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Use of gentamicin-collagen sponge (Collatamp® G) in minimally invasive colorectal cancer surgery: A propensity score-matched study

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Abstract

Background

Minimally invasive surgery is commonly used to treat patients with colorectal cancer, although it can cause surgical site infections (SSIs) that can affect the oncologic outcome. Use of a gentamicin-collagen sponge may help reduce the occurrence of SSIs. We aimed to determine the effectiveness of a gentamicin-collagen sponge in reducing SSIs in minimally invasive surgery for colorectal cancer.

Methods

We retrospectively reviewed the records of 310 patients who were diagnosed with colorectal cancer at our hospital and underwent minimally invasive surgery between December 1, 2018, and February 28, 2021. Propensity score matching was conducted with a 1:1 ratio using logistic regression. The primary outcome was the incidence of SSIs in the mini-laparotomy wound. The secondary endpoints were factors affecting the incidence of SSIs.

Results

After propensity score matching, 130 patients were assigned to each group. There were no differences in clinical characteristics between the two groups. SSIs occurred in 2 (1.5%) and 3 (2.3%) patients in the gentamicin-collagen sponge and control groups, respectively (p<0.999). The following factors showed a statistically significant association with SSIs: body mass index >25 kg/m^2 (odds ratio, 39.0; 95% confidence interval, 1.90–802.21; p = 0.018), liver disease (odds ratio, 254.8; 95% confidence interval, 10.43–6222.61; p = 0.001), and right hemicolectomy (odds ratio, 36.22; 95% confidence interval, 2.37–554.63; p = 0.010).

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Conclusion

Applying a gentamicin-collagen sponge to the mini-laparotomy wound did not reduce the frequency of SSIs. Further studies should be conducted on whether the selective use of gentamicin-collagen sponges may help reduce SSIs in high-risk patients.

Introduction

In patients with colorectal cancer, minimally invasive surgery reduces the hospital stay after surgery and increases patient satisfaction by reducing the incision area. A recent meta-analysis showed that minimally invasive surgery decreased the frequency of surgical site infections (SSIs) from 8.0% to 5.8% compared to open surgery (risk ratio: 0.72, 95% confidence interval [CI] 0.60–0.88) [1]; however, minimally invasive techniques cannot definitively prevent SSIs in colorectal as these are clean-contaminated operations.

The effectiveness of the gentamicin-collagen sponge in reducing SSIs has been reported in various fields of surgery, such as thoracic and orthopedic surgery [2, 3]. However, in the colorectal surgery field, a large-scale randomized control study [4] of gentamicin-containing sponges failed to prove their effectiveness. Nevertheless, a recent meta-analysis that excluded this study due to high risk of bias reported that, based on sensitivity analyses of abdominal wounds, gentamicin-collagen sponges could reduce the risk of SSI (relative risk [RR], 0.38; 95% CI, 0.20–0.72) [5].

For colorectal cancer patients, preventing SSI is important as they can affect long-term survival [6]. Few studies on whether gentamicin-collagen sponges (especially Collatamp® G (Schering-Plough, Stockholm, Sweden)) can prevent SSIs in laparoscopic colorectal cancer surgery have been performed. Therefore, we aimed to investigate the incidence of SSI after laparoscopic colorectal cancer surgery when using the Collatamp.

Materials and methods

This study was approved by the institutional review board (IRB) of the Catholic University of Korea (IRB number: UC21RISI0027). The study was performed in accordance with the relevant guidelines and regulations of the IRB. The investigation conformed with the principles outlined in the Declaration of Helsinki of 1964. Informed consent for participation was waived under IRB approval from the institutional review board of the Catholic University of Korea.

Patients

We enrolled patients who were diagnosed with colorectal cancer at our hospital and underwent minimally invasive surgery from December 1, 2018, to February 28, 2021. The prospectively collected database was analyzed retrospectively. Patients who underwent primary tumor resection via a laparoscopic or robotic approach were included in the study. The inclusion criteria were laparoscopic or robotic operations for biopsy-proven colorectal cancer and specimen extraction via mini-laparotomy wounds. The exclusion criteria were as follows: (1) open surgery, including conversion from laparoscopy; (2) transanal local resection or abdominoperineal resection for rectal cancer; (3) Hartmann's operation; (4) laparoscopic biopsy only; and (5) early postoperative mortality within 7 days.

Procedure

The bowel was prepared using a polyethylene glycol electrolyte solution (4L; CoLyte; Taejoon Pharma Co., Ltd, Seoul, Korea) if the patient had no signs of complete obstruction or perforation, and oral antibiotics for bowel preparation had not been administered before surgery. One hour preoperatively, intravenous cefoxitin 2 g was administered for prophylaxis against infection. Specimen extraction or anastomosis was performed with an additional mini-laparotomy of approximately 5 cm for all patients. For right and left hemicolectomy, an extracorporeal anastomosis was performed using a mini-laparotomy in the upper midline and left upper quadrant, respectively. For an anterior or low anterior resection, after performing an intracorporeal rectal transection, a transverse incision was created in the left lower quadrant to extract the colon and resect it with appropriate margins followed by an intracorporeal end-to-end anastomosis. Dual-ring wound protectors were used for all mini-laparotomy wounds. After closing the abdominal wall fascia, a gentamicin-collagen sponge [Collatamp®G (Schering-Plough, Stockholm, Sweden); 5 cm × 5 cm, containing 50 mg gentamicin] was inserted in the subcutaneous layer.

Definitions

In our study, we focused on SSIs at the mini-laparotomy wound because we aimed to determine the effectiveness of the Collatamp® G in preventing SSIs. An SSI was defined as a clinically reported infection of the mini-laparotomy wound occurring within 30 days of the surgery according to the Center for Disease Control and Prevention (CDC) guidelines [7].

