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REVIEW ARTICLE

Laparoscopic lavage and drainage for Hinchey III diverticulitis: review of technical aspects

Matteo Gregori[1,4] · Diletta Cassini[2] · Norma Depalma[3] · Michelangelo Miccini[3] · Farshad Manoochehri[2] · Gianandrea A. Baldazzi[2]

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Abstract

The surgical treatment for patients with generalized peritonitis complicating sigmoid diverticulitis is currently debated; particularly in case of diffuse purulent contamination (Hinchey 3). Laparoscopic lavage and drainage (LLD) has been proposed by some authors as a safe and effective alternative to single- or multi-stage resective surgery. However, among all the different studies on LLD, there is no uniformity in terms of surgical technique adopted and data show significant differences in postoperative outcomes. Aim of this review was to analyze the differences and similarities among the authors in terms of application, surgical technique and outcomes of LLD in Hinchey 3 patients. A bibliographical research was performed by referring to PubMed and Cochrane. "Purulent peritonitis", "Hinchey 3 diverticulitis", "acute diverticulitis", "colonic perforation" and "complicated diverticulitis" were used as key words. Twenty-eight papers were selected, excluding meta-analysis, reviews and case reports with a very small number of patients. The aim of this review was to establish how LLD should be done, suggesting important technical tricks. We found agreement in terms of indications, preoperative management, ports' positioning, antibiotics, enteral feeding and drain management. On the contrast, different statements regarding indications, adhesiolysis and management of colonic hole and failure of laparoscopic lavage are reported. A widespread diffusion of LLD and standardization of its technique are impossible because of data heterogeneity and selection bias in the limited RCTs. It is necessary to wait for long terms results from randomized clinical trials (RCTs) in progress to establish the efficacy and safety of this technique. More importantly, an increased number of highly skilled and dedicated colorectal laparoscopic surgeons are required to standardized the procedure.

Keywords Laparoscopic lavage · Hinchey 3 diverticulitis · Purulent peritonitis · Complicated diverticulitis · Acute diverticulitis

The article is part of topical collection on mini-invasive colorectal surgery.

✉ Matteo Gregori
matteo.gregori@nhs.net

Diletta Cassini
diletta_cassini@yahoo.it

Norma Depalma
norma.depalma@gmail.com

Michelangelo Miccini
michelangelo.miccini@uniroma1.it

Farshad Manoochehri
fmanoochehri@yahoo.it

Gianandrea A. Baldazzi
gbaldazzi@hotmail.com

[1] University Hospitals Birmingham, "Queen Elizabeth Hospital" Birmingham, Birmingham, UK

[2] Department of Mini-invasive and Robotic Surgery, Abano Terme, Padua, Italy

[3] First Department of Surgery "Pietro Valdoni", "Sapienza" Medical School, Rome, Italy

[4] 3 New Street Chambers, 67A New Street, Birmingham B2 4DU, UK

Introduction

Diverticular disease of sigmoid colon has increased in prevalence over the past century, particularly in Western population older than 50 years with the highest incidence occurring in patients aged over 70, being the fourth most cost-effective gastrointestinal disease in the developed countries. It is the cause for an estimated annual hospitalization of 209 per 1,000,000 adults in Europe [1]. Acute diverticulitis occurs in 25% of these patients causing high rates of urgent hospital admission. Although several classifications to define the extent and severity of diverticulitis have been suggested, the Hinchey's one, proposed in 1978, is currently preferred by the majority of the surgeons [2]. Surgical guidelines on the management of diffuse diverticular peritonitis (Hinchey 3 and 4) have significantly changed through the last 20 years and a unanimous consensus is still not achieved [3].

