Five years of experience with laparoscopic peritoneal lavage as the first line of management for perforated colonic diverticulitis with purulent peritonitis

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Background
Emergency colonic resection with anastomosis or Hartmann's procedure (with colostomy) is the traditional management of acute diverticulitis complicated by perforation. Recently, promising results have been reported after laparoscopic lavage in these cases. Selection of patients for this technique is of great importance. This study presents our early experience in the management of purulent peritonitis (Hinchey III) due to perforated diverticulitis.

Patients and methods
A prospective study of 80 patients was conducted during the period between January 2010 and January 2015. All patients with purulent peritonitis (Hinchey III) underwent a trial of laparoscopic peritoneal lavage and drainage. The degree of peritonitis and the procedure-related information were recorded. The primary endpoint of this study was mortality and major morbidity within 30 days of operation. The secondary endpoint included readmission, postoperative complications, length of hospital stay, reoperation, and mortality within 12 months of the emergency surgery.

Results
A total of 87 patients were treated with laparoscopic peritoneal lavage. Seven patients had fecal peritonitis (Hinchey IV) and were excluded from the study. The other 80 patients with a mean age of 55 years were included in the study; four of them (5%) had Hinchey II disease and 76 (95%) had Hinchey III disease. The mean operative time was 100 min. The overall morbidity was 15% and mortality rate was 5%. There were five early reinterventions because of treatment failure. The mean length of hospital stay was 10 days. There was no recurrence of diverticulitis and no intervention was performed after a median follow-up period of 48 months (range = 12–60 months).

Conclusion
Laparoscopic peritoneal lavage and drainage, for diffuse purulent peritonitis due to perforated diverticulitis, is safe and effective. Using this technique, emergency laparotomy with risk for colostomy can be avoided.

Keywords:
diverticulitis, hinchey classification, laparoscopic lavage, perforation

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Introduction

Diverticular disease of the sigmoid colon and its clinical consequences has increased worldwide and the ideal treatment of its complication has remained controversial over the past 50 years [1,2]. Complicated diverticulitis sometimes requires emergency surgery with considerable morbidity [3]. It is classified on the basis of severity according to the Hinchey grading scale, in which grades I and II represent contained abscesses, whereas grades III and IV are cases of perforated colon with either purulent (III) or fecal (IV) leakage [4]. Less than 10% of patients who developed acute diverticulitis required emergency surgery [5,6]. Over the past few decades, various procedures have been recommended as the most effective treatment option, and there is still controversy exactly which surgical treatment should be considered the procedure of choice [7–9]. Hartmann's procedure became a 'gold standard' for perforated diverticulitis when resection was indicated to improve survival compared with a defunctioning colostomy alone [10,11]. The mortality rate is 10–25% and morbidity rate is 30–50% [12,13]. According to some reports, reversal of the colostomy should be possible for most of these patients but actually more than 30% of them never get their stoma reversed [14,15]. More recently, resection and

primary anastomosis with or without a defunctioning stoma has led to less mortality [12,16]. In recent decades, the treatment of acute diverticulitis has evolved toward a more conservative approach [17]. Laparoscopic lavage and drainage (LLD) for perforated diverticulitis was first described by O'Sullivan and colleagues [18,19] in 1996. This approach is effective with low morbidity and mortality rates and avoids a stoma with a relatively short hospital stay [20]. Some retrospective and little prospective studies reported good results; however, no randomized trials have yet reported any results until beginning of 2016; first results came from a randomized controlled trial (treatment of acute diverticulitis, laparoscopic lavage vs. resection) (DILALA) [21]. Encouraged by all these studies, we took into consideration LLD to be our first choice in the management of all patients presented with acute perforated diverticulitis since 2009, and, now, we present our early experience with this management as the first study in our area, assessing the feasibility, applicability, and efficacy of LLD without resection for generalized peritonitis due to perforated diverticulitis.