Liver disease was defined as the presence of hepatitis B or C, or any form of liver cirrhosis.

Sealed-off perforation was defined as a perforation with a localized abscess on the preoperative computed tomography image or as an intraoperative field without free perforation (i.e., fecal contamination or dirty fluid collection in the peritoneal cavity). Microperforation was defined as postoperative pathologic findings of a perforation.

Partial obstruction was defined as inability of the colonoscope to enter an encircling lesion in a patient who could pass stool. Complete obstruction was defined as no stenting or inability to place a stent.

Progression-free survival was defined as the time from the date of surgery to the date of a diagnosis of recurrence, cancer progression, or death from any cause. The date of the last outpatient visit to the doctor in charge was the last follow-up day for progression-free survival. Overall survival was defined as the time from the date of the operation to the date of death from cancer or any cause. The last follow-up day for overall survival was the last outpatient visit to our hospital.

Outcomes

The primary outcome was the incidence of SSI in the mini-laparotomy wound. The secondary outcome were the factors that affected the development SSIs.

Statistical analysis

For comparisons between the two groups, categorized variables were analyzed using Fisher's exact test, the chi-square test, and linear-by-linear association; while continuous variables were analyzed using the Mann–Whitney test and the Student t-test. Categorized variables were expressed as numbers and percentages. Continuous variables were expressed as mean ± standard deviation. To analyze the survival in the two groups, Kaplan–Meier curves with the log-rank test were used.

Propensity-scored matching with a 1:1 ratio, using logistic regression with the nearest-neighbor method, was conducted to match the two groups. Propensity score matching was conducted using the R package MatchIt (R version 3.2.2; R Foundation for Statistical Computing, Vienna, Austria) [8]. The variables included in the matching were age, sex, height, weight, body mass index (BMI), underlying diseases (e.g., diabetes, hypertension, cardiac disease, pulmonary disease, liver disease, cerebrovascular disease), American Society of Anesthesiologists physical status classification, smoking, alcohol use, cancer location, operation name, operation type (i.e., laparoscopy or robotic), combined resection, preoperative obstruction, preoperative perforation, emergency operation, preoperative hemoglobin level, preoperative albumin level, packed red blood cell transfusion (i.e., preoperative or intraoperative), tumor stage, T stage, N stage, and M stage.

For multivariable analysis of factors affecting SSIs, logistic regression with backward stepwise selection of factors with a p-value <0.2 in the univariable analysis was performed as previously described [9, 10]. SPSS v.21 (IBM Corporation, New York, NY, USA) was used to conduct the analysis. Differences with a p-value <0.5 were considered statistically significant.

Results

After excluding 75 patients who underwent open surgery, 343 patients who underwent minimally invasive surgery from December 1, 2018, to February 28, 2021 remained. Patients who had undergone abdominoperineal resection, a Hartmann operation, or laparoscopic biopsy were excluded. Among the remaining 312 patients whose specimens were extracted through the mini-laparotomy site, 2 were excluded because they died within 7 days after surgery. Therefore, 310 patients were ultimately analyzed for the development of SSIs (Fig 1). One hundred and thirty patients and 180 patients were in the Collatamp group and the control group, respectively. The clinical characteristics of the two groups are shown in Table 1. In terms of patient characteristics, there were significantly more cases of cardiac disease in the control group before propensity score-matching; however, as with most other characteristics, there was no difference in the rates of SSIs.

After propensity score matching was conducted by correcting for covariables that affected the development SSI, 130 patients were assigned to each group. The two groups showed no significant differences in clinical characteristics (Table 2). SSIs occurred in 2 (1.5%) and 3 (2.3%) patients in the Collatamp and control groups, respectively, showing no statistically significant difference (p >0.999). The median length of hospital stay in the Collatamp and control groups was 6.7 days and 6.5 days, respectively, which was not significantly different (p = 0.568). The incidence of postoperative complications, based on the Clavien-Dindo classification, was not significantly different (p = 0.546). Over an average follow-up period of 324 days, the estimated 2-year progression-free survival was higher in the Collatamp group (92.2%) than in the control group (77.3%); however, the difference was not significant (log-rank p-value = 0.092) (Fig 2). Similarly, over an average follow-up period of 347 days, there was no significant difference in estimated 2-year overall survival between the Collatamp group (94.8%) and the control group (92.7%; log-rank p-value = 0.581) (Fig 3).

The univariable analysis for factors affecting SSI among all 310 patients revealed that liver disease (p = 0.004), perforation (p<0.001), and right hemicolectomy (p = 0.001) were all associated with the development of SSI (Table 3).

The multivariable analysis of these factors revealed that BMI >25 kg/m^2 [OR, 39.0; 95% confidence interval (CI), 1.90–802.21; p = 0.018], liver disease (OR, 254.8; 95% CI, 10.43–6222.61; p = 0.001), and right hemicolectomy (OR, 36.22; 95% CI, 2.37–554.63; p = 0.010) were independently associated with SSI (Table 4).

