Analysis of the correlation between defunctioning stoma and postoperative low anterior resection syndrome in rectal cancer: a prospective cohort study

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Abstract

Background To evaluate the effect of stoma-related factors (stoma or no stoma, stoma type, and stoma reversal time) on the occurrence of low anterior resection syndrome (LARS), a highly prevalent condition that can develop after anal sphincter-sparing surgery for rectal cancer and impair quality of life, which includes fecal incontinence, fecal urgency and frequent defecation.

Methods Patients who underwent radical rectal cancer surgery from July 2018 to July 2022 in a tertiary hospital were included. Baseline data, tumor condition, operation condition and postoperative recovery were obtained by clinical observation. Follow-up data were collected by telephone follow-up. The chi-square and Fisher exact tests were used to analyse differences, coefficient of contingency was used to determine correlations, and independent risk factors for the occurrence of LARS (Patients with a score of 21 or more points were defined as having LARS using the LARS score) were further determined by binary logistic regression.

Results A total of 480 patients met the inclusion criteria, of which 267 used a defunctioning stoma and 213 did not use a defunctioning stoma. There was a positive correlation between defunctioning stoma ($P < 0.001$, $P < 0.001$, $P < 0.05$) and the occurrence of LARS at 3, 6, and 12 months postoperatively, and there was no significant correlation between the stoma type or stoma reversal time and the occurrence of LARS at 3, 6 and 12 months postoperatively ($P > 0.05$). In binary logistic regression analysis, high BMI (Exp(B) = 1.072, $P = 0.039$), tumor closer to dentate line (Exp(B) = 0.910, $P = 0.016$), and ultra-low anterior resection (Exp(B) = 2.264, $P = 0.011$) increased the possibility of LARS at 3 months postoperatively; high BMI, proximity of the tumor to the dentate line, and ultra-low anterior resection were not independent risk factors for LARS at 6 months postoperatively ($P > 0.05$). However, proximity of the tumor to the dentate line (Exp(B) = 0.880, $P = 0.035$) increased the likelihood of LARS at 12 months postoperatively, while

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high BMI and ultra-low anterior resection remained non-significant as independent risk factors for LARS at 12 months postoperatively ($P > 0.05$).

Conclusions Defunctioning stoma was not an independent risk factor for the occurrence of LARS, whereas high BMI, tumor closer to dentate line, and ultra-low anterior resection were independent risk factors for the occurrence of LARS.

Trial registration Not applicable.

Keywords Rectal cancer, Low anterior resection, Low anterior resection syndrome, Defunctioning stoma

Background

Colorectal cancer is the third most common cancer in the world, and 1/3 occurs in the rectum [1]. With the continuous change of surgical methods, medical equipment and improving neoadjuvant chemoradiotherapy treatment, anus-conserving surgery for low / ultra-low rectal cancer allows some patients to retain anus while resecting the primary tumor, reducing the possibility of permanent stoma, but anastomotic leakage, as a serious postoperative complication, also affects the patient's quality of life and leads to other complications [2–5]. Therefore, a defunctioning stoma was introduced as a temporary terminal ileostomy or transverse colostomy to achieve fecal diversion after low anterior resection. This procedure prevents mechanical pressure and contamination of the anastomosis by intestinal contents, allowing the anastomosis to grow and heal under relatively clean conditions. In this context, a defunctioning stoma proves to be an effective strategy for mitigating the risk of anastomotic leakage in postoperative rectal cancer patients [6, 7]. Clinical studies indicate that the use of a defunctioning stoma in such patients can reach up to 70% [8].

There will be changes in defecation habits after anterior resection of rectal cancer, including fecal incontinence, fecal urgency and frequent defecation. This combination of postoperative symptoms is called low anterior resection syndrome (LARS) [9]. The risk factors for LARS are complex, however, the influence of defunctioning stoma is still controversial in different studies [9, 10]. Therefore, this study aimed to facilitate clinical decision-making by exploring the correlation between stoma-related factors (such as stoma or no stoma, stoma type, and stoma reversal time) and the occurrence of LARS. Additionally, the study sought to investigate other potential factors influencing LARS, including gender, age, BMI, receipt of neoadjuvant therapy, operative style, and distance from the tumor to the dentate line.

Methods

This study was a prospective cohort study.

Study population

Patients who underwent radical rectal cancer surgery from July 2018 to July 2022 in a tertiary hospital were included.

Inclusion criteria: (I) Age≥18. (II) Diagnosed with rectal cancer by pathological diagnosis. (III) Conscious and able to understand and accept the questionnaire. (IV) Able to obtain complete information of medical records. (V) Agree to sign the informed consent.

Exclusion criteria: (I) Previous history of intestinal dysfunction disease or inflammatory bowel disease.

