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CLINICAL GUIDELINES

Practice parameters for the treatment of colonic diverticular disease: Italian Society of Colon and Rectal Surgery (SICCR) guidelines

G. A. Binda[1] · R. Cuomo[2] · A. Laghi[3] · R. Nascimbeni[4] · A. Serventi[1] · D. Bellini[3] · P. Gervaz[5] · B. Annibale[6]

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Abstract The mission of the Italian Society of Colorectal Surgery (SICCR) is to optimize patient care. Providing evidence-based practice guidelines is therefore of key importance. About the present report it concernes the SICCR practice guidelines for the diagnosis and treatment of diverticular disease of the colon. The guidelines are not intended to define the sole standard of care but to provide evidence-based recommendations regarding the available therapeutic options.

Keywords Diverticulosis · Diverticular disease · Diverticulitis · Colon

Methods

The literature on diverticular disease (DD) of the colon was reviewed by a group of Italian experts joined by a foreign expert on the topic (PG).

✉ G. A. Binda
gian.andrea.binda@galliera.it

[1] Department of Surgery, Galliera Hospital, Genoa, Italy

[2] Department of Clinical Medicine and Surgery, Federico II University, Naples, Italy

[3] Department of Radiological Sciences, Oncology and Pathology, Rome I.C.O.T. Hospital, La Sapienza University, Latina, Italy

[4] Department of Molecular and Translational Medicine, University of Brescia, Brescia, Italy

[5] Coloproctology Unit, La Colline Clinic, Geneva, Switzerland

[6] Division of Gastroenterology, Department of Translational Medicine, Sant'Andrea Hospital, Sapienza University, Rome, Italy

The final grade of recommendation was determined by using the Grades of Recommendation, Assessment, Development and Evaluation (GRADE) system [1]. Recommendations were reviewed by the Board of the Italian Society of Colon and Rectal Surgery.

Definitions

Colonic diverticula are herniations of the mucosa and submucosa through the bowel muscular layer. Diverticulosis is merely the presence of colonic diverticula: if symptoms and/or complications appear, we talk of diverticular disease (DD). Symptomatic uncomplicated diverticular disease (SUDD) is defined as mild, recurring abdominal pain attributed to diverticula and may be difficult to distinguish from irritable bowel syndrome (IBS) [2, 3]. Complicated diverticular disease (CDD) is DD with inflammation and possibly bleeding: the type of onset and duration of symptoms differentiate acute from chronic CDD. The inflammation, by far the most frequent and due to more or less severe diverticular perforation, is called diverticulitis. The presentation of acute diverticulitis (AD) could range from a localized, mild pain and/or tenderness, to an abdominal abscess or a free perforation with diffuse peritonitis. Different classifications of AD have been proposed, and the most utilized is the Hinchey classification [4].

Recurrent episodes of AD could lead to chronic CDD, mainly identified in as the presence of symptomatic chronic bowel stenosis or fistulization, usually colovesical or colouterine fistulas.

Epidemiology

DD imposes a significant burden on Western and industrialized societies.

The prevalence of diverticulosis increases with age, affecting about 70 % of 80-year-olds, and is increasing because the population is getting older [5]. From 10 to 25 % of individuals with diverticulosis develop complications such as diverticulitis [6].

Hospitalizations for diverticular disease have also been on the rise [7–9].

Recent literature has reported an increase in the incidence of DD among younger patients. In a large review of the Nationwide Inpatient Sample (NIS) of 267,000 admissions for AD between 1998 and 2005 [7], incidence rates increased most dramatically in 18- to 44-year-olds and 45- to 64-year-olds, while they remained stable in 65- to 74-year-olds and actually decreased in persons 75 years of age or older.

In summary, the prevalence of diverticulosis and DD is increasing in Western countries and there has been an increasing rate of hospital admission for diverticulitis. Moreover, there is increasing incidence among individuals younger than 40 years of age (Evidence: 2c).

Pathophysiology

The pathophysiology of DD can be categorized as (a) diverticula development, (b) symptoms generation in uncomplicated DD and (c) development of diverticulitis.