In case of generalized peritonitis complicating a diverticulitis, the exploration of abdominal cavity is mandatory to define the severity of peritoneal contamination (purulent or fecal), identify the presence and size of a bowel perforation, and thus, choose the most appropriate surgical strategy [4]. Options for treating these patients include single-stage procedures, represented by colonic resection with primary anastomosis, and multi-stage procedures consisting in a primary Hartmann's resection followed by a secondary intestinal reversal. Even if associated to high rates of morbidity and mortality, Hartmann's resection followed by a secondary reversal is the most common surgical strategy currently adopted for the urgent treatment of Hinchey 4 diverticulitis, also with laparoscopic approach as previously described [5–7]. Primary resection with anastomosis (with or without defunctioning stoma) has been progressively adopted in the last decades for treating Hinchey 3 diverticulitis. Laparoscopic lavage and drainage (LLD), introduced at first in 1996 by O'Sullivan [8], has been proposed as an alternative procedure to resective surgery and, successively, several series of patients treated with LLD have been reported in literature with encouraging results [9]. However, when comparing these studies, many diverging approaches are noticed in terms of indication and technical execution of LLD, especially with regard to the management of purulent collections, debridement of necrotic tissue and search of the perforation site.

The aim of our study was to review the state of the literature regarding LLD as a treatment for peritonitis secondary to Hinchey 3 diverticulitis, to identify differences and similarities during the various surgical steps of this procedure.

Materials and methods

A bibliographical research was performed by referring to PubMed and Cochrane. "Purulent peritonitis", "Hinchey 3 diverticulitis", "acute diverticulitis", "colonic perforation" and "complicated diverticulitis" were used as key words. Two different reviewers screened all studies, from April 1996 to August 2017, reporting on patients treated with LLD for Hinchey 3 diverticulitis. Meta-analysis, reviews, case reports, opinion articles and consensus statements were excluded. In case of disagreement on inclusion criteria a third author was consulted. Only full-text articles were included. Finally, 28 studies in English language were enrolled and reviewed (Table 1).

Extracted data were divided in intraoperative and postoperative details. Data regarding indications, antibiotics, patient's position and access to peritoneum were discussed in the text. Intraoperative data included number of trocars, colonic dissection, adhesiolysis, volume and type of fluids used for lavage, management of colonic perforation, number and position of drain tubes, conversion to open approach and operative time (Table 1). Postoperative data, including hospital stay time of oral diet restoration, length of drain's stay, outcomes of LLD (failure) and mortality are displayed in Table 2. This review is an attempt to group all the information regarding the technical steps of LLD, with the intent to point out differences and specially similarities among the authors, to understand the ones that could be considered as stronghold.

Results

Indication to LLD

There are well-established exclusion criteria for an explorative laparoscopy: hemodynamic instability, ASA IV, coagulopathy, hypercapnia and lack of expertise or equipment [10].

Patients admitted with a clinical picture of generalized peritonitis, history of diverticulosis and CT scan findings of free air, free fluid and signs of acute inflammation of the sigmoid colon were eligible for an explorative laparoscopy.

When a diagnostic laparoscopy was indicated, a conservative treatment consisting in a laparoscopic lavage and drainage of peritoneal cavity has been proposed as a safe and effective alternative to resection for patients with Hinchey 3 diverticulitis [7, 9, 11–16].

Laparoscopic lavage and drainage (LLD) may be a safe and efficient alternative treatment to Hartmann's procedure