Exit criteria: (I) Death or loss during 12 months of follow-up. (II) Formation of permanent stoma.

Grouping methodology

Patients were divided into a defunctioning stoma group and a non-defunctioning stoma group based on whether they had a defunctioning stoma or not.

Data collection

Baseline data, tumor condition, operation condition and postoperative recovery were obtained by clinical observation. Follow-up data were collected by telephone follow-up. Patients were followed up regularly by telephone at 3, 6 and 12 months postoperatively. The follow-up visits were completed by professionally trained members of the group, and the specific questions of the enquiry are shown in Table 1. The collection of the follow-up data was completed in the stipulated time window to ensure that the data were true, reliable and complete.

For patients with defunctioning stoma, the follow-up time was after the second surgery (stoma reversal) as the start point of the postoperative period.

During the follow-up, the follow-up staff dialed the patient three times on different dates and the patient did not answer, which was recorded as the loss of follow-up.

Research indicators

Postoperative bowel function was evaluated using the LARS score, which is an internationally recognised symptom-based LARS scoring system [11]. Patients were graded according to the score: no LARS (0–20 points), minor LARS (21–29 points), and major LARS (30–42 points). In this study, patients with a score of 21 or more

Table 1 LARS Score [11]

Evaluation projects	value of a score	score
1、Do you ever have occasions when you cannot control your flatus (wind)?		
No, never	0	
Yes, less than once per week	4	
Yes, at least once per week	7	
2、Do you ever have any accidental leakage of liquid stool?		
No, never	0	
Yes, less than once per week	3	
Yes, at least once per week	3	
3. How often do you open your bowels?		
More than 7 times per day (24 h)	4	
4–7 times per day (24 h)	2	
1–3 times per day (24 h)	0	
Less than once per day (24 h)	5	
4、Do you ever have to open your bowels again within one hour of the last bowel opening?		
No, never	0	
Yes, less than once per week	9	
Yes, at least once per week	11	
5、Do you ever have such a strong urge to open your bowels that you have to rush to the toilet?		
No, never	0	
Yes, less than once per week	11	
Yes, at least once per week	16	

points using the LARS score were defined as having LARS. The LARS score is an effective screening tool. The reliability, validity and feasibility of the Chinese version of the LARS score were good [12].

We aimed to compare the differences between patients with a defunctioning stoma and those without in terms of age, gender, BMI, education, surgical history, operative style, postoperative complications, and management of postoperative complications.

We compared the occurrence of postoperative LARS with respect to factors such as stoma or no stoma, stoma type, stoma reversal time, gender, neoadjuvant therapy, BMI, distance from tumor to dentate line, age, and operative style.

Quality control

In this study, the patients were selected according to the criteria stipulated in the clinical trial plan, and the subjects were arranged to sign the informed consent form. After the beginning of the study, the data collection was completed in the prescribed time window to ensure the authenticity, reliability and integrity of the data.
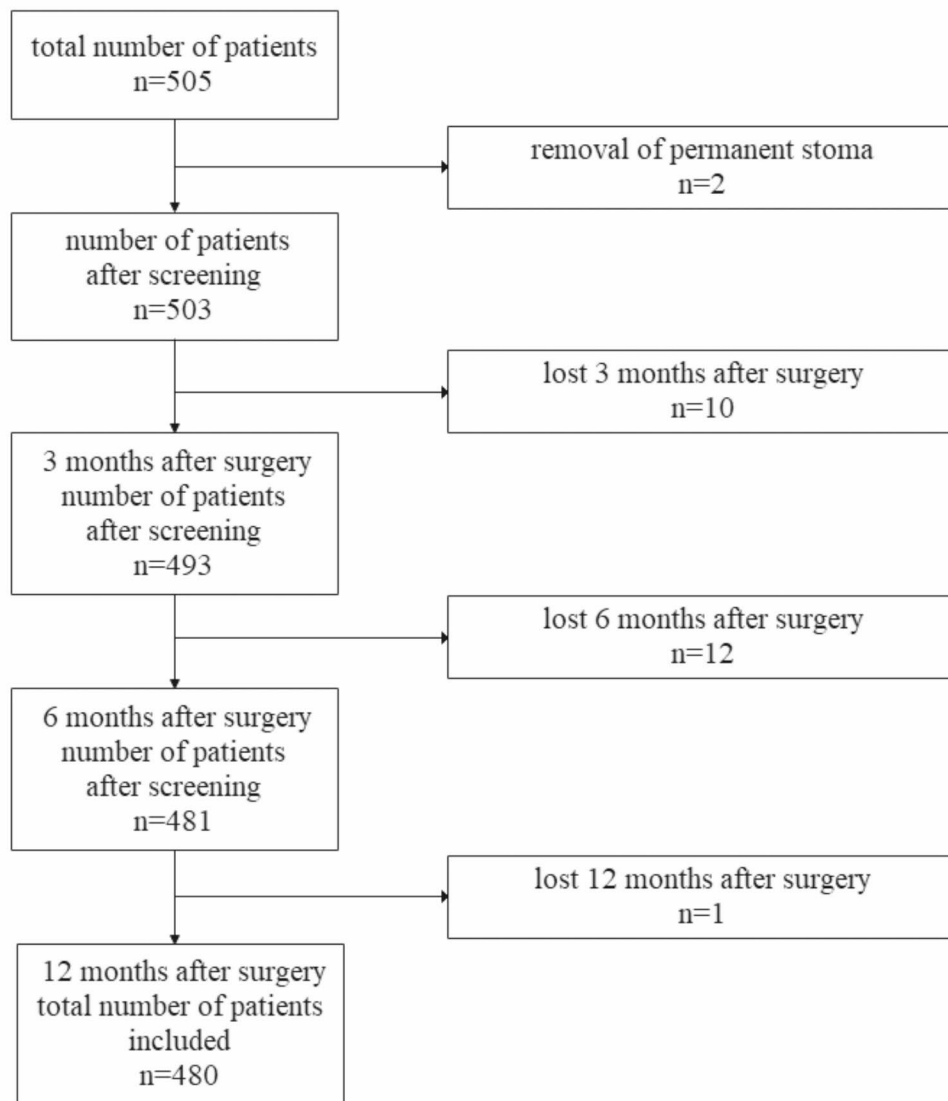
Data analysis and statistical methods

