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Stoma reversal after Hartmann's procedure for acute diverticulitis

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ABSTRACT

Background: Hartmann's procedure is a treatment option for perforated acute diverticulitis, especially when organ dysfunction(s) are present. Its use has been criticized mostly out of fear of high permanent stoma rate. The aim of this study was to investigate the rate of stoma reversal, reasons behind nonreversal, and safety of reversal surgery.
Methods: This was a single-center retrospective study of patients undergoing urgent Hartmann's procedure due to acute diverticulitis between the years 2006 and 2017 with follow-up until March 2021.
Results: A total of 3,319 episodes of diverticulitis in 2,932 patients were screened. The Hartmann's procedure was performed on 218 patients, of whom 157 (72%) had peritonitis (48 (22%) with organ dysfunction). At 2-years, 76 (34.9%) patients had died with stoma, 42 (19.3%) were alive with stoma, and 100 (45.9%) had undergone stoma reversal. The survival of patients with and without reversal were 100% and 42.7% at 1-year, 96.0% and 35.0% at 2-years and 88.9% and 20.7% at 5-years, respectively. The risk factors for nonreversal were old age, a need for outside assistance, low HElsinki Staging for Acute Diverticulitis stage, and higher C-reactive protein level upon hospital admission. The most common reasons for nonreversal in surviving patients were patient not willing to have the operation 18 (41%) and dementia 10 (23%). Twelve (12%) patients had a major complication after reversal (Clavien-Dindo IIIb–IV) and 90-day mortality after reversal was 0%.
Conclusion: After the Hartmann's procedure for acute diverticulitis, one-third died, half underwent stoma reversal, and one-fifth did not undergo stoma reversal within 2 years. Patients who survive with stoma are either not willing to have reversal or have severe comorbidities excluding elective surgery. The Hartmann's procedure remains a viable option for high-risk patients with perforated acute diverticulitis.

Introduction

Most episodes of diverticulitis are uncomplicated and can be safely treated conservatively without antibiotics or hospital admission.[1–3] Although selected patients may be treated non-operatively,[4,5] perforated diverticulitis leading to peritonitis or large abscess often requires operative treatment.[6] Operative treatment usually consists of resection of affected sigmoid colon and either primary anastomosis (with or without a protective stoma) or Hartmann's procedure (HP) with an end colostomy. As primary anastomosis carries a risk of anastomotic leak, especially when tissue healing has been compromised for example by peritonitis, sepsis or ongoing chemotherapy, HP provides a safer operation. The downside of HP is the discontinuity of the colon and the need for another major reversal operation later or alternatively living with a permanent stoma. Stoma reversal surgery has been reported to carry mortality rate of 0.4% to 5%[7–9] and a morbidity rate of almost 50%.[8,9] Previous studies have suggested that Hartmann's colostomy after acute diverticulitis, or even after elective cancer resection with intention to stoma reversal, is not reversed in roughly every third to fourth patient.[7,10–13] These findings have created a vivid debate on the role of HP in treating acute diverticular perforation.[14] Although recent randomized trials,[12,15] meta-analyses,[16–18] and guidelines[19] have suggested sigmoid resection and primary anastomosis as a safe and preferable alternative to HP for perforated diverticulitis in hemodynamically stable patients with no major risk factors, HP will nevertheless remain the method of choice for unstable and/or high-risk patients.

Most studies on Hartmann's colostomy reversal do not take into account underlying disease leading to colonic resection and include

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patients with colorectal cancer.[20,21] Patients operated for perforated diverticulitis comprise a significantly different patient population in regards of fitness and life-expectancy compared to those who are operated due to a malignant disease. Thus, data from cohorts with mixed benign and malignant diseases as the indication for HP is of limited use for guidance in decision making considering patients with perforated diverticulitis. Riansuwan et al created a validated risk scoring system for predicting nonreversal after HP for acute diverticulitis.[10,22] In their study, all patients with predictive score <14 had their stoma reversed compared to only 12% of patients with score >18. However, the scoring system is limited in not considering patient survival as a potential reason for nonreversal.

The aim of this study was to investigate the rate of stoma reversal and the reasons for nonreversal in patients who had undergone HP due to acute diverticulitis. Furthermore, the complications related to stoma reversal and the predictors for complicated recovery are reported.

