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Usefulness of intraoperative colonoscopy and synchronous scoring system for determining the integrity of the anastomosis in left-sided colectomy: a single-center retrospective cohort study

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Abstract

Objectives The aim of this study is to evaluate the utilization of intraoperative colonoscopy (IOC) for determining the integrity of the anastomosis and to establish an IOC scoring system.

Methods A retrospective cohort study was conducted from January 2021 to June 2024, we analyzed the clinical data of 160 patients registered in a database who underwent laparoscopic left-sided colectomy at Pusan National University Yangsan Hospital. IOC was performed on all patients, and Mucosal color (MC), stapled line bleeding (BL), proximal redundancy (PR), and bowel preparation (BP) were evaluated and scored as variables. Logistic regression analysis was used to evaluate risk factors for anastomotic leakage (AL) and Cohen's kappa was applied to assess the reproducibility of the evaluation.

Results Of 160 patients, 10 (6.25%) experienced AL. All the IOC variables had kappa values of 0.8 or higher, indicating good agreement. The logistic regression analysis revealed significant differences in the MC 2 ($P=0.017$, OR 12.86), PR 2 ($P=0.001$, OR 27.64), BP 2 ($p=0.016$, OR 10.50) PR 2 score ($P=0.016$, OR 10.50) and the sum of the scores ($p=0.001$, OR 3.51).

Conclusion IOC can be performed as a reference procedure to assess the integrity of the anastomosis during left-sided colorectal surgery.

Keywords Anastomotic leakage, Colorectal resection, Intraoperative colonoscopy, Lt. sided colectomy

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Introduction

Anastomotic leakage (AL) is the most fatal complication of bowel resection involving colorectal anastomosis following left-sided colectomy. AL occurs in 2% to 30% of cases, substantially increasing morbidity, mortality, local recurrence, and distant metastasis rates as well as delaying the initiation of adjuvant treatment, resulting in poor outcomes [1–3].

In 1973, Richter et al. reported the first instance of intraoperative colonoscopy (IOC) [4]. Since then, IOC has been increasingly performed, particularly in laparoscopic procedures involving tactile loss. IOC has been performed for the following reasons: 1. Intraoperative tumor localization; 2. Observation of the proximal colon in patients with obstructive colorectal lesions; and 3. Verification of anastomotic integrity [5–7]. In particular, real-time visualization of the anastomosis provides more information, allowing for a relatively accurate determination of anastomotic leakage.

Several risk factors have been reported to be associated with AL, including comorbidity, high American Society of Anesthesiologists (ASA) score, stage of malignancy, emergency surgery, and intraoperative complications, but these risk factors cannot be modified. Monitoring and evaluation by the surgeon during surgery is the most effective method for preventing this complication [8, 9].

Ensuring a secure anastomosis during the surgery can enhance the outcome. Air leak test (ALT), water insufflation, methylene blue enema, indocyanine green (ICG) fluorescence angiography, Doppler techniques, tissue oxygen tension and intra-operative colonoscopy have been employed to evaluate the integrity of left-sided colorectal anastomosis [10–16]. Although the risk of AL was found to be higher in patients who tested positive for leaks during these tests, the management of AL remains debatable.

The aim of this study is to establish a scoring system by identifying patient risk factors and factors associated with anastomotic leakage discovered under colonoscopic evaluation during surgery to prevent and evaluate anastomotic leakage.

Methods

This retrospective cohort study was conducted at a single institution. Between January 2021 and June 2024, we analyzed the clinical data of 160 patients registered in a database who underwent left-sided colectomy for colorectal cancer, including left hemicolectomy, anterior resection, and low anterior resection, with intraoperative colonoscopy (IOC) at Pusan National University Yangsan Hospital. Patients who underwent simultaneous ileostomy during surgery (patients who underwent neoadjuvant concomitant chemoradiation therapy (CCRT) before surgery and patients who experienced air leakage), patients who underwent abdominoperineal resection (APR) or intersphincteric resection (ISR) were excluded. (Fig. 1).