Patients and methods

We conducted this prospective study during the period from January 2010 to January 2015. Cases selected for the present study were all patients with a clinical diagnosis of generalized peritonitis from perforated diverticulitis admitted to authors' hospitals and confirmed by means of preoperative radiography using computed tomography (CT) scan with oral and intravenous contrast (free gas with or without fluid on CT), as shown in Fig. 1, whereas cases without free air or collection were kept under conservative treatment and were excluded from the study (Fig. 2). Before starting our study, approval was obtained from the ethics committee of each hospital and every patient was informed about the goal and nature of the study, and written consent was obtained.

Inclusion criteria

Age above 18 years.

CT scan with free air and with or without fluid collection.

Tolerance to general anesthesia.

Hinchey grade III with purulent peritonitis.

Figure 1

(a) Axial view: axial postintravenous contrast shows thickened sigmoid colon with stranding of the pericolic fat (arrow); sagittal and coronal reformatted images show localized paracolic collection with air foci inside (arrow). (b) Sagittal view: axial postintravenous contrast shows thickened sigmoid colon with stranding of the pericolic fat (arrow); sagittal and coronal reformatted images show localized paracolic collection with air foci inside (arrow). (c) Coronal view: axial postintravenous contrast shows thickened sigmoid colon with stranding of the pericolic fat (arrow); sagittal and coronal reformatted images show localized paracolic collection with air foci inside (arrow).

Figure 2

(a) Axial view: computed tomography (CT) image showing multiple sigmoid diverticulosis; sagittal reformatted image showing thickened sigmoid wall with smudginess of the surrounding fat, no collection or extraluminal air. (b) Sagittal view: CT image showing multiple sigmoid diverticulosis; sagittal reformatted image showing thickened sigmoid wall with smudginess of the surrounding fat, no collection or extraluminal air.

Hinchey grade II (pelvic abscess) when percutaneous radiological drainage was not feasible or had failed.

Exclusion criteria

Pelvic irradiation and prior complex abdominal surgery.

Hinchey grade I–II at laparoscopy (no free fluid).

Hinchey grade IV at laparoscopy (gross fecal contamination).

Pregnancy.

Bowel obstruction.

Technique

Antibiotics were started in the emergency room (third-generation cephalosporin and metronidazole). The surgical technique performed was similar to that described by other authors [8,10,22]. Patients under general anesthesia were placed in the Davis-Lloyd position with their arm tucked at the sides and fixed to operating table to allow its position change. Pneumoperitoneum was established using the open Hasson technique and 10 mm port was inserted at the umbilical area. The abdominal cavity was visualized, including all four quadrants, and the Hinchey classification was determined. Evaluation of operative field and placement of other trocars were carried out (at least two trocars in the right upper and right lower quadrants). Patients with Hinchey grade III or lower underwent lavage, whereas those with grade IV were converted to Hartmann's procedure and excluded from the study.

The process of LLD was started by culturing and aspirating free purulent fluid in the peritoneal cavity, bluntly dissecting out the diseased sigmoid colon and washed with 3–6 l of body-temperature saline, and, subsequently, the abdominal cavity was washed with a combination of diluted iodine and saline. If any suturable colonic perforation was faced ($<$1.5 cm), it was closed with 2–0 absorbable suture material in one interrupted layer and reinforced with omental or appendices epiploic patch. Two large drains were placed in the pelvis through small incisions in the lower quadrants. The operation was completed with sigmoid colon submersion in irrigation fluid and insufflating it gently through rectum, looking for any bubbles. The fascia of the 10-mm trocar was closed under vision, pneumoperitoneum was released, and all other trocars removed and skin incisions were closed with 3–0 monocryl.

