Original Article

A Comparison between Hartmann's Procedure, Primary Anastomosis, and Primary Anastomosis with Defunctioning Stoma in Hinchey III and IV Diverticulitis

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Key Words
Perforated diverticulitis;
Hartmann's procedure;
Primary anastomosis;
Postoperative complications;
Mortality rate

Purpose. Complicated perforated colon diverticulitis (Hinchey stages III and IV) is an emergent condition that requires an operation, such as Hartmann's procedure or primary anastomosis, with or without a defunctioning stoma. Mortality, postoperative complications, and ostomy takedown rates remain debatable among these three groups. This retrospective study aimed to compare patients who underwent Hartmann's procedure in our hospital with those who underwent primary anastomosis, with or without a dysfunctioning stoma.

Methods. This study analyzed 26 patients, categorizing them into Hartmann's procedure and primary anastomosis groups with and without a defunctioning stoma. Patient mortality rate, postoperative complication rate, operation time, hospital stay, and surgical reintervention rates were compared.

Results. Lesion location, American Society of Anesthesiologist score, peri-operative shock status, blood loss, intensive care unit stay time, complication rate, and mortality rate were not statistically different between the three groups. However, the Hartmann's procedure group demonstrated a statistical difference with greater age, fecal peritonitis rate, and Hinchey stage IV rates, and lower ostomy takedown rate but the least operation time. The primary anastomosis without a defunctioning stoma group demonstrated shorter hospital stays. Selection bias may have influenced these results.

Conclusion. Hartmann's procedure remained crucial for unstable patients with acute complicated perforated colonic diverticulitis, particularly those at high risk of colostomy reversal failure. Our statistical analysis revealed that primary anastomosis, with or without stoma, could serve as a variable alternative option, provided the patient's condition remains stable during emergency surgery. This approach demonstrated non-inferior operative morbidity/mortality rate and hospital stays, along with a better rate of successful stoma reversal.

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Diverticulitis is a colonic diverticular inflammation, which may be acute or chronic, simple or complicated due to the presence of abscesses, fistulas, bowel obstruction, or free perforation.[1] Diverticulitis develops in 4%-15% of patients with diverticular disease. Diverticulosis-induced peritonitis is caused by purulency (Hinchey stage III) (Fig. 1) or fecal material (Hinchey stage IV) (Fig. 2) with diverticular perforation (occurring in 1% of patients).[1]

Traditional surgical treatment of perforated diverticulitis includes segmental resection of the affected colon with temporary end colostomy and distal stump closure, traditionally known as Hartmann's procedure (HP). Whether or not to proceed with HP or primary anastomosis after colectomy with (PADS) or without defunctioning stoma (PA), remains debatable.[1] Over the past few decades, a large amount of colorectal literature has focused on reporting outcomes related to all of these options.[2]

Identifying the treatment modality with minimal mortality and morbidity is beneficial and important, considering that patients with Hinchey stages III and IV are frequently in a physiologically poor situation that requires emergency surgery and therefore are at high risk.

This study aimed to compare the outcomes after HP, PA, and PADS in patients with purulent perforated diverticulitis and fecal peritonitis perforated diverticulitis at our hospital.

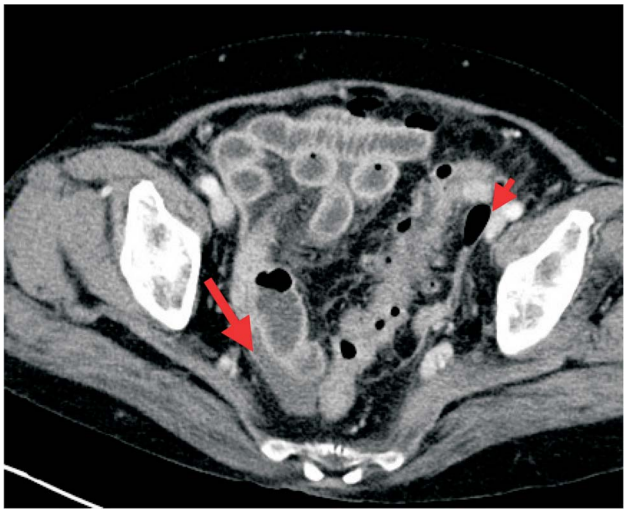

Fig. 1. An axial view of a abdominal computed tomography showed Hinchey stage III diverticulitis with generalized purulent peritonitis (big arrow) and perforation (small arrow).

