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ORIGINAL CONTRIBUTION

Anastomotic Height Is a Valuable Indicator of Long-term Bowel Function Following Surgery for Rectal Cancer

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BACKGROUND: The exact relation between anastomotic height after rectal cancer surgery and postoperative bowel function problems has not been investigated in the long term, resulting in ineffective treatment.

OBJECTIVE: The goal of this study was to determine the effect of anastomotic height on long-term bowel function and generic quality of life.

DESIGN: This was a multicenter, cross-sectional study.

SETTINGS: Seven hospitals in the north of the Netherlands participated.

PATIENTS: All patients who underwent rectal cancer surgery between 2009 and 2015 in participating hospitals received the validated Defecation and Fecal Continence and Short-Form 36 questionnaires. Deceased patients, patients with a permanent stoma or an anastomosis >15 cm from the anal verge, patients with intellectual disability, and patients living abroad were excluded.

MAIN OUTCOME MEASURES: Primary outcomes were constipation (Rome IV), fecal incontinence (Rome IV), and major low anterior resection syndrome. Secondary outcomes were the generic quality of life scores.

RESULTS: The study population ($n = 630$) had a median follow-up of 58.0 months. In multivariable analysis, constipation (OR = 1.08; 95% CI, 1.02-1.15; $p = 0.011$), fecal incontinence (OR = 0.91; 95% CI, 0.84-0.97; $p = 0.006$), and major low anterior resection syndrome (OR = 0.93; 95% CI, 0.87-0.99; $p = 0.027$), were significantly associated with anastomotic height. The curves illustrating the probability of constipation and fecal incontinence crossed at an anastomotic height of 7 cm, with 95% CIs overlapping between 4.5 and 9.5 cm. There was no relation between quality-of-life scores and anastomotic height.

LIMITATIONS: The study is limited by its cross-sectional design.

CONCLUSIONS: This study might serve as a guide for the clinician to effectively screen and treat fecal incontinence and constipation during patient follow-up after rectal cancer surgery. More attention should be paid to fecal incontinence in patients with an anastomosis below

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4.5 cm and toward constipation in patients with an anastomosis above 9.5 cm. See **Video Abstract** at http://links.lww.com/DCR/B858.

con anastomosis por encima de 9,5 cm. Consulte **Video Resumen** en http://links.lww.com/DCR/B858. *(Traducción—Dr. Yazmin Berrones-Medina)*

LA ALTURA ANASTOMÓTICA ES UN INDICADOR VALIOSO DE LA FUNCIÓN INTESTINAL A LARGO PLAZO DESPUÉS DE LA CIRUGÍA PARA EL CÁNCER DE RECTO

ANTECEDENTES: La relación exacta entre la altura anastomótica después de la cirugía de cáncer de recto y los problemas posoperatorios de la función intestinal no se ha investigado a largo plazo, lo que causa un tratamiento ineficaz.

OBJETIVO: Determinar el efecto de la altura anastomótica sobre la función intestinal a largo plazo y la calidad de vida genérica.

DISEÑO: Estudio multicéntrico transversal.

DISEÑO DEL ESTUDIO: Participaron siete hospitales holandeses en el norte de los Países Bajos.

PACIENTES: Todos los pacientes que se sometieron a cirugía de cáncer de recto entre 2009 y 2015 en los hospitales participantes recibieron los cuestionarios validados de Defecación y Continencia Fecal y Short-Form 36. Se excluyeron pacientes fallecidos, pacientes con estoma permanente o anastomosis > 15 cm del borde anal, discapacidad intelectual o residentes en el extranjero.

PRINCIPALES MEDIDAS DE RESULTADO: Los resultados primarios fueron estreñimiento (Roma IV), incontinencia fecal (Roma IV) y síndrome de resección anterior baja mayor. Los resultados secundarios fueron las puntuaciones genéricas de calidad de vida.

RESULTADOS: La población de estudio (N = 630) tuvo una mediana de seguimiento de 58.0 meses. En el análisis multivariable el estreñimiento (OR = 1,08, IC del 95%, 1,02-1,15, $p = 0{,}011$), incontinencia fecal (OR = 0,91, IC del 95%, 0,84–0,97, $p = 0{,}006$) y síndrome de resección anterior baja mayor (OR = 0,93, IC del 95%, 0,87–0,99, $p = 0{,}027$) se asociaron significativamente con la altura anastomótica. Las curvas que ilustran la probabilidad de estreñimiento e incontinencia fecal se cruzaron a una altura anastomótica de 7 cm, con IC del 95% superpuestos entre 4,5 y 9,5 cm. No hubo relación entre las puntuaciones de calidad de vida y la altura anastomótica.

LIMITACIONES: El estudio está limitado por su diseño transversal.

CONCLUSIONES: Este estudio podría servir como una guía para que el médico evalúe y trate eficazmente la incontinencia fecal y el estreñimiento durante el seguimiento de los pacientes después de la cirugía de cáncer de recto. Se debe prestar más atención a la incontinencia fecal en pacientes con anastomosis por debajo de 4,5 cm y al estreñimiento en pacientes

KEY WORDS: Anastomosis; Bowel dysfunction; Follow-up; Postoperative; Rectal cancer.

Annually, more than 700,000 people worldwide receive a diagnosis of rectal cancer.[1] During the past decade, the 5-year survival rate of rectal cancer has improved considerably.[2] Consequently, optimal long-term bowel function has become an important health issue to a growing number of people.

