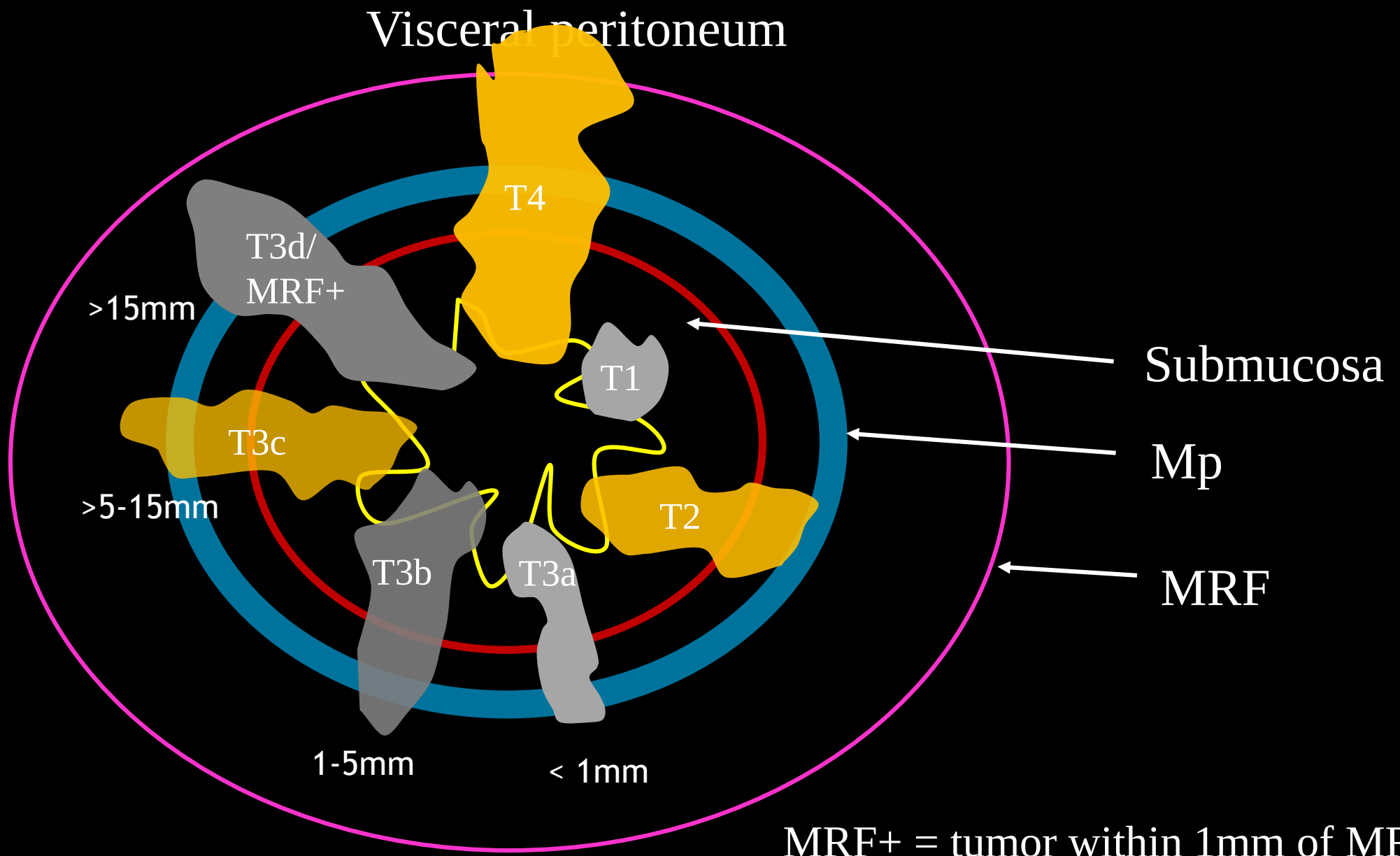
- MRI is better for staging T2/T3/T4 tumors.

- MRI is often the deciding factor for surgical planning, with options including:
  - local transanal excision for small tumors, OR
  - low anterior resection versus abdominoperineal resection along with transmesorectal excision (TME), OR
  - neoadjuvant therapy followed by surgery for larger tumors

T staging for rectal cancer

- T1: tumor is limited to submucosa
- T2: extension of tumor into the muscularis propria (Mp)
- T3: tumor extend into the mesorectal fat. Stage T3 is further divided into four sub stages based on distance of tumor tissue beyond the Mp into the mesorectal fat
  - T3a: tumor < 1mm
  - T3b: tumor 1-5mm
  - T3c: tumor > 5-15mm
  - T3d: > 15mm
  - MRF- : no tumor within 1mm of MRF
  - MRF+ : tumor within 1mm of MRF
- T4 stage: tumor invades through the anterior peritoneal reflection (T4a) or adjacent organs (T4b)
- For low rectal cancer, involvement of the sphincter complex and anal canal is mentioned.

T staging for rectal cancer



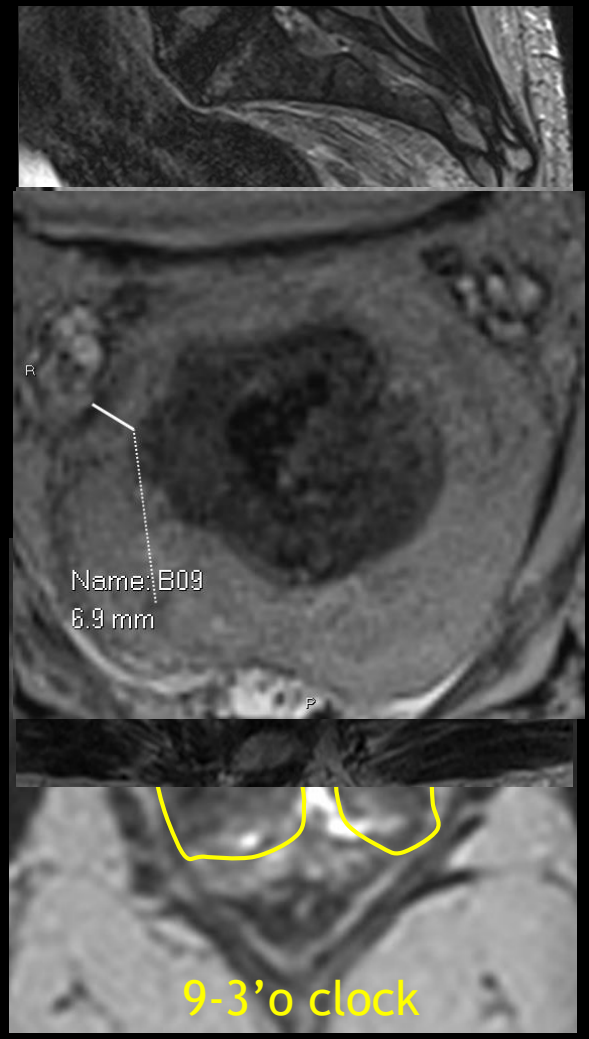
MRF+ = tumor within 1mm of MRF

Approach to rectal cancer evaluation

- The following findings are analyzed in a systematic approach to stage rectal cancer:

1. Location of tumor: measure distance from anal verge (s*)
2. Measure distance of lowest extent of tumor to top of anal sphincter (s)
3. Asses relationship to anterior peritoneal reflection (s)
4. Measure length of the tumor and circumferential extent (clock face) (s, a)
5. Measure extension of tumor beyond the rectal wall if present (a)
6. Measure shortest distance to MRF (a)
7. Assess involvement of adjacent organs (d)
8. Look for sphincter and anal canal involvement (c, a)
9. Assess extramural vascular involvement (EVMI)
10. Look for lymph nodes (a, c)
11. Bones (d)

*Asses finding on axial (a), sagittal (s), coronal (c), all planes (d)



Structured template

- Use of a structured template allows for systematic assessment of rectal cancer, provides a quality report, and consistently includes all the information needed by surgeons to plan the right surgery.

