Diseases of the Colon & Rectum

Current Status

Primary Anastomosis or Hartmann's Procedure for Patients With Diverticular Peritonitis? A Systematic Review

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PURPOSE: This systematic literature review was designed to summarize and compare the reported outcomes of one-stage and two-stage operations for the treatment of perforated diverticulitis with peritonitis. METHODS: This review identified 98 published studies (1957–2003) dealing with the surgical management of perforated diverticulitis with peritonitis, either with primary resection and anastomosis or with the Hartmann's procedure. Aggregated results of adverse outcomes were calculated but statistical comparisons were not appropriate because of data and design heterogeneity. RESULTS: Operative mortality data from patients with diverticular peritonitis undergoing Hartmann's procedure (n = 1,051) were derived from 54 studies. Considering the Hartmann's procedure and its reversal procedures together, the mortality rate was 19.6 percent (18.8 percent for the Hartmann's procedure and 0.8 percent for its reversal), the wound infection rate was 29.1 percent (24.2 percent for the Hartmann's procedure and 4.9 percent for its reversal), and stoma complications and anastomotic leaks (in the reversal operation) occurred in 10.3 and 4.3 percent, respectively. Of 569 reported cases of primary anastomosis from 50 studies, the aggregated mortality rate was 9.9 (range, 0–75) percent with an anastomotic leak rate of 13.9 (range, 0–60) percent and a wound infection rate of 9.6 (range, 0–26) percent. CONCLUSIONS: Reported mortality and morbidity in patients with diverticular peritonitis who underwent primary anastomosis were not higher than those in patients undergoing Hartmann's procedure were. This suggests that primary anastomosis is a safe operative alternative in certain patients with peritonitis. Despite inclusion of only patients with peritonitis in this analysis, selection bias may have been a limitation and a prospective, randomized trial is recommended. [Key words: Diverticulitis; Colonic/surgery; Colostomy; Anastomosis; Surgical; Digestive system surgical procedures/adverse effects; Irrigation; Peritonitis/surgery]

Diverticulosis of the colon affects approximately 50 percent of Americans older than aged 60 years.[1] Diverticulitis—inflammation and infection of these diverticula—occurs in 20 to 30 percent of those with diverticulosis and is one of the most common indications for hospitalization related to the gastrointestinal tract. In the state of Washington, diverticulitis is the associated diagnosis for one-third of all colostomies and colon resections (Flum DR, personal communication). Nearly 80 percent of all patients hospitalized with acute diverticulitis will improve with intravenous antibiotics and pain management and most will never have a recurrence of their disease. Unfortunately, nearly one in four requires an emergency operation because of perforation, peritonitis, or systemic complications.[2] In the setting of perforation or peritonitis (purulent or fecal, Hinchey Stages 3 and 4, respectively), a segmental resection of the involved colon and diverting proximal colostomy (Hartmann's procedure (HP), a two-stage procedure in which colostomy reversal and anastomosis is performed in a second operation) has been recommended.[1]

The acceptance of HP[1,3,4] represents an evolution from three-stage procedures (end colostomy, resection, reanastomosis) that were dominant until the 1980s.[5] A randomized, controlled trial[6] has demon-

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strated that the three-stage procedure is associated with greater morbidity compared with HP. Although perhaps an improvement over the three-stage approach, HP itself is associated with considerable morbidity and mortality[5] and involves the use of a stoma, an outcome dreaded by most patients.[7] Reversal of a stoma from the Hartmann's procedure can be a significant undertaking given the previously operated tissue plains, has a rate of anastomotic leakage reported as high as 30 percent,[8] and a mortality rate that ranges from 0 to 14.3 percent.[9,10] Although considered a temporary colostomy by most surgeons, a significant proportion of patients undergoing HP for diverticulitis (as many as 50–60 percent) never have their stomas reversed.[9,11,12]

One-stage operations for diverticulitis (resection of involved colon and primary anastomosis (PA)) have been recorded since the 1950s.[5] With growing acceptance of PA in patients after traumatic colon perforation,[13] more case series of PA with and/or without protective stoma and with and/or without intraoperative lavage (PAIL) have been reported. Usually performed through a small hole in the cecum or the appendix, intraoperative colonic lavage is a technique that permits antegrade irrigation to clear the colon of feces aimed at reducing anastomotic complications.[14] Unfortunately, there has never been a satisfactory prospective, comparative trial of HP and PA or PAIL for patients with similar-stage diverticulitis. The purpose of this study was to systematically review outcomes from published reports of PA and HP to better assess the role of PA in the management of patients with diverticulitis.