Methods

In this retrospective cohort study, all patients admitted to the Helsinki University Hospital for acute colonic diverticulitis between the years 2006 and 2017 were assessed. The hospital serves both as a secondary and a tertiary referral center and serves a population of roughly 1.6 million. Patients with the *International Classification of Diseases—10* codes K57 (diverticular disease of the intestine), K63.0 (abscess of intestine), K63.1 (perforation of intestine) and K63.2 (fistula of intestine) were identified, and the patient records were manually assessed. Only patients with computed tomography or intraoperatively verified acute left-sided colonic diverticulitis undergoing HP were included in this study. Patients whose pathology report revealed a malignancy in the resected colon were excluded. Patients with inaccessible follow up information were excluded. End of follow-up was defined as the last verified contact to health care documented in the electronic patient records or death, which is automatically updated from the national population registry. Patient records were reviewed up to March 10, 2021.

The Charlson Comorbidity Index (CCI)[23] was used to depict the overall burden of each patient's long-term illnesses. Hinchey's classification[24] and HElsinki Staging for Acute Diverticulitis (HESAD)[25] were used for the staging of diverticulitis. The HESAD considers clinical, radiological and physiological findings, and divides patients with diverticular perforation and peritonitis into 2 groups based on the presence of organ dysfunctions (stage 4: peritonitis without organ dysfunction[s] and stage 5: peritonitis with organ dysfunction[s]). Complications within 30 days after surgery were graded with the Clavien-Dindo classification,[26] complications after HP were graded according to a modified Clavien-Dindo classification for emergency surgery.[27] This modified Clavien-Dindo classification takes into account potential organ dysfunctions before emergency surgery, and only new onset or worsening of existing organ dysfunctions after emergency surgery are considered as complications.[27] Death within 30 days after surgery was always considered as a grade V complication. The comprehensive complication index[28] was calculated for reversal surgery. The Riansuwan risk score was calculated as follows: age (1 point for every decade of age), American Society of Anesthesiologists (ASA) classification (ASA class multiplied by 2), pulmonary comorbidity (3 points), preoperative blood transfusion (2 points), perforation (2 points), and anticoagulants (2 points). Thus, the score for a healthy 60-year-old patient with a perforated diverticulitis would be 10, and in contrast the maximum score for an 80-year-old patient would be 27.

Normally distributed continuous variables are presented as mean (SD) and compared using *t* test. Non-normally distributed continuous variables are presented as median (IQR) and compared using Mann-Whitney *U* test. The χ^2 analysis was used for the categorical variables and the Kruskal-Wallis test for comparing continuous variables between multiple groups. Kaplan-Meier and log-rank test were used to estimate and depict survival functions. Multivariable analyses were carried out using logistic regression. Variables with $P < .1$ in the univariable analyses were included in the multivariable analysis.

This study was approved by the institutional review board. The data was analyzed using IBM SPSS statistics software version 25 (IBM SPSS, Inc, Armonk, NY).

Results

A total of 2,932 patients and 3,319 episodes of computed tomography or intraoperatively verified diverticulitis were identified between January 1, 2006 and December 31, 2017. A total of 399 (14%) patients underwent surgery, of which 354 (89%) included colonic resection. Primary anastomosis without a stoma was performed on 101 patients and colonic resection with a stoma other than end sigmoideostomy on 30 patients, and these patients were excluded. Altogether 223 patients, who were operated with sigmoidectomy and an end colostomy (ie, HP) were included in the study cohort. All of the urgent colonic resections were performed as open surgery. This cohort included 4 (1.8%) patients operated with HP due to anastomotic leakage after primary anastomosis operation. Five patients were excluded because of missing follow-up information, leading to a final study cohort of 218 patients.

