Pelvic Diameter is not Associated with Positive Circumferential Resection Margin in Rectal Cancer: Retrospective Analysis of 78 Cases

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Abstract

Objective To identify if there is an association between pelvic entry and pelvic outlet diameters with increased positive circumferential resection margin (CRM) in rectal cancer.

Introduction Positive CRM in rectal cancer is a major predictor for local and distant recurrence. Pelvic diameters may be related to the difficulty of dissection, as well as intrinsic tumor characteristics such as tumor size, location, distance from the anal margin, and T stage, which may compromise the integrity of the mesorectum and circumferential margin involvement.

Methods A retrospective review of the patient's medical records who underwent surgical resection of rectal adenocarcinoma from January 2012 to June 2022 was performed. The patient's preoperative staging, operative characteristics, and histopathologic outcomes were gathered from the medical records. Preoperative MRI scanning was done in all patients. MRI pelvimetry was done by two observers. CRM involvement was recorded as stated in the pathology report. Pelvimetry variables were dichotomized according to their mean values for correlation analysis. The odds ratio (OR) was calculated from a binary logistics regression model to assess the relation between the positive CRM and the independent variables.

Results A total of 78 patients were included in this study. A positive CRM was reported in 10 patients (12.8%). BMI $>27.4+6.6$ ($p=0.02$), positive extramural vascular invasion ($p=0.027$), positive CRM by MRI scanning ($p=0.004$), and anal sphincter involvement ($p=0.03$) were associated with positive CRM. Pelvimetry values were not associated with a positive CRM.

Conclusion No association was found between the pelvic diameters measured by MRI pelvimetry with a positive CRM.

Keywords
- magnetic resonance pelvimetry
- pelvic outlet diameter
- pelvimetry
- circumferential resection margin
- rectal cancer

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Introduction

Colorectal cancer is the third most common cause of cancer in both men and women worldwide, while it represents the second most common cause of cancer-related deaths.[1] The surgical management of rectal cancer remains one of the cornerstones in its treatment, with the primary objective of achieving complete oncologic resection and avoiding locoregional recurrence.[2]

Since 1988 when Prof. Heald described the "holy plane" of rectal surgery,[3] the importance of total mesorectal excision (TME) was noted to the point that it has now been established as the gold standard of surgical resection in rectal cancer.[4] The circumferential resection margin (CRM) status, distal margin status, and total lymph nodes retrieved have been recognized as the main criteria assessing the quality of the procedure and the most important prognostic factors associated with local recurrence, distant metastasis, and overall survival.[5–7]

A negative CRM requires a distance greater than 1 mm between the tumor and the mesorectal fascia and levator muscles and the absence of invasion into the intersphinteric plane. On the other hand, a positive CRM is defined as a tumor $\leq$ 1 mm from the margin.[8] CRM may be evaluated preoperatively either by CT or MRI scan allowing the surgeon a better understanding of the patient's anatomy and surgical planning to obtain complete integrity of the mesorectum during the procedure.[2,9,10] High spatial resolution MRI is the imaging modality of choice in the evaluation of local staging for rectal cancer.[8,11] Optimal treatment of rectal cancer requires a precise endoscopic and pathologic evaluation of the tumor, as well as accurate staging by MRI scanning, use of neoadjuvant chemoradiotherapy when indicated, complete dissection of the mesorectum and management by a multidisciplinary team.[12]

Difficult surgical dissection has been related to an incomplete mesorectal specimen, therefore increasing the risk of local recurrence. Among the anatomical factors, the assessment of the bony pelvis either by CT or MRI scanning is related to the quality of the rectal cancer resection.[2,13,14] The pelvic width and depth, the size of the tumor relative to the pelvic dimensions, the presence of other enlarged organs and the height of the tumor measured from the anal verge might relate to the difficulty of the procedure and surgeons have to customize their surgery plan according to the patient's pelvic anatomy.[4,15,16] Regarding this relationship between the anatomy of the pelvis and the surgical difficulty, several scores have been proposed to predict it preoperatively.[17,18] In this study, we aim to identify if the pelvic diameters are related to a positive circumferential resection margin in patients with rectal cancer.