Baseline data were expressed as mean±standard deviation (Mean±SD) or rate (%), and t-tests and chi-square tests were used for group comparisons. Differences in the occurrence of LARS at 3, 6, and 12 months postoperatively between different groups (stoma or no stoma, stoma type, and stoma reversal time) were analyzed

using chi-square and Fisher's exact tests. The coefficient of contingency was used to determine the correlations of a single factor with the occurrence of LARS at 3, 6, and 12 months postoperatively. Binary logistic regression was used to assess the effect of multiple factors on the occurrence of LARS postoperatively in patients with rectal cancer, with regression results shown as Exp (B) with a 95% confidence interval.

Results

Study population

A total of 505 patients completed the procedure and 25 who did not meet the criteria were excluded, resulting in the inclusion of 480 patients in the analysis (Fig. 1). Of the patients included in the analysis, 213 had no defunctioning stoma and 267 had a defunctioning stoma, the median stoma closure time of defunctioning stoma group was 115 (interquartile range 95 to 153) days. It is important to clarify that the number of patients changed over the follow-up period as indicated in Table 2. Initially, 69 out of the 480 patients had not reached the follow-up deadlines. As the follow-up continued, the final results showed that at 6 months post-operation, 7 patients were lost to follow-up, and at 12 months post-operation, 29 patients were lost to follow-up. At 6 months, the total number of patients was 473, and at 12 months, it was 451. The reason for this change was that some of the 480 patients initially included in the study had not yet reached the 6-month and/or 12-month follow-up period at the start of the study. We planned to follow up with

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┌─────────────────────┐
│ total number of     │
│ patients            │
│ n=505               │
└─────────────────────┘
          │                    ┌─────────────────────────┐
          ├───────────────────▶│ removal of permanent    │
          │                    │ stoma                   │
          ▼                    │ n=2                     │
┌─────────────────────┐        └─────────────────────────┘
│ number of patients  │
│ after screening     │
│ n=503               │
└─────────────────────┘
          │                    ┌─────────────────────────┐
          ├───────────────────▶│ lost 3 months after     │
          │                    │ surgery                 │
          ▼                    │ n=10                    │
┌─────────────────────┐        └─────────────────────────┘
│ 3 months after      │
│ surgery             │
│ number of patients  │
│ after screening     │
│ n=493               │
└─────────────────────┘
          │                    ┌─────────────────────────┐
          ├───────────────────▶│ lost 6 months after     │
          │                    │ surgery                 │
          ▼                    │ n=12                    │
┌─────────────────────┐        └─────────────────────────┘
│ 6 months after      │
│ surgery             │
│ number of patients  │
│ after screening     │
│ n=481               │
└─────────────────────┘
          │                    ┌─────────────────────────┐
          ├───────────────────▶│ lost 12 months after    │
          │                    │ surgery                 │
          ▼                    │ n=1                     │
┌─────────────────────┐        └─────────────────────────┘
│ 12 months after     │
│ surgery             │
│ total number of     │
│ patients included   │
│ n=480               │
└─────────────────────┘
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Fig. 1 Study participant screening process

these patients as the study progressed. Unfortunately, some patients were lost to follow-up, resulting in a difference in the total number of patients at different follow-up intervals. The differences between patients in the defunctioning stoma group and the non-defunctioning stoma group in terms of age, BMI, education, surgical history, postoperative complications, and postoperative complications management were not statistically significant ($P>0.05$) and were comparable. The proportion of males in the defunctioning stoma group (65.5%) was higher