Table 1 Intraoperative data

Authors	Patients in study	Trocars (*n*)	Colonic dissection (year/*n*)	Adhesiolysis	Lavage (Lt)	Management of perforation	Drain tubes (*n*)	Conversion to open	Mean operative time (min)
O'Sullivan [8]	8	2–3	–	–	Clear fluid	Omentoplasty	0–1	0%	–
Faranda [31]	18	4	–	Yes	15 (9–25)	Fibrin glue ± suture	2	0%	86
Taylor [27]	14	3	–	–	3	–	2	0%	–
Mutter [32]	10	–	No	No	–	Resection	–	–	–
Galleano [33]	4	3	Yes	Yes	5–10	–	2	0%	80
Franklin [26]	40	4 (3–5)	Yes	Yes	20	Suture + omentoplasty	2	0%	62
Bretagnol [12]	24	–	No	No	10	Resection	1	0%	–
Myers [11]	92	3	–	–	≥ 4	–	2	–	–
Mazza [34]	25	4	Yes	Yes	4–10	Suture + fibrin glue	1–3	0%	71
Favuzza [28]	7	–	Yes	Yes	Copious	–	On demand	–	–
Karoui [7]	35	4–6	Yes	No	15 (9–25)	Suture + fibrin glue + omentoplasty	–	0%	98
White [14]	35	4	Yes	Yes	1	Resection	2	0%	50
Liang [30]	47	2–3	Yes	Yes	4	Colporrhaphy (Lambert tech) + patch	2	2.1%	99
Rogers [13]	427	–	–	–	–	–	–	–	–
Swank [24]	38	–	–	–	4	Colorrhaphy	0–3	2.6%	68
Gentile [35]	14	–	–	–	–	–	–	2.33%	75
Radè [36]	71	–	–	–	–	–	–	0%	61
Rossi [29]	44	3	Yes	Yes	3–6	Resection	2 (1–4)	4%	89
Angenete [17]	39	–	–	–	3–10	–	1	0%	68
Vennix [20]	46	–	Yes	–	6	–	1	2.1%	60
Sorrentino [23]	63	3	Yes	Yes	6–8	–	3	–	87
Shultz [19]	101	3	No	No	4	–	1	–	–
Horesh [40]	10	–	Minimal mobilization	No	Clear fluid	–	1	–	–
Catry [39]	15	–	Minimal mobilization	–	5	Colorrhaphy	1–3	0%	80
Parisi [38]	21	3	–	No	–	Exclusion criteria	1–2	–	–
Boselli [37]	5	3	No	No	Clear fluid	Resection	1–2	–	–
Escalante [41]	17	–	–	–	–	–	–	–	–
Roig [47]	10	–	–	–	–	–	–	–	–

– data not found

in complicated diverticular disease where a perforation is the cause of a purulent peritonitis [17]. Unfortunately criteria to opt for laparoscopic peritoneal lavage remain still unsettled.

The lack of clear indications is still due to limited number of randomized controlled trials, being the majority of studies' retrospective analyses. Among the three published prospective studies (DILALA [17], LADIES [18], SCANDIV [19]), the LLD showed good overall results and a reduction of re-operations rate within 12 months in selected Hinchey 3 patients, when compared to urgent colonic resection (Hartmann's procedure (HP) or primary anastomosis) [17, 18, 20]. As a matter, one of these studies (LOLA arm of the LADIES trial) was interrupted because of high postoperative morbidity and mortality after LLD, which seemed to be higher in this cohort of patients than in DILALA trial. The great heterogeneity of randomization procedures, LLD indications and surgical technique represent, though, a selection

Table 2 Postoperative outcomes

Authors	Hospital stay (days)	Oral diet restoration (days)	Drain removal (days)	Failure	Mortality
O'Sullivan [8]	10 (7–17)	5–8	–	0%	0%
Faranda [31]	8 (7–14)	4	–	0%	0%
Taylor [27]	6.5 (5–32)	1 (clear fluid)	3	19% (Hinchey IV)	0%
Mutter [32]	8.5 (4–16)	–	–	10%	–
Galleano [33]	–	6	–	– (bridge to resection)	0%
Franklin [26]	8	2 (1–3)	6	0%	0%
Bretagnol [12]	12 (7–35)	3 (2–10)	–	8% (percutaneous drain)	0%
Myers [11]	8 (7–19)	2 (1–9)	–	2.1%	3%
Mazza [34]	13.8 (6–35)	–	–	4% (percutaneous drain)	0%
Favuzza [28]	7.7 (5–14)	–	–	14%	05
Karoui [7]	8 (5–18)	4	–	5.7% (1 percutaneous drain, 1 Hartmann IV)	0%
White [14]	14 (3–49)	–	3–4	22.8%	0%
Liang [30]	6.6	–	–	6.4%	0%
Rogers [13]	10	–	–	–	4%
Swank [24]	10 (4–77)	–	–	18.42	5%
Gentile [35]	10	4.7	6	7.1%	7%
Radè [36]	12 (5–55)	4	–	15%	6%
Rossi [29]	6 (3–30)	–	–	15%	0%
Angenete [17]	6 (2–27)	–	3 (0–21)	13.2%	7.7%
Vennix [20]	8 (6–159	–	–	24% (Hinchey IV) + 24% (percutaneous drain)	8%
Sorrentino [23]	7 (6–12)	–	–	9.5%	1.6%
Shultz [19]	–	–	–	20%	13.9%
Horesh [40]	11 (5–22)	5	–	30%	0%
Catry [39]	10 (5–20)	–	3–5	40%	6.7%
Parisi [38]	–	6–8	–	33.3%	0%
Boselli [37]	–	6–8	–	0%	0%
Escalante [41]	4.2	2.7 (2–4)	–	0%	0%
Roig [47]	–	–	–	45%	4.5%

– data not found

bias and could be the reason of the differences reported in these trials' outcomes. We are currently awaiting the results of two other randomized trials: the Laparoscopic Lavage for Acute Non-Feculant Diverticulitis (LapLAND) [21] and the laparoscopic lavage observational study (LLOS) [22].

