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Laparoscopic Peritoneal Lavage: A Definitive Treatment for Diverticular Peritonitis or a ''Bridge'' to Elective Laparoscopic Sigmoidectomy?

A Systematic Review

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Abstract: To this day, the treatment of generalized peritonitis secondary to diverticular perforation is still controversial. Recently, in patients with acute sigmoid diverticulitis, laparoscopic lavage and drainage has gained a wide interest as an alternative to resection. Based on this backdrop, we decided to perform a systematic review of the literature to evaluate the safety, feasibility, and efficacy of peritoneal lavage in perforated diverticular disease.

A bibliographic search was performed in PubMed for case series and comparative studies published between January 1992 and February 2014 describing laparoscopic peritoneal lavage in patients with perforated diverticulitis.

A total of 19 articles consisting of 10 cohort studies, 8 case series, and 1 controlled clinical trial met the inclusion criteria and were reviewed. In total these studies analyzed data from 871 patients. The mean follow-up time ranged from 1.5 to 96 months when reported. In 11 studies, the success rate of laparoscopic peritoneal lavage, defined as patients alive without surgical treatment for a recurrent episode of diverticulitis, was 24.3%. In patients with Hinchey stage III diverticulitis, the incidence of laparotomy conversion was 1%, whereas in patients with stage IV it was 45%. The 30-day postoperative mortality rate was 2.9%. The 30-day postoperative reintervention rate was 4.9%, whereas 2% of patients required a percutaneous drainage. Readmission rate after the first hospitalization for recurrent diverticulitis was 6%. Most patients who were readmitted (69%) required redo surgery. A 2-stage laparoscopic intervention was performed in 18.3% of patients.

Laparoscopic peritoneal lavage should be considered an effective and safe option for the treatment of patients with sigmoid diverticulitis with Hinchey stage III peritonitis; it can also be consider as a ''bridge'' surgical step combined with a delayed and elective laparoscopic sigmoidectomy in order to avoid a Hartmann procedure. This minimally invasive staged approach should be considered for patients without systemic toxicity and in centers experienced in minimally invasive surgery techniques. Further evidence is needed, and the ongoing RCTs will better define the role of the laparoscopic peritoneal lavage/drainage in the treatment of patients with complicated diverticulitis.

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Abbreviations: ASA = american society of anesthesiologists, ASCRS = American Society of Colon and Rectal Surgeons, DILALA = Treatment of acute diverticulitis laparoscopic lavage vs. resection, L = Liters, Ladies = Laparoscopic peritoneal lavage or resection for generalised peritonitis for perforated diverticulitis, LapLAND = Laparoscopic lavage for Acute Non-Faeculant Diverticulitis, MeSH = Medical Subject Headings, MINORS = Methodological index for nonrandomized studies, PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses, SCANDIV = Scandinavian diverticulitis trial.

INTRODUCTION

Diverticular disease of the colon (diverticulosis) is one of the most common gastrointestinal disorders in western countries. The incidence of diverticulosis increases with age, with 10% of patients aged <40 years and >60% patients aged >80 years affected by this disorder.[1–3] Recent evidence suggests that during the natural history of diverticular disease, only 1% to 4% of patients develop acute diverticulitis,[4,5] which is contrary to previous findings reporting rates ranging between 10% and 25%.[6] Less than 10% of patients who develop acute diverticulitis require emergency surgery.[7] The operative treatment of acute diverticulitis is based on the severity of the disease according to the Hinchey classification,[8] and it includes antibiotics, computed tomography, or ultrasound-guided percutaneous drainage,[10] laparoscopic peritoneal lavage, laparoscopic or open 1-stage colonic resection with direct anastomosis, and sigmoidectomy with terminal colostomy (Hartmann procedure) with or without subsequent colostomy reversal.[9,11] A recent systematic review and meta-analysis, which analyzed 14 studies involving 1041 patients with Hinchey stage III or IV diverticulitis, resulted in a lower mortality rate ($P = 0.02$) and reduced

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postoperative hospitalization ($P < 0.001$) in patients undergoing primary resection with anastomosis compared with the Hartmann procedure. However, despite numerous published articles on operative treatments ranging from generalized peritonitis to perforated diverticulitis, the marked patient heterogeneity (age, sex, american society of anesthesiologists (ASA) scale, comorbidity, Hinchey stage, Manheim peritonitis index) has limited the meta-analysis findings on a quantitative basis. Therefore, the benefit reported in the group of patients undergoing colon resection with primary anastomosis, in terms of reduced mortality rate and hospitalization, should be carefully interpreted.[12] The Hartmann procedure with subsequent colostomy reversal has a mortality rate of 19.6%, whereas 25% to 70% of the patients had permanent colostomy.[13,14] Mortality rate after sigmoid resection and primary anastomosis is around 10% with an anastomotic leakage rate of 14%.[14] In 1996, O'Sullivan et al[15] proposed laparoscopic peritoneal lavage as an alternative to colonic resection in patients with purulent peritonitis secondary to diverticular perforation. The expected benefit of this minimally invasive approach was an avoidance of urgent laparotomy and colostomy, and a reduction in morbidity and mortality. In addition, even in case of treatment failure, the significantly reduced intestinal inflammatory environment after peritoneal lavage would be expected to minimize complications from a subsequent sigmoid resection. This approach has gained a wide interest, and many surgeons have reported their series, which were recently collected into 3 systematic reviews.[13,16,17] The most recent review, which included a total of 231 patients up to 2010,[17] concluded that peritoneal lavage is feasible in acute perforated diverticulitis with a failure rate (and subsequent emergency Hartmann procedure) of 4%. The authors also evidenced a substantial reduction in hospital stay and postoperative morbidity and mortality after peritoneal lavage compared with the same outcomes after Hartmann surgical procedure. However, despite these findings, the recent Practice Parameters for the Treatment of Sigmoid Diverticulitis published in 2014 by the American Society of Colon and Rectal Surgeons (ASCRS)[18] states: ''The poor quality of the existing literature on peritoneal lavage in aggregate and the inherent selection bias in the literature are major obstacles in advocating the widespread adoption of the laparoscopic lavage,'' and adds, ''The safety of lavage for purulent or fecal peritonitis has not been proven or disproven by the published studies to date.'' Hence, based on available knowledge, the possible advantages of peritoneal lavage are still uncertain, mainly owing to the poor methodological quality and/or small sample size in many of the published studies. Based on this backdrop and following recent studies[19–21] that analyze laparoscopic peritoneal lavage in acute perforated diverticulitis, we decided to perform an up-to-date systematic review of the literature. Our aim was to evaluate the safety, feasibility, and efficacy of the peritoneal lavage, with emphasis on the most recent clinical data on the procedure.