Materials and Methods

This retrospective study was conducted at the Department of Surgery of Chia-Yi Christian Hospital. Coloproctological subspecialists at the Division of Colon and Rectal Surgery performed all surgeries. All patients were followed up at the outpatient department postoperatively until the wounds were healed, including those after the reversal of HP or protective loop ileostomy and those who did not require or were unable to proceed with reversal operation. This study enrolled 26 patients with Hinchey stages III and IV perforated diverticulitis under emergent segmental resection with PA, PADS, or HP from February 2017 to July 2023.

The patients were categorized into three groups, including HP (n = 5), PA (n = 14), and PADS (n = 7). The following data were collected for each patient: age, sex, body mass index (BMI), lesion location, fecal peritonitis, hemoglobin (HB), C-reactive protein (CRP) level, white blood cells (WBC), Hinchey stage, previous diverticulitis and abdominal surgery, the American Society of Anaesthesiologist (ASA) grade, shock during operation, surgical approach (open/laparoscopic), anastomotic type, anastomotic device,

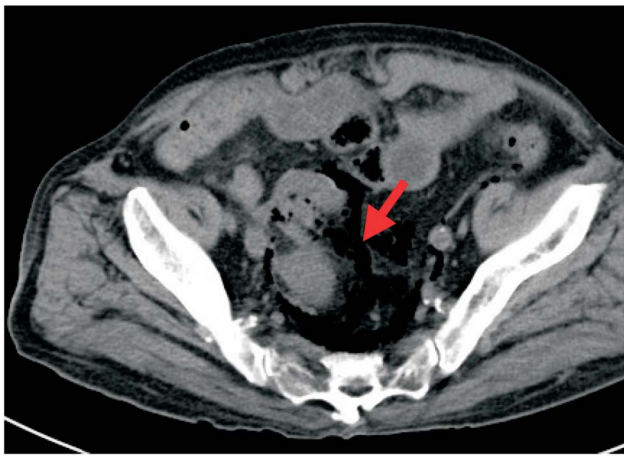

Fig. 2. An axial view of a abdominal computed tomography showed Hinchey stage IV diverticulitis with generalized fecal peritonitis (red arrow).

stoma type, intraoperative lavage (whole abdomen irrigation), blood loss volume (ml), blood transfusion red blood cells (u), blood transfusion fresh frozen plasma (u), operation time, hospital stay, intensive care unit (ICU) stay, inotropic use postoperatively, time until low residual diet, complications, surgical reintevention, morbidity at 30 days, morbidity at > 30 days, mortality at 30 days, readmission rate (in 30 days), Clavien-Dindo classification for grading, and complications. We collected ostomy takedown rate, complication rates after ostomy closure, hospital stay (second time), operation time (second time), 12-month stoma-free survival (day), total operation time, and total hospital stay (day) in the HP and PADS groups. Postoperative complications were those that occurred intraoperatively until the day of discharge from the hospital. Postoperative mortality was the death within 30 days of surgery or death as a direct result of postoperative complications.

All data are reported as the mean standard deviation or median (minimum and maximum) for continuous variables and as the numbers and percentages for categorical variables. Student's t-test was used for comparisons of continuous data between the groups, and the x2-test or Fisher's exact test was utilized for comparisons of the categorical data, as deemed appropriate. Statistical Package for the Social Sciences for Windows version 21.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. A p-value of < 0.05 was considered to indicate statistical significance.

Results

This study included 26 patients with Hinchey stage III and IV acute perforated diverticulitis who underwent surgery from February 2017 to July 2023, including 5, 14, and 7 patients who underwent HP, PA, and 7 PADS, respectively.

