

Review: Current Attitudes in Surgical Treatment of Acute Diverticulitis

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Abstract Diverticular disease is a growing problem in Western countries, with proportional impact on society and health spending. Its characteristic of being age-related together with the growing aging of the population will make diverticular disease as a problem increasing in the coming years. Natural history of the disease predicts that about 80 - 85% of patients with colonic diverticulosis will remain asymptomatic, while about 10 - 15% of population with colonic diverticulosis will develop symptoms, up to about 5% who will suffer from acute diverticulitis with its complications. In spite of a large scientific production, some aspects concerning diverticulitis still lack of high evidence and different topics about the role of surgery in both uncomplicated and complicated diverticulitis have long been under debate. Starting from history, through the natural evolution of the disease, we have reviewed the current trends regarding a surgical interest in acute diverticulitis.

Keywords: *diverticulitis, surgery, elective, emergency*

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1. From Origin to Present Days: Diverticulitis' Milestones

Although french surgeon Alexis Littré had produced a first description about even in 1700, and Fleischman from Germany coined the term *divertikel* in 1815 [1], conventionally the introduction of the concept of colon diverticula is ascribed to Jean Cruveilhier, who described more precisely the herniation process of a diverticulum through the muscular layer of the colon and the perivisceritic phenomena characteristic of diverticulitis [2]. From a surgical point of view, in 1907 Mayo presented the first results of the surgical treatment of diverticular disease to the American Surgical Society [3], while in 1920 Henri Hartmann proposed in front of the audience of the French Society of Surgery, the technique that would take his name, conceived indeed for the treatment of neoplastic obstructions but which will play a great role in the treatment of diverticulitis [4]. In 1942, Smithwick proposed a 3-stage treatment of complicated diverticulitis, reporting the results on 82 patients [5] while in 1961 Madden validated the treatment in two stages [6]. Collaterally, in 1971 Painter and Burkitt published their masterpiece paper about the role of a fiber-rich diet in the etiology of diverticulosis [7], while Hinchey's proposal for the classification of complicated acute diverticulitis was in 1978 [8]. In 1991, with the publication of the first series of 17 video-assisted colectomies including some for benign pathology, the era of laparoscopic colorectal surgery was

conventionally born [9]. Diverticular disease becomes of surgical interest in the form of acute diverticulitis, both in its uncomplicated and complicated presentation. Concerning elective surgery, the questions to be answered are essentially three, whether to operate, when to operate and how to operate. Complicated acute diverticulitis can be subject to different treatments from conservative to surgical, due to clinical presentations, patients' characteristics and institutions' facilities. Essentially the issues under debate concern the role and effectiveness of laparoscopic lavage and drainage in Hinchey 3 diverticulitis and the comparison between resection with primary anastomosis versus Hartmann's procedure for the treatment of perforated diverticulitis with generalized peritonitis. Table 1 summarizes the most recent guidelines from scientific surgical and gastroenterological societies about this topic. Some aspects still lack high evidence and continue to be under discussion.

2. Elective Surgery

Indications for elective surgery remain controversial regarding uncomplicated acute diverticulitis. In 2000, recommendations from American Society of Colon and Rectal Surgeons (ASCRS) proposed an indication for elective sigmoidectomy after 2 episodes of uncomplicated diverticulitis, as well as after 1 episode of complicated diverticulitis conservatively managed [10]. Since then, many surgeons followed that recommended pathway, while many others criticized the indication by claiming that there was no evidence to support that an elective