Up to today, the objective criteria that should lead to opt for LLD rather than for colonic resection have not been clearly indicated. Presence of abundant intra-peritoneal fecal material, evidence of large colonic perforation and/or failure of previous LLD has been indicated as a contraindication to LLD [2, 5, 20], whereas cases with minimal and localized fecal contamination and/or colonic micro-perforation are still considered suitable for LLD.

Consequently, the indication HP is based on intraoperative findings and personal judgment of the surgeon. The significant variability of intraoperative findings justifies why it is still difficult to clearly define international guidelines regarding the use of LLD in Hinchey 3 patients. Among these patients, indeed, there is no clear distinction between evident or occult and large or small perforations, as well as minimal or absent fecal contamination. Furthermore, because of the intrinsic difficulty in recognizing fecal material when mixed with pus, Hinchey 3 and Hinchey 4 diverticulitis may be misdiagnosed, even intra-operatively. A preoperative CT-scan with rectal contrast might be helpful in making a correct diagnosis, by showing contrast extravasation in case of overt colonic perforation, as proposed by Vennix et al. [20] in the LADIES trial.

Furthermore, it can be argued that very few authors, such as Sorrentino and Swank [23, 24], mentioned the Mannheim Peritonitis Index [25] as a complementary scale to the Hinchey score. The duration of preoperative peritonitis appears to be a prognostic tool of LLD outcome and could explain its high morbidity and failure rates when performed in patients affected by a diffuse peritonitis lasting more than 24 h. Future prospective cohort studies, with standardized

patient selection protocols and follow-up, are required to define indications and efficacy of LLD.

Intraoperative finding

Antibiotics

The use of broad-spectrum antibiotics, according to the internal guidelines of every single hospital (commonly metronidazole and a cephalosporine), is diffuse [7, 11, 13–15, 23, 26]. Therapy is usually started as soon as the diagnosis is confirmed, normally in emergency unit. Antibiotics are initially prescribed intravenously and subsequently switched to oral. The length of therapy is standard, from 5 to 7 days, comprehensive of both intravenous and oral. Only Bretagnol et al. [12] used to continue the antibiotics therapy for 3 weeks.

Patient position

After fluid resuscitation, patient is brought to theater and commonly placed in Lloyd–Davies position with the hips and knees slightly flexed at 15°. A supine position with closed leg is also described, but not widely used [26]. Operator and assistant stand at the right side of the patient in any case.

Access to peritoneum

Access to peritoneum is controversial: the direct open approach with Hasson technique [27–29] seems the most preferred, followed by Veress needle [11, 26, 30]. Few authors use indifferently both techniques while some others did not detail about the adopted technique [7, 12–14, 23, 24, 31–36].

Access ports

The number of access ports was three in most cases (one 12 mm optical trocar and two for 5 or 10 mm working trocars), even if additional ports are reported. Trocars position is not standardized and there is less rigidity compared with elective surgery. After insertion of the optical trocar through an umbilical or supraumbilical port, the two operative trocars are usually placed under direct vision to identify safe areas of the abdominal wall free from visceral adhesions. These can be positioned in right upper and lower quadrants (most frequently) or rarely in right and left flank [26]. Placing the trocars in the right quadrants allows the operator to change, if necessary, the operation towards a laparoscopic Hartmann's procedure or any other resective surgery. O'Sullivan [8] and Liang [30] "bravely" start their operations positioning only two trocars, and in case of need, add a third one. On the other hand Karoui [7] starts the operation with 4 trocars and rarely inserts two more trocars.