The patients undergoing HP were generally high-risk patients: the median age was 71.1 (61.3–80.1), median CCI was 2 (0–5), 43 (19.7%) patients had anticoagulative medication, and 89 (40.8%) patients had corticosteroid or other immunosuppressive medication (Table I and Supplementary Table S1). Altogether, 157 (72%) patients had peritonitis, 48 (22%) had a concomitant organ failure (HESAD stage 5), 50 (22.9%) had an abscess, and 11 (5%) had bowel obstruction. The complication rate of HP was 53.7% (117 patients) and the rate of major complications (Clavien-Dindo IIIb–V) was 33.5% (73 patients). Sixty (27.5%) patients were admitted to intensive care unit. In-hospital mortality was 13.8% (30 patients), 90-day mortality 24.8% (54 patients), 1-year mortality 30.7% (67 patients), and 2-year mortality 36.7% (80 patients). The median follow-up was 52 (IQR 3–98, range 0–176) months for all patients, and 91 (IQR 59–141, range 40–176) months in patients who were alive at last follow-up.

The median time from Hartmann to reversal was 216 days (IQR 142–298, range 60–874). All but one of the reversals were performed within 2 years from HP. In 2 operations, stoma reversal was attempted but aborted due to difficult operating circumstances. Two patients had an anastomotic leak after reversal surgery and required a new stoma operation. One of these was later reversed. One patient's reversal operation included a defunctioning transversostomy, which was later reversed. The Kaplan-Meier estimate for death-censored successful stoma reversal rate was 50.1% at 1-year and 63.5% at 2-years from HP (Figure 1).

There were 42 patients (19.3% of all patients) who did not undergo stoma reversal and were still alive at 2-year follow-up after HP. The patients who did not undergo reversal surgery were older, had lower HESAD and Hinchey stage, higher ASA class, more serious complications and longer hospital stay after HP, required outside help more frequently, had higher Riansuwan risk score, lower hemoglobin, and higher thrombocyte count and CRP (C-reactive protein) upon hospital admission compared to patients who underwent reversal (Table I and Supplementary Table S1).

The proportion of nonreversed patients to reversed patients increased with higher Riansuwan risk scores, and so did the

Table I
Patient demographics and patients grouped by reversal status 2 years from Hartmann's procedure

Demographics	All patients	Deceased with stoma within 2 years	Survived with stoma >2 y	Stoma reversal within 2 y[§]	*P*
Patients, n (% of all patients)	218	76 (34.9%)	42 (19.3%)	100 (45.9%)	
Age at HP, y, median (IQR)	71.1 (61.3–80.1)	74.6 (66.2–83.5)	77.8 (68.9–85.2)	65.9 (55.3–75.0)	0.000[*]
Female sex, n (%)	139 (63.8%)	49 (64.5%)	32 (76.2%)	58 (58.0%)	0.063[†]
BMI, mean (SD)[§]	26.4 (5.2)	24.7 (3.9)	26.8 (6.3)	27.4 (5.2)	0.575[‡]
Charlson Comorbidity Index, median (IQR)	2 (0–5)	6.0 (3.0–7.0)	2.0 (0.8–3.0)	1.0 (0–2.0)	0.071[*]
ASA class at HP					0.024[†]
1	3 (1.4%)	0	0	3 (3.1%)	
2	19 (8.7%)	0	2 (4.8%)	17 (17.5%)	
3	87 (39.9%)	20 (26.3%)	18 (42.9%)	49 (50.5%)	
4	88 (40.4%)	46 (60.5%)	20 (47.6%)	22 (22.7%)	
5	18 (8.3%)	10 (13.2%)	2 (4.8%)	6 (6.2%)	
Missing	3 (1.4%)	0	0	3	
Corticosteroid medication	70 (32.1%)	43 (56.6%)	9 (21.4%)	18 (18.0%)	0.810[†]
Length of hospital stay, d, median (IQR)	12 (8–18)	13.0 (6.0–18.8)	16.0 (9.5–25.5)	11.0 (8.3–15.8)	0.016[*]
HESAD staging[‖]					0.003[†]
2–Abscess <6 cm	13 (6.0%)	3 (3.9%)	6 (14.3%)	4 (4.0%)	
3–Abscess >6 cm or distant air	37 (17.0%)	12 (15.8%)	10 (23.8%)	15 (15.0%)	
4–Peritonitis, no organ dysfunctions	109 (50.0%)	39 (51.3%)	11 (26.2%)	59 (59.0%)	
5–Peritonitis, organ dysfunction	48 (22.0%)	21 (27.6%)	11 (26.2%)	16 (16.0%)	
Operative findings (Hinchey)[¶]					0.031[†]
I–Pericolic phlegmon/abscess	12 (5.5%)	4 (5.3%)	2 (4.8%)	6 (6.0%)	
II–Pelvic abscess	38 (17.4%)	11 (14.5%)	14 (33.3%)	13 (13.0%)	
III–Purulent peritonitis	98 (45.0%)	35 (46.1%)	14 (33.3%)	49 (49.0%)	
IV–Fecal peritonitis	59 (27.1%)	25 (32.9%)	8 (19.0%)	26 (26.0%)	
HP complications, Clavien-Dindo					0.042[†]
0	101 (46.3%)	12 (15.8%)	25 (59.5%)	64 (64.0%)	
I	14 (6.4%)	3 (3.9%)	2 (4.8%)	9 (9.0%)	
II	22 (10.1%)	7 (9.2%)	5 (11.9%)	10 (10.0%)	
III (a/b)	8 (3.7%)/22 (10.1%)	4 (5.3%)/9 (11.8%)	0/3 (7.1%)	4 (4.0%)/10 (10.0%)	
IV (a/b)	8 (3.7%)/7 (3.2%)	1 (1.3%)/4 (5.3%)	4 (9.5%)/3 (7.1%)	3 (3.0%)/0	
V (death)	36 (16.5%)	36 (47.4%)	0	0	
Prehospital requirement of help					0.000[†]
No requirement of help	169 (77.5%)	49 (64.5%)	25 (59.5%)	95 (95.0%)	
Supported housing	26 (11.9%)	14 (18.4%)	9 (21.4%)	3 (3.0%)	
Service housing	23 (10.6%)	13 (17.1%)	8 (19.0%)	2 (2.0%)	
Riansuwan risk score, median (IQR)[**]	16.9 (14.9–19.2)	18.3 (16.6–20.3)	17.7 (16.1–19.3)	15.3 (13.2–17.6)	0.000[*]
Anemia[††]	92 (42.2%)	43 (56.6%)	22 (54.4%)	27 (27.0%)	0.007[†]
CRP, mg/l, median (IQR)[††]	189.0 (80.0–285.0)	221.0 (97.0–298.0)	198.5 (118.8–309.3)	137.5 (32.5–241.8)	0.008[*]
In-hospital mortality	30 (13.8%)	30 (39.5%)	N/A	N/A	
90-d mortality	54 (24.8%)	54 (71.1%)	N/A	N/A	

