



Small Bowel Diverticulosis: Pathogenesis, Clinical Management, and New Concepts

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Abstract

Purpose of Review Small bowel diverticulosis is a well-known clinical entity whose diagnosis and management has evolved in recent years. This review covers pathophysiology, incidence, and prevalence, and it also provides an update on modern diagnosis and management. Meckel's diverticula are covered elsewhere in this volume.

Recent Findings CT scan and MRI have largely supplanted barium follow-through for diagnosis. No intervention is needed in asymptomatic individuals. Endoscopic management is playing an increasing role for both bleeding and resection of intraduodenal diverticula, but surgical intervention remains the only definitive intervention for other complications like diverticulitis and small bowel obstruction.

Summary Small bowel diverticulosis is an uncommon condition which is associated with numerous possible complications. While endoscopy is playing an increasingly large role in management, surgical resection remains the treatment of choice for most complications. A high index of suspicion is needed in order to diagnose this entity.

Keywords Small bowel diverticulosis · Periampullary diverticulosis · Intraluminal duodenal diverticulum · Small bowel hemorrhage · Small bowel diverticulitis

Introduction

Small bowel diverticulosis is an uncommon but increasingly recognized cause of various chronic, nonspecific GI tract complaints and also has the potential for causing occasional serious complications. Due to the infrequency of the condition and the challenges associated with diagnosis, much of the existing knowledge about the condition is based on case reports and small case series. Our review will summarize existing knowledge about the condition and provide an overview of diagnostic strategies and management. Meckel's diverticula are covered elsewhere in this volume and are thus not discussed in this review.

Pathogenesis

Similar to colonic diverticulosis (but unlike Meckel's diverticulum), small bowel diverticula contain only mucosal and submucosal layers (and variably, a thin serosal layer) herniating through the muscularis layer and are thus classified as pseudodiverticula [1]. They are thought to arise during periods of increased intraluminal pressure, possibly in the setting of inflammation [2], or intestinal dyskinesia leading to localized areas of high pressure within the small bowel [3, 4]. Evidence of neuromuscular dysfunction of the small bowel was noted in one study that examined histology of small bowel diverticula [5•]. Histologic abnormalities included abnormal myenteric plexus with degeneration of neurons and axons resembling that seen in familial visceral neuropathy, smooth muscle fibrosis resembling that seen in progressive systemic sclerosis, and abnormal smooth muscle cells with degenerated appearance resembling that of visceral myopathy [5•]. Radiographic studies of individuals with small bowel diverticulosis also suggest underlying motor dysfunction as evidenced by small bowel dilation and excess intraluminal fluid and gas [5•].

Duodenal diverticula typically arise along the pancreatic border, distal to the bulb [6]. Periampullary diverticula

Topical Collection on *Small Intestine*

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(PAD), which account for approximately three fourths of all duodenal diverticula [7], are a specific type of duodenal diverticulum occurring within 2–3 cm of the ampulla of Vater or involving the ampulla [7, 8], Fig. 1. In addition to abnormal motility and focal weakness of the duodenal wall, traction of the bile duct on the duodenal wall [8] or sphincter of Oddi dysfunction [7] may also contribute to the formation of PAD.

Jejunioleal diverticula typically arise on the mesenteric border of the small bowel, at locations of weakness of the muscularis layer, generally at sites of entry of vasa recta [3, 9, 10], though location on the anti-mesenteric border has also been described [11••, 12]. Due to their location on the mesenteric border, jejunioleal diverticula can often be located between leaves of the mesentery [11••], which can complicate radiographic visualization and identification. Jejunal diverticula range in size, usually from 1 to 4 cm, but can be as large as 8–9 cm [11••]. Ileal diverticula are generally smaller, ranging from 2 to 15 mm [12].

Prevalence

Small bowel diverticulosis is widely regarded to be an uncommon condition, though there is significant variance in specific estimates of its prevalence. Cited incidence ranges from 0.2 to 4.5% in autopsy studies [13] and 0.5 to 2.3% in small bowel contrast studies [9]. ERCP and EUS studies (which specifically assessed for PAD) have cited incidence ranging from 0.16 to 27% on ERCP [7] and 7.5% on EUS [14••]. This condition can be seen in individuals of all ages, but is more prevalent in adults over age 50 [3, 15]. Diverticulosis is more common in the duodenum compared with the jejunum or ileum; one retrospective review of 208 cases of small bowel diverticulosis noted duodenal location in 79% [4]. An early large case series

noted that among diverticula distal to the duodenum, approximately 80% were in the jejunum [11••]. The increased prevalence in the jejunum compared with the ileum is thought to be due to the presence of larger penetrating blood vessels in the proximal jejunum [3]. While small bowel diverticulosis can be solitary [2], most patients have other diverticula elsewhere in the alimentary tract, usually in the colon [15, 16]. An early case series noted approximately 2:1 male predominance of jejunioleal diverticulosis [11••].