Table 1 summarizes the characteristics of these patients. Among these patients, 15 (57%) were males and 11 (43%) were females. There was a significant difference in patients' age, BMI, fecal peritonitis rate, and Hinchey stage (Table 1). All of the PA was Hinchey stage III, whereas most of the patient in HP and PADS was Hinchey stage IV, in terms of Hinchey stage. Lesion location, HB level, CRP level, WBC level, previous diverticulitis and abdominal surgery rate, ASA score, shock during operation rate, and ECOG performance were not significantly different (Table 1). Furthermore, almost all lesions were located at the sigmoid region and almost all patients performed intraoperative lavage.

Table 2 shows peri-operative data and outcomes of the three groups. Operation time and hospital stay were significantly different. HP demonstrated the least operation time and PADS exhibited the most operation time. PA showed fewer hospital stays than the other two groups. Blood loss, ICU stay time, inotropic use after operation, time until normal intake (low residual diet), post-operation complication rate, and mortality rate at 30 days were not significantly different. However, the PA and PADS groups appeared to have greater surgical reintervention rates, and no patient in the HP group needed to implement surgical reintervention. All of the patients required surgical reintervention were due to wound infection. The HP groups appeared to have less blood loss whereas the PADS groups demonstrated the most blood loss amount. Only one patient in the HP group died 30 days postoperatively.

Table 3 shows the comparison between the takedown rate, second operation time, and hospitalization days of the HP and PADS groups in second operation time for ostomy closure. The ostomy takedown rate was significantly different. Four patients failed to take down ostomy in the HP group due to death (n = 1), loss of follow-up (n = 1), and poor condition to operation (n = 2). Hence, we revealed the results without the p-value about complications after ostomy closure, hospital stay (second time), operation time (second time), 12-month stoma-free survival (day), total operation time (first time plus second time), and total hospital stay (day) (first time plus second time).

Discussion

Colonic diverticulitis is a common disease in patients over 60 years old in Western countries but is

Table 1. Patient characteristics

	HP (n = 5)	PA (n = 14)	PADS (n = 7)	*p*-value
Age	82.20 ± 4.55	58.79 ± 18.59	62.29 ± 11.31	0.024
Sex				0.308
Female	3 (60.00)	4 (28.57)	4 (57.14)	
Male	2 (40.00)	10 (71.43)	3 (42.86)	
BMI	20.80 ± 2.99	25.81 ± 3.98	23.33 ± 2.58	0.031
Lesion location				0.587
Ascending colon	0 (0.00)	1 (7.14)	0 (0.00)	
Transverse colon	0 (0.00)	1 (7.14)	0 (0.00)	
Descending colon	0 (0.00)	0 (0.00)	1 (14.29)	
Sigmoid colon	5 (100.00)	10 (71.43)	6 (85.71)	
Cecum	0 (0.00)	2 (14.29)	0 (0.00)	
Fecal peritonitis				< 0.001
No	1 (20.00)	14 (100.00)	2 (28.57)	
Yes	4 (80.00)	0 (0.00)	5 (71.43)	
HB	10.40 ± 3.86	13.75 ± 2.14	13.47 ± 2.21	0.057
CRP level	3.44 ± 2.35	14.81 ± 12.58	4.92 ± 7.96	0.233
WBC	10978.00 ± 6672.23	14202.86 ± 6584.38	9935.71 ± 4529.03	0.291
Hinchey stage				< 0.001
Stage 3	1 (20.00)	14 (100.00)	2 (28.57)	
Stage 4	4 (80.00)	0 (0.00)	5 (71.43)	
Previous diverticulitis and abdominal surgery				0.925
No	4 (80.00)	11 (78.57)	6 (85.71)	
Yes	1 (20.00)	3 (21.43)	1 (14.29)	
ASA score				0.604
I	0 (0.00)	3 (21.43)	2 (28.57)	
II	1 (20.00)	6 (42.86)	3 (42.86)	
III	3 (60.00)	4 (28.57)	2 (28.57)	
IV	1 (20.00)	1 (7.14)	0 (0.00)	
Shock during operation				0.212
No	3 (60.00)	13 (92.86)	5 (71.43)	
Yes	2 (40.00)	1 (7.14)	2 (28.57)	
Approach (open/laparoscopic)				0.352
Open	5 (100.00)	10 (71.43)	6 (85.71)	
Laparoscopic	0 (0.00)	4 (28.57)	1 (14.29)	
Anastomotic type				NaN
Side to side	0 (NaN)	3 (21.43)	0 (0.00)	
End to end	0 (NaN)	11 (78.57)	7 (100.00)	
Anastomotic device				NaN
Manual	0 (NaN)	1 (7.14)	1 (14.29)	
GIA	0 (NaN)	3 (21.43)	0 (0.00)	
Stapler	0 (NaN)	6 (42.86)	4 (57.14)	
Double stapling	0 (NaN)	4 (28.57)	2 (28.57)	
Stoma type				NaN
End colostomy	5 (100.00)	0 (NaN)	0 (0.00)	
Loop colostomy	0 (0.00)	0 (NaN)	6 (85.71)	
Loop ileostomy	0 (0.00)	0 (NaN)	1 (14.29)	
Intraoperative lavage				0.52
No	0 (0.00)	3 (21.43)	1 (14.29)	
Yes	5 (100.00)	11 (78.57)	6 (85.71)	
ECOG				
0	0 (0.00)	5 (35.7)	2 (28.57)	0.091
1	0 (0.00)	1 (7.14)	1 (14.29)	
2	1 (20.00)	4 (28.60)	4 (57.14)	
3	1 (20.00)	3 (21.43)	0 (0.00)	