Table 2 Results of univariate analysis about stoma-related factors (stoma or no stoma, stoma type, and stoma reversal time) on the occurrence of LARS

research indicators	LARS occurred 3 months after surgery		LARS occurred 6 months after surgery		LARS occurred 12 months after surgery	
	yes	no	yes	no	yes	no
number of patients	185(38.5%)	295(61.5%)	138(29.2%)	335(70.8%)	73(16.2%)	378(83.8%)
stoma or not						
defunctioning stoma	136(50.9%)	131(49.1%)	109(41.4%)	154(58.6%)	52(20.4%)	203(79.6%)
non-defunctioning stoma	49(23%)	164(77%)	29(13.8%)	181(86.2%)	21(10.7%)	175(89.3%)
X^2	39.024		43.156		7.651	
P	<0.001		<0.001		0.006	
coefficient of contingency	0.274		0.289		0.129	
P	<0.001		<0.001		0.006	
number of patients	136(50.9%)	131(49.1%)	109(41.4%)	154(58.6%)	52(20.4%)	203(79.6%)
stoma type						
colostomy	44(56.4%)	34(43.6%)	36(46.8)	41(53.2%)	17(23.6%)	55(76.4%)
ileostomy	92(48.7%)	97(51.3%)	73(39.2%)	113(60.8%)	35(19.1%)	148(80.9%)
X^2	1.321		1.264		0.640	
P	0.250		0.261		0.424	
coefficient of contingency	0.070		0.069		0.050	
P	0.250		0.261		0.424	
number of patients	136(50.9%)	131(49.1%)	109(41.4%)	154(58.6%)	52(20.4%)	203(79.6%)
stoma reversal time						
more than 6 months	10(43.4%)	13(56.5%)	7(31.8%)	15(68.2%)	4(21.2%)	17(78.8%)
less than 6 months	126(51.6%)	118(48.4%)	102(42.3%)	139(57.7%)	48(20.4%)	186(79.6%)
X^2	0.560		0.917		0.025	
P	0.454		0.338		0.873	
coefficient of contingency	0.046		0.059		0.01	
P	0.454		0.338		0.873	

than that in the non-defunctioning stoma group (52.1%) (*P*=0.003), and there were also significant differences in the operative style between the two groups. Intersphincteric resection (ISR) were used more often in the defunctioning stoma group (68.5%), all ISR cases were resected using transanal TME and coloanal anastomosis (CAA) or colon-anal (CAAN) was performed for anastomosis [13]. High anterior resection (HAR) (50.7%) was used more often in the non-protecting stoma group (68.5%). Overall, there was a significant difference in the choice of operative styles between the two groups. (*P*<0.001) (Table 3).

Treatment

The patient's preoperative neoadjuvant therapy regimen was determined on the basis of a preoperative assessment, and the neoadjuvant therapy regimen includes short, intermediate and long course neoadjuvant chemotherapy, short course neoadjuvant radiotherapy, combination of neoadjuvant radiotherapy and chemotherapy. In this study, a total of 190 patients received neoadjuvant therapy, of which 4 (2.1%) patients opted for intermediate/long course neoadjuvant chemotherapy combined with neoadjuvant radiotherapy, 46 (24.2%) patients opted for short course neoadjuvant chemotherapy (1–2 cycles),

100 (52.6%) patients opted for intermediate course neoadjuvant chemotherapy (3–4 cycles), 43 (22.6%) patients opted for long course neoadjuvant chemotherapy (≥5 cycles), and only 1 (0.5%) patient opted for short course neoadjuvant radiotherapy (1 cycle). Preoperative bowel preparation in all patients was done by oral bowel cleansing solutions. All patients had open surgeries and were given postoperative antibiotics: one group of the second-generation cephalosporin, q12.

