

Original Research Article

Intraoperative Colonoscopy in Laparoscopic Rectal Cancer Surgery Reduces Anastomotic Leakage

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Abstract

Objectives: Anastomotic leakage (AL) is the most severe complication of colorectal surgery and is a frequent cause of postoperative mortality. This study aimed to identify the risk factors for AL, including the type of air leak test (ALT) performed, in patients undergoing laparoscopic colorectal cancer surgery.

Methods: This study involved a retrospective review of 201 patients who underwent elective laparoscopic procedures using circular stapled anastomosis for colorectal cancer between January 2015 and December 2020 at Kyorin University Hospital, Tokyo, Japan. In all cases, the distance from the anal verge to the anastomotic site was within 15 cm.

Results: Overall, AL was observed in 16 patients (8.0%). Univariate analysis revealed that the risk factors for AL included diabetes ($P = 0.068$), tumor location ($P = 0.049$), level of anastomosis ($P = 0.002$), number of linear stapler firings ($P = 0.007$), and intraoperative colonoscopy (IOCS; $P = 0.069$). Multivariate analysis revealed that the level of anastomosis ($P = 0.029$) and IOCS ($P = 0.039$) were significant and independent risk factors for AL. One of the 107 patients undergoing ALT without IOCS and 3 of the 94 patients undergoing ALT with IOCS were proven to be positive for air leak. However, these four patients underwent additional suturing intraoperatively and developed no AL following surgery.

Conclusions: This study identified the level of anastomosis and ALT with IOCS as predictors for AL. The results of our study indicate that ALT with IOCS may be more effective than ALT without IOCS in the diagnosis and prevention of AL.

Keywords

anastomotic leakage, intraoperative colonoscopy, laparoscopy, colorectal cancer

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Introduction

Anastomotic leakage (AL) is the most severe complication of rectal cancer surgery (the incidence ranges from 1.8% to 20%) and a frequent cause of postoperative mortality [1-4]. Reducing the incidence of AL remains a major challenge for colorectal surgeons. Various methods, such as oral antibiotics in bowel preparation, left colic artery preservation, and diverting stoma, are used to prevent AL, but

none of these are optimal [3]. Hence, several reliable and objective intraoperative tests have been developed to reduce AL incidence, such as air leak tests (ALTs) [2], intraoperative colonoscopy (IOCS) [5], saline and methylene blue leak tests [6], near-infrared fluorescence [7] and indocyanine green (ICG) fluorescence angiography [8], Doppler technology [9], tissue oxygen tension [10], and oxygen spectroscopy [11]. The risk of AL was found to be significantly higher in patients who tested positive for leaks during these

tests [12]. AL risk has been reported to be affected by tumor factors, the patient's general condition, and other technical factors [1-3,12].

This study aimed to identify the risk factors for AL in patients undergoing laparoscopic colorectal cancer surgery.

Methods

This study involved a retrospective review of 1084 patients who underwent elective procedures for colorectal cancer (adenocarcinoma) between January 2015 and December 2020 at Kyorin University Hospital, Tokyo, Japan. Only those who underwent laparoscopic colorectal cancer resection using circular stapled anastomosis were included. In all cases, the distance from the anal verge (AV) to the anastomotic site was within 15 cm. Patients with the following conditions were excluded: bowel obstruction, tumor perforation, inflammatory bowel disease-associated cancer, or synchronous multiple colorectal cancer. This study was approved by the Research Ethics Committee of Kyorin University Hospital. All patients agreed to participate in the study.

Double stapling technique (DST) anastomosis

DST was performed using a two-row circular stapler for manual anastomosis in all cases.

Assessment of anastomosis integrity using ALTs

ALT was performed without IOCS in 2015-2018 and with IOCS in 2019-2020. Initially, ALTs were performed using a 60-mL bulb irrigation syringe and silicon tube after establishing a circular stapled anastomosis. Since February 2019, this method has become a routine procedure after evaluating the circular stapled anastomosis *via* IOCS. The pelvis of the patients was filled with saline, whereas the colon was clamped using an intestinal clamp on the proximal side of the anastomosis. The anastomotic site was completely soaked in saline.