HP: Hartmann's procedure; PA: primary anastomosis without defunctioning stoma; PADS: primary anastomosis with defunctioning stoma; HB: hemoglobin; CRP: C-reactive protein; WBC: white blood cell; BMI: body mass index; NaN: not a number; ECOG: Eastern Cooperative Oncology Group Performance Status Scale.

Table 2. Patient peri-operative data and outcome

	HP (n = 5)	PA (n = 14)	PADS (n = 7)	*p*
Blood loss	62.00 ± 78.23	91.43 ± 133.87	174.29 ± 219.00	0.400
Operation time (min)	156.00 ± 41.14	206.71 ± 65.01	255.71 ± 31.81	0.016
Hospital stay (day)	15.60 ± 8.99	10.93 ± 2.43	16.57 ± 5.22	0.041
ICU stay	6.80 ± 11.32	1.50 ± 2.28	3.14 ± 4.63	0.208
Inotropic use				0.273
No	2 (40.00)	11 (78.57)	5 (71.43)	
Yes	3 (60.00)	3 (21.43)	2 (28.57)	
Time until normal intake (low residual diet)	9.33 ± 6.66	6.71 ± 0.99	8.43 ± 4.58	0.338
Postoperative abscess/peritonitis	0 (NaN)	0 (NaN)	0 (NaN)	NA
Abscess with drainage	0 (NaN)	0 (NaN)	0 (NaN)	NA
Colostomy ischemia rate	0 (NaN)	0 (NaN)	0 (NaN)	NA
Stoma complications	0 (NaN)	0 (NaN)	0 (NaN)	NA
Anastomotic leakage	0 (NaN)	0 (NaN)	0 (NaN)	NA
Wound infections				0.920
No	4 (80.00)	11 (78.57)	5 (71.43)	
Yes	1 (20.00)	3 (21.43)	2 (28.57)	
Septicemia				0.212
No	3 (60.00)	13 (92.86)	5 (71.43)	
Yes	2 (40.00)	1 (7.14)	2 (28.57)	
Ileus				0.437
No	4 (80.00)	13 (92.86)	7 (100.00)	
Yes	1 (20.00)	1 (7.14)	0 (0.00)	
Fasical dehiscence				0.244
No	5 (100.00)	14 (100.00)	6 (85.71)	
Yes	0 (0.00)	0 (0.00)	1 (14.29)	
Pneumonia				0.264
No	4 (80.00)	14 (100.00)	6 (85.71)	
Yes	1 (20.00)	0 (0.00)	1 (14.29)	
Cardiac complications				0.244
No	5 (100.00)	14 (100.00)	6 (85.71)	
Yes	0 (0.00)	0 (0.00)	1 (14.29)	
Urinary complications				NA
No	5 (100.00)	14 (100.00)	7 (100.00)	
Delirium				0.244
No	5 (100.00)	14 (100.00)	6 (85.71)	
Yes	0 (0.00)	0 (0.00)	1 (14.29)	
Surgical reintervention				0.395
No	5 (100.00)	12 (85.71)	5 (71.43)	
Yes	0 (0.00)	2 (14.29)	2 (28.57)	
Morbidity at 30 days				0.258
No	3 (60.00)	11 (78.57)	3 (42.86)	
Yes	2 (40.00)	3 (21.43)	4 (57.14)	
Morbidity at more than 30 days				0.653
No	5 (100.00)	13 (92.86)	6 (85.71)	
Yes	0 (0.00)	1 (7.14)	1 (14.29)	
Mortality at 30 days				0.113
No	4 (80.00)	14 (100.00)	7 (100.00)	
Yes	1 (20.00)	0 (0.00)	0 (0.00)	
Readmission rate (in 30 days)				0.653
No	5 (100.00)	13 (92.86)	6 (85.71)	
Yes	0 (0.00)	1 (7.14)	1 (14.29)	
Clavien-Dindo classification for grading complications				0.395
No	5 (100.00)	12 (85.71)	5 (71.43)	
Yes	0 (0.00)	2 (14.29)	2 (28.57)	

