Techniques in Coloproctology (2025) 29:83
https://doi.org/10.1007/s10151-025-03126-2

ORIGINAL ARTICLE

Oral antimicrobial prophylaxis was associated with preventing surgical site infection following 2-stage restorative proctocolectomy in patients with ulcerative colitis

Y. Horio[1] · M. Uchino[1] · Y. Tomoo[1] · K. Nomura[1] · K. Nagano[1] · K. Kusunoki[1] · R. Kuwahara[1] · K. Kimura[1] · K. Kataoka[1] · N. Beppu[1] · T. Ueda[2] · K. Ichiki[2] · K. Nakajima[2] · M. Ikeda[1] · H. Ikeuchi[1]

Received: 19 August 2024 / Accepted: 23 February 2025

Abstract

Background Surgical site infection (SSI) is a critical issue in colorectal surgery because it decreases postoperative patient quality of life. The rate of SSI in patients with ulcerative colitis (UC) receiving immunosuppressive therapy is particularly high, suggesting that the SSI rate may increase with the introduction of biologic agents.

Methods UC patients who underwent two-stage restorative proctocolectomy at our institution between April 2012 and December 2023 were included in this study. Clinical characteristics were analyzed and compared between an SSI group and a non-SSI group; possible risk factors for SSIs were also analyzed. Additionally, the following anti-SSI measures adopted at our hospital were included as explanatory variables: laparoscopic surgery, oral antibiotic prophylaxis and change of surgical instruments before wound closure.

Results In total, 501 UC surgical patients were included. The incidence of overall SSIs was 45/501 (8.9%). The rates of incisional SSIs and organ/space SSIs were 26/501 (5.1%) and 30/501 (5.9%), respectively. Oral antibiotic prophylaxis was identified as a risk factor for overall SSIs (odds ratio: 0.45, 95% CI 0.20–0.99, $p = 0.02$), incisional SSIs (odds ratio: 0.34, 95% CI 0.11–1.03, $p = 0.03$) and organ/space SSIs (odds ratio: 0.35, 95% CI 0.12–0.98, $p = 0.04$). The use of biologic and immunosuppressive agents was not associated with any SSIs.

Conclusions Nonadministration of oral antibiotic prophylaxis was identified as a risk factor for SSIs. Oral antibiotic prophylaxis before restorative proctocolectomy may improve the postoperative quality of life of UC patients by preventing SSIs.

Keywords Ulcerative colitis · Restorative proctocolectomy · Postoperative complications · Surgical site infection · Oral antibiotic prophylaxis

Abbreviations

SSI	Surgical site infection
UC	Ulcerative colitis
CD	Crohn's disease
BMI	Body mass index
ASA	American Society of Anesthesiologists
PSL	Prednisolone
Alb	Albumin
CRP	C-reactive protein
ORs	Odds ratios
Cis	Confidence intervals

✉ Y. Horio
yu-horio@hyo-med.ac.jp

1 Department of Gastroenterological Surgery, Hyogo Medical University, 1-1, Mukogawa-Cho, Nishinomiya, Hyogo 663-8501, Japan

2 Department of Infection Control and Prevention, Hyogo Medical University, Nishinomiya, Hyogo 663-8501, Japan

Introduction

Surgical site infection (SSI) is a critical issue in colorectal surgery because it decreases postoperative patient quality of life, prolongs hospital stays and increases medical costs. Furthermore, it is well known that SSI rates are higher among ulcerative colitis (UC) patients than among those who have undergone other standard colorectal surgeries [1]. The reason is that UC surgery patients generally have risk factors for SSIs, such as malnutrition, anemia and an immunosuppressed status due to medical treatment. In particular, biologics (anti-TNF agents) have been approved for the

Published online: 23 March 2025

treatment of UC since 2005 in the US and Europe and since 2010 in Japan; since then, UC treatment has undergone a major transformation over the past decade, with a decrease in the surgery rate and a decrease in the number of cancer cases reported [2, 3]. However, the preoperative administration of biologics has been reported to be a risk factor for infectious complications, including SSIs [4–6].

Some common anti-SSI measures used in colorectal surgery include intravenous antimicrobial prophylaxis, the preoperative use of clippers, closure with antimicrobial absorbent thread, wound cleansing, intraoperative warming and use of wound protectants [7, 8]. In addition to the anti-SSI measures described above, various other strategies have been reported, and we have introduced several of them. The first approach is laparoscopic surgery. Laparoscopic surgery is also recommended in the guidelines as it improves cosmesis, fertility and pregnancy outcomes [9]. However, laparoscopic surgery for UC has been reported to contribute to a decrease in SSIs in only retrospective studie [10, 11]. The second measure is oral antimicrobial prophylaxis. In a previous series, we analyzed the efficacy of oral antimicrobial prophylaxis during UC surgery [12]. Oral antimicrobial prophylaxis significantly reduced the overall incidence of SSIs. However, that study did not include cases of admininstration of biologics or laparoscopic surgery. The third strategy involves changing surgical instruments before wound closure. Based on expert consensus, the SSI guidelines of the American College of Surgeons and Surgical Infection Society recommend changing to new instruments for patients undergoing colorectal surgery [13]. However, the impact of changing surgical instruments on UC surgical cases is still unknown.

Therefore, we aimed to retrospectively investigate the clinical characteristics and risk factors for SSIs in UC patients and to determine the effectiveness of anti-SSI measures.

Materials and methods

Patient selection

UC patients who underwent restorative proctocolectomy at Hyogo Medical University between April 2012 and October 2023 were included in this study. To avoid bias due to surgical procedures, only patients who underwent two-stage restorative proctocolectomy were included. Those who underwent modified two-stage restorative proctocolectomy were not included in this series. Two-stage restorative proctocolectomy consists of total proctocolectomy with ileal j-pouch anastomosis (IPAA), which is followed by creation of a covering ileostomy and stoma closure after approximately 3 months. Modified two-stage restorative proctocolectomy is conducted by first performing subtotal colectomy with end ileostomy, and an IPAA is performed in a subsequent operation after approximately 3 months [14].

