# Diverticulosis and Diverticulitis

# 13

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## 13.1 Definitions

According to the currently accepted definition, "diverticulosis" is merely the presence of colonic diverticula; "diverticular disease (DD)" is defined as clinically significant and symptomatic diverticulosis. Diverticular disease may be subclassified into symptomatic uncomplicated diverticular disease (SUDD) and symptomatic complicated diverticular disease (perforation, fistula, obstruction, bleeding) [1]. Diagnosis and treatment of colonic diverticulitis in older patients may be more difficult than in young patients because of more frequent comorbidities. Precise diagnosis and accurate treatment of colonic diverticular disease are important topics in geriatric clinical practice [2].

## 13.2 Epidemiology

Diverticulosis of the colon is one of the most common diseases of the digestive tract, and its frequency increases with age. The prevalence of diverticulosis and diverticular disease is increasing in Western countries in parallel with increased

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life expectancy; several studies confirmed these data. This is particularly true in industrialized Western countries where the incidence of diverticular disease increases with age; the disease is uncommon in those under the age of 40, the prevalence of which is estimated at approximately 5%; this increases to 65% in those over 65 years of age [3]. A recent, large study on 1091 patients who underwent CT colonography for various reasons has demonstrated a steady increase of the disease prevalence parallel with ageing and, moreover, has found that age was the strongest predictor of diverticula. The diverticula incidence appears to be higher than expected without significant differences according to gender. As regards anatomic distribution, in the Western population, right colon diverticula do not appear to be an uncommon finding, with their prevalence again increasing with patient age. In asymptomatic patients, the highest prevalence of severe diverticulosis was found in the left-sided colon in the sixth and seventh decades. In particular, prevalence was 17.5–20.8% in the sigmoid colon, 15.7–16.2% in the descending colon, 9.7–8.7% in the transverse colon, 6.7–9.8% in the ascending colon and 6.7–7.5% in the caecum [4].

An epidemiological study in the USA has shown that frequency of diverticulitis and diverticular bleeding increases with age [5]. According to another study, age was associated with an increased risk of local and systemic complications [6].

### 13.2.1 Hospitalization

Diverticular disease and its complications are a relevant cause of hospitalization and not without mortality, particularly in elderly patients [7]. An epidemiological study in the USA has shown that diverticular disease imposes an impressive clinical burden. According to the data from the 2004 National Hospital Discharge Survey, it is responsible for 312,000 admissions and 1.5 million days of inpatient care per year [1]. The annual cost of treatment within the USA is estimated at over 2.6 billion dollars per year [2]. Nowadays whereas the overall number of hospitalizations is declining, the hospitalizations due to diverticular disease and diverticulitis are rising, especially in younger patients [8, 9]. Etzioni et al. reported a 26% increase in admissions coded as acute diverticulitis from 1998 to 2005 (120,500–151,000 admissions). The greatest increase in admissions was in the age ranges of 15–44 and 45–64 years [8]. A further study of NIS data from 1998 to 2005 reported an overall age-adjusted increase in hospital admissions from 61.8 per 100,000 to 75.5 per 100,000 hospitalizations, with equal gender and age distribution [9].

On the other hand, the temporal trends of prevalence of hospitalization for diverticulitis and its complications among elderly patients have been stable during the last decade, except those for bleeding which is becoming more frequent especially among octogenarians [5].

## 13.3 Pathogenesis

### 13.3.1 Diverticulosis and Diverticular Disease

As regards pathogenesis, it is well known that diverticula develop at well-defined points of weakness, which correspond to where the vasa recta enter the circular muscle layer of the colon. Change in the extracellular matrix and altered collagen structure with age partly explains this pattern. In addition, emerging evidence suggests that vascular smooth muscle cell behaviour is modified by age. Abnormal colonic motility is another important predisposing factor in the development of diverticula. On this basis, several authors speculate that ageing could be a prominent risk factor for both cardiovascular disease and diverticulosis [10].

Higher prevalence of diverticulosis in older subjects is consistent with several observations. Changes in traditional lifestyle and diet of Western populations probably play some role, of course under the influence of genetic factors [7], but to date, the inherent genetic risk remains unknown [11].