HP: Hartmann's procedure; PA: primary anastomosis without defunctioning stoma; PADS: primary anastomosis with defunctioning stoma; ICU: intensive care unit; NaN: not a number.

Table 3. Comparison between takedown rate, second operation time, and hospitalization days

	HP (n = 5)	PADS (n = 7)	*p*
Ostomy takedown rate			0.023
No	4 (80.00)	0 (0.00)	
Yes	1 (20.00)	7 (100.00)	
Complications after ostomy closure	0	1 (14.29)	NA
Hospital stay (day) (Second time)	13.00 ± NA	11.00 ± 1.15	NA
Operation time (min) (Second time)	215.00 ± NA	94.29 ± 20.50	NA
12-month stoma-free survival (day)	126.00 ± NA	110.86 ± 51.57	NA
Total operation time (min)	395.00 ± NA	344.29 ± 84.82	NA
Total hospital stay (day)	36.00 ± NA	21.86 ± 2.91	NA

HP: Hartmann's procedure; PADS: primary anastomosis with defunctioning stoma.

relatively rare in Eastern societies. The experience of Western countries provides a solid basis for deciding the most appropriate surgical approach for complex colonic diverticulitis (Hinchey stages III and IV).[11]

Treatment of acute perforated diverticulitis includes broad-acting antibiotics and surgical excision. Emergency surgery is required in 15%-32% of patients with diverticulitis.[3] HP or segmental resection and PA can be performed with or without protective ileostomy based on the surgical team or patient characteristics (malnutrition, hemodynamic instability, and tissue characteristics).[11]

The recent study revealed that patients with suppurative perforated diverticulitis who underwent PA (with or without loop ileostomy) demonstrated lower rates of major complications and general morbidity. Further, this group of patients exhibited a higher chance of stoma closure.[1,6] Several review and meta-analysis articles on Hinchey stages III and IV indicate that mortality in patients undergoing primary anastomotic resection may be lower than in patients undergoing HP.[5] Factors in case selection or selection bias may have affected the results. Patients selected for primary resection and anastomosis (PRA) may generally be more physiologically robust with fewer comorbidities, considering that patients with Hinchey stages III and IV are typically in poorer physiological status (due to sepsis, dehydration, systemic inflammatory response, etc.); hence, the perceived favorable outcome. Our case series reported death in only 1 patient in the HP group but with no significant difference in mortality or complications between HP, PA, and PADS, which may be due to the smaller number of patients. These three groups demonstrated no anastomotic leakage in any patient.

Postoperative complications, such as respiratory tract infections, urinary tract infections, cardiopulmonary complications, and venous thromboembolism, remain a problem in this patient population in addition to mortality and anastomotic leak. Some authors have reported that PRA has lower complication rates and length of stay than HP,[10] although case selection may have influenced this result. The lack of significant differences between HP, PA, and PADS in our case series may be due to the small group size.