P values for difference between survived nonreversal and attempted reversal. Anemia was defined as Hb lower than normal variance given by laboratory, for men Hb <134, for women Hb <117.

ASA, American Society of Anesthesiologists; *BMI*, body mass index; *CRP*, C-reactive protein; *Hb*, hemoglobin; *HESAD*, Helsinki staging for acute diverticulitis; *HP*, Hartmann's procedure.
[*] Mann-Whitney *U* test.
[†] Pearson χ^2 statistic (+ continuity correction for 2×2 tables).
[‡] *t*-test.
[§] Includes 3 patients with only attempted reversal and does not include 1 patient whose stoma was reversed >2 years after HP.
[‖] Missing 35.
[¶] 11 patients with obstruction not classified.
[**] Missing 3.
[††] Laboratory tests taken upon arrival at hospital.

proportion of deceased patients (Figure 2). With scores >18, the most probable outcome was death within 2 years.

Patients who were selected for stoma reversal also had better survival compared to patients who did not undergo reversal surgery (Kaplan-Meier estimates for survival with and without reversal were 100% and 42.7% at 1-year, 96.0% and 35.0% at 2-years and 88.9% and 20.7% at 5-years, respectively) (Figure 3). The main reasons for nonreversal in patients surviving >2 years were patient refusal (41%), dementia (23%), and heart or lung disease (9%) (Table II).

In multivariable logistic regression, HP for low HESAD stage diverticulitis, older age, a need for outside assistance, and higher CRP level upon hospital admission predicted nonreversal 2 years after HP (Table III). Patients deceased within 2 years from HP were excluded from multivariable analysis. In univariable analysis, the risk factors for death within 90 days from HP were older age, lower body mass index, higher CCI, higher ASA class, corticosteroid medication, chemotherapy, higher stage diverticulitis (HESAD/Hinchey), anemia, thrombocytopenia, normal white blood cell count, higher CRP, positive blood culture, and organ dysfunction upon arrival (Supplementary Table S2). In multivariable logistic regression, the risk factors for death within 90 days from HP were higher ASA class, higher CCI, corticosteroid medication, higher CRP level upon hospital admission, and positive blood culture (Supplementary Table S3).