METHODS

A systematic and comprehensive review of the scientific literature was conducted using the MEDLINE database for the period from 1966 to 2003. This reproducible search identified all publications dealing with surgical management in patients with diverticular disease, either with primary anastomosis or with the Hartmann's procedure.

Search Strategy/Inclusion Criteria

Three search strategies were used: 1) Hartman* AND diverticul*, 2) "Anastomosis, Surgical"[MeSH: NoExp] AND ("Diverticulum, Colon"[MeSH] OR "Diverticulitis, Colonic"[MeSH]), 3) ("Intestinal Perforation"[MeSH] OR "Peritonitis"[MeSH]) AND "Diverticulitis, Colonic/surgery"[MeSH]. Studies included were those with primary data collection on patients undergoing nonelective surgery for perforated diverticulitis with generalized peritonitis, specifying the outcomes according to the operation type.

Exclusion Criteria

The search was limited to studies involving human subjects published in the English language. Case reports, abstracts only, letters, and incomplete reports in surveys were excluded. Studies including only patients with early-stage diverticulitis (Stage 1 or 2 Hinchey) or reviews also were excluded.

Search Yield

Using the inclusion criteria, 293 publications were detected; 110 publications did not contain data relevant to the research study. Case reports, abstracts, letters, and incomplete reports in surveys and reviews were excluded (63 articles). Studies including only patients with early-stage diverticulitis (Stage 1 or 2 Hinchey) and studies that did not specify the outcomes in patients with late-stage diverticulitis were excluded (42 articles). Seventy-eight articles were reviewed and citations from these reports were used to identify additional studies (20 articles). Prominent authors in the field were contacted for knowledge of unpublished trials, but no additional studies were identified. A single reviewer using review criteria that were established *a priori* evaluated all 98 studies, and two reviewers evaluated all studies related to PA. Differences in reviewer assessment were resolved using established review criteria.

Analysis

The proportions of patients dying, those with wound infections, and those with related complications during follow-up were aggregated for patients with peritonitis or perforation undergoing HP or PA of varying types. In studies that included a mix of patients with Stage 1–4 Hinchey, only those with Stage 3 and 4 diverticulitis were considered in the analysis. HP-related morbidity and mortality was considered separately and also more broadly to include morbidity and mortality related to HP reversals (stoma takedown operations) as well. Related complications included those involving the stoma (bleeding, need for revision, hernia, etc.) and those that involved reversal of the stoma such as leaking after reanastomosis were

derived from all series that contained this information. Although standardized definitions of complications were not provided by most authors, mention of any of these complications was considered to mean that the presence of this complication was evaluated in all patients in that series in a similar way. Although all studies provided information regarding mortality, only selected studies included information about other complications. In aggregations of data, the denominator of each evaluation included only patients in those studies that included the relevant data points. Proportions dying and with complications were determined but no statistical comparisons reported because of the heterogeneity of the data.

RESULTS

Survival data from patients with diverticular peritonitis undergoing HP (n = 1,051) were derived from 54 studies (Table 1). The aggregate proportion dying (mortality rate) was 18.8 (range, 0–100) percent with a wound infection rate of 24.2 (range, 0–63.3) percent in the 289 cases for which such data were available (13 studies). Complications related to the stoma (necrosis, stenosis, retraction, need for revision) were reported in 10.3 (range, 0–13.3) percent of 117 cases for which such data were available (9 studies). Aggregation of reported results derived from patients undergoing stoma reversal (in those with previous HP) demonstrated a mortality rate of 0.8 (range, 0–14.3) percent derived from 787 cases (26 studies; Table 2).

An anastomotic leak rate of 4.3 (range, 0–25) percent was noted in 466 cases for which such data were available (15 studies). Wound infections were found in 4.9 (range, 0–66) percent of HP reversals (derived from 143 cases for which such data were available; 8 studies). Considering HP and reversal procedures together the more inclusive mortality rate for the HP procedure was 19.6 percent (18.8 percent for HP and 0.8 percent for reversal), the wound infection rate was 29.1 percent (24.2 percent for HP and 4.9 percent for reversal) with stoma complication and anastomotic leak rate of stoma reversal occurring in 10.3 and 4.3 percent, respectively.