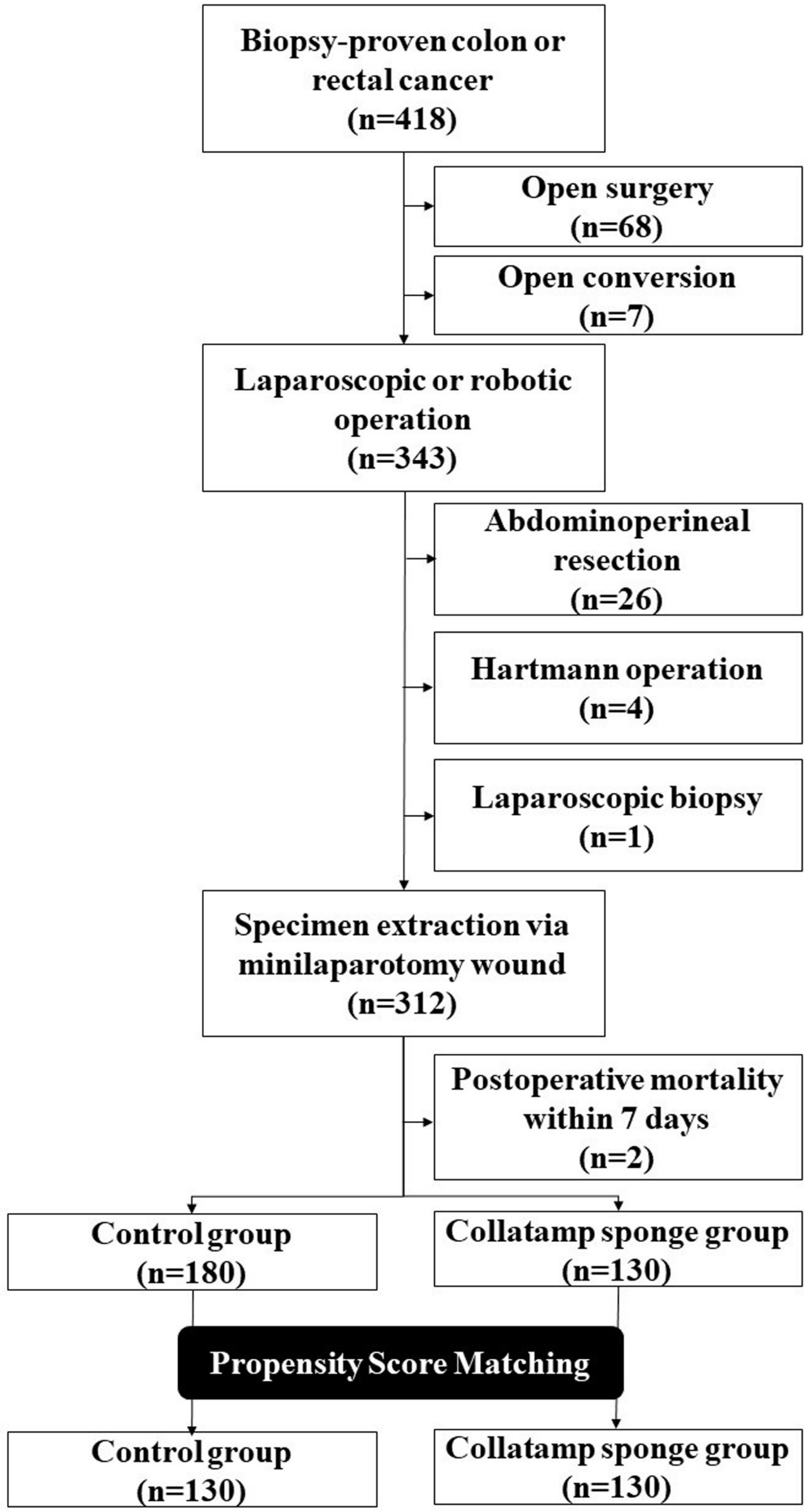

Fig 1. Flowchart of patient inclusion.

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Table 1. Patients' characteristics before propensity score-matching.

	Control group (n = 180)	Collatamp sponge group (n = 130)	p-value
Age (y)	67.7 ± 11.9	66.8 ± 11.6	0.503
Sex			0.755
Male	109 (60.6%)	81 (62.3%)	
Female	71 (39.4%)	49 (37.7%)	
Height (cm)	162.0 ± 9.2	160.9 ± 8.4	0.273
Weight (kg)	61.6 ± 11.8	61.6 ± 11.2	0.987
Body mass index (kg/m^2)	23.4 ± 3.6	23.7 ± 3.7	0.356
Underlying disease			
Hypertension	101 (56.1%)	77 (59.2%)	0.584
Diabetes	56 (31.1%)	37 (28.5%)	0.615
Cardiac disease	31 (17.2%)	9 (6.9%)	0.008
Pulmonary disease	20 (11.1%)	8 (6.2%)	0.133
Liver disease	11 (6.1%)	3 (2.3%)	0.112
Cerebrovascular disease	19 (10.6%)	14 (10.8%)	0.952
Chronic kidney disease	12 (6.7%)	8 (6.2%)	0.856
ASA classification			0.365
1	16 (8.9%)	10 (7.7%)	
2	123 (68.3%)	99 (76.2%)	
3	41 (22.8%)	21 (16.2%)	
Smoking			0.348
Ex-smoker	22 (12.2%)	13 (7.7%)	
Current smoker	27 (15.0%)	17 (13.1%)	
Alcohol			<0.001
Ex-alcoholic	2 (1.1%)	2 (1.5%)	
Current alcoholic	31 (17.2%)	5 (3.8%)	
Hemoglobin (g/dL)	12.0 ± 2.4	12.0 ± 2.3	0.875
Albumin (g/dL)	4.0 ± 0.6	3.9 ± 0.5	0.087
Cancer location			0.215
Cecum	5 (2.8%)	2 (1.5%)	
Appendix	1 (0.6%)	0	
Ascending colon	29 (16.1%)	28 (21.5%)	
Hepatic flexure	8 (4.4%)	9 (6.9%)	
Transverse colon	7 (3.9%)	12 (9.2%)	
Splenic flexure	4 (2.2%)	2 (1.5%)	
Descending colon	2 (1.1%)	5 (3.8%)	
Sigmoid colon	44 (24.4%)	29 (22.3%)	
Rectosigmoid	13 (7.2%)	4 (3.1%)	
Rectum	65 (36.1%)	38 (29.2%)	
Double primary	2 (1.1%)	1 (0.8%)	
Obstruction			0.023
None	122 (67.8%)	104 (80.0%)	
Partial	29 (16.1%)	14 (10.8%)	
Stent insertion	24 (13.3%)	10 (7.7%)	
Complete obstruction	5 (2.8%)	2 (1.5%)	
Perforation			0.505
None	165 (91.7%)	123 (94.6%)	
Microperforation	11 (6.1%)	6 (4.6%)	
Sealed-off perforation	4 (2.2%)	1 (0.8%)	