UC patients were diagnosed according to the original surgical specimens at the time of the operation. The histological features of UC included lymphocytes and plasma cells in the lamina propria; neutrophils in the lamina, crypts or surface epithelium; and changes in surface topography, epithelial damage, metaplastic changes and mucin depletion [15]. We excluded patients with a diagnosis or suspicion of Crohn's disease (CD) based on histological findings that were not included in this series. All colectomy specimens with histological features of UC and no Crohn's-like features, such as granulomas, transmural lymphoid aggregates or fissures, were identified. We also excluded pediatric patients because of the possibility of different postoperative outcomes [16].

The data collected included sex, age at onset, age at initial surgery, duration of disease, disease severity, blood parameters, overweight at body mass index (BMI) $\geq$ 25, current smoking habits, American Society of Anesthesiologists (ASA) score, diabetes (preoperatively diagnosed), total administered prednisolone (PSL) dose, immunomodulator (thiopurines, including azathioprine and 6-mercaptopurine) administration, calcineurin inhibitor (tacrolimus) administration, Janus kinase inhibitor (tofacitinib) administration, biologic (infliximab, adalimumab, golimumab and vedolizumab) administration, oral antimicrobial prophylaxis (since 2017), surgical indication (cancer/dysplasia and refractory disease), urgent/emergent or elective surgery, laparoscopic surgery (since 2018), operative time, amount of blood loss, intraoperative blood transfusion, wound class $\geq$ 3, return to operating room within 30 days, changing of surgical instruments before wound closure (from 2019 to 2020) and SSIs (within 30 days postoperatively), which were retrospectively determined from the clinical records. Severe disease was assessed primarily according to clinical features using the criteria of Truelove and Witts: six or more stools with blood and one or more of the following: hemoglobin (hb) level < 105 g/l, ESR > 30 mm/h, fever > 37.8 °C or pulse rate > 90/min [17]. Blood parameters, including the serum albumin (Alb) level, C-reactive protein (CRP) level and hemoglobin level prior to surgery, were also retrospectively obtained from the patients' clinical records. The total amount of administered corticosteroids was converted into the PSL dose and calculated based on the administered corticosteroid dose since the initial onset of UC. Patients who received immunomodulators, calcineurin inhibitors or Janus kinase inhibitors within 72 h before surgery, regardless of the dosage, were included. All infusions given within 12 weeks before surgery were considered biologically administered.

Surgical site infection

SSIs were diagnosed and recorded according to their location after total proctocolectomy and within 30 days after total proctocolectomy. In general, incisional SSIs included wound infections, whereas organ/space SSIs included abdominal or pelvic abscesses such as those involving anastomotic leakage. Incisional SSIs were detected by the presence of erythema, induration, any purulent drainage or dehiscence at the wound and the grade at which wound infections were opened at the bedside or ambulatory practice was included. Organ/space SSIs were detected by gastrografin enema, abdominal echo or computed tomography (CT) scans. SSIs were diagnosed by designated staff on our infection control team who were trained in applying surveillance methods and identifying SSIs on the basis of definitions stated in guidelines issued by the NNIS system of the Centers for Disease Control and Prevention [18]. In addition, the annual incidence rates of SSIs from 2012 to 2023 were examined.

Laparoscopic surgery

We introduced laparoscopic approaches in April 2018, with indications for laparoscopic surgery, including elective surgery and urgent surgery (such as operations for refractory disease or cancer/dysplasia), and a stable general condition. We did not perform laparoscopic surgery in emergent cases, such as those involving fulminant disease, perforation, toxic megacolon or massive bleeding.

Oral antimicrobial prophylaxis and intravenous antimicrobial prophylaxis

Oral antibiotics (500 mg of kanamycin and 500 mg of metronidazole at 2:00 p.m., 3:00 p.m. and 9:00 p.m.) and preoperative mechanical bowel preparation (1.8 l of magnesium citrate solution at 11:00 a.m.) were administered the day before surgery. These drugs were not administered to emergency surgery patients. All patients were given intravenous antimicrobial prophylaxis with second-generation cephalosporin (Flomoxef, Shionogi and Co., Japan) 30 min before surgery, with this administration repeated every 3 h during surgery; the same antibiotics were continued for 24 h following surgery.

Changing of surgical instruments before wound closure

The surgical nurse replaced the instruments used in the main surgical procedure (which included intestinal resection and/or anastomosis) with new tools before closure of the peritoneum. The new instruments, which included scissors, forceps, suction tubes, electronic scalpels, Kocher's forceps, muscle retractors, spatulas, tweezers and cups for irrigation, were prepared on a separate surgical table before starting the operation. During wound closure, none of the surgical team members touched the surgical instruments used in the main procedure.

Outcomes

The patients were classified into an SSI group or a non-SSI group. The primary outcome, which was defined by possible risk factors for SSIs in UC patients, was analyzed to identify significant predictors in UC patients. Additionally, the following anti-SSI measures adopted at our hospital were included as explanatory variables: laparoscopic surgery, oral antibiotic prophylaxis and changes in surgical instruments before wound closure. We performed a multivariate analysis of risk factors for overall SSIs, incisional SSIs and organ/space SSIs in a model with the factors identified in the univariate analysis.

Ethics approval

All study protocols were approved by the institutional review board at Hyogo Medical University (no. 4724). Written informed consent was obtained via an opt-out method, and an opt-out informed consent protocol was used for the use of participant data for research purposes.

Statistical analysis

The statistical analysis was performed as follows. For the annual SSI rate, trends were analyzed via linear regression analysis. Categorical variables were compared via the chi-square test, ANOVA or Fisher's exact test. Continuous variables are expressed herein as medians and ranges and were compared via the Mann-Whitney *U* test or ANOVA. Each of the anti-SSI measures was introduced at different times, but as mentioned above, oral antimicrobial prophylaxis and laparoscopic surgery are not used in emergency surgery. Therefore, Spearman correlation was used to validate emergency surgery, oral antimicrobial prophylaxis and laparoscopic surgery. The level of statistical significance was set at $p < 0.05$. The odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for all variables in the univariate analysis. Multivariate logistic regression analysis was performed to evaluate the risk factors for SSIs for factors with p values < 0.05. JMP version 17 (SAS Institute, Inc., Cary, NC, USA) was used to perform all analyses.

