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## Original article

# Value of MRI in Pre-operative assessment of Rectal Cancers and its impact on Surgical Decision and Intervention

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## ABSTRACT

**Background:** For accurate staging of rectal cancer, high-resolution MRI is the suggested imaging modality. The standard rectal MRI protocol uses thin-slice, high spatial resolution T2-weighted images to capture the rectal tumor and the surrounding perirectal tissues and also the mesorectum surrounding the rectum. Many other imaging modalities can be used to assess rectal tumors as lower GIT endoscopy and endo-luminal ultrasound, so the accuracy of MRI in assessment of rectal tumors is needed to be evaluated in comparison to the gold standard methods (the operative and histo-pathological findings). This study had been performed on 60 patients diagnosed with rectal cancer in Minia university hospital and in the national cancer institute from March 2021 till February 2023. There was a good correlation between MRI and operative finding of the cases as regard **Distance of the tumor from anal verge**. There was agreement between MRI and operative finding as regard **Location of the tumor** with the accuracy of MRI was 92%. No Significant difference between the final pathology and MRI as regard **Tumor staging and detecting lymph node metastasis**. There was significant correlation between MRI and operative finding of the cases as regard meso-rectal fascia (MRF) involvement. So rectal MRI is an important tool in management of patients with rectal cancer as regard staging rectal cancer which can assist surgeons to obtain negative surgical margins. MRI facilitates the pre-operative accurate assessment of rectal tumors in order to improve patient outcomes.

## Introduction

Rectal MRI is the suggested imaging tool for accurate loco-regional staging of rectal cancer,

as rectal MRI protocol uses thin-slice, high spatial resolution T2-weighted images to capture the rectal

tumors and surrounding tissues. The images are obtained in three different planes: oblique axial perpendicular to the tumors, sagittal determined by the longitudinal axis, and oblique coronal plane parallel to the anal canal[1].

Routine use of an endorectal coil or endorectal contrast is not recommended since it may expand the rectum, making it difficult to assess mural invasion accurately. The addition of intravenous gadolinium contrast does not always increase diagnostic accuracy; on contrary; multiple studies have shown that the inclusion of gadolinium caused the T stage to be downstaged, which may eliminated the requirement for neoadjuvant treatment and altered treatments in 24% of cases[2].

Many important data can be obtained by MRI as tumor size, definite site, relation to muscle complex, status of mesenteric lymph nodes. MRI can also determine circumferential resection margins (CRM) which is defined as the tumor's distance from the mesorectal fascia at its closest point; it is considered positive when the tumour is 1 mm or less from the mesorectal fascia[3].

MRI is preferable to endo-rectal ultrasound( ERUS) for evaluation of the CRM due to its capability to detect the mesorectal fascia involvement, it was the only preoperative factor that significantly predicted local recurrence; disease-free survival; and overall survival according to CRM assesment by MRI in one study. In this study positive CRM had 47% 5-year survival rate compared to a 67% 5-year survival rate in negative CRM [4].

Rectal MRI can also play an important role in accurate T- staging. T3 lesions can be subclassified using rectal MRI into t3-a and t3-b based on depth of invasion of rectal muscle layers. This subclassification has significant potential clinical applications due to variations in recurrence and survival rates within the T3 category; [5], also this subclassification can identify tumors into tumors that need for neoadjuvant treatment and other tumors that will benefit from primary resection[6].

MRI criteria as a tool to identify patients with good prognostic rectal cancer features was used in the Canadian Quicksilver Trial; it was concluded that rectal MRI could select patients who could undergo primary rectal cancer surgery rather than initial chemoradiotherapy [6, 7].

MRI can also assess the tumor's relationship to adjacent organs and near peritoneal reflections which can threaten resection radial margin. The possibility of tumor resection & Neoadjuvant therapy option should be made based on these details rather than an arbitrary anatomic considerations[7].

As regard tumor site; MRI can determine upper, middle and low rectal tumors, it also can categorize low rectal tumours into those that extend to or below the origin of the levators on the pelvic sidewall and those that extend from the anal verge to 6 cm., it also takes into account the tumor's proximity to the intersphincteric region and levators which linked to relatively poor results in comparison to more superficial tumours (T1 and 2) that have not invaded the intersphincteric plane[8].