Lifestyle factors are considered key elements for the development of diverticulosis and its complications. A low-fibre diet appears to play a major role as it appears from case control and prospective dietary studies [10–13]. The low-fibre hypothesis has recently been disputed [14–17]. A study on 2104 individuals undergoing colonoscopy showed that a high-fibre intake was positively associated with the presence of diverticulosis (prevalence ratio = 1.30 95 % confidence interval (CI), 1.13–1.50) [18]. Genetic factors may also play a role [14].

Up to 20 % of individuals with diverticula experience abdominal pain associated with abnormal motor function and a reduced threshold for perception of visceral sensitivity [17], similarly to individuals with IBS [18]. An increased number of mast cells in all the layers of the colonic wall may contribute to pain development [19]. Trauma caused by faecoliths may cause epithelial breakdown and bacterial translocation, which may lead to diverticulitis. Examination of mucosal biopsies from symptomatic DD showed low-grade inflammation (i.e. lymphocytes and neutrophils) despite endoscopically normal mucosa [20]. Post-inflammatory gut dysfunction following acute infectious gastroenteritis (post-infectious IBS) is a condition similar to diverticulitis [21]. Indeed, a recent study showed that patients with diverticulitis were 4.7 times more likely to develop IBS-like symptoms over the observation period compared to matched controls [22].

Diagnostic tests

What is the best diagnostic test to confirm or rule out diverticulosis?

We recommend either computed tomographic colonography (CTC) or colonoscopy (CS) as the most accurate imaging tests to diagnose or exclude colonic diverticulosis. The choice of CTC or CS depends on the patient's preference, age, clinical status and risk factors for colorectal cancer (CRC) (1C). Double-contrast barium enema (DCBE) is an alternative only if CTC is unavailable (1B).

Since CTC offers better diagnostic accuracy [23], less invasiveness and a lower complication rate than CS, it can be chosen as a first-line modality and is the test of choice in elderly and frail patients with potential contraindications to CS and sedation. On the other hand, in young patients (<40 years) where the prevalence of DD is low and the possibility of colonic inflammation is higher, CS might be the first choice [24, 25].

DCBE can effectively diagnose diverticulosis [26–28] but is limited by lower compliance [29], longer examination time, higher number of complications [30], absent evaluations of extracolonic findings and higher radiation exposure [31–34] (1–5 mSv with CTC, 7–9 mSv with DBCE). Ultrasonography (US) plays a very limited role [35], while magnetic resonance colonography (MRC) is a promising alternative due to the lack of ionizing radiation [36, 37]. However, it is more time-consuming and prone to motion artefacts than CTC.

What diagnostic test should be used in patients presenting with acute abdominal symptoms and clinical suspicion of diverticulitis?

We recommend multidetector computed tomography (MDCT) with intravenous administration of contrast medium (CM) as the first-line colon examination in patients with symptoms suggesting AD (1A).

In case of a patient presenting in an acute setting with fever and laboratory findings of active inflammation, CE-MDCT is the best examination [38–41] since clinical evaluation has low sensitivity in these settings (about 64 %) [38]. MDCT is able to evaluate complicated and uncomplicated forms, detect life-threatening complications [42], stage the severity of diverticulitis, provide an alternative diagnosis in patients without diverticulitis and guide therapeutic intervention [43, 44].

A recent meta-analysis of prospective performance studies of CT versus US in AD showed similar sensitivity (95 %) but higher specificity for CT [45]. Therefore, in order to minimize the risk of ionizing radiation, a strategy where CT scan follows a preliminary negative or

inconclusive US might be advantageous, because the number of CT exams can be reduced by about 50 % [46, 47].

The use of DBCE should be discouraged in acute settings [48, 49].

Performance of MRC in diagnosing acute diverticulitis has been examined in two small studies [50, 51] showing good sensitivity (about 95 %) and specificity (about 88 %). However, feasibility is limited by the difficult access to MRC in emergency departments.

What diagnostic test should be used to follow-up patients with DD?

We suggest CS as the imaging modality of choice to follow-up patients after an episode of AD. CTC might become a valuable alternative particularly because of patient preference, but no evidence-based data are available at the moment to sustain this hypothesis (1C).