The selection between PRA and HP depends largely on the severity of inflammation, intraoperative findings, and the surgeon's comfort level with the level of risk when perforated diverticulitis is present. HP is generally considered to be the less risky and safer of the two strategies and is frequently the preset choice for patients with severe physiologic impairment/sepsis or who are elderly and frail. Accordingly, higher postoperative infection and mortality rates have been reported in patients undergoing HP.[12] The mean age and proportion of patients with Hinchey stage IV in the HP group were higher than those in the PA group (including PADS), as in our case series. Results revealed significantly lower stoma removal rates in HP than in PADS. However, the postoperative infection did not significantly differ between HP, PA, and PADS. Similarly, it may also be the small number causing bias.

Removing an end colostomy requires more time than removing a loop colostomy. HP reversal is very challenging, and technical difficulty is frequently the

main factor causing long surgical times.[8] Many reasons were associated, including dense adhesion in the pelvic cavity, pelvic cavity irradiation, pelvic cavity sepsis, etc. Previous reports in the literature revealed that attempts at colostomy removal were sometimes abandoned during surgery due to technical difficulties or ischemia of the rectal stump. Chen et al., in their case analysis, revealed that the stoma reversal operation time was shorter in the PA group with stoma dysfunction.[4] We initially attempted to compare the total operative time and total hospital stay between HP and PADS. However, only one patient in the HP group underwent end colostomy, which made the comparison impossible. This indicates that patients undergoing HP may have difficulty undergoing HP reversal due to advanced age or comorbidities.

The combination of bacterial peritonitis and fecal-laden colon appears to cause an anastomotic leak in the setting of acute diverticulitis. Intraoperative colonic lavage was reported to improve postoperative complications.[7] Almost all patients in this study underwent intraoperative peritoneal lavage, with no anastomotic leakage postoperatively.

The current study indicates that PA with or without ileal diversion ostomy seemed to provide better mortality and lower morbidity rates but no difference in wound infection rates.[2] However, these findings were not confirmed by randomized controlled trials (RCTs), and factors of selection bias wound resulted in these findings. PA or PADS may be not inferior to HP in terms of mortality and complication rate based on current evidence and in the context of Hinchey stage III and IV diverticulitis and our study result. However, selection bias remained and HP would have a high risk that ostomy reversal would be impossible. Conducting an RCT about patients with complicated perforated diverticulitis between PA or PADS and HP would provide more evidence in the future.

This study has the limitations. This study was a nonrandomized retrospective study conducted in a single institute with small sample size; therefore, there is concern about a high risk of selection bias. Further large-scale multicenter randomized trials are necessary to validate our results.

Conclusion

The HP remains important in patients with acute complicated perforated colonic diverticulitis who are intraoperatively unstable. However, the patient demonstrated a high risk of impossible takedown the colostomy. Based on our outcome, PA or PADS is an alternative option as long as the patient's condition remains stable during emergency surgery according to non-inferior operative morbidity/mortality rate and hospital stay and better stoma takedown rate.

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原　著

比較 Hartmann 術式、初次吻合和併保護性腸道造廔之初次吻合在 Hinchey III 期和 IV 期憩室炎的情況

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引言　複雜性穿孔結腸憩室炎是需要手術的腹部急症，其各種手術的死亡率與術後併發症比較仍有爭議。本篇目的在於分析本院接受 Hartmann 術式與初級吻合合併或不合併保護性腸道造廔患者之結果。

方法　這項研究分析了 26 名患者，比較死亡率、術後併發症發生率、手術時間、住院時間、再手術率等差異。

結果　三組之間的併發症發生率及死亡率無統計學上差異。Hartmann 術式組別雖然其造口逆轉率較低，但手術時間最短。沒有保護性腸道造廔的初級吻合組別有較短的住院時間。

結論　Hartmann 術式對於急性複雜性穿孔結腸憩室炎的生命徵象不穩定患者很重要，但有無法逆轉造口風險。我們統計結果顯示，若在緊急手術期間穩定的患者，初級吻合(合併或不合併保護性腸道造廔) 是一種替代選擇。

關鍵詞　穿孔性憩室炎、Hartmann 手術、初級吻合、術後併發症、死亡率。