Reported results of PA (Table 3) demonstrate variation in the use and types of adjunctive procedures targeted at decreasing the risk of anastomotic failure. Of 569 reported cases from 50 studies, 67 percent (379 cases derived from 34 studies) were performed with PA alone, 16 percent (93 cases derived from 18 studies) had a protective, temporary stoma and 10 percent (52 cases derived from 3 studies) were performed with intraoperative lavage. The mean age of the patients in these subgroups was specified only in a few studies, and was 63 years of age for PA alone (3 studies), 67.5 years of age for PA with stoma (2 studies), and 60 years of age for PAIL (2 studies).

Several studies[21,43,48,52,53,60,64,69,92–100] included patients treated with PA with and without a protective colostomy. In some of these studies,[64,92–94,100] the outcomes in these subgroups were not specified and could not be included in the subgroup analysis. As a consequence, the average mortality rate for the whole PA group was higher than that in the different subgroups (Table 4). The aggregated mortality rate associated with PA of any type was 9.9 (range, 0–75) percent with an anastomotic leak rate of 13.9 (range, 0–60) percent and a wound infection rate of 9.6 (range, 0–26) percent. Although the mortality rate was similar for PA with and without adjunctive procedures (Table 4), leak and wound infection rates were highest in patients undergoing PA alone and 25 to 75 percent lower in reports of PAIL or PA with stoma. Reports of patients undergoing PA performed with stoma demonstrated the lowest rate of leak (6.3 percent) and wound infection (4 percent).

DISCUSSION

Although the Hartmann's procedure has become the standard of care in patients with complicated diverticulitis,[1,3] increasing avoidance of stoma in cancer[101–104] and trauma[13,105] care through the use of primary anastomoses and a recognition that a high percentage of temporary colostomies are actually permanent has led many surgeons to suggest the broader use of PA in diverticulitis. In this comprehensive and systematic review of the literature, we found that reported results of patients with perforation or peritonitis related to diverticulitis who underwent HP demonstrated higher rates of mortality and morbidity than those derived from patients undergoing PA. Although patients undergoing any type of PA had a lower morbidity and mortality rate than patients having HP did, those undergoing PA with fecal diversion or intraoperative colonic lavage (PAIL) had the lowest rates.

Since Belding's[75] first report of PA in 1957, there have been more than 50 reports of PA for patients with perforated diverticulitis and peritonitis. Almost all have been retrospective and invariably selection

Table 1.
Reported Results of the Hartmann's Procedure for Patients With Diverticulitis