METHODS

The methodology suggested by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines was followed in performing and reporting this systematic review.[22] For the present study, an ethics committee and/or institutional board approval was not required.

Search Strategy

A bibliographic search was performed in PubMed for case series and comparative studies describing laparoscopic peritoneal lavage in patients with perforated diverticulitis, published from January 1992 to February 2014. The following search strategies were used in PubMed: (''diverticulitis''[MeSH Terms] OR ''diverticulitis''[All Fields]) AND (''peritonitis''[MeSH Terms] OR ''peritonitis''[All Fields]) AND (''laparoscopy''[MeSH Terms] OR ''laparoscopy''[All Fields]) AND (perforation[All Fields]) AND (''therapeutic irrigation''[MeSH Terms] OR ''therapeutic''[All Fields]) AND (''irrigation''[All Fields] OR ''therapeutic irrigation''[All Fields] OR ''lavage''[All Fields]). The list of references of each eligible article was manually evaluated for relevance to the review topic. The selected publications were independently assessed by 2 authors, and any discrepancies in the interpretation of the findings were discussed and resolved with the consensus of both the authors. Only articles written in English were included.

Study Selection and Inclusion and Exclusion Criteria

All articles reporting laparoscopic peritoneal lavage in patients with sigmoid diverticulitis were included irrespective of the study design. Comparative studies were included regardless of the surgical approach or the outcomes reported.

Exclusion Criteria Considered

Case reports (defined as studies describing the laparoscopic peritoneal lavage in only 1 patient) were excluded. In case of patients overlapping between 2 or more studies, only the most recent study was considered.

Data Extraction

Data of interest from articles were independently extracted by 2 authors and entered into a spreadsheet and subsequently compared. Any discrepancies in data entry, were discussed until a consensus was reached. The following characteristics of each study were extracted: name of the first author, year of publication, country, study design, number of patients, Hinchey classification, ASA score, rate of patients in which adhesiolysis was performed, rate of colonic perforation, and length of follow-up. Primary outcome for this systematic review was the success rate of laparoscopic peritoneal lavage, defined as the rate of patients alive without surgical treatment for recurrent attacks of diverticulitis. Secondary outcomes were

1. laparotomic or laparoscopic conversion rate (defined as the conversion during the procedure of laparoscopic lavage in any form of surgery, different from the peritoneal lavage, with or without bowel resection);
2. 30 day postoperative mortality;
3. 30 day postoperative surgical reintervention rate;
4. 30 day postoperative percutaneous drainage rate;
5. hospital readmission rate for diverticulitis recurrence;
6. two-stage laparoscopic management rate;
7. rate of visualization of colonic perforation during the laparoscopic peritoneal lavage;
8. surgical strategies used in case of detection of a colonic perforation;
9. rate of visceral adhesiolysis searching for visceral perforation;
10. duration of follow-up.

Each dichotomous outcome was expressed in the form of rates. The cumulative rates for a given outcome were calculated taking into account the respective number of events occurring for each outcome and the number of patients in each study.

Assessment of the Methodological Quality of the Included Studies

Methodological index for nonrandomized studies (MINORS)[23] was used to evaluate the methodological quality of the included comparative and noncomparative studies.

RESULTS

The PRISMA flow diagram of literature search is presented in Figure 1. The bibliographic search identified a total of 255 abstracts, and 146 of them were excluded on the basis of either the title or the content of the abstract. Of the 109 remaining full-text articles, 90 were excluded because of duplication, overlap of patients, or being irrelevant on the base of the inclusion/exclusion criteria; only 19 studies remained based on the inclusion criteria (Table 1): 10 cohort studies, 8 prospective case series, and 1 controlled clinical trial. These included studies in total consisted of 871 patients.

Quality Score

The methodological evaluation of included studies with the MINORS scale showed that, among noncomparative studies, only 1 scored 14 points,[24] 3 had 12 points,[21,25,26] and 6 a total of 10 points[20,27–33] over a total of 16 points. The remaining studies collected <10 points. The only included comparative study scored 14 points over a total of 24 (Table 2).