Data collection

Preoperative details included patients' demography, comorbidity, American Society of Anesthesiologists (ASA) grade, and preoperative laboratory examination. Intraoperative findings included Hinchey classification, operating time, operative findings, blood loss, intraoperative complications, and reason for conversion. Postoperative course included complications, time to regain enteral feeding, length of postoperative hospitalization,

reoperations, readmissions, and follow-up consulting. All data were collected in previously prepared charts.

Postoperative treatment and follow-up

Intravenous antibiotic was continued for 5 days and then shifted to oral antibiotic for another 5 days. Enteral nutrition and mobilization were started as early as possible. Six weeks after surgery, a sigmoidoscopy was performed to exclude malignancy as the underlying cause of perforation.

Follow-up after discharge was scheduled weekly for the first month, monthly for 3 months, and then every 3 months for the first year. Patients were seen annually after that to detect any complications and were classified according to Clavien–Dindo score [23].

Endpoints

The primary endpoint of this study was mortality and major morbidity within 30 days of the operation.

The secondary endpoint included readmission, postoperative complications, length of hospital stay, reoperation, and mortality within 12 months of the emergency surgery.

Results

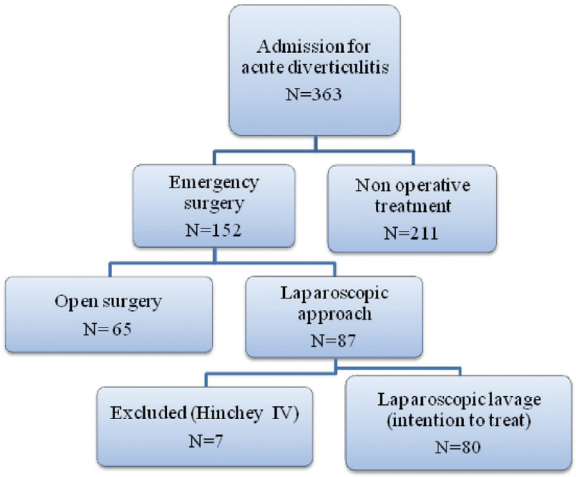
During the study period, a total of 363 patients were admitted with complicated sigmoid diverticulitis; 200 of them (55%) were treated with antibiotic alone and 11 patients were treated with percutaneous drainage (3%).

A total of 152 patients (42%) needed surgical treatment. After application of inclusion and exclusion criteria, 65 of them were not eligible for lavage, and open surgery was performed for them. The surgery included Hartman's procedure with end colostomy in 55 patients and resection with anastomosis in 10 patients.

The remaining 87 patients were eligible for the study and underwent emergency laparoscopic exploration. Seven of these patients underwent fecal contamination and the surgery was converted to Hartman's procedure with end colostomy. The remaining 80 patients presented with purulent generalized peritonitis (Hinchey III) and were managed laparoscopically with peritoneal lavage and drainage (Fig. 3).

The demographic data of the patients are shown in Table 1. A total of 62 men and 18 women with a median age of 55 years were included in the study.

Figure 3



Flow chart showing the distribution of patients presented with complicated diverticulitis.

Table 1 Demographic data of the patients

Variables	Laparoscopic lavage (*n* = 80)
Age (years)	55 (25–77)
Sex (M: F)	62: 18
ASA classification [*n* (%)]	
I	47 (58.75)
II	20 (25)
III	13 (16.25)
IV	0
BMI	26.7 (22–35)
Previous abdominal surgery [*n* (%)]	10 (12.5)
Previous episode of diverticulitis [*n* (%)]	10 (12.5)
Comorbidities [*n* (%)]	
None	45 (56.25)
One or more comorbidities	35 (43.75)

ASA, American Society of Anesthesiologists.

Thirty-five patients had one or more comorbidities. Ten patients had undergone previous abdominal surgery not related to diverticulitis. Ten patients had previous attack of diverticulitis without surgical interference.