Bowel preparation before surgery included sodium picosulfate with magnesium citrate (SPMC) or standard

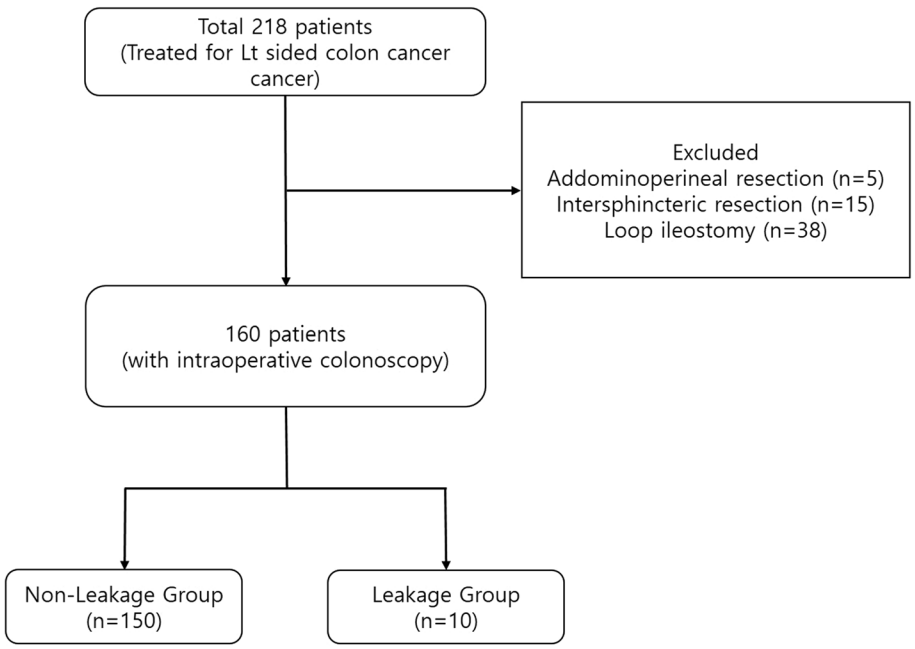

Fig. 1 Flowchart for inclusion and exclusion criteria

polyethylene glycol (PEG) along with 15 mg of bisacodyl oral tablets administered the day before the surgery. Antibiotic bowel preparation was not administered to all patients. All operations were performed laparoscopically and anastomosed with the standard double stapling technique (DST).

Colonoscopy was performed on all patients, and 1) mucosal color (MC), 2) stapled line bleeding (BL), 3) proximal redundancy (PR), and 4) bowel preparation (BP) were evaluated and scored as variables during surgery. The score for each variable ranged from 0 to 2 points, and the sum of the scores for each variable ranged from 0 to 8 points. (Table 1) The time required for conducting the IOC scoring did not measure the mean of all patients, yet it consistently remained under 10 min from insertion to removal.

For the colonoscopic variables,

1) Mucosa color (MC) is a measure of the degree of perfusion at both margins and is defined as discoloration within 1 inch, which is the range that can be observed in the endoscopic field of view from above and below the anastomosis.
2) Stapled line bleeding (BL) may cause partial tissue damage due to hypoperfusion and long-term hypovascularization. The acceptable threshold for bleeding from the anastomosis was set at 0. Continuous bleeding along a portion or the entire stapled line of the anastomosis with some amount of blood clots indicating natural hemostasis was scored as 1 point. Two points were given when immediate intervention was required as a result of continuous pulsative bleeding. All patients with scores of 2 points underwent either endoscopic clipping or laparoscopic suturing.
3) Proximal redundancy (PR) is indicative of a tension-free anastomosis. A score of 0 points is given when there is a significant degree of laxity between the proximal and distal bowels, which results in a hernia in the proximal portion. One point was given for the maintenance of normal semilunar folds, and 2 points were given for the disappearance of semilunar folds.
4) Bowel preparation (BP) is defined as mechanical bowel preparation. A score of 0 points indicates that the entire colon mucosa is clearly visible with no residual staining, a score of 1 point indicates a small amount of residual staining and the presence of a discolored mucous substance, and a score of 2 points indicates that the mucosa of the colon has not been prepared and is not visible owing to staining or residual solid stool. (Fig. 2).

We analyzed the records of the first medical examination conducted at the Department of Surgery, progress records, consultation request forms, operation notes, pre-anesthesia evaluation tables, anesthesia records, and inpatient nursing records. Additionally, examination results, histopathological examination results, and imaging interpretation reports were included. Variables other than those selected during IOC were selected to analyze overall risk. Patient factors included sex, age, height, weight, body mass index (BMI), diabetes status, smoking status, alcohol consumption, and American Society of Anesthesiologists (ASA) class. Preoperative CEA levels and preoperative albumin levels were measured, and the total operation time, pTNM stage, type of operation, and anastomotic level, which is noted as the distance from the anal verge, were investigated as factors related to surgery.