Another risk factor called into play is the Western toilet, described as an unnatural method of defecation [12]. Moreover, current studies have demonstrated a strong association between smoking and symptomatic diverticular disease. In his Swedish cohort study on 4209 individuals with a diagnosis of symptomatic diverticular disease, Humes [13] demonstrated that smoking is associated with symptomatic diverticular disease with an increased risk of developing complicated diverticular disease. In fact, heavy smokers ($\geq$15 cigarettes a day) had a 1.6-fold increased risk of developing symptomatic diverticular disease compared with nonsmokers.

About cardiovascular disease as a risk factor, several studies have provided evidence suggesting a link between diverticular disease and cardiovascular disease. The pathogeneses of diverticular disease and cardiovascular disease are multifactorial and complex. Chronic inflammation contributes to both diseases, particularly in the elderly. As regards physiologic changes, Aldoori et al. [14] found that overall physical inactivity was associated with the risk of diverticular disease, while Williams et al. [15] demonstrated that vigorous physical activity was inversely associated with the risk of incident diverticular disease among older men and women. Obesity is also a significant risk factor for diverticulitis and diverticular bleeding. The Health Care Professionals Follow-Up Study demonstrated after an 18-year follow-up that subjects with a BMI >30 kg/m$^2$ had a significantly increased risk of developing diverticulitis or diverticular bleeding compared with those with a BMI of <21 kg/m$^2$ [16]. Moreover, a Swedish study confirmed that a BMI > 30 kg/m$^2$ increased the risk of being hospitalized with symptomatic diverticular disease over a 28-year follow-up [17].

As regards comorbidity, atherosclerosis is considered the main cause of diverticular bleeding, but also cerebrovascular disease and hyperuricemia are significant predictors of diverticular bleeding [18].

A recent meta-analysis has demonstrated that various medications of common use, especially in aged persons, are implicated in complications of diverticular disease, with pooled data showing significantly increased odds of perforation and abscess formation with steroids (OR: 9.08), opioids (OR: 2.52) and NSAIDs (OR: 2.49). Increased odds of diverticular bleeding from NSAIDs (OR = 2.69), aspirin (OR = 3.24) and calcium-channel blockers (OR = 2.50) were also demonstrated [19].

All factors associated with the development of diverticulitis and complications should be explored in subjects presenting with symptoms of diverticulitis, as they may facilitate diagnosis and suggest possible evolution of disease. Intuitively in aged persons, these roles harbour an enhanced meaning and should be carefully weighed together with outcome predictors.

### 13.3.2 Complicated Diverticular Disease

In general, of patients with diverticula, 80–85% remain asymptomatic, while, for unknown reasons, only three-fourths of the remaining 15–20% of patients develop symptomatic diverticular disease comparatively. It is estimated that 10–30% of patients with diverticulosis will suffer from complications such as diverticulitis and gastrointestinal bleeding, and the associated mortality is estimated at 23,600 deaths per year in Europe [20].

Elderly patients are traditionally thought to be most commonly affected not only by diverticulosis but also by diverticular disease and its complications. The increased risk of diverticulitis, of its septic complications and bleeding in the elderly has been associated with several factors inherent to physiologic changes, comorbidities and chronic medical treatments typical of advanced age.

Moreover, older patients with diverticulitis and complications are at a higher risk of poor outcome [6]. Even if in several studies the impact of age may have been confounded by comorbidity, a large population study, based on the English "Hospital Episode Statistics" database between 1996 and 2006, has demonstrated that age per se is an important predictor of mortality, extended length of stay and early readmission [21]. More specifically, the authors showed that the largest number of admissions was in the 70–79 age group, but the worst outcomes were in the oldest over 80 patients. Further independent predictors of poor outcomes were comorbidity, as measured by the Charlson Index, emergency admission and emergency surgery. The authors concluded that these factors should be identified, allowing management modification to optimize outcomes. Another population study in Olmsted County, Minnesota, found that among people with diverticulitis, the risk of death was greater in older people (HR per decade 2.12; 95% CI, 2.00–2.25, $p < 0.001$) [6].

In accordance with the overall risk of mortality of older patients with diverticulitis, emergent colorectal surgery in the elderly is associated with significant morbidity and mortality [22]. In octogenarians, up to sixfold higher mortality rate has been reported after emergency colorectal surgery [23]. According to these studies, identification of high-risk individuals, aggressive resuscitation and prompt treatment may help in optimizing the outcome of elderly patients undergoing emergency colorectal surgery.

