Chapter 4

Diverticular Disease

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Additional information is available at the end of the chapter

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Abstract

Diverticulosis is a common problem, especially in industrialized countries. The main risk factors for the development of diverticular disease are physical inactivity and consumption of a low-fiber diet. Among the population with diverticulosis, only 10–25% of the patients develop diverticulitis. Computed tomography (CT) scans are very helpful for diagnosis and deciding the treatment strategy. Patients with acute diverticulitis usually have a good response to conservative therapy. However, some of the patients present with complications such as perforation, fistula, abscess, stricture, and obstruction. Depending on disease severity, they commonly require surgical or radiologic intervention. Despite lots of contradictory results on treatment approaches, recent guidelines tend to be less invasive than the ones in the past. As a result, less invasive treatment protocols, including nonsurgical follow-up, percutaneous drainage, minimally invasive surgery and resection with primary anastomosis, are more commonly used than the more invasive Hartmann procedure. In this chapter, we discuss the clinical characteristics, diagnostic workup and different treatment approaches in the management of diverticular diseases.

Keywords: diverticular diseases, diverticulitis, diverticulosis, epidemiology, management

1. Introduction

Diverticulosis is a common medical problem, most frequently in industrialized countries. It is defined as saccular outpouchings of the bowel wall and is usually located at the sigmoid colon. Diverticulosis is not a disease per se but a condition, and thus, it is usually asymptomatic. When these saccular outpouchings become obliterated, inflammation in bowel wall and hence diverticulitis develops. There are many types of diverticular disease with respect

to its clinical presentation. Usually, it presents as a mild and medically treatable uncomplicated diverticulitis. However, complicated diverticulitis such as abscess, perforation, fistula or obstruction can be the first presentation as well. Diverticular hemorrhage is another complication of diverticulosis, but inflammation is not a factor in its pathophysiology and it is a different clinical condition apart from diverticulitis. As a result, diverticular hemorrhage will not be discussed in this chapter.

As its prevalence rises with industrialization, numerous efforts have been made to find the best treatment option. Although some debates are still ongoing, minimally invasive treatments become more common, and necessity of high morbidity-related procedures like the Hartmann procedure is more questionable nowadays.

2. Incidence

In Western countries, the prevalence depends on age. The incidence increases with age, and nearly 70% of the 80-year-old population has diverticulosis [1]. Among the population with diverticulosis, only 10–25% of the patients develop diverticulitis, 10–20% of those patients with diverticulitis will be hospitalized for treatment and surgical therapy will be reserved only for 20–50% of these patients [2].

The left-sided diverticular disease is more common in western countries; on the other hand, the right-sided diverticular disease is more common in eastern countries. In the United States, the localization of diverticular disease involves sigmoid and left colon in 95% of the patients, and 95% of the surgical candidates for diverticular disease have sigmoid colon diverticulosis [3].

Recent studies have estimated that symptomatic diverticulitis under the age of 65 tends to have a male predominance and have more severe CT findings. Additionally, diverticular bleeding is more common in men, whereas obstructions are more common in women [4, 5].

3. Pathophysiology and etiology

The saccular outpouching in diverticulosis is not a true diverticula. They do not contain all layers of the bowel wall; instead, they are formed by the herniation of mucosal and submucosal layers of the bowel wall through the muscular layer. Thus, they are called ‘false’ or ‘pulsion’ diverticula. Diverticular disease tends to occur at the weakest points of the colon wall where the vasa recta penetrate the circular muscle. As a result, diverticula are localized at each side of the mesenteric taenia and on the mesenteric border of the two antimesenteric taenias [6]. Also, the structure of the colon wall contains differences from normal colon wall such as thickened circular muscle, narrow lumen and shortened taenia [7]. Besides the structural changes in the colonic wall, alterations in colonic motility have a role in the development of diverticular disease. Increased colonic motility causes enhanced longitudinal haustral contractions

and temporary isolation of a segment of colon, a process called segmentation. As a result, segmentation generates a pulsion force causing visible distension of the local diverticula [7].

Moreover, the imbalance of the neurotransmitter spectrum reported in diverticular disease involves both excitatory agents, such as acetylcholine and substance P, and inhibitory agents, such as nitric oxide and vasoactive intestinal polypeptide (VIP) released by enteric nerve cells [8, 9].

