



## Technical Note

# Evaluating the outcomes of primary anastomosis with hand-sewn full-circular reinforcement in managing perforated left-sided colonic diverticulitis

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## ABSTRACT

**Background:** It is a challenge to avoid stoma formation in emergency surgery of perforated left-sided diverticulum. The hand-sewn full-circular reinforcement of the colorectal anastomosis is used during complete pelvic peritonectomy to avoid a diverting ileostomy. This study examined the effect of applying the reinforcement method to perforated left-sided colonic diverticulitis with respect to the permanent stoma rate and cost-effectiveness.

**Materials and methods:** This historical cohort study examined all patients who underwent emergency surgery for perforation of a left-sided diverticulum at the Hyogo Prefectural Amagasaki General Medical Center between July 2015 and September 2019. The cohort was divided into two groups: those who underwent conventional method (Group F) and those for whom the hand-sewn full-circular reinforcement method was actively performed (Group L).

**Results:** The number of patients who underwent emergency surgery which did not lead to an ostomy increased significantly from 12% (3/25) in Group F to 42% (11/26) in Group L ( $P = 0.0015$ ). The rate of permanent stoma decreased from 80% in Group F to 27% in Group L ( $P < 0.001$ ). Total treatment costs for patients under the age of 80 in Group L were significantly lower than those in Group F ( $2170000 \pm 1020000$  vs  $3270000 \pm 1960000$  JPY;  $P = 0.018$ ).

**Conclusions:** In emergency surgery for left-sided perforated colonic diverticulitis, applying the hand-sewn full-circle reinforcement of the anastomotic site may reduce stoma formation at the initial surgery and consequently decrease permanent stoma rate and contribute to cost-effectiveness without increasing complications such as anastomotic leakage.

## 1. Introduction

Diverticular disease is a common condition for which the number of hospitalized patients has increased 1.6 times in the last decade [1]. Among diverticular diseases, Hinchey IIb-IV with sepsis is an urgent, life-threatening condition and 8% of patients require emergency surgery [2,3]. Although surgical techniques and perioperative management have improved, mortality remains high at about 10%, and complications (Clavien-Dindo (CD) IIIb or more severe) occur in 40% of cases [4].

Recent randomized clinical trials (RCT) have shown that primary anastomosis (PA) with a diverting stoma is preferable because it is associated with fewer complications in stoma reversal [4–7]. On the

other hand, several studies have shown that a diverting stoma can be avoided even in patients with Hinchey III and IV [8–11]. Thus, various guidelines recommend PA with or without a stoma in cases with hemodynamic instability and in the absence of severe comorbidities [12–15]. However, the problem is that anastomotic leakage has been reported to occur in about 10% of simple PA without a stoma [8,10]. Under these circumstances, the simpler alternative, Hartmann procedure (HP), is still the most commonly performed procedure for left-sided diverticular perforation [1,16].

A stoma reduces patients' quality of life (QoL) [17–19]. Further, a diverting ileostomy also negatively impacts the QoL of patients, since it requires another reversal operation, imposes financial burden, and is

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associated with various well-known early and late complications [17]. In this regard, most patients and their families hope to be treated without a stoma; however, sufficient time is not taken to consult with them regarding stoma formation before emergency surgery. Accordingly, it is extremely important for surgeons to consider the post-operative QoL of patients when deciding the primary strategy of surgery [17]. Therefore, one of the challenges for the surgeons is to perform a one-step procedure while preventing stoma formation in patients with perforation of the left-sided colonic diverticulum.

In 2016, Sugarbaker reported that stoma could be avoided by reinforcing the staple line during complete pelvic peritonectomy [20]. Furthermore, another recent study showed that the hand-sewn full-circular reinforcement of the colorectal anastomosis decreases anastomotic tension, provides additional support to stapler sutures, and secures the anastomosis in case of unknown stapler errors [21]. Therefore, we hypothesized that the reinforcement method could prevent anastomotic leakage of PA performed for perforation of the left-sided colonic diverticulum. The study aims to compare the complication and permanent stoma rates in emergency surgery of cases with perforated left-sided diverticulum before and after applying the hand-sewn full-circle reinforcement of the anastomotic site. Additionally, we evaluated the economic benefits of the reinforcement method.

