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Diverticular Bowel Disease

Diagnosis and Treatment

Edited by Luis Rodrigo

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Meet the editor

Luis Rodrigo has been a Full Professor of Medicine at the University of Oviedo, Spain, since 2010, and Emeritus Professor since 2014. He has been a specialist in gastroenterology since 1972, achieving his Ph.D. in 1975 and being appointed Titular Professor in Medicine at the University of Oviedo in 1983. He has been the head of the Gastroenterology Service of HUCA in Oviedo since 1975. He is the author of 8 books on the treatment of gastroenterological and other digestive and liver diseases, has contributed 58 chapters to books on gastroenterology, and is the main author or co-author of 455 scientific papers in English and 282 papers in Spanish.

Contents

Preface

As an academic editor, it gives me great satisfaction to present the book *Diverticular Bowel Disease – Diagnosis and Treatment*. It discusses diverticulitis, a disease about which little is known and that has experienced notable advances over the last decades.

This book includes six chapters, written with clarity and precision by various international authors with great experience and knowledge of the topics described.

It begins with a short introduction by the academic editor that describes the structure and function of the colonic diverticula. The rest of the chapters discuss epidemiology, complications, and treatments of diverticulitis.

Diverticula are small bulging pouches or sacs that form on the inner wall of the intestine. Most of the time they are found in the lower part of the large intestine, mainly in the sigmoid portion (lower left part of the colon). Acute diverticulitis occurs when these pouches become inflamed or infected. Diverticulitis can cause severe abdominal pain, fever, nausea, and a marked change in bowel habits.

There are several factors that can increase the risk of diverticulitis. These include the following:

- Aging: The incidence of diverticulitis increases with age.
- Obesity: Being very overweight increases the chances of developing diverticulitis.
- Smoking habits: Heavy smokers are more likely to experience diverticulitis than those who do not smoke.
- Increased alcohol consumption: Continuous and heavy drinking over time increases the risk of developing colonic diverticular disease and complications.
- Lack of physical exercise: Moderate-to-intense daily exercise appears to reduce the risk of diverticulitis.
- High-fat, low-fiber diets: A low-fiber diet in combination with high animal fat intake increases the risk of diverticulitis, although the role of low fiber alone is unclear.
- Drugs: Taking several medications chronically, including steroids, opioids, and nonsteroidal anti-inflammatory (NSAID) drugs such as ibuprofen, naproxen sodium, and others has been associated with an increased risk of diverticulitis in susceptible people.

Acute colonic diverticulitis (ACD) is the most common complication of diverticular disease and represents an abdominal emergency. It includes a variety of conditions ranging from localized diverticular inflammation to fecal peritonitis, and thus, accurate diagnosis is important.

Contrast-enhanced computed tomography (CE-CT) plays a pivotal role in diagnosis due to its high sensitivity, specificity, accuracy, and interobserver agreement. In fact, CE-CT allows alternative diagnoses to be excluded, the inflamed diverticulum to be localized, and complications to be identified. Imaging findings can be categorized as bowel or extra-intestinal wall findings and reviewed. Moreover, CE-CT allows staging of the disease; the most used classifications of ACD severity are Hinchey's modified and WSES classifications. Differential diagnoses include colon carcinoma, epiploic appendicitis, ischemic colitis, appendicitis, infectious enterocolitis, and inflammatory bowel disease. Mild diverticulitis can be treated with rest, dietary changes, and antibiotics. Severe or recurrent diverticulitis may require surgery with two available modalities, and the choice between them depends on various local factors.

I want to thank all of the authors for their excellent contributions and the staff at IntechOpen, especially Ms. Papuga for her continuous help and support throughout the editorial process.

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Chapter 1

Introductory Chapter: Diverticular Disease and Complications

Luis Rodrigo

1. Introduction

1.1 Concept and epidemiology

Colonic diverticula are saccular formations of the mucosa and submucosa that extend through the muscular layer of the colon. Their diameter is generally placed between 5 and 10 mm, although sometimes they can reach up to 20 mm. Most are false or "pseudo-diverticula" as they lack a muscular layer.

Diverticulosis is the most common colonic disease in the Western world. Affecting up to 10% of the population, reaching a higher prevalence in elderly people. In fact, 50% of the population over 50 years of age has diverticula, which is more common in women.

All of this represents a high amount of doctor visits and hospital admissions.

However, in recent years, an increasing incidence of episodes of acute diverticulitis has mainly been reported in young people under 44 years of age. They usually present a more aggressive course, with an increased risk of complications and increased need for surgical treatment.

In an amount of less than 5%, it can occur before the age of 40, being more prevalent in obese men. Unlike the Western world, where diverticula are preferentially located in the left colon (less than 15% have them in the right colon), in the East, where the disease is much less frequent, the predominant location (70%) is in the right colon [1].

2. Etiopathogenesis

Diverticula form at the weak points of the circular musculature of the colon, at the insertion site of the intramural vasa recta. The main mechanism responsible for this disorder is not well known and its pathogenesis probably involves intrinsic anatomical abnormalities of the colon, along with motor function disorders.

In most patients with left diverticulosis, both the tapeworms (outer longitudinal muscle layers) and the circular muscle layer are thickened due to excess elastin. At the same time, an increase in the motor activity of the colon has been detected. Both phenomena condition an increase in intraluminal pressure and an increase in intestinal segmentation [2].

As a compensatory effect, cholinergic hypersensitivity and colonic smooth muscle dysfunction would occur, facilitating the formation of diverticula.

The fact that diverticular disease of the colon more frequently affects industrialized societies in the Western world has led us to consider that low fiber intake in the diet is an important factor in its development.

Among the risk factors are included in addition to high age, a sedentary lifestyle, and obesity as the principal contributors.

3. Simple diverticulosis

3.1 Symptomatology

Approximately 75–80% of patients with colonic diverticula remain asymptomatic for life, while the remaining 20–25% may report nonspecific symptoms, such as abdominal pain predominantly located in the hypogastrium, and left hemicolon, flatulence, and/or changes in bowel habit.

In cases of diverticulosis located in the cecum and ascending colon, the symptoms refer to the right iliac fossa.

The pain usually increases with meals and improves with defecation. The clinical picture presented by these patients is largely similar to that of patients with irritable bowel syndrome [3].

The abdominal examination is normal, and the analytical determinations generally show no abnormalities. For these reasons, it is often difficult to attribute the symptoms only to the presence of colonic diverticula.

3.2 Diagnosis

For many years the opaque enema, was the most used single imaging technique for the diagnosis of colic diverticulosis, being a casual finding in routine studies performed for other reasons.

Currently, performing a colonoscopy has largely replaced this indication with great advantages, such as the possibility of detecting associated complications by performing biopsies, complemented by early screening for associated lesions.

3.3 Treatment

Some longitudinal studies suggest that a diet rich in fruits and vegetables significantly reduces the risk of complications in patients with diverticulosis. However, the levels of evidence are low, and the level of recommendation cannot be based on controlled and randomized studies. In any case, it is generally advisable to follow a diet rich in fiber, given that it increases the volume of feces, thereby reducing pressure inside the colon and increasing intestinal transit.

The incidental diagnosis of diverticulosis does not require the prescription of any pharmacological treatment or clinical follow-up.

4. Acute diverticulitis

Diverticulitis is the most frequent complication of diverticular disease (10–25%) and appears when the mucosa is abraded, generally due to the action of fecaliths, which leads to the appearance of necrotizing inflammation of a diverticulum. It has

been reported that only 4–5% of people with diverticulosis end up developing acute diverticulitis [4].

Diverticulitis is considered uncomplicated when the clinical picture is limited to the appearance of "peridiverticulitis or phlegmon" and complicated, when it is accompanied by an abscess, fistula, or free perforation of the peritoneum, when signs of obstruction appear.

Various classifications have been described to study the severity of diverticulitis. The most used is the one proposed by Hinchey in 1978. Since then, other classifications have been proposed that complement or develop this classification, mainly based on the findings provided by performing an abdominal axial tomography.

4.1 Clinical symptoms and signs

The most frequent symptom in patients with sigmoid diverticulitis is the presence of abdominal pain located at the level of the left iliac fossa. In cases of right diverticulitis, the picture is similar to that of acute appendicitis.

Fever is frequent, although it only appears in the most severe cases. Other symptoms that may appear are diarrhea, constipation, and nausea.

Some of the clinical manifestations only appear in the presence of associated complications. Such occurs in patients who develop an intra-abdominal abscess. In these cases, high and permanent fever appears, despite antibiotic treatment, and is associated with a palpable mass and abdominal tenderness [5].

Patients who develop a colovesical or colovaginal fistula, may present pneumaturia or fecaluria, and patients with colic stenosis, present with symptoms suggestive of colonic closure. This happens more often in patients who have had previous episodes.

In these cases, the effects of spasm and edema, typical of acute inflammation, are added to the parietal fibrosis that follows previous episodes of inflammation. Free peritoneum perforation is uncommon.

4.2 Diagnosis

It is fundamentally based on the presence of compatible clinical data. The physical examination. It usually reveals pain on superficial and deep palpation, with signs of peritoneal irritation or filling. More than 50% of cases present obvious leukocytosis. Simple abdominal radiography can show distention of intestinal loops and the presence of air-fluid levels in cases of ileus or occlusion and pneumoperitoneum in cases with perforation.

When there are doubts in the diagnosis, computed tomography (CT) is the method of choice for diagnosis. The examination should be performed, if possible, with oral water-soluble contrast, complemented by the injection of intravenous contrast. This examination assesses the presence of intra and extra-luminal colic pathology, as well as the existence or not, of associated complications. Another added value consists of the possibility of performing an associated therapeutic intervention, through the percutaneous placement of drains, for the evacuation of possible abdominal abscesses.

Abdominal ultrasound is equally useful for the diagnosis of acute diverticulitis and can demonstrate the presence of inflamed colonic diverticula and its complications. Its main advantages are its low cost, wide availability, and its noninvasive nature. It

also allows the placement of percutaneous drains. Its biggest drawback is that it is a technique that depends on the experience of the explorer [6].

Colonoscopy is formally contraindicated, when there is suspicion of severe acute diverticulitis, due to the risk of perforation, although it is actually very low. In cases of acute diverticulitis and in the absence of perforation, or presence of pericolic gas on CT, a colonoscopy with low insufflation can be performed after 5 days from the diagnosis of acute diverticulitis.

A higher frequency of advanced adenomas or colon cancer, in proximity to diverticular disease, has been described in patients with complicated diverticulitis.

4.3 Treatment

4.3.1 Uncomplicated diverticulitis

In mild diverticulitis (75% of cases), oral antibiotic treatment is recommended on an outpatient basis, if there are no complications and there is no alteration of intestinal function. Fluid intake is preserved. Taking spasmolytic drugs, such as octylonium bromide, may be recommended for the treatment of pain.

However, patients who are elderly, immunocompromised, with associated comorbidities, or who have persistent fever and leukocytosis should be hospitalized.

The antibiotics chosen must be active against Gram (−) bacilli. The recommended regimens usually include metronidazole or clindamycin to cover anaerobes and a third-generation cephalosporin or a quinolone against Gram (−) germs.

The association between fiber and rifaximin (400 mg/12 h) 1 week a month for a year not only reduces the associated symptoms of diverticulitis but also reduces the risk of recurrence of this disease [7].

5. Indications for surgical treatment

Its realization can be contemplated in the following circumstances:

a. When two or more episodes of acute diverticulitis occur, in patients controlled with conservative treatment.

b. In patients under 40 years of age, after a single episode that required hospital admission.

c. In patients who had a single acute, severe episode that resulted in perforation, obstruction, or involvement of the urinary tract.

d. In immunocompromised patients, after the first episode, since diagnosis can be difficult there is an added risk of perforation and mortality.

e. In the cases when the impossibility of ruling out underlying colorectal cancer is high.

However, the level of existing scientific evidence is still low, to establish these recommendations.

6. Elective surgical treatment

Consists of removal of the affected colon segment (generally the sigmoid) by open surgery or by laparoscopy.

The laparoscopic approach may offer a lower incidence of surgical wound infection and postoperative ileus and a lower transfusion requirement.

The proximal resection margin should include areas with abnormal thickening of the colonic wall, and it is not necessary to remove all segments with diverticula. The distal margin should reach the rectum to reduce postoperative recurrence (which occurs in 10% of patients) [8].

The most common technique used consists of resection and primary anastomosis, with relative contraindications being intra-abdominal contamination and the inability to perform presurgical lavage of the proximal colon. As a general rule, elective surgery is not recommended in cases of acute diverticulitis.

7. Severe diverticulitis

Approximately 2% of acute diverticulitis present with associated local complications (abscess, obstruction, fistula, or perforation). These cases are accompanied by greater severity in their clinical expression, including persistent pain in the left iliac fossa of greater intensity, febrile syndrome, signs of peritoneal irritation and/or a palpable abdominal mass (plastron). Some patients can evolve to a picture of septic shock. The clinical management of these patients must be individualized, in relation to the clinical state they present and/or the resulting complication.

7.1 Abscess

The abscess is the suppurative complication of a phlegmon, and should be suspected when fever and leukocytosis persist despite antibiotic treatment, or when there is a palpable mass on examination. Diagnosis can be made by ultrasound or CT. Treatment of abscesses has traditionally been surgical, but the advent of imaging techniques that make it possible to precisely guide percutaneous drainage has modified the management of these patients. In addition, it allows the patient to be stabilized, avoiding the need for urgent surgery, which makes it possible to carry out a programmed resection without the need for a colostomy.

The drain is removed when the output is minimal (<10 ml in 24 h). In recent years, it has been confirmed that endoscopic ultrasound is also effective for endoscopic drainage of purulent collections, with similar results to percutaneous drainage.

7.2 Fistulae

The most common fistulas are colovesical. They predominate in men due to the protection exerted by the uterus in women. In fact, in half of the cases presented in them, the history of performing a previous hysterectomy is recorded. The most frequent symptoms are pneumaturia and fecaluria, with the exception of urine elimination with feces [9].

They are followed in frequency by colovaginal, coloenteric, and colouterine fistulas. CT is useful in the study of colovesical fistulas, since, in addition to showing

pneumaturia, it allows evaluation of the extent and degree of pericolic inflammation. Cystoscopy can detect bladder abnormalities in most cases. The treatment of fistulas is usually surgical. In colovesical cases, resection of the diverticular area is usually sufficient, being able to preserve the bladder in most cases.

7.3 Obstruction

It can appear as a complication, both acute and/or chronic, in acute diverticulitis. When the occlusion is the result of edema and spasms associated with inflammation, the symptoms resolve as the inflammatory process disappears. If the stenosis is due to extrinsic compression of a peridiverticular abscess, percutaneous or surgical drainage is usually required. Finally, when the occlusion is the result of a retractile stenosis secondary to scar repair from previous episodes, surgical excision of the affected segment may be necessary [10].

Surgery is also indicated when there are doubts about the benign nature of the stenosis. At this point, it must be considered that colonoscopy may not resolve the differential diagnosis in approximately one-third of cases. An alternative that can avoid urgent two-phase surgery is the insertion of self-expanding metal prostheses. This procedure allows surgery to be undertaken electively and in better conditions.

7.4 Free drilling

Perforation of the free peritoneum is not frequent and occurs more likely in immunocompromised patients. It is associated with high postoperative morbidity, mainly due to sepsis, multiple organ failure, and comorbidity. The treatment of choice is urgent surgery. The most used technique is resection with sigmoid colostomy and closure of the rectal stump (Hartmann procedure). The second intervention to restore intestinal continuity and revise the colostomy is usually carried out between 3 and 6 months. In recent years, there has been a growing trend to perform primary anastomosis and laparoscopic peritoneal lavage at the same time [11].

8. Diverticular bleeding

It is generally a serious complication that appears as a consequence of the rupture of the vasa recta, the dome, or the neck of a diverticulum. Although structural alterations have been observed in the walls of these vessels, the inflammation found in these cases is little or none. It appears in 3–5% of patients with diverticulosis and is responsible for up to 40% of episodes of lower gastrointestinal bleeding. An interesting aspect is that the lesion responsible for the hemorrhage is located in the proximal colon in half of the cases, despite the fact that diverticula are located more frequently in the distal colon.

It has been postulated that this may be due to the fact that the proximal diverticula are wider, leaving the vasa recta more exposed to eventual mechanical trauma. The bleeding is usually of a significant volume, and in a third of cases, some transfusions may be required. The bleeding stops spontaneously in 75% of cases, but up to 50% may experience a hemorrhagic recurrence, with 35% requiring treatment by embolization or surgery. Due to the high bleeding rate, diverticular hemorrhage is a relevant clinical problem, as it mainly affects patients with advanced age and frequent comorbidities.