Non-IOCS (manual method without IOCS)

A silicone tube was inserted from the anal side, and air was injected using a syringe and clamp forceps until dilatation of the intestinal tract was observed. If the dilatation was insufficient, additional air was injected while controlling for air leakage from the tube using clamp forceps.

IOCS

A flexible colonoscope was introduced through the anus while insufflating with carbon dioxide. The colonoscope was carefully introduced until the anastomotic line of the circular staple was visible. Gas infusion was continued until the rectum optimally expanded. Anastomotic lines were evaluated for stapling failure, mucosal defects, ischemia, and bleeding; air was then directly injected into the anastomotic line.

Evaluation

In both methods, the presence of air bubbles from the anastomosis following infusion was considered a positive ALT result.

Measures for intraoperative correction of anastomosis based on endoscopic findings or ALTs

Depending on the nature of the abnormality detected, repair procedures were performed. If the ALT result was positive, the anastomotic defect was repaired using additional sutures, or the anastomosis was re-established. In the initial ALT-negative cases, no additional repair procedures were performed. After anastomotic reconstruction, the ALT was repeated until negative results were obtained. In some cases, an additional preventative diverting ileostomy was performed to protect the anastomosis.

Neoadjuvant chemoradiotherapy (CRT)

CRT was indicated for patients diagnosed with lower rectal cancer with clinical T3-4 or N+. The patients enrolled in the study received a total dose of 50.4 Gy of radiation and concomitant 5-fluorouracil-based chemotherapy. They underwent standardized curative resection 6-8 weeks following CRT.

Drainage

Pelvic and trans-anal drainage were performed in all patients.

Definition of anastomotic leakage

Clinical AL is defined as the presence of clinical signs of leakage, such as evidence of local or generalized peritonitis and discharge of pus or feces from the drain. This includes evidence of a leak on computed tomography imaging and signs of peritonitis infection on clinical, endoscopic, or radiological examinations.

Diabetes

Diabetes cases included patients who received oral treatment only and those who received insulin treatment.

Statistical analysis

The association between the AL and independent factors was studied using univariate analysis (X^2 test or Fisher's exact test). Multivariate regression analysis was conducted using the logistic regression analysis for the variables with P values <0.1 in the univariate analysis. Statistical significance was accepted at $P < 0.05$. The statistical analyses were conducted using SPSS version 15.0. (Copyright ©, SPSS Inc., Chicago, IL, USA).

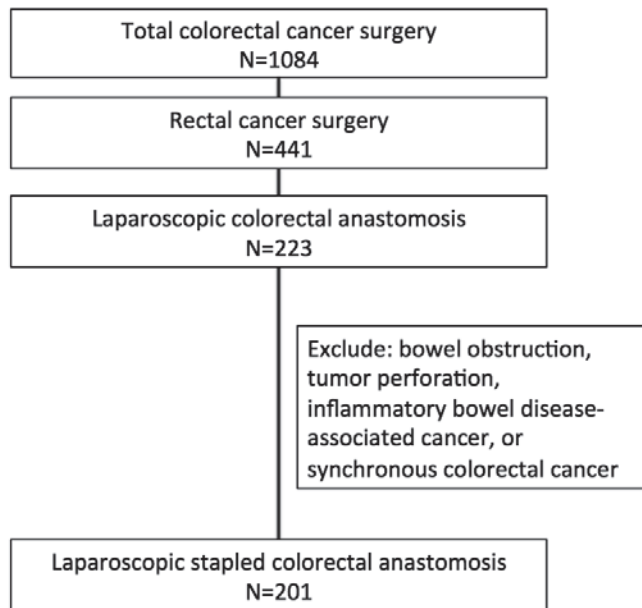


Figure 1. Patient flowchart for the study and reasons for the exclusion of individuals.

Results

The study included 201 patients who met the inclusion criteria (Figure 1). The clinical and demographic characteristics of the patients are presented in Table 1. Overall, AL was observed in 16 patients (8.0%).