## 13.4 Elective Surgery

### 13.4.1 Indications

The indications for elective colectomy following diverticulitis are debated. Guidelines drawn up in the 1990s recommended performing an elective sigmoid resection after two episodes of acute diverticulitis, after a single episode in young patients or in case of chronic complications, such as stenosis or fistulas. These guidelines were based on the following wrong assumptions:

1. Recurrence rate after every episode is at least 33%;
2. Every recurrence means a higher risk of perforation and other acute complications.
3. Complicated diverticulitis is associated with high morbidity and mortality [24]. Therefore, an elective sigmoid resection could prevent mortality and permanent colostomy.

More recently, these recommendations have been challenged because a new data on the natural history of diverticulitis have shown that most severe complications, such as free perforation, do not occur after recurrences but at the first attack of acute diverticulitis. In fact, the rate of diverticulitis recurrence after resection (5–11%) is similar to the rate of recurrent hospitalized events (4–13%) for those who did not have elective resection [25]. Modelled analyses have shown that elective colectomy has little value as a prophylactic measure since its rising rate does not correlate with decreases in emergency hospitalization and colectomy [8, 26]. Recent studies have confirmed that the risk of emergency colectomy is greatest at the initial episode of diverticulitis, with 80–90% of emergency procedures being performed in patients without prior hospitalization [27]. Furthermore, conservative management of recurrent nonperforated diverticulitis is associated with low rates of morbidity and mortality [28] advocating a more individualised and conservative approach [29].

Currently it seems clear that those patients treated conservatively for acute diverticulitis but still complaining of symptoms that are well correlated to colonic stenosis or fistulas to hollow organs are good candidates for elective surgery. An elective sigmoid resection should be performed also in patients with recurrent diverticular bleeding.

When surgery is contemplated, the number of attacks of acute diverticulitis seems less important than the severity of the complaints and patient-related risk factors.

Despite these recommendations leading to increasing support for nonoperative management of uncomplicated diverticulitis, early elective surgery still appears to be a common practice. In a recent retrospective cohort of hospitalized diverticulitis, Simianu [30, 31] and coworkers found that 56.3% of elective resections for diverticulitis occurred in patients with fewer than three episodes, confirming that the incidence of elective colectomy has more than doubled [8], despite suggestions from actual guidelines [29, 32–34].

As regards patient-related factors, age and certain comorbid conditions may be associated with a more hazardous course of diverticular disease. Patients older than 70 years have higher mortality rates, although this does not seem to be an independent factor [35].

Moreover, the presence of other comorbidities, such as chronic renal failure, diabetes, collagen-vascular diseases or use of steroids and NSAIDs (nonsteroidal anti-inflammatory drugs), has been associated with an increased risk of perforation and mortality in diverticular disease [27].

Several authors postulated that the threshold to recommend and undergo surgical resection for diverticulitis might be lowered by the availability of laparoscopy. This hypothesis originated from evidence that in the USA and in other countries, the widespread practice of laparoscopic resection has been associated with higher rates of elective surgery for diverticulitis [36, 37]. A recent large cohort suggests that the number of previous episodes should not drive the decision whether or not to approach resection for diverticulitis laparoscopically [38].

Given the substantial discrepancies in how episodes are counted, a better approach to determining the actual clinical burden of diverticulitis on patients may be evaluation of the healthy time between episodes. A normal interval between episodes has not yet been described. Similarly, a time-based interval definition of smouldering diverticulitis has not been proposed. Rather, this recognised entity is defined by rebound symptoms when the treatment is withdrawn or a more rapid recurrence of diverticulitis occurs in typical patients. This debate is particularly relevant because most elderly patients with newly diagnosed diverticulitis do not have recurrences and do not undergo operations for their disease.

Lidor et al. [39] followed 16,048 individuals after an episode of diverticulitis for an average of 19.2 months; their mean age was 77.8 years, 14.0% of them underwent surgery, and 82.5% had no further recurrences. Of patients initially managed nonoperatively, 97% did not have surgery. Individuals treated as outpatients upon first presentation and patients ≥80 were significantly less likely to have recurrent episodes and were less likely to require an operation. Authors concluded that the majority of elderly patients newly diagnosed with diverticulitis did not require surgery nor experience recurrent episodes. The apparent benign course of this disease in this population suggests that a conservative approach to the management may be appropriate. Accordingly, a recent consensus in Italy concludes that there is no role for prophylactic interval colectomy after one or more episodes of acute diverticulitis, and the decision to perform elective resection after one or more episodes of AD should be undertaken on a “case-by-case” basis statement (EL 2b—RG B) [7, 34].