When bleeding originates from a diverticulum and a colonoscopy is performed after adequate preparation, stigmata of recent bleeding may be identified, including the presence of a visible nonbleeding vessel or firmly adherent clot in a diverticulum. These endoscopic stigmata may be present in 30–40% of patients with diverticular hemorrhage [12].

In patients with active bleeding and hemodynamic instability, urgent exploratory laparotomy should be considered in addition to applying the usual diagnostic and therapeutic measures. However, all efforts to locate the hemorrhagic lesion earlier are justified because the prognosis for blind colectomy in massive hemorrhage is dismal, with a high mortality rate, which can reach up to 30% of cases.

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Chapter 2

Brief Explanation about Diverticular Disease

Ahmet Onur Demirel, Burak Yavuz and Yunus Kaycı

Abstract

Diverticula, sac-like protrusions in hollow organ walls appear throughout the gastrointestinal system, most commonly in the duodenum near the ampulla. They are classified as true (congenital, with all intestinal wall layers) and false diverticula (acquired, with a muscular layer defect). Duodenal diverticula are usually asymptomatic, found incidentally during endoscopies. Symptoms, when present, manifest as dyspeptic complaints. Radiographs show these diverticula as atypical gas balloons, while CT scans reveal them as mass-like structures. Complications are rare but can include obstruction, bleeding, perforation, and blind loop syndrome. Less than 5% require surgical intervention due to complications. Treatment typically involves endoscopic or surgical excision. The management of biliary and pancreatic complications remains debatable.

Keywords: diverticulum, colon, small intestine, diverticulitis, bowel perforation

1. Introduction

Diverticular disease, a common gastrointestinal disorder, has been the subject of extensive research and clinical guidelines. The prevalence of diverticular disease has been increasing, particularly affecting older age groups [1, 2]. The pathogenesis of diverticular disease is multifactorial, with factors such as obesity being identified as increasing the risks of diverticulitis and diverticular bleeding [3]. Furthermore, changes in dietary habits, such as the introduction of roller milling of flour, have been associated with the increased prevalence of diverticular disease [4]. The management of diverticular disease has evolved over the years, with the introduction of novel treatment methods such as laparoscopic colectomy and endoscopic band ligation for colonic diverticular bleeding [5, 6]. Additionally, the development of endoscopic classifications, such as the Diverticular Inflammation and Complication Assessment (DICA), has provided a framework for the clinical assessment and prediction of outcomes in diverticular disease [7–9]. The introduction of such classifications has facilitated a better understanding of the disease and improved interobserver agreement among community endoscopists [9]. Despite these advancements, the place of elective sigmoidectomy for colonic diverticular disease is still debated in the literature, highlighting the ongoing need for further research and consensus in the management of this condition [10]. In conclusion, diverticular disease presents a

complex and evolving clinical landscape, with ongoing efforts to refine its classification, diagnosis, and treatment strategies.

2. Epidemiology, etiology, pathology

Diverticular disease is a prevalent condition in Western society and is a leading cause of outpatient visits and hospitalizations [11]. The etiology of diverticular disease is thought to result from structural abnormalities of the colonic wall, disordered intestinal motility, deficiencies of dietary fiber, and complex interactions among colonic motility, diet, lifestyle, and genetic features [7, 12]. Epidemiological studies have attempted to characterize the association between diverticular disease and colorectal cancer, yielding inconsistent results [13]. Additionally, the presence of associated symptoms such as abdominal pain, bloating, diarrhea, and constipation in the absence of inflammation of peri-diverticular mucosa identifies symptomatic uncomplicated diverticular disease (SUDD) [14]. Furthermore, the characteristic pathologic features of Crohn's disease, such as transmural inflammation, epithelioid cell granuloma, fissuring, or fistula formation, may be seen in complicated diverticular disease or diverticulitis [15].

The epidemiology of diverticular disease has been the subject of evolving insights, with increasing hospital admissions for complications of diverticular disease, particularly in the elderly and emergency admissions [16]. Moreover, the prevalence of colonic diverticula has been increasing in recent years, leading to an increase in opportunities to treat patients with colonic diverticular disease, including diverticular bleeding and diverticulitis [17]. In terms of the pathology of diverticular disease, it is considered to be a chronic illness, and recent literature addresses the emerging insights regarding its pathophysiology and management, providing current answers to common clinical questions [9]. Additionally, diverticular colitis, also known as segmental colitis associated with diverticulosis, is a colonic inflammatory disorder on the spectrum of inflammatory bowel disease (IBD) [18].

In conclusion, diverticular disease is a complex condition with multifactorial etiology and evolving epidemiological insights. The pathology of diverticular disease involves chronic illness and inflammatory disorders, with potential overlap with other conditions such as colorectal cancer and Crohn's disease. Understanding the epidemiology, etiology, and pathology of diverticular disease is crucial for effective management and treatment strategies.

3. Diverticula types by organs

3.1 Duodenal diverticula

Acquired diverticula are most commonly seen in the duodenum and tend to be localized near the ampulla; these diverticula are known as periampullary, juxtapapillary, and perivateral diverticula. Approximately 75% of juxtapapillary diverticula originate from the medial wall of the duodenum [19].

The duodenum is the second most common site of diverticula after the colon. The prevalence of duodenal diverticula detected in upper GI tract examinations has been reported to vary between 0.16 and 6% [4, 19]. The prevalence of duodenal diverticula increases with age. It is rare under 40 years of age. The mean age at diagnosis varies between 56 and 76 years. Duodenal diverticula are twice more common in women.

3.1.1 Clinical findings

The majority of duodenal diverticula are asymptomatic and are detected incidental to endoscopic examination of the upper gastrointestinal tract [20]. Those who are symptomatic have dyspeptic complaints.

They appear as atypical gas balloons on direct radiographs. On CT, it may appear as a mass-like structure containing air, air fluid level, liquid contrast or debris between the duodenum and pancreas. Magnetic resonance cholangiopancreaticography is useful in showing the relationship of the diverticulum with biliary and pancreatic structures.

Complications associated with duodenal diverticulum include biliary or pancreatic duct obstruction leading to cholangitis or pancreatitis, hemorrhage, perforation, and rarely blind loop syndrome (19, 21). Surgery is considered in less than 5% due to complications [21].

3.1.2 Treatment

Most duodenal diverticula are asymptomatic. Symptomatic duodenal diverticula require endoscopic or surgical excision because recurrence and complications cause serious morbidity. Lateral duodenal diverticula are usually treated with diverticulectomy if they cause bleeding or obstruction. Complications associated with medial duodenal diverticula should be treated endoscopically and nonoperatively if possible [21]. In an emergency, bleeding from the medial duodenal diverticulum is treated with lateral duodenotomy and ligation of the diverticulum vessel. Perforation is treated with extensive drainage instead of complex surgery. Diverticulectomy in diverticula with biliary and pancreatic complications is controversial and not routinely recommended [22].

3.2 Small intestine diverticula

Diverticula in the jejunum are more common and larger than in the ileum. Small bowel diverticula are pseudo diverticula (containing mucosa and serosa) and are seen in older age groups [23, 24]. Diverticula are multiple and usually located in the mesenteric wall.

3.2.1 Clinical findings and diagnosis

Most of them are asymptomatic. Common symptoms include severe postprandial pain, dyspeptic complaints, nausea, vomiting, and diarrhea. Acute complications such as bleeding, perforation, and obstruction may occur [24]. Diverticulitis is triggered by obstruction of the diverticulum mouth and consequent bacterial growth. As a complication of diverticulitis, diverticulitis perforation with or without abscess may occur.

A good anamnesis followed by CT examination of the distal duodenum may lead to a diagnosis. Capsule endoscopy can be used for diagnosis although it is costly [23]. Enteroclysis is the most sensitive method to detect small intestinal diverticula. However, most small bowel diverticula are detected incidentally.

3.2.2 Treatment

Small bowel diverticula are mostly asymptomatic and do not require treatment. Segmental resection and anastomosis is recommended in diverticula that are

symptomatic and cause complications such as bleeding, obstruction, and perforation. If peritonitis occurs after perforation, enterostomy is required since anastomosis after resection is risky. Antibiotics are frequently used in the treatment of patients with malabsorption due to bacterial proliferation and blind loop syndrome [25].

3.3 Meckel's diverticula

It is a true diverticulum of the small intestine. It is the most common congenital anomaly of the gastrointestinal tract and may remain silent for life. It occurs in approximately 2% of the population [26]. It is located within 100 cm proximal to the ileocecal valve (**Figure 1**). It usually contains heterotropic mucosa. The most common mucosa is gastric, followed by pancreatic acini [26]. There is the famous rule of twos describing Meckel's: 2% prevalence, 2 feet proximal to the ileocecal valve in adults, half of symptomatic Meckel's diverticula under 2 years of age, 2 times more common in males than females.

3.3.1 Clinical findings and diagnosis

The majority are asymptomatic. They are asymptomatic unless diverticulum-related complications occur. The lifetime incidence of complications in patients with Meckel's diverticulum is estimated to be approximately 4–6% [27].

It manifests itself with complications such as bleeding, obstruction, and diverticulitis. It may also present as Littre's hernia, which occurs when Meckel's diverticulum enters the hernia sac [27]. In patients younger than 18 years of age, it usually causes bleeding, while in adults it usually causes obstruction.

Twenty percent of patients with Meckel's diverticulitis present with a clinical picture that cannot be differentiated from acute appendicitis. Carcinoid tumors are present in 0.5–3.2% of resected Meckel's diverticula [26].

Most Meckel's diverticula are detected radiologically, endoscopically or intraoperatively incidental. CT sensitivity for Meckel's diverticulum is very low (**Figure 2**) [28]. Enteroclysis provides 75% accuracy but is usually not applicable in acute situations due to complications. Radionuclide scintigraphy is effective only in Meckel's

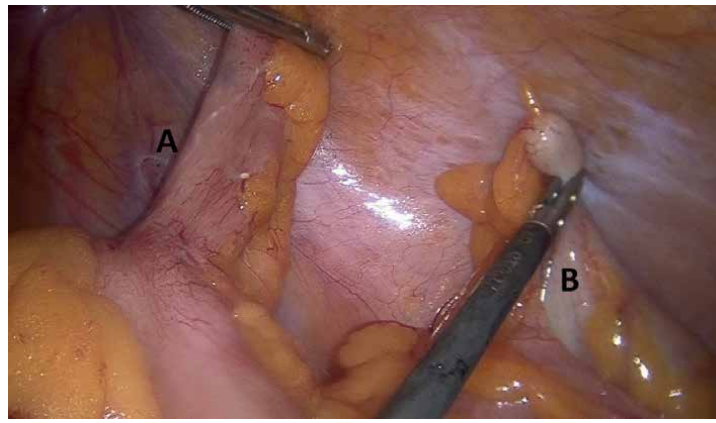

Figure 1.
(A) Meckel's diverticulum; (B) Appendix vermiformis.

diverticulum containing gastric mucosa. Angiography is useful for localization in patients presenting with complications such as bleeding [28].

3.3.2 Treatment

In symptomatic Meckel's diverticulum, diverticulectomy or resection of the diverticulum segment is necessary [29]. If the cause of the symptom is bleeding, the segment containing the diverticulum should be resected. If the diverticulum contains a tumor or there is inflammation or perforation, the treatment is segmental resection.

Surgical treatment for asymptomatic Meckel's diverticulum is not clear. In one study, prophylactic diverticulectomy should be performed on 758 asymptomatic Meckel's diverticula to prevent Meckel-related death. Many people recommend prophylactic removal of diverticula under the age of 50 years, containing ectopic tissue and longer than 2 cm, considering the possibility of complications [30].

3.4 Diverticular disease of the colon

A diverticulum causes symptoms are called diverticular disease. Multiple diverticula without inflammation is called diverticulosis coli. If there is inflammation and infection in the diverticulum, it is called diverticulitis. The majority of colonic diverticula are false diverticula. They protrude between the tenia coli where the blood vessels enter the colon. The pathophysiology is pulsation diverticulum formed after increased intraluminal pressure.

Although the etiology of diverticulosis is not clear, studies have shown that meat products and fiber-poor diets cause smaller amounts of feces and higher intraluminal pressure is required for fecal excretion. Increased intraluminal pressure also predisposes to diverticulum formation [31]. Chronic constipation also causes increased intraluminal pressure and plays a role in the formation of pulsation diverticula. There are many theories about the etiology but none of them have been proven. It is accepted that prophylactic high fiber diets reduce the incidence of diverticula.

Only 10–20% of patients with diverticula have symptoms, the majority of them are asymptomatic. The incidence of symptoms increases with age. After the age of 50 years, the incidence increases. The most common site of diverticular diseases in the

Figure 2.
Meckel's diverticulum CT image.

colon is the sigmoid colon and the second most common site is the descending colon. The rectum is the most rare site.

3.4.1 Clinical findings and diagnosis

Colonic diverticula, like other diverticular diseases, are usually asymptomatic. For a diverticulum to become symptomatic, an infectious condition called diverticulitis must occur. Diverticula become symptomatic when complications such as bleeding, obstruction, perforation, and abscess formation occur [32].

Diverticulitis is caused by pericolonic inflammation of the intestinal contents through the perforated colonic diverticulum. Since the sigmoid colon is the most commonly affected area, patients usually present with left lower quadrant pain. Patients may also present with changes in bowel habits, nausea, anorexia, and urgency if the bladder is affected. Bleeding from the diverticulum causes massive bleeding due to peridiverticular erosion. Most lower GI bleeding occurs in the elderly where diverticulosis or angiodysplasia is common [33]. It is difficult to determine the source of bleeding but it stops spontaneously in 80% of patients. Colonoscopic examination or angiography can be used for diagnostic and therapeutic purposes to show the bleeding diverticulum [34]. Rarely, colectomy is indicated if bleeding persists [35].

If tenderness, distension, and diffuse defensive rebound in the left lower quadrant are present on physical examination, generalized peritonitis due to diverticulum perforation is present. In addition, if there is phlegmon due to left lower quadrant diverticulum, a palpable mass may be palpated. Leukocytosis is dominant in the laboratory [36].

After a good anamnesis and physical examination, CT is very useful in the diagnosis to show the localization of the diverticulum (**Figure 3**), the presence of pericolonic abscess, and fistula. CT diagnosis will also guide the treatment to be performed after the diagnosis. Barium enema is not used in perforation due to the risk of intra-abdominal contamination. If oral contrast is given in CT, water-soluble contrast should be given [34]. USG and MRI can also be used in diagnosis but are not as reliable as CT. Care should be taken in colonoscopic examination in acute condition because the risk of perforation is high. Colonoscopic examination can be performed safely 4–6 weeks after the acute picture [37].

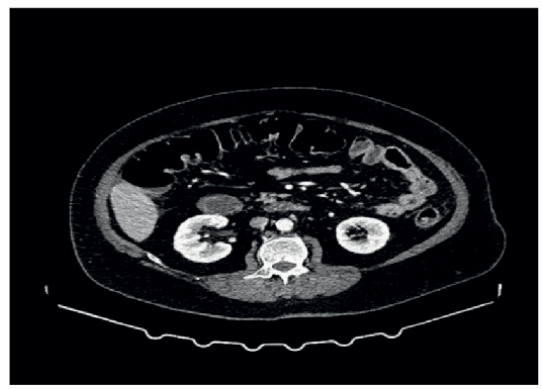

Figure 3.
Colonic diverticulas.

3.4.2 Treatment

Treatment of acute diverticulitis is divided into complicated or uncomplicated diverticula according to the clinical presentation at presentation. In complicated diverticula, abscess, fistula, free perforation, or obstruction are present. In uncomplicated diverticula, none of these complications are present, and diverticulum and pericolonic inflammation are present.

3.4.2.1 Uncomplicated diverticulitis

Uncomplicated diverticula can usually be treated on an outpatient basis with broad-spectrum oral antibiotic therapy and dietary modification. The average duration of antibiotics is 7–10 days [11]. Patients should not be immunosuppressed, afebrile, have stable vital signs, tolerate oral intake, and should not have comorbid conditions in order to be treated as outpatients. Hospitalization should be provided and iv antibiotics should be preferred in patients with fever, increased pain intensity, and leukocytosis who are not suitable for outpatient treatment. If there is no response in clinical findings within 48–72 hours, the patient should be further examined and additional pathology and complications should be investigated with imaging methods. IBD, other colitis or cancer should be ruled out with a control colonoscopic examination 4–6 weeks after the resolution of the acute picture [38].

After acute uncomplicated diverticulum attacks, 33% have a recurrent attack, but most of them are treated without hospitalization [11, 39]. About 1% of patients with recurrent attacks require surgery. In the past, elective surgery was recommended to avoid complications due to recurrences. Today, it is advocated that surgery should be decided according to the patient and comorbid conditions. This is also true in young patients. In the past, elective surgery was recommended in young (<50 years) patients after the first attack even if they were not complicated, but current guidelines do not recommend resection in young (<50 years) patients based on age.