Results

Patient characteristics

We performed 717 colectomies for a preoperative diagnosis of UC. Two-stage restorative proctocolectomy was performed in 521 patients, and other procedures were excluded. In addition, four pediatric patients and 15 CD patients were excluded. Ultimately, 501 UC patients were analyzed in this series (Fig. 1).

Overall, 45/501 (8.9%) patients developed SSIs. The rates of incisional SSIs and organ/space SSIs were 26/405 (5.1%) and 30/501 (5.9%), respectively. The annual SSI incidence rates from 2012 to 2023 and the regression equations are shown in Fig. 2. Although there were differences across years, the linear regression revealed a decreasing trend in the SSIs. Conversely, there was an increasing trend in the rate of biologic administration, and the regression equation was $y = 0.9906x + 31.389$: $R^2 = 0.2168$.

The clinical characteristics of the patients were as follows (Table 1). Alb and Hb levels were significantly lower ($p < 0.01$). The proportion of severe cases tended to be greater in the SSI group, although this difference was not significant. The rate of ASA ≥ 3 was significantly greater ($p < 0.01$) among patients in the SSI group. Regarding pharmacotherapy, there were no significant differences between the SSI and non-SSI groups. The rate of oral antimicrobial prophylaxis was 9/45 (20.0%) in the SSI group and 176/456 (38.6%) in the non-SSI group. The rate of oral antimicrobial prophylaxis was significantly lower ($p < 0.01$) among patients in the SSI group. There were no significant differences between the SSI and non-SSI groups regarding the use of laparoscopic surgery and surgical instrument changes. The proportion of emergency/urgent surgeries tended to be greater in the SSI group, although this difference was not significant.

The incidence of SSIs according to the anti-SSI measures, divided into incisional SSIs and organ/space SSIs, is shown in Table 2. Oral antimicrobial prophylaxis was associated with a significantly lower incidence of SSIs for both

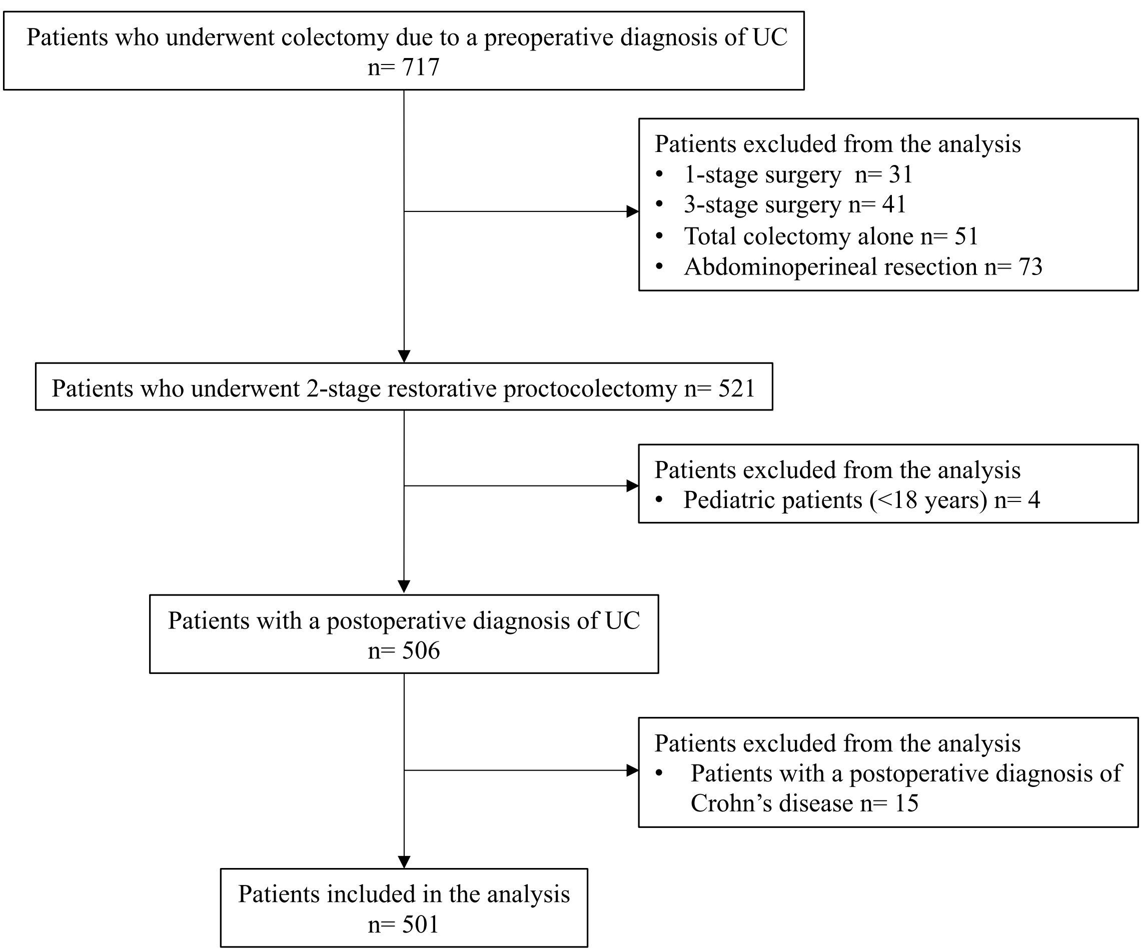

Fig. 1 UC patient flow chart

Fig. 2 Annual SSI incidence rates from 2012 to 2023. Linear regression analysis was performed for overall SSI, incisional SSI and organ/space SSI

incisional and organ/space SSIs as well as overall SSIs. The use of laparoscopic surgery and surgical instrument changes did not significantly decrease the rate of SSI. However, there was a trend toward a lower incidence of SSIs for both incisional and organ/space SSIs regarding laparoscopic surgery. Spearman's rank correlation coefficient was − 0.3128 between emergency/urgency surgery and oral antimicrobial prophylaxis and − 0.1283 between emergency/urgency surgery and laparoscopic surgery.