MRI is a good tool for identifying mesorectal nodes or mesenteric lymph nodes because of the soft tissue contrast it shows[1].

Post treatment MRI can be used to assess the tumor's response to neoadjuvant therapy by Using the MR tumour regression grade (mrTRG) scale in pre- and post-treatment. Some studies showed that MRI can accurately predict the complete pathologic response[3].

In this study we tried to accurately compare the results of MRI in assessment of rectal tumors in comparison to the operative and pathological findings. The sensitivity & specificity of MRI in it's assesment of some different issues in rectal tumors were calculated.

### **Patients & methods**

This study is a case series analysis that had been performed on 60 patients diagnosed with rectal cancer in Minia university hospital and in the national cancer institute Cairo University, in the period from March 2022 to February 2023. Perforated or obstructed lesions; severely ill patients that cannot tolerate surgery and rectal cancer with distant metastasis were not in the scope of our study. Pre-operative items evaluated by MRI included: Distance of the tumor from anal verge (upper, middle & lower); Location of the tumor (anterior, posterior, or lateral); Presence of enlarged mesenteric lymph Nodes; tumor staging and the meso-rectal fascia involvement, then the MRI findings were re-assessed by the surgical and histopathological findings to evaluate the correlation between MRI finding and surgical & final Pathology findings.

### Statistical analysis

Data were assessed by the Statistical Package for Social Science (IBM SPSS) version 20. The qualitative data were presented as number and percentages while quantitative data were presented as mean, standard deviations and ranges when their distribution found parametric. P value was considered significant if  $< 0.05$ . Analyses were made using kappa and intraclass correlation coefficient (ICC) to determine correlation & reliability. positive predictive value (PPV), negative predictive value (NPV), sensitivity, specificity were also calculated.

### Kappa correlations

0.01–0.20	none to slight agreement
0.21–0.40	fair
0.41– 0.60	moderate
0.61–0.80	substantial
0.81–1.00	perfect agreement

### ICC values

Less than 0.5	poor reliability
0.5 and 0.75	moderate reliability
0.75 and 0.9	good reliability
greater than 0.90	excellent reliability

**Sensitivity** was calculated by the equation

**Sensitivity = True Positive / (True Positive + False Negative).**

**Specificity** was determined by the following equation

**Specificity= True Negative / (True Negative + False Positive).**

### Results

Of the 60 patients in our study; there were 27 men and 33 lady, their ages ranged from 23 to 72 years (mean 50.8 years).

### Distance of the tumor from anal verge:

As regard distance of the tumor from the anal verge, **Table (1)** shows highly Significant correlation between MRI and operative finding of the cases, The highest correlation (ICC range 0.797–0.812), the least mean difference was (ranged 0.77–

0.85 cm) and the least standard deviation (ranged 4.3-4.5 cm) that indicate good reliability.

### Tumor location:

**Table (2)** Show the degree of agreement between MRI and operative finding of the cases and show good reliability as regard Location of the tumor with the accuracy of MRI was 92.5% in patients with a tumor located at the upper rectum, 90.5% in patients with a tumor located on the middle rectum, and 95.6% in patients with tumor located lower rectum.

### T-staging:

**Table 3** Show good reliability and agreement between the MRI &operative findings for T staging. The sensitivity and specificity of MRI for T staging were 87% and 93% respectively. The positive predictive value (PPV) and negative predictive value (NPV) of MRI for T staging were 84% and 91% respectively. The overall MR sensitivity of T1-2 tumors were 72-91 % and specificity were 79–88% and sensitivity of T3-4 tumors were 67-95% and specificity were 81-97% **Fig1.**

### Mesenteric lymph nodes:

The specificity and sensitivity of MRI in diagnosing whether lymph nodes had metastasis or not were 95 % and 80.1% respectively **Fig2**, there was excellent agreement between MRI &operative findings in detecting lymph node metastasis (table 4).

