Effect of Intestinal Anastomotic Procedure on Incisional Surgical Site Infection in Colon Surgery

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ABSTRACT

Purpose : Intraoperative bacterial contamination (IOBC) is a major cause of surgical site infection (SSI). We investigated whether changes in surgical procedure could reduce the rates of IOBC and SSI.

Methods : The subjects were 79 patients with colon cancer. In 34 patients, intestinal anastomosis was performed in a functional end-to-end fashion after intestinal transection (2-stage FEE group), and in the other 45 patients intestinal transection was performed after functional end-to-end anastomosis (1-stage FEE group). Three samples were obtained to assess IOBC : irrigation fluid before abdominal closure, cut sutures remaining after peritoneal closure, and subcutaneous swabs of the wound.

Results : Patients with SSI had an extremely high rate of IOBC (88.8%), and patients with IOBC also had a high rate SSI (39.5%). The incidence of IOBC with 1-stage FEE (33.3%) was lower than that with 2-stage FEE (67.3%, $p=0.01$). With 1-stage FEE, a clear demarcation on the intestinal surface could be detected more easily than with 2-stage FEE, because intestinal anastomosis with mesenteric devascularization was performed before intestinal transection.

Conclusion : One-stage FEE for intestinal anastomosis is associated with reduced rates of IOBC and SSI, probably because of the shorter exposure of the colonic mucosa than with 2-stage FEE.

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Key words : surgical site infection, bacterial contamination, functional end-to-end anastomosis, colon surgery

INTRODUCTION

Surgical site infections (SSIs) are the most frequent nosocomial infections, accounting for 38% of nosocomial infections in surgical patients, and are the third most common nosocomial infections, with an incidence of 14% to 16% among hospitalized patients[1-3]. SSIs negatively affect patient satisfaction, because of prolonged hospitalization, and are associated with substantial increases in morbidity, mortality, and healthcare costs[4,5]. Surveillance studies of SSIs have played important roles in reducing the incidence of SSI. Three types of factors have been found to affect the incidence of SSI : 1) patient factors, such as American Society of Anesthesiologists score, diabetes, smoking, obesity, steroid use, and blood transfusion ; 2) environmental factors, such as ventilation in the operating room and steriliza-

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tion of surgical instruments ; and 3) operative factors, such as operation time, wound status at the beginning of the operation, the operative approach, and operative technique[6-8]. SSIs occurs most frequently in colorectal surgery, for which the various strategies recommended to reduce the incidence of SSI include the administration of prophylactic antibiotics, bowel/chemical preparation, and appropriate surgical technique[9-13]. On the other hand, the significance of preoperative bowel preparation to reduce the incidence of SSI has recently been questioned. Given such information, we went back to fundamental viewpoint of management of intraoperative bacterial contamination (IOBC) to decrease SSI. In fact, several previous studies have found that bacterial contamination of the surgical field is a strong predictor of postoperative wound infection[14-16]. As long as bacterial contamination originates from the gut lumen, improved surgical technique may have a beneficial effect on IOBC control and may reduce wound infection. The aim of the present study was to determine whether changes in surgical procedure in colonic surgery can contribute to the control IOBC and SSI.

PATIENTS AND METHODS

The study population consisted of patients who had undergone right-sided, transverse, or left-sided colectomy for either diverticular bleeding or malignant diseases and for whom intraoperative bacterial culture specimens were collected at Machida Municipal Hospital from November 2004 through March 2008. The study was prospectively designed and retrospectively analyzed. SSI was defined as the presence of pus or discharge confirmed by a third-person within 30 days after surgery, and SSI in this study was restricted to wound infection because a primary infection originating from the abdominal cavity might have been caused by a secondary infection of the abdominal wall. In this study, none of the wounds was contaminated at the start of surgery. Patients with deep incisional or organ/space SSI, including preoperative colon perforation and postoperative anastomotic leakage, were excluded.