Outcomes

Univariate and multivariate analyses were performed to identify independent risk factors for SSIs. The results of the analyses of the risk factors potentially associated with overall SSIs are presented in Table 3. The five clinically and statistically significant factors, namely, severe disease by the criteria of Truelove and Witts, Alb level, Hb level, ASA score ≥ 3 and oral antimicrobial prophylaxis, were entered into the multivariate logistic regression analysis. Alb levels (OR = 0.52, 95% CI 0.32–0.85, $p = 0.01$) and oral antimicrobial prophylaxis (OR = 0.45, 95% CI 0.20–0.99, $p = 0.04$) were identified as independent risk factors for overall SSIs. The results of the analyses of the risk factors potentially associated with incisional SSIs and organ/space SSIs are presented in Tables 4 and 5, respectively. Alb levels (OR = 0.53, 95% CI 0.30–0.84, $p = 0.03$) and oral antimicrobial prophylaxis (OR = 0.34, 95% CI 0.18–0.93, $p = 0.03$) were identified as independent risk factors for incisional SSIs. An ASA score ≥ 3 (OR = 2.22, 95% CI 1.08–4.84, $p = 0.04$) and oral antimicrobial prophylaxis (OR = 0.35, 95% CI 0.12–0.98, $p = 0.04$) were identified as independent risk factors for organ/space SSIs.

Preoperative pharmacotherapy with PSL, immunosuppressants, calcineurin inhibitors, Janus kinase inhibitors and biologics was not identified as an independent risk factor for SSIs.

Discussion

In this study, we analyzed the risk factors for SSIs following two-stage restorative proctocolectomy in UC patients and determined the effectiveness of new anti-SSI measures. The results indicated that the overall SSI rate for UC patients who underwent two-stage restorative proctocolectomy was relatively low at 8.9% with a decreasing trend with annual changes in linear regression equations. Oral antimicrobial prophylaxis reduced the risk of SSIs and was found to be an effective anti-SSI measure.

UC patients undergoing surgery had a high risk of surgical site infection [1]. In a Japanese multicenter report,

Table 1 UC patient characteristics

Factors	Overall $n=501$	SSI group $n=45$	Non-SSI group $n=456$	p value
Male sex, n (%)	324 (64.6)	28 (62.2)	296 (64.9)	0.71
Age at surgery, years	47	49	47	0.55
Median (range)	(18–81)	(21–70)	(18–81)	
Age at surgery ≥ 65 years, n (%)	53 (10.5)	3 (6.6)	50 (10.9)	0.38
Duration of disease, months	204.5	203.9	213.5	0.06
Median (range)	(2.0–590.0)	(48.8–419.0)	(2.0–590.0)	
BMI ≥ 25, n (%)	46 (9.1)	3 (6.6)	43 (9.4)	0.78
Smoking, n (%)	45 (8.9)	5 (11.1)	40 (8.7)	0.58
Severe disease, n (%)	131 (26.1)	17 (37.7)	114 (25.0)	0.06
Alb	3.8 (0.7–5.3)	2.9 (0.7–4.7)	3.8 (1.1–5.3)	< 0.01*
Hb	11.8 (5–17.3)	10.3 (7–16.6)	12 (5–17.3)	< 0.01*
CRP	0.31 (0.0–23.8)	0.5 (0–13.7)	0.3 (0–23.8)	0.09
Pancolitis, n (%)	422 (84.2)	37 (82.2)	385 (84.4)	0.69
Cancer/dysplasia, n (%)	116 (23.1)	6 (13.3)	110 (24.1)	0.10
ASA ≥ 3, n (%)	111 (22.1)	16 (35.5)	95 (20.8)	0.02*
Diabetes, n (%)	14 (2.7)	2 (4.4)	12 (2.6)	0.36
Total PSL administration, mg	3000	2960	3042	0.31
Median (range)	(0–76,650)	(0–76,650)	(0–70,000)	
Immunosuppressant administration, n (%)	212 (42.3)	15 (33.3)	197 (43.2)	0.20
Calcineurin inhibitor administration, n (%)	75 (14.9)	9 (20.0)	66 (14.4)	0.49
Janus kinase inhibitor administration, n (%)	16 (3.1)	1 (2.2)	16 (3.5)	0.62
Biologic administration, n (%)	186 (37.1)	17 (37.7)	169 (37.0)	0.92
Oral antimicrobial prophylaxis, n (%)	185 (36.9)	9 (20.0)	176 (38.6)	0.01*
Emergent/urgent surgery, n (%)	85 (16.9)	12 (26.6)	73 (16.0)	0.06
Laparoscopic surgery, n (%)	154 (30.7)	9 (20.0)	145 (31.7)	0.10
Operative time, min	241	228	243	0.22
Median (range)	(114–674)	(133–569)	(114–674)	
Blood loss, ml	180	200	170	0.70
Median (range)	(0–2270)	(10–1020)	(0–2270)	
Wound class ≥ 3, n (%)	8 (1.6)	1 (2.2)	7 (1.5)	0.53
Changing surgical instruments, n (%)	18 (3.5)	2 (4.4)	16 (3.5)	0.74
Return to operating room within 30 days	42 (8.3)	4 (8.8)	38 (8.3)	0.89

SSI surgical site infection, *UC* ulcerative colitis, *BMI* body mass index, *Alb* albumin, *Hb* hemoglobin, *CRP* C-reactive protein, *ASA* American Society of Anesthesiologists, *PSL* prednisolone

The Mann-Whitney *U* test was performed for continuous variables

The chi-square test or Fisher's exact test was used for categorical variables

*$p < 0.05$ (indicates a significant difference)