Recent systematic reviews showed that years after surgery, 35% of patients suffer from fecal incontinence and 41% from major low anterior resection syndrome (LARS).[3,4] Nevertheless, many clinicians still neglect to assess postoperative bowel function comprehensively during regular follow-up visits.[5]

An association between bowel function problems and anastomotic height after surgery for rectal cancer was suggested years ago.[6–9] Regression analyses in more recent studies showed an increase in fecal incontinence or major LARS with anastomotic heights categorized below 3,[10] 6,[11] 7,[12] and 10[13] cm from the anal verge. Other studies advocated that anastomotic height neither influences fecal incontinence[14,15] nor the LARS score.[16,17] Why the association between anastomotic height and different bowel function problems is not universally acknowledged can be attributed to the random categorization of anastomotic height and the short follow-up time in most studies. To date, the exact relation between anastomotic heights and different validated bowel function scores has not been investigated long-term. This information, however, would guide the clinician during the follow-up of patients after surgery for rectal cancer. Given the profound impact on daily life of bowel function problems, we hypothesize that not only bowel function but also generic quality of life varies along with differences in anastomotic height.

Our primary aim was therefore to determine the effect of anastomotic heights on long-term bowel function and generic quality of life after surgery for rectal or rectosigmoid cancer.

MATERIALS AND METHODS

Study Design and Participants

This cross-sectional study was performed between October 2017 and December 2019 in 7 hospitals in the north of the Netherlands. Patients who had undergone a low anterior resection or anterior resection for rectal or rectosigmoid cancer between 2009 and 2015 were identified from the mandatory Dutch ColoRectal Audit (DCRA) registry. A low anterior resection or anterior resection was defined

as a total mesorectal excision with coloanal or colorectal anastomosis <15 cm from the anal verge.[18] Only patients without a permanent stoma or a previous primary colorectal tumor were included. Finally, deceased patients, intellectually disabled patients, patients <18 years at the time of surgery, and patients with an unknown or foreign residential address were excluded. Patients who gave their written informed consent were asked to complete the validated Defecation and Fecal Continence (DeFeC) and the Short-Form (SF) 36 questionnaires.[19–21] The questionnaires were completed either digitally or on paper, depending on the patient's preference. The study was conducted in accordance with the Medical Ethical Review Board of the University Medical Center Groningen (approval code: METc 2017/245).

Outcome Measures

The primary outcomes were constipation, fecal incontinence, and major LARS, which were assessed by the DeFeC questionnaire. It includes different commonly used scoring systems for bowel functions. Constipation was defined according to the Rome IV criteria,[22] including at least 2 of the following symptoms: straining, hard or lumpy stool, sense of obstruction, incomplete defection, manual facilitation of defecation, and/or less than 3 stools per week. Additionally, as described in the criteria, patients were only classified as constipated if loose stools were rarely present without laxatives. Fecal incontinence was also defined according to the Rome IV criteria[23] and described as recurrent uncontrolled passage of stools at least several times per month. The following fecal incontinence–associated symptoms were analyzed separately: soiling (loss of some feces), urge incontinence (inability to reach the toilet in time), solid incontinence (loss of much solid feces without urge), and liquid incontinence (loss of watery stool or diarrhea). Major LARS was defined according to the LARS score, incorporating flatus and liquid incontinence, altered stool frequency, clustering, and urgency. The definition of major LARS is a LARS score between 30 to 42 points.[5]

The secondary outcome was generic quality of life according to the SF-36 questionnaire, which comprises 36 questions in 8 domains. With these questions, a Likert scale can be calculated between 0-100.[20] A higher score indicates better quality of life.

Definitions

Clinical and perioperative variables were verified by one investigator screening the medical records. Anastomotic height was calculated as centimeters from anastomosis to the anal verge and was obtained from the surgical reports. If not mentioned there, the first postoperative endoscopy report was screened. Follow-up time was calculated as the difference between the date of completing the questionnaires and the time of primary surgery or reversal of the temporary stoma. Severity of comorbidity at surgery was classified according to the Charlson Comorbidity Index (CCI).[24] The European Perioperative Clinical Outcome definitions were used to define postoperative complications.[25] The pathological tumor stage was reported. Neoadjuvant radiotherapy was categorized into short-course (25 Gy in 5 fractions) and long-course radiotherapy (45-50.4 Gy in 25 to 28 fractions). Patients without lymphatic involvement but with >5 mm extramural invasion also received radiotherapy. In most cases, long-course neoadjuvant radiotherapy was combined with chemotherapy.

Statistical Analysis

Continuous variables were expressed as mean (SD) or median (IQR). Either one-way ANOVA, Mann-Whitney, or Kruskal-Wallis tests were used. Categorical variables were presented as number (%) with Pearson's χ^2 tests. Univariable and multivariable binary logistic regression analyses were used to determine the association between anastomotic height and constipation, fecal incontinence, and major LARS. Covariates for the multivariable models were selected based on the a priori possibility of confounding and/or tendency toward statistical significance in univariable analysis ($p < 0.10$). Potential interactions were assessed. Cubic spline regression analysis was used for probability figures. Spearman's coefficient test was used for correlations, where rho <0.3 was interpreted as negligible. A p of <0.05 was considered statistically significant. Analyses were performed with IBM SPSS Statistics, Version 23.0 (Armonk, NY, USA) and the probability figures were generated using R, Version 3.6.3 (R Foundation of Statistical Computing, Vienna, Austria). The illustration was created with Biorender.com. The results were reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines of the EQUATOR network.[26]

RESULTS

Between 2009 and 2015, 1071 patients underwent surgery for rectal or rectosigmoid cancer without construction of a permanent stoma, of whom 759 were eligible for inclusion. A total of 656 patients (86.3%) completed the questionnaires (Fig. 1). We excluded 26 patients because of missing data on anastomotic height. All patient characteristics of the included study population are presented in Table 1. Overall median anastomotic height was 8.0 cm (IQR 5.0-12.0) from the anal verge and median follow-up was 58.0 (IQR 39.0-79.0) months. Dropout analysis only revealed a significantly older age in the nonresponders (67.0 vs 65.0 years; $p = 0.025$) (Supplemental Digital Content 1 at http://links.lww.com/DCR/B859).