Adhesiolysis and colonic mobilization

There is a strong debate and still no agreement if a diffuse adhesiolysis or a mobilization of the inflamed segment of colon is necessary to achieve a better control of the sigmoid and a subsequent more accurate cleaning. Most authors consider these steps mandatory to achieve an adequate visibility of the diseased colon, to identify the possible perforation and to gain an efficient wash out of the entire abdominal cavity. A careful dissection of visceral adhesions (great omentum, small bowel, pelvic organs, abdominal wall attachments) is performed with the intent to break down any loculations or abscess cavities to achieve a deep cleaning and reduce the risk of LLD failure due to pus collections left behind [14, 23, 25, 26, 28–30, 33, 34]. In these cases authors are normally prone to search for a colonic hole to treat it with the appropriate surgical procedure. In cases where a difficult search for a perforation is due to a lack or inaccurate adhesiolysis, the hole can result unnoticed. For these reasons, some authors advise to complete the procedure with a hydropneumatic test to look for a bowel perforation, using a methylene blue enema or gastrografin [14, 29].

On the contrary, some authors [7, 12, 32, 37] affirm that all visceral adhesions should be left untouched to avoid any risk of turning a purulent peritonitis into a fecal one, thus promoting the spontaneous healing of any covert perforation. Obviously, even in these cases a comprehensive examination of the abdominal cavity is mandatory to recognize any other causes of peritonitis.

However, a limited adhesiolysis prevents the adequate lavage of the entire abdominal cavity and favors the misdiagnosis of a possible fecal leak. The interruption of the LOLA arm of LADIES trial seems to support this theory; a high re-operation rate (24%) was observed in the group of patients where a limited colonic mobilization and pelvic adhesiolysis had been performed [20].

Management of the colonic perforation

Regarding the management of the colonic perforation, we can find complete opposite statements. The evidence of an overt colonic perforation is considered by some authors as an absolute indication to interrupt LLD and convert to a colonic resection [12, 14, 29, 32, 37, 38]. Other authors state that LLD can be safely pursued even in presence of a visible colonic perforation provided that a colporrhaphy is associated [7, 18, 31]. According to them, seeking for a hole in the diseased colon is a mandatory step to reduce the risk of failure of laparoscopic lavage. When a colporrhaphy was performed, a direct suture with absorbable material covered

by fibrin glue and/or an omental patch or epiploic appendix was suggested [7, 23, 26, 30, 31]. Finally, there are authors who did not report any statement regarding the management of a colonic perforation [8, 11, 13, 27, 28, 33, 35].

Peritoneal lavage

The volume of fluid used is reported in most of the studies being screened with values ranging from 1 to 25 L [7, 11, 12, 14, 17, 19, 20, 23, 24, 26, 27, 29–31, 33, 34, 41]. In all cases it is strongly recommended to carry on with the lavage of the entire abdominal cavity until a clear liquid outflow is obtained from all the quadrants [17]. All the authors agree that there is no indication in using different solution that normal saline apart from Franklin [26] who uses normal saline, heparin and iodine and Liang [30] who prefers diluted betadine.

Abdominal drainage

There is spread accordance regarding the use of abdominal drain, but we found some differences in terms of its position, number and length of stay.

Some authors are used to place drains near the perforation or the inflamed colonic segment to promptly identify a possible fecal leak [14, 23, 30, 31] while in other studies drains are positioned only in the Douglas' pouch [26, 32, 36]. Normally a single drain is placed after the procedure, but some authors prefer to leave two and rarely three [18, 23, 34, 41] or four drains [29]. Surprisingly a couple of authors reported no need for drain in sporadic cases or it was at discretion of the surgeon [25, 28].

Type of drain used is variable: soft silicon, Jackson-Pratt, Penrose, Shirley-type; the size is normally 15–24 Fr [11, 12, 19, 20, 33, 34, 37, 38].

Operative time

When reported, LLD resulted commonly shorter than a HP; in fact the studies revealed an average duration of 77.5 and 154 min for LLD and HP, respectively. This variability is mainly due to the skills of the surgeons and the severity of peritonitis, but obviously open surgery with resective intent is a longer procedure.