Table 2 Incidence of surgical site infection according to SSI measures

	Oral antimicrobial prophylaxis			Laparoscopic surgery			Changing surgical instruments		
	Yes $n=185$	No $n=316$	p value	Yes $n=154$	No $n=347$	p value	Yes $n=18$	No $n=483$	p value
Overall SSIs, n (%)	9 (4.8)	36 (11.3)	0.01*	9 (5.8)	36 (10.3)	0.10	2 (11.1)	43 (8.9)	0.74
Incisional SSIs, n (%)	4 (2.1)	22 (6.9)	0.01*	4 (2.5)	22 (6.3)	0.08	2 (11.1)	24 (4.9)	0.24
Organ/space SSIs, n (%)	5 (2.7)	25 (7.9)	0.01*	5 (3.2)	25 (7.2)	0.08	0 (0)	30 (6.2)	0.27

SSI surgical site infection

Chi-square test or Fisher's exact test was used for categorical variables

*$p < 0.05$ (indicates significant difference)

Table 3 Logistic regression analysis of the risk factors for overall SSIs

Factors	Univariate		Multivariate	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Male sex	0.89 (0.47–1.67)	0.71		
Age at surgery, (10-year intervals)	1.07 (0.86–1.33)	0.51		
Duration of disease (1-month intervals)	1.33 (0.33–5.38)	0.69		
BMI ≥ 25	0.68 (0.20–2.30)	0.78		
Smoking	1.30 (0.48–3.48)	0.58		
Severe disease	1.82 (0.96–3.45)	0.06	1.24 (0.55–2.82)	0.59
Alb (1 g/dl intervals)	0.54 (0.39–0.75)	< 0.01*	0.52 (0.32–0.85)	0.01*
Hb (1 g/dl intervals)	0.86 (0.75–0.98)	0.02*	1.01 (0.84–1.21)	0.86
CRP (1 g/dl intervals)	2.23 (0.95–1.12)	0.43		
Pancolitis	0.85 (0.38–1.97)	0.69		
Cancer/dysplasia	0.48 (0.19–1.17)	0.10		
ASA ≥ 3	2.09 (1.09–4.01)	0.02*	1.89 (0.97–3.71)	0.06
Diabetes	1.72 (0.37–7.94)	0.36		
Total PSL dose (per 100 mg)	1.00 (0.99–1.00)	0.34		
Immunosuppressant administration	0.65 (0.34–1.25)	0.20		
Calcineurin inhibitor administration	0.96 (0.44–2.06	0.92		
Janus kinase inhibitor administration	0.60 (0.07–4.66)	0.62		
Biologics administration	1.03 (0.64–1.93)	0.92		
Oral antimicrobial prophylaxis	0.39 (0.18–0.84)	0.01*	0.45 (0.20–0.99)	0.04*
Emergent/urgent surgery	1.90 (0.94–3.86)	0.06		
Laparoscopic surgery	0.53 (0.25–1.14)	0.10		
Operative time (per min)	0.99 (0.99–1.00)	0.41		
Blood loss (per 100 ml)	0.99 (0.99–1.13)	0.91		
Wound class ≥ 3	1.45 (0.17–12.12)	0.53		
Changing surgical instruments	1.27 (0.28–5.74)	0.67		
Return to operating room within 30 days	1.07 (0.36–3.15)	0.89		

SSI surgical site infection, *UC* ulcerative colitis, *OR* odds ratio, *CI* confidence interval, *Alb* albumin, *ASA* American Society of Anesthesiologists, *BMI* body mass index, *CRP* C-reactive protein, *PSL* prednisolone

*$p < 0.05$ (indicates a significant difference)

the combined incidence of incisional SSIs and organ/space SSIs in UC undergoing colectomy was 19.5% [19]. Alavi et al. reported an overall SSI rate of 22.6% for inflammatory bowel disease (IBD) surgeries via the National Surgical Quality Improvement Program [20]. Preoperative pharmacotherapy as preoperative steroid administration has been widely reported as a risk factor for SSIs [21, 22]. Regarding anti-TNFα treatment, Mor et al. reported that the incidence of postoperative complications significantly increased in IBD patients who underwent restorative proctocolectomy and received anti-TNFα treatment with a 13.8-fold increase in the incidence of postoperative infection compared with that in the nontreated group [4]. Moreover, concomitant therapy with biologics and thiopurines was also reported to be associated with an increased risk of wound infections [23]. However, a recent large prospective multicenter cohort study reported that the SSI rate was approximately 12%, and preoperative anti-TNF therapy was not associated with the occurrence of postoperative infectious complications or SSIs despite the limitation of not defining a specific surgical procedure [24]. In this study, the SSI rate was relatively low at 8.9%, there was no significant difference between the SSI and non-SSI groups regarding preoperative pharmacotherapy, and it was not detected as an independent risk factor for SSI. Furthermore, despite the increasing trend in the administration rate of biologics, the SSI rate tended to decrease with an acceptable coefficient of determination. Risk factors for SSIs other than pharmacotherapy were reported and included malnutrition, ASA score ≥ 3, diabetes, current smoking habits, preoperative corticosteroids and blood loss in retrospective and prospective studies [19, 24–26]. Although diabetes, corticosteroid dose and blood loss were not risk factors in this study, the Alb level was identified as a risk factor for overall SSIs, and incisional SSIs and ASA scores ≥ 3 were identified as risk factors for organ/space SSIs. Current smoking habits was a significant factor as organ/space SSIs but not an independent factor in