After an episode of AD, a colonic investigation is required to confirm the diagnosis and to rule out malignancy, although evidence-based data are not available. Thus, in clinical practice, colonic investigation is often performed only in those patients with persistent colonic symptoms after the resolution of the acute episode [24]. CS has been reported to be more difficult than CTC with a higher risk of vasovagal reactions and complications such as perforation and haemorrhage [52–54]. Thus, CTC might be considered a valid alternative. It has high diagnostic accuracy for polyps and cancer and for findings specific for DD (focal wall thickening, reduced lumen diameter, presence of diverticula) [55]. Moreover, several articles have reported better tolerability for CTC than for CS [55–57].

Therapy

Should diverticulosis without abdominal symptoms be treated?

We suggest that diverticulosis should not be treated pharmacologically. A high-fibre diet should be encouraged, but the evidence that it prevents DD is limited (1C).

Crowe et al. [12] documented that vegetarian and high-fibre diets are associated with a lower risk of admission to hospital or death from DD. Similar results have been obtained by Aldoori et al. [58] Evidence indicates that insoluble fibre is strongly associated with lower risk of DD and this association was particularly strong for cellulose [58, 59]. A recent systematic review evaluates the therapeutic effect of fibre supplements on DD symptoms. Fibre supplementation alone provides controversial results in terms of symptom relief [60]. There is no rationale to avoid the consumption of nut, corn and popcorn to prevent diverticular complications, as shown in a large, prospective study, the exclusion from the diet of these foods to prevent diverticular complications was not effective [14].

Which treatment regimen should be employed in symptomatic uncomplicated DD?

We suggest that some patients may benefit of rifaximin associated with fibre and some from mesalazine alone. However, the most effective duration of therapy and number of doses has not been determined. Evidence is limited at 1- to 2-year follow-up (1B).

There is insufficient evidence that treatment with probiotics is effective in reducing symptoms (2B).

A recent systematic review suggests the potential usefulness of rifaximin, mesalamine, fibre and probiotics, and their possible combinations in the treatment of symptomatic uncomplicated diverticular disease, but reliable controlled therapeutic trials are not available [61].

Data suggest that the cyclic treatment with non-absorbable antibiotics plus high-fibre diet is more effective in obtaining symptom relief than fibre alone [62, 63]. The rationale for the use of non-absorbable antibiotics like rifaximin in colonic DD is that stasis of luminal contents can lead to bacterial overgrowth [64] which in turn may give rise to chronic low-grade mucosal inflammation [65]. It has been shown that rifaximin could be useful in IBS and small bowel bacterial overgrowth by reducing bloating, abdominal pain, flatulence and loose stools [66]. A meta-analysis found that 64 % of patients treated with rifaximin plus standard fibre supplement were symptom free at 1-year follow-up, compared with 34.9 % of patients treated with fibre alone [67].

It has been proposed that the chronic inflammation in DD is similar to that in inflammatory bowel disease (IBD) [68]. For this reason, 5-aminosalicylic acid (5-ASA) drugs that are commonly used in IBD have been studied in the management of SUDD [69]. Mesalazine has been investigated in multiple studies as a single agent to achieve and to maintain remission [70, 71]. Mesalazine has demonstrated greater complete symptom response than placebo [72, 73]. Mesalamine has also been studied in combination with rifaximin in patients with recurrent diverticulitis and SUDD suggesting that mesalazine was as effective as rifaximin for diminishing some of the symptoms, but it was better than rifaximin for improving the total symptom score [74, 75].

Considering dosage (800–3000 mg), timing (bid vs. tid), length (4 weeks–1 year) and modality (continuous vs. 7 or 10 days/month) of treatment, superiority of one regimen versus another has not been tested in clinical trials, and therefore, treatment should be adapted to the individual patient.

The rationale for the use of probiotics in symptomatic DD is formed by their anti-inflammatory effects and capability to enhance the immune response [76–78]. A recent review suggests that therapy with probiotics is safe and potentially useful in the management of patients with DD [79]. Three studies investigated the efficacy of Lactobacillus casei together with mesalazine on reduction of abdominal symptoms in patients with DD [80, 81] showing that the use of probiotics was at least equivalent to the use of the anti-inflammatory drug [80] and enhanced its beneficial effect [80–82]. In a study [83] that investigated a multistrain probiotic (Streptococcus thermophilus, Bifidobacteriaand and Lactobacilli) together with another anti-inflammatory drug, balsalazide, both treatment arms were effective in reducing abdominal symptoms without a statistically significance difference between groups (73 vs. 60 %).