On microscopic examination, the structure of the taenia contains more elastin, which is increased over 200% compared to controls, and colonic collagen changes are similar to the ones that occur with aging [7–9]. These structural changes are similar to connective tissue disorders such as Marfan syndrome or Ehler-Danlos syndrome in which diverticulosis tends to occur earlier than the normal population [10].

The localization of the colonic segment of diverticular disease and complications, such as diverticulitis, microperforation and abscess, depends on the intraluminal pressure of the colonic segment. As a result, sigmoid colon is the most common localization for the disease since it has the highest intraluminal pressure and increased motility index with regard to its smaller diameter [3].

4. Risk factors

The main risk factors for the development of diverticular disease are physical inactivity and consumption of a low-fiber diet [11–13]. Fiber from fruits and vegetables has the most protective effect against diverticulosis development while higher consumption of red meat and fat increases the incidence [11, 14]. Thus, the incidence of diverticulosis increases with a Western-style diet [11, 15]. On the other side, diverticulosis is less common among vegetarians [16]. As the fiber intake increases, the stool becomes more bulky and lesser segmentation forms in the colon and diameter of the sigmoid colon increases. By that way, transportation of the stool becomes easier with lower intracolonic pressures obtained [3].

Other identified risk factors for the development of complicated diverticular disease are smoking (three times higher risk of developing complications), NSAID use, steroid use, renal failure, and organ transplantation [17, 18].

Several studies have been evaluated the role of age in diverticular disease and diverticulitis. The incidence of diverticular disease increases with age. At the age of 40, its incidence is 5%, whereas at the age of 80 the incidence rises up to 80% [19]. As the age gets older, diverticula are more proximally located and increased in number. On the other hand, diverticulitis at younger ages is more likely to develop complications [20, 21].

Recent studies demonstrated that obesity and higher body mass index are also associated with an increased incidence of diverticulitis, especially patients under the age of 40 years [21–24]. Additionally, an association between increased cross-sectional visceral fat area and complicated diverticulitis had been demonstrated [25].

5. Signs and symptoms

The degree of inflammation and existing complications are the two main factors determining the clinical presentation of diverticular disease.

In acute diverticulitis, the most common complaint is abdominal pain. Since sigmoid colon is the most common localization of diverticulitis in adults, the pain is usually located in the left lower quadrant. Variable localizations can occur depending on the anatomy of the sigmoid colon such as right lower quadrant or suprapubic pain. Especially in Asian populations, cecal diverticulitis may present as right lower quadrant pain [26–28].

About 50% of the patients with acute diverticulitis have constipation, while 25–35% are accompanied by diarrhea [29].

The degree and radiation of pain vary according to the severity and extent of inflammation. Early in the presentation, a localized left lower quadrant sensitivity can be observed while acute abdomen due to peritoneal irritation develops after perforation. Dysuria and urinary urgency may occur as well due to the presence of inflammation which is in close proximity to the bladder [30]. The persistent abdominal pain can be based on increased pain-mediating neurotransmitters (e.g. galanin, neuropeptide K) and enteric nerve fiber remodeling most likely due to postinflammatory reactions—similar to irritable bowel syndrome [7].

Nausea and vomiting can be present due to peritoneal irritation or the development of complications such as bowel obstruction [30].

6. Laboratory findings

In patients with acute diverticulitis, inflammation-related leukocytosis and elevated C-reactive protein (CRP) may be detected. Nevertheless, in uncomplicated patients, leukocyte levels may remain within the normal range of up to 45% of patients [31]. Serum amylase levels may be increased in patients with perforation and colonic flora may contaminate urine cultures if colovesical fistula develops.

7. Imaging

Abdominal X-rays may detect subdiaphragmatic free air due to a perforation in patients with acute diverticulitis. However, direct X-rays have no diagnostic value in patients with uncomplicated diverticulitis.

Abdominal ultrasonography is a preferred method of imaging since it is cheap and noninvasive. However, it is an operator-dependent method and has an inferior sufficiency in the evaluation of luminal organs and ruling out other causes of abdominal pain. Hypoechoic peridiverticular inflammatory reaction, detection of a peridiverticular or mural abscess,

thickening of the intestinal wall more than 4 mm in the area of abdominal sensitivity and presence of diverticula in other segments of bowel are among the ultrasonographic findings that support a diagnosis of acute diverticulitis [32].