Table 4 Logistic regression analysis of risk factors for incisional SSIs

Factors	Univariate		Multivariate	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Male sex	0.96 (0.42–2.21)	0.93		
Age at surgery, (10-year intervals)	1.26 (0.94–1.69)	0.11		
Duration of disease (1-month intervals)	0.99 (0.99–1.00)	0.29		
BMI ≥ 25	0.38 (0.05–2.88)	0.33		
Smoking	0	0.15		
Severe disease	1.82 (0.82–4.13)	0.14		
Alb (1 g/dl intervals)	0.50 (0.33–0.76)	< 0.01*	0.53 (0.30–0.84)	0.03*
Hb (1 g/dl intervals)	0.83 (0.70–0.98)	0.03*	0.99 (0.79–1.24)	0.95
CRP (1 g/dl intervals)	2.23 (0.95–1.12)	0.17		
Pancolitis, *n* (%)	0.85 (0.38–1.97)	0.69		
Cancer/dysplasia, *n* (%)	0.26 (0.06–1.13)	0.05		
ASA ≥ 3, *n* (%)	1.60 (0.67–3.79)	0.27		
Diabetes	1.42 (0.17–11.30)	0.53		
Total PSL dose (per 100 mg)	1.00 (0.99–1.00)	0.37		
Immunosuppressant administration	0.59 (0.25–1.38)	0.22		
Calcineurin inhibitor administration	0.91 (0.33–2.49)	0.86		
Janus kinase inhibitor administration	1.10 (0.14–8.73)	0.92		
Biologics administration	0.74 (0.31–1.74)	0.49		
Oral antimicrobial prophylaxis	0.29 (0.10–0.87)	0.01*	0.34 (0.11–1.03)	0.03*
Emergent/urgent surgery	1.50 (0.58–3.86)	0.39		
Laparoscopic surgery	0.39 (0.13–1.16)	0.08		
Operative time (per min)	0.99 (0.99–1.00)	0.52		
Blood loss (per 100 ml)	1.00 (0.87–1.19)	0.78		
Wound class ≥ 3	2.67 (0.31–22.58)	0.34		
Changing surgical instruments	2.39 (0.51–10.99)	0.24		
Return to operating room within 30 days	2.09 (0.68–6.38)	0.26		

SSI surgical site infection, *UC* ulcerative colitis, *OR* odds ratio, *CI* confidence interval, *Alb* albumin, *ASA* American Society of Anesthesiologists, *BMI* body mass index, *CRP* C-reactive protein, *PSL* prednisolone

*$p < 0.05$ (indicates a significant difference)

the multivariate analysis. We reaffirmed the strong influence of the preoperative condition on the postoperative course.

A unique feature of the present study is that, in addition to laparoscopic surgery, we added oral antimicrobial prophylaxis and changing surgical instruments as explanatory factors. Although laparoscopic surgery did not significantly reduce the risk of SSIs, the SSI rate tended to be lower in patients who underwent laparoscopic surgery. Furthermore, laparoscopic surgery has been reported to have certain advantages, such as cosmesis, early postoperative oral intake and better quality of life [27, 28]. Consequently, the introduction of laparoscopic surgery has advantages other than SSI measures. Regarding surgical instrument changes, there was no difference in the rate of SSIs. This finding parallels that of our previous study on colorectal surgery; consequently, instrument changes may not need to be performed routinely [29]. However, the results in cases limited to contaminated surgeries in IBD patients are unknown; therefore, in future studies, surgical instrument changes should be evaluated in patients with contaminated or infected wounds. Preoperative oral antibiotics have already been shown to be effective in open colorectal surgery in a Cochrane meta-analysis [30]. Reducing the number of aerobic and anaerobic microorganisms in the colon may have additional benefits for preventing SSIs [31]. Nevertheless, after minimally invasive surgery became more popular, only 36% of surgeons used oral antimicrobial prophylaxis according to a 2010 report [32]. In Japan, only 18% of facilities administer oral antimicrobial prophylaxis for colorectal surgery [33]. Recently, the benefits of preoperative oral antimicrobial therapy have been reevaluated regarding the benefits of preoperative antimicrobial therapy in general. For example, oral antimicrobial prophylaxis was reported to significantly reduce the risk of SSIs following elective laparoscopic colorectal surgery [34]. Moreover, we previously

Table 5 Logistic regression analysis of risk factors for organ/space SSIs

Factors	Univariate		Multivariate	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Male sex	0.91 (0.41–1.98)	0.81		
Age at surgery, (10-year intervals)	0.99 (0.96–1.01)	0.61		
Duration of disease (1-month intervals)	0.99 (0.99–1.00)	0.12		
BMI ≥ 25	0.69 (0.15–3.00)	0.62		
Smoking	2.76 (1.06–7.18)	0.04*	2.46 (0.90–6.67)	0.07
Severe disease	1.97 (0.92–4.21)	0.07		
Alb (1 g/dl intervals)	0.65 (0.44–0.96)	0.03*	0.73 (0.44–1.21)	0.24
Hb (1 g/dl intervals)	0.93 (0.79–1.08)	0.37		
CRP (1 g/dl intervals)	1.05 (0.96–1.14)	0.26		
Pancolitis, *n* (%)	1.23 (0.41–3.62)	0.70		
Cancer/dysplasia, *n* (%)	0.82 (0.32–2.05)	0.67		
ASA ≥ 3, *n* (%)	2.50 (1.16–5.37)	0.01*	2.22 (1.08–4.84)	0.04*
Diabetes	1.21 (0.15–9.61)	0.58		
Total PSL dose (per 100 mg)	1.00 (0.99–1.00)	0.80		
Immunosuppressant administration	0.77 (0.36–1.67)	0.51		
Calcineurin inhibitor administration	0.76 (0.28–2.03)	0.58		
Janus kinase inhibitor administration	0 (–)	0.28		
Biologics administration	0.97 (0.45–2.10)	0.95		
Oral antimicrobial prophylaxis	0.32 (0.12–0.85)	0.01*	0.35 (0.12–0.98)	0.04*
Emergent/urgent surgery	2.22 (0.98–5.05)	0.04*	1.03 (0.35–3.04)	0.95
Laparoscopic surgery	0.43 (0.16–1.15)	0.08		
Operative time (per min)	0.99 (0.99–1.00)	0.34		
Blood loss (per 100 ml)	1.02 (0.89–1.18)	0.72		
Wound class ≥ 3	2.28 (0.27–19.20)	0.39		
Changing surgical instruments	0 (−)	0.27		
Return to operating room within 30 days	1.23 (0.35–4.24)	0.74		

SSI surgical site infection, *UC* ulcerative colitis, *OR* odds ratio, *CI* confidence interval, *Alb* albumin, *ASA* American Society of Anesthesiologists, *BMI* body mass index, *CRP* C-reactive protein, *PSL* prednisolone

*$p < 0.05$ (indicates a significant difference)

reported that oral antimicrobial prophylaxis in patients with Crohn's disease contributed to the prevention of SSIs [35]. Therefore, of the three SSIs measures, oral antimicrobial prophylaxis had the strongest impact on reducing SSI in two-stage restorative proctocolectomy.