- Society of Abdominal Radiology, Radiological Society of North America and ESGAR have structured templates on their websites as a guide.

- An example of the template used at our institution is provided on the following slide.

Structured template

- **Image Quality**: [Good/Adequate/Suboptimal/Non-diagnostic]
- **Technique**: []
- **Comparison**: []
- **Rectum**:

Tumor Location (from anal verge):

[ ] Low (0-5 cm)

[ ] Mid (5-10 cm)

[ ] High (10-15 cm)

- -Distance of the lowest extent of tumor from anal verge: [ ] cm
- -Distance of the lowest extent of tumor from top of the anal sphincter: [ ] cm
- -Relationship to anterior peritoneal reflection:

[ ] Above

[ ] At or straddles

[ ] Below

[ ] Not able to assess

- Craniocaudal tumor extent: [] cm
- Circumferential extent/location: [] o'clock
- DWI: [diffusion restriction, present or absent]
- *Tumor Characteristics (for Mid and High tumor):*
- Depth of mesorectal fascia invasion:

[ ] Tumor not seen (Tx)

[ ] Invades submucosa (T1)

[ ] Invades muscularis propria (T2)

[ ] Beyond muscularis propria < 1mm (T3a)

[ ] Beyond muscularis propria 1-5 mm (T3b)

[ ] Beyond muscularis propria >5-15 mm (T3c)

[ ] Beyond muscularis propria >15 mm (T3d)

[ ] Penetrates visceral peritoneum (T4a)

[ ] Directly invades other organs (T4b): [describe the organs involvement]

- Tumor Characteristics (for Low tumor):

[ ] Absent

[ ] Invades internal sphincter

[ ] Invades internal sphincter and extends into intersphincteric plane

[ ] Invades internal sphincter, intersphincteric plane and extends into or through external sphincter

[Dictate anal canal involvement- upper, mid, distal]

- Distance to the MRF

Shortest distance of the definite tumor border to the MRF: [ ] mm

Cannot be estimated or tumor in peritonealized rectum: [ ]

Separate tumor deposit, LN, EVMI extending (≥ 1mm and ≤2 mm) or invading (<1mm) the MRF: [ ] Yes (describe) [ ] No

- EVMI: [ ] Absent [ ] Possibly present [ ] Present

- Mesorectal Lymph Nodes:

[] N0 (no visible lymph nodes)

[] N+ (short axis ≥ 9 mm)

[] N+ (short axis 5-8 mm AND at least 2 morphologic criteria)

[] N+ (short axis <5 mm AND all 3 morphologic criteria)

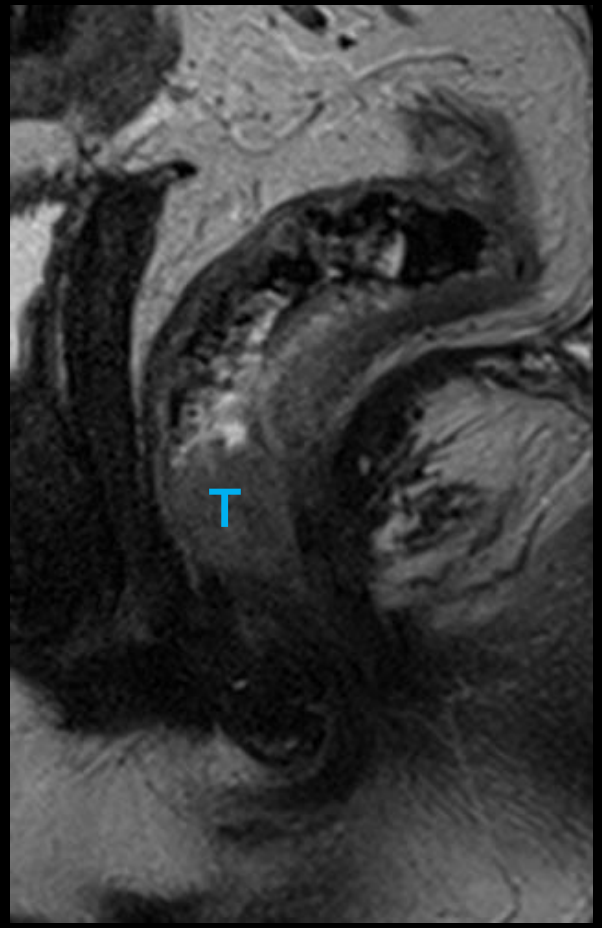
Extramesorectal Lymph Nodes: [ ] Yes [ ] No

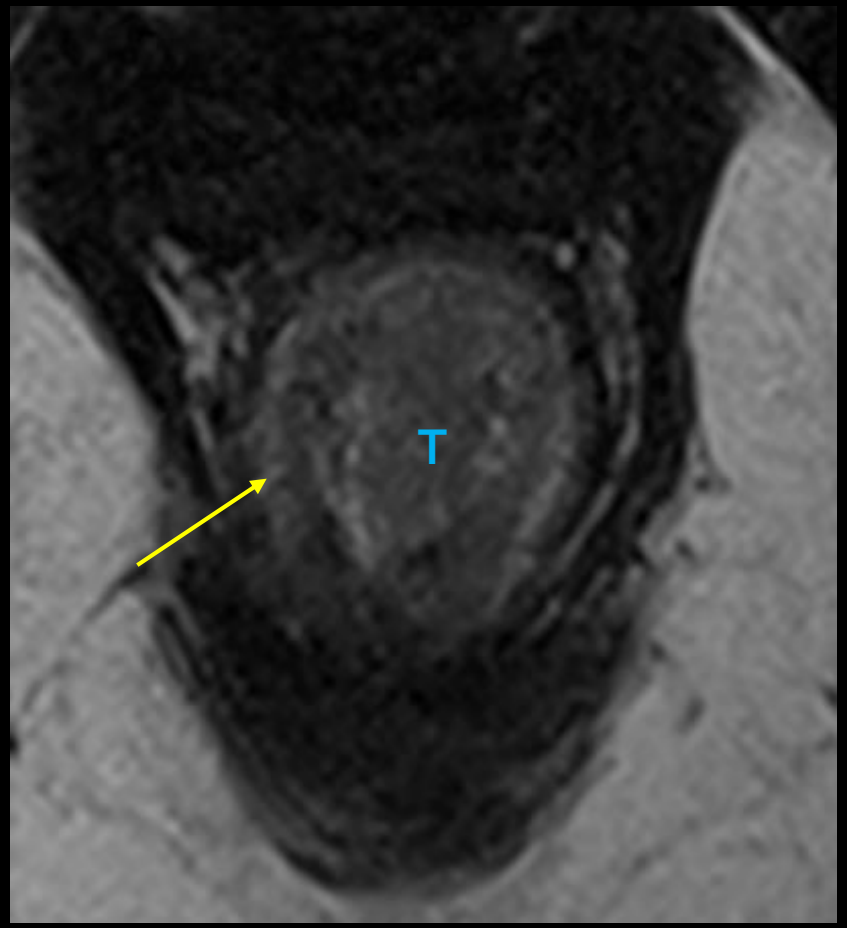
[If yes describe location, locoregional or M1]