Univariate analysis revealed no significant differences among the patients in age, sex, body mass index (BMI), albumin level, American Society of Anesthesiologists scores, presence of diabetes, and surgery-related factors, such as pathological staging, CRT administration, use of a self-expandable metallic stent, lymph node dissection, high ligation of the inferior mesenteric artery, splenic flexure mobilization, robot-assisted surgery, distance of the anastomotic site from the AV, circular stapler size, IOCS, and diverting stoma. On the other hand, significant differences were observed in tumor location ($P = 0.049$), level of anastomosis ($P = 0.002$), and number of linear stapler firings ($P = 0.007$) (Table 2). Multivariate analysis was conducted by including factors that were significant in the univariate analysis, as well as diabetes ($P = 0.068$) and IOCS ($P = 0.069$). Multivariate analysis revealed that the levels of anastomosis ($P = 0.029$) and IOCS ($P = 0.039$) were significant and independent risk factors for AL (Table 2).

Only 1 of the 107 patients undergoing ALT without IOCS was proved to be positive for air leak, whereas 3 of the 94 patients undergoing ALT with IOCS were proved to be positive for air leak. These four patients underwent additional suturing (including one diverting stoma) intraoperatively. As a result, no AL occurred in these patients.

Discussion

Several risk factors for AL have been reported, including patient characteristics such as male sex, high BMI, smoking habit, steroid use, preoperative nutritional status, and tumor factors such as a low tumor location, large tumor size, high tumor stage, and use of neoadjuvant therapy [1-4,13-15]. In this study, the risk factors for AL were found to be the level of anastomosis and IOCS. The distance at which an anastomosis is located from the AV is the most important predictive factor for AL. Several studies have demonstrated that a lower anastomosis is associated with a higher risk of AL [3,16]. It is difficult to change the level of anastomosis as this depends on the tumor location. In this study, we targeted cases in which the distance of the anastomotic site was within 15 cm of the AV. Several objective and reliable intraoperative tests have been developed to diagnose incomplete anastomoses, such as intraoperative endoscopy, saline and methylene blue leak tests, ICG fluorescence angiography, Doppler technology, and tissue oxygen tension [12]. The risk of AL is significantly higher in patients whose intraoperative test indicates incomplete anastomosis [15]. ALTs can detect incomplete anastomoses through anastomotic mechanical failure. Moreover, several types of intraoperative anastomotic ALTs have been widely used to prevent AL. However, recent studies have demonstrated that ALTs do not significantly reduce the AL rate [14]. In addition, each of these studies revealed different methods for ALTs with varying results. This may lead to inconsistent outcomes for detecting mechanically failed anastomoses, which can lead to different clinical outcomes and interpretations [14-17]. The efficacy and safety of IOCS use have not been adequately considered in previous studies [2,12]. Moreover, the intra-abdominal pressure was found to be 10-15 mmHg when measured using a laparoscopic device. It is important to maintain the capacity from the anus, from the anastomotic region to the clamped intestinal tract, and keep the air pressure constant. The amount of air insufflated through an ALT varies depending on the anatomical differences between individuals. There have also been reports of air leaks through the anal side when the intraluminal pressure exceeds 35 mmHg [18]. Therefore, it is difficult to maintain the capacity and control pressure using manual (non-IOCS) methods. These methods are suboptimal for predicting anastomotic complications as they do not allow sufficient intraluminal pressure, thus potentially generating false-negative results. Furthermore, previous studies have shown that the pressure is 70-200 mmHg [19,20] when a new anastomosis bursts. Air leakage prevention through the anal side using a ureteral catheter renders it impossible to control the pressure at the anastomotic site, making it dangerous to apply excessive pressure. Therefore, the use of a catheter is not considered effective. IOCS allows for the maintenance of constant

Table 1. Patients and Tumor Backgrounds (n = 201).