The preoperative clinical characteristics of patients are summarized in Table 2. Half of the patients had a high fever and leukocytosis and increased CRP concentration. Diagnosis was based on preoperative imaging with CT scan in all patients; 80 patients (100%) showed free air in peritoneal cavity, and

Table 2 Preoperative clinical characteristics

Variables	Laparoscopic lavage ($n=80$)
Leukocyte count ($\times 10^3$ cells/μl)	14.5 (5.4–23.2)
Body temperature (°C)	37.7 (36.9–40.7)
C-reactive protein (mg/l)	170 (2–400)
CT findings [*n* (%)]	
Free air	80 (100)
Large abdominal abscess	60 (75)
Time between admission and surgery (hh: mm)	4: 10 (2: 45–15: 30)

CT, computed tomography.

Table 3 Operative data

Variables	Laparoscopic lavage ($n=80$)
Operative time (hh: mm)	1: 40 (0: 50–3: 45)
Amount of saline used for lavage (l)	
3	45
4	20
5	10
More	5
Conversion to open surgery [*n* (%)]	2 (2.5)
Use of drain [*n* (%)]	80 (100)
Operative findings and Hinchey staging [*n* (%)]	
Pelvic abscess (Hinchey II)	4 (5)
Purulent exudates (Hinchey III)	76 (95)
Sigmoid perforation [*n* (%)]	5 (6.25)
Operative complications	0

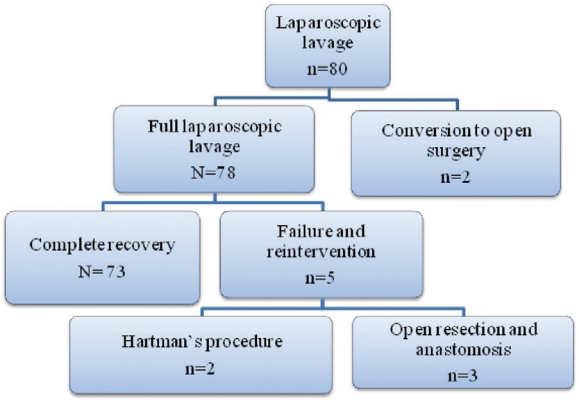
large abdominal abscess was observed in 60 patients (75%).

As regards operative data (Table 3), the median duration of operation was 1 h and 40 min. The median amount of irrigation fluid was 4 l (range = 3–6 l). Placement of drains was reported in all patients. Two patients (2.5%) required conversion to an open procedure due to technical difficulties; thus, the 'feasibility' of the technique was 97.5%. These cases were managed with Hartman's procedure. Laparoscopic lavage was successfully performed in 78 of 152 patients who required emergency surgery; thus, 'applicability' of the method was 51.3%. Most of the patients were of grade III according to the Hinchey classification, with only four patients of grade II. We detected five cases with sigmoid perforation, which was closed intraoperatively according to our protocol.

Table 4 Postoperative outcome

Variables	Laparoscopic lavage ($n=80$)
Admission to ICU [*n* (%)]	12/80 (15)
Blood transfusion [*n* (%)]	8/80 (10)
Period of drains (days)	6 (4–17)
Postoperative hospital stay (days)	10 (5–35)
Reoperation within 30 days [*n* (%)]	5/80 (6.25)
Mortality within 30 days [*n* (%)]	4/80 (5)
Readmission within 30 days of discharge (*n*)	0

Figure 4



Flow chart of surgical outcome after laparoscopic peritoneal lavage.

Short-term postoperative outcomes are summarized in Table 4. Twelve patients needed admission to ICU and eight of them needed blood transfusion postoperatively (Fig. 4).

In addition to the two patients who required conversion during the procedure, another five patients showed symptoms and signs of peritonitis postoperatively; laparotomy was performed with Hartman's procedure for two patients because of fecal peritonitis, and three cases were managed with resection and anastomosis due to residual purulent peritonitis. Four patients died early postoperatively; one of them died 3 days postoperatively because of pulmonary embolism, and the other three cases died 1 week postoperatively because of multiorgan failure. All four patients with diversion (two at first operation and two at second surgery) (5%) underwent reconstruction later on within the first 6 months after discharge.