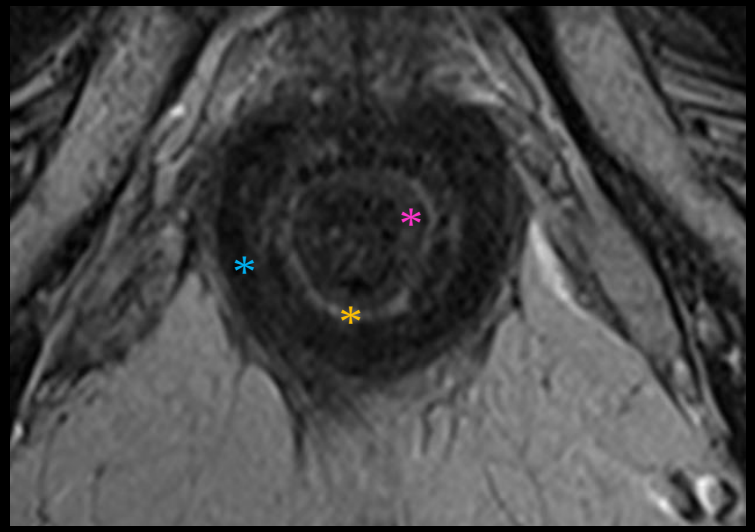
- Bone:[]
- Others: []

Impression: []