## 2. Methods

A historical cohort study was carried out to examine all patients who underwent emergency surgery for perforation of the left-sided diverticulum at the Hyogo Prefectural Amagasaki General Medical Centre between July 2015 and September 2019. Data were obtained from the electronic clinical records, including age, sex, body mass index (BMI), comorbidity, Hinchey classification, American Society of Anesthesiologists-physical status (ASA-PS), Sequential Organ Failure Assessment (SOFA) score, white blood cell count, serum albumin level, serum C-reactive protein level, presence or absence of stoma formation, presence or absence of PA, operation duration, bleeding volume, post-operative complications, postoperative hospital stay, hospitalization fee for emergency surgery and stoma closure, pouch cost, and total treatment cost. The appropriate ethical review board approved this study at the Amagasaki General Medical Centre (30–136). Informed consents were obtained from all individual participants included in this study.

The cohort was divided into two groups to examine the effect of PA using the reinforcement method: before (Group F) and after (Group L) applying the full-circle reinforcement of colorectal anastomosis using the double stapling technique (DST) in 2018. Additionally, patients with Hinchey III or IV were examined to evaluate the effect of PA in cases with peritonitis.

Reconstruction of the PA after colonic resection was performed using the DST. Full-circular reinforcement was performed with a hand-sewn serosal suture around the circumference of the anastomosis using 3-0 Vicryl® or 3-0 silk thread after performing the DST. The anal excision margin was also buried. Functional or hand-sewn end-to-end anastomosis (EEA) was performed in case DST was not possible.

Postoperative complications were classified according to the CD classification, and major complications were defined as a CD classification of  $\geq 3$  [22]. Sepsis as a disease severity was defined according to Sepsis 3 which indicates an acute change in the total SOFA score of  $\geq 2$  points consequent to the infection [23]. The hospitalization fee was calculated from “Diagnosis Procedure Combination” records, the bundled payment system per day based on the diagnosis group classification for acute inpatient medical care in Japan. The pouch cost per month was estimated to be 10,000 JPY, based on the average cost of pouch replacement at the hospital. In case of a permanent stoma, the pouch cost was calculated assuming that the patients lived to the average life expectancy: 81 years for men and 87 years for women. The total treatment cost was calculated by adding the hospitalization fees to the pouch costs. Additionally, the costs were separately evaluated in

patients younger than 80 years of age.

Continuous variables were analyzed using Student's t-test and are expressed as means and standard deviations. Categorical variables were analyzed using the  $\chi^2$  test and are expressed as numbers (%). All P-values were two-sided, and P-values  $<0.05$  were considered statistically significant. Statistical analysis was performed using JMP software version 8.0 (SAS Institute, Cary, NC, USA).

## 3. Results

### 3.1. Clinical characteristics

A total of 51 consecutive patients underwent emergency surgery for a perforated left-sided colonic diverticulitis during the observation period. The number of patients with Hinchey classification II, III, and IV were 17 (33%), 23 (45%), and 11 (22%), respectively. Accordingly, PA was performed in 17 cases (33%), DST in 15 patients, and EEA in two patients. The mortality and major postoperative complication rates were 26% and 6%, respectively. The rate of stoma closure was 37%, and the rate of permanent stoma was 53%. The average hospitalization fee for emergency surgery and total treatment cost were 1.74 million JPY and 2.43 million JPY, respectively. A total of 26 and 25 patients were included in Groups L and F, respectively. Table 1 shows the clinical variables of the two groups. No significant differences between the two groups were observed considering the age, sex, comorbidities, Hinchey classification, and sepsis. However, the rate of ASA-PS  $\geq 4E$  was significantly higher in Group L ( $P = 0.021$ ).