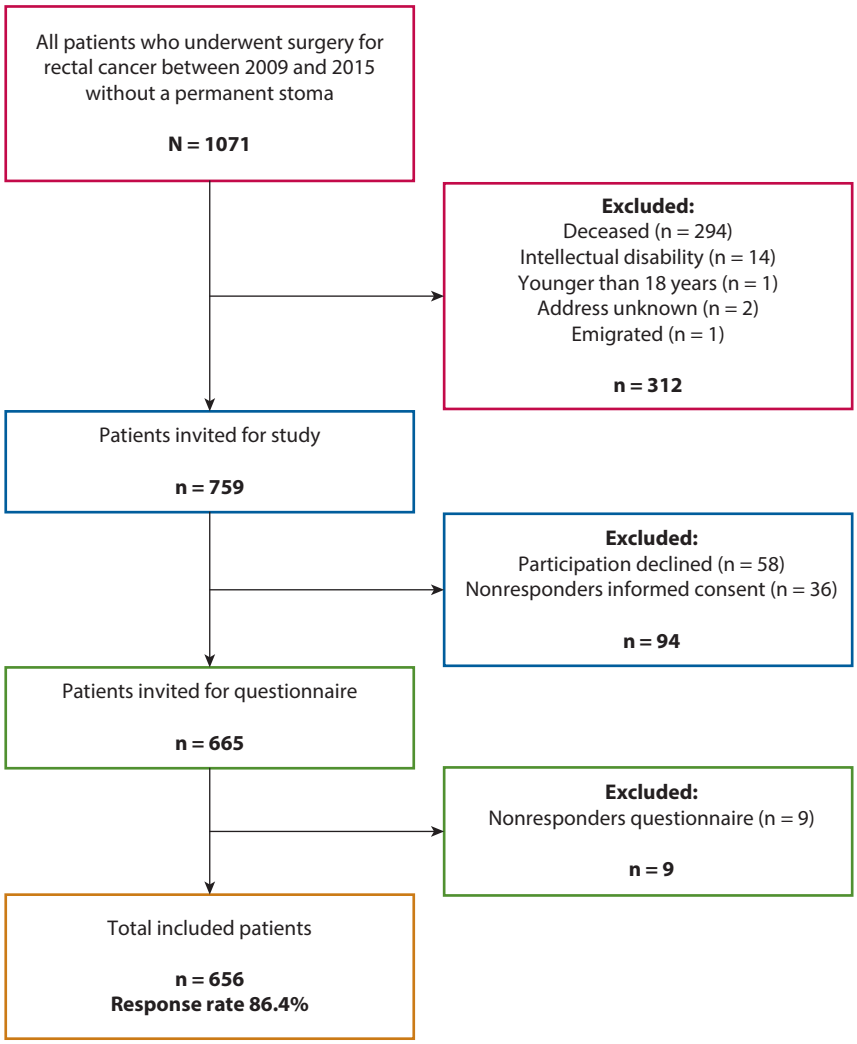

FIGURE 1. Flow chart of inclusion and exclusion.

Univariable and Multivariable Analysis of Bowel Function Problems

Constipation, fecal incontinence, and major LARS were prevalent in 31.0%, 24.5%, and 30.0% of the study population. Univariable analysis showed increased odds for constipation along with higher anastomotic heights, while fecal incontinence and major LARS were associated with lower anastomotic heights ($p < 0.001$ for all variables, Supplemental Digital Content 2 at http://links.lww.com/DCR/B860). The univariable associations of constipation, fecal incontinence, and major LARS with different patient characteristics can be found in Supplemental Digital Content 2 http://links.lww.com/DCR/B860. Type of anastomosis did not show a significantly different association with constipation, fecal incontinence, or major LARS. A stapled anastomosis showed a significantly increased association with major LARS (OR = 6.46; 95% CI, 1.52–27.4; $p = 0.011$). A temporary stoma was significantly associated with less constipation (OR = 0.65; 95% CI, 0.46–0.92; $p = 0.014$) but more fecal incontinence (OR = 2.52; 95% CI, 1.72–3.69; $p < 0.001$) and more major LARS (OR = 3.56; 95% CI, 2.46–5.16; $p < 0.001$).

In multivariable analysis, constipation, fecal incontinence, and major LARS all remained significantly associated with anastomotic heights, when theoretically adjusted for sex, age, and follow-up time, and mathematically for all other variables tending toward significance in univariable analysis (Table 2). Constipation was associated with higher anastomotic heights (OR = 1.08; 95% CI, 1.02–1.15; $p = 0.011$). Apart from an increased American Society of Anesthesiologists (ASA) score at surgery (OR = 1.43; 95% CI, 1.05–1.95; $p = 0.022$), no other variables were independently associated with constipation in multivariable analysis.