### Meso-rectal Fascia involvement:

**Table 5** shows that the overall accuracy of MRI was 95% for predicting Mesorectal fascia involvement by MRI. The sensitivity, specificity **Fig3**, positive predictive value, and negative predictive value were 85%, 86.4%, 91.7% and 92.3%respectively.

**Table 1.**Correlation between MRI and operative finding of the cases as regard Distance of the tumor from anal verge.

Data NO = 60 cases	Range (cm)	Mean $\pm$ SD	Intraclass correlation (ICC)*	Mean difference in cm**	P value***
Distance from anal verge by MRI	1.2-15.3 Cm	7.13SD4.3	0.812	0.77	0.003
Distance from anal verge by Surgical finding	1-15 cm	7.8SD4.5	0.797	0.85	0.004

\* ICC values between MRI and operative finding.

\*\* Mean difference between MRI and operative finding.

\*\*\*Mean difference between MRI and operative finding, with statistical significance by paired t-test.

**Table 2.**Correlation between MRI and operative finding of the cases as regard Location of the tumor.

Preoperative MRI	Operative finding			kappa	ICC (95% C.I.)	p-value
	Upper	Middle	Lower			
Upper	16(88.9%)	1(7.1%)	0(0%)	<b>0.872</b>	0.943 (0.906-0.965)	0.061
Middle	2(11.1%)	13(92.9%)	2(7.1%)			
Lower	0(0%)	0(0%)	26(92.9%)			
Total	18	14	28			

**Table 3.**Correlation between MRI and operative finding of the cases as regard Tumor staging.

preoperative MRI	Pathological Finding		kappa	ICC (95% C.I.)	p-value
T staging	T1/2	T3/4			
T1/2	11(73.3%)	1(2.2%)	0.762	0.765 (0.636-0.852)	0.005
T3/4	4(26.7%)	44(97.8%)			
Total	15	45			

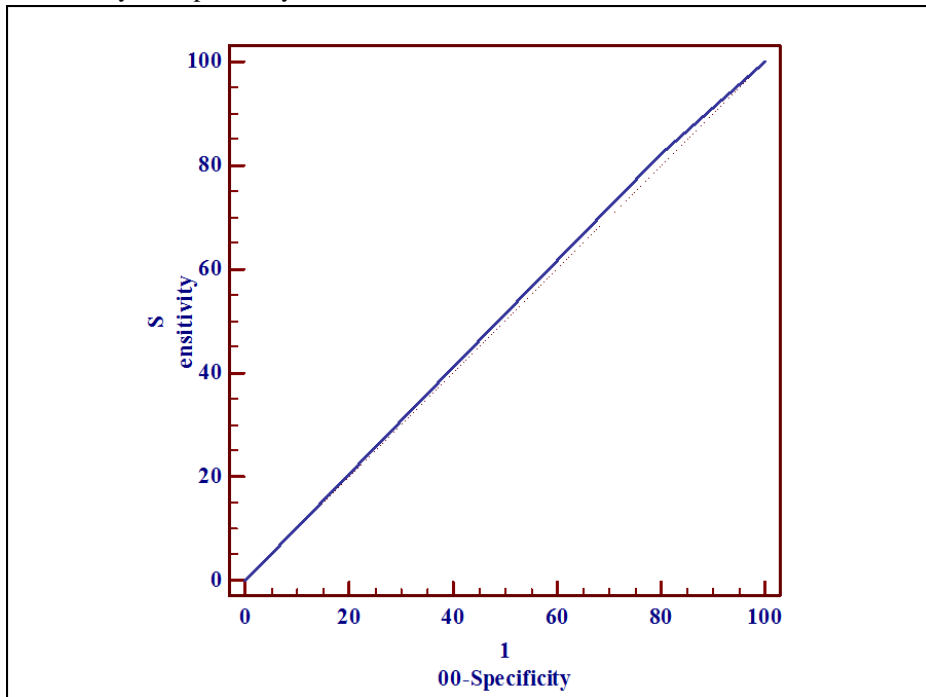
**Table 4.**Correlation between MRI and operative finding of the cases as regard Lymph Nodes.