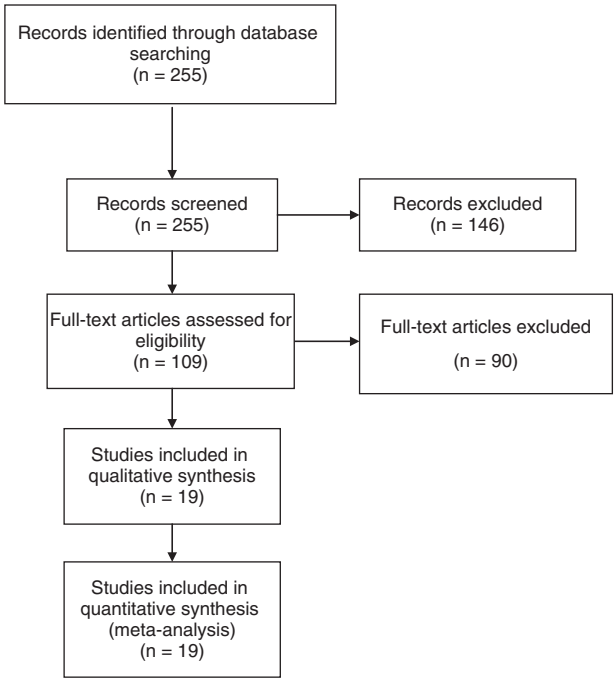

FIGURE 1. The PRISMA flow diagram for systematic review. PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Characteristics of Studies

The included studies were performed in USA, Europe, and Australia; their sample size ranged from a minimum of 4 patients to a maximum of 427. Patients were recruited between 1991 and 2010 with a mean age between 46 and 80 years. Only 8 trials (202 patients) reported the ASA score of each patient (Table 1); the ASA score was I in 27.2% (55 patients), II in 39.6% (80 patients), III in 25.7% (52 patients), and IV in 7.4% (15 patients). The majority of patients presented with a Hinchey stage III or IV (90.1%), and, of these, 9.3% showed fecal peritonitis (stage IV).

Risk of Bias

Only 7 studies described the ASA score for all included patients (202/871, 23.4%); 4 trials[26,30,32,33] reported patients in ASA III and IV but did not distinguish the score (145/871, 16.6%). In the studies by Galleano et al,[34] Mutter et al,[37] and Edeiken et al,[21] the median ASA score was II (24/871, 2.7%). Only 9 trials[15,19,24,27,29,33,34,37,48] reported the detection of perforation, whereas in the remaining studies this was not reported (41/871, 4.7%). The overall conversion rate was reported in 18 studies (444 patients); only Rogers et al[20] did not report this data (427 patients, 49%). Eight trials did not report any surgical strategy in case of perforation[15,20,26,31,32,34,37,48] (594/871, 68.2%). Only 2 trials[26,43] reported the causes of postoperative deaths (103/871, 11.8%). Few trials reported the causes of 30-day postoperative reintervention or percutaneous drainage.[21,24,26,29–31,43,48]

The lenght of follow-up was reported in a total of 344 patients (39.5%). The duration of follow-up was reported in 11 studies, the range reported was very wide: between 6 weeks and 96 months (Table 3). Rogers et al[20] and Mazza et al[29] did not report data about new hospital readmission rate after the first hospitalization, but these 2 studies represent the majority of enrolled patients (452 patients, 51.9%); 10 studies reported the cause of readmission. Seven trials reported the indications to surgical treatment and only a few trials reported the timing[19] and type of surgical treatment[19,21,28,35,37] (Table 3).

Results

A follow-up period ranging from 1.5 to 96 months was reported in 11 trials (Table 3). The success rate of laparoscopic peritoneal lavage, defined as patients alive without surgical treatment for a recurrent episode of diverticulitis or complication from diverticular disease, was 24.3%. Only in 19 patients (19/41, 46.3%), the detection of perforation during laparoscopy was reported (Table 4). A more invasive approach with colon isolation and adhesiolysis was described in only 5 trials,[28,29,34–36] whereas, conversely in 3 trials, any adhesion to colon was left untouched to avoid the intentional opening of a possible covered colonic perforation.[24,31,37] In the study by Edeiken et al,[21] the presence of loculated purulent collections was an indication for conversion and resection of the diseased colon. The volume of wash fluid used for peritoneal lavage was reported in 9 studies.[19,24,26,28,31–34,36] In 5 studies, the fluid volume was between 10[31,34] and 15 L,[24,33,36] whereas, in 4 studies, <5 L was used.[26,28,30,32] The overall conversion rate for Hinchey stages I–IV was 3.8% (17/444), but in stage IV diverticulitis the incidence of conversion was 45% (Table 4). The 30-day postoperative mortality rate was 4.8% (5/103) as a result of multiple organ failure (80%) and embolism (20%) (Table 3). The 30 day postoperative reintervention rate was 4.95%, whereas 2.02% of the patients required percutaneous drainage (Table 3); the major

TABLE 1. Characteristics of Included studies

Study	No. of Patients	Years of Study	Type of Study	Nation	Median Age (Range)	ASA score	Hinchey Classification I	II	III	IV
Swank et al,[19] 2013	38	2008–2010	Retrospective cohort	The Netherlands	59 (23–79)	I 12 II 11 III 12 IV 3	0	5	33	0
Edeiken et al,[21] 2013	10	2009–2012	Prospective case series	USA	50 (39–85)	2.6 median	0	1	8	1
Rogers et al,[20] 2012	427	1995–2008	Retrospective cohort	Ireland	60.7^	NR	0	0	427	
Liang et al,[25] 2012	47	1991–2010	Retrospective cohort	USA	62.6^	I 9 II 24 III 6 IV 5	0	00	47	
White et al,[28] 2010	35	1998–2008	Retrospective cohort	Australia	61^ (36–86)	I 2 II 20 III 11 IV 2	2	20	11	2
Lam et al,[35] 2009	9	1999–2006	Retrospective cohort	Belgium	65^ (43–81)	NR	0	1	5	3
Karoui et al,[24] 2009	35	1994–2006	Clinical control trial	France	56 (35–80)	I 7 II 8 III 10 IV	0	0	35	0
Favuzza et al,[48] 2009	7	NR	Retrospective cohort	USA	46 (35–66)	NR	0	1	6	0
Mazza et al,[29] 2009	25	2003–2007	Prospective case series	France	56^ (19–81)	I 9 II 10 III 6 IV	2	8	9	6
Lippi et al,[30] 2009	13	2000–2008	Prospective case series	Italy	80^ (72–90)	III (84.6%)	0	5	7	1
Myers et al,[26] 2008	100	2000–2007	Prospective case series	Ireland	62 (39–94)	III median	o	25	67	8
Bretagnol et al,[31] 2008	24	2000–2004	Prospective case series	France	55 (26–82)	I 11 II 13 III IV	0	5	18	1
Franklin et al,[36] 2008	40	1991–2006	Retrospective cohort	USA	60^ (28–99)	I 9 II 19 III 7 IV 5	0	5	32	3
Galleano et al,[34] 2007	4	NR	Prospective case series	Italy	67 (60–79)	2.5 median	0	2	2	0
Mutter et al,[37] 2006	10	1996–2003	Retrospective cohort	France	60 (38–76)	II mean	0	0	10	0
Taylor et al,[32] 2006	14	2002–2005	Retrospective cohort	Australia	57 (36–86)	1/3 ASA III or IV	0	2	10	2
Da Rold et al,[27] 2004	7	1996–2001	Retrospective cohort	Italy	65^ (45–95)	NR	1	1	5	0
Faranda et al,[33] 2000	18	1994–1998	Prospective case series	France	53^ (37–74)	The majority ASA III or IV	0	0	16	2
O'Sullivan et al,[15] 1996	8	1991–1994	Prospective case series	Ireland	57^ (30–67)	NR	0	0	8	0