Intraoperative complications

Data regarding intraoperative complications were not reported in 20 studies. When described, surprisingly, very few authors reported surgical complications (postoperative ileus, wound abscess, recurrent sepsis) [7, 14, 24, 26, 27, 29, 31, 32]. Only White et al. [14] recorded one case of small bowel enterotomy during LLD, managed laparoscopically by direct suture without any further complication.

The absence of demolitive maneuvers during LLD, as well as the advanced laparoscopic skills of surgeons who generally decide to use this technique can justify the low rates of intraoperative complications compared to colonic resective procedures.

Conversion to open technique

As the complexity of the clinical situation requests, this procedure is normally carried out by highly experienced surgeons, with skills in emergency laparoscopic surgery and special interest in colorectal pathologies. This led to a very low conversion rate.

In twelve papers this rate is 0% [7, 8, 12, 14, 17, 26, 27, 31, 33, 34, 36, 39]; Liang [30] reports a 2.1% rate (1/47), Swank [24] a 2.6% rate (1/38), Gentile [35] a 2.33% rate, Vennix [20] a 2.1 and 4% for Rossi [29] (2/44).

Rossi et al. [29] converted patients with evidence of feculent peritonitis during the explorative laparoscopy, and these patients underwent resection. The remnant cases of conversions have to be ascribed to a difficult exposure due to obesity and adhesions or to massive bowel distension that led to a more complex, unsafe and unfeasible procedure.

Postoperative outcomes

Enteral feeding

Analyzing all articles, a shared opinion regarding restoring the enteral feeding is not obvious, especially because just half of them reported some data [7, 8, 11, 12, 26, 27, 31, 33, 35–37, 40, 41].

Generally, a complete gut rest is prescribed for the first 24 h when clear fluids are allowed. According to the majority of the authors, an enteral feeding is generally restarted at fourth to fifth postoperative day [7, 26, 35].

Hospital stay

In all the papers, it is evident how the hospital stay for patients who received LLD is shorter than the one for patients who underwent laparoscopic or open resective surgery (mean stay LLD 8.5 days vs Hartmann 15 days) [7, 8, 11, 12, 26, 27, 31, 33, 35–37, 40, 41].

Drain removal

Very few authors stated a clear indication regarding drain's removal. When reported, authors agree in leaving the drain until the outflow becomes serous, with a stay ranging from 1 to 6 days [14, 26, 27, 35, 39]. An exception is represented

by the LADIES trial in which is reported a median drain stay of 3 days with a range between 0 and 21 days [17].

LLD failure

Lack of improvement in patient's clinical course, worsening of septic status, development of a fecal peritonitis and/or need for re-intervention are considered indicators of LLD failure. Commonly these cases required a reoperation with colonic resection; very rarely cases of a second LLD are reported [30], but there is also a good percentage of "failure cases" simply treated with placement of a CT-guided percutaneous drain, without any general anesthesia [7, 12, 20, 34].

In five articles, no cases of failure are reported [8, 26, 31, 37, 41]. In all of them, a meticulous dissection of the colon was used, interrupting the adhesions and looking for a colonic hole with the intent to close it. This accurate lavage and breaking down any possible abscess wall could be the explanation of a deeper cleaning favoring a reduced risk of failure.

Unfortunately, great variability of unsuccessful LLD rates has been noticed, ranging from 2 to 45%. In these series, the highest percentages of failure are reported when a colonic perforation was clearly visible and in case of incorrect selection of patients (Hinchey IV) [18]. Probably the attempt to close a hole in a diseased colon increases the risk of failure with necessity of a second urgent unplanned operation. Authors with the lowest rates of LLD failure, on the contrary, managed visible perforations by converting LLD procedure into a resection [25, 29]. An exception is represented by White et al. [14] who reported high rates of unsuccessful LLD in spite of converting to resection all patients in case of a visible perforation.

Due to these conflicting results, is difficult to establish whether LLD failure is related or not to the use of dissecting maneuvres and colorrhaphy.

Even the clinical significance of the re-intervention rate deserves some further considerations. According to a large multicenter French study conducted between 1989 and 1996 [42], the re-intervention rate in the lavage group was significant higher when compared to the resection group. Indeed, 37.8% of re-interventions after LLD consisted in percutaneous abscess drainage without any general anesthesia. Excluding these cases, the rate of re-intervention between the two groups was not statistically significant and this was also confirmed by the fact that the increase rate in early re-intervention did not translate into an increased short-term mortality rate [37, 43].