Cases: T2 low rectal cancer



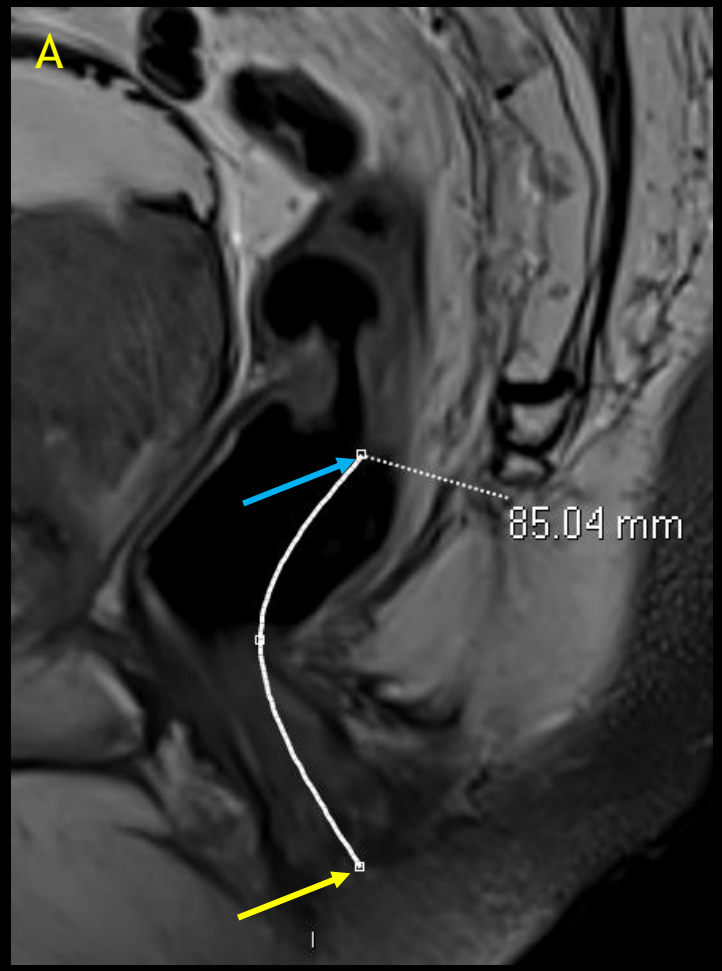


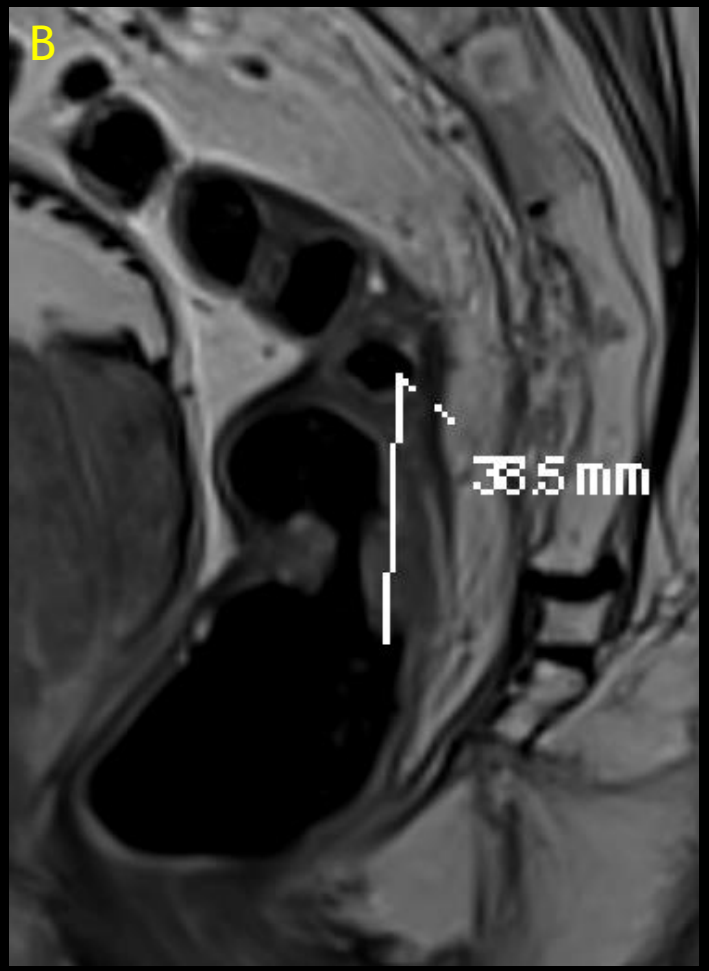


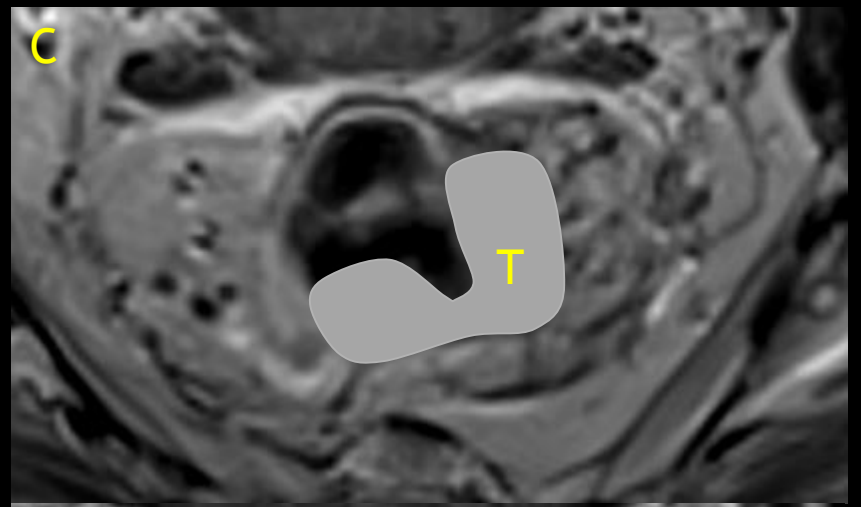
Normal sphincter complex image for comparison.
*Internal sphincter;
*intersphincteric space
*external sphincter

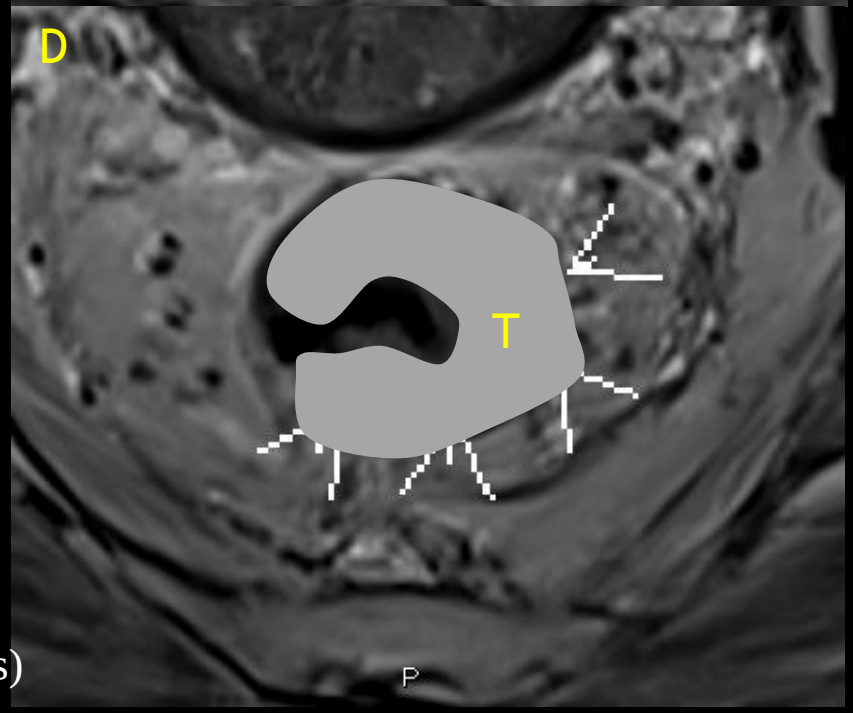
T2WI coronal image shows intermediate signal low rectal tumor, below the anterior peritoneal reflection.
On axial image the tumor extents to the intersphincteric plane (arrow).

T3a mid rectal cancer









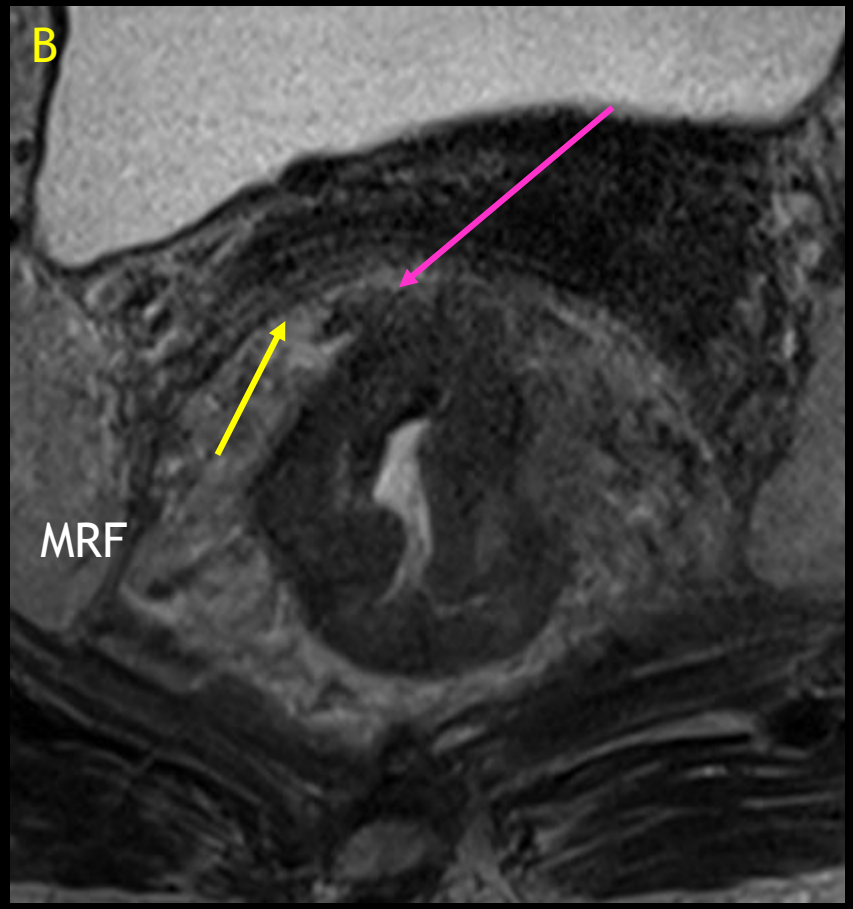
T2WI images:

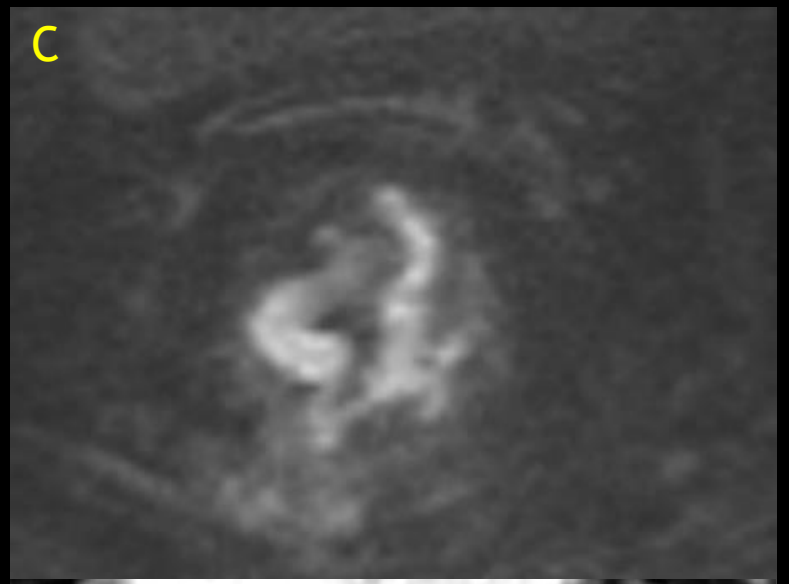
A: shows the distance of lower end of tumor (↗) from the anal sphincter (↗)