Morbidity rate was 15% (12 of 80), with surgical complication in 10% (eight of 80) and medical complication in 5% (four of 80).

Patients were followed up for a median of 48 months postoperatively (range = 12–60 months). No malignancy was detected in the specimens for patients operated with resection. Colonoscopy was performed in the remaining patients, who were treated with LLD successfully, 6 weeks after discharge and also no malignancy was detected.

Discussion

The treatment of complicated acute diverticulitis is still a matter of debate and there is controversy about its ideal treatment. Until few years ago, the ideal treatment for peritonitis with perforated diverticulitis was colonic resection with primary anastomosis or Hartmann's procedure [24,25]. Both procedures are associated with significant morbidity and mortality and chance of reversal of Hartmann's procedure is low, ranging from 16 to 40% [7,26,27].

Laparoscopic lavage for perforated diverticulitis has emerged as a promising therapeutic option in nonfeculent peritonitis [16,28]. Intraoperative lavage significantly reduces endotoxin levels in the peritoneal fluid as a result of early debridement of fibrin, blood, bacteria, and intestinal debris from the abdominal cavity [5].

The progress of CT scan makes it the imaging study of choice as it gives good idea about the extent of intraluminal inflammation, degree of pericolic disease, distant abscess collections, obstruction, and fistula. The specificity of CT scan has allowed it to become the substitute to intraoperative assessment made using the Hinchey classification [29].

In our study, all patients were diagnosed by means of CT scan and all of them had free air in the peritoneal cavity and 75% had large pelvic abscess; 76 of 80 (95%) patients had Hinchey III disease intraoperatively, and four of 80 (5%) had localized pelvic abscess of Hinchey II. This is more accurate compared with studies conducted by Myers *et al*. [10] and Franda *et al*. [30] as both reported that 25% of patients who were thought to have generalized peritonitis on clinical examination and preoperative imaging, had only localized abscess at operation. This is due to our strict inclusion and exclusion criteria and the advanced CT machines used in imaging our cases.

We found that the majority of patients had no previous episodes of diverticulitis and this was similar to that reported in the series by others [8,17,31].

As regards the technique of lavage, we broke down all adhesions and loculations before lavage and we faced difficulties in two cases due to marked adhesions and converted to open. This is similar to the study conducted by White *et al.*[18]. Other authors described leaving omental attachment in place and using a large amount of lavage [30–32].

Dealing with colonic perforation is still a matter of controversy as it usually cannot be found intraoperatively and usually it is sealed by means of inflammatory process [2,19]. Some consider it a sign for resection [19,29,33], and others perform laparoscopic colonic repair with stitching, biological fibrin glue, or omental patch [7,22,34]. In our series, we faced five cases with obvious perforations less than 1.5 cm without gross fecal peritonitis, all stitched and covered with omental patch.

From our study and studies by other authors [20,35], we agree with recommendations that LLD is indicated in cases with purulent generalized peritonitis (Hinchey III), and those with fecal peritonitis (Hinchey IV) should be subjected to resections. In contrast, Lippi *et al.*[36] in their series sutured the perforation in fecal peritonitis with proximal transverse colostomy in 55% of patients. Franda *et al*. [30] used fibrin glue.

As regards morbidity and mortality, we reported promising results; mortality occurred in four of 80 (5%) cases, which is similar to that reported in the study conducted by others such as the Irish group [10], as they reported a mortality rate of 4% in a series of 92 patients; Swank *et al.*[8] reported 5% mortality, White *et al.*[18] reported 0% mortality in a series of 35 patients, and Rade *et al.*[20] showed 6% mortality. In the first randomized controlled multicenter trial (DILALA) [21] published in 2016, the mortality rate was 7.7% in the lavage group.