Most studies report a decreasing incidence of diverticula in the more distal small bowel [4, 17–19], higher prevalence with age [4, 11••, 18], and male prevalence [18]. However, prior studies have also reported no evidence of male predilection [4, 12] and increased rather than decreased incidence in the distal small bowel [12].

Diagnosis

Radiographic imaging of small bowel diverticulosis is currently the test of choice, though it has been suggested that laparotomy is the true gold standard way of diagnosing the condition [9]. Prior to CT and MRI studies, diagnosis was usually made on the basis of barium contrast follow-through studies. Currently, diagnosis is typically made on the basis of abdominal CT scan or MRI. Common CT scan findings include discrete round or ovoid small bowel outpouchings outside the small bowel lumen and without any recognizable small bowel folds, which may contain air, fluid, or contrast [20]. Recent studies have suggested that MR enterography is an effective modality in diagnosis [19], Fig. 2. In the setting of a suspected complication of small bowel diverticulosis, CT scan is considered the preferred diagnostic tool currently, particularly in assessing for diverticulitis [17, 19]. There is no specific CT or MR protocol for detection of small bowel diverticulosis [21]. Both oral and IV contrast are generally preferred, except in cases of acute bleeding, where administration of oral contrast may complicate subsequent endoscopic or angiographic attempts to isolate and control hemorrhage. Small bowel endoscopy (either capsule endoscopy or double balloon endoscopy) has the highest diagnostic yield in diagnosing bleeding secondary to small bowel diverticulosis [22••].

Despite the utility of CT or MRI in the diagnosis of small bowel diverticulosis, diagnosis can still be challenging, as diverticula may be difficult to distinguish from gas or fluid filled loops of small bowel [20]. Diagnosis often requires a degree of clinical suspicion on the part of the radiologist. One study retrospectively examined the records of 28 patients who carried a diagnosis of small bowel diverticulosis on the basis of a barium study (either small bowel follow through or small bowel enema) and underwent a CT scan as well. In this study, the diagnosis of small bowel diverticulosis was made on the initial read of only 7% of CT scans, but on retrospective CT

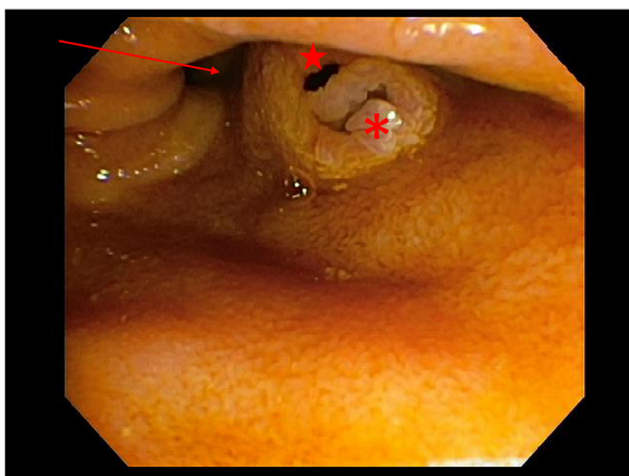


Fig. 1 Endoscopic view of periampullary diverticulum (red arrow), with papilla arising on diverticular rim. Common bile duct opening (asterisk) and pancreatic duct opening (star) are both visible