preoperative MRI	Pathological Finding		Kappa	ICC (95% C.I.)	p-value
N staging	N0	N1/2			
N0	11(78%)	8 (17%)	0.962	0.963 (0.938-0.977)	0.007
N1/2	3 (22%)	38 (82%)			
Total	14	46			

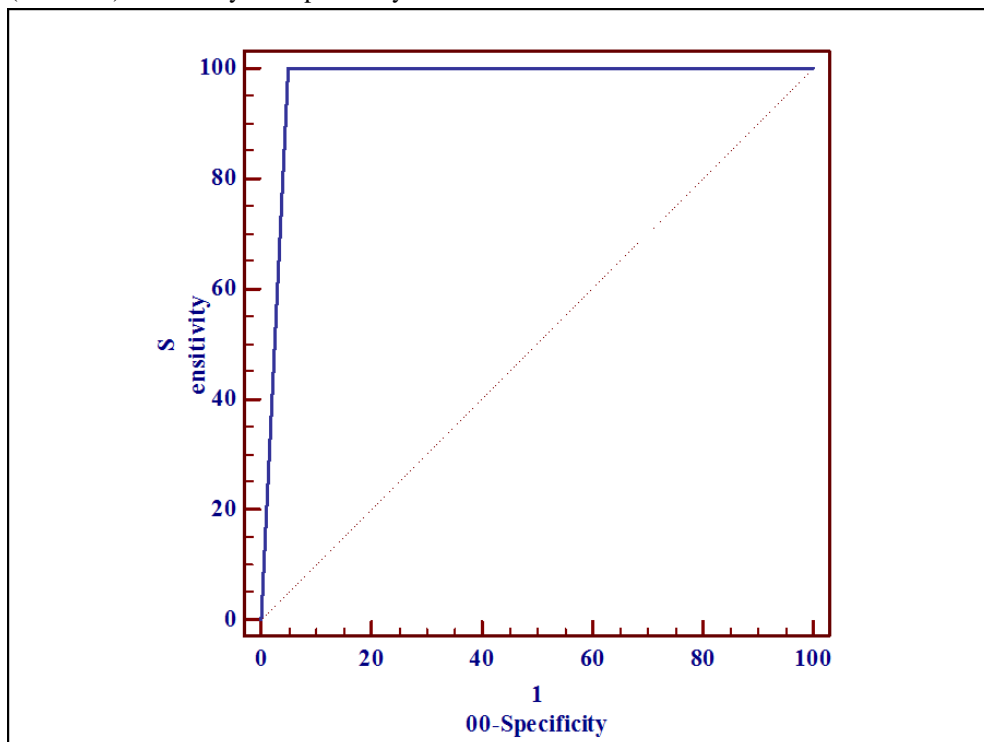
**Table 5.**Correlation between MRI and operative finding of the cases as regard Mesorectal Fascia involvement (MRF).