Anastomotic leakage was defined as leakage from the anastomosis within 30 days after surgery according to the definition of the International Study Group of Rectal Cancer. Accordingly, "anastomotic leakage should be defined as a defect of the intestinal wall at the anastomotic site leading to communication between the intraluminal and extraluminal compartments" [17]. Anastomotic leakage is characterized by 1) the presence of amylase and lipase

Table 1 Definition of Score for determining the integrity of anastomosis

Colonoscopic Score for determining the integrity of anastomosis			
Variable	**0**	**1**	**2**
Mucosa Color (MC)	No discoloration	Discoloration within one inch of the anastomosis (one side)	Discoloration within one inch of the anastomosis (both sides)
Stapled Line Bleeding (BL)	None or Minor oozing	Self-limited; self hemostasis with clot	Significant bleeding; one or more pumping lesions requiring immediate intervention
Proximal Redundancy (PR)	Proximal portion hernia	Maintain normal semilunar folds	Disappear semilunar folds
Bowel Preparation (BP)	Entire colon mucosa seen well with no residual staining	Minor amount of residual staining and observation of discolored mucous substances	Unprepared colon with mucosa not seen due to staining or residual solid stool

MC mucosa color, *BL* stapled line bleeding, *PR* proximal redundancy, *BP* bowel preparation

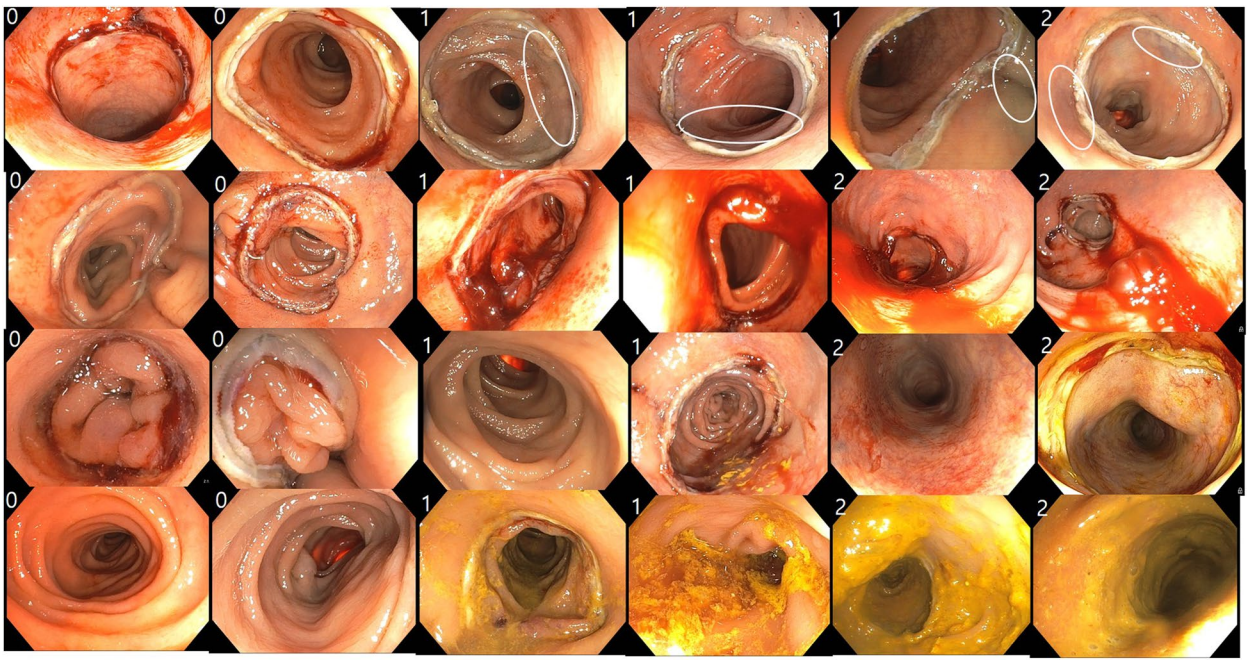

Fig. 2 PNUYH IOC score 1st row; MC, 0- No discoloration, 1- Discoloration of one side, 2- Discoloration of both sides 2nd row; LB, 0- None or Minor oozing, 1- self hemostasis with clot, 2- one or more pumping lesions requiring immediate intervention 3rd row; PR, 0- Proximal portion hernia, 1- Maintain normal semilunar folds, 2- Disappear semilunar folds 4th row; BP, 0 Entire colon mucosa seen well, 1- Observation of discolored mucous substances 2- Unprepared colon with unvisible mucosa

in the intraabdominal drainage tube contents in amounts exceeding the reference values and 2) evidence of fluid retention around the anastomotic site on imaging such as abdominal computed tomography (CT). The risk factors for anastomotic leakage were statistically analyzed by dividing the study subjects into two groups: the patient group with anastomotic leakage (AL+; $n=10$) and the patient group with no leakage (AL-; $n=150$).