The aim of elective surgery is to remove the affected diseased segment of the colon and anastamosis of the remaining bowel segments [40]. When the sigmoid colon is resected, if the distal part of the sigmoid colon remains, resection should be performed proximal to the rectum because of the risk of recurrence. In addition, if malignancy cannot be ruled out or the patient is immunosuppressed, surgery is indicated [15].

3.4.2.2 Complicated diverticulitis

Complicated diverticulitis includes abscess, obstruction, generalized peritonitis due to perforation or fistula of the diverticulum with adjacent organs [1].

Diverticulum-related abscesses present as pelvic or pericolic abscesses. Abscesses <2 cm are treated with parenteral antibiotics, while larger abscesses are treated with CT-guided percutaneous drainage and antibiotics (**Figure 4**). Failure to respond to percutaneous drainage and antibiotic treatment requires urgent surgical intervention [37, 41].

Kaiser et al. modified Hinchey classification that is used to determine the treatment of complicated diverticulitis due to abscess in 2005 (**Table 1**) [42].

Hinchey 1–2 is treated with percutaneous drainage and antibiotics if possible and primary anastamosis if the emergency situation becomes elective. Elective preoperative colonoscopic evaluation is important. Hinchey 3–4 requires emergency surgery

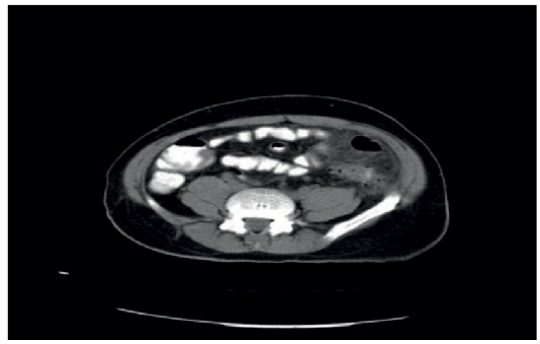

Figure 4.
An abscess due to diverticulitis.

Stage	Modified Hincey	Hincey
Stage 0	Mild clinical diverticulitis	—
Stage 1a	Confined pericolic inflammation—phlegmon	—
Stage 1b	Confined percolic abscess	—
Stage 1	*(See above)*	Colonic inflammation and pericolic abscess
Stage 2	Pelvic, distant abdominal, or retroperitoneal abscess	Colonic inflammation and retroperitoneal or pelvic abscess
Stage 3	Generalized purulent peritonitis	Generalized purulent peritonitis
Stage 4	Fecal peritonitis	Generalized fecal peritonitis
Fistula	Colo-vesical/–enteric/–vaginal/–cutaneous	—
Obstruction	Large and/or small bowel obstruction	—

Table 1.
Classification of Hincey and modified Hincey stages.

as it presents with generalized peritonitis. Resection of the diseased segment and Hartman colostomy is recommended. In recent studies, resection anastamosis and diversion ileostomy decrease patient mortality if the patient is suitable [43, 44]. According to some opinions, laparoscopic lavage and placing a drain near the perforated area, which is thought to be the focus of peritonitis, may be one of the treatment methods in Hinchey 3 patients. This method protects the patient from emergency surgery with high morbidity.

Obstruction due to diverticulum is rare and usually heals with stricture. Treatment of partial obstruction due to diverticulum includes nasogastric decompression, fluid resuscitation, low volume water, or Gastrografin enemas. Elective surgery is possible if obstruction regresses. High-volume, oral bowel preparation is contraindicated in obstructive conditions. Emergency surgery and colectomy with primary anastamosis and diversion stoma are recommended if obstruction does not regress [44, 45].

Fistula develops between the colon and surrounding organs in 5% of complicated diverticula. Colovesical fistula is the most common. Colovaginal, coloenteric, and rarely colocutaneous fistulas are also seen [6, 36]. Frequent urinary tract infection and fecaluria may be observed in patients presenting with colovesical fistula. Air

seen in the bladder on CT is useful in making the diagnosis. In a diverticulum patient presenting with fistula, malignancy, crohn's disease, and radiation-induced fistula should be excluded and colonoscopic examination is recommended [46]. In patients who have received radiotherapy due to malignancy, fistula is considered as cancer recurrence until proven otherwise. CT and small bowel imaging can be used to determine the anatomy of the fistula. Once the anatomy of the fistula is determined, the segment including the fistula tract is treated with colectomy and repair of the affected organ [47].

3.4.3 Giant colonic diverticula

Giant colonic diverticula are rare and mostly on the antimesenteric aspect of the sigmoid colon [48]. It is important to note that giant colonic diverticula are distinct pathologic entities, and there have been reported cases of only 113 in the literature [49]. Direct radiography supports the diagnosis and barium enema is diagnostic. Complications include obstruction, perforation, and volvulus. Resection of the diseased colon and diverticula is recommended for treatment.

3.4.4 Right colon diverticula

Right colon diverticula are rare and usually asymptomatic. They usually present with right lower quadrant pain and appendicitis and are usually diagnosed intraoperatively [50]. Unlike left colon diverticula, it occurs in young patients [51]. If there is a single, large, and minimal inflammation, excision of the diverticulum can be performed; however, ileocecal resection is preferred. Bleeding is rare and management is the same as for left colonic diverticulum [52].

4. Conclusions

In this chapter, we have explored various aspects of diverticular disease, encompassing its epidemiology, etiology, pathology, and different types of diverticula in various organs of the gastrointestinal system. Diverticular disease is a complex condition with multifactorial origins, and its understanding has evolved over the years. Here, we summarize the key points discussed in this chapter.

Diverticular disease is becoming increasingly prevalent, particularly among older age groups, and its pathogenesis involves various factors such as structural abnormalities of the colonic wall, disordered intestinal motility, dietary habits, and genetic predisposition. The disease presents itself in different organs of the gastrointestinal tract, each with its own clinical manifestations and management considerations.

Duodenal diverticula, while often asymptomatic, can lead to complications such as obstruction, bleeding, and pancreatitis. Treatment options depend on the severity of symptoms and complications, with endoscopic or surgical excision being the primary approaches.

Small intestine diverticula, including Meckel's diverticulum, are less common but can cause symptoms such as abdominal pain, nausea, and diarrhea. Surgical intervention may be required for symptomatic cases or complications such as bleeding, obstruction, or perforation.

Colonic diverticular disease is the most common form and can lead to a range of symptoms, including diverticulosis coli, diverticulitis, and diverticular bleeding.

Management varies based on the presentation, with conservative approaches for uncomplicated cases and surgery for complicated diverticulitis, abscesses, or fistulas.

While this chapter provides a comprehensive overview of diverticular disease, it is essential to recognize that ongoing research and clinical guidelines continue to shape the understanding and management of this condition. Advances in diagnostic techniques, treatment strategies, and patient selection for surgery highlight the evolving landscape of diverticular disease.

In conclusion, diverticular disease represents a multifaceted gastrointestinal condition that demands a tailored approach for diagnosis and management. Clinicians must stay abreast of the latest developments in the field to provide the best care for patients with diverticular disease, ensuring that treatments are aligned with individual needs and risk factors. Continued research efforts and collaborative endeavors will further enhance our understanding of this complex disease and refine its management strategies in the future. It is preferable to include a Conclusion(s) section that will summarize the content of the book chapter.

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Conflict of interest

The authors declare no conflict of interest.

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Chapter 3

Bowel Diverticulosis

Badie Batti and Waseem Mohammad

Abstract

Colonic diverticulosis is the presence of outpouchings of the intestinal walls in the colon. It remains without symptoms in most individuals, but about 25% of individuals will develop symptoms of diverticulosis at some point in time, and this is termed as colonic diverticular disease. The severity of this illness is variable and ranges from symptomatic uncomplicated diverticular disease (SUDD) to symptomatic disease with complications such as inflammation of these outpouchings or occasional bleeding. The diagnosis of diverticular disease depends mainly on radiological studies, such as computed tomography (CT) abdomen pelvis and magnetic resonance imaging (MRI) scan. The management is a multilevel approach that focuses on lifestyle modifications and pharmacotherapies to provide symptomatic relief and reduce progression risks into complicated diseases. Rarely, endoscopic interventions may be needed in some complicated cases.

Keywords: diverticulosis, colonoscopy, diverticulitis, computerized tomographic scan, irritable bowel syndrome, pseudodiverticula

1. Introduction

Diverticulosis is a prevalent gastrointestinal disorder characterized by the development of small pouches, called diverticula, in the colon's lining.

These pouches typically develop in areas of the colon that are considered weak and most susceptible to intraluminal pressure such as where bleed vessels penetrate the muscular layer of the colon wall.

While many individuals with diverticulosis remain with no symptoms, complications such as diverticulitis, inflammation, or infection of the diverticula can occur.

This comprehensive review explores the epidemiology, risk factors, pathogenesis, diagnosis, management, and potential complications of diverticulosis.

2. Epidemiology and risk factors

Diverticulosis is common, with its prevalence increasing with age. In Western countries including Western Europe, United States, and Australia, it affects approximately 35% of individuals over the age of 50. The incidence is noted to be lower in Asian and African populations, but it has been rising in recent years

as well. Diverticulosis is more common in industrialized or developed countries, and this may be due to dietary and lifestyle factors. It is also worth noting that the incidence of diverticulosis, generally speaking, is higher in the left side of the colon in Western countries as compared to the right side in Asian countries, and this skewed distribution is probably related to differences in colonic anatomy and physiology [1].

Several factors contribute to the development of diverticulosis, including age, genetics, and lifestyle choices.

Studies have shown that advancing age is strongly associated with an increased risk. Bowel diverticulosis exhibits a substantial prevalence, with a notable increase in occurrence among older individuals. A study in 2020 [2] reported a prevalence of approximately 42% among individuals aged 40–59 years and an increased prevalence of 80% among those aged 60 years and above in the United States.

Other risk factors include a low-fiber diet, obesity, sedentary lifestyle, smoking, and the use of nonsteroidal anti-inflammatory drugs (NSAIDs).

Regarding dietary factors, it has been found that a diet low in fiber and high in red meat and processed foods increases the risk of developing diverticular disease [3]. Conversely, higher intake of dietary fiber, particularly from fruits and vegetables, has been associated with a reduced risk of diverticulosis.

Studies have also shown that environmental factors in lifestyle and diet interact with genetic factors in predisposed individuals to contribute to the overall risk of developing the disease.

Research on the genetic predisposition to diverticulosis is still evolving, but recent studies have provided insights into potential genetic influences. Specific genetic variants associated with diverticulosis susceptibility have been identified, suggesting a role for genetic factors in the development of this condition [4].

3. Pathogenesis

The exact cause of diverticulosis is not fully understood, but it is believed to be multifactorial. The condition usually arises from a combination of structural, mechanical, and dietary factors that affect the integrity of the bowel wall.

The primary factor is thought to be increased colonic pressure due to a low-fiber diet, leading to muscular hypertrophy and weakness in the colon wall. This increased intraluminal pressure exerted during periods of constipation or straining prior to bowel movements causes the formation of pouches at sites of structural weakness, typically where blood vessels penetrate the muscular layer of colonic wall (**Figure 1**). In the diverticulosis of descending colon, the mucosa and submucosa protrude away from the colonic lumen forming ("pseudo-diverticula"), while in the diverticulosis of the ascending colon, all colonic layers protrude forming ("real diverticula") [5].

The role of the microbiota in diverticulosis and diverticular disease is unknown at this time as there is no proven evidence of microbial imbalance in colonic diverticula to suggest that the microbiota contributes to the pathogenesis of asymptomatic diverticulosis, symptomatic uncomplicated diverticular disease, or complicated diverticular disease [6].

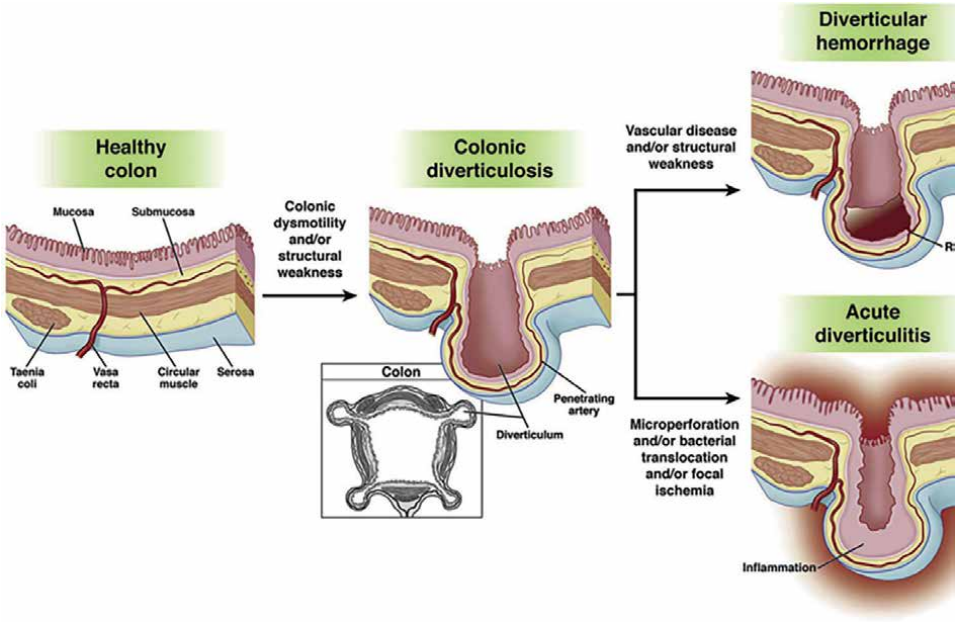


Figure 1.
Colonic diverticula form when mucosa and submucosa herniate through the envelope that surrounds the vasa recta. Diverticular hemorrhage is arterial bleeding into an uninflamed diverticulum. Acute diverticulitis is complicated diverticula by inflammation.

4. Classification of diverticular disorders

The classification of diverticulosis of the bowel is based on the presence of symptoms. In symptomatic illness, it is further subclassified based on the type of complication associated with that illness (**Figure 2**) and as follows.

4.1 Asymptomatic diverticulosis

This is often found incidentally in those undergoing certain radiological studies for other reasons [7]. However, no medical treatments or interventions are necessary here, and no additional follow-up is needed as there are unclear benefits.

4.2 Acute and chronic diverticulitis

This type of Inflammatory complication may present acutely or chronically in up to 25% of individuals with preexistent diverticulosis. The pathophysiology involves obstruction of the diverticular sac by feces, causing mucosal irritation leading to inflammation, edema, congestion, and further obstruction. Diverticulitis may be subclassified into complicated and uncomplicated. These complications include fistulas, abscesses, bowel obstruction and/or perforation of the gut. An important consideration in managing diverticulitis is the hospitalization decisions. The factors incorporated here include failure of clinical improvement and tolerating oral intake, certain comorbidities like heart failure or immunosuppression status, and the mentioned complications.

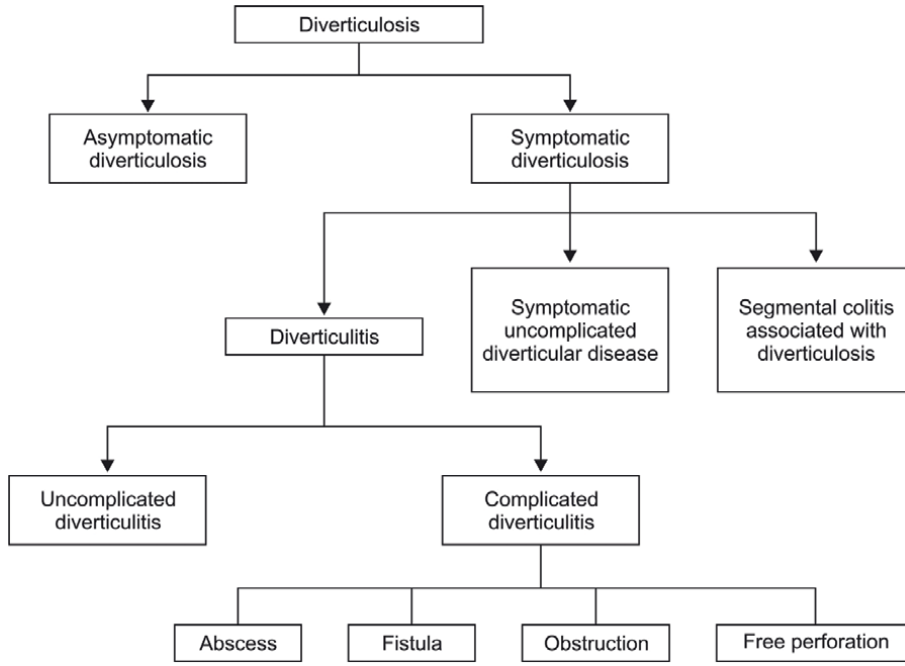


Figure 2.
Classification of diverticulosis spectrum disorders.