In contrast to constipation, fecal incontinence was associated with lower anastomotic heights (OR = 0.91; 95% CI, 0.85–0.98; $p = 0.010$). The likelihood of fecal incontinence was almost triple for both short-course and long-course neoadjuvant radiotherapy (OR = 2.60; 95% CI, 1.49–4.54; $p = 0.001$ and OR = 2.64; 95% CI, 1.40–4.97;

TABLE 1. Patient characteristics

Variables	*Total (N = 630)*
Anastomotic height (cm) [a]	8.0 (5.0–12.0)
Basic characteristics, n (%)	
Male patients	389 (61.7)
Age at surgery (years) [a]	65.0 (58.0–69.0)
Follow-up (months) [a,b]	58.0 (39.0–79.0)
BMI at surgery (kg/m^2) [c]	26.1 (3.8)
ASA score at surgery	
I	192 (31.3)
II	355 (57.8)
III	64 (10.4)
IV	3 (0.5)
Charlson comorbidity index at surgery [a]	2.0 (2.0–2.0)
Previous lower abdominal surgery	158 (25.1)
Previous upper abdominal surgery	55 (8.7)
Smoking	
No	467 (81.8)
Yes	87 (15.2)
Recently quit	17 (3.0)
Oncologic characteristics, n (%)	
Tumor stage (UICC)	
I	229 (36.4)
II	202 (32.1)
III	180 (28.6)
IV	18 (2.9)
Distant metastasis	
No	572 (90.8)
Liver	35 (5.6)
Lung	14 (2.2)
Multiple locations	9 (1.4)
Neoadjuvant and adjuvant treatment, n (%)	
Radiotherapy	
No	314 (50.3)
Neoadjuvant short course	185 (29.6)
Neoadjuvant long course	118 (18.9)
On pelvic region for other reason	7 (1.1)
Adjuvant chemotherapy	114 (18.4)
Years since last radiotherapy [a]	6.0 (4.0–8.0)
Years since last chemotherapy [a]	5.0 (3.0–7.0)
Surgical characteristics, n (%)	
Setting	
Elective	569 (96.4)
Emergency	22 (3.6)
Surgical approach	
Open	226 (35.9)
Laparoscopic	351 (55.8)
Conversion	52 (8.3)
Method of anastomosis	
Hand-sewn	30 (4.8)
Stapled	589 (95.2)
Reconstruction	
Side-to-end	418 (77.6)
Side-to-side	18 (3.3)
End-to-end	103 (19.1)
Temporary stoma	320 (50.8)
Postoperative characteristics, n (%)	
Anastomotic leakage	37 (5.9)
Reoperation	32 (5.1)
Overall other types of complications	
No	445 (70.6)
One complication	136 (21.6)
More complications	49 (7.8)

[a] Values are expressed as median (IQR).
[b] Time between completing the questionnaires and the primary surgery or the reversal of the temporary stoma.
[c] Values are expressed as mean (SD).
ASA = American Society of Anesthesiologists; BMI = body mass index; UICC = Union for International Cancer Control.

$p = 0.003$). Likewise, anastomotic leakage (OR = 2.17; 95% CI, 1.03–4.56; $p = 0.041$) was also independently associated with increased odds of fecal incontinence. Usage of a temporary stoma was no longer significantly associated with fecal incontinence.

Finally, multivariable analysis confirmed that major LARS was associated with lower anastomotic heights (OR = 0.93; 95% CI, 0.87–0.99; $p = 0.032$). Also, short-course and long-course neoadjuvant radiotherapy were associated with increased odds of major LARS (OR = 3.41; 95% CI, 2.00–5.86; $p < 0.001$ and OR = 2.02; 95% CI, 1.09–3.73; $p = 0.025$). Neither method of anastomosis nor usage of a temporary stoma remained significantly associated with major LARS.

Probability of Bowel Function Problems

In accordance with the results of the univariable and multivariable analyses, the probability of constipation increased along with higher anastomotic heights, while the probability of fecal incontinence decreased (Fig. 2). The curves indicating the probability of constipation and fecal incontinence crossed at an anastomotic height of 7 cm. Given the overlapping 95% CIs of the probability of constipation and fecal incontinence at an anastomotic height between 4.5 cm to 9.5 cm, 3 functional groups can be distinguished according to anastomotic height (Fig. 2). The probability of major LARS showed an almost linear decline along with anastomotic height, reaching from 0.54 to 0.09.

Because both fecal incontinence and major LARS showed significant associations with neoadjuvant radiotherapy, the same probability analysis was performed separately for patients with and without neoadjuvant radiotherapy (Fig. 3). As is shown in this figure, the combination of neoadjuvant radiotherapy and lower anastomotic heights resulted in a peak in the probability of both fecal incontinence (Fig. 3A) and major LARS (Fig. 3B).

Pattern of Bowel Symptoms According to Anastomotic Height

Of all constipation-associated symptoms, the probability of incomplete defecation was highest in patients with an anastomotic height below 9.5 cm (Fig. 4A). Soiling showed the highest probability among all fecal incontinence–associated symptoms (Fig. 4B).

Use of Defecation Treatment

Both antidiarrheals and colonic irrigations were used more frequently in patients with a lower anastomosis (OR = 0.81; 95% CI, 0.71–0.91; $p < 0.001$ and OR = 0.81; 95% CI, 0.67–0.97; $p = 0.022$, Supplemental Digital Content 3 at http://links.lww.com/DCR/B861). The use of laxatives and enemas to treat constipation did not significantly differ along with anastomotic height. Antidiarrheals

TABLE 2. Multivariable logistic regression of constipation, fecal incontinence, and major LARS