Results of univariate analysis

The results of the univariate analysis indicated that the percentage of patients who developed LARS at 3, 6, and 12 months postoperatively was significantly higher in the defunctioning stoma group compared to the non-defunctioning stoma group (*P*<0.001, *P*<0.001, *P*<0.05). However, no significant differences in LARS occurrence were observed between groups with different stoma types or stoma reversal time (*P*>0.05). Therefore, we selected 6 months as the cut-off time for stoma reversal. Correlation analysis showed that there was a positive correlation between defunctioning stoma (*P*<0.001, *P*<0.001, *P*<0.05) and the occurrence of LARS at 3, 6, and 12 months postoperatively, with correlation coefficients of 0.279, 0.289, and 0.129, respectively. The stoma type and

Table 3 Comparison of general information of patients in the two groups (*N*=480)

characteristic	defunctioning stoma (*n*=267)	Non-defunctioning stoma(*n*=213)	test statistic	*P*
age, y[Mean±SD]	58.90±11.46	60.47±11.20	t=1.515	0.130
BMI, kg/m^2[Mean±SD]	23.73±2.97	23.16±3.56	t=-1.920	0.055
distance from tumor to dentate line, cm[Mean±SD]	4.23±3.56	13.60±5.55	t=-22.418	<0.001
gender[n(%)]			X^2=8.874	0.003
male	175(65.5)	111(52.1)		
female	92(34.5)	102(47.9)		
education[n(%)]			X^2=7.799	0.351
illiteracy	8(3.0)	5(2.4)		
secondary schools	90(33.7)	55(25.9)		
junior high school	74(27.7)	61(28.8)		
senior high school	34(12.7)	37(17.5)		
vocational secondary school	13(4.9)	8(3.8)		
three-year college	29(10.9)	23(10.8)		
undergraduate	18(6.7)	23(10.8)		
bachelor's degree	1(0.4)	0(0.0)		
surgical history [n(%)]			X^2=3.727	0.155
none	166(62.2)	115(54.0)		
Yes, non-pelvic	72(27.0)	74(34.7)		
Yes, it's pelvic	29(10.9)	24(11.3)		
TNM			X^2=9.643	0.047
0	26(9.7)	9(4.2)		
I	74(27.7)	48(22.5)		
II	68(25.5)	73(34.3)		
III	78(29.2)	63(29.6)		
IV	21(7.9)	20(9.4)		
operative style [n(%)]			X^2=320.483	<0.001
HAR	4(1.5)	108(50.7)		
LAR	17(6.4)	78(36.6)		
ULAR	63(23.6)	21(9.9)		
ISR	183(68.5)	6(2.8)		
anastomosis technique[n(%)]			X^2=21.526	<0.001
end-to-endanastomosis	235(88.0)	196(92.0)		
side-to-side anastomosis	2(0.7)	8(3.8)		
end-to-side anastomosis	3(1.1)	6(2.8)		
arrow-shaped anastomosis (longitudinal closure method)	27(10.1)	3(1.4)		
postoperative complications [n(%)]			X^2=9.378	0.095
none	259(97.0)	197(92.5)		
anastomotic bleeding	4(1.5)	10(4.7)		
anastomotic leaks including invisible leaks	1(0.4)	0(0.0)		
other: e.g. high blood pressure, cardiac arrhythmia, deep vein thrombosis of the lower limbs	1(0.4)	3(1.4)		
stoma obstruction or intestinal obstruction	2(0.7)	1(0.5)		
incisional infection or incisional hernia	0(0.0)	2(0.9)		
postoperative complications management [n(%)]			X^2=4.321	0.115
no readmission	250(93.6)	206(96.7)		
re-hospitalisation for conservative management	16(6.0)	5(2.3)		
re-admission and re-operation	1(0.4)	2(0.9)		

Table 4 Results of binary logistic regression analysis (3 months after surgery)

	B	S.E.	wald	freedom	*p*	Exp(B)	95% confidence interval for Exp(B)	
							lower limit	limit
gender(male)	-0.359	0.217	2.735	1	0.098	0.699	0.457	1.069
age	-0.004	0.009	0.146	1	0.702	0.996	0.978	1.015
BMI	0.069	0.033	4.269	1	0.039	1.072	1.004	1.144
stoma	0.090	0.342	0.069	1	0.793	1.094	0.559	2.140
receiving neoadjuvant therapy	-0.016	0.229	0.005	1	0.944	0.984	0.629	1.540
ISR			15.429	3	0.001			
HAR	-0.702	0.639	1.205	1	0.272	0.496	0.142	1.735
LAR	-0.186	0.460	0.164	1	0.685	0.830	0.337	2.046
ULAR	0.817	0.320	6.515	1	0.011	2.264	1.209	4.241
distance from tumor to dentate line	-0.094	0.039	5.857	1	0.016	0.910	0.843	0.982
constant	-1.050	0.995	1.114	1	0.291	0.350		

Table 5 Results of binary logistic regression analysis(6 months after surgery)