4.3 Symptomatic uncomplicated diverticular disease

This is basically presenting as chronic mild abdominal pain with no inflammation-related signs or symptoms. There may be an overlap between SUDD and irritable bowel syndrome (IBS) [8]. It is still unclear whether these two disorders are under the same spectrum representing different severities or are they different as both present similarly chronic episodic abdominal pain that seems more functional in origin with IBS rather than structural in SUDD.

4.4 Segmental colitis associated with diverticulosis

It is worth noting that this one does not necessarily involve the diverticula so there is some segmental involvement and some sparing of adjacent segments.

5. Diagnosis of diverticulosis and diverticulitis

Diagnosing diverticulosis involves a comprehensive assessment, including medical history, physical examination, and diagnostic tests. Imaging modalities such as computed tomography (CT) scans and barium enemas help identify diverticula and assess their complications (**Figure 3**).

Other than the presenting symptoms, the medical history should focus on the individual risk factors for gastrointestinal diseases. The age of the patient, along with social and dietary histories, are more relevant here. During the physical examination, physicians may look for signs of rectal bleeding.

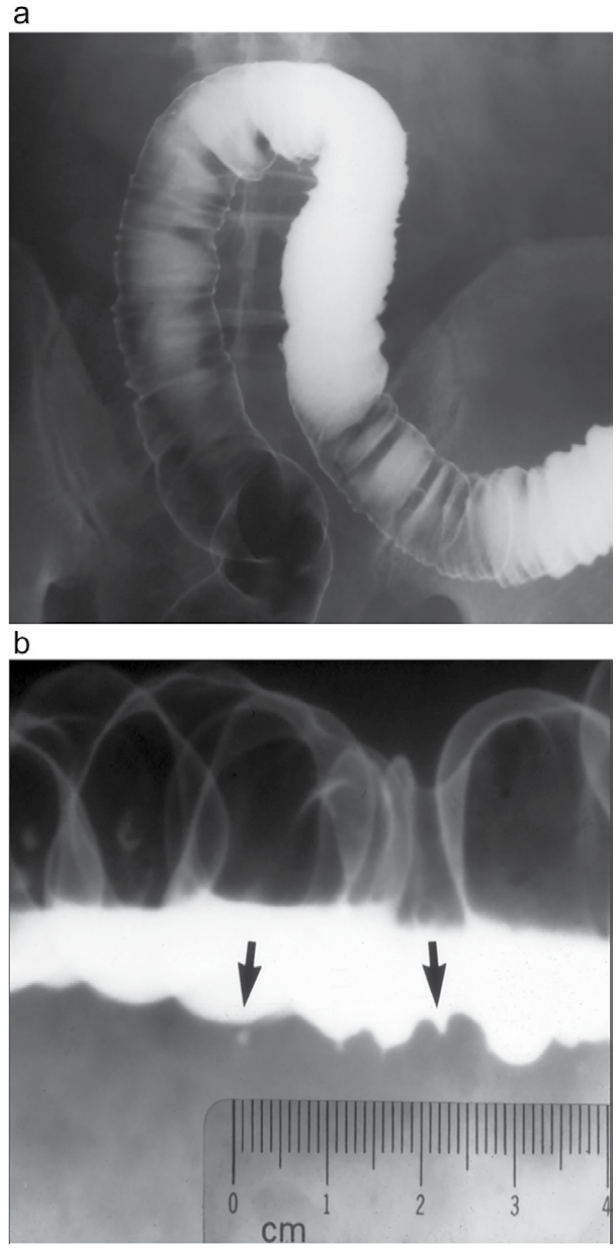


Figure 3.
Radiological appearance of early intramural diverticulosis in a 52-year-old man. A. Barium enema examination shows the serrated margins of the sigmoid loop caused by thorn-like mucosal protrusions into the wall. B. Magnified radiograph of the descending colon demonstrates several 1–2 mm diverticula (arrows). Source: [10].

Colonoscopy allows direct visualization of diverticula and the detection of other lesions that are not uncommon to be seen simultaneously.

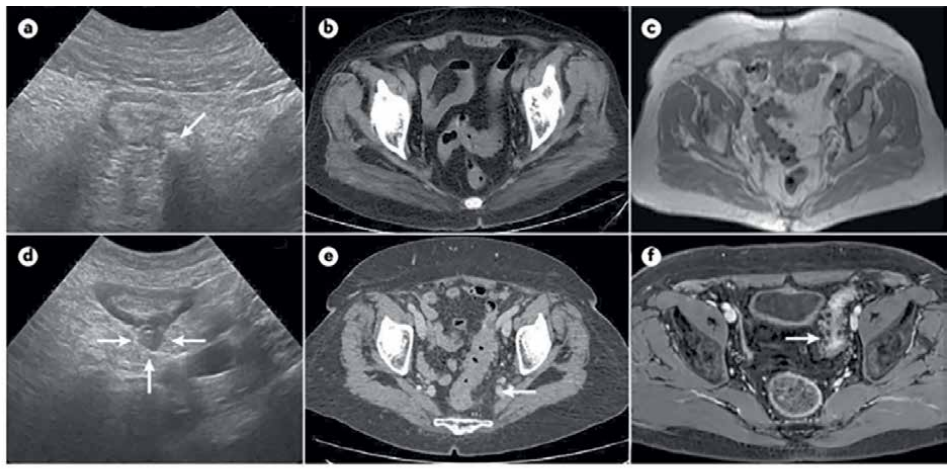
There are emerging technologies for the diagnosis of diverticulosis, and these may include virtual colonoscopy, also known as computed tomography colonography (CTC). This noninvasive imaging technique uses CT to create a 3D reconstruction of the colon. It offers advantages such as reduced invasiveness, no need for sedation, and

shorter procedure time. CTC has shown promise in detecting diverticula and associated complications [9]. Another technology is wireless capsule endoscopy, which involves swallowing a small camera capsule that captures images as it traverses the digestive tract. Although primarily used for small bowel evaluation, recent studies have explored its potential application for assessing the colon, including the detection of diverticula. Further research is needed to establish its diagnostic utility in diverticulosis. The last one is the use of Biomarkers [10] and Genetic Testing; research is underway to identify potential biomarkers and genetic markers associated with diverticulosis. These markers may aid in early detection, risk stratification, and personalized management of the condition. While still in the early stages, these emerging technologies hold promise for future diagnostic advancements.

For acute diverticulitis, there is acute left lower quadrant abdominal pain, fever, and usually leukocytosis in almost all cases. CT scan findings can also be suggestive but should not be given top priority over the clinical picture in making a diagnosis (**Figure 4**).

Ultrasound may be used as an initial tool for those who want to avoid radiation; however, American College of Physicians suggests that clinicians use abdominal CT scans when there is reasonable suspicion of diverticulitis, and this is considered low-certainty evidence [11].

Magnetic resonance imaging (MRI) is a nonionizing imaging alternative to CT that can be considered for diagnosis of diverticulitis, especially in pregnant women



| Cross-sectional imaging of diverticulosis and diverticular disease. Colonic diverticulosis can be clearly visualized using ultrasonography (part a), CT (part b) and MRI (part c). On ultrasonography , the absence of pericolonic involvement (namely absence of thickening of the diverticular wall and absence of involvement of pericolic fat) is indicative of a lack of inflammation (part a, transverse section of the sigmoid colon characterized by a thickened muscularis propria, with a diverticulum appearing as a hyperechoic lesion (arrow) with a posterior hypoechoic halo). Ultrasonography can also be very useful in detecting acute inflammation of diverticula (part d, transverse section of the sigmoid colon characterized by a thickened muscularis propria, with an inflamed diverticulum appearing as a hypoechoic protrusion (arrows) surrounded by hyperechoic mesenteric tissue). CT can reveal thickening of the diverticular wall with inflammation of the pericolonic fat (so-called fat stranding; part e, arrow), and MRI can also show diverticular inflammation (part f, arrow). Images in parts a and d courtesy of G. Maconi, University of Milan, Italy. Images in parts b, c, e and f courtesy of M. Maiorano, L. Bonomo Hospital, Italy.

Figure 4.
As above, note comparison of three different modalities of imaging including ultrasonography, computerized tomography, and magnetic resonance imaging scans.

and those who refuse CT scans; however, it has its own limitations as well such as the presence of metals implants in joints, inner ears that makes it risky to use and there are financial limitations.

There are no current indications for colonoscopy in acute diverticulitis. However, it should be performed in most patients after acute diverticulitis episode resolution for reasons that may include ruling out colonic neoplasms.

6. The management of diverticulosis and complications

General Guidelines

1. Dietary Modifications:

Increasing dietary fiber intake is crucial for managing diverticulosis. Fiber adds bulk to stool, promotes regular bowel movements, and reduces the risk of diverticula becoming inflamed. Whole grains, fruits, vegetables, and legumes are excellent sources of fiber. Maintaining adequate hydration is often advised for optimal bowel function and stool consistency.

2. Lifestyle Modifications:

Engaging in regular physical activity helps maintain bowel regularity and reduces the risk of complications. Maintaining a healthy weight is crucial, as obesity has been associated with an increased risk of diverticulosis.

3. Pharmacotherapy:

Bulk-forming agents: Fiber supplements such as psyllium can increase stool bulk and ease bowel movements but are associated with side effects like bloating and flatulence. Antispasmodics like dicyclomine may be prescribed to relieve abdominal cramping and discomfort associated with diverticulosis.

On the other hand, there are medications to avoid. The American Gastroenterology Association guidelines recommend avoiding nonaspirin NSAIDs (but not avoiding therapeutic aspirin) in patients after acute diverticulitis; however, it is a very low quality of evidence, given that it is derived from observational data [12].

The newest American Gastroenterology Association (AGA) guidelines suggest against the use of rifaximin as an agent to reduce diverticulitis recurrence as there is no scientific proof of its efficacy, and the same applies to mesalamine.

Recurrent diverticulitis can cause changes in microbial contents of the bowels, but relevant data is still lacking at this time. A meta-analysis conducted by Lahner et al. [13] examined 11 studies in which some probiotics were used in the treatment of symptomatic diverticular disease. Upon examination of an overall pool of 764 patients, there seems to be some drop in the frequency of abdominal symptoms with some Lactobacilli use. Data on preventive roles are still lacking; however, the 2015 AGA guidelines recommend against the use of probiotics after diverticulitis episodes.

Management of Complications:

1. Diverticular bleeding

Colonic diverticular disease sometimes presents with bleeding, which is the most common cause of lower gastrointestinal bleeding (LGIB), colonoscopy is done here to identify bleeding locations and to do onsite hemostasis.

Unfortunately, the bleeding detection rate is relatively low, and access to the bleeding sites is not always achievable. In patients with suspected diverticular bleeding, colonoscopy is generally indicated: (a) Electively, when bleeding has stopped spontaneously. This approach also rules out vascular ectasia or colonic neoplasia. (b) As an urgent intervention in treating diverticular bleeding. (c) As a last resort in patients with recurrent episodes of LGIB, computerized tomography angiography was nondiagnostic.

When endoscopic methods fail to control bleeding or in cases of severe hemorrhage, surgical interventions play a role in managing diverticular bleeding, and these surgical approaches include segmental resection, which involves the removal of the affected portion of the colon, which includes the diverticula responsible for the bleeding. This procedure aims to eliminate the source of bleeding and prevent future episodes. The remaining healthy ends of the colon are then reconnected [14]. Another approach is Hartmann's Procedure, which involves the removal of the affected portion of the colon, creating an end colostomy, and closing the rectal stump. In a subsequent surgery, the colostomy can be reversed [15]. Another approach is Angiographic Embolization, which is a minimally invasive technique that involves the insertion of a catheter into the blood vessels supplying the bleeding diverticula. Through the catheter, embolic agents, such as coils or particles, are delivered to occlude the vessels and stop the bleeding [16]. Angiographic embolization can be an effective alternative to surgery, particularly in cases where the patient is not a suitable candidate for surgery or when a less invasive approach is desired. An adjustment of the latter technique is transarterial embolization, which involves the delivery of embolic agents to the bleeding vessels. This technique specifically targets the branches of the superior mesenteric artery that supply the bleeding diverticula [17].

2. Diverticulitis:

Mild cases can often be managed with rest, a clear liquid diet, and oral antibiotics covering anaerobes and gram-negative rods, such as ciprofloxacin and metronidazole or amoxicillin clavulanic acid continued for seven to 10 days is the usual treatment.

Patients are expected to improve within 48 to 72 hours, at which time the diet may be advanced cautiously.

Severe cases defined by picture of sepsis, immunocompromised or elderly patients above 65-year-old or those with significant comorbidities will need hospitalization, intravenous antibiotics like metronidazole or clindamycin, and third-generation cephalosporins like ceftriaxone, and in some cases, surgical intervention may be necessary to treat complicated diverticulitis or recurrent episodes.

3. Abscesses and Perforation:

In situations when fever, leukocytosis, or both persist despite use of antibiotic trial then a peri-diverticular abscess should be suspected, and an abdominal exam may or may not show a palpable tender mass; then comes the CT scan findings suggesting a collection or collections.

In such situations, percutaneous drainage guided by imaging like CT scan is the primary treatment for abscesses associated with diverticulitis, and this procedure is indicated mainly for abscesses that may have enteric communication, more than

3 cm in size, multi-loculated in nature, especially in those who fail initial medical treatment [18].

Colonic perforation is rare; however, if it happens, it is usually followed by peritonitis and unfortunately, carries a considerably high mortality rate, as high as 35 percent, and requires surgical urgency. Surgical interventions with a partial colectomy may be required to manage perforations and prevent further complications.

4. Obstruction and Fistula Formation:

Colo-vesical fistulas usually need surgical corrections. Fistulas involving the bladder are more common in men; as in women, the uterus is anatomically located between the colon and the bladder.

Patients with this complication present with urinary tract infection, pneumaturia, and fecaluria. Abdomen computed tomography (CT) scan with contrast may show the diverticula in the colonic walls, fistulae tracks, or contrast leaking in the bladder or air in bladder, suggesting this type of complication.

Surgical repair is typically required for fistulas, abnormal connections between the colon and other organs or structures.

Bowel obstruction is generally self-limited and responds to conservative therapy. If persistent, obstruction of the colon can be treated by a variety of endoscopic and surgical techniques. Surgical intervention may be necessary to address bowel obstructions caused by strictures or adhesions resulting from recurrent diverticulitis episodes.

7. Summary and conclusion

Diverticulosis is a prevalent gastrointestinal condition that requires a comprehensive approach to diagnosing, managing, and recognizing potential complications. Understanding the epidemiology, risk factors, pathogenesis, and appropriate management strategies allows for early detection, prevention of complications, and improved patient outcomes. By adopting dietary modifications, lifestyle changes, and prompt medical attention, individuals with diverticulosis can effectively manage their condition and enhance their overall well-being. Those with diverticulitis should be treated medically when indicated and will need regular follow-up care by a designated gastroenterologist to reduce risks of potential future complications and recurrence.

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Conflict of interest

The authors declare no competing conflicts of interests in preparing this book chapter.

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Chapter 4

Diverticular Disease in Africans: Myth or Fact?

Nomcebo Myeni and Bongani Mafuleka

Abstract

Diverticulosis coli is an acquired disease of the colon where small outpouchings of the colonic mucosa occur due to mucosal herniation of the colonic wall at sites of vascular perforation. The disease is very common in developed countries and its prevalence increases with age. Risk factors for its development include inadequate dietary intake of fiber, abnormal colonic motility, and elevated pressures within the colon. Studies done in the late 1900s showed that this disease was unknown in the African population who are known to consume a lot of fiber in their diet. With urbanization in the African population, the prevalence of this disease has somewhat increased over the years. Just how common is this condition among African people? This chapter will review the literature regarding this condition in Indigenous Africans.

Keywords: diverticular disease, Africans, fiber, diet, colon motility

1. Introduction

Diverticular disease was first described by a French surgeon, Alexis Littre, in the late 1700s. Fleischman, in 1815, described the condition as "divertikel". Cruveillher described the mucosal herniation in the colon found in diverticular disease in 1849. In 1869, Klebs was the first surgeon to link the "divertikel" to constipation. Graser, in 1899, described the first case of diverticulitis and emphasized that diverticulitis resulted in peri-sigmoiditis and perforation [1]. Painter and Burkitt in 1971 published the first paper on diverticular disease among Africans in a Johannesburg hospital in South Africa. During their 20-year tenure of working in a tertiary hospital in Johannesburg, not even one case of diverticular disease was found among the African population.