The study population was randomly assigned to 1 of 2 groups just before the operation. Patients who underwent intestinal anastomosis after intestinal transection were classified as the "2-stage functional end-to-end anastomosis" (2-stage FEE) group, and patients who underwent intestinal resection after mesenteric diversion and intestinal anastomosis were classified as the "1-stage functional end-to-end anastomosis" (1-stage FEE) group (Fig. 1). Informed consent was obtained from all patients before the start of the study. All operations were performed as open

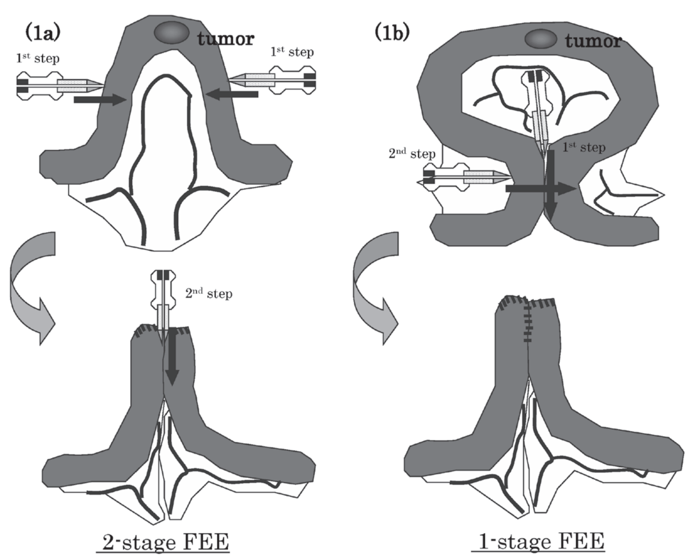

Fig. 1. Technical scheme of 1-stage FEE and 2-stage FEE
(1a) For 2-stage FEE, intestinal anastomosis is performed after mesointestinal transection. The hole for inserting the suturing device must be repaired after anastomosis. (1b) For 1-stage FEE, a side-to-side anastomosis is performed after intestinal devascularization. Intestinal resection is performed by mass transection of oral/anal intestine including the hole for inserting the suturing device. FEE : functional end-to-end anastomosis.

abdominal operations with standard procedures by well-trained specialists or junior surgeons assisted by a specialist in charge of the patient. To standardize the operative procedure, all intestinal anastomoses were performed with a single mechanical anastomotic device. All patients underwent preoperative mechanical bowel preparation with either 2 L of polyethylene glycol lavage or sodium phosphate. The decision to use preoperative oral antibiotics (levofloxacin, 300 mg for 1 day) was made by each surgeon. All patients received 1 g of cefmetazole intravenously at the time of anesthesia induction and 2 g/day for 3 consecutive days after surgery. The abdominal cavity was irrigated with a copious amount (2-6 L) of warmed saline solution before wound closure. Abdominal suction drains were used for 3 to 5 days after surgery, if necessary. The abdominal wall was closed with absorbable coated braided or monofilament surgical sutures, and the skin incision was closed with a skin stapler without subcutaneous suturing.

Three specimens were collected intraoperatively from the surgical field for bacterial cultures : the retained fluid after peritoneal lavage, fascial sutures cut after knots were tied, and subcutaneous swabs obtained after abdominal closure. IOBC was diagnosed when bacteria were detected from at least 1 of the samples obtained during surgery. Statistical analyses were performed with chi-squared tests, and $p<0.05$ was considered to indicate significance.

Results

A total of 84 patients were enrolled during the 40-month period. Patients who met the perioperative exclusion criteria (intraoperative bacterial culture not collected in 4 patients and anastomotic leakage in 1 patient) were excluded from the study. Finally, 79 patients were enrolled in the study ; 45 patients underwent 1-stage FEE, and 34 patients underwent 2-stage FEE. A comparison of the demographic characteristics, types of surgery, and other variables associated with SSI is shown in Table 1. No significant differences were observed between the groups.