On the other hand, the Sigma trial and previous studies have demonstrated very low mortality rates after elective resection for diverticular disease even in such high-risk patients, who should be thus considered good candidates for an elective sigmoid resection when responding to individualized criteria mentioned above [40]. Patient’s quality of life and anxiety about future episodes may also be considered as important factors in decision making related to early, elective surgery.

### 13.4.2 Principles of Surgical Technique

As far as timing is concerned, in order 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), it is important to choose the optimal time for elective surgery. 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 [41]. Similar results have been reported by Zingg et al. [42].

Surgical technique does not differ greatly from the standard open approach to the minimally invasive approach. As this is for a benign disease, the dissection should be close to the colonic wall, to avoid ureteric injury. Consideration should be given to preoperative (or intraoperative) ureteric stenting if a diverticular phlegmon or colo-vesical fistula is suspected. In order to avoid recurrence, resection should be extended to the upper rectum [43]. Sacrifice of the inferior mesenteric artery or superior rectal artery has not been shown to affect rates of anastomotic leak [44, 45]; however, patients may have a better functional outcome if the vessels are preserved [46, 47]. Mobilisation of the splenic flexure may be required to allow for a tension-free anastomosis [48].

A left colic resection for diverticular disease must provide for the resection of all the sigmoid tract, a resection that can be extended proximally if it involves inflammation of the descending colon. The simple presence of diverticula is not an indication for a more proximal extension of the resection.

The vascular time may foresee the conservation of the left colic artery or even the whole mesenteric and rectal arteries with bindings exclusively of sigmoid arteries. The ligation of the inferior mesenteric artery is not mandatory in elective sigmoidectomy for diverticulitis but can facilitate identification of the ureter in complex diverticulitis: however, its preservation may improve the blood supply of the anastomosis and avoid damage to the pre-aortic nerves. In a recent meta-analysis [45], the leak rate was 7.3% in the patients with preservation of the inferior mesenteric artery versus 11.3% in the ligation group, a difference which was not statistically significant. For this reason, there is limited evidence that there may be a benefit in preserving the inferior mesenteric artery.

A colorectal anastomosis is then performed using a circular stapler of adequate size (at least 2.8 cm) introduced to the transanal way after having positioned the anvil of the stapler in the descending colon prior to packaging a colonic suture.

At the end of the procedure, a pneumatic test can be performed, by introducing air through the anus, having first filled the pelvic cavity with water: if bubbles appear, a simple suture of the hole, if clearly visible, or a protective ostomy can be performed. The intervention concludes with the positioning of drainage in the pelvic cavity and the closure to anatomical layers of the abdominal wall.

Laparoscopic access for elective colon resection could be recommended 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) [34]. Two randomised controlled trials [49, 50] demonstrated less blood loss, less pain (fewer analgesic requirements), shorter hospital stay and improved quality of life. Conversion rates are in the order of approximately 9% but may be much lower in expert hands. The results of the Sigma trial [40] suggested a 15.4% reduction in major complications and a 27% reduction in major morbidity with no difference in late outcomes at 6-month follow-up.

A recent meta-analysis comprising 19 studies (2383 patients) comparing open and laparoscopic sigmoid colectomy demonstrates that laparoscopic sigmoid resection is safe and has fewer post- operative surgical complications in terms of wound infection, post-operative ileus, transfusion requirements and incisional hernia (3%) [51, 52]. A systematic review of case-control studies [53] reports the findings of the above RCTs with lower overall morbidity and fewer minor complications in the laparoscopic group. A retrospective review of ACS-NSQIP data demonstrates a lower risk of complications (major wound, respiratory, cardiovascular and sepsis) in patients undergoing laparoscopic resection with primary anastomosis [54].

Hand-assisted laparoscopic surgery maintains the advantages of laparoscopy in complicated disease while avoiding conversion to open surgery in very inflamed and laparoscopically challenging operative fields. A systematic review of hand-assisted laparoscopic surgery in colonic surgery [55] suggests it may be useful especially in complicated diverticular disease [56, 57]. Compared to open surgery, hand-assisted laparoscopic surgery colectomy is associated with shorter hospital stay, smaller incision lengths, faster recovery of gastrointestinal function, less analgesic requirements, less blood loss and lower post-operative pain scores [58].