There are several limitations to the present study. First, this was a retrospective analysis performed at a single institution. Second, a problem with studies examining outcomes over a specific period is that medical practices evolve over time. Advances in UC treatments and newly developed SSI measures could be potential confounding factors. Third, the oral antimicrobial prophylaxis introduced after 2017 could have influenced the results, as it must be administered with preoperative mechanical bowel preparation on day before surgery and it could not be administered in emergency surgery cases such as perforations. However, in the present study, no strong correlation was found among emergency/urgent surgery, antibiotics and laparoscopic surgery in terms of the Spearman's rank correlation coefficient, which could be added to the multivariate analysis as an explanatory variable. Oral antimicrobial prophylaxis is difficult to administer before emergency surgery; consequently, future research should address the question of what measures should be taken to prevent SSIs in emergency surgeries with frequent infectious complications.

Conclusions

Among the three SSI-related measures, nonadministration of oral antibiotic prophylaxis was identified as a risk factor for SSIs. The use of biologic and immunosuppressive agents was not associated with any SSIs. Oral antibiotic prophylaxis during two-staged restorative proctocolectomy may outcomes of UC patients by preventing SSIs.

Author contributions Yuki Horio: conception and design of the study; acquisition, analysis and interpretation of the data; drafting of the article. Yusuke Tomoo, Kazunori Nomura, Kentaro Nagano, Kurando Kusunoki, Ryuichi Kuwahara, Kei Kimura, Kozo Kataoka, Naohito Beppu: conception and design of the study; acquisition, analysis and interpretation of the data. Kazuhiko Nakajima, Kaoru Ichiki and Takashi Ueda, SSI data acquisition (infection control team). Motoi Uchino, Masataka Ikeda, Hiroki Ikeuchi: acquisition of the data, drafting of the article and critical revision of the article for important intellectual content, and final approval.

Funding None.

Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no conflicts of interest. The authors declare that they have no competing interests.

References

1. Pendlimari R, Cima RR, Wolff BG, Pemberton JH, Huebner M (2012) Diagnoses influence surgical site infections (SSI) in colorectal surgery: a must consideration for SSI reporting programs? J Am Coll Surg 214:574–580. https://doi.org/10.1016/j.jamcollsurg.2011.12.023. (**discussion 580-571**)
2. Sandborn WJ, Rutgeerts P, Feagan BG et al (2009) Colectomy rate comparison after treatment of ulcerative colitis with placebo or infliximab. Gastroenterology 137:1250–1260
3. Alkhayyat M, Abureesh M, Gill A et al (2021) Lower rates of colorectal cancer in patients with inflammatory bowel disease using anti-TNF therapy. Inflamm Bowel Dis 27:1052–1060. https://doi.org/10.1093/ibd/izaa252
4. Mor IJ, Vogel JD, da Luz Moreira A, Shen B, Hammel J, Remzi FH (2008) Infliximab in ulcerative colitis is associated with an increased risk of postoperative complications after restorative proctocolectomy. Dis Colon Rectum 51:1202–1207. https://doi.org/10.1007/s10350-008-9364-7. (**discussion 1207-1210**)
5. Gu J, Remzi FH, Shen B, Vogel JD, Kiran RP (2013) Operative strategy modifies risk of pouch-related outcomes in patients with ulcerative colitis on preoperative anti-tumor necrosis factor-α therapy. Dis Colon Rectum 56:1243–1252. https://doi.org/10.1097/DCR.0b013e3182a0e702
6. Bregnbak D, Mortensen C, Bendtsen F (2012) Infliximab and complications after colectomy in patients with ulcerative colitis. J Crohns Colitis 6:281–286. https://doi.org/10.1016/j.crohns.2011.08.014
7. WHO Guidelines Approved by the Guidelines Review Committee Global Guidelines for the Prevention of Surgical Site Infection (2018) World Health Organization© World Health Organization 2018, Geneva
8. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM (1988) CDC definitions for nosocomial infections, 1988. Am J Infect Control 16:128–140
9. Spinelli A, Bonovas S, Burisch J et al (2022) ECCO guidelines on therapeutics in ulcerative colitis: surgical treatment. J Crohns Colitis 16:179–189. https://doi.org/10.1093/ecco-jcc/jjab177
10. Fleming FJ, Francone TD, Kim MJ, Gunzler D, Messing S, Monson JR (2011) A laparoscopic approach does reduce short-term complications in patients undergoing ileal pouch-anal anastomosis. Dis Colon Rectum 54:176–182. https://doi.org/10.1007/DCR.0b013e3181fb4232
11. Causey MW, Stoddard D, Johnson EK et al (2013) Laparoscopy impacts outcomes favorably following colectomy for ulcerative colitis: a critical analysis of the ACS-NSQIP database. Surg Endosc 27:603–609. https://doi.org/10.1007/s00464-012-2498-7
12. Oshima T, Takesue Y, Ikeuchi H et al (2013) Preoperative oral antibiotics and intravenous antimicrobial prophylaxis reduce the incidence of surgical site infections in patients with ulcerative colitis undergoing IPAA. Dis Colon Rectum 56:1149–1155. https://doi.org/10.1097/DCR.0b013e31829f71a0
13. Ban KA, Minei JP, Laronga C et al (2017) American College of Surgeons and Surgical Infection Society: surgical site infection guidelines, 2016 update. J Am Coll Surg 224:59–74. https://doi.org/10.1016/j.jamcollsurg.2016.10.029
14. Clement E, Lin W, Shojaei D, Au-Yeung P, Motamedi A, Phang PT (2024) Modified 2-stage IPAA has similar postoperative complication rates and functional outcomes compared to 3-stage IPAA. Am J Surg 231:96–99. https://doi.org/10.1016/j.amjsurg.2024.02.032
15. Dignass A, Eliakim R, Magro F et al (2012) Second European evidence-based consensus on the diagnosis and management of ulcerative colitis part 1: definitions and diagnosis. J Crohns Colitis 6:965–990. https://doi.org/10.1016/j.crohns.2012.09.003
16. Ghodasara SK, Hauser KM, Oldewurtel KM, Rolandelli RH, Nemeth ZH (2024) A comparison of clinical outcomes of colectomies for pediatric and adult patients with inflammatory bowel disease. Am Surg. https://doi.org/10.1177/00031348241256066
17. Truelove SC, Witts LJ (1955) Cortisone in ulcerative colitis; final report on a therapeutic trial. Br Med J 2:1041–1048. https://doi.org/10.1136/bmj.2.4947.1041
18. Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG (1992) CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC definitions of surgical wound infections. Infect Control Hosp Epidemiol 13:606–608
19. Araki T, Okita Y, Uchino M et al (2014) Risk factors for surgical site infection in Japanese patients with ulcerative colitis: a multicenter prospective study. Surg Today 44:1072–1078. https://doi.org/10.1007/s00595-013-0809-9
20. Alavi K, Sturrock PR, Sweeney WB et al (2010) A simple risk score for predicting surgical site infections in inflammatory bowel disease. Dis Colon Rectum 53:1480–1486. https://doi.org/10.1007/DCR.0b013e3181f1f0fd
21. Ferrante M, D'Hoore A, Vermeire S et al (2009) Corticosteroids but not infliximab increase short-term postoperative infectious complications in patients with ulcerative colitis. Inflamm Bowel Dis 15:1062–1070. https://doi.org/10.1002/ibd.20863
22. Nguyen GC, Elnahas A, Jackson TD (2014) The impact of preoperative steroid use on short-term outcomes following surgery for inflammatory bowel disease. Journal of Crohn's and Colitis 8:1661–1667