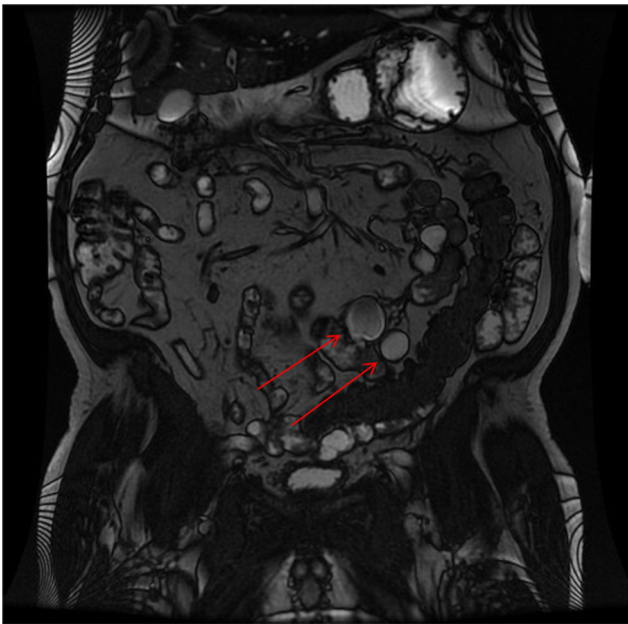


Fig. 2 MR Enterography, coronal fast imaging employing steady state acquisition (FIESTA) image, with two large small bowel diverticula (red arrows)

scan review by two radiologists, the diagnosis was made on 75% of these studies [20].

Complications

Most patients with small bowel diverticulosis are asymptomatic [9, 22••] and are often identified on imaging studies aimed at other conditions. Jejunioileal diverticulosis is more likely than duodenal diverticulosis to be associated with chronic symptoms as well as acute complications [4, 23, 24]. Bleeding is thought to be the most common complication of duodenal diverticula, while diverticulitis has been cited as the most common complication of jejunal and ileal diverticulosis [4, 12]. Jejunal diverticula are thought to be more prone to complications than ileal diverticula [12, 17]. Small bowel diverticulosis is also associated with many more serious complications. Cited rates of complications in large case series have ranged from approximately 10–20% [4, 11••]. Common complications of small bowel diverticulosis are summarized in Table 1.

Chronic Symptoms and Bacterial Overgrowth

Small bowel diverticulosis can be associated with nonspecific symptoms like chronic abdominal pain, dyspepsia, nausea/vomiting, borborygmi, and altered bowel habits [3, 9, 19, 25]. These nonspecific symptoms may arise in part due to diverticular distension, which in turn may result from underlying intestinal dyskinesia [4]. The lack of specificity of

symptoms and lack of any one pathognomonic clinical feature make diagnosis challenging [26]. There is no correlation between the size of diverticula and the degree of symptoms [9].

Bacterial overgrowth may also be the cause of nonspecific symptoms in small bowel diverticulosis. In addition, bacterial overgrowth can also be associated with vitamin deficiencies. Vitamin B12 deficiency can occur due to disturbances in proximal small bowel pH and resulting inactivation of intrinsic factor by bacterial flora specific to these diverticula [27]. Stasis of intestinal contents can also lead to anaerobic bacterial growth and deconjugation of bile salts, with possible subsequent development of fat soluble vitamin deficiency [9].

Diverticulitis

Diverticulitis is the most common complication of small bowel diverticulosis [18, 25]. While this complication typically presents as acute abdomen, recognition can be challenging, as it frequently presents in a manner similar to more common conditions like biliary colic, renal colic, sigmoid diverticulitis, and pancreatitis [23]. Furthermore, due to the duodenum's retroperitoneal location distal to the bulb, diverticulitis of this segment of the small bowel may result in less peritoneal irritation, further complicating clinical recognition [6]. With jejunoileal disease, diverticula are usually located on the mesenteric side of the bowel, and associated diverticulitis is often associated with focal inflammation of the adjacent mesenteric fat [19]. While surgical resection is the only definitive treatment, nonoperative management can be considered in cases where only localized peritonitis is noted [1, 3, 9].

Hemorrhage

Bleeding is a recognized complication of duodenal diverticulosis [4] and is being increasingly recognized in more distal small bowel diverticular disease as well. In a retrospective study of 28 individuals [22••], 7.1% mortality was noted [22••]. As previously noted, small bowel endoscopy has shown good diagnostic yield in cases of bleeding. Brisk bleeding may also be detected on traditional angiography or CT angiography, while slower bleeding may be detected on nuclear medicine bleeding scan. Multidetector CT scan can also be a useful test in the setting of suspected small bowel bleeding, as it has high diagnostic yield for small bowel neoplasia, which can give bleeding symptoms similar to that of small bowel diverticulosis [28].

