MRI evaluation of rectal anatomy

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Learning objectives

- to know MRI indication and techniques in rectal study;
- to know the normal anatomy of male and female pelvis by MRI;
- to evaluate and stage rectal cancer.
Background

The knowledge of normal anatomy is fundamental in MRI rectal cancer staging. The distance between the tumour and the mesorectal fascia modifies the therapeutic approach to the disease. The best imaging technique, in local preoperative staging of the tumour is MRI that, unlike transrectal ultrasonography, allows a better study of mesorectal lymph nodes.

As a result of evidence that a careful surgical dissection of the rectal cancer has great benefits in terms of prognosis, in recent years the anatomy of the rectum has been redesigned.

Colorectal cancer has an estimated worldwide incidence of 1.4 million cases with 693,900 deaths (in 2012); it is the third most diagnosed cancer in men and the second in females. The highest incidence rates are found in Australia/New Zealand, Europe and North America.

Normal anatomy of the rectum

The rectum is the continuation of the sigmoid colon and it ends with the anus; it has a total approximate length of 15 cm. It is possible to distinguish a pelvic part, which appears dilated and takes the name of the rectal ampulla, and a restricted perineal part called anal canal.

The anatomical boundary between these two parts is the insertion in the rectal wall of the elevator ani muscle (Fig. 1-2)

Course: pelvic portion describes an anterior concave sagittal curvature (sacral curve) in front of the sacrum and coccyx vertebrae. This curvature reverses its trend (perineal curve) at the level of the prostatic apex in males and at the level of the middle part of the vagina in the female.

Peritoneal layers: The peritoneum covers partially the rectum, mainly the anterior wall, and then it reflects on the bladder forming the recto-vescical pouch in man, and on the uterus in women forming the Douglas pouch in females. Therefore, the distal portion of the anterior and side walls, and totally the posterior wall, are extraperitoneal.

Pelvic rectum
Anterior wall relations:

- Male → peritoneal portion is in contact with bowel and rectum-bladder pouch. The subperitoneal portion is in relation with the bladder trigone, the posterior surface of the prostate, the vas deferens and seminal vesicles. Between the rectum and these structures interposes the recto-vesical fascia.
- Female → peritoneal portion is in contact with bowel loops and the Douglas pouch. The subperitoneal portion is in relation with the rear wall of the vagina. Between the rectum and vagina interposes the recto vaginal septum.

Rear wall relation:

- Male/Female → it is extraperitoneal; it is in relation with the last three sacral vertebrae and the coccyx, the levator ani, piriformis and coccygeal muscle, and the sacral plexus.

Lateral walls relation:

- Male/Female → peritoneal portion corresponds to the pararectal recesses. The Subperitoneal portion is covered by the rectus fascia; they are in contact with the hypogastric artery branches, with the hypogastric plexus, with the levator ani muscle and, in male, with seminal vesicles and vas deferens.

**Perineal rectum**

Anterior wall:

- Male à it is in relation with the prostate apex, membranous and bulbar urethra, by which delimits the rectourethral space. In rectourethral space there are bulbourethral glands, levator ani, external anal sphincter, superficial transverse perineal and bulbocavernous muscles.
- Female à it is related to the back wall of the vagina with which delimits the rectovaginal space. Inside this space there are parts of the external anal sphincter, superficial transverse perineal and constrictor of the vagina muscles.

Lateral and rear walls:

- Male/Female → they are in relation with the levator ani and the external anal sphincter muscles.

**Mesorectum and fascial structures**
**Mesorectal fascia**

The pelvis is supported by endopelvic fascia, which is composed by a parietal layer and visceral layer. The visceral layer delimits the mesorectum (proper rectum fascia), the parietal layer covers the sacrum (presacral fascia).

The mesorectum is mainly composed by adipose tissue segmented by connective septa; the extremes of these septa, peripherally, converge to form the mesorectal fascia. This fascia extends from the peritoneal reflection until the puborectalis sling.

**Lateral ligaments of the rectum**

They are dense connective tissue structures that run from the lateral sides of the lower rectum to the mesorectal fascia and pelvic parietal fascia, above the levator ani muscle. Blood vessels, nerve fibers and lymph vessels run through lateral ligaments.

**Denonvilliers' fascia**

It is made up by the merging of two of the layers of the primitive coelomic cavity and lies anteriorly to the mesorectal fascia.