colectomy should follow always two attacks of diverticulitis. ASCRS revised these indications in 2014, suggesting a more cautious attitude and individualizing on a case-by-case basis the indication for elective sigmoidectomy after episodes of uncomplicated acute diverticulitis [11]. It was suggested by the observation perforation generally characterized the first acute episode and the number and severity of recurrences progressively decrease afterwards [12,13]. Many patients will have no other acute episodes after the first and the risk of complicated recurrence after an uncomplicated episode is between 3 and 5% [14,15]. Recurrent diverticulitis rate after segmental resection appears to be around 5%, while the rate of patients reporting residual symptoms after surgery despite the absence of diagnostic evidence of recurrent inflammation reaches up to 20% [16]. In addition, complication rate after elective surgery is described up to 15% [17]. Mäkelä et coll, in 2010, published the review of a large 20-year series of patients hospitalized for acute diverticulitis concluding that 2 acute episodes would not justify an elective surgical treatment [18]. But epidemiological analysis by Peppas et al about over than 30,000 cases estimated a hospital readmission rate of 18.6% in patients treated conservatively, as well as the presence of residual symptoms in 43-86% of the cases, compared with 6.1% of rehospitalizations in patients undergoing surgery [19] and a big 4-years nationwide retrospective cohort study by Simianu et coll concluded that 56.3% of elective procedures were performed before the third uncomplicated episode [20]. Moreover, long-term results from DIRECT randomized controlled trial, which compared sigmoidectomy after 3 or more uncomplicated episodes versus conservative management, showed better outcomes in terms of surgical outcomes, quality of life and economic benefits in favor of surgical treatment, despite a 15% anastomotic leakage rate [21,22]. Timing and indications for elective surgery are subject of a constantly evolving debate and the current trend, promoted by the major international guidelines, seems to prefer a tailored approach, assessing factors related to both the disease and the patient [23]. There is agreement that young patients are more likely to have an acute relapse due to a longer life expectancy, and that they are looking for an improvement in quality of life [24,25], that an elective surgical treatment, especially a minimally invasive one, could provide to them [26]. There is more debate about the attitude towards immunocompromised patients, considering that the risk of perforation during an acute episode is up to 5-times greater than in immunocompetents, however the post-operative morbidity and mortality rates are also greater [27,28]. What is certain is that the "mise à mort" of elective surgery,

especially the minimally invasive one, is not yet justifiable [29]. An excessive delay in surgical indication would be poorly preparatory to minimally invasive surgery as patients with less than 3 episodes of diverticulitis could benefit particularly from an elective laparoscopic procedure [30], considering that an increasing number of attacks over 3 affected conversion rate and perioperative complications in laparoscopic diverticulitis surgery [31]. Sigma trial showed that laparoscopic surgery, despite a 19.2% conversion rate, produced better results than conventional surgery in terms of morbidity, length of hospital stay and quality of life assessed by SF-36 questionnaire [32]. Quality of life and post-operative comfort have been evaluated, also by us, through GastroIntestinal Quality of Life Index (GIQLI) questionnaire, showing a statistically significant improvement in almost all the sample of patients undergoing elective laparoscopic surgery [33,34]. Despite this, the much of published literature is of low evidence, and meta-analysis by Abraha et al was not conclusive in defining whether laparoscopic surgery provides any advantage over conventional surgery in the elective management of acute diverticular disease [35]. Regarding to the timing of surgery, a procedure performed more than 90 days after the last acute episode conservatively treated showed better results in terms of overall morbidity, length of hospital stay and percentage of residual inflammation compared to an early surgery within 90 days [36]. Recently, the low-ligation (LL) of inferior mesenteric artery (IMA), meaning a preservation of left colonic artery, has been compared with the standard high-ligation (HL) at aortic origin level. The rationale was in the attempt to improve anastomotic perfusion and minimize nerves damages. For the treatment of colorectal cancer, the oncological and functional outcomes of LL were similar if not better than HL [37,38]. Although regarding to laparoscopic diverticulitis surgery the type of IMA ligation does not seem to impact on leakage rate [39]. More recently, the concept of smoldering diverticulitis has introduced that condition characterized by recurrent symptoms of uncomplicated diverticulitis, unresponsive to medical therapy but not even progressive towards a complicated form. Patients with smoldering diverticulitis complain of a poor quality of life related to symptoms and so in these cases surgery is strongly an opportunity. Rink et coll described a significant improvement in quality of life at 6 months in patients with smoldering diverticulitis underwent surgery [40]. Mari et al showed that 66% of the patients with smoldering diverticulitis treated by laparoscopic sigmoidectomy in election had histopathologically intramural micro- and macro-abscesses compatible with complicated disease, justifying a surgical treatment [41].

Table 1. Available Guidelines From Scientific Societies Worldwide

Country	Year	Society	Author
USA	2014	ASCRS	American Society of Colon and Rectal Surgeons Feingold D [11]
Germany	2014	DGVS, DGAV	German Society for Gastroenterology, German Society for General and visceral surgery. Kruis W [63]
Italy	2015	SICCR	Italian Society of Colon and Rectal Surgery Binda G [64]
Poland	2015	PSS	Polish Surgical Society Pietrzak A [65]
USA	2015		American Gastroenterological Association Stollman N [66]
World	2016	WSES	World Society of Emergency Surgery Sartelli M [67]
Europe/ USA	2018	EAES, SAGES	European Association for Endoscopic Surgery, Society of American Gastrointestinal and Endoscopic Surgeons Francis NK [68]
USA	2018	AAST	American Association for the Surgery of Trauma Schuster KM [69]
Japan	2019	JGA	Japan Gastroenterological Association Nagata N [70]