Since 1971, there have been a number of reports from the African countries documenting cases of diverticular disease among native Africans. This chapter will explore the published data on diverticular disease arising from Africa. There has been a shift in the socio-economic climate in African countries whereby more and more native Africans are now having better jobs. There is a growing number of them in the middle-income group and they are now more urbanized. With urbanization, a lot more of them have adopted the Western diet.

The exact incidence of diverticular disease in Africans is unknown. However, an increase in the number of cases in Africa could also be due to more awareness of the disease. Lack of resources in Africa does play a role in being a limiting factor to the investigation of patients presenting with symptoms of diverticular disease, hence it is highly possible that the numbers may be slightly higher than reported.

2. Classification

2.1 Asymptomatic

In the Western population, 80-85% of patients with colonic diverticulosis are asymptomatic. Most of these patients are diagnosed as an incidental finding on colonoscopy or imaging when being investigated for other indications.

2.2 Symptomatic

15–20% of symptomatic patients can present symptomatic uncomplicated diverticulitis or diverticulitis with/without complications.

History taking is important in differentiating these phenotypes and identifying risks of diverticular disease. Symptoms of symptomatic uncomplicated diverticular disease include recurrent abdominal pain, bloating, and altered bowel habits. In addition, acute diverticulitis presents with low-grade fever, left lower quadrant tenderness (Sigmoid colon), possibly palpable mass, and rarely hematochezia. Acute abdomen indicates possibly complicated diverticulitis with perforation and peritonitis.

Clinical evaluation also includes identifying risk factors. Non-modifiable risk factors include age, sex, and genetics. The prevalence of diverticular disease is particularly high in individuals >65 years of age, although the occurrence is currently increasing in people <40 years of age. Increased life expectancy explains the increasing prevalence in non-Western countries, which were previously considered as low risk for diverticular disease. Modifiable risk factors include diet, lifestyle, and pharmacological factors. A low fiber diet has been regarded as a significant risk factor. It results in increased intraluminal pressure and formation of diverticula. Countries with high fiber diets, like Africa and Asia, have lower incidence of diverticular disease, as compared to Western countries. Other risk factors should be considered: Obesity, physical inactivity, alcohol consumption, and prolonged use of NSAIDs and steroids are associated with increased risk of diverticular disease (DD).

3. Diverticular disease in Africa

3.1 Prevalence

There is a paucity of studies done in Africa on diverticular disease, as it is an uncommon condition. Due to this fact, the exact incidence is unknown. There have been few studies done in South Africa, Nigeria, Kenya, and Uganda. These studies have been done mainly in referral (tertiary) hospitals. They all seem to show an increase in the prevalence of this condition in Africa over the past 40 years. Painter and Burkitt [1] published the first paper on diverticular disease in Africa, where they

described the fact that there is a close relationship between the incidence of diverticular disease and economic development. Secondly, they alluded to the fact that it would take about 40 years for diverticular disease to develop even after the colon's environment has been changed. Hence, diverticular disease would not be expected to be seen until that community had departed from their traditional eating habits for approximately 40 years.

Archampong et al. [2] published a study in Ghana, in 1978, of 14 patients diagnosed with diverticular disease in a period of 3 years. The patients were from an urban area in Ghana and presented with features of diverticulitis. The commonest presenting symptom was rectal bleeding. However, the authors described that even though their patients were upper class, their diet had not changed. They still consumed a traditional high-fiber, low-calorie diet.

Calder et al. [3] found 20 cases of diverticular disease over 1 year in Kenya in 1980. He noted that even though the Kenyan subjects were seen to be consuming more refined maize and sugars, their diet was still high in fiber as compared to their Western counterparts.

Segal et al. found 42 cases of diverticular disease over a period of 3 years in Baragwanath Hospital, Johannesburg, South Africa. The patients were from an urban population. The main presenting symptoms were rectal bleeding, abdominal mass, or pain. The average age was 62 years; 16 were men and 26 were women. The mean daily dietary fiber intake of African subjects was 26.5 ± 8.5 g, as compared to the Indigenous White subjects, which was 22.4 ± 6.0 g.

Madiba and Mokoena [4] reported 26 cases of diverticular disease over a period of 5 years in an urban hospital in Durban, South Africa. The commonest presenting symptom was rectal bleeding, and 77% of the diverticulae were left sided. Of note, the study was published in 1994, which was the year when South Africans were all allowed to vote, elected the first democratic government, and there was a definite shift in the socio-economic climate of that country. Urbanization greatly increased as more Black people became affluent as compared to 10 years ago.

Kiguli-Malwadde et al. [5] published a study in 2002 in Uganda, a retrospective and prospective study conducted over 5 years. They found 31 cases of diverticular disease. All the patients were over 40 years of age and consumed a mixed diet, both high and low residue. The commonest presenting symptoms were rectal bleeding, abdominal mass, or pain.

Alatise [6] found 40 cases of diverticular disease over a period of 5 years in Nigeria. The median age of the patients was 64 years. 72.5% of the patients were male and 27.5% were female. The most common symptoms were rectal bleeding, abdominal pain, or mass. All the patients were placed on a high-fiber diet, antibiotics, Ciprofloxacin. and metronidazole. Five patients had a recurrence within 6 months of follow-up, and one required emergency colectomy.

Oluyemi [7] found 28 cases of diverticular disease over a 5-year period in Nigeria. This group also found a higher percentage of males with diverticular disease as compared to females. The most common presentation was rectal bleeding.

Vally et al. [8] found 47 cases of diverticular disease over a period of one year in South Africa in 2017. One can certainly appreciate the rising incidence in Africa from 1971 where no cases were found over a period of 20 years until 2017 when 47 cases were found in a period of only 1 year. The studies by Painter and Vally were conducted in the same province in South Africa. One can appreciate that possibly more awareness of the disease exists now, compared to 50 years ago.

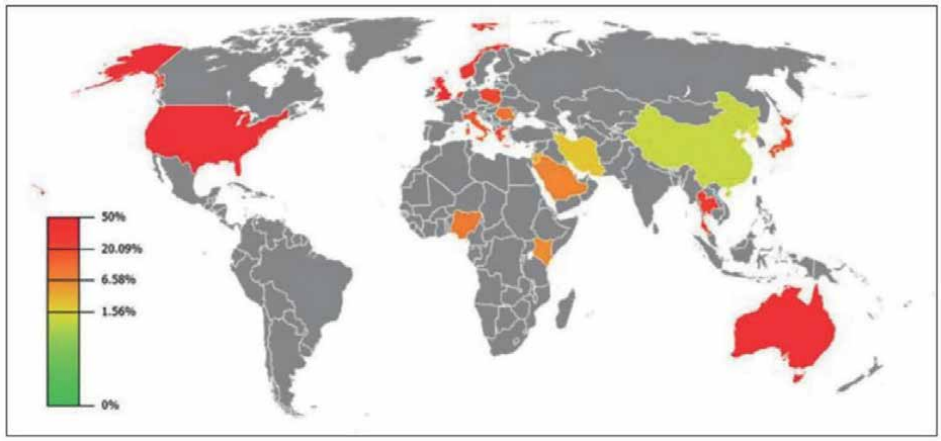

Figure 1.
World map showing incidence of diverticular disease. Source: Violi et al. [10].

A study done by Golder et al. [9] showed that the risk of diverticular disease in Black Africans was higher than that of their Indigenous counterparts, even if one accounts for an increase in the prevalence of diverticular disease following urbanization in Africa.

Figure 1 shows the world map and the distribution of diverticular disease. One can appreciate that more cases are found in countries like the United States and Australia. In Africa, there are fewer cases that are also found in fewer countries across the continent.

4. Location of the diverticulae in Africans

There seems to be a discrepancy regarding the location of diverticulae in Africans. Some studies show a Pancolonic distribution [6, 11]. Ihekwaba [9, 12] and Golder found a predominance of right-sided diverticular disease. Kiguli [5] found that the majority of the diverticulae were found on the left colon. **Table 1** is taken from the

Complete exploration	Group AC with complete exploration N = 106	Group E with complete exploration N = 31	OR (95% CI)	p-value
Pancolonic DD	78 (73.6)	11(35.5)	5.06 (2.15–11.88)	0.0002
Right-side DD*	9 (8.5)	1 (3.2)	9 (1.03–78.17)	0.03
Left-side DD*	10 (9.4)	18 (58.1)	0.06 (0.01–0.32)	0.0002
Bipolar left and right-side DD**	9 (8.5)	1 (3.2)	9 (1.03–78.17)	0.03

*Group AC, African Caribbean; group E, European; DD, diverticular disease. Qualitative values are expressed as n, %. *without diverticula in controlateral side. **without diverticula in transverse colon.*

Table 1.
Complete exploration of the colon in African Caribbean and European patients.

study by Gelu-Simeon [13] where they compared the distribution of diverticular disease in African Caribbean versus European.

5. Risk factors for diverticular disease

5.1 Diet

Dietary deficiency of fiber is a risk factor for diverticular disease. Painter and Burkitt [1] described diverticular disease as a deficiency disease of Western civilization. Indeed, diverticular disease is more common in Western countries like America, Australia, and Europe. Africans have been known to consume a high-fiber and low-calorie diet for centuries, this has been shown to have a "protective" effect against colonic diseases such as diverticular disease as well as colorectal carcinoma. Due to the high fiber in the African diet, the disease has been largely uncommon in Africans. Data has been largely lacking in Africa, regarding the quantity of fiber in the African diet. Urbanization, especially of Native Africans, has resulted in "westernization" of their diet. Kiguli-Malwadde [5] found that their study subjects ate a mixed type of diet that is both low and high-residue food.

Studies done in Africa show conflicting data as to whether diet is the main protective factor against diverticular disease, with some studies like Kiguli [5] showing that despite their patients still consuming a high-fiber diet, they still developed diverticular disease. Other studies show an increase in diverticular disease in patients who had adopted a Western diet. This conflict in data may suggest that there are more factors at play, which may contribute to diverticular disease, e.g., genetics. More data is needed in Africa. A prospective study was done in South Africa by Golder et al. [13] looking at changes in diet between rural men and women versus urban men and women over a period of 5 years. Their findings were as follows:

5.1.1 Beneficial and detrimental changes in food intake

The results of the analysis of changes in foods eaten clearly showed some beneficial effects over the 5 years (more vegetables and fruit, milk and milk products, fish, and foods from animal sources), which will all contribute to improved micronutrient intakes. Unfortunately, these changes were small and did not allow the majority of participants to reach the recommended intakes of vegetables, fruits, and milk and milk products. Furthermore, some detrimental changes were observed, especially an increase in added sugar intake, mainly in the form of sugar-sweetened beverages, increased consumption of beer by women, and increased intakes of processed meat, savory snacks, and hard margarine (and therefore a higher saturated fat intake), illustrating an emergence of processed foods in the diet, which is of concern. More and more global dietary and food recommendations mention the need for home-prepared meals from fresh ingredients because of the high energy content of processed foods and their links to obesity.

There was no evidence of "new" foods eaten in 2010, and the "top ten" consumed foods remained unchanged from 2005 to 2010. Examples of these include white-flesh fruit eaten by 77.6% of rural women in 2005 and by 88.3% of them in 2010. Similarly, more men consumed products such as milk, eggs, organ meats, processed meats, hard margarine, and cooked starchy vegetables with added fat in 2010 than in 2005.

5.1.2 Dietary staples

The group found a decrease in the intake of cooked maize porridge and bread, which was concerning because of the mandatory fortification of maize meal and bread flour to provide micronutrients. However, the data show that porridges are replaced to a certain extent by micronutrient-rich foods such as vegetables, fruit, milk, and animal-origin foods.

5.2 Age

Diverticular disease is most prevalent in old age and in the distal colon. Watters et al. compared the mechanical properties of the colon between African and European patients in vitro. They found that with old age, the distal colon was weaker and less distensible. Furthermore, they found that the distal colon was narrower, weaker, and less expansile than the proximal colon. These factors and more show that the aged sigmoid colon is predisposed to develop diverticular disease because of its aged features, static mechanical changes, and greater intraluminal pressures. Despite the differences in race and ethnicity, one can appreciate that there's an increase in the prevalence of diverticular disease with increasing age, as demonstrated in **Figure 2** below-, taken from the study done by Watters [14].

Table 2 summarizes the findings of a paper published by Vally [8] in a Johannesburg hospital in South Africa. One can appreciate the sharp increase in number of cases in the age category (60–80 years). In this study, there was a slight female preponderance as compared to the male subjects. This is in contrast to studies done by Oluyemi [8], which showed a higher percentage of the disease in males.

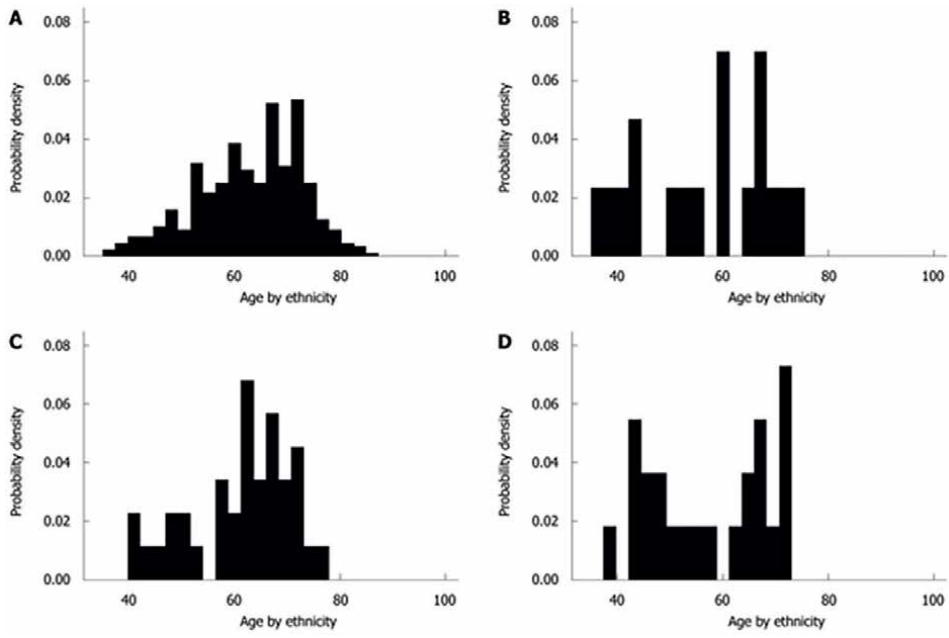

Figure 2.
Age and probability density by ethnicity in patients diagnosed with diverticular disease. A: White; B: Asian; C: Other Black; D: Black African. Source: Golder et al. [9].

Age (years)	N	Male	Female
40–49	1	0	1
50–59	6	3	3
60–69	16	6	10
70–79	15	7	8
80+	4	2	2
Unknown	5	2	3
Total	47	20	27
Youngest	—	50	46
Oldest	—	83	86

Table 2.
Summary of cases per decade. Source: Vally et al. [8].

5.3 Abnormal colonic motility and pressures

Watter [14] also found that Africans had a wider and more distensible distal colon. The Edinburgh group had impaired stretch capacity, which made them prone to developing diverticular disease. Furthermore, Africans have shorter stool transit times and greater stool weights than their European counterparts, according to Painter and Burkitt: The stool transit time takes about 48 hours, and they produce a less viscous stool, which passes out easier compared to a Caucasian's stool. The colonic pressures in the African's gut are lower compared to their European counterparts, hence the African's colon would tend to be less "traberculated" and form less diverticulae. Caucasians may also have a tendency to ignore the call of nature, which will lead to drying out of the stools, greater colonic pressure, and increased tendency to form diverticulae.

6. Discussion

Diverticular disease is a disease that is very common in developed countries like the United States and Australia. The incidence thereof increases with age, especially in the 60–80 years category. Risk factors for diverticular disease include age, diet, abnormal colonic motility, and pressures as well as obesity. In Africa, the exact incidence per country is unknown because there have not been a lot of studies done. The reason for this is that diverticular disease has been rare among the Indigenous People of Africa. However, over the past 40 years, the disease is becoming more common. It is postulated that the increase in incidence of diverticular disease in Africans is due to a change in diet of the native Africans, who traditionally consume a high-fiber diet, but are now consuming a more Western diet. The Western diet, being low-residue and high-protein diet.

The most common clinical presentation noted in the African studies is rectal bleeding followed by abdominal pains. This seems to be on par with studies done elsewhere in the world. There is also not much difference in terms of gender distribution in the subjects. The study by Vally et al. however, found a higher male preponderance as compared to females. They also found the incidence of diverticular disease in

South Africa to be around 13%, which is more or less the same as that in other parts of Africa, OLuyemi, and Alatise (Nigeria). One can appreciate that the incidence of diverticular disease in Africans is on the increase, however, it is important to note that these studies were conducted in tertiary hospitals, hence there is probably some bias as well.