In the initial subsection of 58 cases, the most relevant endoscopic variables were selected, and their reliability was assessed in an interobserver variation study. Cohen's kappa was used to confirm the degree of agreement of categorical variables between the two evaluators, and the intraclass correlation coefficient (ICC) was used to confirm the degree of agreement of continuous variables between the two evaluators.

This study protocol was approved by the Institutional Review Board (IRB) of Pusan National University Yangsan Hospital. (IRB No. 05–2024-108). Written informed consent forms concerning colorectal resection and intraoperative colonoscopy were obtained. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki. The clinical trial number is not applicable to this investigation, as it is not a prospective clinical study of health outcomes.

All the statistical analyses were performed using version 21 of IBM SPSS Statistics (SPSS Inc., Chicago, IL, USA). Several scale variables were converted to nominal variables by grouping and then analyzed. For nominal variables, chi-square tests and Fisher's exact tests were used, whereas Mann–Whitney U tests were used for scale variables. Logistic regression analysis was used to evaluate patient-related risk factors and colonoscopy-related risk factors for anastomotic leakage. A P value less than 0.05 was considered indicative of statistical significance.

Results

Patient characteristics

Of 160 patients enrolled in this study, 10 (6.25%) experienced anatomic leakage. Table 2 show the patients' characteristics. No significant differences in demographic variables, including age ($p=0.330$), sex ($p=0.497$), or BMI ($p=0.722$), were detected between the AL (-) and AL (+) groups. With respect to the surgery-related variables, no differences were observed in the operation time ($p=0.383$), surgical method ($p=1.000$), or anastomotic level ($p=0.761$) between the two groups. The postoperative pathological stage (p=0.743) was also not significantly different between the two groups Table 3.

Reliability of IOC

The study was divided into two sections. The initial objective was to assess the degree of reproducibility of the investigation. In the initial 58 consecutive cases,

Table 2 Characteristics of patients ($n = 160$)

Variables	AL (-) ($n = 150$)	AL (+) ($n = 10$)	P-value
Age in years			0.330
< 65.0	63 (42.0%)	6 (60.0%)	
≥ 65.0	87 (58.0%)	4 (40.0%)	
Gender			0.497
Female	55 (36.7%)	2 (20.0%)	
Male	95 (63.3%)	8 (80.0%)	
BMI			0.722
< 25.0	109 (74.1%)	7 (70.0%)	
≥ 25.0	38 (25.9%)	3 (30.0%)	
ASA			0.379
I	27 (18.0%)	3 (30.0%)	
II-	105 (70.0%)	7 (70.0%)	
III	18 (12.0%)	0 (0.0%)	
DM, n (%)			1.000
No	109 (72.7%)	8 (80.0%)	
Yes	41 (27.3%)	2 (20.0%)	
Smoking, n (%)			0.360
No	126 (84.6%)	10 (100.0%)	
Yes	23 (15.4%)	0 (0.0%)	
Alcohol, n (%)			0.119
No	114 (76.5%)	10 (100.0%)	
Yes	35 (23.5%)	0 (0.0%)	
Preop CEA (ng/mL)			0.283
< 5.0	104 (69.3%)	9 (90.0%)	
≥ 5.0	46 (30.7%)	1 (10.0%)	
Preop Alb (g/dL)			1.000
< 3.5	52 (34.7%)	3 (30.0%)	
≥ 3.5	98 (65.3%)	7 (70.0%)	
Operation time (min)			0.383
< 120	25 (16.8%)	3 (30.0%)	
≥ 120	124 (83.2%)	7 (70.0%)	
pTNM Stage, n (%)			0.743
I-II	88 (58.7%)	5 (50.0%)	
III-IV	62 (41.3%)	5 (50.0%)	
Type of operation			1.000
LaLAR	93 (62.0%)	7 (70.0%)	
LaAR	50 (33.3%)	3 (30.0%)	
LaLHC	7 (4.7%)	0 (0.0%)	
Level of anastomosis from AV (cm)			0.716
< 5	42 (28.0%)	3 (30.0%)	
5 ~ 10	46 (30.7%)	4 (40.0%)	
> 10	62 (41.3%)	3 (30.0%)	