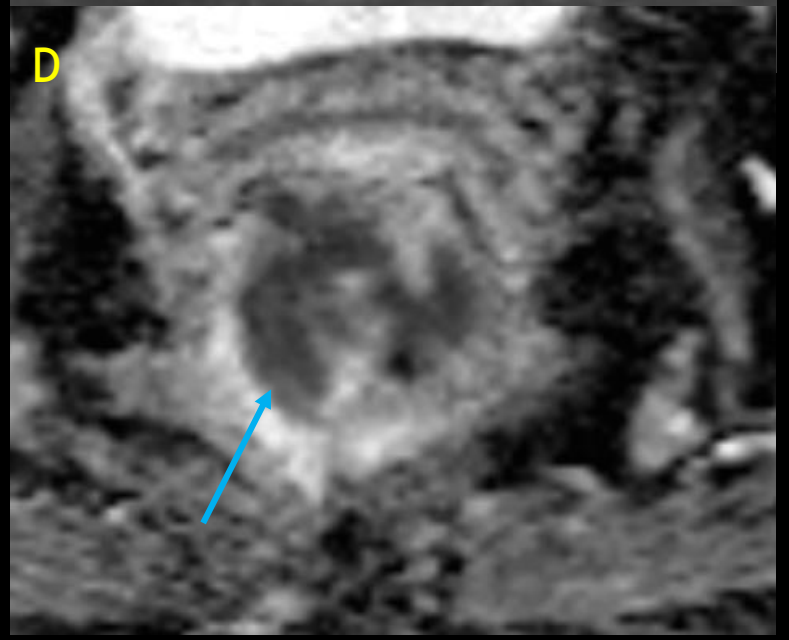
B: shows length of tumor

C & D: shows involvement of Mp and <1mm extension into the mesorectal fat (arrows)

T3c MRF+ rectal cancer

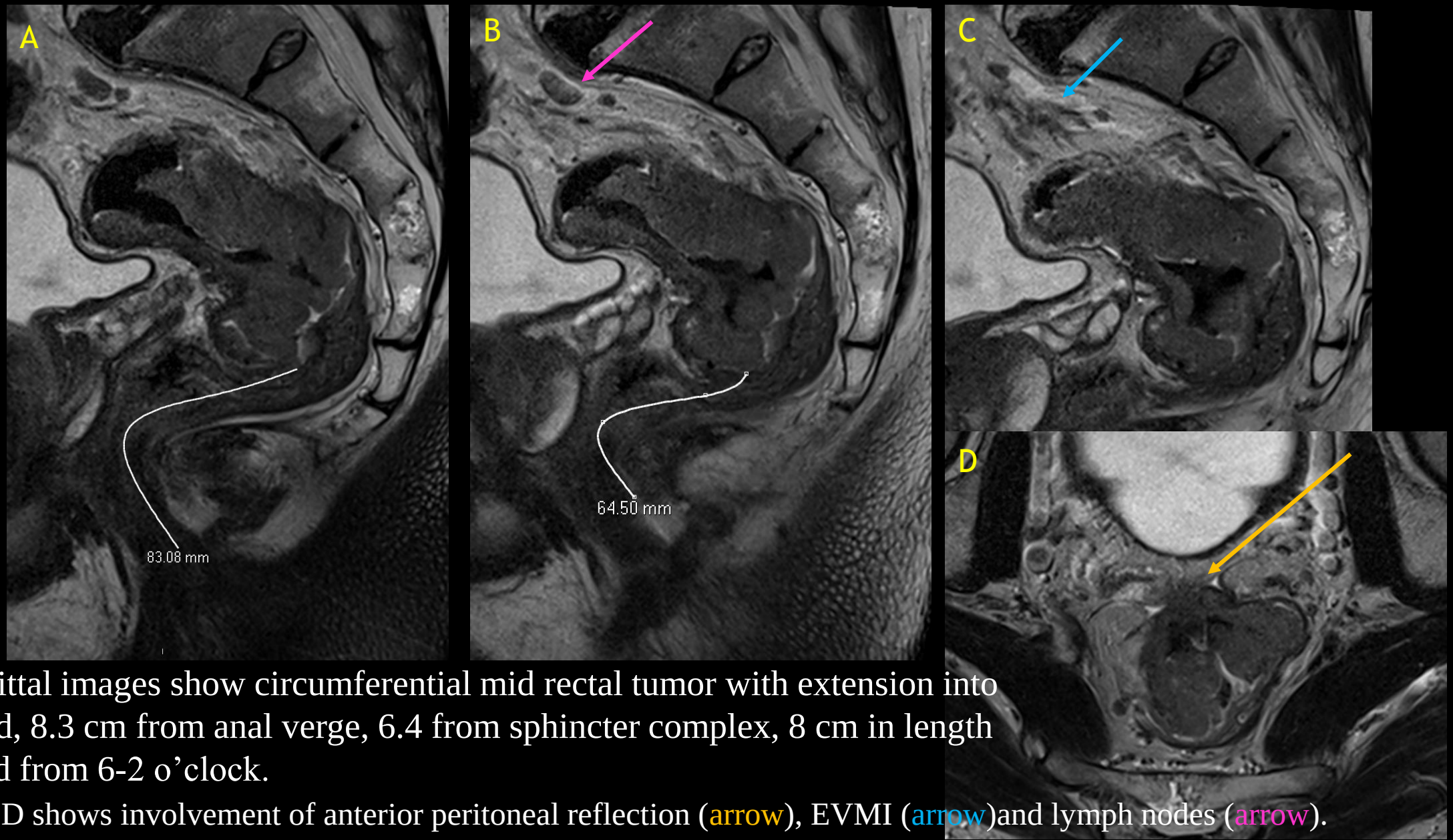






T2WI images:
A: shows length of rectal tumor
B: shows extension of tumor into the mesorectal fat (arrow, 6mm) & proximity to MRF (<1mm)
C & D: diffusion weighted imaging shows restricted diffusion (arrow)