**Pelvic diaphragm**

It is a funnel-shaped musculature structure, whose front edge is formed by the levator ani muscle and the bottom of the coccygeus muscle. Above those muscles there is the pelvic fascia, derived from the merging of the proper fascia of those two muscles. The pelvic fascia continues posteriorly with the piriformis muscle fascia, and laterally with the obturator internus muscle fascia.

**Blood supply**

The rectum is mainly supplied by superior rectal arteries (branches of the inferior mesenteric artery) and the middle and lower rectal arteries (branches of the hypogastric artery).

Venous blood of the upper and middle rectum drains to branches of the inferior mesenteric vein, while venous blood of the lower rectum drains to hypogastric vein branches.

**Lymphatic drainage pathways**
Upper rectum: it drains to upper rectal lymph nodes up to the inferior mesenteric vein lymph nodes.

Middle and lower rectum:

- above the mucocutaneous junction (dentate line): they drain to the hypogastric, common iliac and lumbar lymph nodes;
- below the mucocutaneous junction: they do not follow the vessels and drain into the superficial inguinal lymph nodes.
Images for this section:

**Fig. 1:** Anatomical model

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**Fig. 2:** Anatomical scheme
Findings and procedure details

Magnetic Resonance Imaging is a fundamental non-invasively techniques used for the assessment of pelvic diseases, especially to stage and restage rectal cancer.

**MRI SEQUENCES**

The main sequences for locoregional staging of rectal cancer are T2-weighted and high resolution (section thickness <3 mm) acquired using surface coils. The acquisition plans are axial, sagittal and coronal; in particular, the axial plane must be oriented perpendicularly to the major axis of the rectum to demonstrate the parietal extension of the tumour through the rectal wall and any contact with the mesorectal fascia. The sagittal plane is useful to locate the distance of the tumour from the anal and its cranio-caudal extension. Finally, the coronal plane is useful to demonstrate the relationship between the tumour and the anal sphincter muscles.

The use of the fat saturation sequences is not necessary, but useful to identify any inflammation signs.

The Diffusion Weighted Imaging, more than for the initial staging, it has a fundamental role in the re-evaluation after neoadjuvant chemoradiation therapy.

The use of intravenous contrast medium is not necessary in the local staging of rectal cancer as well as the distension of the rectum with water or ultrasound gel is currently controversial.

**MRI ANATOMY**

The rectal wall

It consists of mucosa, muscularis mucosa, submucosa and muscularis propria.

On MR imaging the mucosa appears as a thin low signal line surrounded by a thicker line of hypersignal represented by the submucosa. The muscularis propria can be divided sometimes into two additional layers: an inner circular musculature layer and an outer longitudinal musculature layer. The latter can have an irregular appearance for the presence of some interruptions from the penetrating vessels (Fig. 3).
**The mesorectum and the mesorectal fascia**

Mesorectum has a high intensity signal, like fat, and it surrounds the rectum; it contains vessels and lymphatic structures. Lymph nodes within the mesorectum appear as ovoid structures with high signal.

The mesorectal fascia is best displayed in axial planes with high resolution sequences; it appears as a linear, hypointense and thin structure, which delimits the mesorectum (Fig. 4).

**The lateral ligaments**

They are not displayed on MR imaging, although they can be supposed by following the middle rectal vessels when these are present.

**The Denonvilliers' fascia**

It appears as a hypointense structure located anteriorly the surface of the mesorectum; it is best displayed in sagittal planes and it ends in the peritoneal reflection (Fig. 5).

**The peritoneal reflection**

It is well displayed in sagittal planes as a hypointense linear structure that starts from the superior-posterior surface of the bladder and runs posteriorly until its insertion on the rectum (in male between the middle-lower rectum; in female at the lower rectum, but with much variability). In axial planes the insertion of the peritoneum on the rectum appears as a V-shaped linear structure, recognised as "seagull sign" (Fig. 6-7).

**The rectosacral fascia**

Best displayed in sagittal sequences, it appears as a linear structure with variable thickness, which runs from the sacrum to the mesorectal fascia, at the level of the fourth sacral vertebra.

**The retrorectal space**

The mesorectal fascia bound it anteriorly and posteriorly by the presacral fascia; it contains fat and vascular structures (Fig. 8).

**The parietal fascia**
It has a signal isointense to the pelvic floor muscles (piriform, elevator anus, coccyx and internal shutter) and it is not visualized as an isolate structure. It separates from the muscles only in the lateral portion where it appears as a layer above the internal obturator muscle.

The pelvic nerve plexus

The inferior hypogastric plexus is displayed in a more mesial plane than that of the pelvic vessels. It is a rectangular fenestrated structure of fenestrated a length of about 3-4 cm in anteroposterior.