23. Waterman M, Xu W, Dinani A et al (2013) Preoperative biological therapy and short-term outcomes of abdominal surgery in patients with inflammatory bowel disease. Gut 62:387–394. https://doi.org/10.1136/gutjnl-2011-301495
24. Cohen BL, Fleshner P, Kane SV et al (2022) Prospective cohort study to investigate the safety of preoperative tumor necrosis factor inhibitor exposure in patients with inflammatory bowel disease undergoing intra-abdominal surgery. Gastroenterology 163:204–221. https://doi.org/10.1053/j.gastro.2022.03.057
25. Uchino M, Ikeuchi H, Matsuoka H, Tsuchida T, Tomita N, Takesue Y (2010) Risk factors associated with surgical site infection after ileal pouch-anal anastomosis in ulcerative colitis. Dis Colon Rectum 53:143–149. https://doi.org/10.1007/DCR.0b013e3181bb0d1d
26. Park KT, Sceats L, Dehghan M et al (2018) Risk of post-operative surgical site infections after vedolizumab vs anti-tumour necrosis factor therapy: a propensity score matching analysis in inflammatory bowel disease. Aliment Pharmacol Ther 48:340–346. https://doi.org/10.1111/apt.14842
27. Uchino M, Ikeuchi H, Horio Y et al (2024) The impacts of laparoscopic restorative proctocolectomy for ulcerative colitis: systematic review and meta-analysis. Inflamm Intest Dis 9:62–70. https://doi.org/10.1159/000535832
28. Ahmed Ali U, Keus F, Heikens JT et al (2009) Open versus laparoscopic (assisted) ileo pouch anal anastomosis for ulcerative colitis and familial adenomatous polyposis. Cochrane Database Syst Rev. https://doi.org/10.1002/14651858.CD006267.pub2
29. Kuwahara R, Uchino M, Ikeuchi H et al (2022) Effect of changing surgical instruments before wound closure to prevent wound infection in lower GI surgery: a randomized controlled trial. Dis Colon Rectum 65:100–107. https://doi.org/10.1097/dcr.0000000000002035
30. Nelson RL, Gladman E, Barbateskovic M (2014) Antimicrobial prophylaxis for colorectal surgery. Cochrane Database Syst Rev 2014:Cd001181. https://doi.org/10.1002/14651858.CD001181.pub4
31. Gillespie G, McNaught W (1978) Prohylactic oral metronidazole in intestinal surgery. J Antimicrob Chemother 4(Suppl C):29–32. https://doi.org/10.1093/jac/4.suppl_c.29
32. Markell KW, Hunt BM, Charron PD et al (2010) Prophylaxis and management of wound infections after elective colorectal surgery: a survey of the American Society of Colon and Rectal Surgeons membership. J Gastrointest Surg 14:1090–1098. https://doi.org/10.1007/s11605-010-1218-7
33. Sumiyama Y, Kusachi S, Yoshida Y et al (2006) Questionnaire on perioperative antibiotic therapy in 2003: postoperative prophylaxis. Surg Today 36:107–113. https://doi.org/10.1007/s00595-005-3112-6
34. Hata H, Yamaguchi T, Hasegawa S et al (2016) Oral and parenteral versus parenteral antibiotic prophylaxis in elective laparoscopic colorectal surgery (JMTO PREV 07–01): a phase 3, multicenter, open-label, randomized trial. Ann Surg 263:1085–1091. https://doi.org/10.1097/sla.0000000000001581
35. Uchino M, Ikeuchi H, Bando T et al (2019) Efficacy of preoperative oral antibiotic prophylaxis for the prevention of surgical site infections in patients with crohn disease: a randomized controlled trial. Ann Surg 269:420–426. https://doi.org/10.1097/sla.0000000000002567