CT is the most useful imaging technique for diagnosing acute diverticulitis with a sensitivity of 94% and a specificity of 99% [33]. Additionally, it allows assessment of the complications and other causes of abdominal pain. CT findings that support the diagnosis of acute diverticulitis are the presence of diverticula in the bowel, pericolic fat stranding, colonic wall thickening that is more than 4 mm and abscess formation (**Figure 1**) [34].

It is a fast and reliable test and also serves as a guide for percutaneous drainage. It can also be used to determine the severity and extent of the disease. Ambrosetti et al. was first to classify the disease severity according to the CT findings [31]. They divided acute diverticulitis into two groups as mild and severe according to the CT findings (**Table 1**). Surgical intervention was more frequently needed in patients who had severe disease. Similarly, in people who had

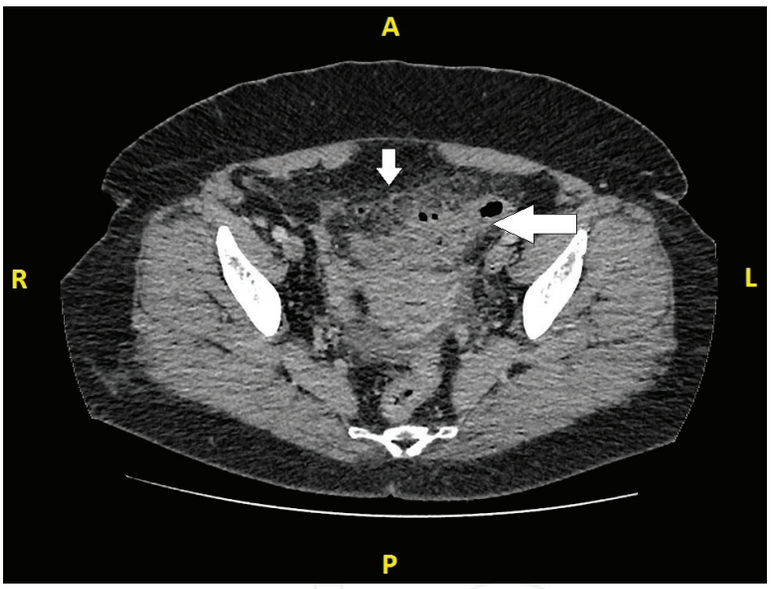

Figure 1. Computed tomography scan demonstrates infiltration of the fat surrounding the sigmoid colon (small arrow) whose wall is thickened and irregular (big arrow).

Mild diverticulitis	**Wall thickening (>5 mm)** **Pericolic fat stranding**
Severe diverticulitis	Mild diverticulitis findings and at least one of the followings: • Abscess • Extraluminal air • Extraluminal contrast

Table 1. Ambrosetti CT criteria for diverticulitis severity.

severe disease under the age of 50 years, recurrences and complications were more frequent [31]. According to another study, the markers of nonoperative treatment failure were defined as the presence of abscess formation or extraluminal air >5 mm in diameter [35].

A modified Hinchey classification system was defined by the addition of preoperative CT findings to the parameters of Hinchey classification used in the evaluation of acute diverticulitis (**Table 2**) [36–38]. In the modified system, stage I was divided into stage Ia characterized by the presence of pericolic inflammation and phlegmon and stage Ib with pericolic abscess (**Figure 2**). While BT can provide sufficient discrimination in stages 0, I and II, it is insufficient in distinguishing stages III and IV, which are purulent and feculent peritonitis, respectively [36].

Stage	Findings
0	Mild clinical diverticulitis
Ia	Confined pericolic inflammation phlegmon
Ib	Confined pericolic abscess within sigmoid mesocolon
II	Pelvic, distant intraperitoneal abscess
III	Generalized purulent peritonitis
IV	Feculent peritonitis

Table 2. Modified Hinchey classification system for acute diverticulitis.