Obstruction

While a less common complication, there are numerous potential causes of obstruction, which include compression from a distended diverticulum, stricture or adhesion formation from prior diverticulitis, intussusception (with a diverticulum serving

Table 1 Complications of small bowel diverticulosis

Complication	Mechanism	Treatment	Other notes
Diverticulitis	Fecalith or other diverticular obstruction	Small bowel resection with primary anastomosis. Conservative management (broad spectrum antibiotics, bowel rest, close observation) can be considered in cases with only localized peritonitis	Most common complication of jejunoileal diverticulosis. Typically presents as acute abdomen, with associated peritonitis. CT scan with oral and IV contrast is typical way of diagnosing
Bleeding	Ulcer formation, exposed blood vessel	Surgical resection is only definitive treatment. Deep enteroscopy and angiography are playing an increasing role in management	Most common complication of duodenal diverticulosis, but seen with jejunoileal diverticulosis as well. Bleeding duodenal diverticulosis typically presents with hematemesis and melena. Bleeding jejunoileal diverticulosis typically presents with hematochezia
Intestinal obstruction	Compression from distended diverticulum, stricture or adhesion from prior diverticulitis, intussusception, volvulus, enterolith impaction	Surgical resection	Can also be seen with Intraluminal Duodenal Diverticulum, which can often be managed endoscopically
Bacterial overgrowth	Stasis of intestinal contents, with subsequent anaerobic bacterial growth	Antibiotic treatment	Associated with deficiency of Vitamin B12 (due to inactivation of intrinsic factor) and fat soluble vitamin deficiency (due to deconjugation of bile salts)
Biliary obstruction	Mechanical compression of CBD by a periampullary diverticulum (Lemmel syndrome), choledocholithiasis secondary to colonization or periampullary diverticulum with β -glucouronidase producing bacteria	Endoscopic stone removal, possible biliary stenting	Presence of a periampullary diverticulum can complicate successful biliary cannulation with ERCP

as lead point), volvulus of a diverticulum bearing segment of small bowel, enterolith formation and impaction, or nonmechanical obstruction due to intestinal dyskinesia [9, 13, 29].

Pancreaticobiliary Disorders

Given their location, periampullary diverticula can cause obstructive jaundice by mechanical compression of the common bile duct (an entity often referred to by the eponym Lemmel's syndrome) [30, 31], particularly when the papilla is located within a diverticulum [31]. Periampullary diverticula are also a risk factor for bacteriobilia, and colonization with β -glucouronidase producing bacteria can lead to subsequent deconjugation of bilirubin and formation of calcium bilirubinate stones [7]. PAD have also been associated with gallbladder stones [32], CBD stones [32, 33], and idiopathic pancreatitis [7, 33]. Some of these associations are controversial, with one study showing no increase in the risk of acute or chronic pancreatitis with PAD [32]. A recent large retrospective study of 2475 patients using EUS to assess the relationship between PAD and pancreaticobiliary disease noted an

association between PAD and cholangitis, dilated CBD, and choledocholithiasis, but no association between PAD and obstructive jaundice, acute or chronic pancreatitis, and recurrent pancreatitis [14••].

Given their proximity to (and frequent involvement of) the ampulla, PAD can complicate successful biliary cannulation during ERCP [8, 32], particularly when the ampulla is located within a diverticulum [7]. They may also lead to an increased risk of postsphincterotomy bleeding [32], though another study showed no such association [8]. Recent studies, however, have shown that techniques like needle knife fistulotomy have led to comparable cannulation success rates even in those with PAD [34]. PAD can cause filling defects on cholangiography that can be confused with periampullary tumor or CBD stone [7].

Management

No treatment is required for asymptomatic small bowel diverticulosis [18, 29]. In cases of diverticulitis, the only definitive

intervention is small bowel resection with primary anastomosis [13, 16, 26]. Nonsurgical management can be considered in certain cases [15], generally consisting of broad spectrum antibiotics and close observation for development of perforation or other complication. In those cases responding to supportive management, surgery to prevent recurrence is not recommended [10], as diverticulitis may recur in a different location. Similarly, surgery remains the definitive treatment in cases of severe bleeding. In the setting of overt GI bleeding in which small bowel diverticulosis is the only possible causative lesion noted, it has been recommended to pursue surgical resection [13]. However more recently, successful interventions with argon plasma coagulation and endoclip placement have also been noted [22•]. The increasing availability of double balloon enteroscopy (or other deep enteroscopy) has led to increased utilization of endoscopic control of bleeding rather than surgical management.