Our overall morbidity was 15%, which seems to be high, although only seven patients presented with severe complications, including the five patients with failure of lavage who needed resection. Our morbidity rate was near to that published in other series [8,10,17].

No patients required readmission for the treatment of diverticulitis in the present series. Janes *et al.*[37] estimated that only 1% might present with recurrent symptoms. Myers *et al.*[10] reported no recurrence in their study. The course of acute diverticulitis is more benign than that previously thought, and the recommendation of elective sigmoid colectomy after two attacks of acute diverticulitis has been recently

questioned [7,10,38]. Recent studies suggest that an episode of diverticulitis may result in buttressing effect around the affected portion of the colon, thereby protecting from subsequent attacks [10,38].

From our prospective study, we found that laparoscopic lavage in perforated diverticulitis was feasible in 97.5%, similar to that reported in DILALA trial, as it showed only 4% of laparoscopies could not be performed.

This study showed authors' early experience, and it is confirmed that the effectiveness of laparoscopic lavage in the management of perforated diverticulitis is 91%, as 73 of 80 patients were successfully treated with this technique. Similar results were obtained by Rade *et al.* [20].

Unlike other retrospective studies with the risk for patients' selection bias and small study size, the strength of our study due to its prospective nature can be attributed to the fact no data were missed and to the homogenous nature of population due to strict inclusion and exclusion criteria.

The weakness of our study is that it concentrated on one technique without comparative study with other modalities for the treatment of perforated diverticulitis. However, our limitation is that we introduced our early experience with LLD and we are working now on this randomized controlled trial comparing LLD with resection (with or without anastomosis). Nowadays, there are four ongoing randomized controlled trials comparing LLD with resection in the management of peritonitis due to perforated diverticulitis. These studies are as follows: treatment of acute diverticulitis laparoscopic lavage versus resection *DILALA*[3], Scandinavian diverticulitis trial *SCANDIV*[12], the laparoscopic peritoneal lavage or resection for generalized peritonitis for perforated diverticulitis *Ladies Trial*[39], and laparoscopic lavage for acute nonfeculent diverticulitis *LapLAND*) [40].

Conclusion

LLD is a safe and effective alternative to the traditional open resection in patients with diverticulitis and purulent peritonitis (Hinchey III). It is applicable in more than half of patients who require urgent surgery. Careful intraoperative case selection is important to outcome. This approach has a low morbidity and mortality rate and colostomy avoidance. We strongly recommend that LLD is contraindicated in fecal peritonitis (Hinchey IV). The results of randomized clinical trials will define the effectiveness of LLD versus resection for purulent peritonitis due to perforate diverticulitis.

Acknowledgements

Conflicts of interest

There are no conflict of interest.

REFERENCES

1 Franklin MEJr, Portillo G, Treviño JM, Gonzalez JJ, Glass JL. Long-term experience with the laparoscopic approach to perforated diverticulitis plus generalized peritonitis. World J Surg 2008; 321507–1511.

2 Taylor CJ, Layani L, Ghusn MA, White SI. Perforated diverticulitis managed by laparoscopic lavage. ANZ J Surg 2006; 76962–965.

3 Thornell A, Angenete E, Gonzales E, Heath J, Jess P, Läckberg Z*et al.* Scandinavian Surgical Outcomes Research Group, SSORG. Treatment of acute diverticulitis laparoscopic lavage vs. resection (DILALA): study protocol for a randomised controlled trial. Trials 2011; 12186.

4 Hinchey EJ, Schaal PG, Richards GK. Treatment of perforated diverticular disease of the colon. Adv Surg 1978; 1285–109.

5 Cirocchi R, Trastulli S, Vettoretto N, Milani D, Cavaliere D, Renzi C*et al.* Laparoscopic peritoneal lavage: a definitive treatment for diverticular peritonitis or a 'bridge' to elective laparoscopic sigmoidectomy?: a systematic review. Medicine (Baltimore) 2015; 94e334.