	Constipation		*Fecal incontinence*		*Major LARS*	
Variables	*OR (95% CI)*	*p*	*OR (95% CI)*	*p*	*OR (95% CI)*	*p*
Anastomotic height, cm	1.08 (1.02–1.15)	0.011*	0.91 (0.85–0.98)	0.010*	0.93 (0.87–0.99)	0.032*
Sex						
Male	Reference		Reference		Reference	
Female	1.22 (0.84–1.77)	0.302	0.74 (0.48–1.14)	0.169	0.79 (0.51–1.21)	0.279
Age at surgery, y	0.99 (0.97–1.01)	0.250	1.00 (0.98–1.02)	0.976	1.00 (0.98–1.02)	0.987
Follow-up, mo	1.00 (0.99–1.01)	0.776	1.00 (0.99–1.01)	0.836	1.00 (0.99–1.01)	0.908
ASA score at surgery	1.43 (1.05–1.95)	0.022*	0.81 (0.57–1.14)	0.228		
Previous lower abdominal surgery						
No					Reference	
Yes					1.47 (0.94–2.30)	0.094
Radiotherapy						
No	Reference		Reference		Reference	
Neoadjuvant short-course	0.93 (0.55–1.57)	0.791	2.60 (1.49–4.54)	0.001**	3.41 (2.00–5.86)	<0.001**
Neoadjuvant long-course	0.88 (0.47–1.65)	0.699	2.64 (1.40–4.97)	0.003**	2.02 (1.09–3.73)	0.025*
Adjuvant chemotherapy						
No	Reference				Reference	
Yes	1.24 (0.77–1.99)	0.383			0.82 (0.44–1.51)	0.513
Setting						
Elective					Reference	
Emergency					0.40 (0.05–3.27)	0.395
Surgical approach						
Open	Reference		Reference		Reference	
Laparoscopic	1.49 (0.99–2.26)	0.058	0.79 (0.51–1.22)	0.288	0.85 (0.55–1.33)	0.481
Conversion	0.97 (0.46–2.05)	0.940	0.84 (0.38–1.84)	0.667	1.04 (0.49–2.20)	0.914
Method of anastomosis						
Hand-sewn					Reference	
Stapled					2.70 (0.57–12.87)	0.212
Temporary stoma						
No	Reference		Reference		Reference	
Yes	1.08 (0.67–1.75)	0.749	0.94 (0.56–1.61)	0.843	1.57 (0.93–2.64)	0.091
Anastomotic leakage						
No			Reference		Reference	
Yes			2.17 (1.03–4.56)	0.041*	1.31 (0.60–2.87)	0.497

* Statistical significance of $p < 0.05$.
** Statistical significance of $p < 0.005$.
LARS = low anterior resection syndrome.

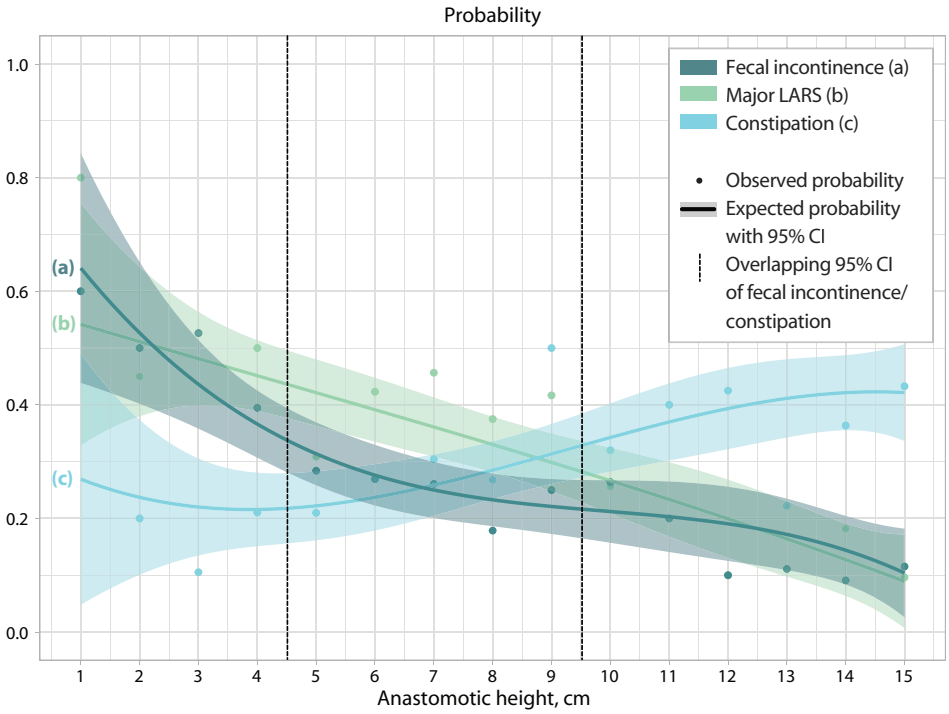

FIGURE 2. The probability of constipation, fecal incontinence, and major LARS according to anastomotic height. LARS = low anterior resection syndrome.