Three further studies investigated the efficacy of Lactobacillus acidophilus, *L. helveticus* and Bifidobacterium spp. 420 or Lactobacillus paracasei in patients with uncomplicated DD observing a reduction in abdominal pain and bloating [84–86]. Albeit small and uncontrolled, these studies suggest that probiotics may be effective in the management of DD. Larger randomized, placebo-controlled studies would be needed before probiotics can be definitely recommended in the management of DD.

What therapy regimen should be used to prevent recurrence of diverticulitis?

Fibre plus rifaximin is more effective than fibre alone in preventing AD with a low therapeutic advantage. There is no substantial evidence that mesalazine alone is effective in preventing recurrence of diverticulitis (1B).

A meta-analysis of 4 RCTs has studied the ability of rifaximin (added to fibre treatment) to prevent acute diverticulitis in patients with colonic diverticular disease, the pooled rate difference used as a measure of the therapeutic effect in the treatment group was −1.9 % (95 % CI −3.4 to −0.6 %, $p = 0.0057$), and the number needed to treat was 50 [67].

Moreover, a recent multicenter, randomized, open study investigated the efficacy of rifaximin (plus high-fibre intake) in the secondary prevention of AD. Recurrences occurred in 10.4 % of patients given rifaximin plus fibre versus 19.3 % of patients receiving fibre alone ($p = 0.033$) [87]. Despite the methodological limitations, this study suggests that cyclic rifaximin treatment has the potential to prevent recurrence of diverticulitis in patients with colonic DD [88]. However, the level of evidence of superiority of non-absorbable antibiotics over dietary fibre or fibre supplementation is poor [89], and both the cost and efficacy of a long-life cyclic treatment with non-absorbable antibiotics to prevent diverticulitis in all patients with symptomatic DD have been questioned [61].

The efficacy of mesalazine in preventing recurrence of AD was the primary end point of two recently published RCT placebo studies which failed to show a significant efficacy of mesalazine alone or combined with probiotics over placebo in a follow-up of 12 and 24 months [72, 90]. Some open randomized studies assessed the effectiveness of mesalazine. Except for one study, which failed to show any effectiveness of medical therapy in preventing AD in patients with uncomplicated DD [91], the others, conducted on patients with recent attacks of AD, showed that 7 days/month therapy with mesalazine alone or combined with rifaximin was significantly more effective than rifaximin alone in preventing recurrences of AD in 12- and 24-month follow-up [74, 92]. However, recent results of a robust RCT, where the patients were treated for 2 years, showed that mesalazine was not superior to placebo in preventing recurrent diverticulitis, thus making this treatment highly questionable for this condition [93].

Does acute uncomplicated diverticulitis need antibiotic treatment?

We suggest avoiding antibiotic in acute uncomplicated diverticulitis since may not improve short- or long-term outcomes. Use on a case-by-case basis should possibly be considered (1B).

Recently strong evidence from a large RCT showing no benefit of antibiotics in AD raised important questions about the aetiology and management of diverticulitis [94, 95]. It has been argued that AD may be an inflammatory rather than an infectious condition [96] making the use of antibiotics questionable.

In a retrospective audit of 311 patients hospitalized for AD, it was observed that antibiotic or conservative treatment yielded the same clinical outcome, with an overlapping rate of recurrence [97]. The so-called DIABOLO trial (more than 500 patients, Hinchey stage 1a or 1b), a randomized multicentre clinical trial comparing two treatment strategies for AD, is ongoing [98]. Patients will be randomized to a conservative strategy (antibiotics for 10 days, hospital admission, supportive measures) or to a liberal strategy (no antibiotics, supportive measures and admission only if needed on clinical grounds). The study should be completed by the end of 2014 and will surely provide objective evidence for clinical decisions. At the present time, however, there is no evidence mandating the routine use of antibiotics in AD, despite several guidelines recommending their use [99, 100].

Does acute uncomplicated diverticulitis (CT confirmed) need hospitalization?