AL Anastomotic leakage, *BMI* body mass index, *ASA* American Society of Anesthesiologists classification, *DM* Diabetes mellitus, *LaLAR* laparoscopic low anterior resection, *LaAR* laparoscopic anterior resection, *LaLHC* laparoscopic left hemicolectomy

Table 3 Reliability of the colonoscopic evaluation

Variables	unweighted		weighted	
	Kappa	95% CI	Kappa	95% CI
Mucosa Color (MC)	0.851	(0.726–0.976)	0.897	(0.808–0.986)
Stapled Line Bleeding (BL)	0.967	(0.904–1.000)	0.980	(0.939–1.000)
Proximal Redundancy (PR)	1.000		1.000	
Bowel Preparation (BP)	1.000		1.000	
Colonoscopic Score	0.848	(0.733–0.964)	0.953	(0.913–0.992)

MC mucosa color, *BL* stapled line bleeding, *PR* proximal redundancy, *BP* bowel preparation

each colonoscopy-related variable associated with anastomotic leakage was selected to assess the reliability of interobserver (operator and colonoscopist) agreement before the commencement of the main investigation. The intraclass correlation coefficient (ICC) between each evaluated score was determined after colonoscopy during surgery. Kappa statistics were applied to assess the degree of agreement among observers regarding each colonoscopy-related variable. Kappa values below 0.4 indicate low agreement, between 0.4 and 0.60 indicate normal agreement, between 0.6 and 0.81 indicate good agreement, and above 0.80 indicate very good agreement [18]. The ICC was considered significant when the p value was < 0.05. All the variables showed very good agreement (kappa values 0.8 or higher), especially PR and BP, which showed perfect agreement. Despite the possibility of some communication errors between observers, this can be attributed to an evaluation method that is easily identified by any surgeon who is competent in simple evaluation and scoring, as illustrated in Fig. 2.

Risk factors related to patient characteristics and colonoscopic evaluation

Table 4 presents the logistic progression analysis of patient characteristics between the two groups. Univariate analysis revealed no significant differences among the patients in terms of age, sex, body mass index (BMI), albumin level, CEA level, ASA class, diabetes status, or surgery-related factors, such as pathological stage, operation time, surgical method, anastomotic level. A multivariate analysis was not conducted because of the absence of significance in the univariate analysis.

In the main section of the study, the selected endoscopic variables were used to calculate the IOC score, which was subsequently simplified. Additionally, the data that were accumulated were obtained through colonoscopic evaluation during surgery. The 1) MC, 2) BL, 3) PR, and 4) BP were evaluated and scored during surgery,

Table 4 Univariate Analysis of Patient-related Risk Factors for AL

Factor	Event rate %	Univariate Analysis		
		Adjusted Odds ratio	95% Confidence Interval	P Value
Age	< 65 (8.7%) ≥ 65 (4.4%)	1 0.48	(0.12–1.76)	0.274
Gender	Male (3.5%) Female (7.8%)	1 2.32	(0.56–15.7)	0.299
BMI	< 25.0 (6.0%) ≥ 25.0 (7.3%)	1 1.23	(0.26–4.67)	0.773
ASA	I (10.0%) II (6.2%) III (0.0%)	1 0.60 0.00	(0.16–2.92)	0.480 0.992
DM	Nondiabetic (6.8%) Diabetic (4.7%)	1 0.66	(0.10–2.79)	0.615
Smoking	Nonsmoker (7.4%) Smoker (0.0%)			0.991
Alcohol	Nonalcoholic (8.1%) Alcoholic (0.0%)			0.992
Preop CEA (ng/mL)	< 5.0 (8.0%) ≥ 5.0 (2.1%)	1 0.25	(0.01–1.39)	0.196
Preop Alb (g/dL)	< 3.5 (5.5%) ≥ 3.5 (6.7%)	1 1.24	(0.33–5.93)	0.764
Operation time (min)	< 120 (10.7%) ≥ 120 (5.3%)	1 0.47	(0.12–2.30)	0.298
pTNM Stage	I-II (5.4%) III-IV (7.5%)	1 1.42	(0.38–5.30)	0.592
Type of operation	LaLAR (7.0%) LaAR (5.7%) LaLHC (0.0%)	1 0.80	(0.17–3.00)	0.750 0.992
Level of anastomosis from AV (cm)	< 5 (6.7%) 5 ~ 10 (8.0%) > 10 (4.6%)	1 1.22 0.68	(0.25–6.48) (0.12–3.81)	0.804 0.643