(*Continued*)

Table 1. (Continued)

	Control group (n = 180)	Collatamp sponge group (n = 130)	p-value
Operation methods			0.086
Right hemicolectomy	45 (25.1%)	51 (39.2%)	
Left hemicolectomy	7 (3.9%)	6 (4.6%)	
Anterior resection	70 (39.1%)	33 (25.4%)	
Low anterior resection	55 (30.7%)	38 (29.2%)	
Total or subtotal colectomy	2 (1.1%)	2 (1.5%)	
Combined resection			0.898
No	170 (94.4%)	122 (93.8%)	
Liver	1 (0.6%)	2 (1.5%)	
Uterus	2 (1.1%)	0	
Small bowel	1 (0.6%)	2 (1.5%)	
Stomach.	1 (0.6%)	0	
Gallbladder	1 (0.6%)	0	
Ovary	2 (1.1%)	3 (2.3%)	
Spleen	1 (0.6%)	0	
Bladder	1 (0.6%)	1 (0.8%)	
Operation type			0.078
Laparoscopic	168 (93.3%)	127 (97.7%)	
Robotic	12 (6.7%)	3 (2.3%)	
Emergency operation	8 (4.4%)	4 (3.1%)	0.538
Transfusion			
Preoperative	17 (9.4%)	13 (10.0%)	0.870
Intraoperative	25 (13.9%)	9 (6.9%)	0.053
Stage			0.362
0 (Tis)	6 (3.3%)	2 (1.5%)	
1	45 (25.0%)	31 (23.8%)	
2	41 (22.8%)	27 (20.8%)	
3	62 (34.4%)	49 (37.7%)	
4	26 (14.4%)	21 (16.2%)	
T stage			0.539
Tis	6 (3.3%)	2 (1.5%)	
1	27 (15.0%)	20 (15.4%)	
2	21 (11.7%)	15 (11.5%)	
3	97 (53.9%)	72 (55.4%)	
4a	28 (15.6%)	17 (13.1%)	
4b	1 (0.6%)	4 (3.1%)	
N stage			0.914
0	95 (52.8%)	64 (49.2%)	
1	45 (25.0%)	43 (33.1%)	
2	40 (22.2%)	23 (17.7%)	
M stage			0.782
0	153 (85.0%)	109 (83.8%)	
1	27 (15.0%)	21 (16.2%)	
Surgical site infection	6 (3.3%)	2 (1.5%)	0.475

ASA, American Society of Anesthesiologists

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Table 2. Patients' characteristics after propensity score matching.

	Control group (n = 130)	Collatamp sponge group (n = 130)	p-value
Age (y)	66.7 ± 12.0	66.8 ± 11.6	0.966
Sex			0.703
Male	78 (60.0%)	81 (62.3%)	
Female	52 (40.0%)	49 (37.7%)	
Height (cm)	161.3 ± 8.8	160.9 ± 8.4	0.716
Weight (kg)	61.4 ± 10.6	61.6 ± 11.2	0.874
BMI (kg/m^2)	23.5 ± 3.3	23.7 ± 3.7	0.638
Underlying disease			
Hypertension	72 (55.4%)	77 (59.2%)	0.531
Diabetes	36 (27.7%)	37 (28.5%)	0.890
Cardiac disease	17 (13.1%)	9 (6.9%)	0.098
Pulmonary disease	8 (6.2%)	8 (6.2%)	>0.999
Liver disease	5 (3.8%)	3 (2.3%)	0.722
Cerebrovascular disease	15 (11.5%)	14 (10.8%)	0.844
Chronic kidney disease	5 (3.8%)	8 (6.2%)	0.393
ASA classification			0.903
1	13 (10.0%)	10 (7.7%)	
2	92 (70.8%)	99 (76.2%)	
3	25 (19.2%)	21 (16.2%)	
Smoking			0.488
Ex-smoker	14 (10.8%)	13 (7.7%)	
Current smoker	19 (14.6%)	17 (13.1%)	
Alcohol use			0.131
Ex-alcoholic	2 (1.5%)	2 (1.5%)	
Current alcoholic	11 (8.5%)	5 (3.8%)	
Hemoglobin (g/dL)	12.1 ± 2.5	12.0 ± 2.3	0.667
Albumin (g/dL)	4.0 ± 0.5	3.9 ± 0.5	0.067
Cancer location			0.323
Cecum	5 (3.8%)	2 (1.5%)	
Appendix	1 (0.8%)	0	
Ascending colon	20 (15.4%)	28 (21.5%)	
Hepatic flexure	6 (4.6%)	9 (6.9%)	
Transverse colon	6 (4.6%)	12 (9.2%)	
Splenic flexure	3 (2.3%)	2 (1.5%)	
Descending colon	2 (1.5%)	5 (3.8%)	
Sigmoid colon	28 (21.5%)	29 (22.3%)	
Rectosigmoid	10 (7.7%)	4 (3.1%)	
Rectum	48 (36.9%)	38 (29.2%)	
Double primary	1 (0.8%)	1 (0.8%)	
Obstruction			0.334
None	96 (73.8%)	104 (80.0%)	
Partial	19 (14.6%)	14 (10.8%)	
Stent insertion	13 (10.0%)	10 (7.7%)	
Complete obstruction	2 (1.5%)	2 (1.5%)	
Perforation			0.518
None	121 (93.1%)	123 (94.6%)	
Microperforation	7 (5.4%)	6 (4.6%)	
Sealed-off perforation	2 (1.5%)	1 (0.8%)	