TNM STAGING

T stage

The T stage describes the primitive tumour and its invasion of the rectal walls and surrounding structures. We distinguish 4 stages:

- **T1** # focal thickening of the rectal wall extended to the hyperintensity of the submucosa, without involvement of the external profile of the rectal wall (Fig. 9).

- **T2** # involvement of muscularis propria with interruption of the hypointense ring. MRI shows sensitivity of 75% and specificity of 78% (Fernandez-Esparrach et al. 2011) (Fig. 10)

- **T3** # involvement of the mesorectal fat; complete interruption of the hypointense muscular ring, with extension beyond the rectal wall.
  
  o T3a: <1 mm beyond the muscularis propria
  
  o T3b: 1-5 mm beyond the muscularis propria (Fig. 11)
  
  o T3c: 5-15 mm beyond the muscularis propria
  
  o T3d: >15 mm beyond the muscularis propria (Fig. 12)

  MRI shows sensitivity of 75-91% and specificity of 76-90%, variable when using high-resolution techniques (Fernandez-Esparrach et al. 2011; Futterer JJ et al. 2007).

- **T4** # involvement adjacent anatomical structures (Fig. 13):
  
  o T4a: infiltration of the visceral peritoneum
  
  o T4b: infiltration of organs or nearby structures.
MRI shows sensitivity of 94-100% and specificity of 95-98% (Fernandez-Esparrach et al. 2011)

In tumour extension morphological description it is essential to specify the possible involvement of the mesorectal fascia because this parameter is predictive of relapse. When neoplastic tissue (primitive tumour or lymph node metastatic) is found at a distance less than 1 mm from the mesorectal fascia, it is defined as a involvement of mesorectal fascia.

NODAL DISEASE

- **N0** # not regional lymph nodes
- **N1** # from 1 to 3 lymph nodes perirectal
- **N2** #more than 4 regional lymph nodes

Careful assessment of nodes involvement is important for the indication of a neoadjuvant therapy regardless of the T stage. Nevertheless, it is still complex an effective characterization of nodes using MRI. It can be used as a parameter of malignancy a heterogeneous signal and irregular boundaries, with a sensitivity of 45-85% and specificity of 83-100% (Zhou J et al. 2014).

The size of the lymph nodes on the other hand can be a deceptive indicator because, also an endoscopic procedure can cause nodes reactivity; a cut-off of 7 mm was found to have a sensitivity of 71% and a specificity of 61% (Arii K et al. 2006).

Currently there are not universal cut-off for the evaluation of nodes pathology.

In addition, it is important to locate the possible malign nodes, if internal or external to the mesorectal fascia (internal nodes are removed in total mesorectal excision).

M STAGE

The evaluation of distant metastases is not the achievement of pelvic MRI.

A correct staging is essential because the therapeutic approach is different; in particular:
• Patients with a MRI staging of T1 and T2 are subjected to surgical resection (endoscopic or open) without neoadjuvant chemoradiation therapy.
• Patients with MRI staging of T3 and T4 perform neoadjuvant chemoradiation therapy followed by a MRI restaging and possible surgery.
**Fig. 3:** Mucosa (white arrow); sub-mucosal layer (green arrow); Internal muscular layer (yellow arrow); external muscular layer (red arrow).

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Fig. 4: Mesorectum

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**Fig. 5:** Denonvillier's fascia

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**Fig. 6:** Peritoneal reflection (sagittal plane)

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Fig. 7: Peritoneal reflection (axial plane)

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Fig. 8: Retrorectal space

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**Fig. 9:** T1 rectal tumor in a 65 y.o. man. There is no invasion of the muscolaris propria layer

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Fig. 10: T2 rectal tumor. There is a partial interruption of the isointense muscular ring (arrow)

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**Fig. 11:** T3b rectal tumor in a 54 y.o. woman. There is an interruption of the isointense muscular ring (arrow) with invasion of the surrounding fat tissue. There are even numerous local nodes.

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**Fig. 12:** Two examples of T3d tumors. On the left a mesorectal fascia invasion by neoplastic lesion.

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Fig. 13: T4 rectal cancer with invasion of seminal vesicles

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Conclusion

MRI is essential for the correct local staging of rectal cancer because of its high contrast resolution that allows distinguishing even small interruption of the *muscularis propria* and the relationship of neoplastic tissue with the pelvic anatomical structures, especially in high rectal tumours.
References