Furthermore, the studies were conducted in urban areas, and due to urbanization and improved socio-econimic status of Indigenous Africans, it is possible that dietary change has a huge factor, which is accounting for the increase in number of diverticular diseases being diagnosed. The authors of the studies did not go in-depth about the amount of fiber consumed. This would be very interesting to know since it is always thought that the Indigenous African diet (high fiber) is protective against diverticular disease. More research is needed to probe deeper into the question of diverticular disease among Indigenous Africans, whether this is still a myth or a common 21st-century problem.

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Chapter 5

The Role of Elective Surgery: Which Patients Should be Selected?

Mónica Sampaio and Marisa D. Santos

Abstract

Although the incidence of acute diverticulitis (AD) has risen over the past few decades, particularly in younger patients, the rate of emergency surgery has been dropping due to a major paradigm shift toward more conservative management approaches. The long-term management strategy after successful nonoperative treatment of AD remains unclear, and indications for elective resection are a matter of ongoing debate. Most modern professional guidelines advise considering elective surgery in an individualized approach, particularly after recovery of acute complicated diverticulitis (ACD) with abscess and in patients with recurrence, persisting symptoms, and complications such as abscess, fistula, and stenosis, focusing on the patient's quality of life, where recurrence, severity, and symptoms are major determinants. However, guidelines are still not clearly standardized for appropriate decision-making, with patients being managed very differently from institution to institution, and surgeon to surgeon, mainly due to a lack of risk stratification for recurrence and severity that have been the scope of numerous studies but still need to be clarified. In this chapter, we explore the current surgical indications for AD, considering this disease's ongoing prognostic factors, for proper decision-making.

Keywords: diverticulitis, severity, recurrence, elective surgery, prognostic factors, risk factors, prediction

1. Introduction

Although the incidence of acute diverticulitis (AD) has risen over the past few decades, particularly in younger patients, with 1/5 of them under 50 years old [1], the rate of emergency surgery has been dropping due to a major paradigm shift toward more conservative management approaches [2–4]. Evolving data on the natural history of AD has led to increased nonoperative management of the acute episode and long-term expectant strategy [2–5]. Still, the long-term management strategy after successful nonoperative treatment of AD remains unclear and indications for elective resection are a matter of ongoing debate. Historically, the goal of elective surgery for the long-term management of AD was the treatment of complications like fistula or stenosis, preventing recurrence, namely complicated recurrence, and avoiding the morbidity risk associated with emergency surgery or an eventual stoma. In this order, surgery was advised for the management of fistula or stenosis, after a second episode of acute uncomplicated diverticulitis (AUD), after a solitary episode of acute

complicated diverticulitis (ACD) and considered in younger patients after any attack [6]. However, every aspect of colonic diverticulitis has been examined over the last two decades, challenging long-held beliefs. So, data have emerged contesting prior standards to proceed with elective colectomy to prevent relapse [7, 8].

2. Current evidence on long-term outcomes in recurrence and severity

The first evidence to be noticed was that complications were more likely to present in the first episode, decreasing with the number of recurrences [9, 10], and therefore, interval colectomy in recurrent AUD did not decrease the rate of emergency surgery or morbidity [10–12]. As a result, since 2006, The American Society of Colon and Rectal Surgeons (ACRS) strongly advise that the decision should be individualized in recurrent AUD [13]. In 2014, a systematic review, including 68 studies, reviewed the decision-making data and outcomes of elective surgery from 2000 to 2013 [14]. They reported a low rate of complicated recurrence after recovery of AUD (<5%), and that early-onset age and two or more prior episodes did not rise complications. In addition, current data announced that recurrence is lower than previously thought [15–17]. It is estimated to be around 13–36%, with higher recurrence after each bloat of AUD and a single episode of ACD with abscess [9, 18]. In 2016, Devaraj et al. noticed a 60.5% global recurrence rate in ACD, with a 46% increment in the modified Hinchey grade [19]. Later, in 2020, a systematic review from Lee et al. reported a 25–30% recurrence rate, without a rise of complications, namely with emergency surgery need [20]. More importantly, it has been noted that all risks associated with recurrent ACD significantly decreased after the first year of observation. However, the risk of recurrence increases with the number of previous attacks [17]. In particular, Aquina et al. observed a 66% decrease in all recurrence-associated risks after one year of follow-up [21]. In their study with 5412 patients, the overall recurrence lowered from 27.4% to 12.5%, as the complicated recurrence and need for emergency surgery fell off from 18.6% and 11.4%, to 7.6% and 3%, respectively. Other modern studies reported similar results in long-term follow-up of ACD. Garfinkle et al. reported an overall recurrence of 30.1% after observing 78 patients with a two-year median follow-up, with complications in 9.6%, and emergency surgery in 2.7% [2]. Buchwald et al. observed 107 patients with ACD with a median duration of 110 months and noticed recurrence in 20% of the patients, in a median time of 4 months, raising to 27% in patients with percutaneous abscess drainage, although non-significant [22]. Moreover, You et al. in a RCT with 107 patients with abscess or extraluminal air initially managed conservatively, and an aleatory allocation of 1:3 to elective surgery or observation, found treatment failure in only 15 patients, which again had medical treatment [23]. Failure was more significant in patients with ≥20 extraluminal air bullae, and with abscess ≥5 cm or pelvic. Further, a 2020's meta-analysis summarizes these trends, pointing out similar relapse for ACD and AUD, variating between 25% and 30%, with a low complicated recurrence rate that occurs mainly in the first year [20].

3. Revised guidelines on indications for elective surgery

The DIRECT trial compared the results of elective surgery vs. conservative management in patients with recurrent diverticulitis or ongoing symptoms, and found little but significant QoL (Quality of Life) gains in the operative group [24].

The recent LASER trial (LAparoscopic Elective Sigmoid Resection following diverticulitis) found an improved QoL (12.95 points in GIQLI score) after elective surgery but with major complications in 10% [25]. Attending to the new data, international guidelines were revised and adopted a position in which quality of life became the main goal of elective surgery [9, 18]. More precisely, the European Society of Coloproctology (ESCP) guidelines stated that elective surgery to prevent complicated disease is no longer justified, irrespective of the number of previous attacks, with level 2 evidence, and that there is no evidence to support resection in symptomatic patients without radiological or endoscopic signs of ongoing inflammation, stenosis, or fistula [9]. The ESCP also stated that the indication for surgery should be individualized and based on the frequency of recurrences, duration, and severity of symptoms after the attacks and the comorbidity of the patient, independently of being AUD or ACD, based on level 3 evidence. For this matter, ACRS was more cautious and stated that elective resection should typically be considered after successful nonoperative treatment of ACD with abscess, with level Ib evidence [18]. So, most modern professional guidelines advise to consider elective surgery in an individualized approach, particularly after recovery of ACD with abscess, and in patients with recurrence, persisting symptoms, and complications such as fistula and stenosis [9, 18, 26]. This strategy, besides being focused on the patient's quality of life, regards patients' preferences, coexisting medical conditions, and surgical risk rather than fear of future life-threatening complications [7, 27]. Moreover, elective surgery can improve quality of life [28, 29], the results are imperfect, with an overall morbidity of 7.6% to 19.6%, namely leak and stoma risk, with persistent symptoms in 25% of the patients, even in the laparoscopic era [8, 30–32]. It would be interesting to have predictive factors for symptom persistence. It also must be said that elective resection does not decrease the rate of emergency surgery and does not eliminate the risk of recurrence (15 vs. 61%). Considering all this, it is a frequent concern for surgeons to know which patients should be operated on and when, where recurrence and complications are significant surgery determinants.

An issue that remains unclear puts into question which ACD characteristics prone patients to a higher risk of failure in wait-and-see management. It appears that abscess size matters, with abscess ≥5 cm having a relapse rate of about 28% and oscillating between 9.6% and 61% in multiple studies [5, 18, 33, 34]. Due to their frequent early relapse after the index attack, it is suggested that they could be persistent abscesses instead. A distant pelvic abscess was also described to confer a higher risk of relapse, with an almost three times higher failure rate of nonoperative management compared with pericolic location, besides a slight increase in emergency surgery risk (4.3 vs. 1.4) [20, 35]. Regarding percutaneous drainage of abscess at index attack, there is a significant body of literature with some discrepancies and bias due to a high selection rate for elective surgery in this group of patients [19, 33, 36–38]. However, most recent studies describe that despite the increased risk of recurrence in the first year, the risk of emergency surgery is low [34, 35]. Moreover, unlike abscess size and location, percutaneous drainage did not act as an independent factor in multivariate analysis [5].

Finally, recent studies on diverticulitis in alleged high-risk groups such as young and immunosuppressed patients did not confirm the same risks of complications as previous studies. More specifically, research comparing patients younger and older than 50 years of age, namely a 2020's meta-analysis, have determined that although a relative increase in the recurrence rate was possible in the younger, the cumulative risks of complications and emergency surgery were similar [35, 39–42]. Therefore,

guidelines were updated and recommended to manage young patients as the older ones based on level 1C evidence [9, 18]. In relation to immunosuppressed patients, a group with significantly more comorbidities, the discussion is still burning. The 2020ESCP's guidelines stated that the decision for elective resection in immunocompromised patients should follow the same principles as for the immunocompetent patients and was not recommended routinely. In a similar way, the 2020-ACRS suggested an individualized decision for this group of patients. In the other hand, the 2020 guidelines of the World Society of Emergency Surgery (WSES) were more cautious and suggested that all immunocompromised patients should be planned for surgery after recovery from an episode with successful nonoperative management, based on level 2D evidence [32]. It is generally accepted that AD has a higher incidence in immunocompromised patients and worse outcomes in ACD after medical or surgical management. A study by Biondo et al. analyzed the relationship between the different causes of immunosuppression and diverticulitis. Immunocompromised patients were divided into five groups according to the reasons of immunosuppression: chronic corticosteroid therapy, transplant patients, malignant neoplasm disease, chronic renal failure, and other immunosuppressant treatments [37]. The authors observed that the emergency surgery rate in the first episode was high (39.3%) and needed more frequently in the chronic corticosteroid therapy group. The overall postoperative mortality was 31.6%, and recurrence after successful non-operative management occurred in 27.8%, with no differences among groups. So, the authors concluded that elective surgery in immunosuppressed patients should be individually indicated according to the persistence of symptoms or early recurrences, with a low threshold in patients with chronic corticosteroid therapy. Sugrue et al. compared the outcomes between 20 renal transplant patients and 134 immunocompetent patients with AD [43]. The authors observed similar results for AUD and concluded that the nonoperative management in this situation was safe. However, the optimal treatment for renal transplant patients with ACD remained unclear, as they were more likely to undergo an emergency operation with additional complications. Another study by Lee et al. did not find differences in the morbidity and mortality of renal transplant patients that underwent elective colectomy after index or recurrent episodes and concluded that the fear of postoperative complications from recurrent diverticulitis should not be a reason to recommend elective colectomy after an initial attack [44].

A meta-analysis published in 2022 by Yeow et al., including 7415 patients from 11 studies, three of them RCTs, compared the outcomes between elective surgery and nonoperative treatment for the long-term management of ACD. The authors reported significantly increased odds of recurrence in the conservatively treated group, as it would be expected (OR = 0.24). However, the stoma rate (OR = 2.34) and the morbidity rate (OR = 4.29) were significantly higher in the elective surgery group, although with an increase in QoL and cost-effectiveness [45].

Regarding the approach, laparoscopy is safe in the setting of elective surgery for diverticular disease and is associated with reduced rates of morbidity and length of stay compared to open surgery [46]. So, laparoscopic colectomy is recommended when feasible and when there is expertise available [18, 46]. The timing is still unclear, and limited evidence suggests no difference in morbidity or mortality when comparing early (< 6 weeks) versus late (> 6 weeks) elective resection for diverticular disease, although with a trend to a higher rate of conversion in early surgery. Thus, EAES-SAGES guidelines recommend delaying elective interval sigmoid resection for a minimum of six weeks from the previous episode of AD.

Considering all these, it is a frequent concern for surgeons to know which patients should be operated on and when, with recurrence and complications being major determinants. Asymptomatic patients with recurrent AUD and following an episode of ACD with abscess are managed very differently from institution to institution, and surgeon to surgeon, addressing the paramount need to improve and standardize guidelines in decision-making with better stratification of risk for recurrence and severity [47].

4. Assessment of predictive factors for severity and recurrence

Although recent evidence has emerged, AD's natural history and pathophysiology remain unclear. Current evidence highlights the role of genetic susceptibility, environment, colonic dysmotility, visceral hypersensitivity, chronic inflammation, and gut microbiota imbalance in the pathogenesis of this disease, and further studies are needed to identify more potential targets for medical or surgical decision-making and establish well-defined preventive strategies [1, 8, 48, 49]. To know upfront which patients are more prone to have complicated or recurrent diseases and which patients are more likely to maintain symptoms after surgery could enormously contribute to tailored decision-making for elective surgery. The identification of risk factors for recurrence and severity has been the scope of numerous studies over the past few decades, but still needs to be clarified [7, 50]. Despite high-level evidence is lacking, several risk factors for AD have been found, falling into some broad categories, including anthropometric and anatomic features, diet, lifestyle, medications, genetics, and others, however, with little value in predicting the course of this disease [7, 51]. Current systematic reviews suggested that recurrence is associated with younger age, female gender>50 years, smoking, obesity, Charlson comorbidity index score (CCI) ≥ 3, dyslipidemia, first ACD with abscess, number of previous episodes, as well with the extension of the disease, and pancolonic diverticula [7, 16, 50]. On the other hand, severity has been associated with obesity, lifestyle, drugs, comorbidities, previous ACD with abscess, and high C-reactive protein (CRP) or leucocytes (LCT) on admission [51–58]. There are numerous studies addressing this subject, and **Table 1** lists the most frequently suggested predictive factors for severity and recurrence.

Particularly, there has been increasing interest in the role of biological markers as non-invasive and reliable tools, able to support physicians in diagnosis, assessment of activity, monitoring the potential development of complications, and predicting recurrence in AD, as already reported widely for inflammatory bowel disease (IBD), and grounded on recent data suggesting continuous chronic inflammation in patients after an episode of AD [7, 52, 59–62]. LCT count was not found to be sensitive nor specific for the diagnosis of AD and its severity, while CRP has been demonstrated to be the best laboratory marker for diagnosis and prognosis [46]. In fact, countless studies indicated that CRP levels correlate with the disease's severity and recurrence rates [52, 59, 63–67]. The optimal cut-off of CRP that discriminates AUD from ACD is not yet well-defined and ranges between 50 mg/L and 175 mg/L in different studies. Particularly, a cut-off of 150 mg/L was associated with a specificity of 75–91% for ACD [64, 66, 68]. Interestingly, levels over 240 mg/L during the index episode of AUD have been related to recurrence in the first six months [63]. Other studies have demonstrated that elevated fecal calprotectin (FC), an inflammatory colonic mucosal marker, was associated with diverticulitis recurrence and severity as long as symptomatic uncomplicated diverticular disease (SUDD) [69–72]. Moreover, Tursi

Predictive factors	Possible predictive factors for recurrence	Possible predictive factors for severity
Demographics	Younger age Female gender>50 years	
Anthropometric features	Obesity	Obesity BMI
Anatomic features	Pancolonic diverticula	
Lifestyle	Smoking	Smoking
Diet	Low fiber intake	
Drugs		NSAID's Aspirin Corticosteroids Opioids
Comorbidities	CCI ≥ 3 Dyslipidemia	CCI ≥ 3 Immunosuppression
Related to the disease	First ACD with abscess Number of previous episodes Extension of the disease	Previous ACD with abscess Severe disease on radiological imaging
Biochemical markers	High CRP on admission FC?	High CRP and LCT on admission FC? PCT?
Genetic markers		TNFSF15, LAMB4? ARHGAP15, COLQ, FAM155A?

AD—acute diverticulitis; BMI—body mass index; NSAID's—non-steroidal anti-inflammatory drugs; CCI—Charlson comorbidity index score; ACD—acute complicated diverticulitis; CRP—C-reactive protein; LCT—leucocytes; FC—fecal calprotectin; PCT—procalcitonin; TNFSF15—tumor necrosis superfamily 15 gene; LAMB4—laminin β4 gene; ARHGAP15—Rho-GTPase-activating protein 15; COLQ—collagen-like tail subunit of asymmetric acetylcholinesterase; FAM155A—family with sequence similarity 155A.

Table 1.
Possible predictive factors for severity and recurrence of AD.

et al. showed that abnormal FC values at least once during the follow-up strongly correlated with recurrence, thus confirming the eventual role of persisting subclinical inflammation in causing it [70, 72]. Finally, procalcitonin (PCT), a biomarker of bacterial infections has been proposed as an accurate marker to differentiate AUD from ACD [73].