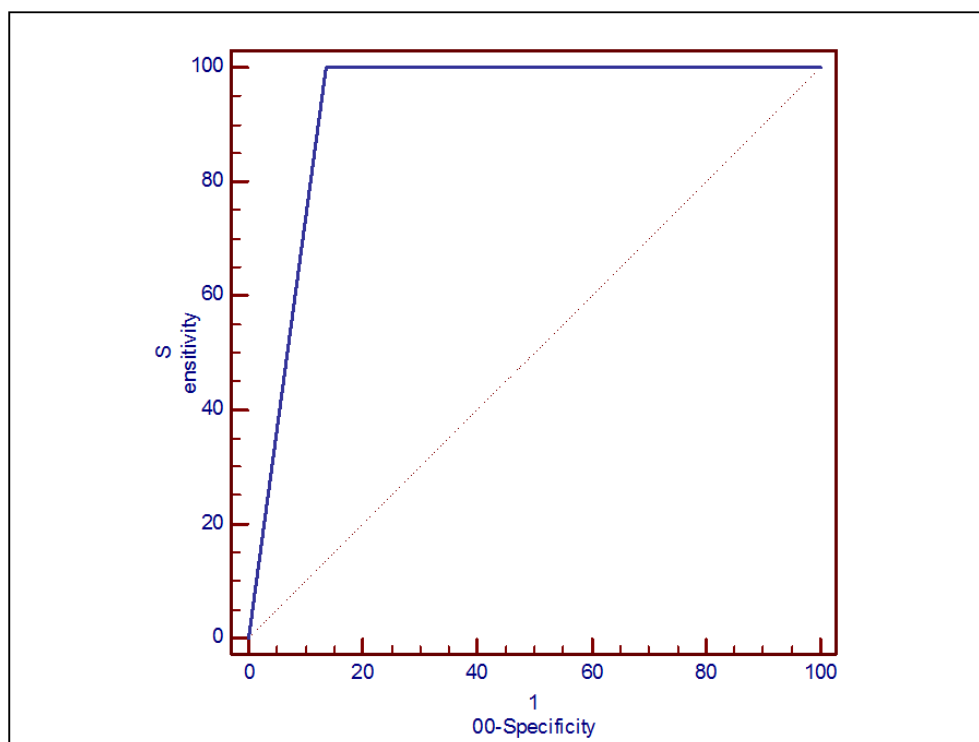
MRF by MRI	MRF by pathology		P value	Sensitivity	Specificity	PPV	NPV	Accuracy %
	NO No =22	YES No =38						
NO	19	0	0.001	85%	86.4%	91.7%	92.3%	95%
	86.4%	0.0%						
YES	3	38						
	13.6%	100.0%						

**Figure 1.** T 1-2/3-4 sensitivity and specificity



**Figure 2.** LN (N0/N1-2) Sensitivity and specificity



**Figure 3.** MRF Sensitivity and specificity

### Discussion

In our study there was Significant correlation between MRI and surgical finding as regard mean tumor distance from anorectal junction (ARJ), MRI and operative findings gave The highest correlation (ICC range 0.797–0.812) and the least mean difference (range 0.77–0.85 cm) which means excellent agreement. (9) studied the mean distance of the tumor from the Anorectal Junction (ARJ) and the ICC was high which is consistent also with excellent agreement[9]. (10) in his study concluded also excellent agreement between MRI and surgical findings as regard distance of the tumor from the anal verge[10], this was also concluded in (11) study [11].

The accuracy of MRI as regard location of the tumor in our study was **92.5%** in patients with a tumor located at the upper rectum (18 cases); **90.5%** in patients with a tumor located on the middle rectum (14 cases); and **95.6%** in patients with tumor located lower rectum (28 cases) ( $p=0.061$ ). (12) in his study worked on 354 cases, 95 tumors located in the upper rectum, 106 in the mid rectum, and 153 in the distal rectum (less than 5 cm from the anal verge), the overall accuracy of the MRI in determining tumor site in relation to the anterior Peritoneal reflection was 92.1%[12]. While (13) study worked on 67 cases, 42 tumors were located

in the upper rectum, 12 in the mid rectum, and 13 in the distal rectum with accuracy of MRI in upper, middle and lower rectal lesions was 94.7%, 91.2% and 97.4% Respectively[13]. (14) study also searched 112 cases, 10 tumors were located in the upper rectum (high 9–12 cm above the anal verge) with MRI accuracy of 95.6%, 38 in the mid rectum (5–8 cm from the anal verge) (Accuracy 93.7%) and 64 in the low rectum (less than 5 cm from the anal verge) (Accuracy 98.1%)[14]. In the study of (6) who worked on 82 cases, 6 tumors were located in the upper rectum, 53 in the mid rectum, and 23 in the distal rectum ; the overall accuracy of MRI was 94.5%[6]. **So, our study is almost similar to other studies, as the percentages are close to each other as regard accuracy of MRI in determining rectal-tumor locations.**

In our study the sensitivity and specificity of MRI for T staging were 87% and 93% respectively. The positive predictive value (PPV) and negative predictive value (NPV) of MRI for T staging were 84% and 91% respectively. The overall MR sensitivity of T1-2 tumors were 72-91 % and the specificity were 79–88% while the sensitivity of MRI in T3-4 lesions was 67-95% and the specificity was 81-97% , the overall MR accuracy was 89.1%. After histo-pathologic examinations of the 354 neoplasms; (15)study concluded the sensitivity of each T stage, it was 48.4% for T1 stage; 78.8% for