### 3.2. Differences in clinical outcomes after applying reinforcement of the anastomosis

Table 2 shows the clinical outcomes between Group L and Group F. There were no significant differences in operation duration, bleeding volume, and major postoperative complications. The length of post-operative hospital stays in Group L tended to be shorter ( $P = 0.057$ ). Further, no anastomotic leakage was observed in patients who underwent PA. The ratio of patients with PA increased significantly from 16% (4/25) in Group F to 50% (13/26) in Group L ( $P = 0.010$ ). The percentage of patients who underwent emergency surgery without stoma formation was significantly lower in Group F compared to that in Group

**Table 1**  
Clinical variables in Group L and Group F.

	Group L (n = 26)	Group F (n = 25)	P value
Age, mean $\pm$ SD	68.8 $\pm$ 12.8	71.6 $\pm$ 16.1	0.490
Gender, male	14 (54%)	10 (40%)	0.322
BMI, kg/m <sup>2</sup> , mean $\pm$ SD	23.6 $\pm$ 4.3	22.4 $\pm$ 5.3	0.388
Comorbidity, yes	17 (65%)	18 (72%)	0.229
Position of perforation, D/S/R	1 (4%)/24 (92%)/1 (4%)	3 (12%)/19 (76%)/3 (12%)	0.278
Hinchey classification, II/III/IV	10 (39%)/11 (42%)/5 (19%)	7 (28%)/12 (48%)/6 (24%)	0.725
Time from onset to surgery, 6h/6–24h/24h	5 (19%)/10 (39%)/11 (42%)	6 (24%)/8 (32%)/11 (44%)	0.864
ASA-PS, $\leq 3E/\geq 4E$	21 (81%)/5 (19%)	25 (100%)/0 (0%)	0.021*
Sepsis, yes	7 (27%)	8 (32%)	0.691
WBC count, $\times 10^9/L$ , mean $\pm$ SD	11.6 $\pm$ 7.5	10.7 $\pm$ 6.0	0.626
CRP, mg/dl, mean $\pm$ SD	12.5 $\pm$ 12.6	13.5 $\pm$ 13.4	0.781
Albumin, g/dl, mean $\pm$ SD	3.15 $\pm$ 0.72	3.05 $\pm$ 0.77	0.653
Operative time, mean $\pm$ SD	192 $\pm$ 63	191 $\pm$ 53	0.967
Bleeding volume, ml, mean $\pm$ SD	306 $\pm$ 291	330 $\pm$ 280	0.766

SD: standard deviation, D: descending colon, S: sigmoid colon, R: rectum, BMI: body mass index, ASA-PS: American Society of Anesthesiologists-physical status, WBC: white blood cell, CRP: C-reactive protein.

**Table 2**  
Comparison of clinical outcomes between Group L and Group F.

	Group L (n = 26)	Group F (n = 25)	P value
Operative time, mean $\pm$ SD	192 $\pm$ 63	191 $\pm$ 53	0.967
Bleeding volume, ml, mean $\pm$ SD	306 $\pm$ 291	330 $\pm$ 280	0.766
Major postoperative complications	5 (19%)	8 (32%)	0.296
Intrahospital death, yes	2 (8%)	1 (4%)	0.575
Postoperative hospital stay, mean $\pm$ SD	23 $\pm$ 17	38 $\pm$ 36	0.057
Primary anastomosis, yes	13 (50%)	4 (16%)	0.010*
Stoma formation, yes	15 (58%)	22 (88%)	0.015*
Closure of stoma, yes/no	8 (53%)/7 (47%)	2 (9%)/20 (91%)	0.003*
Permanent stoma, yes	7 (27%)	20 (80%)	<0.001*

SD: standard deviation.

L (12% (3/25) vs 42% (11/26);  $P = 0.015$ ). Further, the rate of stoma closure in Group L was higher than in Group F (53% (8/15) vs. 9% (2/22);  $P = 0.003$ ), and the rate of permanent stoma was lower in Group L compared to that in Group F (27% vs. 80%;  $P < 0.001$ ).