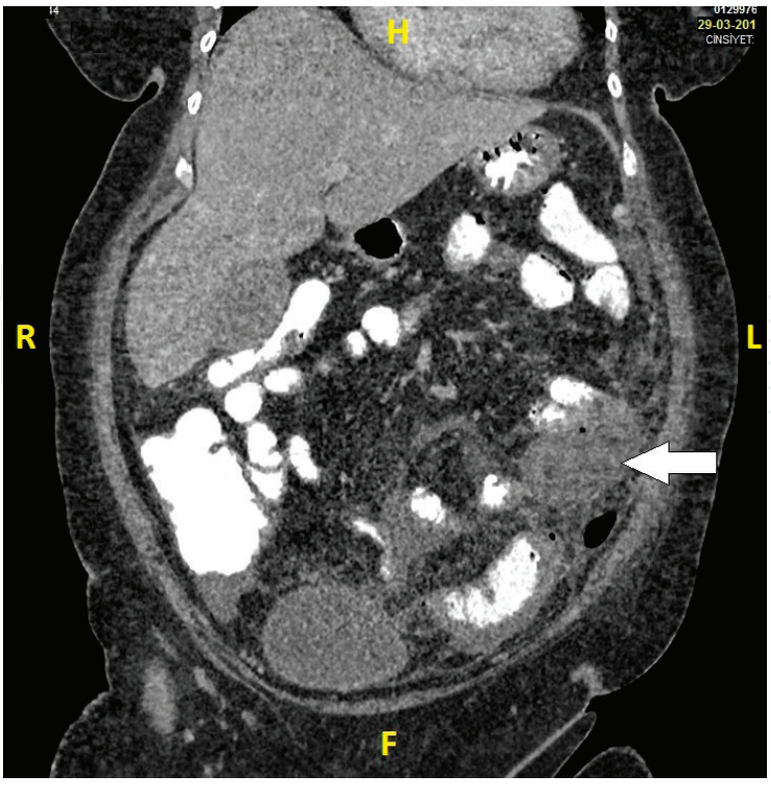

Figure 2. Coronal view of the inflamed sigmoid colon with characteristic findings of diverticular abscess.

Another method that can be used for diagnosis is MRI. However, it is slower, more expensive and less accessible than CT and thus still not routinely used. It may be useful in situations where CT is insufficient such as colovesical or colovaginal fistulas.

8. Differential diagnosis

The differential diagnosis of acute diverticulitis includes other causes of lower abdominal pain. Colorectal cancer; acute appendicitis; inflammatory bowel disease; infectious colitis; ischemic colitis; bowel obstruction; irritable bowel syndrome; gynecologic causes like tubo-ovarian abscess, ectopic pregnancy and ovarian torsion and urologic causes like urolithiasis, cystitis and pyelonephritis should be excluded before establishing the diagnosis of acute diverticulitis. Many of these entities can be ruled out by history, physical examination, laboratory studies and imaging.

Colorectal cancer (CRC) is probably the most important and challenging condition in the diagnostic evaluation since it can mimic the clinical features and CT findings of acute diverticulitis such as bowel wall thickening. The findings that are suggestive for acute diverticulitis, in that case, are the presence of pericolonic and mesenteric inflammation, colonic segment involvement of more than 10 cm and absence of metastatic mesenteric lymph nodes [39, 40]. In almost 10–20% of the cases, CRC and acute diverticulitis differentiation cannot be clearly established and endoscopic evaluation needs to be scheduled after the resolution of inflammatory process [41].

9. Role of endoscopy

In acute diverticulitis, endoscopic evaluation of the colon is not recommended because of the risk of free perforation [42]. But in order to exclude underlying malignancy, colonoscopic evaluation is recommended after at least 6 weeks from the resolution of clinical findings (**Figure 3**) [42–44]. The incidence of finding CRC after an acute diverticulitis episode is between 2.8 and 3.4% [45, 46].

10. Treatment of acute diverticulitis

In acute diverticulitis, treatment protocol depends on the severity of the disease. Generally, mild diverticulitis can be treated in outpatient settings. On the other hand, complicated diverticulitis usually requires hospitalization and surgical intervention.