AL Anastomotic leakage, *BMI* body mass index, *ASA* American Society of Anesthesiologists classification, *DM* Diabetes mellitus, *LaLAR* laparoscopic low anterior resection, *LaAR* laparoscopic anterior resection, *LaLHC* laparoscopic left hemicolectomy

with scores ranging from 0 to 2 points. The sum of the scores for each variable ranged from 0 to 8 points. Figure 3 shows the distribution of scores for AL (+) and AL (-).

Univariate and multivariate analyses of colonoscopy-evaluated risk factors for AL are summarized in Table 5. The univariate analyses revealed significant differences in MC 2 (P = 0.017, OR 12.86), PR 2 (P = 0.001, OR 27.64), BP 2 (p = 0.016, OR 10.50) and the sum of the scores (p = 0.001, OR 3.51). A multivariate analysis of the variables that were significant in the univariate analysis was conducted; however, the score included each variable so multivariate analysis was not appropriate.

Discussion

This study shows that applying the IOC scoring system produces a meaningful value that is reproducible and replaceable to evaluate the integrity of the anastomosis in left-sided colectomy. However, it should be emphasized that the current study design cannot determine to what extent each variable contributed to evaluate AL and this scoring system is initially designed to assess the integrity of the anastomosis site and has not superiority over conventional methods for evaluating AL.

AL after left-sided colon resection is associated with increased risks of morbidity and mortality and significantly increases the risks of anastomotic stenosis and local recurrence [19–21]. Various risk factors for AL have been reported, including patient characteristics such as male sex, positive smoking status, high BMI, and steroid use, and tumor factors such as tumor location, tumor stage, and neoadjuvant chemotherapy [2, 22]. In this study, none of the patients' characteristics, tumor factors, or surgical factors were significantly different.

Surgical techniques and intraoperative evaluation of the integrity of the anastomosis play important roles in the outcome of surgery, which affects the occurrence of AL [23]. Reliable and accurate assessment methods are needed because assessing technical defects in stapled anastomoses is important. ALs are conventionally

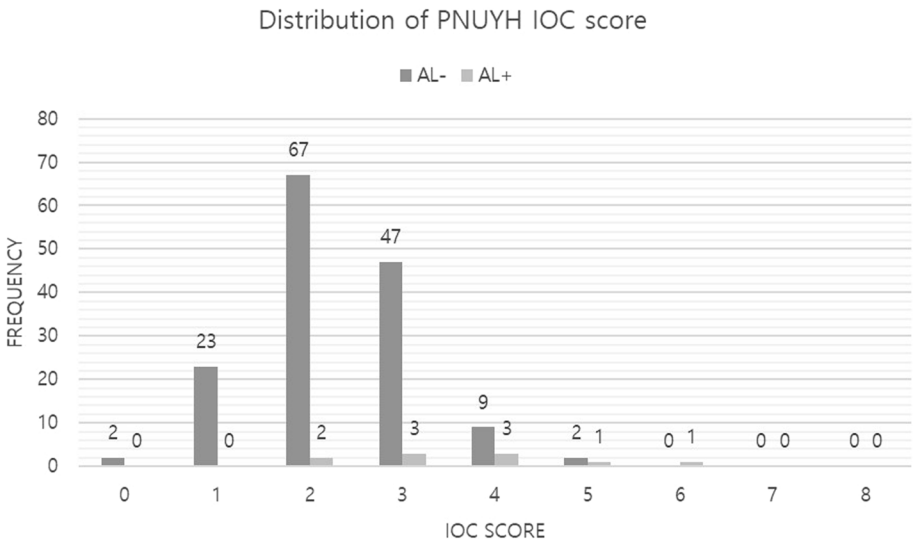

Fig. 3 Distribution of PNUYH IOC score

Table 5 Univariate and Multivariate Analysis of colonoscopy-evaluated Risk Factors for AL