Altogether, 12 (12.1%) patients had a major complication (Clavien-Dindo IIIb–IV) after reversal operation: Three patients required postoperative intensive-care, and 9 patients required re-operation (2 anastomotic leaks, 2 deep infections, 1 iatrogenic small bowel perforation, 2 fascial dehiscence, and 1 postoperative intraluminal hemorrhage) (Table IV). Ninety-day mortality after reversal was 0%.

Age, ASA class, comorbidity index, the timing of reversal, and the staging of diverticulitis or body mass index did not correlate with reversal complications assessed both with Clavien-Dindo

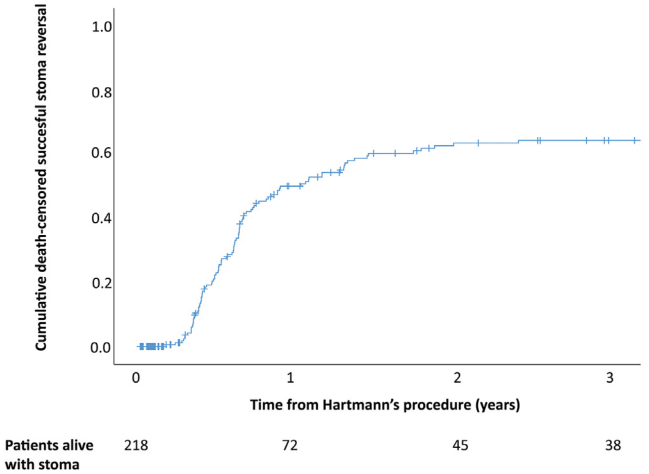

Figure 1. Kaplan-Meier survival curve for death-censored successful stoma reversal during 3-year follow-up.

classification and comprehensive complication index (Table IV). There was significant correlation with preoperative anemia and postoperative complications. Patients operated laparoscopically had fewer complications compared to patients operated with open surgery (Table IV).

Discussion

Several important findings regarding reversal surgery after HP for diverticulitis were observed in this study. First, only one-fifth of the patients undergoing emergency HP were living with a stoma 2 years after the initial operation. The rate was lower than usually reported in earlier series.[7,10–13] Second, the most common reasons for not undergoing reversal were patients not willing to have reversal operation and dementia. Third, although 12% of patients had a major complication after reversal surgery, 90-day mortality was nil, demonstrating the safety of reversal surgery.

Although there has been a debate on abandoning HP once and for all, HP remains a procedure of choice for patients in whom a risk

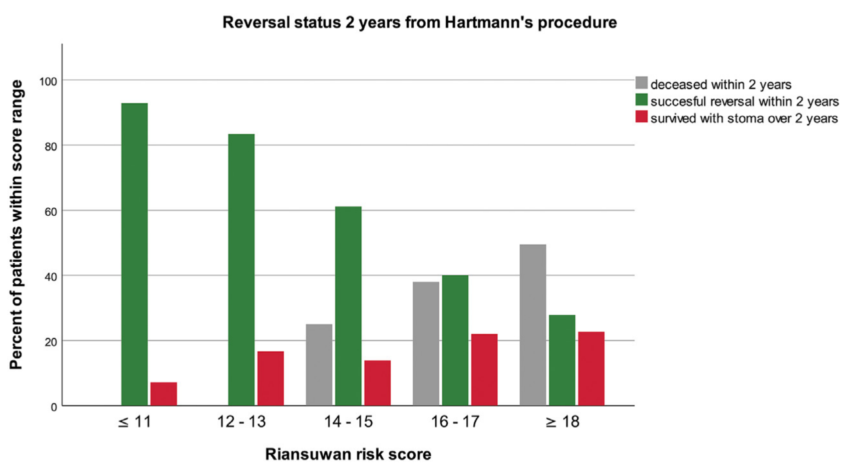

Figure 2. Two-year outcomes with different Riansuwan risk score values.