Additional studies are needed to establish the role of biomarkers and identify appropriate cut-off values that could be integrated into prediction models of severity, recurrence, and its timing, as long as appropriate decision-making algorithms for patients with AD.

Furthermore, recent studies highlighted the role of genetic markers in recurrence and severity. According to the 2021 American Gastroenterological Association clinical practice update, approximately 50% of the risk for AD is attributable to genetic markers based on conclusive evidence [30]. However, few genes have yet been implicated in disease pathogenesis. *In silico* analyses point to diverticulosis primarily as a disorder of intestinal neuromuscular function and impaired connective fiber support, while an additional diverticulitis risk might be conferred by epithelial dysfunction [74]. Reports of early onset and severe AD in otherwise healthy families have led to the association still not confirmed with variants in the tumor necrosis superfamily 15 gene

(TNFSF15) and the laminin β4 gene (LAMB4), supporting a role for collagen vascular disorder combined with an immunologically based susceptibility [75]. Genome-wide association studies (GWAS) have identified more than 200 risk loci for diverticulosis and diverticulitis, containing genes that regulate immunity, connective tissue integrity, cell adhesion, membrane transport, and intestinal motility. Of these, ten variants have been associated with AD phenotype. The most frequently addressed are in genes ARHGAP15 (Rho-GTPase-activating protein 15), COLQ (collagen-like tail subunit of asymmetric acetylcholinesterase), FAM155A (family with sequence similarity 155A) [76, 77]. Finally, research in therapeutic strategies aimed to modulate gut microbiota and reduce mucosal inflammation on its way [27, 78–85]. More studies designed to assess risk factors for recurrence and severity could greatly improve stratification along with tailored treatment and prevention strategies in patients with AD.

5. Discussion

Considering actual data, the goals of elective surgery for AD are the improvement of QoL in symptomatic patients with ongoing chronic inflammation or recurrent boats and the management of complications such as abscess, fistula, or stenosis [9, 18, 26]. This decision should be individualized, keeping in mind that although surgery can improve a patient's QoL and treat complications, the results are imperfect, with an overall morbidity of 7.6% to 19.6%, namely with leak and stoma, with persisting symptoms in at least 25% of the patients [8, 30–32]. In addition, while a significant reduction in the need for emergency surgery is no longer expected, it also does not eliminate the risk of relapse [14, 33]. Thus, while the indication is mostly linear for the treatment of complications such as enduring abscess, fistula, and stenosis, the remaining indications are personalized, taking into account the comorbidities, symptoms, QoL, degree of active inflammation, or severity of the episode [9, 18]. In symptomatic patients, besides the frequency, duration, and severity of the attacks, there should be disease-specific QoL measures, namely quantifying the negative impact in work [9]. Further, for surgery to be beneficial in persistently symptomatic patients with low QoL, active inflammation must be associated with translation on computed tomography (CT) scan, colonoscopy, or biochemical markers such as CRP or FC. After successful nonoperative treatment of ACD in asymptomatic patients, decision-making is more challenging since professional guidelines based on different data are discordant [9, 18]. The risk of a recurrent bloat needing emergency surgery is low, especially after the first year. However, it appears that size matters as the location. Abscesses ≥5 cm relapse more frequently (28%), ranging between 9.6 and 61%, looking like refractory episodes [34, 35, 86] and pelvic or distant abscesses have a higher rate of emergency surgery (4.3 vs. 1.4%), with previous percutaneous drainage not functioning as an independent variable, but in association with size and location [36]. Finally, surgery should be considered after recovery of Hinchey III episodes and contained perforations with distant or voluminous extraluminal air [87, 88].

Lastly, the decision for resection in young or immunocompromised follows the same principles as in other patients, though with a recommendation of a lower threshold [9, 18]. More specifically, immunosuppressed patients, with a higher risk of complicated recurrence, should be individually indicated according to the persistence of symptoms or early recurrences. The threshold in patients with chronic corticosteroid therapy is even lower, especially after an episode of ACD, where a close follow-up

with a CT scan should be considered [26, 38]. On the other hand, the strategy can be more expectant in kidney transplant patients [38, 44, 45].

6. Conclusions

Currently, the main indication for elective surgery in AD, besides complications, is the persistence of symptoms with low QoL after recovery of successful conservative management. Most modern professional guidelines advise considering elective surgery in an individualized approach, particularly after recovery of ACD with abscess, and in patients with recurrence, persisting symptoms, and complications such as abscess, fistula, and stenosis, focusing on the patient's quality of life, where recurrence, severity, and symptoms are significant determinants. However, we still struggle in the decision-making of alleged high-risk patients, namely with previous ACD with abscess ≥5 cm, or pelvic location needing percutaneous drainage, contained perforations with large and distant bullae of pneumoperitoneum, as long with young and immunocompromised patients. The guidelines still need to be standardized for appropriate decision-making, with patients being managed very differently from institution to institution, and surgeon to surgeon, mainly due to a lack of risk stratification for severity and recurrence. Further studies are needed to identify more potential targets for surgical decision-making to implement a stratified-management approach with the selection of patients for elective surgery tailored to the risk of recurrence, its timing, and severity.

Conflict of interest

The authors declare no conflict of interest.

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Chapter 6

Surgical Management of Complicated Diverticulitis

Carlos Vaccaro and Nicolas Avellaneda

Abstract

Diverticular disease is a prevalent condition that affects more people as they get older. Even though some patients have colonic diverticulosis with no symptoms and then require no treatment, some of the patients affected with this disease present repeated episodes of inflammation and end up requiring surgical treatment in an elective or urgent setting. When an acute episode of diverticulitis arises, it may require surgery, and these procedures are often challenging even for specialized colorectal surgeons. Furthermore, a lot has been written in the last years about what to do in an urgent scenario, ranging from just making a lavage of the abdominal cavity, to making a colonic resection with or without primary anastomosis (which brings more debate into the topic). Therefore, a chapter explaining the evidence-based management of acute colonic diverticulitis seems a relevant topic for this chapter.

Keywords: diverticular disease, perforation, urgent, abscess, complication

1. Introduction

Diverticular disease arises from the formation of small bulges or pockets, (diverticula), more frequently affecting the left and sigmoid colon in the western countries. This is a prevalent disease that used to be associated with aging, but some studies have suggested a rising incidence in the younger population recently [1–3].

Diverticula can be found incidentally in colonoscopies performed for other reasons, but there is a risk that these become symptomatic in about 4% of these findings. Further, in the Netherlands, an estimation was made that about 22,000 patients will require medical attention for diverticular disease. Of those, 10% will present with complications such as abscesses or bowel perforation [4, 5].

When diverticulosis presents with symptoms (diverticular disease), the most common presentation is an uncomplicated scenario (abdominal pain without collections or other complications). In this case, the patient can be successfully managed with anti-inflammatory drugs with or without antibiotics [6].

On the other hand, a number of patients might suffer an acute presentation that requires an interventional approach, either percutaneous or surgical, because of complications like an associated abdominal abscess, bowel perforation, colonic fistulae to other organs, etc. This chapter will mainly focus on those situations and the best approach for each one of them. Even though, as we stated before, this is not the most frequent presentation of diverticular disease, the management of these patients

is often challenging for the attending physician, which highlights the importance of the contents that will be developed here.

2. Management of complicated acute diverticulitis

2.1 Diagnosis and classifications of acute diverticulitis

Patients presenting with an acute diverticulitis episode can usually refer to several symptoms, including fever, vomiting, and abdominal pain mainly focused in the lower left quadrant.

When the suspicion of an episode of acute diverticulitis arises, the definitive diagnosis should be made by combining clinical findings, history of previous episodes and prior colonoscopies (which would also help to rule out other causes of colonic diseases, like malignancies), and serological markers to assess the inflammatory response (white blood count, C-Reactive protein, etc.).

As regards imaging methods, CT scan is the current gold standard, because not only it allows the physician to make a diagnosis but also to correctly stage the disease, looking for associated abscess, pneumoperitoneum, and free fluid in the abdominal cavity. In centers where CT scan is not available in the urgent setting, secondarily Ultrasonography can be used to look for inflammation related to the left colon and abdominal abscesses. However, this method is associated with significant limitations, starting with the fact that it is operator-dependent, in obese patients, it can be a challenging procedure, and it can miss essential findings like deep pelvic abscesses. Further, few or none of the classifications for acute diverticulitis are based on Ultrasonography, therefore it does not allow a proper stratification of the patient [7–9].

The most frequently used classification of acute diverticulitis based on imaging is the Hinchey classification [10], which stratifies the disease into four grades according to CT-scan information and operative findings:

1. Pericolic abscess

2. Abscess located in the abdominal cavity (not near the affected colon), in the pelvis, or in the retroperitoneum.

3. Purulent peritonitis.

4. Fecal Peritonitis.

More recently, Kaiser et al. [11] introduced a modification of this classification, including the size of abscesses (dividing grade I into A and B), and the severity of peritonitis.

Based on this classification, most guidelines propose different approaches for each stage, which will be further discussed.

Even though other classifications have been proposed for the stratification of acute diverticulitis based on CT-scan findings, these remain highly unadopted [12, 13].

2.2 Management of abdominal abscess associated with acute diverticulitis

About 15% of patients with an acute diverticulitis episode can present with an associated abdominal abscess, which can be pericolic (Hinchey I) or else pelvic (Hinchey II). The management of such abscesses should be guided by the size and clinical condition of the patient [14].

In stable, non-immunocompromised patients, with abscesses that are limited in size (less than 3–5 cm.), an initial antibiotic treatment can be started. Several publications have shown a high success rate without requiring interventional treatment (either percutaneous drainage or surgery). However, most data that support used to support this conduct come from observational studies with significant implicit bias, therefore it should be taken cautiously, and also, consider all patient's clinical conditions while deciding the need for more invasive treatment [15, 16].

Larger abscesses require additional treatment (besides antibiotics), the percutaneous drainage being the preferred intervention when possible. Although ultrasonographic-guided drainage can be feasible, a CT scan has proven to be a more efficient method to guide this procedure. Further, obtaining a sample of the abdominal abscess will aid in identifying the specific causal agent and adequate antibiotics for it [17].

Lastly, surgery in the scenario of a patient with a diverticular abscess and no other complications should be the last choice, for those patients who do not respond to antibiotics, do not have an adequate window for percutaneous drainage, or in case of clinical instability.

In case a patient with a diverticular abscess has been successfully managed without surgery, the indication of colonic exploration (colonoscopy) afterwards (usually between 4 and 6 weeks after the episode) remains controversial, since most observational studies suggest that the risk of hidden malignancies in these patients is low. Nonetheless, the World Society of Emergency Surgery suggests that a colonoscopy would be advisable, in case the patient has not received one recently (weak recommendation based on low-quality evidence) (**Figure 1**) [18].

2.3 Management of patients with an abscess and pericolic gas

A relatively common finding in patients undergoing CT scan during the acute episode is pericolic gas (outside the bowel lumen), without free air or fluid elsewhere

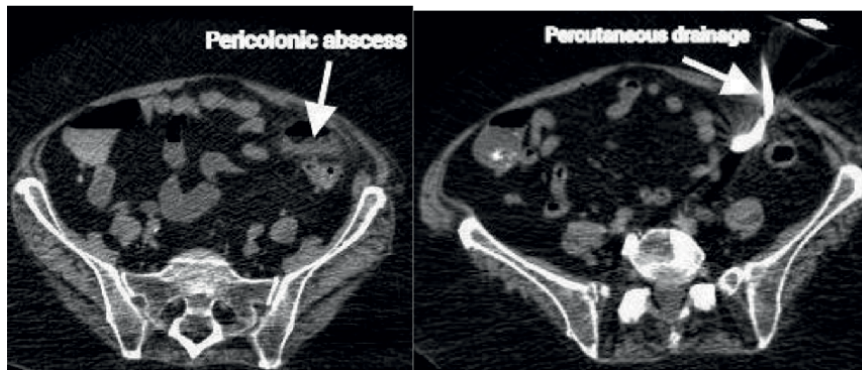

Figure 1.
Diverticular abscess treated with percutaneous drainage.

in the abdominal cavity. This finding (previously denominated *acute diverticulitis with pericolic free gas*) implies a blocked colonic perforation and its treatment may be challenging. Although these findings were associated with a more aggressive acute episode, requiring a longer length of stay, and keener to require emergent surgical treatment, initial conservative management with antibiotics has been successful in selected patients under strict clinical control [19, 20].

The most important study to date, regarding patients with pericolic-free gas, is the *ADIFAS* collaboration [21] published in 2023 by Tejedor et al. In this initiative, the authors recruited 810 patients from centers in Europe and South America who had diverticular pericolic free air with or without pericolic free fluid diagnosed by CT. Further, for patients who had distant free air or abscess, generalized peritonitis, or less than 1-year follow-up, focusing on the rate of failure of nonoperative management within the index admission as primary objective. In this cohort, 92% of patients were initially managed without surgery, of whom 94% were discharged after successful conservative treatment without surgery and complications. On the other hand, only 4.7% required an operation, and 1.6% percutaneous drainage. The factors associated with a higher risk of failure of non-operative management were free pericolic fluid on CT.

Based on the findings of the *ADIFAS* study, and on current recommendations of most guidelines, it seems reasonable that, in the event of patients presenting with pericolic free gas, those could be initially managed conservatively provided they are clinically stable. Particular care should be taken in those individuals who also present pericolic free fluid associated with gas (**Figure 2**).

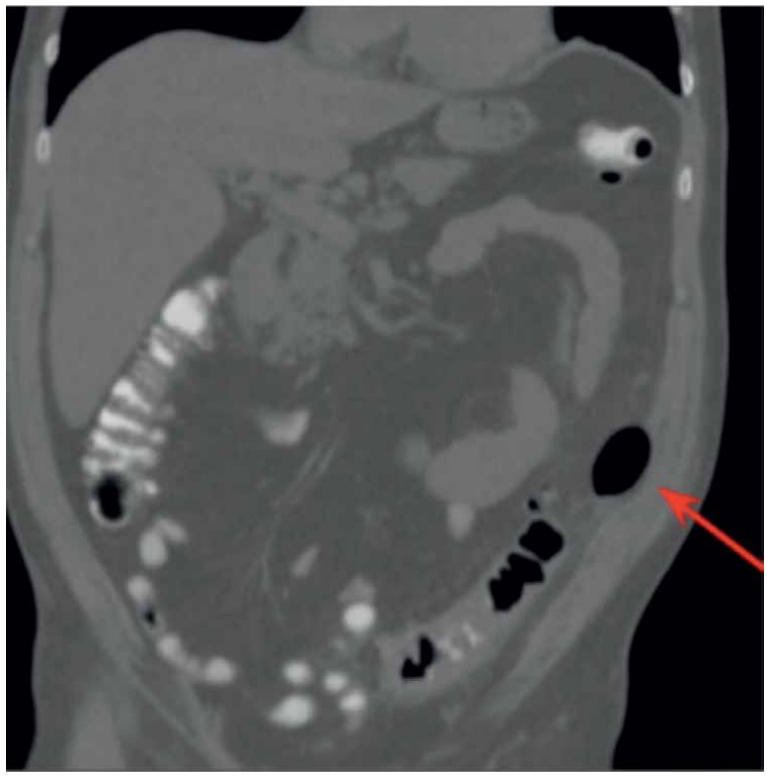

Figure 2.
Patient with a localized collection and pericolic free gas.

2.4 Treatment of patients with diffuse peritonitis

Grades III and IV of the Hinchey classification include patients who present with diffuse peritonitis, which can be either purulent or fecaloid respectively. These groups of individuals can present with diffuse abdominal pain, fever, hemodynamic instability, and distant free gas and generalized free fluid on a CT scan. Sometimes, it can also be a consequence of the failure of conservative treatment (progression of the disease) of a patient who initially presented with pericolic-free gas. These patients represent a challenge for the surgeon since they are often clinically unstable and require an urgent procedure, without a colorectal specialist available.

An alternative to major surgery is the peritoneum lavage which consists of draining the free fluid and abdominal abscesses, afterwards performing a profuse peritoneal lavage of all four quadrants of the peritoneal cavity and finally putting drains and ending the procedure (provided a free perforation is not encountered during the surgical procedure, in which case this strategy would be contraindicated) [22, 23].

When it comes to the surgical approach of perforated diverticulitis with diffuse peritonitis, a minimally invasive or conventional exploration of the abdominal cavity, draining the free fluid, and performing a lavage of the abdominal cavity is mandatory. After these, the attending surgeon should make a decision:

1. In case the perforation is blocked (not uncommon in this scenario), put abdominal drainages and "bailout" (end the procedure).