Study	Year	No. of Patients	Mortality	Wound Infections	Stoma Complications
Byrne[15]	1966	2	0	NS	NS
Fenger *et al.*[16]	1969	2	2	NS	NS
Barabas[17]	1971	1	1	NS	NS
Miller *et al.*[18]	1971	4	0	NS	NS
Labow *et al.*[19]	1973	5	0	NS	NS
Nunes *et al.*[20]	1974	6	2	NS	NS
Nilsson[21]	1976	3	0	0	0
Eng *et al.*[22]	1977	8	0	2	0
Sweatman *et al.*[23]	1977	1	0	NS	NS
Nahrwold *et al.*[24]	1977	10	1	2	NS
Hinchey *et al.*[25]	1978	8	1	NS	NS
Howe *et al.*[26]	1979	17	1	3	2
Haglund *et al.*[27]	1979	6	2	NS	NS
Edelmann[28]	1981	2	1	NS	NS
Sakai *et al.*[29]	1981	13	3	NS	NS
Killingback[30]	1983	17	3	NS	NS
Underwood *et al.*[8]	1984	9	1	NS	NS
Drumm *et al.*[31]	1984	5	1	NS	NS
Auguste *et al.*[32]	1985	25	5	NS	NS
Nagorney *et al.*[33]	1985	69	6	NS	NS
Shephard *et al.*[34]	1986	17	3	NS	NS
Hulkko *et al.*[35]	1986	16	5	NS	NS
Finlay *et al.*[36]	1987	26	6	NS	NS
Marien[37]	1987	23	2	4	3
Mealy *et al.*[38]	1988	4	0	NS	NS
Christie *et al.*[39]	1988	15	0	0	2
Kourtesis *et al.*[40]	1988	4	0	NS	0
Schein *et al.*[41]	1988	7	2	NS	NS
Berry *et al.*[42]	1989	23	7	NS	NS
Hold *et al.*[43]	1990	31	6	NS	NS
Peoples *et al.*[44]	1990	25	6	NS	NS
Medina *et al.*[45]	1991	3	1	NS	0
Smirniotis *et al.*[46]	1991	8	0	NS	NS
Sarin *et al.*[47]	1991	7	0	NS	NS
Binda *et al.*[48]	1993	17	6	1	NS
Nespoli *et al.*[49]	1993	30	10	NS	NS
Totte *et al.*[50]	1993	11	4	7	0
Kronborg[51]	1993	19	7	NS	NS
Kriwanek *et al.*[52]	1994	24	7	NS	NS
Tudor *et al.*[53]	1994	44	10	NS	NS
Kressner *et al.*[54]	1994	17	2	NS	NS
Bade *et al.*[55]	1994	21	8	NS	NS
Isbister *et al.*[56]	1995	25	2	13	NS
Khan *et al.*[57]	1995	34	7	NS	NS
Belmonte *et al.*[9]	1996	10	0	NS	NS
Tucci *et al.*[58]	1996	5	1	NS	NS
Faltyn *et al.*[59]	1996	34	8	11	NS
Wedell *et al.*[60]	1997	15	4	NS	NS
Desai *et al.*[55]	1998	90	10	NS	NS
Zeitoun *et al.*[6]	2000	52	13	NS	NS
Gooszen *et al.*[61]	2001	19	4	NS	NS
Schilling *et al.*[62]	2001	42	4	NS	NS
Regenet *et al.*[63]	2003	33	4	9	5
Zorcolo *et al.*[64]	2003	87	19	18	NS
Total		1,051	198 (18.8)	70 (24.2)	12 (10.3)

NS = not significant.
Data are numbers with percentages in parentheses unless otherwise stated.

bias was a component of their design. The expected selection bias is that patients at lowest risk for anastomotic complications might get PA, whereas higher risk patients might get HP. Interestingly, both the di-

Table 2.
Reported Results of Colostomy Reversal in Patients With Diverticulitis

Study	Year	No. of Patients	Mortality	Leaks	Wound Infections
Labow *et al.*[19]	1973	14	0	NS	NS
Eng *et al.*[22]	1977	7	0	NS	NS
Liebert *et al.*[65]	1981	17	1	NS	NS
Bakker *et al.*[66]	1982	5	0	0	NS
Underwood *et al.*[8]	1984	10	0	3	NS
Bell *et al.*[12]	1984	54	0	NS	NS
Ling *et al.*[10]	1984	7	1	0	0
Hackford *et al.*[67]	1985	10	0	NS	NS
Shephard *et al.*[34]	1986	12	1	2	NS
Mallonga *et al.*[68]	1986	30	0	0	1
Gregg[69]	1987	14	0	NS	NS
Sweeney *et al.*[70]	1987	23	0	2	0
Haas *et al.*[11]	1988	32	0	NS	NS
Kourtesis *et al.*[40]	1988	6	0	0	0
Hold *et al.*[43]	1990	47	1	4	NS
Geoghegan *et al.*[71]	1991	32	0	NS	NS
Totte *et al.*[50]	1993	3	0	0	2
Eisenstat *et al.*[72]	1993	40	0	NS	NS
Khan *et al.*[73]	1994	28	0	2	2
Belmonte *et al.*[9]	1996	157	0	1	NS
Elliot *et al.*[74]	1997	72	0	1	NS
Desai *et al.*[55]	1998	69	0	NS	NS
Zeitoun *et al.*[6]	2000	34	0	0	0
Schilling *et al.*[62]	2001	32	1	NS	NS
Regenet *et al.*[63]	2003	20	0	2	NS
Gooszen *et al.*[61]	2003	12	1	3	2
Total		787	6 (0.8)	20 (4.3)	7 (4.9)

NS = not significant.
Data are numbers with percentages in parentheses unless otherwise stated.