10.1. Treatment of uncomplicated diverticulitis

In mild cases without fever and marked peritonitis, outpatient treatment is recommended [47]. Routine antibiotic usage is still contradictory in the guidelines [47–50]. If antibiotic treatment

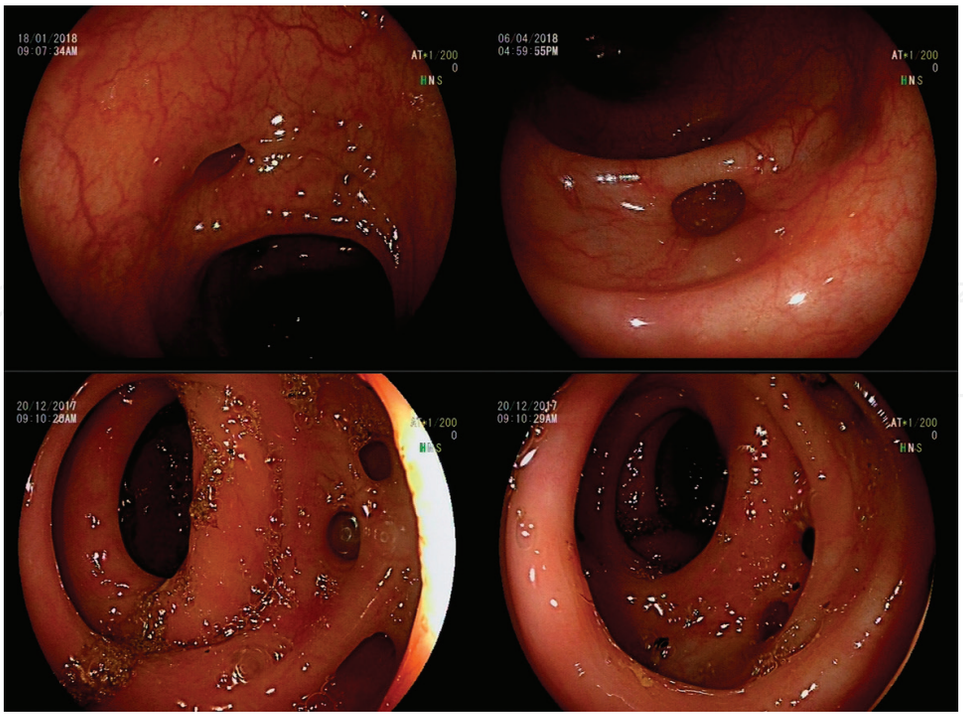

Figure 3. Endoscopic visualization of diverticulosis.

is planned, the coverage of the therapy should include Gram-negative rods, Gram-positive rods and especially the anaerobic flora of the colon [47, 51]. Most common microorganisms are *Escherichia coli* and *Bacteroides fragilis* [52, 53]. There is no clear recommendation for dietary restriction for outpatient treatment. A diet rich in fiber (20–30 g/daily) is recommended for the patients with diverticulosis to lower the risk of developing diverticulitis [11, 54]. Recent studies demonstrated that combination of mesalamine use with antibiotics lowers symptom severity and prevents disease recurrence [55–57]. Probiotic use is another topic under investigation in the management of acute diverticulitis [58–60].

Patients with fever, immunosuppression, sepsis, severe abdominal pain or diffuse peritonitis, those who failed outpatient treatment and intolerant of oral intake, and those with significant comorbidities or older age should be treated as an inpatient. Restriction of oral intake until the resolution of the symptoms and intravenous antibiotics are recommended [61–63].

Traditional teaching for the treatment of recurrent uncomplicated diverticulitis used to be planning an elective operation after the second acute episode [64]. But recent studies showed that in patients followed up with a nonoperative management protocol for uncomplicated diverticulitis, only 5.5% of them required emergency operations [65, 66]. As a result, waiting until third or even fourth episode before deciding for an elective operation has been defined as a more cost-effective management plan with less morbidity [47, 67]. Also, it is found that the probability of surgery after the first hospitalized attack was the same after three attacks [66].

Today, it is thought that after a conservatively managed episode, diverticular disease usually follows a rather benign clinical course and that complications develop mostly at first

presentation [33]. Therefore, elective sigmoid resections should be restricted for use in treating complicated disease, such as symptomatic stenosis, fistulas to an adjacent organ or recurrent diverticular bleeding [33, 64–66].

10.2. Treatment of complicated diverticular disease

Complications of diverticulitis are perforation, fistula, abscess, stricture and obstruction. Depending on disease severity, they usually require surgical or radiologic intervention. While parenteral antibiotics and bowel rest could be adequate for the treatment of mild cases, exploratory laparotomy could be needed for patients with severe clinical findings [65].