6 Anaya DA, Flum DR. Risk of emergency colectomy and colostomy in patients with diverticular disease. Arch Surg 2005; 140681–685.

7 Sorrentino M, Brizzolari M, Scarpa E, Malisan D, Bruschi F, Bertozzi S*et al.* Laparoscopic peritoneal lavage for perforated colonic diverticulitis: a definitive treatment? Retrospective analysis of 63 cases. Tech Coloproctol 2015; 19105–110.

8 Swank HA, Mulder IM, Hoofwijk AG, Nienhuijs SW, Lange JF, Bemelman WA. Early experience with laparoscopic lavage for perforated diverticulitis. Br J Surg 2013; 100704–710.

9 Gaertner WB, Kwaan MR, Madoff RD, Willis D, Belzer GE, Rothenberger DA, Melton GB. The evolving role of laparoscopy in colonic diverticular disease: a systematic review. World J Surg 2013; 37629–638.

10 Myers E, Hurley M, O'Sullivan GC, Kavanagh D, Wilson I, Winter C. Laparoscopic peritoneal lavage for generalized peritonitis due to perforated diverticulitis. Br J Surg 2008; 9597–101.

11 Krukowski ZH, Matheson NA. Emergency surgery for diverticular disease complicated by generalized and faecal peritonitis: a review. Br J Surg 1984; 71921–927.

12 Ø resland T. Scandinavian Diverticulitis Trial (SCANDIV). Available at: *https://clinicaltrials.gov/ct2/show/NCT01047462*.[Accessed on 14 May 2014]..

13 Salem L, Flum DR. Primary anastomosis or Hartmann's procedure for patients with diverticular peritonitis? A systematic review. Dis Colon Rectum 2004; 471953–1964.

14 Salem L, Anaya DA, Roberts KE, Flum DR. Hartmann's colectomy and reversal in diverticulitis: a population-level assessment. Dis Colon Rectum 2005; 48988–995.

15 Seetharam S, Paige J, Horgan PG. Impact of socioeconomic deprivation and primary pathology on rate of reversal of Hartmann's procedure. Am J Surg 2003; 186154–157.

16 Rogers AC, Collins D, O'Sullivan GC, Winter DC. Laparoscopic lavage for perforated diverticulitis: a population analysis. Dis Colon Rectum 2012; 55932–938.

17 Rossi GL, Mentz R, Bertone S, Ojea Quintana G, Bilbao S, Im VM, Vaccaro CA. Laparoscopic peritoneal lavage for Hinchey III diverticulitis: is it as effective as it is applicable?. Dis Colon Rectum 2014; 571384–1390.

18 White SI, Frenkiel B, Martin PJ. A ten-year audit of perforated sigmoid diverticulitis: highlighting the outcomes of laparoscopic lavage. Dis Colon Rectum 2010; 531537–1541.

19 O'Sullivan GC, Murphy D, O'Brien MG, Ireland A. Laparoscopic management of generalized peritonitis due to perforated colonic diverticula. Am J Surg 1996; 171432–434.

20 Radé F, Bretagnol F, Auguste M, Di Guisto C, Huten N, de Calan L. Determinants of outcome following laparoscopic peritoneal lavage for perforated diverticulitis. Br J Surg 2014; 1011602–1606 discussion 1606.

21 Angenete E, Thornell A, Burcharth J, Pommergaard HC, Skullman S, Bisgaard T*et al.* Laparoscopic lavage is feasible and safe for the treatment of perforated diverticulitis with purulent peritonitis: the first results from the randomized controlled trial DILALA. Ann Surg 2016; 263117–122.

22 Liang S, Russek K, Franklin MEJr. Damage control strategy for the management of perforated diverticulitis with generalized peritonitis: laparoscopic lavage and drainage versus laparoscopic Hartmann's procedure. Surg Endosc 2012; 262835–2842.