	B	S.E.	wald	freedom	*p*	Exp(B)	95% confidence interval for Exp(B)	
							lower limit	limit
gender(male)	-0.091	0.229	0.157	1	0.692	0.913	0.583	1.431
age	-0.004	0.010	0.147	1	0.701	0.996	0.977	1.016
BMI	-0.014	0.035	0.156	1	0.693	0.986	0.921	1.056
stoma	-0.462	0.379	1.489	1	0.222	0.630	0.300	1.323
receiving neoadjuvant therapy	-0.329	0.239	1.888	1	0.169	0.720	0.450	1.151
ISR			5.883	3	0.117			
HAR	-0.518	0.793	0.426	1	0.514	0.596	0.126	2.820
LAR	-0.107	0.539	0.039	1	0.843	0.899	0.313	2.586
ULAR	0.514	0.345	2.222	1	0.136	1.627	0.851	3.289
distance from tumor to dentate line	-0.073	0.046	2.553	1	0.110	0.929	0.849	1.017
constant	0.576	1.043	0.305	1	0.581	1.779		

the stoma reversal time did not have significant correlation with the occurrence of LARS at 3, 6, and 12 months postoperatively ($P>0.05$) (Table 2).

Results of binary logistic regression analysis

Binary logistic regression analysis showed that BMI (Exp(B)=1.072, $P=0.039$) and ultra-low anterior resection (Exp(B)=2.264, $P=0.011$) were positively associated with the occurrence of LARS at 3 months postoperatively. An increase of one unit in BMI raised the risk of LARS by 1.072 times at 3 months postoperatively. Compared with ISR, patients who underwent ultra-low anterior resection had a 2.264 times higher risk of developing LARS at 3 months postoperatively. The effects of HAR and LAR on the occurrence of postoperative LARS were not statistically different from ISR. Additionally, there was a negative relationship between the distance from the tumor to the dentate line (Exp(B)=0.910, $P=0.016$) and the occurrence of LARS at 3 months postoperatively. An increase in the distance from the tumor to the dentate line by one unit decreased the risk of LARS by 0.910 times at 3 months postoperatively.

At 6 months postoperatively, high BMI, distance of the tumor to the dentate line, and ultra-low anterior resection did not show an independent risk effect on LARS ($P>0.05$).

However, at 12 months postoperatively, the distance from the tumor to the dentate line (Exp(B)=0.880, $P=0.035$) continued to have a negative effect on the occurrence of LARS. An increase in the distance from the tumor to the dentate line reduced the risk of LARS by 0.880 times at 12 months postoperatively. BMI and ultra-low anterior resection were no longer independent risk factors ($P>0.05$).

Tables 4 and 5, and 6 provide further details.

Discussions

The results of this study showed that the incidence of LARS was higher in patients with defunctioning stoma than in patients without defunctioning stoma at 3, 6, and 12 months postoperatively, and the defunctioning stoma showed a strong positive correlation with the incidence of LARS, which was in agreement with the results of several previous reports [10, 14–16]. Winslet, M. C. et al. [17] suggested that the defunctioning stoma is a risk

Table 6 Results of binary logistic regression analysis(12 months after surgery)

	B	S.E.	wald	freedom	p	Exp(B)	95% confidence interval for Exp(B)	
							lower limit	limit
gender(male)	0.137	0.277	0.245	1	0.620	1.147	0.667	1.973
age	0.007	0.012	0.296	1	0.587	1.007	0.983	1.031
BMI	0.031	0.043	0.517	1	0.472	1.032	0.948	1.123
stoma	0.162	0.470	0.119	1	0.730	1.176	0.468	2.955
receiving neoadjuvant therapy	-0.187	0.294	0.404	1	0.525	0.830	0.466	1.476
ISR			0.284	3	0.963			
HAR	0.347	1.007	0.119	1	0.730	1.415	0.197	10.172
LAR	0.239	0.695	0.118	1	0.731	1.269	0.325	4.956
UALR	0.240	0.451	0.283	1	0.594	1.272	0.525	3.079
distance from tumor to dentate line	-0.128	0.060	4.463	1	0.035	0.880	0.782	0.991
constant	-2.045	1.301	2.470	1	0.116	0.129		

factor for the occurrence of LARS, which may result from changes in the intestinal environment and microbiota. In the intestinal segment downstream of the stoma, the intestine often shows atrophy and fibrosis due to loss of luminal contents, loss of intestinal nutrition and loss of activity. The total microbial load in this de-functioning intestinal segment is reduced and the diversity is altered. Defunctioning stoma-induced faecal shunting, by affecting the nutrient environment and flora distribution in the gut, may lead to dysfunction of the gut and an increased risk of LARS. Whether this can be improved by probiotics cannot be concluded due to imperfect data collection in that part of this study. A small number of studies have shown that probiotics do not have a significant effect in improving intestinal function in patients after ileostomy reversal [18]. However, probiotic administration showed a trend towards improvement in some subscale indicators of bowel function, suggesting that further studies may be needed [9, 18]. In addition, prolonged inactivity of the pelvic floor and sphincter complex after ileostomy may contribute to the development of LARS [19].