(*Continued*)

Table 2. (Continued)

	Control group (n = 130)	Collatamp sponge group (n = 130)	p-value
Operation type			0.500
Laparoscopic	124 (95.4%)	127 (97.7%)	
Robotic	6 (4.6%)	3 (2.3%)	
Emergency operation	5 (3.8%)	4 (3.1%)	>0.999
Transfusion			
Preoperative	13 (10.0%)	13 (10.0%)	>0.999
Intraoperative	10 (7.7%)	9 (6.9%)	0.812
Operation methods			0.185
Right hemicolectomy	34 (26.2%)	51 (39.2%)	
Left hemicolectomy	6 (4.6%)	6 (4.6%)	
Anterior resection	49 (37.7%)	33 (25.4%)	
Low anterior resection	40 (30.8%)	38 (29.2%)	
Total or subtotal colectomy	1 (0.8%)	2 (1.5%)	
Combined resection			0.294
No	125 (96.2%)	122 (93.8%)	
Liver	1 (0.8%)	2 (1.5%)	
Uterus	1 (0.8%)	0	
Small bowel	1 (0.8%)	2 (1.5%)	
Stomach	1 (0.8%)	0	
Ovary	0	3 (2.3%)	
Spleen	1 (0.8%)	0	
Bladder	0	1 (0.8%)	
Operation time (min)	193.2 ± 60.9	179.7 ± 66.2	0.089
Surgical site infection	3 (2.3%)	2 (1.5%)	>0.999
Clavien–Dindo classification			0.546
0	108 (83.1%)	112 (86.2%)	
1	4 (3.1%)	4 (3.1%)	
2	13 (10.0%)	10 (7.7%)	
3a	4 (3.1%)	2 (1.5%)	
3b	1 (0.8%)	2 (1.5%)	
Hospital stay (days)	6.7 ± 3.7	6.5 ± 2.4	0.568
Stage			0.607
0 (Tis)	4 (3.1%)	2 (1.5%)	
1	31 (23.8%)	31 (23.8%)	
2	29 (22.3%)	27 (20.8%)	
3	46 (35.4%)	49 (37.7%)	
4	20 (15.4%)	21 (16.2%)	
T stage			0.623
Tis	4 (3.1%)	2 (1.5%)	
1	17 (13.1%)	20 (15.4%)	
2	17 (13.1%)	15 (11.5%)	
3	74 (56.9%)	72 (55.4%)	
4a	17 (13.1%)	17 (13.1%)	
4b	1 (0.8%)	4 (3.1%)	
N stage			0.812
0	67 (51.5%)	64 (49.2%)	
1	34 (26.2%)	43 (33.1%)	
2	29 (22.3%)	23 (17.7%)	

(*Continued*)

Table 2. (Continued)

	Control group (n = 130)	Collatamp sponge group (n = 130)	p-value
M stage			0.865
0	110 (84.6%)	109 (83.8%)	
1	20 (15.4%)	21 (16.2%)	
Lymphatic invasion	35 (27.6%)	68 (52.3%)	<0.001
Venous invasion	52 (40.9%)	46 (35.4%)	0.359
Perineural invasion	44 (34.6%)	48 (36.9%)	0.703
Adjuvant chemotherapy	70 (53.8%)	67 (51.5%)	0.709

ASA, American Society of Anesthesiologists; BMI, body mass index

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A subgroup analysis of patients was performed with the factors that were statistically significant in the multivariable analysis. This analysis revealed that in patients with a BMI >25 kg/m^2, the frequency of SSI was lower in the Collatamp group [2.2% (1/84 patients)] than in the control group (7.1% (4/56)] (OR, 0.29; 95% CI, 0.03–2.68; p = 0.375). In the right hemicolectomy group, the Collatamp group [3.9% (2/51 patients)] also exhibited fewer SSIs than the control group [11.1% (5/45 patients)] (OR, 0.33; 95% CI, 0.06–1.77; p = 0.247). However, the differences in these subgroups were not significant (Table 5).

Discussion

In our study, we found that applying the Collatamp® G to the subcutaneous layer of the specimen extraction site did not affect the incidence of SSI. Therefore, no statistically significant difference in the length of stay and oncological results was observed between the two groups. Furthermore, the frequency of SSI in the Collatamp group was lower than that in the control group in a subgroup analysis of factors that affected the occurrence of SSI; however, the difference was not statistically significant.

SSI increases hospital stays and medical costs [11]. Furthermore, it can also affect a patient's quality of life [12]. Efforts are needed to reduce the incidence of SSIs in cancer patients are needed as they can also affect survival [13–15]. In particular, one study showed that in patients with colon cancer, the 5-year disease-free survival rate was significantly lower in patients with SSI (83%) than in those without (87%) [16]. Thus, various efforts to reduce SSIs are required.

To date, several reports have been published regarding the effects of the gentamicin-collagen sponge. In 2013, in a meta-analysis on the effect of gentamicin-collagen implants on SSIs in all surgical fields, Chang et al. [3] reported that the OR was 0.51 (95% CI, 0.33–0.77; p = 0.001). In another meta-analysis [2], the investigators reported that the RR in four randomized controlled trials (RCT) was 0.61 (95% CI, 0.39–0.98; p = 0.04) in reducing the sternal wound infection after inserting a gentamicin-collagen sponge into the sternal wound after heart surgery.

Various studies have also used investigated the gentamicin-collage sponge in colorectal surgery [4, 17, 18]. A large-scale RCT [4] that involved all colorectal operations performed in 54 countries failed to prove the hypothesis that the gentamicin-collagen sponge would reduce the frequency of SSI. Similarly, an RCT [18] that included 291 patients who underwent laparoscopic colorectal surgery at a single center also failed to prove the efficacy of the gentamicin-collagen sponge. However, in a recent meta-analysis [5], a sensitivity analysis of abdominal wounds revealed that a gentamicin-collagen sponge could reduce SSI in colorectal surgery (RR, 0.38; 95% CI, 0.20–0.72).