TABLE 2. Assessment of the Methodological Quality of the Included Studies With the MINORS Scale

The Revised and Validated Version of MINORS	Edeiken	O'Sullivan	Faranda	Taylor	Franklin	Bretagnol	Myers	Lippi
Methodological items for nonrandomized studies score								
1. A clearly stated aim The question addressed should be precise and relevant in the light of available literature.	2	2	2	2	2	2	2	2
2. Inclusion of consecutive patients All patients potentially fit for inclusion (satisfying the criteria for inclusion) have been included in the study during the study period (no exclusion or details about the reasons for exclusion).	2	1	2	2	0	2	2	2
3. Prospective collection of data Data were collected according to a protocol established before the beginning of the study.	2	0	0	0	0	0	2	0
4. Endpoints appropriate to the aim of the study Unambiguous explanation of the criteria used to evaluate the main outcome, which should be in accordance with the question addressed by the study. Also, the endpoints should be assessed on an intention-to-treat basis.	2	2	2	2	2	2	2	2
5. Unbiased assessment of the study endpoint Blind evaluation of objective endpoints and double-blind evaluation of subjective endpoints; otherwise, the reasons for not blinding should be stated.	0	0	0	0	0	0	0	0
6. Follow-up period appropriate to the aim of the study The follow-up should be sufficiently long to allow the assessment of the main endpoint and possible adverse events.	2	2	2	2	2	2	2	2
7. Loss to follow-up <5% All patients should be included in the follow-up; otherwise, the proportion lost to follow-up should not exceed the proportion experiencing the major endpoint.	2	2	2	2	2	2	2	2
8. Prospective calculation of the study size Information of the size of detectable difference of interest with a calculation of 95% confidence interval, according to the expected incidence of the outcome event, and information about the level for statistical significance and estimates of power when comparing the outcomes.	0	0	0	0	0	0	0	0
Additional criteria in the case of comparative study								
9. An adequate control group Having a gold standard diagnostic test or therapeutic intervention recognized as the optimal intervention according to the available published data.								
10. Contemporary groups Control and studied group should be managed during the same time period (no historical comparison).								
11. Baseline equivalence of groups The groups should be similar regarding the criteria other than the studied endpoints. Absence of confounding factors that could bias the interpretation of the results.								
12. Adequate statistical analyses Whether the statistics were in accordance with the type of study with calculation of confidence intervals or relative risk.								
Total	12	9	10	10	8	10	12	10

The items are scored 0 (not reported), 1 (reported but inadequate), or 2 (reported and adequate). The global ideal score is 16 for noncomparative studies and 24 for comparative studies.

The Revised and Validated Version of MINORS	Mazza	Favuzza	Kaouri	Lam	White	Liang	Rogers	Swank
Methodological items for nonrandomized studies score								
1. A clearly stated aim The question addressed should be precise and relevant in the light of available literature.	2	2	2	2	2	2	2	2

The Revised and Validated Version of MINORS	Mazza	Favuzza	Kaouri	Lam	White	Liang	Rogers	Swank
2. Inclusion of consecutive patients All patients potentially fit for inclusion (satisfying the criteria for inclusion) have been included in the study during the study period (no exclusion or details about the reasons for exclusion).	2	0	2	0	2	2	2	0
3. Prospective collection of data Data were collected according to a protocol established before the beginning of the study.	0	0	0	0	0	2	0	0
4. Endpoints appropriate to the aim of the study Unambiguous explanation of the criteria used to evaluate the main outcome, which should be in accordance with the question addressed by the study. Also, the endpoints should be assessed on an intention-to-treat basis.	2	2	2	2	2	2	2	2
5. Unbiased assessment of the study endpoint Blind evaluation of objective endpoints and double-blind evaluation of subjective endpoints. Otherwise, the reasons for not blinding should be stated.	0	0	0	0	0	0	0	0
6. Follow-up period appropriate to the aim of the study The follow-up should be sufficiently long to allow the assessment of the main endpoint and possible adverse events.	2	2	2	2	2	2	2	2
7. Loss to follow-up <5% All patients should be included in the follow-up. Otherwise, the proportion lost to follow-up should not exceed the proportion experiencing the major endpoint.	2	2	2	2	2	2	2	2
8. Prospective calculation of the study size Information of the size of detectable difference of interest with a calculation of 95% confidence interval, according to the expected incidence of the outcome event, and information about the level of statistical significance and estimates of power when comparing the outcomes.	0	0	0	0	0	0	0	0
Additional criteria in the case of comparative study								
9. An adequate control group Having a gold standard diagnostic test or therapeutic intervention recognized as the optimal intervention according to the available published data.			2					
10. Contemporary groups Control and studied group should be managed during the same time period (no historical comparison).			0					
11. Baseline equivalence of groups The groups should be similar regarding the criteria other than the studied endpoints. Absence of confounding factors that could bias the interpretation of the results.			0					
12. Adequate statistical analyses Whether the statistics were in accordance with the type of study with calculation of confidence intervals or relative risk.			2					
Total	10	8	14	8	10	12	10	8

The items are scored 0 (not reported), 1 (reported but inadequate), or 2 (reported and adequate). The global ideal score is 16 for noncomparative studies and 24 for comparative studies.