Methods

Study Population

A retrospective, observational study was made of patients from our institution submitted to surgical treatment for stage I-III rectal cancer, defined by the lower edge of the tumor being 16 cm or less from the anal verge, from January 1, 2012, to June 1, 2022. The distance from the anal verge to the lower margin of the tumor was measured by digital rectal examination (DRE) and/or colonoscopy. Patients were included if they received a preoperative MRI, regardless of the receipt of neoadjuvant therapy. All patients included had diagnosis of an adenocarcinoma confirmed by biopsy before the surgical procedure. Patients with tumors other than adenocarcinomas, stage IV rectal cancer, or that were treated by surgical derivation for obstructive rectal cancer were excluded.

Patient demographics (age, gender, body mass index, comorbidities defined by the Charlson Comorbidity Index), preoperative staging (distance to anal verge, clinical TNM staging, clinical circumferential (CRM) involvement, use of neoadjuvant treatment), operative characteristics, and histopathologic outcomes (size of tumor, extramural venous invasion (EMVI) involvement, neoadjuvant response, pathological T- and N-stage, lymph node harvest, mesorectal excision grade, CRM involvement, and distal margin involvement) were gathered from the medical records.

All patients included underwent preoperative pelvic MRI scanning for tumor staging and categorization. Indications for neoadjuvant treatment included: T4 disease, close or involved CRM, N$\geq$2, lateral pelvic node involvement, or extramural venous invasion involvement. All surgical specimens underwent histopathologic examination and CRM involvement was described as stated in the pathology report.

MRI Pelvimetry

Sagittal, coronal, and axial T2-weighted sequences of initial MRI scanning were downloaded onto a workstation, and measurements were made by two observers for interobserver variation assessment who were blinded to all clinical information. Six pelvic dimensions were measured, as described in ►**Table 1**, and demonstrated in ►**Fig. 1**.

Statistical Analysis

The SPSS Statistics IBM software package version 25.0 (Armonk, NY) was used for the statistical analysis. The data are presented as proportion (n/total), mean (SD), or median [Q1-Q3].

The CRM was dichotomized (positive/negative) according to the histopathology report and contingency tables were created to evaluate the association between the dependent and independent variables. Univariate analyses consisted of $\chi 2$ or Fisher's exact tests for categorical variables, and Student's t or Mann-Whitney U test for quantitative variables. The odds ratio (OR) was calculated with a confidence interval (CI) of 95% from a binary logistics regression model, this model was used to assess the relation between the positive CRM as the dependent variable and one or more of the independent variables. A value of $p \leq 0.05$ was considered as statistically significant. Pelvimetry variables were dichotomized based on mean values for the correlation analysis.

Results

A total of 78 patients who underwent surgical resection for rectal adenocarcinoma were included. This cohort included 50 male (64.1%) and 28 female (35.3%) patients. The mean

Table 1 Pelvic dimensions measured on MRI scans and mean values

Pelvic dimension	*Description*	*Symbol*	*Mean measurement (cm)*
Pelvic inlet length	Distance in the sagittal axis from the superior, middle aspect of the pubic symphysis to the sacral promontory	a	10.8
Pelvic depth	The line in the sagittal axis between the sacral promontory and the tip of the coccyx	b	11.57
Pelvic outlet length	Distance in the sagittal axis from the inferior, middle aspect of the pubic symphysis to the coccyx	c	8.57
Interspinous distance	The line in the axial axis between both ischial spines	d	9.35
Intertuberous distance	The line in the axial axis between both ischial tuberosities	e	9.94
Transverse diameter	The line in the coronal axis between the outermost point of the iliopectineal lines	f	11.75