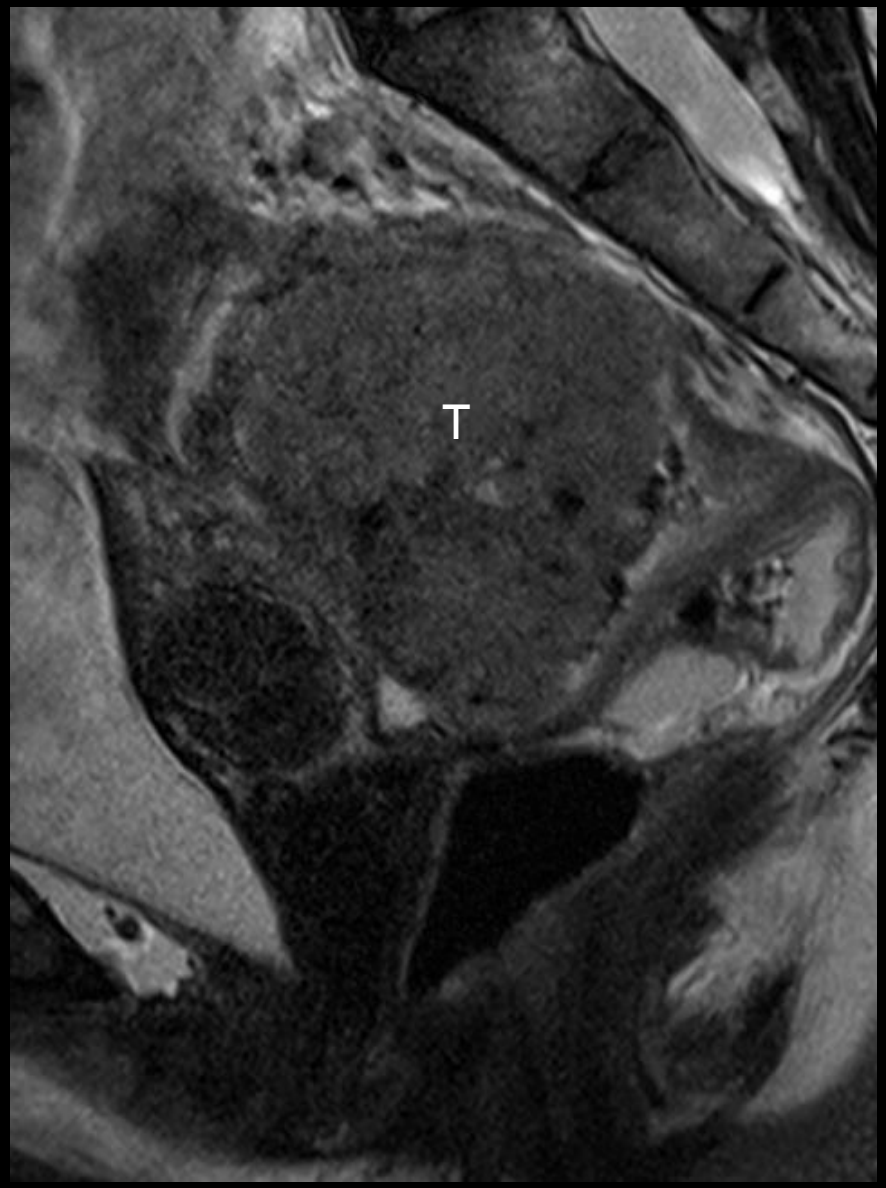
T4aN+ EVMI mid rectal cancer



T2WI sagittal images show circumferential mid rectal tumor with extension into upper third, 8.3 cm from anal verge, 6.4 from sphincter complex, 8 cm in length and extend from 6-2 o'clock.

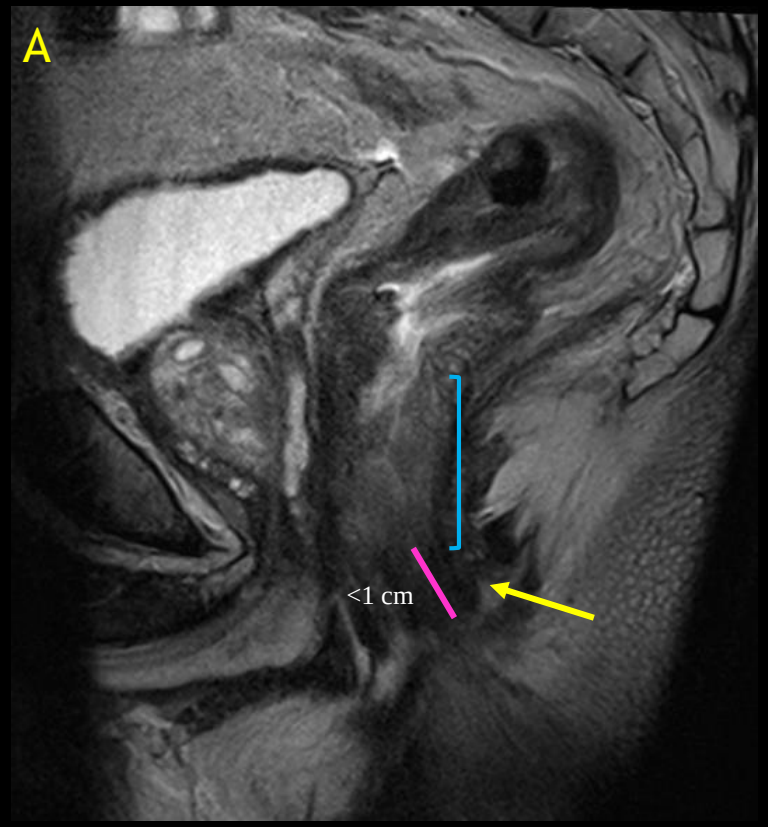
Image C & D shows involvement of anterior peritoneal reflection (arrow), EVMI (arrow)and lymph nodes (arrow).