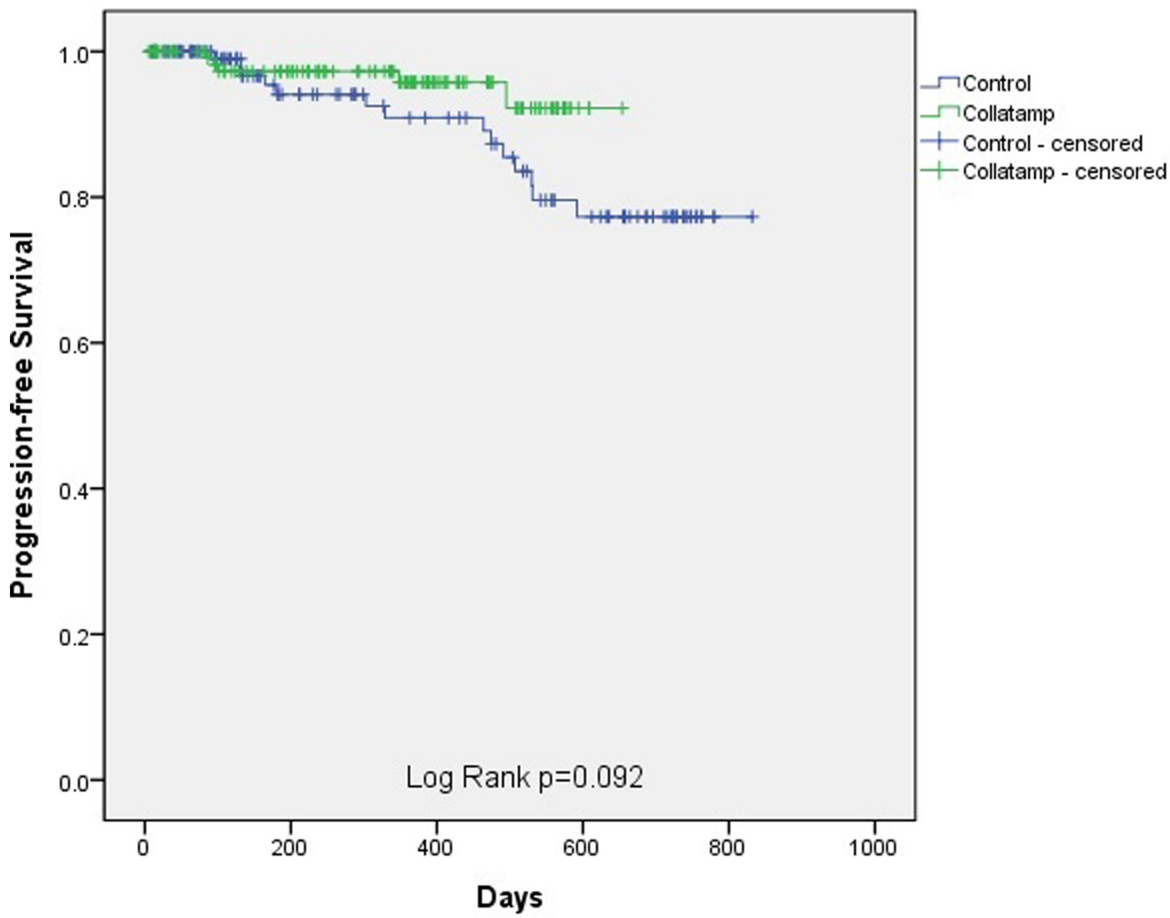

Fig 2. Progression-free survival between the Collatamp group and the control group. There was no significant difference in the estimated 2-year progression-free survival rate between the two groups (log-rank p-value = 0.092).

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With regard to this debate, we conducted a study to investigate whether the gentamicin-collagen sponge could reduce SSIs, which may affect the oncologic outcome of colon and rectal cancer; however, our study also failed to prove its efficacy.

The reason we could not demonstrate any difference between the two groups in our study was that the frequency of SSIs was low. The incidence of SSIs reported in large-scale RCTs [19–24] ranges from 3.7% to 8.9%. However, the incidence in our study was only 2.5%. This may be explained by our routine use of wound protectors. Dual-ring wound protectors have been widely used to significantly reduce SSI rates after elective surgery for colorectal cancer [25]. Another possible reason is that the sample size was insufficient for the application of the Collatamp to affect SSI. Even in the subgroup analysis, there was no significant difference between the Collatamp and control groups, which may have been due to the small sample size.

The effect of obesity on SSIs in laparoscopic colon surgery has already been demonstrated in other studies [26–28]. A meta-analysis by He et al. [28] revealed that overweightness was associated with an increased risk of SSI compared to normal weight (OR, 1.56; 95% CI 1.36–1.78; $p < 0.001$). Unlike in Western countries, the BMI cut-off for defining obesity in Asia-Pacific countries is set at 25 kg/m^2 [29]. In fact, in our study, there were only 8 patients with a BMI of 30 kg/m^2, none of which developed an SSI. Therefore, we also used the 25 kg/m^2 cut-