Single-incision laparoscopic surgery for diverticular disease has been performed although the evidence is limited to small case series demonstrating feasibility and safety of the technique [59, 60].

Actually, there is little experience and few papers about the use of the robotic approach in diverticulitis, but there are some reasons to use that approach: to simplify a challenging situation, lower conversion rate, simplify pelvic stitch (fistula), avoid ureter injury (0.3–1.5%) and improve sexual and urinary outcomes [61]. The conversion rate is 6% in laparoscopic approach versus 2% with robotic technique, considering that the degree of inflammation and BMI [62] are the most important risk factors. In surgery for fistula as well, conversion rate is higher in laparoscopic (14–61%) versus robotic (0–4%) procedures [63]. Robotic colorectal surgery in diverticulitis is a safe and feasible option, but longer operation time and high costs are the main actual limitations to employing it.

## 13.5 Treatment of Diverticulitis, Diverticular Bleeding and Septic Complications in Elderly Patients

### 13.5.1 Outpatient Treatment of Acute Uncomplicated Diverticulitis

Between 1998 and 2005 in the USA, there have been 323,097 hospital admissions for diverticulitis, and more than 50% of them were in elderly patients [64].

While outpatient treatment of patients with uncomplicated acute diverticulitis appears to be safe in younger patients [65], in elderly ones it is still a matter of debate. The following parameters should be considered in making this decision: patient's presentation, ability to tolerate oral intake, comorbidity and adequate outpatient support. Based on these criteria, elderly patients have a high probability of needing hospital admission for adequate treatment. Hence, hospitalization for uncomplicated diverticulitis is recommended if the patient is over 75 years of age, especially if she/he has comorbidity [66]. According to several other authors, however, treatment of elderly patients with uncomplicated diverticulitis at home may be safe and effective even in the presence of associated but stabilized comorbidity (cardiopathy, diabetes, renal failure, etc.) [67]. This may be facilitated by the presence of Hospital at Home or other outpatient support services.

In patients with uncomplicated diverticulitis who are clinically stable and able to tolerate fluids, outpatient treatment is based on broad-spectrum antibiotics covering anaerobes and gram-negative rods for 7–10 days and a clear liquid diet. Patients should improve within 48–72 h, at which time solid foods may be cautiously introduced. Close follow-up is considered crucial: patients experiencing increasing pain, fever or inability to tolerate oral fluids should be promptly hospitalized [66].

### 13.5.2 In-Hospital Treatment of Acute Uncomplicated Diverticulitis

Hospitalization is recommended if patients show signs of significant inflammation, are unable to take oral fluid, are over 75 years of age or have significant comorbidity (diabetes, chronic renal failure, malignant haematological diseases, HIV infection, chemotherapy, steroid therapy, transplant). Treatment options are triaged according to severity of clinical and radiologic findings.

Contrast-enhanced computer tomography with multi-detector technology is the first-line colonic examination [7] and offers a comprehensive evaluation of uncomplicated and complicated forms [68]. The severity of diverticulitis on CT scan is also statistically predictive of the risk of medical treatment failure during the acute phase and of the chances of bad secondary outcome after a successful medical treatment of the first episode [69].

In case of acute uncomplicated diverticulitis, as in patients with acute complicated diverticulitis who do require emergency surgery, bowel rest, intravenous antibiotics and intravenous fluid support are mandatory. Improvement of symptoms should be expected within 2–4 days, at which point a solid diet can be progressively reintroduced. If improvement continues, patients may be discharged to complete a 7–10-day oral antibiotics course. Those not responding within 2–4 days require surgical consultation.

### 13.5.3 Management of Septic Complications

Septic complications of diverticulitis include abscess and free perforation with peritonitis. They are among the most frequent causes of severe abdominal sepsis in

elderly patients, which accounts for a mortality rate ranging from 54 to over 90%. Recently, Ukkonen and coworkers have shown that hospital and 1-year mortality rates of patients with abdominal sepsis increased with age, being over 90% in subjects aged 80 years or more. The mortality was higher in patients with comorbidities including cardiac, chronic pulmonary and chronic renal diseases and in those on cancer chemotherapy [70].