However, further binary logistic regression analysis in this study found that defunctioning stoma was not an independent risk factor for the occurrence of LARS at 3, 6, and 12 months postoperatively, which was consistent with the findings of Hughes, D. L. et al. [19]. Univariate analyses yielded that defunctioning stoma may be a risk factor for LARS mainly due to other confounding factors. In a study by Croese, A. D. et al. [10], it was stated that the increased risk of LARS in patients with defunctioning stoma was not due to the stoma per se, but to the underlying cause of the stoma. Defunctioning stomas are more likely to occur in low anastomoses, which are considered an independent risk factor for the development of LARS. In addition, defunctioning stomas are often used as a treatment option for anastomotic leak, which has been identified as a risk factor for the development of LARS. Therefore, it was suggested that the risk of developing

LARS in patients with low anastomosis and anastomotic leak should be attended to in clinical practice and effective interventions should be carried out.

The type of stoma had no significant effect on the occurrence of postoperative LARS. Comparison of stoma type in this study showed that the proportion of patients with LARS in the ileostomy group was smaller than that in the transverse colostomy group at the same time point, but this difference was not statistically significant. Similarly, there was no strong correlation between stoma type and LARS. However, studies on stoma type remain somewhat controversial, with a study by Lertsithichai, P. et al. [20] concluding that transverse colostomy is significantly more likely to cause stoma complications, as well as infection and wound complications. Whereas ileostomy tends to cause more post reversal surgical complications as well as symptoms such as obstruction and dehydration [21]. However, overall ileostomy has less impact on patients.

The results of this study confirmed that the stoma type has no strong correlation with the occurrence of postoperative LARS, and the choice of stoma type can be decided according to the site of the tumor. However, combining the results of various studies, for patients with defunctioning stoma who have the need for reversal, ileostomy is preferred to colostomy because ileostomy is more conducive to subsequent reversal. If the patient chooses to have a permanent stoma, it is recommended to consider colostomy, which has a low dehydration rate and is more conducive to postoperative care [20, 22–24].

The effect of reversal time on the risk of developing LARS postoperatively should be interpreted with caution. While our study concluded that reversal time did not show a significant effect on LARS, this finding should be considered in light of the broader body of evidence. In this study, we chose 6 months as the cut-off time for stoma reversal time because in previous studies, Vogel I et al. [25] showed that ileostomy reversal within 6

months after initial surgery was protective against major LARS (OR 0.2, 95% CI, 0.1−0.3, $P<0.01$) and that reversal after 1 year was associated with increased risk of major LARS (OR 3.7, CI 95%, 1.1–13.1, $P=0.03$). This study also showed that the incidence of postoperative LARS was higher in patients in the group with a reversal time of less than 6 months than in the group with a reversal time of more than 6 months, but the difference between the two groups was not statistically significant. In the correlation analysis, stoma reversal time did not show a stronger correlation with LARS. This was consistent with the findings of Pieniowski, E. H. A. et al. [26]. The reason for this may be that there are many factors that affect the time to stoma reversal in daily clinical care, such as hospital surgical resources and priorities between different surgical procedures and diseases, which affect the time to stoma reversal and influence the final trial results. However, there is still a majority of studies that consider early reversal to be superior to delayed reversal, although further trials are needed to determine this [25, 27−29]. It is possible that multicentre, large-sample studies excluding the influence of other higher priority factors on the stoma reversal time are needed in such studies. There is no consensus on the stoma reversal time, but according to Lasithiotakis, K. et al. [28], it is known that early reversal of ileostomy after the initial anastomosis reduces the time of exposure to stoma-related complications and may improve quality of life, reduce stoma-related costs, and still protect against distal anastomosis. Early reversal is therefore supported by the evidence regardless of whether the reversal time poses a risk for LARS. Physicians are advised to choose the timing of early reversal according to the patient's situation.

Ultra-low anterior resection, BMI, and distance from tumor to dentate line were independent risk factors for the development of postoperative LARS at 3 and 12 months.

Based on our study, we observed that ULAR is an independent risk factor for developing LARS at 3 months postoperatively compared to ISR. This finding contrasts with existing literature, which generally suggests that ISR is more likely to lead to bowel dysfunction and associated issues [30, 31]. These issues are likely due to the surgical approach's impact on the anal sphincter and surrounding neurovascular structures. The trans-anal approach of ISR carries a risk of damaging the neurovascular bundle located posterior-laterally to the prostate and urethra, which could contribute to these functional deficits. However, some studies have not found sufficient evidence to definitively categorize ISR as an independent risk factor for postoperative LARS [14]. Regarding our study results, we believe that ULAR may lead to LARS due to potential damage to the bowel's autonomic nerve plexus, which could affect bowel function and contribute to the

development of LARS. In summary, further research is needed to clarify these relationships and refine treatment approaches based on individual patient characteristics and surgical outcomes.