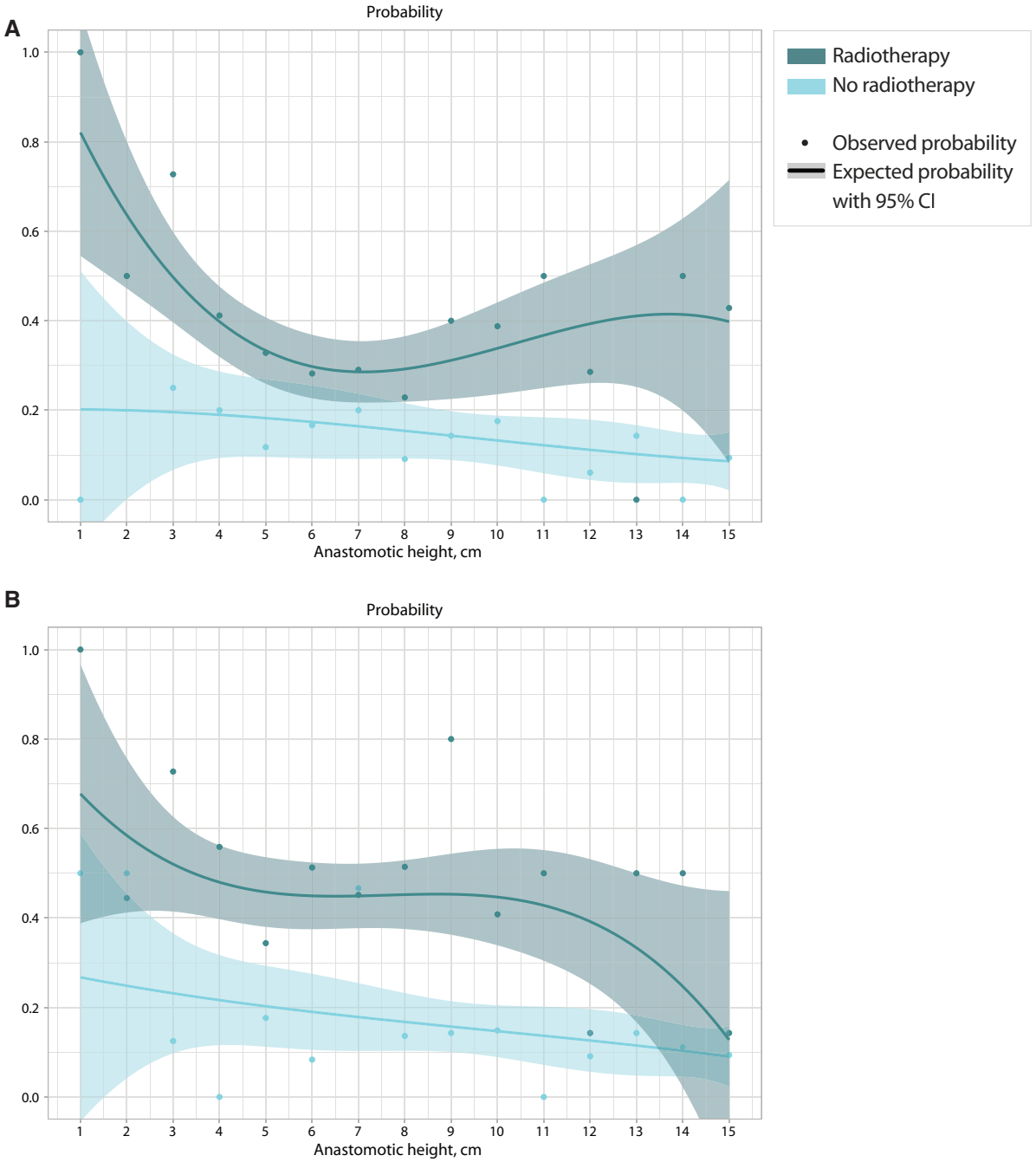

FIGURE 3. The impact of neoadjuvant radiotherapy on the probability of fecal incontinence and major LARS according to anastomotic height. A, Fecal incontinence. B, Major LARS. LARS = low anterior resection syndrome.

or colonic irrigations were given to 17.9% of the patients with fecal incontinence. Of the constipated patients, 37.8% were treated with a laxative or enema.

Quality of Life

Only the physical functioning and bodily pain domains significantly correlated with anastomotic heights, but both correlations were negligible (rho, -0.115; p = 0.004 and rho, -0.081; p = 0.045, Supplemental Digital Content 4 at http://links.lww.com/DCR/B862).

DISCUSSION

This study is the first to demonstrate the exact relation between anastomotic height and the probability of constipation, fecal incontinence, and major LARS in the long