Mortality

The majority of authors proved that the LLD was a safe and effective procedure, being the postoperative mortality null. Eleven papers out of 24 described an uneventful course post-LLD with a mortality rate ranging from 0 to 13.9% (mean value of 6.12%). These rates seem to be aligned to those reported by the three major randomized trials after procedures involving colonic resection (DILALA 11.4%, LOLA 9.5%, SCANDIV 7.1%), and they are due mainly to ongoing sepsis and multi-organ failure [44].

Discussion

Management of purulent peritonitis due to complicated acute diverticulitis (Hinchey 3) is still controversial. O'Sullivan [8] described LLD for the first time in 1996 with a small series of eight patients who were successfully treated with this technique without requiring a second elective operation. After this first experience, multiple series have been published regarding indications and outcomes of LLD when compared to resective procedures. However, there is a lot of uncertainty and reluctancy in choosing a conservative approach in this peculiar clinical setting, mostly due to a lack of standardization. The aim of our analysis is to examine all the papers present in the literature and try to solve this dilemma to determine if this procedure is technically safe and feasible.

Cirocchi et al. [44] concluded in a well-conducted meta-analysis, based on the major RCTs recently published, that, in Hinchey 3 diverticulitis, LLD proved to have no differences compared to resective procedures in terms of early postoperative mortality and surgical re-intervention. Moreover, it showed benefits including a reduction in the operative time, length of hospital stay and stoma formation rate. The main concern in the lavage group seemed to be the higher rate of intra-abdominal abscess, with ongoing sepsis, which justified a greater number of patients who required a secondary delayed colonic resection.

All the series included in this review, apart from the studies conducted by Schultz [19], Rogers [13] and Myers [11], have a limited number of patients enrolled, probably because the criteria to undergo LLD are not so commonly satisfied and mostly because it is not clear whether this approach is the best option for patients admitted with purulent peritonitis.

Undeniably, LLD is an operation that requires a small amount of equipment, with no need for expensive devices, thus reducing the overall costs [45]. Equally, it is widely acknowledged how long-term experience and advanced laparoscopic skills are necessary. Probably this is the reason why LLD is not so diffusely used, in association with the lack of certain results regarding the safety of the procedure.

From a technical point of view, is not simple to define proper indications regarding the correct technique to use,

since the various approaches reported bring to a lack of strong recommendation in almost all fields analyzed.

It is possible to find agreement among the authors about specific technical points: amount and quality of lavage, number and position of ports used, antibiotic therapy, enteral feeding and number of drains.

On the contrary it is difficult to establish recommendations regarding other steps. It is problematic to assess if a meticulous adhesiolysis is the appropriate maneuvre. Some authors, as previously described, are convinced that all adhesions have to be left untouched to consent a good healing of any covert perforation, but this increases the risk of leaving the abdominal quadrants not accurately clean, as well as misdiagnosing fecal peritonitis [7, 12, 19, 32, 37, 38, 40].

Recent results from LOLA trial, interrupted by safety board, demonstrated a high rate of morbidity within 30 days from the lavage. A 24% rate of failure in this trial could be attributed to a limited mobilization and adhesiolysis in the pelvis as described in the study protocol [20]. Indeed, some doubts on the premature interruption of the LLD arm in the LADIES trial, have been raised by Di Saverio et al. [46] regarding the great heterogeneity among the participating centers. Both experience and technical skills might have negatively influenced the results of LLD group; a thorough inspection being necessary in differentiating a Hinchey 3 from Hinchey 4 stage, which would bring down the chances of successful outcome for a non-resectional approach to nothing.

In contrast, carrying out a diffuse adhesiolysis increases the risk of uncovers a healing colonic hole, with the possibility to turn a purulent peritonitis into a fecal one. Adhesiolysis raises the question about the management of a visible colonic perforation. In this case, the main question is: could a suture still be considered feasible or is a resection the right approach? [47].

Another crucial technical point is the extremely difficult selection process. It is not easy to define the right preoperative indication since it is impossible to distinguish a purulent peritonitis from a fecal one based on radiologic findings, and a correct evaluation can be only made during the surgery.