3. Emergency Surgery

Original Hinchey classification and its modifications, as reported in [Table 2](#), still represent the most used scores in international guidelines to quantify the severity of complicated acute diverticulitis [\[8,42\]](#). More recent classification systems seemed to be better for a CT scan-based evaluation of complicated diverticulitis, categorizing common findings such as pericolic fat inflammation and the presence of pericolic air bubbles, cutting-off the size of abscesses, detecting the presence of free air at a distance from the inflammation site [\[43,44\]](#). However, Hinchey classification remains easily understandable and allows to speak a common and functional language that aims at a uniform analysis of the data. Low Hinchey scores found a certain uniformity in treatment from surgical societies guidelines, with 100% concordance that small abscesses may be treated by antibiotics solely while large abscesses, usually defined as more than 3-5 cm in diameter, can be interventionally drained in addition to antibiotic treatment [\[8\]](#). In case of poor response to conservative treatment, when patient- and disease-related factors suggest it, as well as for high Hinchey scores, surgical treatment is indicated. We have several arrows at our bow, however, as summarized in [Table 3](#), there is still no clear consensus as to which procedures to use based on disease severity due to results from randomized trials have been conflicting. Laparoscopic lavage and drainage was firstly introduced by O'Sullivan in 1996 for the treatment of 8 patients with generalized purulent peritonitis secondary to perforated diverticulitis diagnosed laparoscopically, showing a 100% success, no conversions, 25% morbidity rate and no sigmoid resection delayed [\[45\]](#). After then some case-series have demonstrated its effectiveness while others criticized its safety stressing high recurrence and reoperation rates [\[46\]](#). Multicenter retrospective LLO study collected 212 patients underwent laparoscopic lavage for Hinchey III diverticulitis showing a successful sepsis control associated with low rates of perioperative mortality and reoperation [\[47\]](#). Randomized trials that compared laparoscopic lavage and drainage with other therapeutic options for different complicated stages have provided controversial results. DILALA trial compared laparoscopic peritoneal lavage versus conventional Hartmann's procedures for Hinchey 3 diverticulitis, where laparoscopic lavage was performed by using 3 liters of saline, positioning of an abdominal drainage and a broad-spectrum antibiotics. The 2-years clinical and economic considerations seemed to favor laparoscopic lavage and drainage technique [\[48,49\]](#). SCANDIV randomized multicenter study that compared 150 patients treated by laparoscopic lavage versus 150 patients undergoing resection with primary anastomosis in acute perforated diverticulitis concluded that both 90-days and 1-year findings didn't support laparoscopic lavage for the treatment of perforated diverticulitis and that any potential advantages of laparoscopic lavage clashed against the risk of secondary surgery and the lack of assessment for malignancies although uncommon [\[50,51\]](#).

Dutch LADIES trial consisted of two arms with different purposes. LOLA arm aimed to compare laparoscopic lavage and drainage versus resection and primary anastomosis in Hinchey 3 complicated diverticulitis, but unfortunately this arm was suspended in March 2014 due to unacceptable results from the laparoscopic lavage cohort, with a 23% early and 17% delayed reoperation rate and a morbidity rate twice that of the controls [\[52\]](#). DIVA arm, comparing resection and primary anastomosis (PA) versus Hartmann's procedure (HP) in Hinchey 3 and 4 complicated diverticulitis concluded that in haemodynamically stable, immunocompetent patients younger than 85 years old, PA seemed to be preferable to HP [\[53\]](#). This appears to be the correct level of comparison in Hinchey's stages 3 and 4. If operative treatment is considered the standard for severe diverticulitis due to perforation and generalized peritonitis, the pathway of choice between PA and HP remains under debate. Recent metanalysis from Cirocchi *et al* highlighted 3 randomized trials that compared PA versus HP for perforated diverticulitis for a total of 254 patients, not reporting statistically significant differences in terms of leakage rate, overall morbidity and mortality between the two methods [\[54\]](#). However, studies with a high level of evidence were lacking and those available often showed bias especially in order to the allocation of patients in the treatment arms. The guidelines from World Society of Emergency Surgery (WSES) also suggested how PA was applicable in case of Hinchey 3 and 4 diverticulitis in selected patients [\[55\]](#). The effectiveness of PA has been confirmed in a broad sense through a prospective analysis by the European Society of ColoProctology (ESCP), which has shown a complication rate comparable to HP. In addition, ESCP suggested that a defunctioning stoma reduced not the rate of anastomotic leakage but the severity of leak-related complications [\[56\]](#). Indications for diverting ileostomy in colorectal surgery remain low- and very-low anastomoses, presence of peritonitis and sepsis, high-risk patients [\[57\]](#), considering then that the reversal rate after diverting ileostomy reaches 90%, as opposed to the Hartmann's reversal rate which does not exceed 50%, also due to the complexity and risk of the procedure. Furthermore, if the patient's hemodynamics is stable, laparoscopic surgery can amplify its vocation to minimize the proinflammatory response to surgical stress in the septic patient [\[58\]](#). The analysis of a retrospective cohort parallel to the LADIES trial indicated that laparoscopic sigmoidectomy for perforated Hinchey 3 diverticulitis was superior to open sigmoidectomy in terms of postoperative morbidity and hospital stay [\[59\]](#). However, there are many factors of variability, related to the disease, the patient and the surgeon. PA was better than HP also in terms of stoma restoration rate, significantly impacting quality of life [\[60,61\]](#). However, we have to stress that Hinchey 4 diverticulitis represents a life-threatening condition that requires a damage-control surgery, considering that fecal peritonitis, especially in high-risk patients, could rapidly lead to septic shock. Therefore HP is the option still more accepted in this setting and in case of frail patients [\[62\]](#).