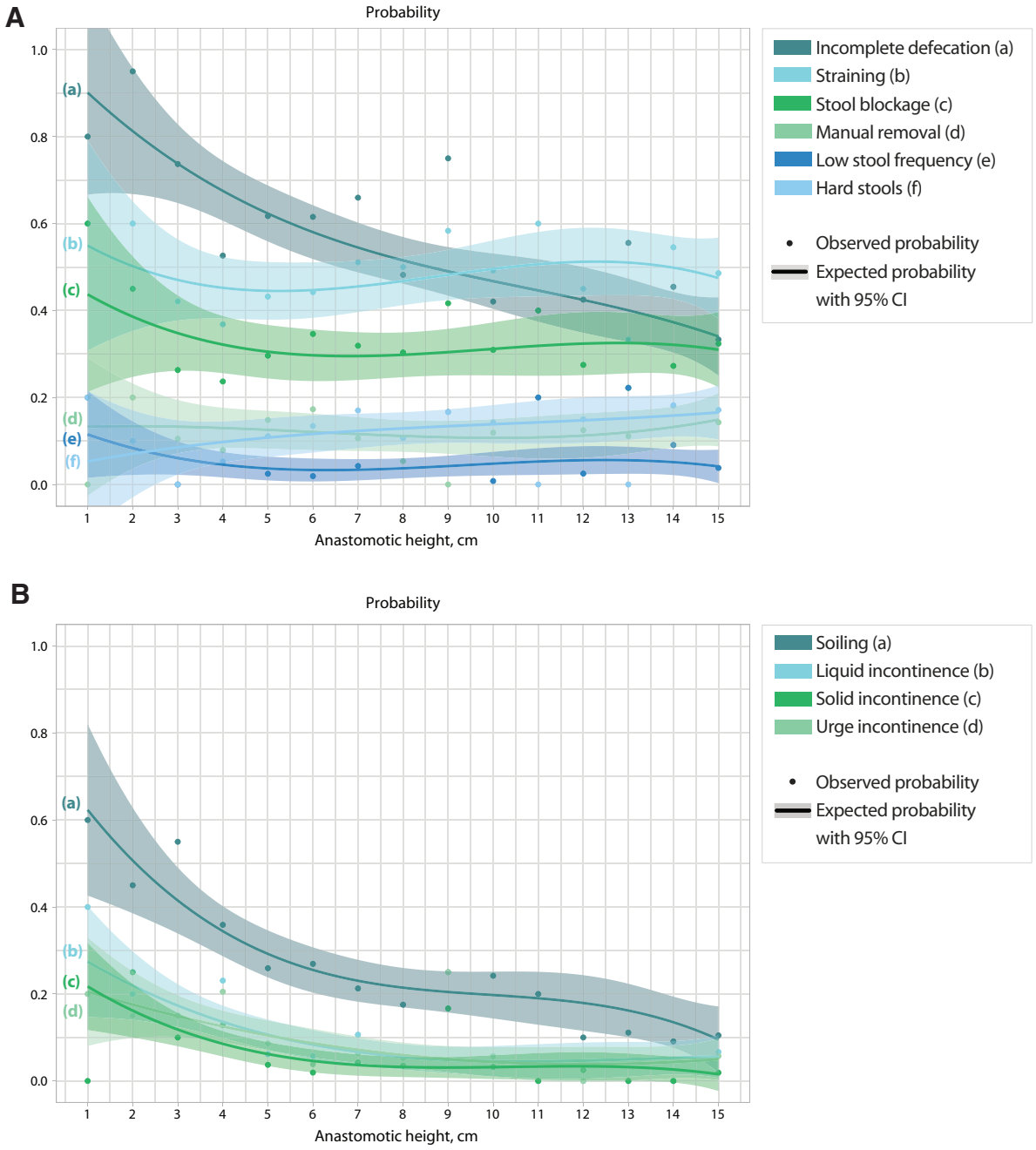

FIGURE 4. The probability of constipation and fecal incontinence-associated symptoms according to anastomotic height. A, Constipation-associated symptoms. B, Fecal incontinence-associated symptoms. LARS = low anterior resection syndrome.

term. Although anastomotic height cannot be controlled in oncological surgery, the screening of postoperative bowel function according to anastomotic height can be improved.

In accordance with clinical experience, constipation was more frequent in patients with higher anastomotic heights, while fecal incontinence and major LARS were associated with lower anastomotic heights. These findings withstood multivariable analysis in which we adjusted for sex, age, and follow-up time. Most studies corroborate our findings of no significant association of both sex[10,11,16,17,27–29] and age[10,11,13,17,28,29] with constipation, fecal incontinence, or major LARS. Regarding follow-up time, longitudinal studies showed no significant improvements of bowel function after 1-year follow-up.[28,30] Therefore, our study confirms the persistent nature of bowel function problems after surgery for rectal or rectosigmoid cancer, which indicates that clinicians should screen for and treat these problems.

Until now, only 1 long-term study analyzed anastomotic height as a continuous variable, and it also reported increased odds of major LARS along with lower anastomotic heights in multivariable regression.[29] The varying pattern of bowel function problems according to varying anastomotic heights clearly indicates a multifactorial pathophysiology of the postoperative bowel function problems. Pathophysiological research on rectal cancer patients showed indications of surgical damage to at least 3 factors: innervation of anal sphincter mechanisms,[8,31,32] rectal reservoir function,[15,31,33] and colorectal propagating motility.[34] A balance between these three factors hypothetically explains the clinical pattern of bowel function problems along with anastomotic height (Fig. 5). At first, in patients with an anastomosis above 9.5 cm, specifically, colorectal propagating motility might be surgically damaged, which is clinically illustrated by the high probability of constipation in these patients. Second, in patients with an anastomosis between 4.5 cm and 9.5 cm, light surgical damage to all 3 factors can be expected, given the fact that the resection was close to the sigmoid, considerable rectal length was removed, and surgery was performed deep into the pelvis, which might have damaged the innervation of the anal sphincter mechanisms. Some constipation might therefore be counterbalanced by some fecal incontinence, which coincides with the clinical picture of acceptable rates of both constipation and fecal incontinence. Finally, in patients with an anastomosis below 4.5 cm, the lack of rectal reservoir function and damage to anal sphincter mechanisms will dominate,[6,8] resulting in an increased probability of fecal incontinence. Remarkably, our results showed that apart from fecal incontinence, the