Factor	Event rate %	Univariate Analysis			Multivariate Analysis		
		Adjusted Odds ratio	95% Confidence Interval	*P* Value	Adjusted Odds ratio	95% Confidence Interval	*P* Value
Mucosa Color (MC)	0 (2.2%)	1	(1.13–35.63)	0.051			
	1 (10.2%)	5.09					
	2 (22.2%)	12.86	(1.38–121.78)	0.017			
Line Bleeding (BL)	0 (7.1%)	1	(0.23–3.20)	0.811			
	1 (6.2%)	0.86					
	2 (0.0%)	0.00					
Proximal Redundancy (PR)	0 (0.0%)	1	(4.00–238.50)	0.001			
	1 (5.1%)	27.64					
	2 (60.0%)						
Bowel Preparation (BP)	0 (3.7%)	1	(0.60–11.59)	0.187			
	1 (9.1%)	2.62	(1.25–69.98)	0.016			
	2 (28.6%)	10.50					
Score	0–8	3.51	(1.84–7.57)	0.001			

MC mucosa color, *BL* stapled line bleeding, *PR* proximal redundancy, *BP* bowel preparation

identified by injecting 50 cc of air or a combination of saline solution with methylene blue through the anus using a syringe. Furthermore, several objective and reliable intraoperative methods, such as ICG fluorescence angiography, Doppler techniques, tissue oxygen tension measurement techniques, and IOC, have been developed to determine the presence of an incomplete anastomosis [10–16, 24]. Conventional procedures for detecting a leakage of an incomplete anastomosis involve an evaluation of defects in the anastomosis. However, recent studies have shown that conventional procedures do not significantly reduce the AL rate [25]. In addition, each of these studies revealed different methods for identifying AL, with varying results. This can lead to inconsistencies in detecting anastomotic failure, which can lead to different clinical outcomes and interpretations.

Surgeons can identify potential problems undetectable from conventional methods by performing a thorough assessment via colonoscopy during the surgery. These proactive approaches can reduce the morbidity associated with anastomotic failure, leading to better patient outcomes and shorter hospital stay. Ultimately, incorporating IOC score assessment through colonoscopy is critical to optimize surgical efficacy, improve recovery, and ensure long-term success of surgical interventions.

In this study, IOC factors that can be used to evaluate the integrity of anastomosis were selected and scored.

1. MC as well as the color of the proximal margin and the color of the distal margin, which are indicators of the degree of perfusion of the tissue, were scored after the anastomosis was created. There are no reliable clinical indicators for adequate perfusion, and surgeons often have to rely solely on their own judgment to evaluate the patency of the blood supply. Although MC is not always a reliable indicator, changes in the color of the anastomotic mucosa, such as the absence of mucosal bleeding at the cut-off point, can raise concerns about its appropriateness. In this study, bowel anastomoses were created after the marginal artery was confirmed to have a sufficient supply, and changes in the field of view at the 1 inch proximal and distal margins of the anastomosis observed during IOC were measured. This is the quickest way to obtain the most objective data without continuously increasing the pressure in the lumen of the large intestine. The anastomotic tissue oxygen saturation ($TSaO_2$) probe and the laser Doppler flow measurement method were suggested in a previous study, but the maneuverability of an endoscope in an actual surgical environment, not experimental, is limited [26, 27]. The narrow band image (NBI) available in the current endoscopic system also has limitations in measuring the perfusion of the anastomotic region. These endoscopic optical digitization data will be very helpful in the endoscopic evaluation of the integrity of the anastomosis in the future.
2. Stapled line bleeding (BL) was indicative of partial tissue damage caused by low perfusion and long-term hypovasularization if persistent bleeding was present [28]. Hemorrhage during the creation of a gastrointestinal anastomosis typically presents as a moderate and self-restricting condition. In some situations, the presence of symptomatic significant bleeding may be caused by ruptured or trapped blood vessels, and it may be necessary to make an effort to manage the problem. Following the completion of an end–to-end stapled anastomosis, it can be challenging to detect signs of severe bleeding, even when a rectal examination is conducted during an air leak test. Early colonoscopy can guarantee a good view of the bleeding site, providing an appropriate estimation of the blood loss volume. Fortunately, the occurrence of clinically substantial postoperative bleeding is still uncommon.
3. The assessment of tension in the anastomosis is a very important principle and seems elementary, but its significance is difficult to find in previous literature. The importance of the effect of tension on the integrity of the anastomosis has not been adequately investigated as the majority of leak experimental models evaluate bursting pressure rather than strain. Shikata et al. conducted an experimental study with canines in which they discovered that the effect of tension on submucosal blood flow was better tolerated in the small intestine than in the large intestine. These data substantiate clinical assertions that an anastomosis that is subjected to tension is more susceptible to failure [29]. Although no colorectal surgeon will purposely construct an anastomosis under excessive tension, the level of tension that will not diminish the effectiveness of the anastomosis is not known. This investigation assessed proximal redundancy (PR), which signifies a tension-free anastomosis. PR was significantly more precise and straightforward to assess than the degree of tension observed laparoscopically was.
4. Bowel preparation (BP) before colorectal surgery is a common practice to reduce bacterial levels and the risk of infection. This practice is believed to reduce the risks of postoperative infections and anastomotic leakage, but there is no evidence to support this [30]. BP is beneficial for reducing the bacterial content of the large intestine, making it easier to manipulate the large intestine during laparoscopic surgery, and facilitating lesion formation. However, there are also potential drawbacks, such as patient discomfort, electrolyte imbalance, increased length of hospital stay, and the need for additional medication to improve taste. Recent meta-analyses and systematic considerations have revealed that BP can be omitted before surgery for select colon cancer patients because it does not affect the incidence of complications [31]. However, in general, BP is still performed in many centers, including our center, at least for left-sided colon cancer, including rectal cancer, and, according to the Society for Enhanced Recovery After Surgery (ERAS), BP is considered beneficial for rectal surgery but is not routinely recommended for colon surgery [32]. In addition, a recent prospective randomized single-blind trial evaluating the role of BP in rectal resection suggested the benefits of BP before sphincter-preserving rectal surgery to reduce the anastomosis leak rate [33].