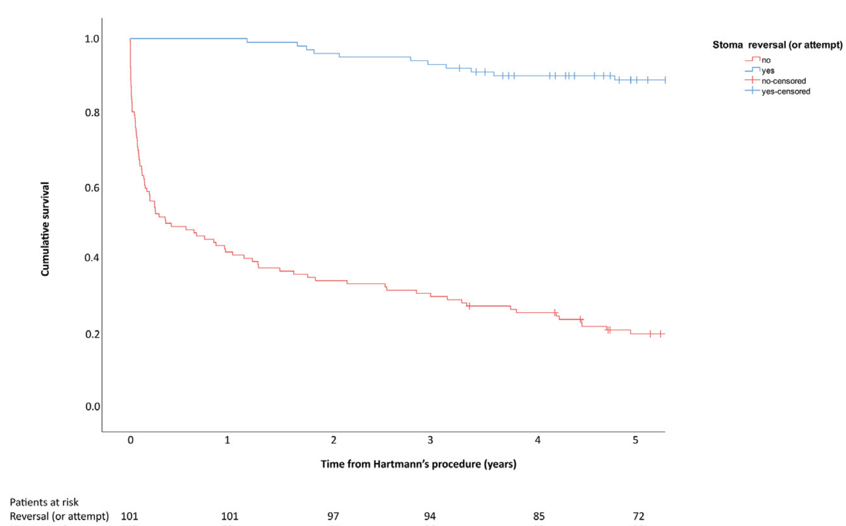

Figure 3. Kaplan-Meier survival curve. Separate curves for patients with attempted reversal and patients with no reversal attempt. Note that difference in survival does not imply that stoma reversal could improve survival or lack of reversal would decrease survival, but rather demonstrates that patients who have short life-expectancy are not selected for stoma reversal. Log-rank $P < .0001$.

Table II
Reasons for nonreversal for patients surviving >2 years after Hartmann's procedure

Reason for nonreversal	Number (%) $N = 44$
Patient declined	18 (40.9%)
Dementia	10 (22.7%)
Heart/lung disease	4 (9.1%)
Immunosuppressive medication	3 (6.8%)
Metastatic malignancy	2 (4.5%)
Frailty	2 (4.5%)
Failed attempt of reversal	3 (6.8%)
Unclear	2 (4.5%)

One reversal operated >2 years after Hartmann's procedure not included.

for anastomotic leakage needs to be minimized due to ongoing organ dysfuctions, comorbidities, or frailty. The results of this study demonstrated that most of the patients who survive >2 years do undergo reversal surgery. On the other hand, most patients who never underwent reversal surgery because they did not survive died within 90 days from HP. It can be argued that the surviving patients who ended up with a permanent end colostomy could have benefitted from a primary anastomosis. However, these patients were quite old (median 78 years), had high number of comorbidities and a severe diverticulitis, mostly diffuse peritonitis and one-fourth had an accompanying organ dysfunction. To maximize the chances for surviving such condition, HP is a safe option. Paradoxically, lower HESAD stage was independently associated with an increased risk of nonreversal. The finding may be explained, at least partly, by selection of patients. Most patients with low HESAD stage usually undergo primary anastomosis, and Hartmann's procedure is only reserved for the patients with severe comorbidities, which may prevent elective reversal surgery as well. Although primary anastomosis has been equally safe to HP in randomized controlled studies, most of these studies have excluded patients with organ failure[12,15] or included only patients with mild peritonitis (mean Mannheim Peritonitis Index 11–13).[29]

The Riansuwan-score is the only validated score for prediction of nonreversal after HP for diverticulitis. As shown in this study, the score predicts survival better than nonreversal. We argue that death shortly after the operation should be considered as a failure to cure rather than failure to reverse the stoma. If a higher score predicts both higher mortality and higher nonreversal rate, should the surgeon choose primary anastomosis with higher risk of complications and potentially even higher risk of death, or should patients with a high Riansuwan score be offered a safer HP, but potentially higher risk of permanent stoma? In this study, the risk of permanent stoma was very low in patients with a score of ≤11 (7.1%), but the risk of nonreversal remains roughly the same in scores >11 (between 16.7% for scores 12–13 and 22.7% for scores ≥18). With this in mind, separate multivariable analyses were performed for 90-day mortality and for nonreversal in surviving patients. These suggested a different risk profile for these 2 types of outcomes. Although older age, lower diverticulitis stage, and a need of outside assistance were predictive of nonreversal, a higher CCI, higher ASA class, corticosteroid medication and blood culture positivity predicted 90-day mortality. Interestingly, a high CRP count predicted both.