The frequency of IOBC was significantly higher in patients with SSI (88.8%) than in patients without SSI (37.1% ; $P<0.001$). Similarly, SSI occurred in only 4.9% of the patients without IOBC, whereas SSI occurred in 39.5% of patients with IOBC ($P<0.001$; Fig. 2). The rate of IOBC among samples obtained intraoperatively was compared (Fig. 3). Although the frequency of IOBC was significantly higher for fluid retained after abdominal lavage than for fascial sutures cut after knots were tied or subcuta-

Table 1. Patient Demographic Characteristics and Variables

	1-stage FEE (n=45)	2-stage FEE (n=34)	P-value
Age, years (range) *mean±SD	68.8±5.9*(38-91)	68.0±4.3*(46-88)	0.492
Sex			
Male	19	19	0.229
Female	26	15	0.229
Operation performed			
Right-sided colectomy	27	19	0.236
Transverse colectomy	4	3	
Left-sided colectomy	14	12	
American Society of Anesthesiologists score			
1	40	30	0.236
2	5	3	
3	0	1	
Mechanical bowel preparation	35%	30%	0.228
Oral antibiotic administration (levofloxacin, 300 mg)	0	0	1.00
Prophyalactic antibiotics (cefmetazole)	2 g/day × 4 days	2 g/day × 4 days	N/A
Perioperative blood transfusion	4%	5%	0.863
Intraoperative blood loss (ml)	195.9	258.9	0.416
Duration of operation (min)	204	220	0.256

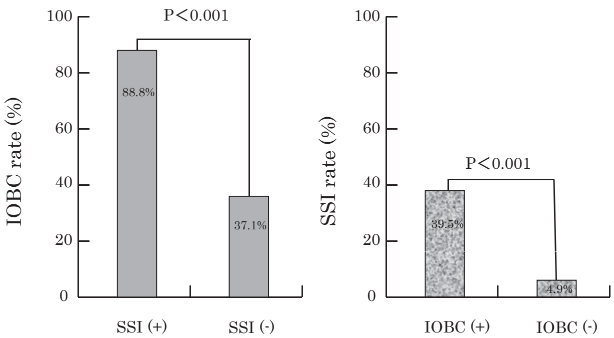

Fig. 2. Relation between the IOBC and the incidence of SSI
In patients with SSI, the rate of IOBC (88.8%) was significantly higher than that in patients without SSI ($p<0.001$). The rate of SSI was significantly lower in patients without IOBC (4.9%) than in patients with IOBC (39.5% ; $P<0.001$). SSI : surgical site infection. IOBC : intraoperative bacterial contamination.

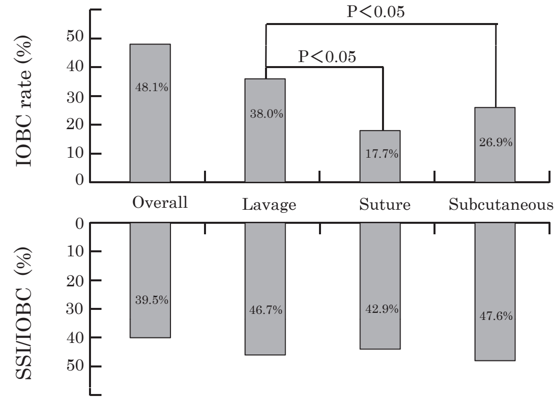

Fig. 3. IOBC rate in samples obtained intraoperatively
Samples obtained after peritoneal lavage ("Lavage") had a significantly higher rate of bacterial isolation than did samples of fascial sutures ("Suture") cut after knots were tied or subcutaneous swabs obtained after abdominal closure ("Subcutaneous"). The incidence of SSI was similar in all 3 samples : 46.7%, 42.9%, and 47.6%, respectively. SSI : surgical site infection. IOBC : intraoperative bacterial contamination.

neous swabs obtained after abdominal closure ($P<0.05$), the incidence of SSI was similar in all 3 groups and ranged from 42.9% to 47.6%.