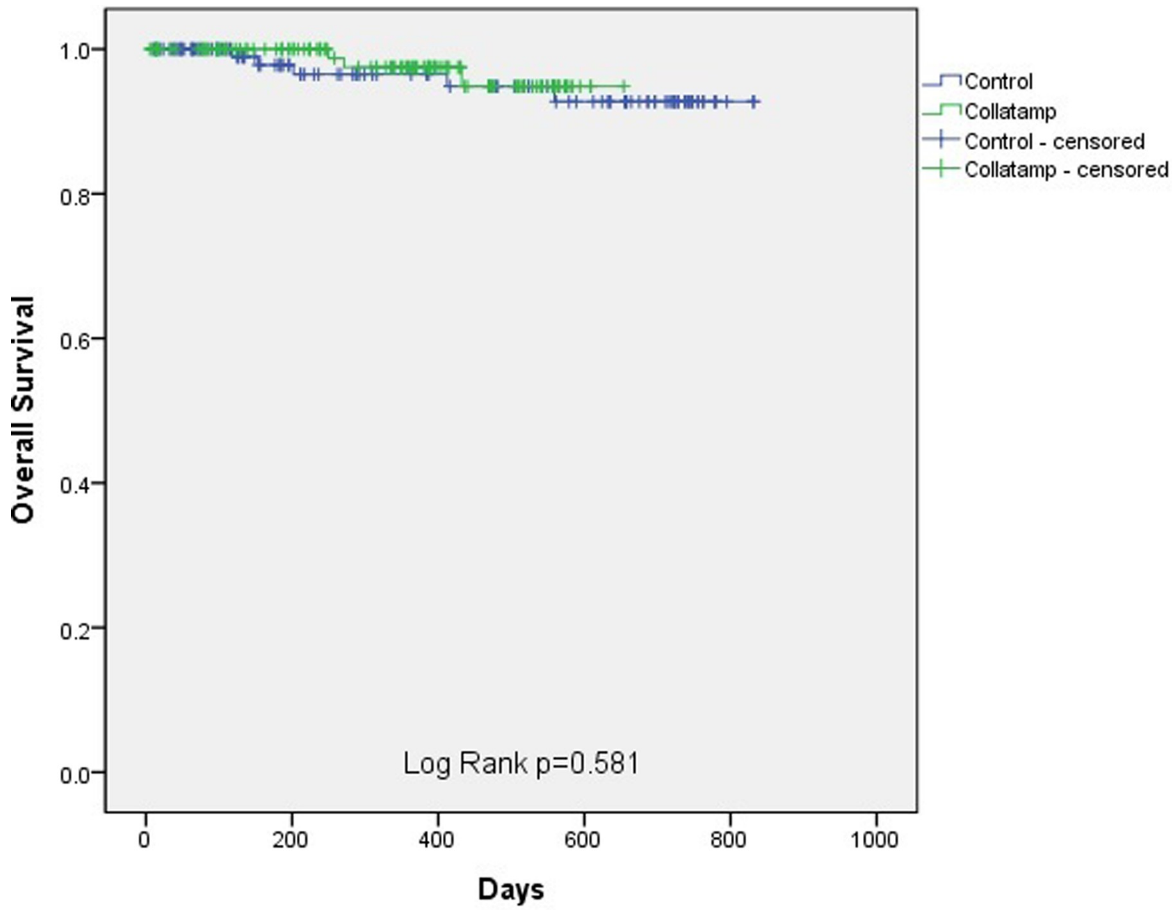

Fig 3. Overall survival between the Collatamp group and the control group. There was no significant difference in the estimated 2-year overall survival rate between the two groups (log-rank p-value = 0.581).

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off to define obesity. Among obese patients with a BMI of ≥25 kg/m^2, the incidence of SSI was significantly increased with an OR of 39.0 (95% CI, 1.90–802.21; p = 0.018). In particular, in the subgroup analysis, when the Collatamp was used in the BMI>25 kg/m^2 group, the incidence of SSIs were reduced, with an OR of 0.29 (95% CI, 0.03–2.68; p = 0.375), compared with that in patients with a BMI<25 kg/m^2; however, this difference was not statistically significant. This finding implied that the Collatamp sponge would be effective in obese patients.

When reviewing the current literature, there are few studies comparing SSIs in laparoscopic procedures such as laparoscopic right hemicolectomy or low anterior resection. Konish et al reported that the frequency of SSI was significantly higher in low anterior resection (9.5%) than in right hemicolectomy (7.5%) (p<0.001) [30]. Similarly, Degrate et al also reported that rectal surgery led to more frequent SSIs than right colonic surgery (17.6% vs 8.0%, p = 0.049) [31]. However, these studies also included open surgery. Our routine use of end-to-side anastomoses during right hemicolectomy may explain the high SSIs rates observed with this procedure in our study, where wound contamination may have occurred due to fecal spillage during insertion and withdrawal of the circular stapler through the incision. Since fecal contamination occurs when the anvil is inserted, the chances of wound contamination are lower in anterior or low anterior resection than in right hemicolectomy, which requires inserting and removing a circular stapler.

Table 3. Univariable analysis for factors that affect surgical site infection in the overall cohort (n = 310).