### 3.3. Differences in clinical outcomes in patients with Hinchey III or IV

Table 3 shows the clinical outcomes in patients with Hinchey III and IV. Accordingly, no anastomotic leakage was observed in patients who underwent PA. All patients in Group F underwent a stoma formation, while stoma formation was avoided 31% of cases in Group L ( $P = 0.010$ ). The rate of stoma closure was significantly higher and the rate of permanent stoma was significantly lower in Group L ( $P = 0.028$  and  $P < 0.001$ , respectively).

### 3.4. Differences in medical cost after applying reinforcement of the anastomosis

Although the hospitalization fee for emergency surgery did not vary, the total treatment cost tended to be lower in Group L, compared to that of Group F (2.20 million  $\pm$  1.00 million JPY vs. 2.77 million  $\pm$  1.71 million JPY;  $P = 0.150$ ). Further, pouch costs were significantly lower in Group L than those in Group F (0.39 million  $\pm$  0.57 million JPY vs. 1.52 million  $\pm$  1.26 million JPY;  $P = 0.008$ ). In patients under 80 years old, the total treatment costs were significantly lower in Group L than those in Group F (2.17 million  $\pm$  1.02 million JPY vs. 3.27 million  $\pm$  1.56 million JPY;  $P = 0.018$ ) (Table 4).

## 4. Discussion

In this study, the PA rate without a diverting stoma increased by

**Table 3**  
Comparison of clinical outcomes in Hinchey III and IV between Group L and Group F.

	Group L (n = 16)	Group F (n = 18)	P value
Operative time, mean $\pm$ SD	173 $\pm$ 44	182 $\pm$ 55	0.581
Bleeding volume, ml, mean $\pm$ SD	215 $\pm$ 204	274 $\pm$ 281	0.494
Major postoperative complications	4 (25%)	5 (28%)	0.855
Intrahospital death, yes	1 (6%)	1 (6%)	0.932
Postoperative hospital stay, mean $\pm$ SD	27 $\pm$ 20	35 $\pm$ 35	0.395
Primary anastomosis, yes	6 (38%)	0 (0%)	0.004*
Stoma formation, yes	11 (69%)	18 (100%)	0.010*
Closure of stoma, yes/no	6 (54%)/5 (46%)	1 (6%)/17 (94%)	0.003*
Permanent stoma, yes	5 (31%)	17 (94%)	<0.001*

SD: standard deviation.

**Table 4**  
Comparison of medical costs between Group L and Group F.

	Group L (n = 26)	Group F (n = 25)	P value
Hospitalization fee (emergency surgery), 10 <sup>4</sup> JPY, mean $\pm$ SD	170 $\pm$ 740	179 $\pm$ 95	0.704
Hospitalization fee (closure of stoma), 10 <sup>4</sup> JPY, mean $\pm$ SD	103 $\pm$ 4	79 $\pm$ 8	0.035*
Pouch cost, 10 <sup>4</sup> JPY, mean $\pm$ SD	39 $\pm$ 57	152 $\pm$ 126	0.008*
Total treatment cost, 10 <sup>4</sup> JPY, mean $\pm$ SD	220 $\pm$ 100	277 $\pm$ 171	0.150
Total treatment cost, 10 <sup>4</sup> JPY, (below age 80), mean $\pm$ SD	217 $\pm$ 102	327 $\pm$ 196	0.018*

SD: standard deviation.

applying full-circle reinforcement of the anastomotic site to PA without an increase in major postoperative complications, including anastomotic leakage. Consequently, the permanent stoma rate significantly decreased in patients who underwent emergency surgery for left-sided perforated colonic diverticulitis. This reinforcement method is mainly used for complete pelvic peritonectomy with hyperthermic perioperative chemotherapy to avoid diverting ileostomy [20,21]. The reinforcement method is technically and theoretically applicable in all cases of perforated left-sided colonic diverticulum, since perforation always occurs at the oral side of the peritoneal reflection, and the damage to the anastomotic colon caused by inflammation of the diverticular perforation is considered similar to the damage caused by hyperthermic perioperative chemotherapy. Furthermore, the reinforcement method decreases anastomotic tension, which provides additional support to stapler sutures, and secures the anastomosis in case of unknown stapler errors [21]. Additionally, we believe that with hand-sewn reinforcement, the strength of the suture can be adjusted depending on the level of intestinal oedema due to peritonitis. Consequently, we believe this method effectively reduces anastomotic leakage.