rection and the magnitude of this bias has been variable because studies have detailed both very high and very low rates of morbidity and mortality with PA. Although some of the earlier series[76,78,89,94,95] reported a low mortality and morbidity rate, a prospective survey of treatment of diverticulitis throughout Australia and New Zealand in 1970 reported clinical anastomotic leaks in 30 percent, concluding that PA should be performed only by expert colorectal surgeons, if at all. To date, although there have been no randomized, controlled trials comparing PA to HP, several prospective studies[83,84,90,102] attempted to address the issue of selection bias by treating all patients with diverticular disease with PA. Unfortunately, most of these studies included only a small number of patients with peritonitis and did not report outcomes in this subgroup with peritonitis.[83,84,102] For example, Gooszen *et al.*,[84] Hoemke *et al.*,[83] and Landen and Nafteux[90] reported results from prospective cohorts and in each of these series there were very low rates of adverse outcome overall, with limited data to indicate outcomes in patients with advanced disease.

Two recent prospective trials evaluated PAIL in diverticular peritonitis. Biondo *et al.*[88] reported 23 patients with Stage III diverticulitis treated with PAIL, without protective colostomy. There were two deaths (8.6 percent), one anastomotic leak (4 percent), four wound infections (17 percent), and two patients required reintervention. Regenet *et al.*[63] compared 27 patients with generalized peritonitis caused by diverticulitis, 3 of which had fecal peritonitis, who were treated with PAIL without colostomy with 33 patients treated by the same group with HP. In this nonrandomized study, the PAIL group had three deaths (11 percent), three anastomotic leaks (11 percent), three fistulas (11 percent), one intra-abdominal abscess (4 percent) that required reintervention, and two (7 percent) wound infections. They found no difference in operative mortality when comparing HP with PA, but the patients in the HP group had more wound infections (27 percent), secondary peritonitis/abscesses (9 percent), and required reintervention more frequently (12 percent). It remains to be seen if the leak rate identified with PA is higher than expected. In reviewing our results, not surprisingly, the lowest rate of anastomotic leak in the PA group (6.3 percent) was

Table 3.
Outcomes of Primary Anastomosis in Patients With Diverticular Peritonitis

Study	Year	No. of Patients	With Protective Stoma?	With Intraoperative Colonic Lavage?	Mortality	Total Leak Related	Wound Infections
Belding[75]	1957	3	no	no	0	0	0
Large[76]	1964	18	no	no	2	NS	NS
Giffin *et al.*[77]	1967	2	no	no	1	1	NS
Ryan[78]	1974	23	no	no	0	4	6
Rodkey *et al.*[79]	1974	1	no	no	1	NS	NS
Howe *et al.*[26]	1979	2	no	no	0	NS	NS
Killingback[30]	1983	37	no	no	3	11	NS
Farkouh *et al.*[80]	1982	15	no	no	1	1	0
Drumm *et al.*[31]	1984	3	no	no	2	NS	NS
Peoples *et al.*[44]	1990	11	no	no	2	NS	NS
Sarin *et al.*[47]	1991	4	no	no	1	NS	NS
Faltyn *et al.*[59]	1996	9	no	no	1	2	2
Nespoli *et al.*[49]	1993	44	no	no	4	NS	NS
Isbister *et al.*[56]	1997	4	no	no	0	NS	NS
Trillo *et al.*[81]	1998	4	no	no	0	0	NS
Umbach *et al.*[82]	1999	28	no	no	0	NS	NS
Hoemke *et al.*[83]	1999	10	no	no	NS	0	NS
Schilling *et al.*[62]	2001	13	no	no	1	0	NS
Gooszen *et al.*[84]	2001	10	no	no	0	NS	NS
Blair *et al.*[85]	2002	9	no	no	2	NS	NS
Makela *et al.*[86]	2002	1	no	no	0	NS	NS
Thow[87]	1980	2	no	yes	0	0	NS
Biondo *et al.*[88]	2000	23	no	yes	2	1	4
Regenet *et al.*[63]	2003	27	no	yes	3	4	2
Botsford *et al.*[89]	1971	20	no	no	1	0	NS
Underwood *et al.*[8]	1984	1	yes	no	0	0	NS
Nagorney *et al.*[33]	1985	4	yes	no	0	NS	NS
Medina *et al.*[45]	1991	3	yes	no	0	1	0
Tucci *et al.*[58]	1996	1	yes	no	0	NS	NS
Belmonte *et al.*[9]	1996	1	yes	no	0	0	NS
Gooszen *et al.*[61]	2001	21	yes	no	3	NS	NS
Landen *et al.*[90]	2002	20	yes	no	3	1	1
Koruth *et al.*[91]	1985	4	yes	yes	2	NS	NS
Madden *et al.*[92]	1965	16	some	no	1	5	1
Dandekar *et al.*[93]	1968	7	some	no	1	2	0
Roxburgh *et al.*[94]	1968	8	some	no	1	0	NS
Tagart[95]	1969	11	some	no	0	1	0
Whelan *et al.*[96]	1971	6	some	no	0	3	1
Endrey-Walder *et al.*[97]	1973	5	some	no	1	3	NS
Nilsson[21]	1976	5	some	no	0	0	0
Gregg[69]	1987	27	some	no	0	6	NS
Alanis *et al.*[98]	1989	3	some	some	0	0	0
Hold *et al.*[43]	1990	16	some	no	3	NS	NS
Saccomani *et al.*[99]	1993	11	some	some	NS	0	NS
Binda *et al.*[48]	1993	9	some	some	1	1	1
Kriwanek *et al.*[52]	1994	7	some	no	1	NS	0
Tudor *et al.*[53]	1994	8	some	some	6	NS	NS
Wedell *et al.*[60]	1997	14	some	no	1	NS	NS
Schwesinger *et al.*[100]	2000	6	some	no	0	NS	NS
Zorcolo *et al.*[64]	2003	32	some	some	3	2	3