10.3. Diverticular abscess

In acute diverticulitis, diverticular abscess occurs between 16 and 56% of the patients and can be localized in pericolic, pelvic, hepatic or retroperitoneal areas [38, 68]. CT is the most effective tool for diagnosis since it can identify the size, localization, and surrounding structures that preclude percutaneous drainage (**Figure 4**). The size of the abscess is essential for the treatment plan, as abscesses less than 4 cm usually resolve with parenteral antibiotics. On the other hand, larger abscesses require percutaneous drainage or surgical drainage if they are not suitable for percutaneous access (**Figure 5**) [38, 63, 69]. Transabdominal route is the preferred method for percutaneous drainage if possible [70]. But percutaneous drainage is

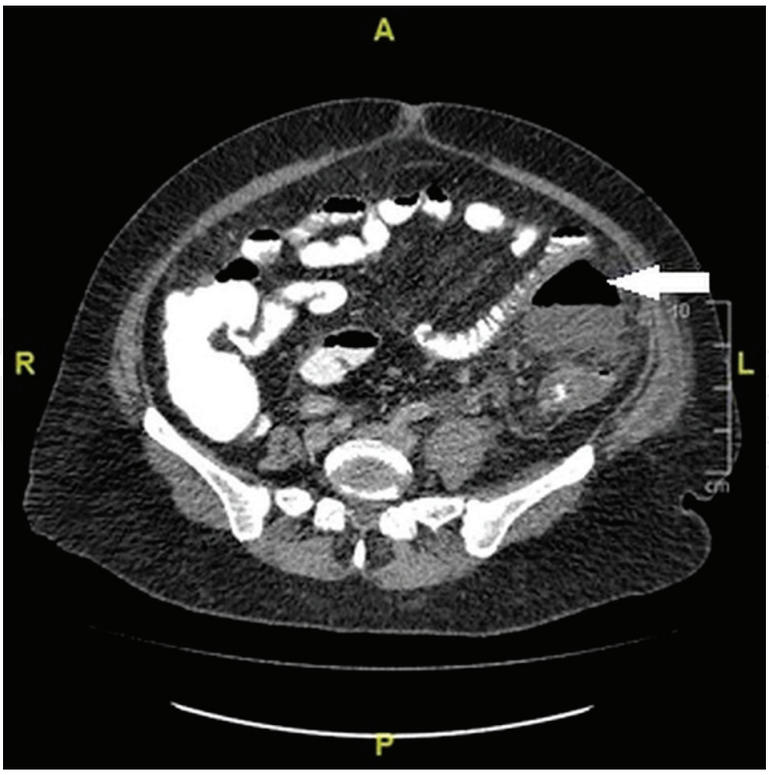

Figure 4. Computed tomography revealed a modified Hinchey stage II diverticulitis.