We suggest that an ambulatory treatment protocol is safe and effective for a majority of patients and it is justified in clinical practice (1A).

Four studies compared outpatient versus inpatient treatment [101–104]. One RCT (the DIVER Trial) conducted on 132 AD patients has shown that, in selected patients, outpatient treatment is safe and effective [103]. In a recent RCT, 623 patients with CT-verified acute uncomplicated left-sided diverticulitis were recruited. Patients were randomized to treatment with or without antibiotics, and antibiotic use neither accelerated recovery nor prevented complications. Recurrent diverticulitis was similar in the two groups [94]. Recent systematic reviews pointed out that a more progressive, ambulatory-based approach to the majority of cases of acute uncomplicated diverticulitis should be encouraged [105]. This new evidence needs, however, further confirmations before it can be safely adopted in clinical practice [106]. In patients who have comorbidities and/or are immunocompromised, hospitalization should still be considered a good option.

Elective surgery for diverticular disease

Is there a role for prophylactic interval colectomy after one or more episodes of AD?

We recommend that the decision to perform elective resection after one or more episodes of AD should be undertaken on a "case by case" basis (1C).

In the late 1990s, three scientific associations, the American Society of Colon and Rectal Surgeons (ASCRS), the European Association for Endoscopic Surgery (EAES) and the American College of Gastroenterology (ACG) [107–109], agreed on the necessity of prophylactic interval sigmoidectomy after two previous episodes of acute diverticulitis (AD), or one episode only if the patient was under 50. This statement was mainly based on outdated studies by Parks [110] and Farmakis [111], which suggested that with each further episode of diverticulitis, there was a higher probability of recurrent attacks with less chances of response to medical treatment and an increasing risk of complicated diverticulitis (as high as 60 %) with a doubling of the mortality rate. A review by Janes in 2005 [112] concluded that these studies give "inadequate evidence" to support such an aggressive surgical policy. In 2006, one of these associations (ASCRS) already adopted a more prudent policy, considering the indication for elective surgery on a "case by case" basis [113].

More recently, many studies have questioned these indications primarily because the majority of patients experience an acute complication at their first presentation of DD, the long-term risk of relapse is quite low [114–118], recurrent episodes of uncomplicated diverticulitis do not lead to failure of conservative treatment or to an increased risk of poor outcomes if patients develop complicated diverticulitis [119, 120], and most important of all, the long-term risks of subsequent emergent surgery, stoma formation and death are low [114, 115, 121–123]. Moreover, the risk of severe complications, as perforation, is usually associated with the first episode of AD [112, 119–121, 124]. A recent nationwide study [125] confirms that a less aggressive strategy is not associated with an increase in complicated diverticulitis at recurrence. Moreover, a retrospective, statewide study on 84,313 patients admitted for diverticulitis from 1987 to 2012, the period of time in which the elective colectomy rate doubled, failed to show a decrease in emergency surgery or admission for diverticulitis [126].

Furthermore, surgery for diverticulitis does not seem to fully protect against the risk of recurrence since the incidence of recurrent attacks is between 5.8 and 15 % [111, 115, 127], and risk of further surgery is up to 3 % [112, 115, 128, 129].

In conclusion, the indication for elective sigmoid resection should not be based on the number of previous episodes of AD [112, 113, 130].

What are the actual indications for elective surgery?

Elective surgery should be recommended to patients with symptomatic complicated DD (fistula, stenosis). Specific clinical situations should be carefully evaluated (persisting symptoms and signs, age, degree of diverticulitis, immunecompromised patients) (1C).

The first step is to connect the symptoms to DD as the differential diagnosis with IBS, segmental colitis associated with diverticulosis (SCAD), or other colitis very challenging. If symptoms are clearly connected with DD, their severity has to be balanced with operative risks (i.e. age, body mass index, comorbidities and specific surgical complications) and the risk of severe complications.

Age should not be considered an indication for more aggressive surgery. It has been reported that younger patients are more prone to recurrent disease and more frequently require surgery [131–135], but more recent studies suggested that age is not a predictive factor of poor outcome [114, 136–139]. Similarly, the cut-off age (40 or 50 years) to identify patients at increased risk of recurrence is also controversial.