		Mean	Range
Age, in years		65.4	31–88
Body mass index (kg/m ²)		23.5	15.9–34.8
Albumin (g/dL)		4.3	2.6–5.5
Bleeding (mL)		65	0–735
Operation time (min)		345	142–962
Postoperative hospital stays (days)		17	7–110
		n	%
Sex	Male	124	62
	Female	77	38
ASA score	I and II	196	98
	III	5	2
Diabetes	–	165	84
	+	31	16
Tumor location	RS; Upper	110	55
	Ra; Middle	66	33
	Rb; Lower	25	12
pTNM Stage (AJCC 9th)	0 and I	95	47
	II	39	19
	III	59	30
	IV	8	4
CRT	–	195	97
	+	6	3
SEMS	–	197	98
	+	4	2
Lymph node dissection	D1 and 2	39	19
	D3	162	81
High ligation of IMA	–	190	95
	+	11	5
Splenic flexure mobilization	–	197	98
	+	4	2
Robot-assisted surgery	–	171	85
	+	30	15
Level of anastomosis	Non-LAR	101	50
	LAR	100	50
Distance of the anastomosis site from AV (cm)	≤5	40	20
	≤10	85	42
	≤15	76	38
Circular stapler size (mm)	25	122	61
	28 or 29	79	39
Number of linear stapler firings	1 and 2	179	89
	3	22	11
Lateral lymph node dissection	–	195	97
	+	6	3
Diverting stoma	–	175	87
	+	26	13
IOCS	Without IOCS	107	53
	With IOCS	94	47
Results of ALT	Negative	198	98
	Positive	4	2

ASA, American Society of Anesthesiologists
 RS, rectal rectosigmoid
 Ra, rectum above the peritoneal reflection
 Rb, rectum below the peritoneal reflection
 pTNM, pathologic tumor–node–metastasis
 AJCC, American Joint Committee on Cancer
 CRT, neoadjuvant chemoradiotherapy
 SEMS, self-expandable metallic stent
 IMA, inferior mesenteric artery
 LAR, low anterior resection
 IOCS, intraoperative colonoscopy
 AV, anal verge
 ALT, air leak test

Table 2. Univariate and Multivariate Analysis of Risk Factors for AL.

		AL (+)		AL (-)		Univariate p-value	Multivariate	
		N	%	N	%		OR [95% CI]	p-value
Sex	Male	10	8	114	92	0.945		
	Female	6	8	71	92			
Age, in years	<75	13	9	138	91	0.555		
	≥75	3	6	47	94			
Body mass index (kg/m ²)	<25	11	9	117	91	0.660		
	≥25	5	7	68	93			
Albumin (g/dl)	<4	3	10	28	90	0.701		
	≥4	13	8	154	92			
ASA score	I and II	15	8	181	82	0.314		
	III	1	20	4	80			
Diabetes	-	11	6	159	94	0.068	0.413 [0.121–1.408]	0.158
	+	5	16	26	84			
Tumor location	RS; Upper	5	5	105	95	0.049	1.103 [0.285–4.272]	0.887
	Ra; Middle and Rb; Lower	11	12	80	88			
pTNM stage (AJCC 9th)	0, I and II	12	9	122	91	0.461		
	III and IV	4	6	63	94			
CRT	-	15	8	180	92	0.424		
	+	1	17	5	84			
SEMS	-	16	8	181	92	0.552		
	+	0	0	4	100			
Lymph node dissection	D1 and 2	3	8	36	92	0.945		
	D3	13	8	149	92			
High ligation of IMA	-	14	7	176	93	0.198		
	+	2	18	9	82			
Splenic flexure mobilization	-	16	8	181	92	0.552		
	+	0	0	4	100			
Robot-assisted surgery	-	15	9	156	91	0.310		
	+	1	3	29	97			
Level of anastomosis	Non-LAR	2	2	99	98	0.002	0.136 [0.023–0.811]	0.029
	LAR	14	14	86	86			
Distance of the anastomotic site from AV (cm)	≤5	5	12	35	88	0.236		
	6–15	11	7	150	93			
Number of linear stapler firings	1 and 2	11	6	168	94	0.007	0.318 [0.88–0.149]	0.081
	3	5	23	17	77			

Table 2. Univariate and Multivariate Analysis of Risk Factors for AL. (continued)