The influence of BMI on the occurrence of postoperative LARS is primarily due to excessive fat accumulation in the rectal mesentery of patients with higher BMI. This accumulation can affect the surgical procedure, making it more likely to damage the pelvic nerves and the internal and external anal sphincters. Additionally, patients with higher BMI are more susceptible to postoperative complications, which can impede the recovery of bowel function after surgery [32]. Although the factors contributing to the development of LARS have been clearly identified, the actual intraoperative preventive measures are limited by technical and oncological constraints. Even so, there are still some measures that can reduce the likelihood of LARS. Intraoperative nerve monitoring (IONM) combined with pelvic floor rehabilitation prior to stoma reversal can be considered in patients with high BMI and tumors closer to the dentate line. IONM, by intraoperative stimulation of the pelvic nerves with continuous electromyography of the internal anal sphincter and cystometry, reduces the effects of obesity and other factors on intraoperative manipulation and helps the surgeon to dissect the rectal mesentery and preserve autonomic nerves. Kneist [33] first compared a small group of patients undergoing proctocolectomy with IONM with a control group and showed a trend towards impaired anorectal function and reduced sexual dysfunction in the IONM group. Pelvic floor rehabilitation before stoma closure, including pelvic floor muscle training (PFMT), biofeedback (BF) and rectal balloon training (RBT), has now been used to treat LARS symptoms, but it has been shown to be effective in improving the recovery of anal sphincter and bowel function, and to have a preventive effect against LARS [34]. Additionally, robotic surgery offers certain advantages in postoperative functional recovery, particularly in patients undergoing more complex procedures. This may be related to the precise operational capabilities of robotic surgery, which help reduce damage to nerves and muscles [35].

Limitations and strengths

This was a prospective cohort study with a large sample size with long-term follow-up outcomes. The present study has several strengths. First, the number of participants was large, data were collected prospectively, and follow-up data were handled by trained professionals to ensure that the data are authentic and reliable. Secondly, in the actual clinical diagnosis and treatment process, there is no consensus on whether rectal cancer patients have a stoma, the choice of stoma site, and the time of reversal, this study provides a reference for the actual

clinical operation by exploring the relationship between the above factors and postoperative LARS. However, there are still some limitations. Firstly, there was a significant difference in the number of patients between the subgroups of stoma type, with only 78 patients in the transverse colostomy group and 189 patients in the ileostomy group. This large discrepancy in numbers may have impacted the results of our analyses, potentially leading to biases. Secondly, this study was conducted at a single center, which limited the generalizability of the findings. A multicenter trial with a larger sample size is needed in the future to further investigate these issues and confirm our results. Thirdly, in this study, we did not include information on postoperative adjuvant chemotherapy. Although our previous research has confirmed that chemotherapy alone is not an independent risk factor for LARS, the absence of this data may still affect the accuracy of the results to some extent. We acknowledge these limitations and will consider them in future research to enhance the robustness and applicability of our findings.

Conclusions

Defunctioning stoma is not an independent risk factor for postoperative LARS, although the effect of defunctioning stoma on the occurrence of LARS is still controversial in the current study, but since defunctioning stoma can reduce the probability of anastomotic leak, it should be chosen in the actual clinical application with a balance of advantages and disadvantages. Neither stoma type nor reversal time had a significant effect on the occurrence of postoperative LARS, so patients can choose the stoma reversal time and stoma type according to the actual situation. In addition, BMI, distance from tumor to dentate line, and ultra-low anterior resection were independent risk factors for the occurrence of postoperative LARS, which should be taken into account when predicting the risk of LARS in patients, and appropriate preventive measures should be taken during and after surgery.

Abbreviations
LARS   Low anterior resection syndrome
IONM   Intraoperative nerve monitoring
BMI   Body mass index
PFMT   Pelvic floor muscle training
BF   Biofeedback
RBT   Rectal balloon training

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Author contributions
QYH and HMJ developed the study concept and design. ZZY and YQR collected the patient samples. QYH and HMJ performed the statistical analyses. QYH wrote the original draft of the manuscript. LL, WXD and HMJ revised the manuscript. All authors have read and approved the manuscript.

Data availability
The datasets generated and/or analysed during the current study are not publicly available due to database confidentiality but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This work followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines.
This study was approved by the Biomedical Research Ethics Committee of West China Hospital of Sichuan University. Approval No.: 2020 Review (832). Only investigators and monitors participating in the clinical trial had access to the participants' personal medical records. Subject trial records are strictly protected and never leaked. Participants sign an informed consent form prior to participation in our studies. During the trial, the rights of the subjects are fully respected and sufficient information is provided so that the subjects understand the purpose, process, and possible risks and benefits of the trial. Participants could withdraw from the trial at any time.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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