Intraluminal Duodenal Diverticulum

Intraluminal duodenal diverticulum (IDD), also known as “Windsock diverticulum” is a specific type of duodenal diverticulum that forms by a different mechanism than traditional small bowel diverticula. This type of diverticulum is thought to form in individuals with a congenital duodenal web or diaphragm (forming due to incomplete foregut recanalization during embryonic development). Over the course of decades, continued peristalsis leads to the formation of a pulsion diverticulum [35•, 36] (Fig. 3), sometimes large enough to lead to clinically significant compression of the true duodenal lumen

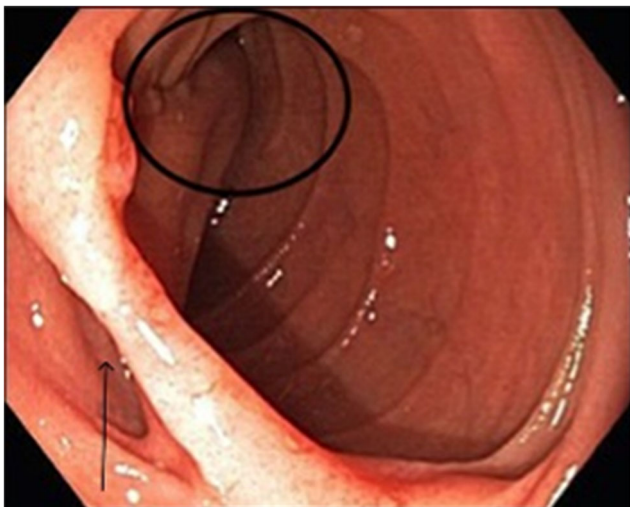


Fig. 3 Intraluminal duodenal diverticulum, visualized on endoscopy. Arrow indicates false lumen, and circle represents body of diverticulum extending into true lumen. Reproduced with permission from: Anand et al. Two cases of intraluminal “Windsock” diverticula resulting in partial duodenal obstruction. *ACG Case Rep J.* 2016 Sep 28;3 [4]:e135. [36]. Used with permission from Wolters Kluwer Health

[35•]. These diverticula almost always form in the second part of the duodenum, just distal to the ampulla of Vater [35•]. Unlike other small bowel diverticula, IDD have epithelial lining on both surfaces [35•, 36] and involve 3 layers of the duodenum [36]. Endoscopic identification is challenging, as these lesions can commonly be confused with other lesions like choledochocoele, periampullary cystic mass, or duodenal duplication cyst [37]. Additionally, a collapsed diverticulum may not be noted [36], or an inverted diverticulum may be mistaken for a large polyp [38]. Thus, a combination of endoscopy and radiographic imaging (such as upper GI series or CT scan) is often needed in order to confirm the diagnosis [36–38].

Due to the amount of time taken for Windsock diverticula to form, symptoms (when present) usually do not come on until the third or fourth decade of life. As is the case with traditional small bowel diverticula, symptoms most commonly include nausea, vomiting, postprandial pain, and early satiety [35•, 39], while more serious complications like bleeding [38], partial or complete obstruction [36], and biliary obstruction and possible pancreatitis [37] have been described as well. Gold standard treatment is surgical duodenotomy and diverticulectomy. More recently, however, endoscopic intervention with high success rates has also been described [35•, 39]. While there is significant variation in the specifics of described techniques, most techniques involve either diverticulectomy (with endoscopic removal of the diverticulum, and subsequent incision of the bridge separating diverticular from duodenal lumen) or diverticulotomy (with longitudinal cut made along the diverticulum, often with needle knife papillotome or standard sphinctertome) in order to create a common lumen for both the diverticulum and true duodenum [35•]. IDD are noted to be very vascular, and delayed bleeding is a noted delayed complication of resection [35•, 39].

Conclusion

Small bowel diverticulosis is a relatively infrequent entity that can cause both acute and chronic gastrointestinal symptoms. While diagnostic and therapeutic modalities have advanced significantly since this disorder was first described (for example, with imaging modalities like enterography now playing a major role in diagnosis, and therapeutic modalities like deep enteroscopy available for treating bleeding complications), a high degree of clinical suspicion is needed for both timely diagnosis and treatment, particularly in elderly individuals in whom this condition is most common.

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Compliance with Ethical Standards

Conflict of Interest The authors declare no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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