Thus, patients undergoing emergency HP can be divided into 3 groups: group 1: patients who die shortly after HP or have a very short life expectancy; group 2: patients who survive long enough after HP to potentially undergo reversal surgery, but for various reasons do not; and group 3: patients who undergo reversal surgery. With patients in group 1 it is often clear from the beginning that the stoma will not be reversed. Patients in this group may have metastatic malignancy and complicated diverticulitis during chemotherapy. Tissue healing in these patients is compromised and the risk for anastomotic leak is significant, making primary anastomosis a risky endeavor. Group 1 patients did not survive long enough for the reversal to be possible and considering the situation as failure to reverse is incorrect—the reversal was never an option. Patients in group 2 survived long enough for the stoma to be reversed but did not get reversal surgery. Most common reasons for nonreversal were patients not willing to have reversal and significant dementia with impaired mental and physical capacity.

As all patients in this study underwent HP, the patients were highly selected based on the judgment of the operating surgeon. Patients were older (median age 71) and most had comorbidities, as well as a severe acute diverticulitis (90% ASA class ≥3, 89% HESAD stage ≥3, 70% Hinchey III–IV). As a result, hospital mortality was 14%, 90-day mortality 25% and 2-year survival was only 63%. In 4 randomized controlled trials (RCTs) comparing primary anastomosis to HP in patients with Hinchey 3 to 4, the long-term survival rates were significantly higher[12,15,29,30]: 1- and 3-year survival rates were 92% and 81%, respectively, in Oberkofler et al,[30] 18 months survival was 94% in the DIVERTI trial,[12] 1-year survival was 92% in Binda et al,[29] and the LADIES trial reported 97% 30-day survival rate.[15] The differences in the survival rates between the RCTs and this study suggest that the patient cohorts in the RCTs are highly selected and do not include patients who are at high risk of death.

This study was limited by its retrospective nature. As the decision to perform a HP was made by the surgeon on call, it was unclear whether some patients would have been fit for primary anastomosis instead. The study was limited by including patients only from one center and the results need to be externally validated. The study cohort consisted of 218 consecutive patients during 12 years and can be considered as a relatively large cohort. The follow-up rate was good, and only few patients were excluded due to lack of follow-up as nearly all reversal operations and preoperative evaluations were done in the Helsinki University Hospital. The study period ended in 2017 to include a necessary follow-up period for the stoma reversal surgery. Although the authors are not aware of changes in treatment strategies for perforated diverticulitis in our center after the study period, this cannot be ruled out as new guidelines were published in 2020.[19] The survival difference between patients who underwent stoma reversal versus patients who did not (Figure 3) is obviously biased as stoma cannot be reversed after death. The survival difference between patients with or without stoma reversal does not imply that stoma reversal could improve survival or lack of reversal would increase mortality. However, the figure merely illustrates the fact that the reversal was not an option in many patients as their life-expectancy was known to be short.

To summarize, one-fifth of patients are left with a permanent stoma after HP for acute diverticulitis despite surviving long enough to undergo reversal. These patients are mostly older,

Table III
Multivariable logistic regression, risk factors for nonreversal 2 years after Hartmann's procedure

Demographics	OR	95% CI	*P*
Age at Hartmann's procedure, per 10 y	1.72	1.17–2.55	0.006
HESAD stage ≤3	3.19	1.22–8.31	0.018
Prehospital requirement of help	6.24	1.77–22.00	0.004
C-reactive protein upon arrival, per 10 U	1.05	1.01–1.09	0.011

Nonreversals deceased within 2 years from Hartmann's procedure excluded from analysis. Variables with $P < .1$ in Table I were included in the analysis. Nagelkerke R square = 0.345.
HESAD, Helsinki staging for acute diverticulitis.