T2; 82.7% for T3; and 78.6% for T4. The specificity of each T stage was 99.1% for T1; 80.1% for T2; 84.8% for T3; and 99.4% for T4 lesions. The PPV of each T stage was 83.3% for T1, 65.0% for T2, 87.1% for T3, and 84.6% for T4. The NPV for each T stage was 95.2% for T1, 88.9% for T2, 79.8% for T3, and 99.1% for T4. The overall MR accuracy was 78.2% [15]. **In (16) study**, The overall accuracy of T staging was 74.5% and overall sensitivity; specificity; positive predictive value and negative predictive values was 73%, 90.5%, 85%, 93% respectively [16]. Also in **(17) study**, The overall MR accuracy was 85.1% for **T staging**, while sensitivity, specificity, accuracy, positive predictive value, and negative predictive value was 70%, 97.9%, 89.6%, 93.3% and 88.5% for  $\leq$  T2 tumors and 90.5%, 76%, 85.1%, 86.4% and 82.6% for T3 tumors, 100%, 95.2%, 95.5%, 62.5% and 100% for T4 tumors respectively [17]. **(18) study** determined The overall MR sensitivity of T1-2 tumors to be 64–90% and specificity of MRI in his study were 83–100% however the sensitivity of T3-4 lesions were 50–100% and specificity were 83–100% respectively [18]. The overall MRI accuracy of **T staging** in **(19) study** was 93.6%. while the accuracy, sensitivity, specificity, PPV and NPV for each T stage were as follows: 91.8%, 86.2%, 95.5%, 92.6% and 91.3% for the group  $\leq$  T2 tumors; 90.4%, 94.6%, 86.1%, 87.5% and 94% for T3 tumors; 98.6%, 85.7%, 100%, 100% and 98.5% for T4 tumors, respectively [19].

As regards the accuracy of MRI in detecting lymph node metastases, the suspicious LNs in MRI were calculated, 41 (68.3 %) lymph nodes were positive and 19 (31.7 %) were negative. This was compared with pathological examination which revealed 46 (76.7 %) lymph nodes were positive for and 14 (23.3 %) were negative for lymph node metastasis. So the specificity and sensitivity of MRI in diagnosing whether lymph nodes had metastasis or not were 95 % and 80.1% respectively, Positive predictive value was 96% and Negative Predictive Value was 73.3%. **While** in **(19) study** as regard **N** staging The accuracy, sensitivity, specificity, PPV and NPV were: 68.49% ( $k = 0.4$  [95% CI: 0.21-0.58]), 85.71%, 57.78%, 55.81% and 86.67% respectively [19]. **While** in **(18) study** as regard **N** staging the overall sensitivity, specificity, PPV, NPV and accuracy of MRI were 97, 81, 52, 99, and 84%, respectively [18]. and last **(16) study** as regard to lymph nodes metastasis the accuracy, sensitivity, and specificity were 85.1% (63/74), 90.2% (37/41), and 78.8% (26/33) respectively [16].

In our study the overall accuracy was 95% for predicting Mesorectal fascia involvement by

MRI and the sensitivity, specificity, positive predictive value, and negative predictive value was 85%, 86.4%, 91.7% and 92.3% respectively. **(20)** in his study demonstrated the diagnostic accuracy of MRI for determining MRF invasion to be in the range of 0.829–0.890 (sensitivity: 75%; specificity: 88%–98%; accuracy: 85%–92%; PPV: 66.7–92.3%; NPV: 91.5–92.3%) [20]. **While** in **(6) study** Twenty-nine percent (24 of 82) of cases had positive mesorectal lymph nodes and the accuracy of the MRF status, sensitivity, specificity, PPV and NPV were 90%, 85%, 79%, 92%, and 94.4% respectively [6]. **While** in **(13) study** the overall accuracy was 88% for predicting Mesorectal fascia involvement The sensitivity, specificity, positive predictive value, and negative predictive value was 80% (12/15), 90.4% (47/52), 70.6% (12/17) and 94% (47/50), respectively [13]. **While** in **(19) study** the accuracy of the MRF status, sensitivity, specificity, PPV and NPV were 94.5% ( $k = 0.86$  [95% CI: 0.72-0.99]), 89.5%, 96.3%, 89.5%, and 96.3% respectively [19].