The Revised and Validated Version of MINORS	Mutter	Galleano	Da Rold
Methodological items for nonrandomized studies score			
1. A clearly stated aim The question addressed should be precise and relevant in the light of available literature	2	2	2
2. Inclusion of consecutive patients All patients potentially fit for inclusion (satisfying the criteria for inclusion) have been included in the study during the study period (no exclusion or details about the reasons for exclusion)	0	0	2
3. Prospective collection of data Data were collected according to a protocol established before the beginning of the study.	0	0	0

The Revised and Validated Version of MINORS	Mutter	Galleano	Da Rold
4. Endpoints appropriate to the aim of the study Unambiguous explanation of the criteria used to evaluate the main outcome, which should be in accordance with the question addressed by the study. Also, the endpoints should be assessed on an intention-to-treat basis.	2	2	2
5. Unbiased assessment of the study endpoint Blind evaluation of objective endpoints and double-blind evaluation of subjective end points. Otherwise, the reasons for not blinding should be stated.	0	0	0
6. Follow-up period appropriate to the aim of the study The follow-up should be sufficiently long to allow the assessment of the main endpoint and possible adverse events.	2	0	2
7. Loss to follow-up <5% All patients should be included in the follow-up. Otherwise, the proportion lost to follow-up should not exceed the proportion experiencing the major endpoint.	2	2	2
8. Prospective calculation of the study size Information of the size of detectable difference of interest with a calculation of 95% confidence interval, according to the expected incidence of the outcome event, and information about the level of statistical significance and estimates of power when comparing the outcomes.	0	0	0
Additional criteria in the case of comparative study			
9. An adequate control group Having a gold standard diagnostic test or therapeutic intervention recognized as the optimal intervention according to the available published data.			
10. Contemporary groups Control and studied group should be managed during the same time period (no historical comparison).			
11. Baseline equivalence of groups The groups should be similar regarding the criteria other than the studied endpoints. Absence of confounding factors that could bias the interpretation of the results.			
12. Adequate statistical analyses Whether the statistics were in accordance with the type of study with calculation of confidence intervals or relative risk.			
Total	8	6	10
The items are scored 0 (not reported), 1 (reported but inadequate), or 2 (reported and adequate). The global ideal score is 16 for noncomparative studies and 24 for comparative studies.			

MINORS = methodological index for nonrandomized studies.

TABLE 3. Follow-Up After Laparoscopic Peritoneal Lavage

Author	30 d Postoperative Mortality for Laparoscopic Peritoneal Lavage (Number of Patients—Causes of Deaths)	Readmission in Hospital (Number of Patients—Causes of New Recovery)	Treatment of Patients Readmitted in Hospital	Follow-Up (Number of Patients)	Median Follow-Up (Range) [months]
Edeiken et al,[21] 2013	0	4 (2 Diverticulitis recurrence and 2 with missing colon cancer)	1 Sigmoidectomy with primary anastomosis 1 Left hemicolectomy with end-colostomy 2 Medical therapy	10	NR*
Swank et al,[19] 2013	2 Died (multiorgan failure)	3	2 Elective resection for recurrent sigmoid diverticulitis 1 Emergency sigmoid resection for recurrent perforated diverticulitis	28	69 (12–529)
Liang et al,[25] 2012	0	0		100%	NR
Rogers et al,[20] 2012	17	NR	NR	NR	NR
White et al,[28] 2010	0	8 (3 Recurrent diverticulitis with a painful phlegmon, 1 obstructive recurrence caused by fibrosis from ongoing phlegmon, 3 colovesical fistulas, and 1 repeat perforation)	8 Resection and primary anastomosis		20
Favuzza et al,[48] 2009	0	1 (Pelvic abscess)	Percutaneous drainage	100%	NR
Karoui et al,[24] 2009	0	1 (Recurrent diverticulitis)	Medical treatment	100%	86
Lam et al,[35] 2009	0	3 (Generalized peritonitis)	3 One-staged resection with primary anastomosis	100%	6
Lippi et al,[30] 2009	3	3 (Recurrent diverticulitis)	Surgical treatment	100%	NR
Mazza et al,[29] 2009	0	NR		100%	NR
Bretagnol et al,[31] 2008	0	0		100%	NR
Franklin et al,[36] 2008	0	0		100%	96
Myers et al,[26] 2008	3 (Multiorgan failure in 2 patients and pulmonary embolism in 1)	3 (2 Patients recurrent diverticulitis and 1 patient with left colon cancer) 1 (Patient having a descending colon carcinoma)	Medical treatment	100%	36
Galleano et al,[34] 2007	0	0		100%	NR
Mutter et al,[37] 2006	0	1 (Generalized peritonitis)	Open sigmoidectomy with primary anastomosis and a protective right-sided colostomy	100%	2–3
Taylor et al,[32] 2006	0	0		100%	6 weeks
Da Rold et al,[27] 2004	0	0		100%	38
Faranda et al,[33] 2000	0	0		100%	4
O'Sullivan et al,[15] 1996	0	2	Medical treatment	100%	37

*Not reported.