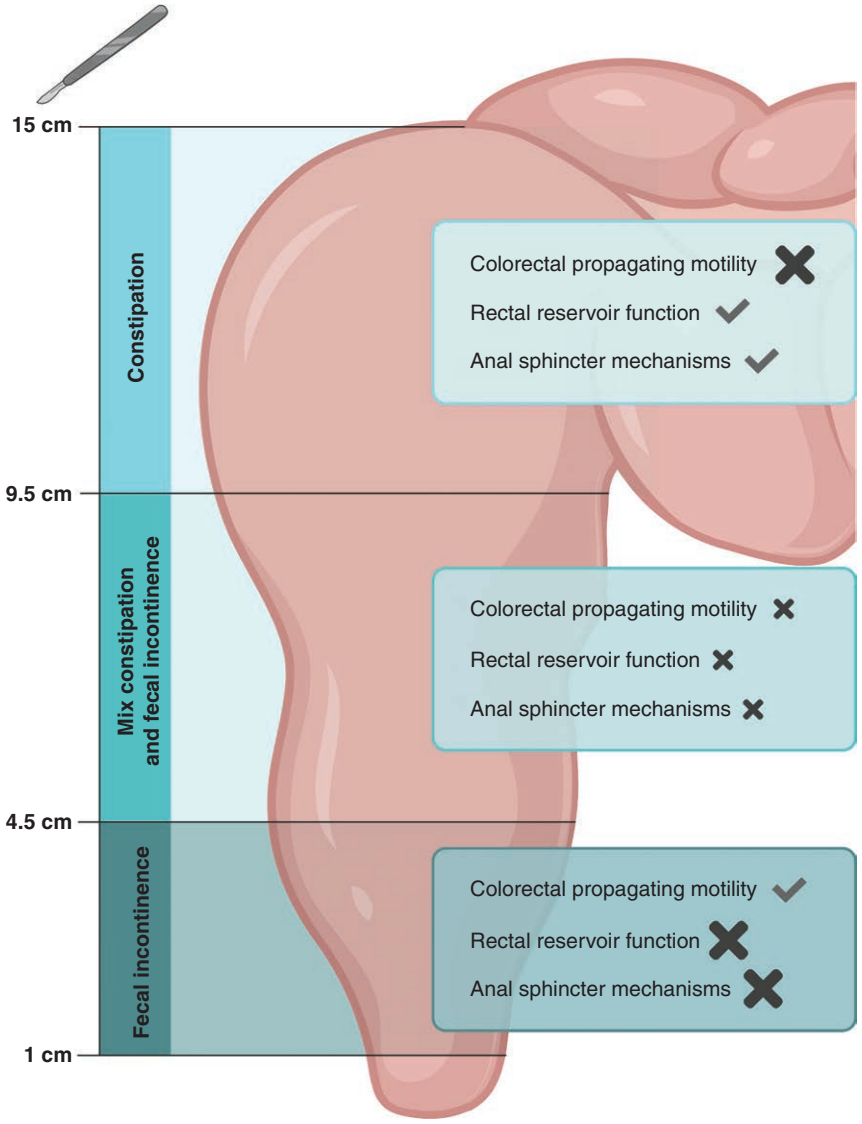

FIGURE 5. Proposed pathophysiological balance of surgical damage after resection with different anastomotic heights. Check mark indicates no damage, a large cross indicates severe damage, and a small cross indicates light damage.

probability of incomplete defecation was also extremely high in patients with low anastomoses, as was described previously.[7] This might be caused by surgical disruption of a specific neural pathway in the anorectal region, but further pathophysiological research is required in this field.

The probability of major LARS showed an almost linear decline along with anastomotic height, mainly corresponding to the pattern of fecal incontinence. Although the LARS score helped to diminish the heterogeneity of bowel function scores in research about surgery for rectal cancer, the score heavily underestimates constipation-associated symptoms.[35] Our findings underscore the substantial presence of constipation in patients who had undergone surgery for rectal or rectosigmoid cancer, which cannot be captured by solely focusing on fecal incontinence–associated symptoms.

Despite the increased probability of constipation with increasing anastomotic height, the use of laxatives or enemas did not vary along with the anastomotic height. Interestingly, only 38% of constipated patients received laxatives or enemas and only 18% of patients with fecal incontinence received antidiarrheals or colonic irrigations. The current study therefore illustrates how both postoperative fecal incontinence and constipation are undertreated.

Apart from surgical damage, radiotherapy has been frequently shown to increase both fecal incontinence[15,36,37] and major LARS[11,17,27,29,38] in the long term. This issue is reinforced by our findings, which showed that both short-course and long-course neoadjuvant radiotherapy almost tripled the likelihood of fecal incontinence and major LARS, especially in combination with low anastomotic heights; findings that are also supported by others.[11,36,39] Radiotherapy-related problems had mainly been attributed to ischemia and fibrosis of the irradiated tissue, resulting in additional loss of rectal capacity and damage to the internal anal sphincter.[15,33,40] Notably, the time since the last radiotherapy is neither associated with constipation, fecal incontinence, nor major LARS, indicating that improvement with time of radiotherapy-related problems does not seem to persist in the long term.[33] Other independent significant predictors in the multivariate models in this study were the ASA score and anastomotic leakage. Constipation was associated with a higher ASA score at surgery, which might reflect a general effect of comorbidities on bowel motility. The likelihood of fecal incontinence was also doubled after the occurrence of anastomotic leakage, although the significance was borderline. Other long-term reports evaluating this association presented contradictory conclusions,[11,16,27] which is probably caused by the small number of events and the lack of a uniform definition of anastomotic leakage.

Although this study shows a strong association between bowel function problems and anastomotic height, both physical and mental generic quality of life scores were not related to anastomotic height. Previous research found an association between generic quality of life and fecal continence or worse LARS scores after surgery for rectal cancer.[12,41] It might be that patients with high anastomoses are equally bothered by constipation when compared to patients with low anastomoses, who mainly suffer from fecal incontinence. Furthermore, the long follow-up time in this study may also have played a role, as coping with bowel function problems may improve.[41]

This study is strengthened by the high response rate (86.3%), large study population, and long follow-up time. Moreover, simultaneous collection of different validated bowel function scores enhances interstudy comparisons. Nonetheless, there are some limitations. First, given the cross-sectional study design, we were unable to assert whether bowel function problems already existed preoperatively and how they developed over time. To rule out this theoretically confounding effect as much as possible, we adjusted for follow-up time in all multivariable models. Second, some clinical data were missing in the medical records, but data regarding anastomotic height, our main variable, were only lacking in fewer than 4% of cases. Third, anastomotic height was obtained retrospectively from the surgery or endoscopic reports. Lastly, the exclusion of deceased patients and patients with a permanent stoma and the slightly higher age of the nonresponders could have led to selection bias. This would, however, only strengthen the conclusion of this study, because bowel function problems were already prevalent in the included "healthier" patients.

CONCLUSION

This study revealed that anastomotic height is valuable as a predictor of whether patients will suffer from constipation and/or fecal incontinence after surgery for rectal or rectosigmoid cancer in the long term. To enable effective screening and treatment, more attention should be drawn toward fecal incontinence in patients with an anastomosis below 4.5 cm. In patients with an anastomosis above 9.5 cm, the focus should be on constipation. Patients with an anastomosis between 4.5 cm and 9.5 cm should be screened and treated for both fecal incontinence and constipation. The detrimental effects of neoadjuvant radiotherapy on long-term continence should also be heeded, especially in patients with the lowest anastomoses. The fact that generic quality of life was comparable between patients with different anastomotic heights might indicate that they are bothered in equal measure by constipation and fecal incontinence. This study might serve as a guide for the clinician to effectively screen and treat fecal incontinence and constipation during the follow-up of patients after surgery for rectal and rectosigmoid cancer.

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