A further consideration is that not all the patients with a purulent peritonitis have the same intraoperative findings, the same amount of pus or abdominal involvement. This can cause several difficulties in terms of establishing exclusion or inclusion criteria.

Regarding the intraoperative findings, Hinchey's classification can be misleading in decision-making process. It classifies patients with a generalized purulent peritonitis and patients with fecal peritonitis. Unfortunately, it is rarely possible to identify a clear purulent or a fecal peritonitis. In fact, most of the time there is presence of both pus and feces, with different proportions causing an enormous variability of pictures. When is still feasible and reasonable proceeding with LLD rather than a HP? The presence of an unclear picture in association with ill-defined results about the safety of the procedure is one of the principal reasons of reluctance in using LLD.

We also have to consider that generalized peritonitis can involve all the abdominal quadrants or just the lowest ones.

Moreover, the very limited spread of the Mannheim Peritonitis Index (MPI) contributes to misdiagnose cases of long-lasting Hinchey 3 or 4 with poor postoperative outcomes and these should not be offered a LLD procedure. A purulent generalized peritonitis, in fact, can represent the clinical picture but its severity usually depends on whether the pathological condition started less or more than 24 h before. Only in two articles [23, 24] out of 24 is specified the fundamental role of timing, not even in the DILALA, SCANDIV and LOLA trials. In our opinion, the decision to treat a patient with a conservative surgery rather than a Hartmann's procedure should be guided also by a correct evaluation of the clinical condition, often influenced by the onset of peritonitic symptoms. To establish the best management, we suggest that the MPI should be included in the preoperative protocol of future randomized controlled trials to help clarifying all these opposing results.

Analyzing all the series, it is clear how this technique is characterized by a lower rate of intraoperative complications and rate of conversion. It is surely due to surgeons' skills and correct indications, but it is worth considering that probably all the complicated patients were treated with demolitive surgery.

Moreover, other reasons could justify the current limited use of LLD. First of all, a pure Hinchey 3 with a generalized purulent peritonitis is not a common condition, in fact most of patients admitted with acute diverticulitis presented a less severe condition and do not require an operation; on the other hand, patients with a colonic hole, even when it is covert, normally present an intraoperative picture of feculent peritonitis, secondary to the initial spreading of feces in the abdomen.

Hospitals with skilled surgeons ready to perform LLD at every hour of the day, is not a common condition; for this reason, a Hartmann's procedure is considered safer and easier, especially when surgical covering is reduced. This is true especially in cases where less experienced or skilled surgeons, like residents, are the responsible of the management.

The last reason, more convincing in this decade, could be represented by the importance and centrality that defensive medicine has acquired. We might think that in the absence of clear guidelines, a surgeon prefers to perform a colonic resection, with well-established and worldwide accepted risks and complications, rather than a conservative surgery with the risk of failure causing a worsening of the septic condition and consequently the necessity for a new urgent operation.

Conclusions

Although having some promising results, LLD cannot be yet light-heartedly recommended as a safe alternative to colonic resection for treatment of patients with Hinchey 3 diverticulitis. Main obstacles might be likely due to the presence of contrasting data on indications and adopted surgical techniques, vague and thus confusing data on postoperative outcomes.

Consequently, a dedicated training and long personal experience in advanced colorectal laparoscopic surgery is, eventually, the key factor in choosing LLD as therapeutic option.

Considering all these factors, a traditional colonic resection is presently preferred by most surgeons, especially those with less laparoscopic expertise, and this policy may be also justified by the rising level of defensive medicine. Probably, surgeons prefer to perform a more invasive, but well-standardized procedure, exposing to well-recognized risks and complications, rather than a still non-standardized conservative surgery exposing to high risk of recurrence, secondary fecal peritonitis and consequent urgent reoperation. It is a technique worth to be considered as an effective option in specific clinical conditions, but it is necessary to wait for long-term results from the ongoing trials before considering it to be widely acknowledged and consequently well standardized.

Compliance with ethical standards

Conflict of interest We have no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

Research involving human participants and/or animals All procedure performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent An informed consent was obtained from the patient involved in the study.

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