TABLE 4. Surgical Treatment following Laparoscopic Peritoneal Lavage

Author	Conversion Rate	Display of Colonic Perforation	Treatment of Adhesions	Treatment of Colonic Perforation	Failure Requiring Reintervention
Swank et al,[19] 2013	1 (The left lower quadrant colud not visualized)	2	NR	Laparoscopic colorrhaphy	5: 2 faeculent peritonitis, 1 purulent peritonitis, 2 NR
Edeiken et al,[21] 2013	2 (Feculent pelvic abscess—wide-spread intra-abdominal purulence and a loculated collection in left lower quadrant)	NR	NR	Hinchey IV: laparoscopic or open resectional therapy	2 (2 Recurrent abscess that are percutaneously drained)
Rogers et al,[20] 2012	NR	NR	NR	NR	NR
Liang et al,[25] 2012	1 (Technical difficulty with multiple intestinal perforations)	NR	NR	Free perforation (size <1.5 cm) underwent laparoscopic colorrhaphy.	3 (Worsening of septic symptoms during post-LLD *laparoscopic* peritoneal lavage and *drainage* (LLD) course: 1 relavage and 2 open Hartmann)
White et al,[28] 2010	0 (1 patient required a hand-assisted laparoscopy to completely drain a large recurrent mesocolic abscess, after an initial washout)	NR	Adhesiolysis of omental attachment, loculations, interloop attachments	When communication with colonic lumen is easily demonstrated, patch suture or glue is not attempted and resection is always performed	8 (2 Fecal fistula formation, 1 perforated cancer, 5 inadequate washout, and ongoing sepsis): 6 HP and 2 resections and primary anastomosis 4 (Requiring a second additional laparoscopic washout: 2 for a ongoing sepsis and 2 for an abscess)
Lam et al,[35] 2009	3 HP for generalized peritonitis	NR	The inflammatory sigmoid colon was carefully and blunt dissected	Fecal peritonitis was not treated laparoscopically and were converted to open laparotomy with resection of the diseased colon (Hartman procedure)	0
Karoui et al,[24] 2009	0	6	Any adhesion to the colon was left untouched to avoid disturbing a sealed perforation.	Spontaneously visible perforation, if present, was closed by biologic fibrin glue, omental patch, or sutures	One patient developed a colonic fistula requiring an open Hartmann procedure. One other patient with intra-abdominal abscess further underwent CT guidance drainage.
Favuzza et al,[48] 2009	0	The colonic perforation was not visualized in any of the patients	NR	NR	One pelvic abscess: percutaneous drainage
Mazza et al,[29] 2009	0	10	Adhesiolysis of omental attachment, loculations, interloop attachments	Laparoscopic colorrhaphy and fibrin glue in colonic-free perforation	One pelvic abscess: percutaneous drainage
Lippi et al,[30] 2009	0	NR	NR	Laparoscopic colorrhaphy and fibrin glue in colonic-free perforation. Free perforation with gross fecal was t reated with laparoscopic colorrhaphy and transverse colostomy	1 Enterocutaneous fistula resolved after conservative treatment of 1 case of sepsis, chronic persistent 1 sigmoidectomy
Myers et al,[26] 2008	8 Free perforations with gross fecal peritonitis was not treated laparoscopically and were converted to open laparotomy with resection of the diseased colon (Hartman procedure)	NR	NR	NR	2 Pelvic abscess: Hartman and percutaneous drainage

TABLE 4. Surgical Treatment After Laparoscopic Peritoneal Lavage

Author	Conversion Rate	Display of Colonic Perforation	Treatment of Adhesions	Treatment of Colonic Perforation	Failure Requiring Reintervention
Bretagnol et al,[31] 2008	0	NR	Any adhesion to the colon was left untouched to avoid disturbing a sealed perforation.	NR	2 Pelvic abscess: percutaneous drainage
Franklin et al,[36] 2008	0	NR	Adhesiolysis	Laparoscopic colorrhaphy reinforced by a patch of epiploic appendices in colonic-free perforation	
Galleano et al,[34] 2007	0	The colonic perforation was not visualized in any of the patients	Adhesiolysis of omental attachment, loculations, interloop attachments	—	0
Mutter et al,[37] 2006	0	The colonic perforation was not visualized in any of the patients	Any adhesion to the colon was left untouched to avoid disturbing a sealed perforation	—	0
Taylor et al,[32] 2006	0	NR	NR	NR	3 Reoperation with resection of the diseased segment for consideration if a patient's condition deteriorated or progressed poorly.
Da Rold et al,[27] 2004	1	0	0	Laparoscopic colorrhaphy in colonic-free perforation	0
Faranda et al,[33] 2000	0	Stuck with biologic glue on the infected sigmoid lesion In selected cases omentoplasty	NR	Laparoscopic colorrhaphy and fibrin glue in colonic-free perforation	0
O'Sullivan et al,[15] 1996	0	1	NR	NR	0

CT = computed tomography, HP = hartmann procedure, LLD = *laparoscopic* peritoneal lavage and *drainage*, NR = not reported.