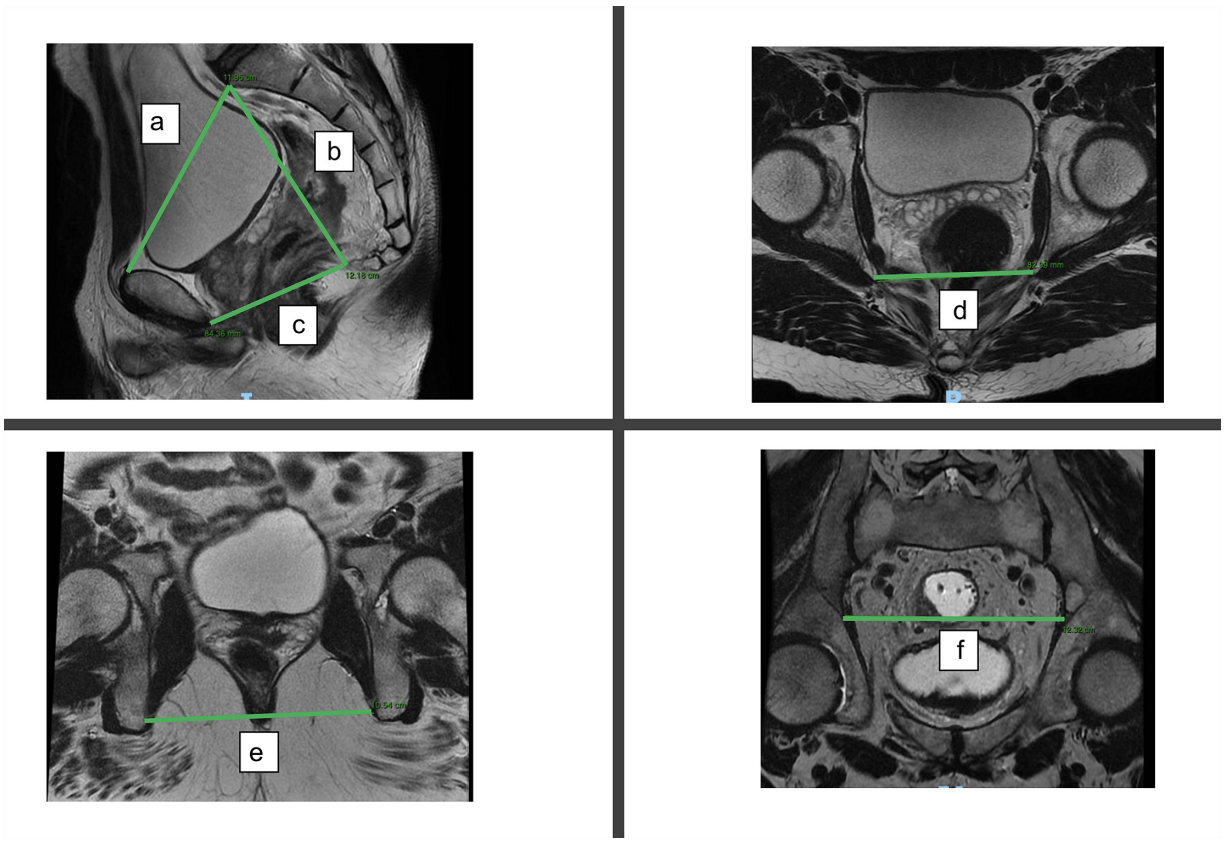

Fig. 1 Magnetic resonance imaging (MRI) scan showing pelvimetric measurements.

age at the time of surgery was 64.1 ± 11 years. In the unadjusted analysis, positive and negative CRM cohorts were comparable in age, race, comorbidity, and neoadjuvant chemotherapy. The most common tumor location was the middle third of the rectum in at 65.4% ($n = 51$), followed by the upper third at 21.8% ($n = 17$) and the lower third at 12.8% ($n = 10$). The patients' characteristics are presented in ►**Table 2**.

Extramural venous invasion (EMVI) was found in 20.5% ($n = 16$) of the patients, and invasion of the anal sphincter complex in 14.1% ($n = 11$). Mesorectum integrity was complete in 59% ($n = 46$) of cases, near complete in 9% ($n = 7$) and incomplete in 29.5% ($n = 23$). There was 12.8% ($n = 10$) positive CRM in the pathology report as well as in the preoperative MRI scan. Of the patients with positive CRM 80% were male and 20% female ($p = 0.31$). BMI was higher in patients with positive CRM vs those with negative CRM (27.4 ± 6.6 vs 25.5 ± 3.8, $p = 0.02$). The preoperative characteristics associated in our study with positive CRM were positive EMVI ($p = 0.027$), anal sphincter complex involvement ($p = 0.03$), and positive CRM by MRI scan ($p = 0.004$). Tumor location and height respective to the rectum length were not associated with positive CRM.