The organisms isolated from samples collected from the surgical field were compared with those collected from SSI wounds. *Enterococcus sp.*, *Enterobacter sp.*, and *Pseudomonas aeruginosa* were isolated more frequently from the SSI wounds than from surgical fields, but the difference reached statistical significance only for *Enterococcus sp.* ($P<0.01$). In contrast, *Escherichia coli* was isolated from the surgical fields but not from SSI wounds ; however, the difference in isolation rate did not reach statistical significance (Table 2).

The rate of IOBC was significantly lower with 1-stage FEE (33.3%) than with 2-stage FEE (67.3% ; Fig. 4). Moreover, the rate of SSI was lower with 1-stage FEE than with 2-stage FEE.

Table 2. Organisms isolated intraoperatively from SSI wounds

Intraoperative isolated pathogens		Isolated organisms		*P*-value
		SSI wound (25*)	IOBC (73*)	
Gram-positive cocci				
Aerobes	*Streptococcus sp.*	2 (8%)	7 (9.6%)	NS
	Staphylococcus sp.	1 (4%)	10 (13.7%)	NS
	Enterococcus sp.	9 (36%)	5 (6.8%)	$P<0.01$
Anaerobes		1 (4%)	3 (4.1%)	NS
Gram-positive rods				
Aerobes	*Corynebacterium sp.*	0	6 (8.2%)	NS
	Bacillus	0	1 (1.4%)	NS
Anaerobes		2 (8%)	5 (6.8%)	NS
Gram-negative rods				
Aerobes	*Escherichia coli*	0	7 (9.6%)	NS
	Enterobacter sp.	2 (8%)	1 (1.4%)	NS
	Serratia	0	1 (1.4%)	NS
	Pseudomonas aeruginosa	3 (12%)	2 (2.7%)	NS
Anaerobes		5 (20%)	18 (24.7%)	NS

*Gross number of pathogens isolated from all patients

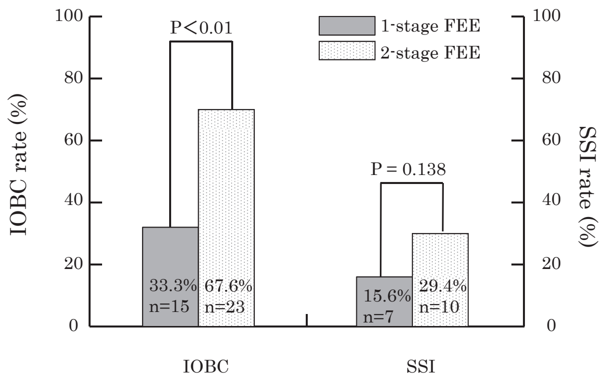

Fig. 4. Rates of IOBC and SSI in 1-stage FEE and 2-stage FEE
The IOBC rates of 1-stage FEE and 2-stage FEE were significantly different ($P<0.01$). Although the incidence of SSI with 1-stage FEE was slightly lower than that in 2-stage FEE, the difference did not reach the level of significance. FEE : functional end-to-end anastomosis. SSI : surgical site infection. IOBC : intraoperative bacterial contamination.

Discussion

Surgical stresses weaken the immune system of patients during the perioperative period, resulting in immunocompromise that predisposes to infectious complications after surgery. Therefore, managing patient factors and improving operative factors that minimize immunocompromise have traditionally been considered to have important roles in controlling SSI[6-8]. Because surgical indications have recently been expanded to include aged or high-risk patients, the ability to control patient factors is limited. Under such circumstances, to minimize bacterial contamination in the surgical field is important to reduce the occurrence of SSI, because SSI cannot occur without pathogens[14-16]. When the bowel is opened, the spillage of feculent contents can easily contaminate both the abdominal cavity and the extraperitoneal area. Once the surgical field has been contaminated, eliminating the spilled bacteria entirely is nearly impossible, regardless of the amount of the lavage fluid used. Contamination of the surgical field results in a high incidence of bacterial proliferation and growth in healing tissues, affects all processes of healing, impairs collagen synthesis, and promotes the release of proteolytic enzymes that may lead to wound complications, such as infection, delayed healing, and wound dehiscence[17,18].