T4bN+ high rectal tumor

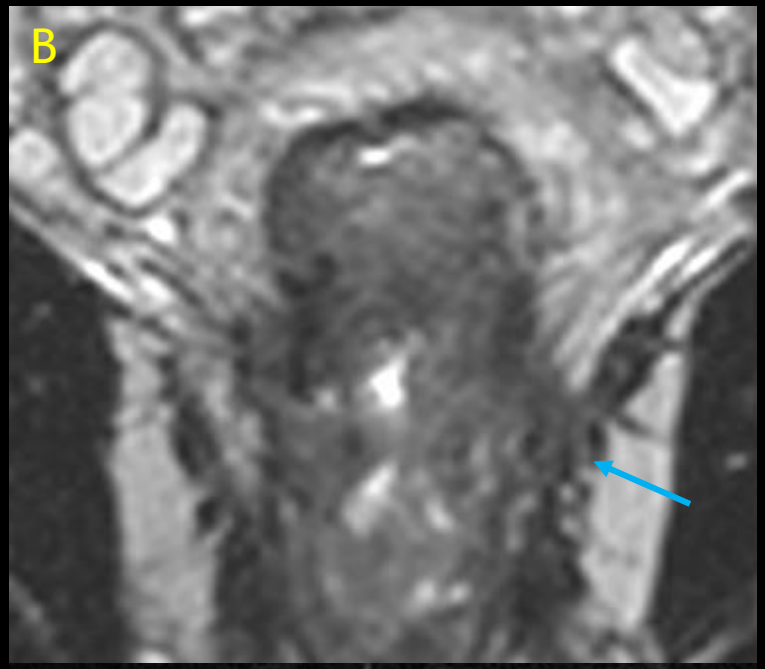


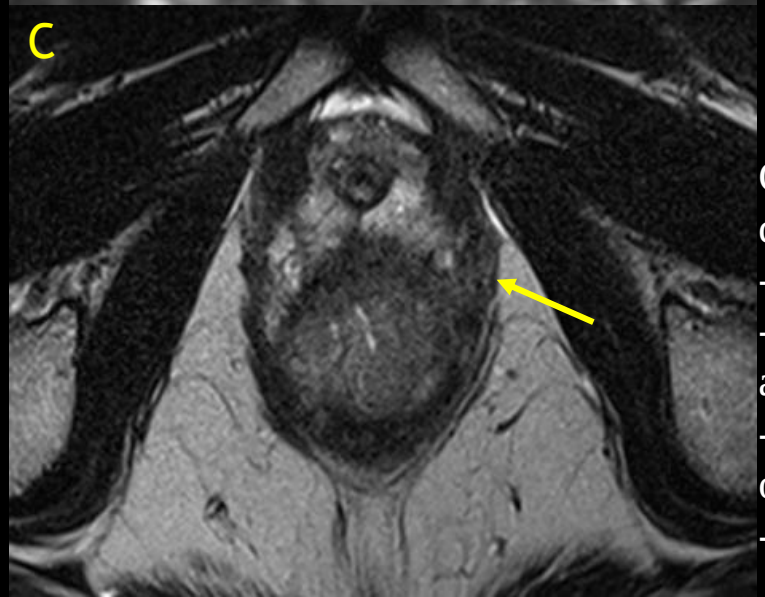
Sagittal T2WI images demonstrates large lobulated high rectal tumor (T) invading the uterus (U, yellow arrows). There is an enlarged and morphologically abnormal lymph node (blue arrow)

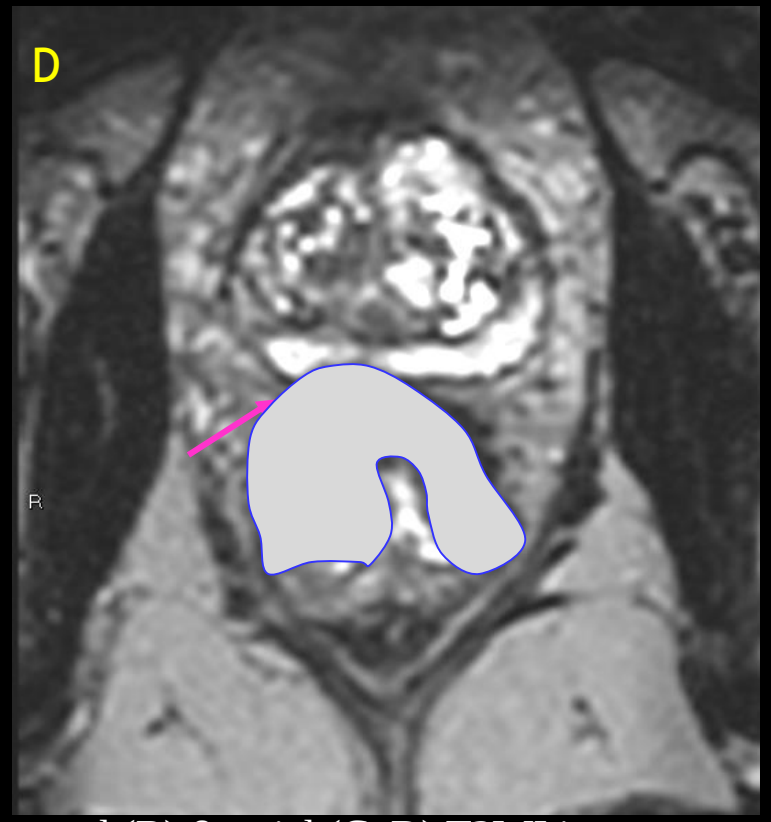
T4b low rectal cancer



Sagittal T2WI image (A) demonstrates
extent of tumor (blue line)
level of anal sphincter (yellow arrow)
distance of tumor from the anal sphincter (pink line)
Distance from anal verge is less than 5 cm, not shown







Coronal (B) & axial (C, D) T2WI images demonstrates:
-involvement of levator ani (blue arrow)
-intermediate tumor signal in the levator ani and obliteration of fat (yellow arrow)
-tumor involving the right peripheral zone of prostate (pink arrow),
-extension of tumor (gray shaded area, 9-3'o clock)

Lymph nodes (LN)

Rectal cancer nodes are assessed in following regions:

- Mesorectal/Superior rectal
- Extramesorectal
  - Locoregional LN: internal iliac, obturator
  - M1: external iliac, commom, retroperitoneal and inguinal

- Nodal staging is describe as N0 (no LN) or N+ (enlarged or morphologically abnormal LNs present)

Lymph nodes (LN)

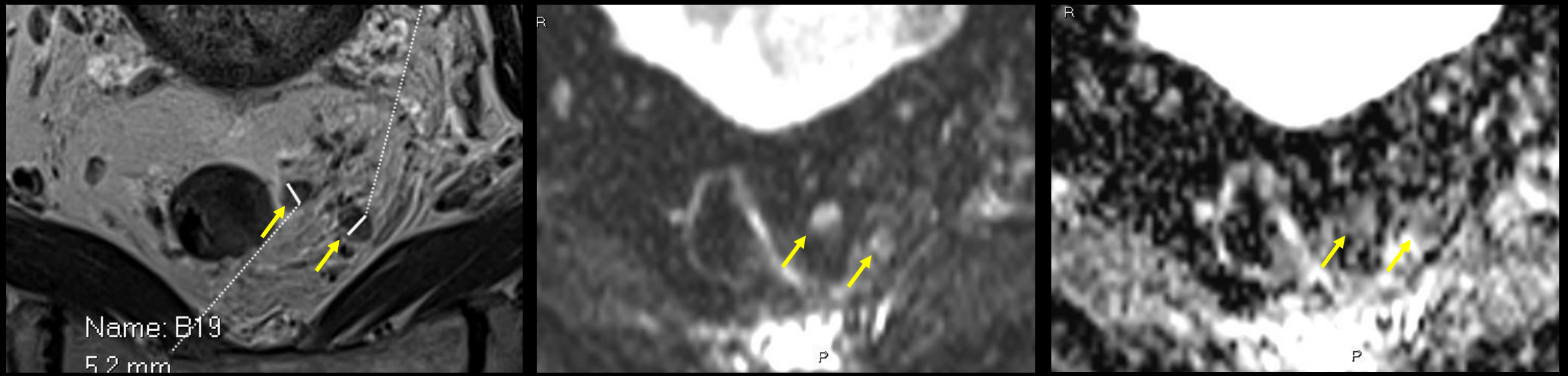
- When N+, the size of the LN in short axis and morphology should be described

N+	> 9 mm
	5-9 mm AND at least 2 malignant characteristics
	<5 mm AND 3 malignant characteristics