The primary surgical approach was open surgery in 51 cases (65.4%), 24 cases (30.8%) by laparoscopy, and 3 cases (3.8%) that required conversion from laparoscopic to open surgery.

Table 2 Patient characteristics, demographics, MRI pelvimetry and surgical outcomes

Variable		*n (%)*		
		CRM positive (n = 10)	*CRM negative (n = 68)*	*p*
Gender	Male	8 (80)	42 (61.8)	0.31
	Female	2 (20)	26 (38.2)	
Age (SD)		60.7 ± 10.1	64.6 ± 11.1	0.5
Age	30–50 years	1 (10)	6 (8.8)	0.30
	51–70 years	8 (80)	39 (57.4)	
	≥ 71 years	1 (10)	23 (33.8)	
BMI		27.4 ± 6.6	25.5 ± 3.8	0.02
BMI by group	18.5–24.9	4 (40)	27 (39.7)	0.42
	25–29.9	3 (30)	31 (45.6)	
	≥30	3 (30)	10 (14.7)	
Charlson Comorbidity Index	No comorbidities	0 (0)	1 (1.5)	0.92
	Low comorbidities	2(20)	13 (19.1)	
	High comorbidities	8 (80)	54 (79.4)	
Previous pelvic surgery		2 (20)	13 (19.1)	0.94
Preoperative CEA		17.30 (0.49–46.6)	3.4 (0.2–225)	
Approach	Open	7 (70)	44 (64.7)	0.45
	Laparoscopic	2 (20)	22 (32.4)	
	Conversion	1 (10)	2 (2.9)	
Type of surgery	LAR	2 (20)	23 (33.8)	0.57
	ULAR	6 (60)	22 (32.4)	
	APR	1 (10)	9 (13.2)	
	ISR	0 (0)	4 (5.9)	
	PE	1 (10)	5 (7.4)	
	TaTME	0 (0)	5 (7.4)	
Tumor height from anal verge	High (10.1–16 cm)	3 (30)	14 (20.6)	0.78
	Mid (6.1–10 cm)	6 (60)	45 (66.2)	
	Low (0–6 cm)	1(10)	9 (13.2)	
Tumor location	Anterior	2 (20)	15 (22.1)	0.64
	Posterior	3 (30)	9 (13.2)	
	Circumferential	3 (30)	18 (26.5)	
	Lateral	1 (10)	15 (22.1)	
	No data	1 (10)	11 (16.2)	
Positive CRM by MRI scanning	Positive	6 (60)	10 (14.7)	0.004
	Negative	4 (40)	56 (82.4)	
	No data		2 (2.9)	
Anal sphincter involvement		4 (40)	7 (10.3)	0.03
Positive EMVI		5 (50)	11 (16.4)	0.027
Neoadjuvant therapy		9 (90)	59 (86.8)	0.62
Type of radiotherapy	Long course	5 (50)	47 (69.1)	0.38
	Short course	1 (10)	7 (10.3)	
	No	4 (40)	14 (20.6)	

Table 2 (*Continued*)