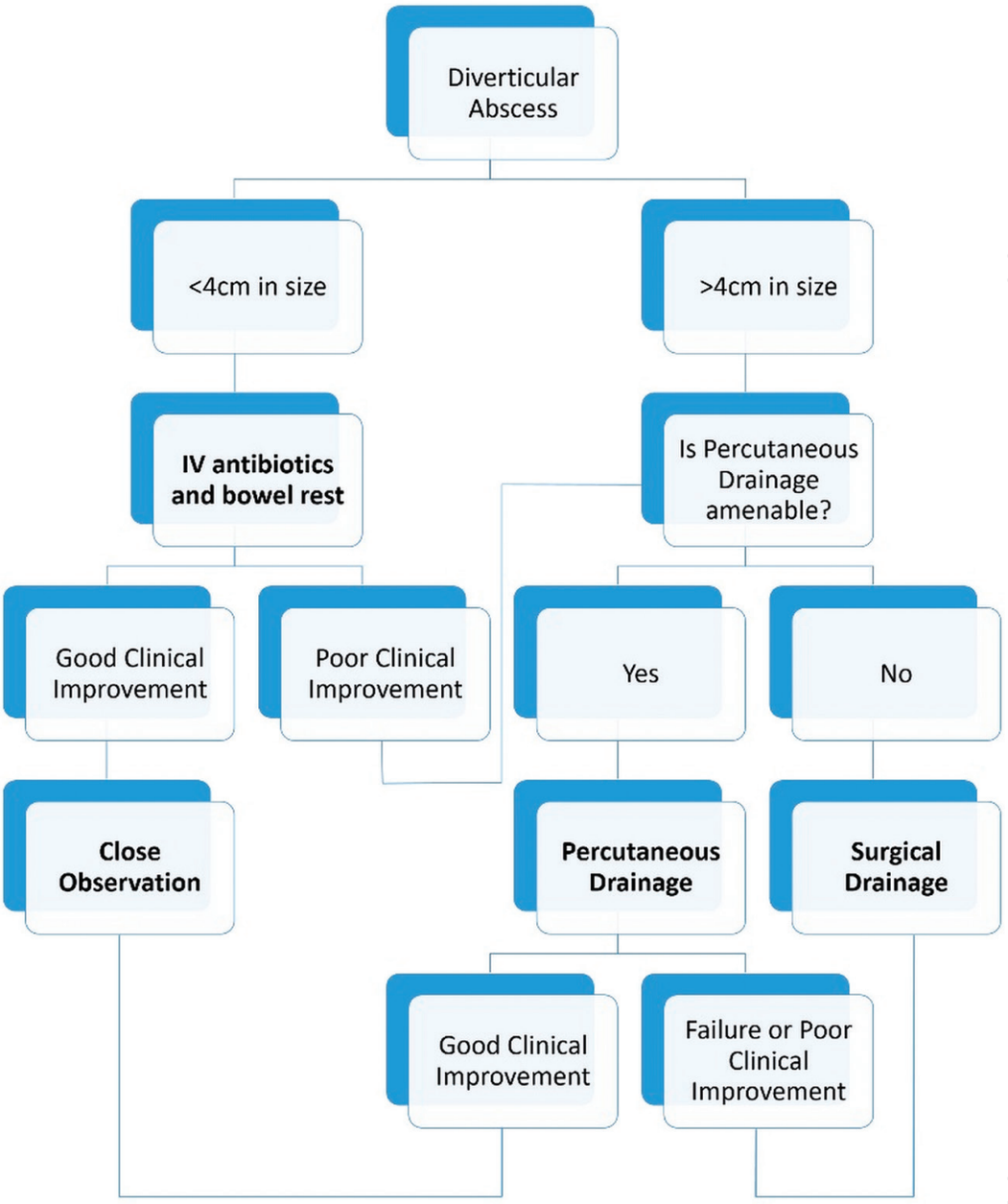

Figure 5. A management for diverticular abscess.

amenable in 20–30% of diverticular abscesses with a 20–30% failure rate [71]. In multilocular and complex abscesses, the failure rate is higher than simple unilocular abscesses [70].

Percutaneous drainage does not negate the need for surgery, but in 60–80% of the patients, surgery can be performed in a single stage and electively [47, 72]. Traditionally, patients with diverticular abscess referred for surgery because of the high risk of recurrent sepsis [37]. With recent studies showing asymptomatic follow-up of the patients treated with successful percutaneous or surgical drainage, the need for elective surgery becomes questionable [38, 73, 74]. As a result, recent guidelines do not recommend routine elective resections after successful nonsurgical treatment of diverticular abscess [47]. On the other hand, symptomatic or immunocompromised patients should be referred for elective surgery [47, 72].

10.4. Perforated diverticulitis

Only 1–2% of the patients with acute diverticulitis presents with free perforation. There are two types of perforation in acute diverticulitis: purulent peritonitis and feculent peritonitis. The differential diagnosis of these conditions is difficult with CT and often requires exploratory laparoscopy or laparotomy. Usually, patients have a fever, acute abdominal findings on examination and significant leukocytosis. Free perforation of acute diverticulitis usually occurs on the first attack and presents with abdominal distention with diffuse tenderness, rigidity and rebound tenderness. The condition can lead to sepsis and septic shock if not treated with a rapid intervention and the mortality rates approach 20% [75, 76].

The goal of the treatment is to eliminate the septic focus. Traditionally, the Hartmann procedure was the choice of treatment, but it has a high morbidity and mortality rate and requires a second major abdominal surgery for reversal colostomy. Studies have shown that nearly one-third of the patients could not undergo the second reversal operation and have permanent colostomy, especially in the elderly population [77]. As a result, resection with primary anastomosis has been studied as an alternative method for the treatment of perforated diverticulitis. Several studies have shown superior results with that procedure compared to the Hartmann procedure depending on the patient's condition [76, 78]. Recent guidelines recommend open or laparoscopic resection with primary anastomosis in hemodynamically stable patients [47]. The factors affecting the choice of treatment are hemodynamic instability, the severity of diffuse peritonitis, ischemia or edema of the bowel at the anastomotic segment, immunocompromised state and malnutrition.