Moreover, it is estimated that 22–28% of patients with diverticular disease [25], presenting with septic complications, will require an urgent operation. These complications are associated not only with increased mortality and need for surgery but also with prolonged hospital stays, increased intensive care requirements and increased costs.

Even if specific outcome data and evidence-based indications in the elderly are scarce, it is widely recognised that rapid diagnosis, proper treatment with both antibiotics and supportive therapy and source control are crucial. In the elderly, however, physiological aspects and poor cooperation may interfere with the diagnostic and therapeutic process.

When there is a suspicion of intra-abdominal sepsis, an urgent CT study reduces diagnostic delay and guides the appropriate measures in order to rapidly control the source of infection.

### 13.5.4 Treatment of Diverticular Abscesses

Diverticular abscesses are associated with an acute mortality of 5–10% [71] but are also associated with a high risk of recurrences and further disease complications [72]. Patients with a CT diagnosis of diverticular abscess have three treatment options: (a) diverticular abscesses with a diameter of 3–4 cm or less should be medically treated with broad-spectrum antibiotics, (b) diverticular abscesses with a diameter of 4 cm or larger should undergo percutaneous-guided drainage (PGD) and (c) diverticular abscesses not amenable of or not responding to nonoperative treatment (including PGD) should undergo surgery with bowel resection.

In 2014, a systematic review showed that percutaneous drainage was successful in 49% of patients (diameter > 3 cm) and antibiotic therapy in 14% of patients. An urgent surgery during the index hospitalization was performed in 30% of patients, elective resection in 36% and no surgery in 35%. Recurrence rates were as high as 39% in patients awaiting elective resection and 18% in the non-surgery group, with an overall recurrence rate of 28%. Of the whole cohort, only 28% had no surgery and no recurrence during follow-up [71]. A recent series confirmed that recurrences after medical treatment are frequent and may be more severe than the index presentation [72]. On the other hand, previous retrospective studies have shown that percutaneous CT-guided (or US-guided) drainage of diverticular abscesses is safe and effective in treating acute intra-abdominal sepsis, bridging patients to elective single-stage resection [73–76].

The size of the abscesses is an important determinant of success of treatment: those of 4 cm or more in diameter are less likely to be associated with successful

antibiotic treatment alone and more likely to be amenable to percutaneous-guided drainage [73–75]. Besides the size of abscess, other factors may influence the risk of nonoperative treatment failure, but the evidence is mostly based on small retrospective series. Factors associated with PGD failure have been ASA 4 (OR: 11.6) [77], pelvic location of abscess [76], systemic features of inflammation [75], immunosuppression and chronic kidney disease [78]. Age per se has not been associated to PGD failure.

Once it is evident that percutaneous drainage has failed, there are two options: positioning a new drain or proceeding to surgery. Both have drawbacks that must be carefully considered, especially in elderly persons. First, the number of drainage attempts is directly correlated to the risk of urgent Hartmann' resection [79]. Second, drainage failure and older age are associated with increased post-operative morbidity [77]. An elderly patient presenting with a diverticular abscess should be treated according to the criteria applied in younger subjects, and age should not dissuade surgeons from urgent action when indicated.

A controversial issue, with substantial meaning in the aged frail person, is the need of subsequent elective colectomy after a first episode of diverticular abscess, successfully treated medically or with PGD. The high risk of recurrence and further disease complications after successful nonoperative treatment advocates for an interval elective colectomy [77], whereas an expectant management is supported particularly in patients with comorbidities and a high risk for mortality [80].

Case-by-case decision making is mandatory, balancing on one side, the risk of recurrence based on the above-mentioned factors, including comorbidities and polypharmacy, and on the other side the risk of elective surgery in the aged person.

### 13.5.5 Treatment of Diffuse Peritonitis

Diverticular perforation and diffuse peritonitis are life-threatening conditions with a mortality rate of up to 13% for purulent contamination and 43% for fecal contamination [28, 81–85]. It requires emergency surgery, independently of patient's age. The choice of procedure to perform is based primarily on severity of peritonitis, which is most commonly graded according to Hinchey classification. Further factors that should influence the decision-making process are age, comorbidities, steroid or immunosuppressant treatments.