### Conclusion

Rectal MRI plays a key role in management of patients with rectal cancer. MRI facilitates the accurate assessment of tumor location, distance from anal verge, T-stage, mesenteric lymph node status and meso-rectal fascia involvement SO MRI can assist the surgeon to obtain negative surgical margins and help tailor treatment and improving patient outcomes.

### Compliance with ethical standards

The protocol of the study was discussed and approved regarding ethics of research in the general surgical department. The study had been approved by the ethical committee for human studies in our institution. Approval number was 13:3/2021

### Funding & Competing interests:

No funding was received for conducting this study. The authors have no competing interests to declare that are relevant to the content of this article.

### References

- 1- M. Dattani and G. Brown (2019), Rectal carcinoma: imaging for staging. *Fundamentals of Anorectal Surgery*: p. 359-389
- 2- M.J. Corines, S. Nougaret, M.R. Weiser, M. Khan, and M.J. Gollub (2018), Gadolinium-Based Contrast Agent During Pelvic MRI: Contribution to Patient Management in Rectal

- Cancer. *Dis Colon Rectum*. 61(2): p. 193-201.10.1097/DCR.0000000000000925
- 3- A.V. Hayman and C.-A. Vasilevsky (2022), Colorectal Cancer: Preoperative Evaluation and Staging. *The ASCRS Textbook of Colon and Rectal Surgery*: p. 429-450
  - 4- G. Luglio, G. Pagano, F.P. Tropeano, E. Spina, R. Maione, A. Chini, F. Maione, G. Galloro, M.C. Giglio, and G.D. De Palma (2021), Endorectal ultrasonography and pelvic magnetic resonance imaging show similar diagnostic accuracy in local staging of rectal cancer: An update systematic review and meta-analysis. *Diagnostics*. 12(1): p. 5.10.3390/diagnostics12010005
  - 5- R.J. Nicholls, R. Zinicola, and N. Haboubi (2019), Extramural spread of rectal cancer and the AJCC Cancer Staging Manual 8th edition, 2017. *Ann Oncol*. 30(8): p. 1394-1395.10.1093/annonc/mdz147
  - 6- E.D. Kennedy, M. Simunovic, K. Jhaveri, R. Kirsch, J. Brierley, S. Drolet, C. Brown, P.M. Vos, W. Xiong, and T. MacLean (2019), Safety and feasibility of using magnetic resonance imaging criteria to identify patients with “good prognosis” rectal cancer eligible for primary surgery: the phase 2 nonrandomized QuickSilver clinical trial. *JAMA oncology*. 5(7): p. 961-966.10.1001/jamaoncol.2019.0186
  - 7- A. Patra, A. Baheti, S. Ankathi, A. Desouza, R. Engineer, V. Ostwal, A. Ramaswamy, and A. Saklani (2020), Can post-treatment MRI features predict pathological circumferential resection margin (pCRM) involvement in low rectal tumors. *Indian Journal of Surgical Oncology*. 11: p. 720-725.10.1007/s13193-020-01218-z
  - 8- N. Horvat, C. Carlos Tavares Rocha, B. Clemente Oliveira, I. Petkovska, and M.J. Gollub (2019), MRI of Rectal Cancer: Tumor Staging, Imaging Techniques, and Management. *Radiographics*. 39(2): p. 367-387.10.1148/rg.2019180114
  - 9- R.G. Beets-Tan, D.M. Lambregts, M. Maas, S. Bipat, B. Barbaro, L. Curvo-Semedo, H.M. Fenlon, M.J. Gollub, S. Gourtsoyianni, and S. Halligan (2018), Magnetic resonance imaging for clinical management of rectal cancer: updated recommendations from the 2016 European Society of Gastrointestinal and Abdominal Radiology (ESGAR) consensus meeting. *European radiology*. 28: p. 1465-1475.10.1007/s00330-017-5026-2
  - 10- I.M. White, E. Scurr, A. Wetscherek, G. Brown, A. Sohaib, S. Nill, U. Oelfke, D. Dearnaley, S. Lalondrelle, and S. Bhide (2019), Realizing the potential of magnetic resonance image guided radiotherapy in gynaecological and rectal cancer. *Br J Radiol*. 92(1098): p. 20180670.10.1259/bjr.20180670
  - 11- J.B. Yuval, H.M. Thompson, C. Firat, F.S. Verheij, M. Widmar, I.H. Wei, E. Pappou, J.J. Smith, M.R. Weiser, and P.B. Paty (2022), MRI at restaging after neoadjuvant therapy for rectal cancer overestimates circumferential resection margin proximity as determined by comparison with whole-mount pathology. *Diseases of the Colon & Rectum*. 65(4): p. 489-496.10.1097/DCR.00000000000002145
  - 12- X.H. Gao, B.Z. Zhai, J. Li, J.L.T. Kabemba, H.F. Gong, C.G. Bai, M.L. Liu, S.T. Zhang, F. Shen, and L.J. Liu (2021), Which definition of upper rectal cancer is optimal in selecting Stage II or III rectal cancer patients to avoid postoperative adjuvant radiation? *Frontiers in Oncology*. 10: p. 625459.10.3389/fonc.2020.625459
  - 13- N. Lalwani, D.D. Bates, H. Arif-Tiwari, A. Khandelwal, E. Korngold, and M. Lockhart.