The total treatment cost tended to be lower after applying the reinforcement method, although it was not statistically significant. One reason for this is that the rate of stoma closure is higher in Group L which incurs higher costs. It has been reported that PA is more cost-effective than HP for perforated diverticulitis with purulent or fecal peritonitis [24]. In patients under 80 years old, total treatment costs were significantly lower in Group L than in Group F. Accordingly, particularly in these patients the reinforcement method might be cost-effective.

It is challenging to decide which patients should undergo PA without a diverting stoma. Low-risk patients tend to be treated with PA, whereas high-risk patients (elderly, frail, profound physiological disturbance, and sepsis) should receive HP [4,25]. In clinically stable patients with no comorbidities, PA with or without a diverting stoma is recommended [26]. With the limited evidence to date, the first suitable option would be younger patients than 80 years who do not have sepsis. In addition, it may be better to consider PA as the first choice, and a stoma should be created if there are concerns such as strong oedema.

Laparoscopic lavage was not performed in this hospital during the study period. Laparoscopic lavage and drainage without resection have been used in patients with purulent peritonitis caused by perforated colonic diverticulitis, with great potential to improve outcomes and reduce costs [27,28]. However, no significant differences in the rate of severe complications, mortality, and readmission were observed after long-term follow-ups [29–31]. Further, laparoscopic lavage compared with colectomy is associated with higher rates of secondary intervention, reoperation due to treatment failure, and intra-abdominal abscess formation [26,32].

There have been reports of laparoscopic colonic resection for diffuse peritonitis due to perforated diverticulitis, which has reduced hospital stays and had fewer complications compared to those of open surgery [33,34]. However, most patients in this review underwent laparoscopic HP, while only 20% underwent PA without a diverting ileostomy [35].

In the present study, 42% of patients underwent PA without a diverting ileostomy, and stoma formation was avoided in 85% cases with PA. Whether the hand-sewn full-circle reinforcement method can be applied laparoscopically is another matter for consideration.

This study has several limitations. This was a single-institution retrospective analysis with a small number of patients and limited clinical variables. This study did not compare PA with or without the reinforcement method. However, this is the first study to examine the full-circular reinforcement of the anastomotic site for perforated left sided colonic diverticulitis. It would be desirable to conduct an RCT to evaluate the rate of anastomosis leakage in PA. However, this trial may be difficult due to ethical issues and low number of cases. Accordingly, accumulating evidence from retrospective studies is essential. Future studies are warranted to determine whether the reinforcement method in PA helps reducing the need for a diverting ileostomy in emergency surgery for perforated left-sided colonic diverticulitis.

## 5. Conclusion

In conclusion, applying full-circular reinforcement of the anastomotic site may possibly increase the primary anastomosis rate and decrease the permanent stoma rate without increasing anastomotic leakage in patients who undergo emergency surgery for left-sided perforated colonic diverticulitis. Furthermore, it may contribute to cost-effectiveness, particularly for patients below age 80.

## Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Bioethics Committee of Amagasaki General Medical Center (No. 30–136).

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## Author contributions

Kenya Yamanaka mainly analyzed and interpreted the patient data. Hikaru Aoki was a major contributor in writing the manuscript. Data were collected and analyzed by all authors. All authors read and approved the final manuscript.

## Registration of research studies

- 1 Name of the registry: Not applicable
- 2 Unique Identifying number or registration ID:
- 3 Hyperlink to your specific registration (must be publicly accessible and will be checked):

## Guarantor

The Guarantor is Kenya Yamanaka in this paper.

## Funding sources

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## Consent to participate

Written informed consent was obtained from the patient for publication. A copy of the written consent is available for review by the

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## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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