Resection and primary anastomosis with or without proximal fecal diversion and non-restorative sigmoid resection, namely, Hartmann's procedure, peritoneal laparoscopic lavage and less invasive stepwise strategies including damage control surgery constitute the main available armamentarium. At present time, the Hartmann's procedure remains the surgical gold standard for many surgeons as it provides removal of septic source with relative ease and safety [86, 87].

However, as far as *purulent peritonitis* is concerned, two recent, prematurely interrupted RCTs [88, 89], along with data from previous studies with weaker design [90–99], plus systematic reviews [100–102], have indicated that resection

and primary anastomosis with or without proximal fecal diversion are not inferior to Hartmann's procedure, in terms of surgical efficacy and safety.

Moreover, reversal of colostomy after Hartmann's procedure adds a challenging operation, associated with relevant morbidity and mortality; as such it will never be performed in a wide proportion of patients leaving them with a permanent stoma [85, 88]. Even if ageing exerts a significant influence on physical health-related quality of life independently of single-staged or staged resection for complicated diverticulitis [100], age and comorbidities are determinants of non-reversal of Hartmann's procedure [95]. Accordingly, generally speaking resection with primary anastomosis is considered a preferable approach in most patients with purulent peritonitis, reserving the Hartmann's procedure to cases at increased risk of anastomotic leakage [103, 104]. A propensity score analysis has indicated that factors influencing the choice between Hartmann's and primary anastomosis are body mass index >30 kg/m$^2$, Mannheim peritonitis index >10, operative urgency and Hinchey stage >II [105]. A subsequent decision-analysis suggests that central to the operative strategy decision is an accurate calculation of the risk of complications using validated prediction models, as well as determination of patient attitudes towards complications and reversal operations [38]. Furthermore, surgical specialization remains a potent predictor of operation performed in the setting of severe acute diverticulitis [106].

Recently *laparoscopic peritoneal lavage (LPL)* with drainage and antibiotics has been introduced into the surgical practice for purulent peritonitis from diverticular colonic perforation, with the aim to decrease the rate of HP [107, 108]. In 2009, Toorenvliet's systematic review identified 231 patients with acute diverticulitis who underwent LPL, drainage and antibiotics therapy [109]. In 95.7% of patients this minimally invasive procedure permitted adequate control of the abdominal and systemic sepsis, with low rates of mortality (1.7%), morbidity (10.4%) and stoma (1.7%). Most patients subsequently had a delayed elective laparoscopic PRA. Patients who did not undergo subsequent resection had a long recurrence-free period. The authors concluded that LPL was an effective and safe treatment of peritonitis secondary to perforated diverticulitis [109]. However, the use of peritoneal lavage without primary resection in generalised peritonitis originating from perforated diverticulitis remains controversial. Recently three RCT (DILALA-trial, Scandiv-trial, LADIES trial) including a total of 343 participants (178 in the lavage group versus 175 in the resection group) have been published on this topic [110–112].

Five meta-analyses of these RCT trials have been published [113–117] that failed to demonstrate significant benefits. Overall, the quality of evidence was low due to serious concern regarding the risk of bias and imprecisions. A significantly increased rate of intra-abdominal abscess formation (RR = 2.54, 95% CI 1.34–4.83) (moderate quality of evidence) was seen with this approach. However, LPL does not appear inferior to traditional surgical resection and may achieve reasonable outcomes (lower rate of post-operative wound infections, R = 0.10, 95% CI 0.02–0.51) and less hospital resources (shorter duration of post-operative hospital stay during index admission, WMD = −2.03, 95% CI − 2.59−−1.47).

*Fecal peritonitis* is usually a polymicrobial infection with a high bacterial load due to the high density of Bacteroides spp., Enterobacteriaceae, and enterococci. As

such, it is frequently a cause of sepsis and is associated with high mortality rates. A recent study [118] on a large cohort of patients with fecal peritonitis admitted to the European ICUs found a 6-month mortality of 31.6%. As reported in previous series of patients with abdominal sepsis [119, 120], the most significant prognostic factor in this study was increased age. In the elderly undergoing gastrointestinal surgery with severe sepsis, Ukkonen et al. reported an in-hospital mortality of 47.9% and a 1-year mortality of 64.4%, including 31.6% of the discharged patients [70].

Limited data are available to sustain a specific surgical strategy in diffuse fecal peritonitis.

In most retrospective series, the Hartmann's procedure is the first choice in patients with diverticular perforation and fecal peritonitis [100–102]. In fact, even if resection with primary anastomosis has 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 [88, 89].