- Baseline MR staging of rectal cancer: a practical approach. in *Seminars in Roentgenology*. 2021. Elsevier.
- 14-M.E. Branda, D.J. Sargent, A.M. Boller, V.V. George, M.A. Abbas, W.R. Peters Jr, D.C. Maun, G.J. Chang, A. Herline, and A. Fichera (2019), Disease free survival and local recurrence for laparoscopic resection compared to open resection of stage II-III rectal cancer: follow up results of the ACOSOG Z6051 randomized controlled trial. *Annals of surgery*. 269(4): p. 589.10.1097/SLA.0000000000003002
- 15-L. Xu, Z. Zhang, Q. Qin, C. Zhang, and X. Sun (2020), Assessment of T and N staging with MRI(3)T in lower and middle rectal cancer and impact on clinical strategy. *J Int Med Res*. 48(6): p. 300060520928685.10.1177/0300060520928685
- 16-L. Soydan, M. Torun, K. Canpolat, U. Kına, T. Öner, H. Özen, and I.E. Subaşı (2021), Diagnostic Performance of Diffusion-Weighted and Conventional MR Imaging in Staging of Rectal Cancer. *Turkish Journal of Colorectal Disease*. 31(3)
- 17-S. Nougaret, K. Jhaveri, Z. Kassam, C. Lall, and D.H. Kim (2019), Rectal cancer MR staging: pearls and pitfalls at baseline examination. *Abdominal Radiology*. 44: p. 3536-3548.10.1007/s00261-019-02024-0
- 18-N.W. Schurink, D.M.J. Lambregts, and R.G.H. Beets-Tan (2019), Diffusion-weighted imaging in rectal cancer: current applications and future perspectives. *Br J Radiol*. 92(1096): p. 20180655.10.1259/bjr.20180655
- 19-C. Dahlback, K. Korsbakke, T. Alshibiby Bergman, J. Zaki, S. Zackrisson, and P. Buchwald (2022), Accuracy of magnetic resonance imaging staging of tumour and nodal stage in rectal cancer treated by primary surgery: a population-based study. *Colorectal Dis*. 24(9): p. 1047-1053.10.1111/codi.15905
- 20-M.Z. Wei, Z.H. Zhao, and J.Y. Wang (2020), The Diagnostic Accuracy of Magnetic Resonance Imaging in Restaging of Rectal Cancer After Preoperative Chemoradiotherapy: A Meta-Analysis and Systematic Review. *J Comput Assist Tomogr*. 44(1): p. 102-110.10.1097/RCT.0000000000000964