Immunocompromised patients or patients on immunosuppressive therapy, patients with chronic renal failure or collagen vascular disease had a fivefold greater risk of

perforation in a recurrent episode of AD [119, 130, 140], and therefore, these patients may benefit from an early elective resection after a conservatively treated episode of diverticulitis. This statement has been challenged by a study on 166 immunosuppressed patients that showed that they had a significantly higher mortality rate than non-immunosuppressed patients, but only during the first episode of the disease, and that patients who required emergency surgery for AD had no previous history of diverticular disease [141]. Therefore, no firm conclusions can be drawn about the need of elective, prophylactic sigmoidectomy in immunocompromised patients.

Based on Ambrosetti's classification, the degree of diverticulitis on CT is predictive of long-term outcome. After successful medical treatment of the acute episode, patients with severe diverticulitis on CT had a statistically greater incidence of secondary bad outcome than patients with moderate diverticulitis (36 vs. 17 %) [142, 143]. Hall [144] showed in a multivariate analysis of 672 patents that left-sided AD, length of involved colon >5 cm and a retroperitoneal abscess were predictors for recurrence. However, the study could not report a multivariate model for complicated recurrence because of the small number of events. The extent but not the severity of diverticulitis may be associated with a higher risk of recurrence but could not be considered an independent risk factor.

In conclusion, there is no clear evidence that one single risk factor could be considered an independent indication for elective surgery for DD.

Surgical technique

What is the best timing for elective surgery?

We recommend that an elective colon resection for diverticulitis should be performed in an inflammation-free interval after complete remission of the acute inflammation (1B).

Choosing the optimal time for elective surgery following an episode of AD is important to minimize the risk of intraoperative complications, caused by oedema, acute inflammation, adhesions causing difficulty in identifying the right planes and ureter, and any resulting perioperative complications (fistula, leakage, haematoma or abscess). Early elective surgery was initially considered to be at lower risk [145]. However, Natarjan [146] and Hoffman [147] found no outcome difference in their retrospective case control studies. A prospective comparison of early and late laparoscopic resection showed a significantly higher rate of anastomotic leak, abdominal abscess, hospital stay and conversion rate during early elective surgery [148]. Similar results are reported by Zingg [149].

What is the optimal distal level of resection?

We suggest that anastomosis after resection for DD be made between the colon and the rectum with complete resection of the sigmoid colon, although there is poor evidence that constructing an anastomosis on the rectum prevents symptoms and recurrent AD (2B).

There are two old retrospective studies [128, 150] showing a significant reduction in symptoms and recurrent AD when a colorectal anastomosis was constructed, after resection of the entire sigmoid colon. In a prospective study conducted by Binda [115] on 242 patients followed for more than 10 years after surgery, recurrence or persisting symptoms were not associated with the level of resection.

What is the best level of vascular ligation?

We suggest that, if malignancy is ruled out preoperatively, the inferior mesenteric artery (IMA) may be preserved in selected patients if it does not reduce the safety of the procedure, although the evidence is limited (2C).

In elective sigmoidectomy for diverticulitis, ligation of the IMA is not mandatory, although it can facilitate identification of the ureter in patients with severe perisigmoid inflammation and/or adhesions. On the other hand, its preservation may improve the blood supply of the anastomosis and avoid damage to the pre-aortic nerves. However, in a recent meta-analysis [151] the leak rate was 7.3 % in the IMA preservation group versus 11.3 % in the ligation group, a difference which was not statistically significant. The only randomized study included patients undergoing open surgery and was considered of poor quality [151]. Preservation of the IMA is also achievable laparoscopically: however, two studies on laparoscopic resection for DD show similar effects on sexual and urinary function with [152] or without [153] IMA preservation.

In conclusion, there is limited evidence that there may be a benefit in preserving the IMA. Further studies are needed to clarify advantage and disadvantages of IMA ligation.

Can elective surgery be performed through a laparoscopic access?

We recommend laparoscopic access for elective colon resection for uncomplicated diverticulitis, but it has to be performed by well-trained surgeons. Laparoscopy has short-term advantages over open surgery in terms of blood loss, post-operative ileus, morbidity, hospital stay and overall costs (1B).