Table IV
Reversal operations and patients grouped by reversal operations comprehensive complication index

Reversal complications	Number						*P*
Comprehensive complication index	All reversals	≤8	9–16	17–24	25–32	≥33	
Patients (% of all patients)	101 (100%)	54 (53.5%)	10 (9.9%)	17 (16.8%)	7 (6.9%)	13 (12.9%)	
Age at reversal, y, median (IQR)	66.5 (55.5–75.5)	67.2 (56.5–76.3)	67.9 (53.1–77.2)	65.1 (52.1–71.7)	60.4 (50.0–84.6)	65.7 (59.1–73.3)	0.975*
BMI, median (IQR)‡	26.4 (24.4–31.5)	26.0 (24.5–29.3)	25.8 (22.1–30.5)	27.2 (24.6–32.7)	26.2 (19.3–28.7)	30.4 (25.1–32.3)	0.607*
Charlson Comorbidity Index, median (IQR)	1 (0–2)	1.0 (0–2.0)	1.5 (0–3.3)	0 (0–2.5)	0 (0–4.0)	2.0 (0.5–2.5)	0.616*
Days from HP to reversal, median (IQR)	216 (142–298)	200 (139–307)	230 (202–316)	202 (162–347)	215 (138–263)	215 (165–336)	0.912*
Female sex	58 (57.4%)	31 (57.4%)	5 (50.0%)	12 (70.6%)	4 (57.1%)	6 (46.2%)	0.716†
Hemotocrit before reversal, %, median (IQR)	42.0 (38.5–45.0)	42.5 (40.8–45.0)	40.0 (36.0–43.0)	41.0 (36.5–43.5)	40.0 (37.0–44.0)	41.0 (38.0–44.0)	0.05*
Anemia before reversal	16 (15.8%)	1 (1.9%)	4 (40.0%)	4 (23.5%)	2 (28.6%)	5 (38.5%)	0.001†
Riansuwan risk score, median (IQR)§	15.3 (13.2–17.6)	15.1 (13.1–17.5)	15.7 (14.5–22.3)	15.6 (13.0–17.9)	14.1 (10.4–17.8)	16.3 (13.9–18.3)	0.487*
Anticoagulation	17 (16.8%)	7 (13.0%)	3 (30.0%)	3 (17.6%)	2 (28.6%)	2 (15.4%)	0.639†
Operation							0.005†
Laparoscopic	33 (32.7%)	22 (40.7%)	3 (30.0%)	3 (17.6%)	1 (14.3%)	4 (30.8%)	
Conversion	18 (17.8%)	7 (13.0%)	0	5 (29.4%)	5 (71.4%)	1 (7.7%)	
Open	50 (49.5%)	25 (46.3%)	7 (70.0%)	9 (52.9%)	1 (14.3%)	8 (61.5%)	
Duration of operation, min, median (IQR)‖	158 (130–196)	155 (125–184)	156 (135–196)	184 (148–215)	158 (115–358)	155 (123–224)	0.676*
(Any) stoma 30 d after reversal	5 (5.0%)	2 (3.7%)	0	0	1 (14.3%)	2 (15.4%)	
Reversal complications Clavien-Dindo							
0	54 (53.5%)	54 (100.0%)	0	0	0	0	
I	10 (9.9%)	0	10 (100.0%)	0	0	0	
II	22 (21.8%)	0	0	17 (100.0%)	5 (71.4%)	0	
IIIa/IIIb	3/7 (9.9%)	0/0	0/0	0/0	2/0 (28.6%)	1/7 (61.5%)	
IVa/IVb	3/2 (5.0%)	0/0	0/0	0/0	0/0	3/2 (38.5%)	
V (death)	0	0	0	0	0	0	
Anastomotic leak¶	3	0	0	0	1 (33.3%)	2 (66.7%)	

BMI, body mass index; *HP*, Hartmann's procedure.
* Kruskal-Wallis.
† Pearson χ^2 statistic.
‡ Missing 9.
§ Missing 3.
‖ Missing 4.
¶ Two reoperations and one drainage.

high-risk patients who require outside assistance in their daily routines. In patients who underwent reversal surgery, the rate of major complications was relatively low (12%): 3% had an anastomotic leak and mortality was 0%. The HP remains a viable option for high-risk patients with perforated acute diverticulitis.

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Conflict of interest/Disclosure

The authors have no conflicts of interests or disclosures to report.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.surg.2022.10.028.

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