Table 2. Hinchey Classification for Complicated Acute Diverticulitis

Hinchey classification	Original ⁸	Modified ⁴²
Stage I	Pericolic abscess confined by the mesentery of the colon	Pericolic abscess
Stage II	Pelvic abscess resulting from a local perforation of a pericolic abscess	II A. Distant abscess amenable to percutaneous drainage II B. Complex abscess associated with/without fistula
Stage III	Generalized peritonitis resulting from rupture of pericolic/ pelvic abscess into the general peritoneal cavity	Generalized purulent peritonitis
Stage IV	Fecal peritonitis results from the free perforation of a diverticulum	Fecal peritonitis

Table 3. Selected Randomized Trials on Complicated Diverticulitis Treatment

Study	Author	Year	Inclusion criteria	Plot	Main Findings
Stella	Tartaglia D	to now	Hinchey 2 no-responders and Hinchey 3 - CT scan based	6-liters saline solution LPL (n 27) versus laparoscopic sigmoidectomy (n 38)	In progress
Ladies LOLA	Vennix S [52]	2015	Hinchey 3 - Laparoscopy based	LPL (n 45) versus sigmoidectomy (n 42)	Suspended in March 2014 due to 40% reoperation rate (23% early - 17% delayed) in LPL arm, as well as doubled mortality rate
Ladies DIVA	Lambrechts DPV [53]	2019	Hinchey 3 and 4 - Laparoscopy based	Sigmoidectomy with PA (n 118) versus HP (n 118)	Sigmoidectomy with PA is preferable than HP in hemodynamically stable, immunocompetent, younger than 85 yo patients
SCANDIV	Schultz JK [51]	2017	Perforated diverticulitis requiring surgery - CT scan based	LPL (n 101) versus sigmoid resection (n 98)	Complications rate and disease-related mortality were similar. Patients in the LPL group underwent more unplanned reoperations
DIVERTI	Bridoux V [71]	2017	Hinchey 3 and 4 - CT scan based	PA with diverting stoma (n 50) versus HP (n 52)	Morbidity and mortality rate comparable. At 18 months stoma reversal rate was superior for PA arm
Dilala	Kohl A [48]	2018	Hinchey 3 - Laparoscopy based	3.liters saline solution LPL (n 43) versus Hartmann's procedure (n 40)	LPL group showed reduced risk of undergoing one or more operations within 24 months and had fewer operations than HP. No difference in mean number of readmissions and mortality rate

LPL - Laparoscopic Peritoneal Lavage; HP - Hartmann's procedure; PA - Primary Anastomosis.

4. Conclusions

Some aspects of the surgical treatment of acute diverticulitis lack of evidence and future high-value studies are desirable. However, it should be noted that elective surgery must follow a tailored indication focused on both type of patient and disease, and be performed laparoscopically. As for complicated disease, conditions classifiable with low Hinchey scores can be treated conservatively or by percutaneous drainage after the failure of a conservative strategy. The role of laparoscopic lavage and drainage seems to be contradictory and in any case does not represent a definitive treatment. Generalized peritonitis can be treated by PA in fit patients, while HP remains an effective procedure in frail patients or life-threatening situations.

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