		AL (+)		AL (-)		Univariate	Multivariate	
		N	%	N	%	p-value	OR [95% CI]	p-value
Circular stapler size (mm)	25	11	9	111	91	0.492		
	28 or 29	5	6	74	94			
Lateral lymph node dissection	-	15	8	180	92	0.424		
	+	1	17	5	83			
Diverting stoma	-	14	8	161	92	0.957		
	+	2	8	24	92			
IOCS	Without IOCS	12	11	95	89	0.069	3.661 [1.068–12.548]	0.039
	With IOCS	4	4	90	96			
Results of ALTs	Negative	16	8	182	92	0.608		
	Positive	0	0	3	100			

OR, odds ratio,
 95% CI, 95% confidence interval
 ASA, American Society of Anesthesiologists
 RS, rectal rectosigmoid
 Ra, rectum above the peritoneal reflection
 Rb, rectum below the peritoneal reflection
 pTNM, pathologic tumor–node–metastasis
 AJCC, American Joint Committee on Cancer
 CRT, neoadjuvant chemoradiotherapy
 SEMS, self-expandable metallic stent
 IMA, inferior mesenteric artery
 LAR, low anterior resection
 AV, anal verge
 IOCS, intraoperative colonoscopy

and sustained air pressure to perform a safe ALT by releasing air through the anal side to avoid excessive pressure [2]. As a result of these considerations, IOCS is more effective in performing ALT compared with a silicone tube. However, no previous studies have conducted intraluminal pressure measurements during ALTs. In this study, intestinal pressure was not measured during the ALT, and therefore, the measurements are not reliable. In the future, it is important to study the relationship between intestinal pressure during ALT and AL.

In this study, 4 of the 201 patients (2%) undergoing ALT were proven positive for air leak (1 patient without IOCS and 3 patients with IOCS). One retrospective study revealed that 7.8% of the ALT results were positive [21]. Patients with positive ALT results underwent an additional laparoscopic procedure (suture and/or diverting stoma) to avoid AL immediately after anastomosis. In this study, four patients underwent additional suturing (including one diverting stoma) intraoperatively and developed no AL following surgery. However, the method of repair for an intraoperative AL was left to the surgeons' discretion: simple suture alone,

re-anastomosis, or diverting stoma. The degree and site of the incomplete anastomosis, as well as the skill of the surgeon, must be considered for the repair method. In this study, treatments such as additional suturing did not cause AL, and as a result, it is considered an appropriate treatment. However, after suturing, the rate of AL was reported to be significantly higher than that in patients with an initial negative result [21]. The optimal treatment for ALT-positive anastomosis has not been established [22]. Despite the negative ALT results, four patients in the IOCS group had AL. Although ALT with IOCS appears to reduce false-negative results, AL may still occur. With respect to risk factors, only two patients had three linear stapler firings, and one had left colic artery ligation and CRT. Only one patient was male, and no other risk factors were identified. The cause of AL may be associated with factors such as anastomosis blood flow or the general condition of the patient [12,14,16].

Limitations

The limitations of this study include the relatively small number of patients and its retrospective, single-center design

and nonrandomized nature. Since ALT with IOCS was introduced into routine clinical practice in 2019, the difference in the study period with the non-IOCS group may also have influenced the outcomes. Because studies on IOCS use have only begun recently, the results may have been affected by the development of new surgical techniques and proficiency of the surgical team. However, no significantly associated factors were identified in the study groups for complications other than AL. Furthermore, there was no significant difference in the Clavien-Dindo complication rates of CD2 or higher ($P = 0.25$). Therefore, it is considered that the impact on the quality of surgery was small. Further studies are required to validate our findings in a larger, randomized population.

Conclusion

In this study, the risk factors for AL were found to be the level of anastomosis and whether IOCS was performed in the ALT. The results of our study indicate that ALT with IOCS may be more effective than ALT without IOCS to prevent AL. Further studies are required to elucidate the complications associated with AL.

Conflicts of Interest

There are no conflicts of interest.

Author Contributions

Tomokazu Kishiki, Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND

Drafting or critical revision of the work for important intellectual content; AND

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Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Approval by Institutional Review Board (IRB)

The Research Ethics Committee of Kyorin University Hospital (IRB Approval code; 1403)

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