Variable		*n (%)*		
		CRM positive (n = 10)	*CRM negative (n = 68)*	*p*
Type of TNT	Induction	3 (30)	30 (44.1)	0.63
	Consolidation	1 (10)	8 (11.8)	
	No	6 (60)	30 (44.1)	
Interspinous distance		9.11 ± 0.67	9.66 ± 1.00	0.2
Intertuberous distance		9.93 ± 0.80	9.84 ± 1.33	0.07
Pelvic inlet		10.79 ± 0.5	10.82 ± 0.92	0.10
Pelvic outlet		8.76 (6.58–11.07)	8.59 (7.1–10.1)	
Pelvic depth		11.43 ± 1.51	11.86 ± 1.41	0.547
Transverse diameter		11.75 ± 1.28	11.79 ± 1.09	0.321
Distal margin involvement		2 (20)	1 (1.5)	
Mesorectum integrity	Complete	3 (30)	43 (63.2)	0.025
	Near complete	0 (0)	7 (10.3)	
	Incomplete	7 (70)	16 (23.6)	
Tumor size		3(0.5–11)	2.35(0.2–11.7)	
Tumor perforation		3 (30)	3 (4.4)	0.025
Lymphovascular invasion		9 (90)	9 (13.2)	0.000
Perineural invasion		5 (50)	4 (5.9)	0.003
Recurrence		5 (50)	13 (19.1)	0.045
OVS (months)		17.5(2–69)	41(0–102)	
DFS (months)		11.3 ± 5.5	16.67 ± 12.83	0.19

Abbreviations: APR, Abdominopelvic resection; BMI, Body mass index; CEA, Carcinoembryonic antigen; CRM, Circumferential radial margin; DFS, Disease-free survival; EMVI, Extramural venous invasion; ISR, Intersphincteric resection; LAR, Low anterior resection; OVS, Overall survival; PE, Pelvic exenteration; SD, Standard deviation; TaTME, Transanal total mesorectal excision; TNT, Total neoadjuvant therapy; ULAR, Ultra-low anterior resection.

The pelvic dimensions were measured based on preoperative MRI pelvimetry. The mean distance is described in ►**Table 1**. Univariate analysis showed an association of a positive CRM with BMI of 27.4 + 6.6 ($p = 0.02$), positive EMVI ($p = 0.027$), anal sphincter involvement ($p = 0.03$), CRM involvement by MRI assessment ($p = 0.03$) and mesorectum integrity ($p = 0.025$) (►**Table 2**).

In the binary logistics regression model, we found as factors associated with a positive CRM the involvement of the anal sphincter complex (OR 5.61, 95% CI (1.26–24.88), $p = 0.02$), incomplete mesorectum (OR 6.27, 95% CI (1.44–27.25), $p = 0.01$) and tumor perforation (OR 9.28 95% CI (1.56–55.07) $p = 0.01$). (►**Table 3**).

No association was found between the pelvic diameters measured by MRI pelvimetry with a positive CRM, pelvimetry measurements were dichotomized according to their mean values without finding any significative association with a positive CRM (►**Table 3**).

Discussion

CRM is one of the major and most significant prognostic factors in rectal cancer surgery that directly impacts the rates of local recurrence, distant metastasis, and overall survival.[7,19] Our study aimed to identify if there is an association between pelvic diameters measured by MRI pelvimetry and a positive CRM in patients with rectal adenocarcinoma treated by surgical resection. Of the total of 78 patients included in this study, only 12.8% ($n = 10$) had a positive CRM, which was expected according to previously reported incidence between 1–28%.[6,20]

In rectal cancer surgery, one of the most important indicators assessing the quality of the procedure is the integrity of the mesorectum, given that TME and negative CRM are the most important prognostic factors.[6,7,21] In our study we found that one of the factors closely related to a positive CRM was an incomplete mesorectum specimen, given that when the plane of dissection goes through the mesorectum, close to the rectal wall, the radial margin is often compromised, as stated by Nagtegaal and Quirke.[6]

0In the study published by Boyle et al[13], the relationships between the pelvic dimensions and the CRM status were evaluated. They found that interspinous distance and the intertuberous distance were significantly narrower in women with positive CRM, whereas in men no association was found. Conversely, Salerno et al. reported no association between the

Table 3 Odds ratio (OR) by binary logistics regression model showing the association between positive CRM and the different variables