	No SSI (n = 302)	SSI (n = 8)	p-value
Age (y)	67.2 ± 11.5	71.3 ± 18.4	0.220
Sex			0.715
Male	186 (97.9%)	4 (2.1%)	
Female	116 (96.7%)	4 (3.3%)	
BMI (kg/m^2)			0.120
<25	205 (98.6%)	3 (1.4%)	
>25	97 (95.1%)	5 (4.9%)	
Hypertension			
None	126 (95.5%)	6 (4.5%)	0.076
Present	176 (98.9%)	6 (1.1%)	
Diabetes			
None	212 (97.7%)	5 (2.3%)	0.700
Present	90 (96.8%)	3 (3.2%)	
Cardiac disease			
None	262 (97.0%)	8 (3.0%)	0.603
Present	40 (100%)	0	
Pulmonary disease			
None	275 (97.5%)	7 (2.5%)	0.535
Present	27 (96.4%)	1 (3.6%)	
Liver disease			
None	291 (98.3%)	5 (1.7%)	0.004
Present	11 (78.6%)	3 (21.4%)	
Cerebrovascular disease			
None	269 (97.1%)	8 (2.9%)	>0.999
Present	33 (100%)	0	
Chronic kidney disease			0.417
None	283 (93.7%)	7 (87.5%)	
Present	19 (6.3%)	1 (12.5%)	
ASA classification			0.523
1	24 (92.3%)	2 (7.7%)	
2	218 (98.2%)	4 (1.8%)	
3	60 (96.8%)	2 (3.2%)	
Smoking			0.587
Nonsmoker	227 (97.0%)	7 (3.0%)	
Ex-smoker	32 (100%)	0	
Current smoker	43 (97.7%)	1 (2.3%)	
Alcohol			0.983
Nonalcoholic	263 (97.4%)	7 (2.6%)	
Ex-alcoholic	4 (100%)	0	
Current alcoholic	35 (97.2%)	1 (2.8%)	
Hemoglobin (g/dL)			0.148
<12	135 (95.7%)	6 (4.3%)	
>12	167 (98.8%)	2 (1.2%)	
Albumin (g/dL)			0.051
<3.5	57 (93.4%)	4 (6.6%)	
>3.5	245 (98.4%)	4 (1.6%)	
Obstruction			0.231

(*Continued*)

Table 3. (Continued)

	No SSI (n = 302)	SSI (n = 8)	p-value
None	223 (98.7%)	3 (1.3%)	
Partial	39 (90.7%)	4 (9.3%)	
Stent insertion	33 (97.1%)	1 (2.9%)	
Complete obstruction	7 (100%)	0	
Perforation			<0.001
None	282 (97.9%)	6 (2.1%)	
Microperforation	20 (100%)	0	
Sealed-off perforation	3 (60.0%)	2 (40.0%)	
Operation type			>0.999
Laparoscopic	287 (97.3%)	8 (2.7%)	
Robotic	15 (100%)	0	
Emergency operation			0.274
Elective	291 (98.4%)	7 (2.3%)	
Emergency	11 (91.7%)	1 (8.3%)	
Transfusion			
Preoperative			>0.999
None	272 (97.1%)	8 (2.9%)	
Done	30 (100%)	0	
Intraoperative			0.215
None	270 (97.8%)	6 (2.2%)	
Done	32 (94.1%)	2 (5.9%)	
Collatamp sponge insertion			0.475
No	174 (96.7%)	6 (3.3%)	
Yes	128 (98.5%)	2 (1.5%)	
Operation methods			0.001
Right hemicolectomy	89 (92.7%)	7 (7.3%)	
Left hemicolectomy	13 (100%)	0	
Anterior resection or low anterior resection	195 (99.5%)	1 (0.5%)	
Total or subtotal colectomy	5 (100%)	0	
Combined resection			>0.999
None	284 (97.3%)	8 (2.7%)	
Done	18 (100%)	0	
Operation time (min)	190.6 ± 66.3	201.8 ± 44.3	0.280
Stage			0.493
0 (Tis)	8 (100%)	0	
1	76 (100%)	0	
2	65 (95.6%)	3 (4.4%)	
3	106 (95.5%)	5 (4.5%)	
4	47 (100%)	0	

ASA, American Society of Anesthesiologists; BMI, body mass index

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Limitations

The first limitation of our study is its retrospective, single-center design. Because of the retrospective study design, there was a possibility of selection bias. Furthermore, the single-center setting means that our results cannot be generalized. The second limitation is that the sample size was too small to prove the efficacy of the Collatamp in laparoscopic surgery. The

Table 4. Multivariable analysis for factors that affect surgical site infection.

	Odds ratio	95% Confidence interval	p-value
BMI >25 (kg/m^2)	39.02	1.90–802.21	0.018
Albumin <3.5 (g/dL)	4.75	0.60–37.84	0.142
Liver disease	254.76	10.43–6222.61	0.001
Any type of perforation	8.86	0.51–154.74	0.135
Operation methods			0.010
AR/LAR	Reference	Reference	
Right hemicolectomy	36.22	2.37–554.63	

AR, anterior resection; BMI, body mass index; LAR, low anterior resection

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Table 5. Subgroup analysis of surgical site infection in high-risk patients.

	Control group	Collatamp sponge group	p-value
BMI (kg/m^2)			
>25	4/56 (7.1%)	1/46 (2.2%)	0.375
<25	2/124 (1.6%)	1/84 (1.2%)	>0.999
Liver disease			
None	4/169 (2.4%)	1/127 (0.8%)	0.396
Present	2/11 (18.2%)	1/3 (33.3%)	>0.999
Operation methods			
AR/LAR	1/125 (0.8%)	0/71 (0%)	>0.999
Right hemicolectomy	5/45 (11.1%)	2/51 (3.9%)	0.247

AR, anterior resection; BMI, body mass index; LAR, low anterior resection

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inadequate sample size might lead to insufficient interpretation of the study results. As mentioned previously, the lack of a sufficient sample seems to underlie the inability to confirm statistical significance, even after subgroup analysis. When the sample size was calculated based on the results of our study, 1,134 participants were needed in each group. However, when the sample size was calculated based on the results of the right hemicolectomy group, only 209 patients were needed in each group. Therefore, it would be helpful to conduct multicenter studies focusing on this high-risk group in the future.

Conclusion

We demonstrated that, in patients with colon or rectal cancer who undergo minimally invasive surgery, applying a gentamicin-collage sponge to the mini-laparotomy wound did not reduce the frequency of SSIs, even in high-risk patients. However, since the possibility of a negative result due to the small sample size cannot be excluded, further multicenter RCTs should be conducted to determine whether the selective use of the gentamicin-collagen sponge may help reduce SSIs in patients at high risk.

Author Contributions

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Writing – review & editing: Kil-yong Lee, Jaeim Lee, Youn Young Park, Seong Taek Oh.

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