Diverticular perforation with diffuse peritonitis and severe sepsis is an extreme often-fatal infectious event, especially in an elderly subject. Patients have poor pre- and intraoperative conditions (septic shock and organ failure) and are haemodynamically unstable with a significant need for catecholamines. The ICU scoring systems (APACHE, SAPS and SOFA) and elevated lactate levels predict increased mortality, and a rapid control of source of infection is mandatory. In the past, patients deemed at high risk for the Hartmann's procedure underwent a three-stage procedure with colostomy as first stage.

A recent alternative for these "extreme" cases has been introduced as *damage control surgery* [121]. It is based on a fast procedure with peritoneal lavage, limited resection of the perforated segment with blind ending of bowel stumps or closure of the perforation site by suture, limited intestinal mobilisation and abdominal closure by vacuum-assisted systems. The decision to restore continuity or create a colostomy is postponed to an elective second-look laparotomy 24–48 h afterwards, following resuscitation at the intensive care unit. Accordingly, the decision-making process takes place in a haemodynamically stable patient with the possibility to consider the clinical course (deterioration or improvement), the comorbidities and other risk factors and to re-evaluate the local peritoneal and colonic conditions. This strategy offers the advantages of a rapid source control and a "delayed" reconstruction of bowel continuity with reduction of ostomy rate. Data are still scarce, and no specific evidence in elderly patients has been published so far, but Kafka-Ritsch have reported their 5-year experience in 2012 [122]. They showed an in-hospital mortality rate of 9.8% which compares favourably with general and peritoneal/septic conditions of patients in their series. Most notably, 76% were older than 65 years, 84% were ASA IV/V, 63% had a >25 MPI and 22% had fecal peritonitis. Furthermore, 77% of all patients and 50% of patients with fecal peritonitis were discharged with their colon reconstructed. Although further evidence is clearly needed, this emergency option may be a valuable tool when dealing with older and frail patients at high risk of septic complications.

## 13.6 Diagnosis and Treatment of Diverticular Bleeding

Colonic diverticula are the most typical source of lower gastrointestinal bleeding accounting for more than 40% of episodes [123, 124]. Diverticular bleeding resolves spontaneously in up to 90% of episodes but has an overall recurrence rate from 22 to 38% [125–127]. Severe haemorrhage can arise in 3–5% of patients with diverticulosis [125, 126].

Early recurring or persistent or massive bleeding usually requires interventional treatment.

The following risk factors for recurring bleeding have been identified: old age, diverticulitis, peripheral vascular disease and chronic kidney disease [128]. Several other factors, such as blood pressure medications, tachycardia, low diastolic blood pressure, low haemoglobin and INR > 1.5, may help to predict severe diverticular haemorrhage at the time of presentation [129].

Female sex, warfarin use and chronic kidney disease were associated with significantly greater risk of transfusion need, while NSAID use was associated with significantly greater risk of further bleeding during hospitalization and subsequent prolonged stay [130].

Intuitively most of those conditions are associated with advanced age.

At the present time, diagnosis of diverticular bleeding is based on contrast-enhanced computed tomography and colonoscopy. In about 30% of patients, CT can identify the diverticular source of bleeding; hence, it should precede colonoscopy to guide haemostasis in these cases [131].

Though different algorithms have been suggested, the initial management is most commonly based on support and surveillance. Once it has been established that bleeding has not stopped spontaneously, interventional endoscopy is mandatory. Endoscopic haemostatic manoeuvres, by means of epinephrine injection, multipolar or heat probe coagulation, placement of endoclips, band ligation or combinations of the above, are successful in controlling most diverticular bleeding.

If colonoscopy is not available or if it fails to reveal or control the bleeding source, further intervention is required. Usually angiographic selective embolization or intraarterial infusion of vasopressin is performed, but the subsequent risk of bowel infarction must be considered.

Surgery may be required for massive bleeding with haemodynamic instability or failure of previous treatment attempts. Segmentary resection is appropriate when the bleeding source has been identified; otherwise a subtotal colectomy has to be performed. Urgent surgery is associated with high rates of post-operative complications and mortality (10–30%).

Elective resection might be considered in patients with comorbidity and two or more episodes of diverticular haemorrhage, but surgical decision is again on a case-by-case basis.

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