Variable		*OR*	*P*
Gender	Male	1.00	
	Female	2.47 (0.48–12.57)	
Age	30–50 years	1.00	
	51–70 years	1.23 (0.13–11.67)	0.85
	>70 years	0.261 (0.01–4.80)	0.36
BMI	18.5–24.9	1.00	
	25–29.9	0.65 (0.13–3.18)	0.59
	≥30	2.02 (0.38–10.68))	0.40
Previous pelvic surgery	No	1.00	
	Yes	1.05 (0.20–5.58)	0.94
Charlson Comorbidity Index	No comorbidities	1.00	
	Low comorbidities	0.00 (0.00)	1.00
	High comorbidities	1.03 (0.19–5.48)	0.96
Locally advanced tumor	No	1.00	
	Yes	0.72 (0.07–6.94)	0.78
Type of radiotherapy	Long course	1.00	
	Short course	2.68 (0.63–11.38)	0.18
	None	1.34 (0.13–13.25)	0.80
Type of TNT	Consolidation	1.00	
	Induction	1.6 (0.16–15.27)	0.68
		0.8 (0.73–8.76)	0.85
Approach	Laparoscopic	1.00	
	Open	1.91 (0.37–9.77)	0.43
Surgery	LAR	1.00	
	ULAR	2.68 (0.48–14.46)	0.25
	APE	1.27 (0.10–15.89)	0.84
	Pelvic exenteration	2.30 (0.17–30	0.52
	TaTME	0.00	0.99
Neoadjuvant chemotherapy	Yes	1.00	
	No	0.26 (0.05–1.27)	0.09
Tumor height from anal verge	High (10.1–16 cm)	1.00	
	Mid (6.1–10 cm)	0.51 (0.04–5.79)	0.59
	Low (0–6 cm)	0.62 (0.13–2.81)	0.53
Tumor location	Lateral	2.50 (0.34–17.94)	0.36
	Circumferential	1.25 (0.18–8.49)	0.81
	Posterior	0.50 (0.04–6.14)	0.58
	Anterior	0.68 (0.05–8.50)	0.76
Anal sphincter involvement	No	1.00	
	Yes	5.61 (1.26–24.88)	0.02
EMVI	Negative	1.00	
	Positive	6.12 (0.14–26.58)	0.015

Table 3 (*Continued*)

Variable		*OR*	*P*
Mesorectum integrity	Complete	1.00	
	Near complete	–	–
	Incomplete	6.27 (1.44–27.25)	0.01
Perforation	No	1.00	
	Yes	9.28 (1.56–55.07)	0.01

Abbreviations: APR, Abdominopelvic resection; BMI, Body mass index; EMVI, Extramural venous invasion; ISR, Intersphincteric resection; LAR, Low anterior resection; PE, Pelvic exenteration; TaTME, Transanal total mesorectal excision; TNT, Total neoadjuvant therapy; ULAR, Ultra-low anterior resection.

MRI pelvimetry dimensions and CRM involvement.[4] In our study we analyzed six pelvic measurements by MRI pelvimetry (pelvic inlet, pelvic outlet, pelvic depth, interspinous distance, intertuberous distance, and transverse diameter). No significant association was found between the mean values of such pelvic dimensions and a positive CRM.

The utility of measuring the pelvic dimensions by MRI pelvimetry is still out for debate. Previous studies have found an association between narrow pelvic dimensions and increased difficulty in surgery, such as an intertuberous distance <10.1 cm,[18] large pelvic outlets,[22] S1-S5 pubic symphysis angles $\geq 74.2°$.[15] Also interspinous distance has been related to positive CRM.[23] In this study we found no statistically significant relation between CRM involvement and MRI pelvimetry dimensions, our study has limitations regarding its retrospective nature and limited number of patients. Even if there was no direct association found between pelvimetry and a positive CRM, variables such as pelvic diameter and BMI may factor into multi-disciplinary meeting decision-making regarding the treatment modality, sequence, and type of therapy recommended. Further investigation studies with a larger sample are needed to clarify the role of MRI pelvimetry in rectal cancer surgery. As stated in the systematic review by Hong et al.,[24] MRI assessments of soft tissue measurements may also be implicated in the difficulty of the operation.

Statement

What does this paper add to the literature?

This manuscript shows that no significant association between narrow margins in MRI pelvimetry and CRM involvement was found. Concluding that MRI pelvimetry dimensions are not associated with CRM involvement in rectal cancer surgery.

Ethics Approval

This paper has not been presented in any meeting presentation.

This paper is not currently under review by another journal. This paper has not been accepted for publication elsewhere.

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Conflict of Interests

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