A meta-analysis by Siddiqui on 2383 patients, comparing open and laparoscopic sigmoid colectomy,

demonstrated that laparoscopic sigmoid resection is associated with less of the following post-operative complications: wound infection, post-operative ileus, transfusion and incisional hernia [154]. In two prospective randomized trials (PRTs) [155, 156], laparoscopy was shown to reduce blood loss, pain (fewer analgesic requirements) and length of hospital stay and to improve quality of life. The conversion rate is approximately 9 %, but it less (3 %) if the procedure is performed by expert surgeons [157]. In addition, laparoscopic sigmoid resection is more cost-effective [158].

What are the indications for urgent surgery?

We suggest urgent surgery for patients with diffuse peritonitis and for those who fail to improve despite appropriate medical therapy (2B).

About 15–20 % of patients hospitalized for AD undergo emergency surgery [159, 160]. The majority of them have symptoms and signs of diffuse peritonitis, and/or pneumoperitoneum at admission. The remainder fail to improve promptly despite an appropriate medical approach. As regards the latter group, there is no information on the optimal timing for surgery, and the decision should be based on clinical and imaging features. Even if non-operative management has been adopted in selected stable patients with diverticular perforation and pneumoperitoneum, further studies are needed in order to establish the efficacy and safety of such an approach [161, 162].

What are the treatment options for feculent peritonitis?

We recommend that patients with diverticular perforation and feculent peritonitis (Hinchey IV) undergo urgent sigmoid resection without restoration of bowel continuity. The appropriateness of resection and primary anastomosis has not been clearly established (2B).

A number of studies, including 2 RCTs, have compared the efficacy and safety of primary anastomosis with those of non-restorative surgery (Hartmann's procedure) in patients with diverticular perforation and diffuse peritonitis [163–166].

Even if both techniques have shown similar results in terms of efficacy, when considering feculent peritonitis the number of accrued patients is still inadequate to challenge the established use of non-restorative surgery [163, 164].

What are the treatment options for purulent peritonitis?

We suggest that sigmoid resection and primary anastomosis with or without proximal diversion are the appropriate surgical option for AD with diffuse purulent peritonitis (Hinchey III). Laparoscopic lavage/drainage combined with antibiotics may be an alternative, but specific indications have not been defined. Hartmann's procedure has to be adopted when a primary anastomosis is judged unsafe (1B).

For patients with diverticular perforation and purulent peritonitis, several surgical options may be appropriate depending on the severity of intra-abdominal and general conditions.

Two prematurely interrupted RCTs [163, 164] and several studies with weaker methodology [165, 166] have demonstrated similar mortality and morbidity after resection with primary anastomosis and non-restorative procedures: it seems highly unlikely that an exhaustive RCT will be performed [167].

Similarly, a RCT (the DILALA study) has shown that morbidity and 90-day mortality after laparoscopic lavage are the same as after Hartmann's procedure [168]. However, a word of caution is in order, as the mortality rate of patients undergoing laparoscopic lavage was substantially higher than previously reported [169]. Moreover, another RCT has stopped accrual in the laparoscopic lavage arm due to safety concerns [170].

Besides, eventual specific criteria for choosing between resection with primary anastomosis and laparoscopic lavage are still undefined.

Hartmann's procedure is advisable when a patient is hemodynamically unstable or has intra-abdominal conditions which make primary anastomosis unsafe.

What are the treatment options for diverticular abscess?

We recommend the guided percutaneous drainage combined with antibiotics as the preferable treatment for $\geq$4 cm diverticular abscesses. Those abscesses not responding to or not amenable to non-operative management should be treated surgically (2A).

Though solid supporting evidence is lacking, most abscesses $\leq$3 cm in diameter can be treated safely and successfully with antibiotics alone, while larger abscesses most often require combined percutaneous drainage and antibiotics [171–173]. There is no evidence supporting a specific drainage or aspiration technique.

Patients with diverticulitis-related abscesses that are not drainable or who do not respond to percutaneous treatment should undergo urgent surgery [173]. There is no agreement nor evidence supporting a conservative or surgical regimen for abscesses treated successfully by guided percutaneous drainage [173].

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this type of study informed consent is not required.

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