NS = not significant.

still higher than that in patients undergoing HP reversal (4.3 percent), but HP reversal takes place in a very different clinical setting.

Patients who had PA of any type had a similar mortality rate (~9 percent), whereas the anastomotic leak rate varied from 6.3 to 19.3 percent depending on the use of protective colostomy and PAIL. This suggests that anastomotic leak is not the only factor impacting perioperative death and that other factors such as age, comorbid conditions, disease severity, and degree of

Table 4.
Summary of Outcomes in Primary Anastomosis

	PA Overall	PA Alone	PA + Stoma	PAIL
Mortality	9.9	8.1	9.2	9.6
No. of studies	48	29	17	3
No. of cases	548	297	109	52
Anastomotic leak	13.9	19.3	6.3	9.6
No. of studies	29	14	8	3
No. of cases	353	145	64	52
Wound infection	9.6	16.4	4	12
No. of studies	17	6	3	2
No. of cases	219	55	25	50

PA = primary anastomosis; PAIL = primary anastomosis and intraoperative colonic lavage.

peritoneal soiling and inflammation may play an important role. Gooszen *et al.*[84] evaluated the relationship between disease severity and the patient's general condition to adverse outcomes of PA but found the rate of anastomotic leakage was not related to a higher Manheim peritonitis index, Acute Physiology and Chronic Health Evaluation (APACHE) II scores, or the Hinchey grade.

Resistance to PA relates to concern for the integrity of the colonic anastomosis and this barrier also was noted when PA was considered for traumatic injuries of the colon. Although some investigators have reported an increased incidence of anastomotic leakage in the setting of peritonitis,[30,53,56,59,69,85,106] this finding is inconsistent.[64,107,108] In a meta-analysis of five, randomized, controlled trials of patients with penetrating colonic injuries, treatment with PA was shown to be superior to HP with regard to intra-abdominal infectious complications, although the grade of the injury was higher in the PA group.[13] Animal studies fail to show that anastomotic dehiscence is increased in the setting of peritonitis,[109–111] but leakage does seem to be related to the fecal load at the time of the anastamosis.[109,110,112] In clinical studies, a threefold increase in the incidence of anastomotic dehiscence has been reported after PA in "loaded" colon in emergency cases compared with elective cases (with bowel preparation).[108,113] Intraoperative colonic lavage[14] has been used to minimize the fecal load and has been shown to reduce fecal loading along with intraluminal bacterial content. In experimental models, intraoperative colonic lavage seems to have a positive effect on anastomotic integrity and collagen metabolism.[114] Primary anastomosis and intraoperative colonic lavage (PAIL), has been shown to be safe in acute obstruction of the left colon, even in the presence of fecal contamination, and without fecal diversion.[115–121] HP may be more appropriate when patients are hemodynamically compromised because of the longer length of operation in PA. It remains to be seen, however, how PAIL performs in the setting of diverticulitis when appropriately compared with HP.