2. Make a colonic resection involving the segment affected by the disease, and then either leave an end-stoma (Hartmann's procedure) or perform a primary anastomosis with or without a proximal diversion.

Option one (formerly called *peritoneal lavage and drainage*) has been extensively evaluated in the literature, as, theoretically, it would be a very good option for an inexperienced surgeon to get the patient out of the problem with low morbidity.

To this extent, one of the first studies to report the results of this strategy was published by a Dutch group [22], reporting outcomes of this strategy in 38 patients. The morbidity of the procedure was high, with 17 patients developing complications after the procedure, 2 patients presenting with an overt perforation that was missed in the original procedure, and 2 patients dying after the intervention. Further, three patients had to be operated on after a successful lavage for recurrent diverticulitis. This group found some factors associated with unsuccessful treatment (more comorbidities, higher C-reactive protein, higher peritonitis index), proposing that the selection of patients to use this strategy should be of utmost importance.

After this initial report, three randomized controlled trials evaluated the potential use of this strategy in patients with diverticular peritonitis.

In 2016, the DILALA study [23] included 83 patients with Hinchey III diverticulitis randomized into laparoscopic lavage (39) and Hartmann procedure (36). This study found similar morbidity between both strategies, but shorter operating time and shorter hospital stay in the laparoscopic lavage group. After this initial report, the authors furtherly assessed the long-term (2-year follow-up) results of both strategies, finding that the laparoscopic lavage group had less risk of undergoing reoperations, with no difference in readmissions or mortality between both groups. Further, 3 patients in the lavage group vs. 9 patients in Hartmann's group had a colostomy at

24 months, concluding that laparoscopic lavage seemed like a better option in these patients than doing a resection and stoma.

A second randomized controlled trial, the SCANDIV study [24, 25], involving 199 patients from Sweden and Norway, divided patients into two groups, those receiving a laparoscopic peritoneal lavage (101) and those who received a colonic resection (98). The primary outcome was severe postoperative complications. Even though the differences between groups were not significant in terms of morbidity mortality, length of postoperative stay, and quality of life after surgery, those patients in the laparoscopic lavage group had more reoperations. Operations, on the other hand, were shorter in this group. Interestingly, four sigmoid carcinomas were missed during the procedures that only involved lavage. For all the aforementioned findings, the conclusion of the study was not to support the use of laparoscopic lavage when compared to colonic resection.

The SCANDIV group also published the comparative analysis at a median follow-up to 59 months, showing that even though the stoma prevalence was higher in the resection group (33 vs. 8%, p: 0.002), recurrence of diverticulitis was higher following peritoneal lavage (21 vs. 4%, p: 0.004). In this group, 30% of patients required a sigmoid resection.

The LADIES collaborative study [26] was an RCT that involved patients operated at 34 centers from Belgium, Italy, and the Netherlands, which were randomized in either laparoscopic lavage or sigmoidectomy (LOLA group) or Hartmann's procedure or sigmoidectomy with primary anastomosis. The primary endpoint was to assess the morbidity and mortality of the procedures during the first 12 months after surgery (using a composite score).

The LADIES trial was prematurely terminated after enrolling 90 patients for the LOLA group since the composite outcome to assess morbidity and mortality was much higher in the laparoscopic lavage group than in the sigmoidectomy group (39 vs. 19%, OR: 2.74, p: 0.004). Some other findings from this study are that control of sepsis (without the need for reoperations) was more successful in the sigmoidectomy group than in the laparoscopic lavage group (90 vs. 76%). Further, after being reoperated, one patient was found to have a missed diagnosis of colorectal carcinoma.

Lastly, an observational study published by Rossi et al. [27], assessed short-term results of laparoscopic lavage in 46 patients who had purulent peritonitis, reporting a 4% conversion to open surgery rate, with 24% of postoperative morbidity and no deaths after the procedure. Five patients in this group required reoperation because of uncontrolled sepsis after the original procedure.

This same group furtherly assessed the long-term results of 69 patients successfully treated with laparoscopic lavage for purulent peritonitis due to diverticular disease [28]. In this group, four patients had an elective sigmoid resection, whereas 42% of the cohort presented recurrent episodes of diverticulitis, with a cumulative global recurrence rate of about 50% at 5 years.

On the other hand, a number of observational studies have been published to date, highlighting that performing a primary anastomosis in patients operated in an urgent setting for diffuse purulent peritonitis (Hinchey III) could be an option in patients who are clinically stable during the procedure and immunocompetent [29]. For this strategy, the selection of patients is critical. The long-term results of the LADIES trial comparing Hartmann's procedure versus resection and primary anastomosis showed that the latter was superior in terms of patients being without a stoma in the long term and overall hospitalization rates, without being associated with more morbidity or mortality after the procedure.

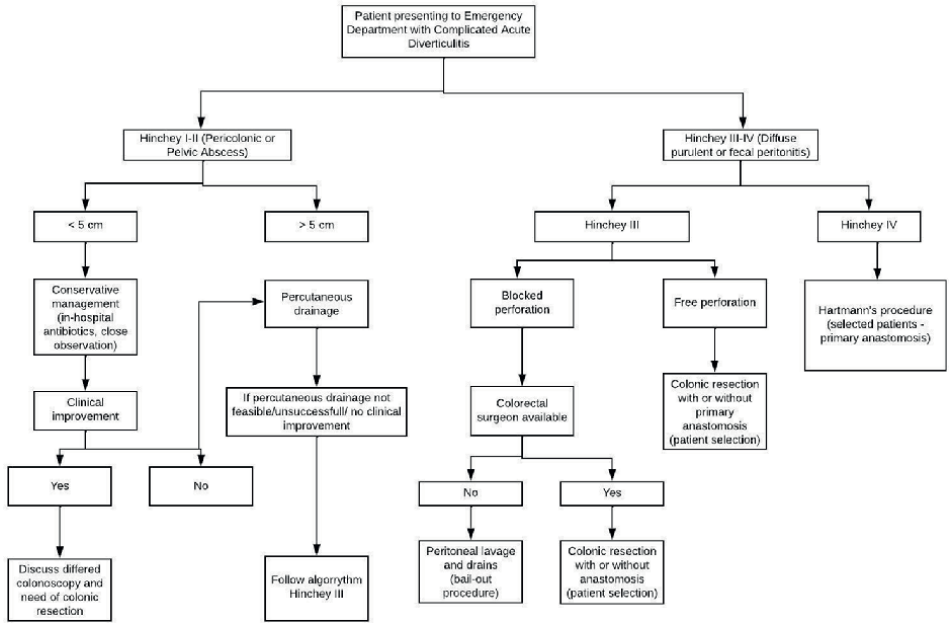

Figure 3.
Proposed algorithm for management of diverticulitis associated with an abscess or perforation.

Furthermore, a recent meta-analysis [30] showed that, when a decision is made on performing a primary anastomosis on a patient being operated on for perforated diverticulitis, there seems to be no benefit associated with performing a proximal diversion to protect the colorectal anastomosis.

Lastly, for patients with fecal peritonitis (Hinchey IV), the treatment should involve resection of the affected bowel without a primary anastomosis (Hartmann's procedure). Nevertheless, in carefully selected patients, a primary anastomosis could be performed.

Based on the aforementioned information, the recommendation for patients who present with diffuse peritonitis due to diverticular disease, in the event that a surgeon with sufficient expertise in colorectal surgery is available, would be to perform a laparoscopic sigmoid resection with primary anastomosis if the patient is fit and clinically stable. On the other hand, in the presence of a general surgeon without experience, laparoscopic lavage could represent a possible "*bail-out*" procedure in cases where a perforation is not detected during surgery. However, it must be noted that this strategy has been associated with questionable outcomes and a high risk of recurrent diverticular disease (**Figure 3**).

2.5 Treatment of colovesical fistulas

Colovesical fistulas associated with diverticular disease are a significant clinical problem. They arise when the diverticula in the colon erodes through the bladder wall, leading to the formation of communication between the two organs. The presence of a colovesical fistula results in the passage of fecal material into the urinary tract, leading to a range of distressing symptoms.

The clinical presentation of colovesical fistulas associated with diverticular disease can vary widely, but common symptoms include:

- Pneumaturia (passing gas through the urine)
- Fecaluria (presence of feces in the urine)
- Recurrent urinary tract infections
- Dysuria (painful or difficult urination)
- Urgency and frequency of urination
- Abdominal pain, especially in the lower quadrants
- Flank pain
- Hematuria (blood in the urine)
- Bowel disturbances (constipation or diarrhea)
- Weight loss and fatigue in advanced cases

The prevalence of colovesical fistulas increases with age, as diverticular disease is more common in the elderly population. Moreover, men are affected more frequently than women, with a male-to-female ratio of approximately 2:1.

A thorough evaluation is essential for the accurate diagnosis of colovesical fistulas associated with diverticular disease. Imaging studies are important, including computed tomography (CT) scans, magnetic resonance imaging (MRI), and contrast studies such as a barium enema or cystography can help visualize the fistula and its extent. In CT scans, indirect signs such as the absence of a cleavage plane between the bladder and the sigmoid colon, or air inside the bladder, can lead to suspicion of a colovesical fistula.

The background of diverticular disease (multiple episodes of colonic inflammation) and repeated urinary infections can also lead to suspicion of a colovesical fistula. Lastly, a cystoscopy can give direct visualization of the bladder through a cystoscope, confirming the presence of the fistula and identifying its location and its relation to the ureters.

2.5.1 Treatment

The management of colovesical fistulas associated with diverticular disease requires a multidisciplinary approach involving gastroenterologists, urologists, and colorectal surgeons. The choice of treatment depends on the severity of the fistula, the patient's overall health, and the presence of complicating factors. It is recommended that, before the patient is taken to the OR, stents are introduced in both ureters (right and left) which will serve as adequate markers to avoid undetected injuries during the procedure.

The operation usually consists of resecting the diseased bowel segment including the fistula tract and the affected portion of the bladder. This can be done either using a minimally invasive (in experienced centers) or a conventional approach.

After resecting the bladder, some surgeons feel it with water or methylene blue in order to diagnose defects that require suturing. However, often the defect is not

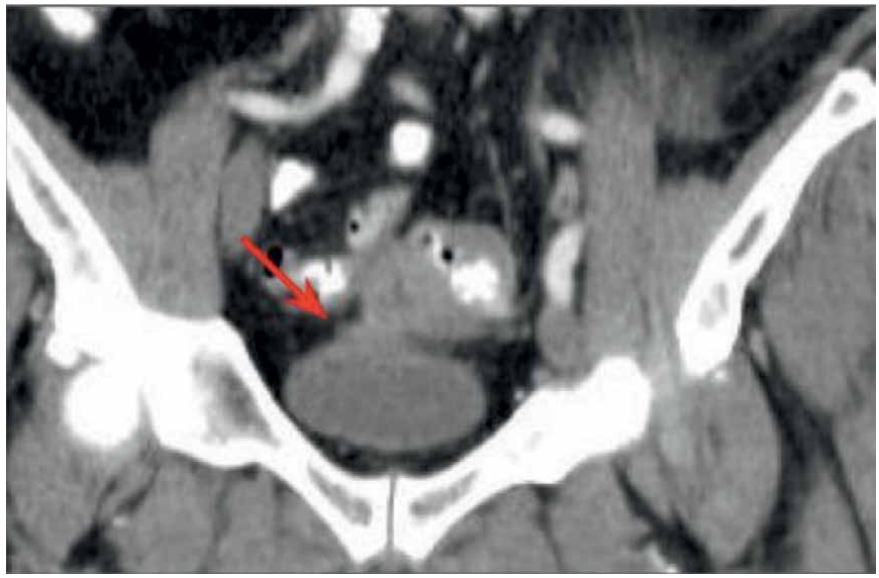

Figure 4.
CT-scan showing the sigmoid colon in close relation with the bladder (suspicion of colovesical fistula).

detected, and most guidelines suggest that patients should use a urinary catheter for 7 days, after which it can be safely removed.

In patients with a colovesical fistula, after the bowel resection, a primary anastomosis without diversion can be safely performed without the requirements of a proximal diversion (**Figure 4**).

2.6 Management of diverticular bleeding

Diverticular bleeding is a significant cause of lower gastrointestinal hemorrhage, accounting for a substantial number of hospitalizations and medical interventions. The bleeding can range from mild to severe and may necessitate urgent medical attention.

Regarding clinical presentation, the most common symptom of diverticular bleeding is painless hematochezia (bright red or maroon blood in stools). Other symptoms may include abdominal discomfort, changes in bowel habits, and anemia due to chronic blood loss. It is essential to differentiate diverticular bleeding from other causes of gastrointestinal bleeding, such as angiodysplasia, inflammatory bowel disease, and colorectal cancer.

An accurate diagnosis of diverticular bleeding involves a combination of clinical evaluation, endoscopic examination, and radiological studies. Endoscopy, specifically colonoscopy, is the gold standard for diagnosing diverticular bleeding and locating the bleeding source. Colonoscopy allows for direct visualization of the diverticula and identification of active bleeding sites. Radiological techniques like computed tomography angiography (CTA) may be employed when endoscopy is inconclusive or contraindicated.

The management of diverticular bleeding aims to control hemorrhage, prevent recurrent bleeding, and manage complications. Treatment strategies may vary based on the severity of bleeding.

- Conservative Management: In cases of mild diverticular bleeding, where hemodynamic stability is maintained, conservative management may be appropriate. This includes supportive care, such as blood transfusions if anemia is severe, along with close monitoring for signs of clinical improvement or worsening.

- Endoscopic Management: For active diverticular bleeding observed during colonoscopy, endoscopic techniques can be employed to achieve hemostasis. These techniques include epinephrine injection, thermal coagulation (e.g., heater probe or argon plasma coagulation), and placement of hemostatic clips over the bleeding site.

- Surgical Intervention: If bleeding persists or recurs despite conservative and endoscopic measures, surgical intervention might be necessary, including the resection of the affected bowel with or without a primary anastomosis (depending on the patient's general condition). Other less invasive procedures, like angioembolization, which targets the blood vessels supplying the diverticula, could be used in case the patient is too compromised to face surgery.

3. Conclusion

The surgical management of complicated diverticular disease plays a vital role in the treatment of patients who experience severe complications or fail to respond to conservative measures. This chapter has highlighted various scenarios related to complicated diverticulitis and has addressed complications such as perforation, abscess formation, fistula formation, and recurrent diverticulitis. Surgical intervention aims to control the disease, prevent life-threatening conditions, and improve the patient's overall quality of life.

Management of complicated diverticular disease requires a personalized approach, considering the patient's overall health, the extent of the disease, and the specific complication. Surgeons must carefully weigh the benefits and risks of each surgical option to optimize outcomes and ensure the best possible care for patients with complicated diverticular disease. Additionally, a multidisciplinary approach involving gastroenterologists, radiologists, and colorectal surgeons is crucial in the decision-making process and postoperative care to achieve optimal results and improve patient outcomes. Further research and advancements in surgical techniques will continue to enhance our understanding and treatment of complicated diverticular disease in the future.

Conflict of interest

The authors declare no conflict of interest.

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Diverticulosis refers to an outpouching of colonic mucosa and submucosa outside of the intestinal lumen. It commonly occurs around the penetrating blood vessels. It can occur in any segment of the bowels; however, the sigmoid colon is the most affected segment. Diverticulosis (the presence of diverticula in the colon) remains asymptomatic in most individuals, but approximately 25% of people with diverticulosis will experience symptomatic diverticulosis, which is referred to as diverticular disease. In the past two decades, diverticular disease has become one of the most commonly diagnosed bowel disorders. It is seen across the globe and its incidence is high, especially in Western countries. It is estimated that in many developed countries around 50% of the population older than 50 years is affected by diverticular disease. It was once believed to be associated with increasing age, however, in recent studies, its prevalence in younger populations has increased. In about 10%–25% of patients with diverticulosis, the disease progresses and leads to diverticulitis. Many theories have been suggested for the different etiologies of diverticular disease, and the most common cause is believed to be a low-fiber diet. It is believed that diets low in fiber are associated with increased intracolonic pressure, which leads to diverticula formation. Diverticular disease can have variable clinical presentations. Most often it presents as abdominal pain or change in bowel habits and rectal bleeding. Its clinical picture can at times mimic inflammatory bowel disease or bowel malignancy. Its common sequelae include diverticulitis, perforation, and peri-colic abscess/phlegmon. The complications of diverticular disease include abscess, fistula, and bowel strictures. Small or localized collections can be managed with intravenous antibiotics and depending on the available resources, intervention radiology can also be used to manage such cases. CT scan is considered a more specific technique for diagnosis. It can also be used for reviewing the patient's progress to treatment, with serial scans over time. It is also used for treating some complications, such as performing percutaneous drainage of abdominal abscesses.

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