This study had several limitations. First, this was a retrospective study conducted by a single institution based on 3 year-data that included relatively small number of patients and there is a significant difference in the number of patients in the two groups compared due to the incidence rate of AL. Second, the IOC evaluation of MC in this study may be sub-

ject to considerable error by relying only on gross endoscopic findings. Third, this did not include a control group to confirm that this new method is superior to the current methods used to predict and prevent anastomotic leakage.

Conclusion

The current study suggests that IOC can be performed as a reference test to assess the integrity of the anastomosis during left-sided colorectal surgery. The IOC score, which is calculated based on colonoscopy-evaluated variables such as MC, BL, PR, and BP, was calculated by experienced surgeons. It is also simple to calculate in a clinical setting. The risk factor evaluation revealed significant results in terms of MC2, PR2, BP2 and the sum of scores; however, the retrospective analysis was limited by the small quantity of accumulated data. Further study is needed to validate the findings presented and assess the significance of each individual indicator of the IOC score.

Abbreviations

AL	Anastomotic leakage
Alb	Albumin
ALT	Air leak test
APR	Abdominoperineal resection
ASA	American Society of Anesthesiology
AV	Anal verge
BL	Stapled line bleeding
BMI	Body mass index
BP	Bowel preparation
CCRT	Concurrent chemoradation therapy
CT	Computed tomography
DM	Diabetes mellitus
EBL	Estimated blood loss
Hb	Hemoglobin
ICC	Intraclass correlation coefficient
ICG	Indocyanine green
IOC	Intraoperative colonoscopy
ISR	Intersphincteric resection
LaAR	Laparoscopic anterior resection
LaLAR	Laparoscopic low anterior resection
LaLHC	Laparoscopic left hemicolectomy
MC	Mucosa color
NBI	Narrow band image
PEG	Polyethylene glycol
PNUYH	Pusan national university Yangsan hospital
PR	Proximal redundancy
SPMC	Sodium picosulfate with magnesium citrate

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Authors' contributions

HSK designed the study, analyzed and interpreted the data, and made a draft and revised the manuscript. SHC analyzed and interpreted data and revised the manuscript. MSY BP, helped to acquire the data and performed the statistical analysis. GMS, SBP was responsible for the study's conception and design. All authors have read and approved the final manuscript.

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Data availability

The data supporting the findings of this study are not publicly accessible due to sensitivity concerns and can be obtained from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study protocol was approved by the Institutional Review Board (IRB) of Pusan National University Yangsan Hospital. (IRB No. 05–2024-108) Written informed consent forms concerning colorectal resection and intraoperative colonoscopy were obtained. The clinical trial number is not applicable to this investigation, as it is not a prospective clinical study of health outcomes.

Consent for publication

We obtained written consent to publish all the personal details included in our dataset from all participants prior to surgery.

Competing interests

The authors declare no competing interests.

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