23 Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD*et al.* The Clavien–Dindo classification of surgical complications: five-year experience. Ann Surg 2009; 250187–196.

24 Khalil HA, Yoo J. Colorectal emergencies: perforated diverticulitis (operative and non operative management). J Gastrointest Surg 2014; 18865–868.

25 Sallinen VJ, Mentula PJ, Leppaniemi AK. Non operative management of perforated diverticulitis with extra luminal air is safe and effective in selected patients. Dis Colon Rectum 2014; 57875–881.

26 Afshar S, Kurer MA. Laparoscopic peritoneal lavage for perforated sigmoid diverticulitis. Colorectal Dis 2012; 14135–142.

27 Bissolati M, Orsenigo E, Staudacher C. Role of minimally invasive surgery in the treatment of diverticular disease: an evidence-based analysis. Updates Surg 2015; 67353–365.

28 Welbourn HL, Hartely JE. Management of acute diverticulitis and its complications. Indian J Surg 2014; 76429–435.

29 Favuzza J, Friel JC, Kelly JJ, Perugini R, Counihan TC. Benefits of laparoscopic peritoneal lavage for complicated sigmoid diverticulitis. Int J Colorectal Dis 2009; 24797–801.

30 Faranda C, Barrat C, Catheline JM, Champault GG. Two-stage laparoscopic management of generalized peritonitis due to perforated sigmoid diverticula: eighteen cases. Surg Laparosc Endosc Percutan Tech 2000; 10135–138 discussion 139-141.

31 Bretagnol F, Pautrat K, Mor C, Benchellal Z, Huten N, de Calan L. Emergency laparoscopic management of perforated sigmoid diverticulitis: a promising alternative to more radical procedures. J Am Coll Surg 2008; 206654–657.

32 Chouillard E, Maggiori L, Ata T, Jarbaoui S, Rivkine E, Benhaim L*et al.* Laparoscopic two-stage left colonic resection for patients with peritonitis caused by acute divericulitis. Dis Colon Rectum 2007; 501157–1163.

33 Mutter D, Bouras G, Forgione A, Vix M, Leroy J, Marescaux J. Two-stage totally minimally invasive approach for acute complicated diverticulitis. Colorectal Dis 2006; 8501–505.

34 Mazza D, Chio' F, Khoury-Helou A. Conservative laparoscopic treatment of diverticular peritonitis. J Chir (Paris) 2009; 146265–269.

35 Collins D, Winter DC. Laparoscopy in diverticular disease: controversies. Best Pract Res Clin Gastroenterol 2014; 28175–182.

36 Lippi CE, Beatini L, Cervia S, Fabbricotti A, Miaruelli PA, Spessa E*et al.* Laparoscopic lavage and drainage in the surgical treatment of diverticular disease complicated by peritonitis. Chir Ital 2009; 61467–474.

37 Janes S, Meagher A, Frizelle FA. Elective surgery after acute diverticulitis. Br J Surg 2005; 92133–142.

38 Chapman JR, Dozois EJ, Wolff BG, Gullerud RE, Larson DR. Diverticulitis: a progressive disease? Do multiple recurrences predict less favorable outcomes?. Ann Surg 2006; 243876–830 discussion 880-883.

39 Swank HA, Vermeulen J, Lange JF, Mulder IM, van der Hoeven JA, Stassen LP*et al.* Dutch Diverticular Disease (3D) Collaborative Study Group The ladies trial: laparoscopic peritoneal lavage or resection for purulent peritonitis and Hartmann's procedure or resection with primary anastomosis for purulent or faecal peritonitis in perforated diverticulitis (NTR2037). BMC Surg 2010; 1029.

40 Winter DC. LapLAND laparoscopic lavage for acute non-faeculant diverticulitis. Available at: http://clinicaltrials.gov/ct2/show/NCT01019239. [Accessed on 14 May 2014]..