- Morphologically abnormal LNs are
  - round in shape
  - irregular borders
  - heterogeneous signals

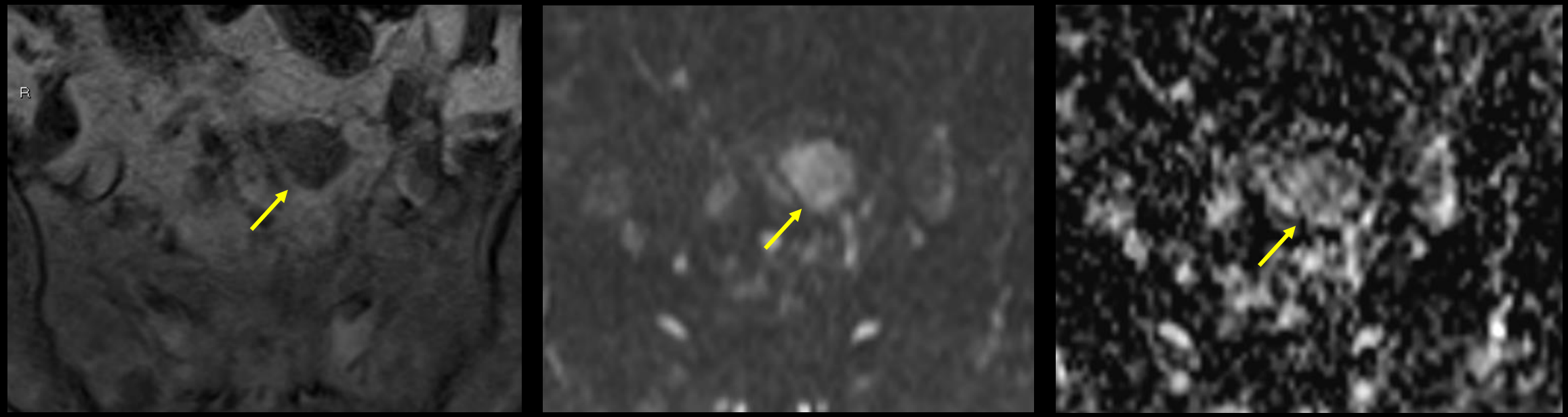
Lymph nodes (LN)

- Diffusion weighted imaging (DWI) is useful in localizing the LNs



T2WI and DWI with ADC map demonstrates two LNs (arrow) in mesorectal fat with restricted diffusion.

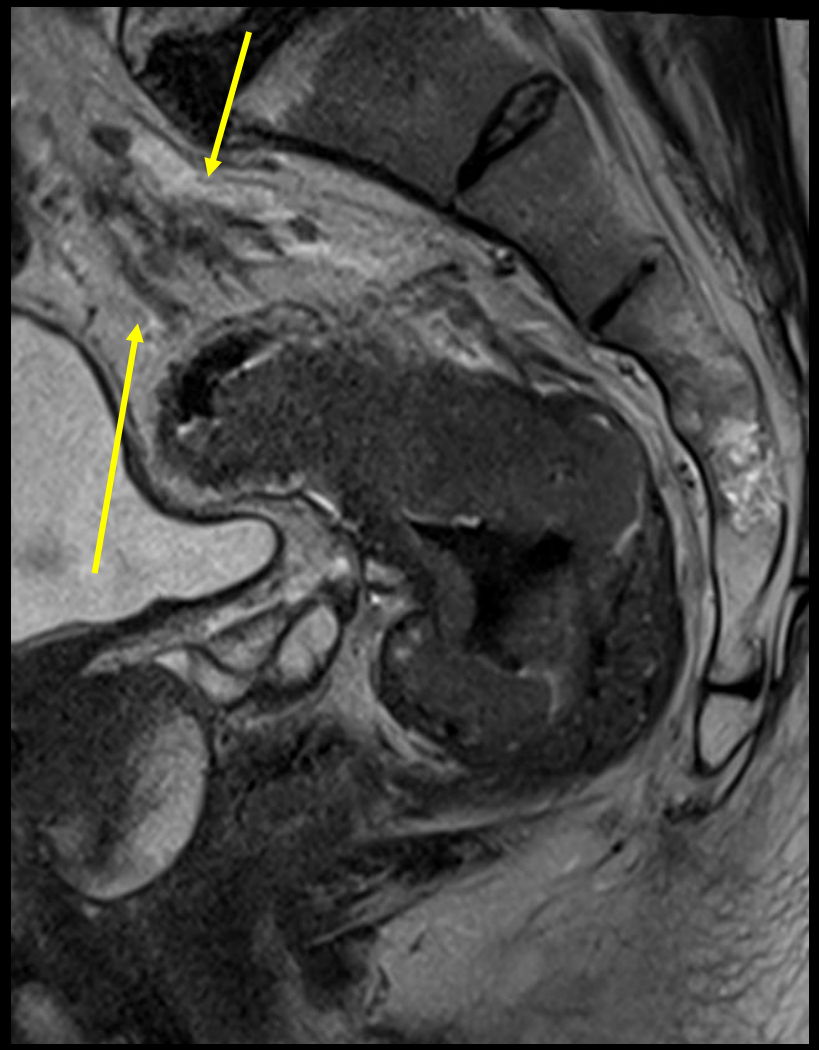
Lymph nodes (LN)



T2WI and DWI with ADC map demonstrates LN (arrow) with indistinct margins and heterogeneity

Exramural vascular invasion (EVMI)

- Involvement of blood vessels by tumor applies to T3 and above tumors.
- The blood vessels can show change in signal intensity or distension (arrows)
- Proximity of EVMI to MRF is assessed



Pitfalls in staging

- Use of rectal gel can distort the tumor; over distension can alter the surrounding anatomy, distance of tumor into mesorectal fat or to the MRF, and obscure lymph nodes. Avoid overdistension of rectum when using gel.

- T1 and T2 stage tumors can be difficult to differentiate. Endorectal ultrasound or endorectal coil may be better.

- Fibrosis vs desmoplastic response vs recurrence may be difficult to differentiate. DWI can be helpful to differentiate

- Imaging in the incorrect orthogonal plane can cause volume averaging and pseudospiculation of tumor margins leading to overstaging. Repeat the sequence for adequate staging.

Pitfalls in staging

- Poor positioning of the coil can result in inadequate coverage of anatomic structures of interest and result in understaging.

- Motion artifact can limit adequate staging. Patient comfort (empty bladder, pain relief), increasing the FOV, and decreasing the number of signal acquisitions can help.

- Small FOV may exclude pelvic sidewall nodes and large FOV may not provide enough spatial resolution to evaluate LN size, margins and signal as accurately as needed. Combination of large FOV and small FOV T2WI in different planes to covers the area of interest.

Conclusion

- MRI, due to its high spatial resolution and higher signal to noise ratio, allows better evaluation of the rectal anatomy and surrounding structures in rectal cancer staging and surgical planning.

- Thin section (3mm) small field of view, and T2WI perpendicular to the long axis of tumor at the level of the tumor are key for rectal cancer staging.

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