Recent studies investigated laparoscopic lavage for the definitive treatment of Hinchey III diverticulitis and considered it as a safe approach for selected patients [47, 79]. On the other hand, there are conflicting results in the literature against laparoscopic lavage [80–82]. Further trials will be needed for the standardization of this technique.

10.5. Fistulas

Approximately 2% of the patients with acute diverticulitis will develop fistula formation to the adjacent structures [83]. Fistula formation is a result of spontaneous rupture and decompression of an abscess to an adjacent structure like urinary bladder, vagina, colon, small intestine, uterus or abdominal wall and skin. They usually do not require emergency surgery. Colovesical fistula can be seen in 65% of the cases and is the most common type of fistula [84–86]. Because of the anatomic blockage of uterus and vagina in women, colovesical fistulas are more common in men. Patients with colovesical fistulas present with polymicrobial urinary infections, pneumaturia, and fecaluria. Air or contrast in the bladder can be seen on CT scans. Cystoscopy and colonoscopy should be done in those patients to exclude bladder or colon cancer involvement.

In women who have undergone prior hysterectomy, colovaginal fistulas are more common. Fecal vaginal discharge and passage of air per vagina can be seen in these patients.

Surgery is indicated when fistula formation diagnosed. Resection of the colonic segment and suture repair of the affected structure with interpositioning of the omentum between anastomosis and the repair site is the treatment of choice [87, 88].

10.6. Diverticular stricture/obstruction

Recurrent attacks of diverticulitis can lead to sigmoid stricture and less commonly obstruction. Because obstructing colon cancer is far more common than diverticular stricture, the differential diagnosis should be focused to exclude malignancy.

The treatment plan depends on the severity of the obstruction. Patients with partial obstruction can be treated in elective settings; on the other hand, patients with complete obstruction will require emergency surgery. Options for surgery include the Hartmann procedure, resection and primary anastomosis with or without on-table lavage [89, 90].

11. Prognosis

Among patients with diverticulosis, only 4% will develop acute diverticulitis and 15% of these patients will require surgical treatment [91, 92]. Although the incidence is as low as 16% below 45 years of age, it has been proposed that younger individuals have the more severe disease but require lesser surgical intervention [31].

Mortality rates of the patients with peritonitis vary between 0 and 36% depending on the patients' characteristics. On the other hand, elective colectomy has a low rate of mortality rate around 1% [93]. The anastomotic leakage rate is also higher in Hinchey III or IV diverticulitis (8–22%) than elective colectomy (1–3%) [76, 93–95]. On the other hand, Hartmann reversal rates are between 20 and 50% depending on the patients' comorbidities and condition [96–98].

Recurrent diverticulitis or its symptoms develop at a rate of 3–13% after elective resection [99, 100]. The most important determinant is the level of the anastomosis [100]. When anastomosis is established with the distal sigmoid colon, the incidence of recurrence is 12.5% while the incidence is 6.7% for the anastomosis with the proximal rectum [101]. Thus, resection of the sigmoid colon entirely and anastomosis to the proximal rectum is recommended. It is not necessary to resect all the diverticular segments more proximal than sigmoid colon but the proximal resection margin should be soft pliable bowel [63].

Immunocompromised patients usually present with severe and complicated disease. Studies have shown that approximately 40% of them had free perforation and emergency surgery required in 60% of the patients. As a result, they have higher postoperative morbidity and mortality rates as 65 and 40% accordingly [102–104].

12. Conclusion

Diverticular disease is a common condition in developed countries. In order to lower the rising incidence, population-based dietary modifications should be considered. Recent treatment guideline recommendations are focused on less invasive and elective solutions. As a result, a shift to nonsurgical follow-up or elective minimally invasive surgery from high morbidity-related Hartmann procedure should be done whenever possible, depending on the patients' condition, to achieve lesser morbidity and mortality rates.

Conflict of interest

The authors declare that they have no conflict of interest.

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