This systematic review had several important limitations. In aggregating data from many different sources, any assessment of the quality of individual study design, definitions, standardization of procedures, and data gathering was problematic. Given the variability in these studies and because none included prospective, randomized data, we believed that meta-analytic or higher level statistical comparisons were inappropriate and have simply provided aggregated and stratified (by PA type) proportions. Although selection bias or confounding by indication may have been a consideration in the improved results found in the reports of PA, the extent of this bias could not be assessed. We addressed this by only including patients described as having perforation or peritonitis in this analysis, but it is possible that other unreported or unmeasured covariates were included in the selection of patients for PA or HP. Because advanced age is linked to worse outcome, when available, we calculated patient age in the PA and PAIL treatment groups. The mean age of the patients undergoing PA and PAIL was specified only in a small number of studies, but it (range, 60–67) was not dramatically lower than the age of patients in several larger series of HP (mean age, 61–69 years).[6,33,55,64]

An additional limitation relates to study size heterogeneity. Although case reports were not included in this analysis, some of the published series included only a small number of patients with generalized peritonitis. To determine if aggregated results were skewed by including reports from small case series, we recalculated the rates of the aggregated outcomes using series with ten or more cases to see its impact on the rates of mortality. Except for a decrease in the mortality of PA overall and PA alone (from 9.9 and 8.1 percent to 7.7 and 6 percent, respectively), the aggregated outcomes were unchanged. Changes in the mortality rate of HP and PAIL in series with more than or less than ten cases did not seem to be clinically important (rates of 18.8 and 9.62 percent in < 10 and 19.2 and 10 percent in > 10). Because of data limitations, we were unable to determine the rate of reversal of the temporary stoma used adjunctively with PA, but the reported rates in the literature are > 89

(range, 89–100) percent with no reported mortalities.[60,61,67,69,90] The stoma used during PA is most often a loop colostomy or ileostomy and reanastomosis usually does not involve as extensive an operation as stoma reversal after HP.

Another potential limitation of any comparison of HP and PA/PAIL is that most of the data for PA/ PAIL comes from studies published after 1990, whereas aggregated data of HP spanned a wider timeline. Because there have been other advances in health care during this broader timeline that have resulted in improved survival over time, we performed a subset analysis of all cases reported after 1990. Of reports published after 1990, mortality of HP was still 20 percent compared with 11.4 percent in PA overall. This demonstrates that reported mortality of HP in the modern age is considerable and during a similar period reported survival in patients with PA was certainly not worse, and may in fact have been better. It was not possible to directly identify the effect of postoperative antibiotics on the results, because their use was not consistently specified. The effect of surgeon experience on outcomes was not addressed by any of these studies but may be an important consideration because PA involves more extensive dissection than HP and may be more challenging in the setting of peritonitis. Last, in most studies the choice of the operation type was left to the discretion of the surgeon, and no explanation was given to why one operation was preferred over the other. It is possible that the choice had to do with the patient's condition (*i.e.*, patients who are hemodynamically compromised received HP), surgeon's experience with each operation, and personal preference.

CONCLUSIONS

Although some advocate PA for patients with perforation or peritonitis related to diverticulitis, there have been no randomized trials to support this decision and the vast majority of reports in this area are of poor quality. They suffer from small sample size and likely include elements of selection and publication bias. As a result, these studies cannot be compared statistically and this represents a limitation of the data. When considering these reports in aggregate, this comprehensive review demonstrates that reports of PA compare favorably to reports of HP for patients with diverticular perforation or peritonitis. Lower rates of mortality, wound infection, and other complications are reported in patients undergoing PA than in reports of patients undergoing HP for similar-stage (Stage 3 and 4 Hinchey) diverticulitis. Reports of patients undergoing PA who have a proximal diversion have the lowest rates of anastomotic leak, reintervention, and wound infection with an acceptable mortality rate. Given patients' aversion to colostomy, the high risk that the "temporary" stoma of the HP is permanent and the significant morbidity and mortality associated with patients undergoing HP this study strongly supports the development of an appropriately designed randomized trial of HP and PA/PAIL. The broader use PA/PAIL should be considered only if it is found to provide increased patient satisfaction or a lower rate of permanent stoma and is as safe or safer than HP.

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