Various methods, such as laparoscopic surgery and wound protectors, for reducing bacterial contamination of the surgical field have been reported[19-21]. However, the SSI rate has not yet been decreased even with such methods. Studies evaluating these methods have focused on improving immune status or protecting against bacterial contamination but not on controlling sources of contamination.

We have recently reported that the rate of SSI can be minimized with surgical techniques that reduce bacterial contamination during anterior resection and Hartmann's or Miles' operation[22]. In our previous report, the IOBC rate when the intestine was not transected before anastomosis or creation of the stoma was 50% less than when early intestinal transection was performed. The difference in IOBC rate between the surgical procedures can be explained by the degree of contamination of the abdominal cavity originating from the bowel stump. The chance of contamination presumably increases with the length of time after transaction of the bowel.

According to the beneficial effect of short-duration bowel transection on the occurrence of wound infection, 1-stage FEE has the advantage of minimizing fecal contamination time compared with 2-stage FEE for the following reasons. 1) In 2-stage FEE, bowel stumps remains for a long time in the surgical field until both bowel ends are prepared for anastomosis ; in contrast, the bowel ends are not amputated until anastomosis in 1-stage FEE. 2) In 2-stage FEE, the insertion hole for the stapling device must be repaired manually or additional bowel resection is needed after anastomosis, whereas in 1-stage FEE the insertion hole is immediately resected with the diseased intestine after anastomosis. Because the stump of the transected bowel is focally contaminated despite the use of mechanical stapling devices, it is impossible to entirely control bacterial contamination. Because the immune system is suppressed during surgery, prolonged intraoperative exposure of the abdominal cavity to feces can spread directly or hematogenously to promote infective complications, although the amount of spillage of feces from the bowel stump is small. Once the operation is finished, the immune system promptly recovers from its compromised status. Therefore, minimal intraoperative contamination can result in minimal predisposition to bacterial infection after surgery. Perioperative administration of antibiotics and postoperative recovery of the immune system can control bacterial infection, including SSI, when fecal contamination is minimal.

Other advantages of transecting the bowel during the late operative period during 1-stage FEE include visualization of ischemic demarcation that reflects bowel viability. In 2-stage FEE, additional bowel resection is sometimes needed for anastomosis when the bowel is transected with the mesentery during the early operative period ; in contrast, the transection line can easily be determined in 1-stage FEE.

The isolation rate of bacteria from the cut suture samples was lower than that from peritoneal lavage fluid or subcutaneous swabs, presumably because the sutures that we used were absorbable coated braided sutures or monofilament sutures, which are less susceptible to contamination[23]. In contrast, the organisms isolated from SSI wounds and surgical fields were different, presumably because of the use of antibiotics. Cefmetazole is preferred as a prophylactic antibiotic agent in colorectal surgery because of its high sensitivity against bacteria such as *Escherichia coli*, *Bacteroides species* (*sp*.), some anaerobes, and *Staphylococcus sp*. ; however, cefmetazole has a low antibacterial activity against *Enterococcus sp*. Thus, bacteria in healing tissue that were not eliminated by the antibiotic during the perioperative period may proliferate and overgrow.

In the present study, we found that minimizing bacterial contamination originating from the gut lumen reduced the incidence of SSI. From the point of view of infection, therefore, the bowel should not be transected until bowel anastomosis or abdominal wall closure is ready to be performed. However, performing colorectal operation while bowel continuity is retained can be somewhat awkward for surgeons. Nevertheless, patients who undergo 1-stage FEE benefit from several advantages, including secure bowel transection and a reduced risk of SSI.

Conclusion

One-stage FEE is superior to 2-stage FEE in regards to SSI, presumably because intraoperative bacterial contamination is of smaller amount and of shorter duration. To reduce the incidence of SSI, a multifaceted approach, which includes minimizing immunocompromise and thoroughly controlling bacterial contamination, is recommended.

Authors have no conflict of interest.

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