causes of reintervention or percutaneous drainage were sepsis, from generalized peritonitis[19] or intra-abdominal/pelvic abscess,[21,26,29,31,48] and colonic fistula[24,30] (Table 4). Some patients required a reintervention for ongoing sepsis: a second additional laparoscopic washout,[25,28] a percutaneous drainage,[24] or a Hartman procedure[25] (Table 4). The hospital readmission rate after the first hospitalization, during which the patients underwent laparoscopic lavage, was 6.9% (29/419); the most frequent reason for rehospitalization was recurrent diverticulitis (16 patients, 55.2%); other pathologies were generalized peritonitis (6 patients, 20.7%), colo-vesical fistulas (3 patients, 10.3%), undetected colon cancer (2 patients, 6.9%), intestinal obstruction caused by colonic wall fibrosis (1 patient, 3.4%), and pelvic abscess (1 patient, 3.4%) (Table 3). Among the patients readmitted to the hospital, 69% required redo surgery. The most frequent indication for surgical treatment after hospital readmission was a new episode of recurrent diverticulitis (9 patients, 45.0%); other indications were generalized peritonitis (6 patients, 30.0%), colovesical fistula (3 patients, 15.0%), undiagnosed colon cancer (2 patients, 10.0%), and intestinal obstruction caused by colonic wall fibrosis (1 patient, 5.0%). Both the timing and the type of redo surgical treatment was only reported in a few cases and was highly variable. Resection and primary anastomosis represents the most performed treatment (11/12, 91.7%) and only in 1 patient a covering stoma was performed (1/12, 8.3%). Nine patients (31.0%) were readmitted but did not require further surgery: 1 (3.4%) underwent a percutaneous drainage for a pelvic abscess and 8 (27.6%) received conservative medical treatment (Table 3). A 2-stage laparoscopic management (laparoscopic peritoneal lavage followed by laparoscopic sigmoid resection) was performed in 35.8% (159/444) of patients. The timing of the 2-stage laparoscopic procedure from the first intervention varied greatly, ranging from 2 weeks[34] to 21 months.[24] During the 2-stage laparoscopic management, the conversion rate for laparoscopic resection was 4.2% (Table 5); 155 patients that have not received a planned sigmoid resection (34.9%) were alive without surgical treatment for recurrent attacks of diverticulitis or complication of diverticular disease (Table 3). In 5 studies,[15,19,26,27,30] 2-stage laparoscopic management was not performed, and the procedure always resulted in a complete remission of the clinical condition without the need to perform further surgical resection of the sigmoid colon. The data analysis also revealed heterogeneity in the surgical approach to colonic perforation. Some authors reported a colorrhaphy only if the perforation was <1.5 cm in diameter,[25] whereas others performed suturing with[19,27] or without the use of a patch and/or glue.[24,29,30,33,36] The only exception was Lippi et al[30] who performed a colorrhaphy with a lateral colostomy on the transverse in Hinchey IV patients, in order to protect the suture from fecal transit. Edeiken et al,[21] White et al,[28] and Lam et al[35] described sigmoidectomy in case of perforation.

DISCUSSION

Peritonitis, commonly associated with diverticulitis, is the typical manifestation of bowel perforation. The treatment, described in the early twentieth century by Mikulicz,[38] consists of early laparotomy, elimination of the source of infection, and peritoneal cleansing. Later, Rehn[39] described an intraoperative irrigation of the peritoneum with saline solution resulting in a decrease of the mortality rate at 38%.[40] Intraoperative lavage significantly reduces endotoxin levels in the peritoneal fluid and impairs the onset of secondary disease foci as a result of early debridement of fibrin, blood, bacteria, and intestinal debris from the abdominal cavity. Hence, because of its dialytic effect,

TABLE 5. Management After Laparoscopic Peritoneal Lavage

			Two-Stage Laparoscopic Management (Delayed Laparoscopic Sigmoid Resection)	
Author	**Alive Without Surgical Treatment For Recurrent Attacks of Diverticulitis**	**No. of Patients**	**Time lapse From First Intervention (Mean)**	**Conversion Rate**
Edeiken et al,[21] 2013	4	1	NR*	0
Swank et al, 2013[19]	25	0		
Liang et al,[25] 2012	26	21	NR	NR
White et al,[28] 2010	12	8	20 mo	NR
Favuzza et al,[48] 2009	1	4	NR	NR
Karoui et al,[24] 2009	8	25	21 mo	4%
Lam et al,[35] 2009	0	3	NR	NR
Lippi et al,[30] 2009	6	0		
Mazza et al,[29] 2009	9	16	NR	NR
Bretagnol et al,[31] 2008	0	24	3.5 mo	4 (Required a conversion to laparotomy because of pelvic inflammatory adherences the fixed sigmoid)
Franklin et al,[36] 2008	0	24	24	NR
Myers et al,[26] 2008	87	0		
Galleano et al, 2007[34]	0	4	2–28 wks	NR
Mutter et al, 2006[37]	4	6	2–3 mo	NR
Taylor et al,[32] 2006	3	8	6 wk	0
Da Rold et al,[27] 2004	6	0		
Faranda et al,[33] 2000	15	15	3–4 mo	1
O'Sullivan et al, 1996[15]	6	0		

* Not reported.

peritoneal lavage is able to rapidly improve the condition of a septic patient. Extensive intraoperative lavage is easy to perform, safe, and has no serious side-effects.[41] Intraoperative peritoneal lavage, although well entrenched in modern surgical practice, has not yet been demonstrated to decrease mortality. Moreover, there is currently no definitive evidence that the addition of antibiotics to the solution used for the intraoperative lavage is beneficial.[42] The treatment of complicated acute diverticulitis is still a matter of debate.[45,46] The severity of peritoneal involvement varies depending on the stage as classified by Hinchey and subsequent amendments. In nonperitonitis forms, there is general agreement toward a conservative medical treatment (Hinchey I) or a percutaneous drainage (Hinchey II). In more severe forms, (Hinchey III and IV) surgical resection (Hartmann procedure vs colon resection and anastomosis with or without stoma) is still considered the treatment of choice by most surgeons.[47,49] Basically, 3 types of surgical procedures are available:

1. The Hartmann procedure, which comprises resection of the affected colon, debridement, lavage, drainage, and a end colostomy; this procedure in both laparotomic and laparoscopic approach is associated with high rates of morbidity (33%) and mortality (19%).[50] Moreover, the procedure requires additional surgery to restore intestinal continuity, which also contributes to the significant increase of morbidity and mortality. As a result, a high number of patients undergoing this procedure remain with a permanent stoma (25% to 70%), which impacts quality of life.
2. One-stage colonic resection and anastomosis, with or without loop ileostomy or colostomy. This treatment approach is characterized by significant rates of overall-morbidity (29%) and mortality (9%) and in case of stoma confectioning requires a second surgical intervention.[50]
3. Laparoscopic peritoneal lavage and drainage, as first described by O'Sullivan,[15] plus repair of a colonic perforation if necessary. Laparoscopic lavage and drainage is also cited in the most recent clinical guidelines, despite the lack of solid evidence. However, 4 randomized controlled trials (the Laparoscopic peritoneal lavage or resection for generalised peritonitis for perforated diverticulitis Ladies Trial, Treatment of acute diverticulitis laparoscopic lavage vs. resection DILALA, Laparoscopic lavage for Acute Non-Faeculant Diverticulitis LapLAND, and Scandinavian diverticulitis trial SCANDIV)[43,44] (Scandinavian diverticulitis trial. Laparoscopic lavage vs primary resection as treatment for perforated diverticulitis. A randomized prospective multicenter trial. Available at http://www.clinicaltrials.gov/show/NCT01047462. Accessed: July 2014 unpublished data, October 2014; Hogan, A., K. Ryan, and D. C. Winter. ''The LapLAND Trial: Laparoscopic lavage for acute non-faeculant diverticulitis.'' *NCT01019239 at http://clinicaltrials. gov/show/NCT01019239. Accessed May* 5 (2012). Available at http://www.clinicaltrials.gov/ct2/show/NCT01019239?term=LapLAND&rank=1. Accessed: July 2014 unpublished data, October 2014) will be completed shortly, and they should provide more consistent, comprehensive and conclusive data on this subject. The most obvious advantage advocated by the supporters of this technique consists in the avoidance of a large laparotomy and derivative procedures, thus, reducing their consequent complications. Also a reduction of postoperative pain and the subsequent use of analgesics, a lowering of surgical site infections, a potential reduction of the rate of incisional hernias, and an amelioration in postoperative disability should be considered. In addition, the recurrence rate of acute diverticulitis' attacks requiring hospitalization is low, and in most patients there is no need for a deferred colonic resection. Whenever an elective colonic resection is indicated, laparoscopic peritoneal lavage reduces adhesions, therefore, facilitating the laparoscopic approach.

Based on our review of the literature, the laparoscopic peritoneal lavage procedure was effective in almost 1/4 patients; in fact, in this subgroup, additional surgical procedures for recurrent diseases were not performed. Less than one fifth of the patients underwent elective laparoscopic sigmoid resection (2-stage laparoscopic procedure) for prophylactic purposes. Only 6% of patients had second emergency hospitalization for recurrent disease and with about 65% of them requiring surgery. The present study confirms the conclusions of a previous review by Alamili et al,[16] which considered the laparoscopic approach more suitable in nonstercoraceous peritonitis forms (Hinchey III), in which the conversion rate (1%), mean hospital stay, and morbidity and mortality rates were low. However, in cases of colonic perforation (either confirmed or suspected), there is still no consensus regarding the indications for laparotomy and/or colonic resection, to be performed during the first operation in association with laparoscopic peritoneal lavage. In most cases, peritoneal lavage is the only procedure performed.[15,37,48] However, in case of obvious colonic perforation (<1.5 cm), without gross fecal peritonitis, most surgeons performed colic repair, employing different procedures: laparoscopic raphy of the large bowel,[24,25,27,29,30,33,36] biologic fibrin glue,[24,29,30,33] and omental patch.[24,29,33] Also, there are different attitudes toward adhesiolysis, debridement, and/or explorative drilling if the perforation was not immediately visible. Some authors advocate adhesiolysis in order to debride and drain any localized peritonitis or abscess.[28,29,34,36] Other authors prefer to leave the colon untouched in order to preserve an eventual sealed perforation.[24,31] Fecal peritonitis (Hinchey IV) is a rare indication (9%) for laparoscopic lavage. For this condition, some authors[26,31] still prefer traditional laparotomy with an associated bowel resection. In contrast, Lippi et al[30] performed a laparoscopic raphy of the large bowel with a transverse colostomy in 55% of cases. In the remaining cases (45%) with no obvious visceral perforation, a laparoscopic peritoneal lavage was performed.[29,33,36] Indeed, in these cases, the need for a laparotomy increases dramatically (45%). Thus, this procedure must be limited to surgeons with a consistent experience in laparoscopic surgery. Moreover, despite the data presented in the present review, there is some evidence to suggest that laparoscopic peritoneal lavage could be an effective option in patients with an Hinchey III peritonitis if used as a bridge to elective colonic resection; some authors reported that stable patients with Hinchey III peritonitis can be managed successfully also with percutaneous drainage. For these reasons further randomized studies, which compare these 2 different treatments are needed especially to identify the better candidates to each of these approaches.

CONCLUSION

Laparoscopic peritoneal lavage may be considered an effective and safe option for the treatment of patients with sigmoid diverticulitis with Hinchey stage III peritonitis and can be performed as a ''bridge'' procedure with the intent to avoid

the Hartmann procedure. In fact, after an initial ''damage control'' surgery (laparoscopic peritoneal lavage/drainage), these patients may undergo an elective laparoscopic sigmoid resection. Performing this minimally invasive staged approach should be considered suitable to patients without systemic toxicity and only in centers experienced in minimally invasive surgery. Further evidences from the ongoing RCTs are needed to confirm the data of the present review and to finally define the role of the laparoscopic peritoneal lavage and drainage in the treatment of patients with complicated diverticulitis.

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