39 Large Bowel Obstruction

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Key Concepts

- Perforation associated with obstructing colonic neoplasms may either be at the site of the tumor or the cecum based on the law of Laplace.
- Sigmoid volvulus is usually best treated with endoscopic detorsion followed by sigmoid resection.
- Cecal volvulus is typically best managed with urgent right hemicolectomy.
- Neostigmine is often successful in the management of acute colonic pseudo-obstruction.

Introduction

Large bowel obstruction (LBO), a relatively common entity in the practice of colorectal surgery, can be due to any number of underlying pathologies and may be challenging to manage (Table 39.1) The main causes of LBO reviewed in this chapter, colorectal cancer, volvulus, and acute colonic pseudo-obstruction, each have unique operative and nonoperative therapies available; it is important to determine what the ideal intervention is for each individual patient. Patients with LBO are typically older and have comorbidities that influence decision-making. These patients may present along a spectrum of clinical scenarios ranging from subacute, gradual derangements in bowel function that are evaluated in an outpatient setting to life-threatening, complete obstruction with ischemia and even perforation requiring emergency surgery.

Recognizing that a patient is at imminent risk for developing colonic ischemia or perforation requires clinical awareness and a recognition of the underlying etiology. Patients with a more subacute presentation should be counselled about symptoms to watch for that may signify acute worsening of their obstruction (e.g., worsening abdominal distension, clothes not fitting as they had previously, obstipation, abdominal pain, etc.) as these patients may progress to the point of needing emergency intervention and are at risk for worse outcomes. Obstructions due to a diverticular or inflammatory bowel disease stricture, a stercoral process, abdominal wall hernia, or extrinsic compression and obstructions in pediatric patients are not discussed in detail in this chapter.

Table 39.1 Differential diagnosis of large bowel obstruction

Intraluminal	Intramural	Extrinsic
Intussusception	Malignancy	Compressive mass
Impacted material	Colorectal cancer	Neoplasia
Feces (stercoral)	Inflammatory	Abscess
Foreign body	Diverticular disease	Cyst
Bezoar	Ulcerative colitis	Urinary retention
Gallstones	Crohn's disease	Pregnancy
Worms	Iatrogenic/trauma	Cysts
	Radiation	Pseudo-obstruction
	Anastomotic stricture	Volvulus
	Hematoma	Hernia
		Endometriosis
		Pancreatitis

Modified from Gore [77]

Pathophysiology

Bowel obstruction leads to proximal accumulation of gas and fluid, which in turn leads to distension of the gut. This accumulation causes increased intraluminal pressure and bowel distention, which leads to an intermittent increase in peristalsis, followed by a flaccid relaxation as the bowel obstruction persists. Intestinal stasis associated with obstruction facilitates bacterial and endotoxin translocation to the mesenteric lymph nodes and possibly the systemic circulation [1]. LBO

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can be classified according to whether it is deemed partial, complete, simple, or complicated. Partial obstruction indicates there is some liquid and/or gas getting through the obstructive process, while complete obstruction implies that there is no passage of fluid or gas. A simple obstruction suggests that the blood flow to the colon is preserved in the presence of either a partial or complete obstruction. A complicated obstruction suggests that there is compromise to visceral blood flow, leading to bowel wall edema, intestinal ischemia, and possibly bowel necrosis and perforation.

The clinical manifestations of a colon obstruction are related, in part, to the competency of the ileocecal valve. If the ileocecal valve is competent, which is the case in approximately 75% of patients, LBO will result in a closed loop obstruction which cannot decompress retrograde into the small bowel [2]. In this situation, both the afferent and efferent limbs of the colon are occluded, leading to a marked rise in intraluminal pressure; this can progress to impair the arterial blood flow to the bowel. Once ischemia commences, necrosis of the mucosal villi can occur within 4 hours and, if the pressure is not relieved, can progress to transmural infarction and ultimately perforation [3, 4].

Laplace's law states that the intraluminal pressure required to stretch the wall of a hollow tube is inversely proportional to the radius of the tube. As the cecum has the largest diameter of the colon, it requires the least amount of pressure to distend. The actual diameter that potentially puts the cecum at risk varies in the literature [2, 5]. In cases of chronic obstruction, the cecum may accommodate, without an imminent risk of perforation. Thus, the acuity of the presentation and the rapidity of cecal distention may be more important in determining the risk of perforation than the cecal size alone [6].

Clinical Presentation

A thoughtful history and directed physical examination can elicit the acuity of the presentation and help formulate a differential diagnosis. LBO can present acutely, with colic-like abdominal pain reflecting increased peristaltic activity. This can be followed by reduced peristaltic activity as the proximal bowel distends and relaxes so that the initially colicky pain transitions to a more constant pain. Markogiannakis reported on the clinical presentation of a series of 150 patients who presented with acute bowel obstruction. Cessation of flatus (90%), cessation of feces (80.6%), and abdominal distension (65%) were the most common symptoms and physical signs [7]. Vomiting tends to occur later in the clinical course of LBO compared to small bowel obstruction [3, 8]. Progression to bowel ischemia may be suggested by continuous abdominal pain, a tender irreducible mass in a hernia, fever, tachycardia, or signs of peritonitis with toxicity on physical examination. Bowel ischemia presentation can be quite insidious; a high index of suspicion should be maintained if there is clinical evidence of sepsis [8].

A complete blood count, renal profile, and electrolyte studies are appropriate first-line laboratory investigations for patients presenting with LBO. Marked electrolyte disturbances, especially with regard to potassium, can be present due to a combination of third-space losses, dehydration, sepsis, and duration of the obstructive process. An arterial blood gas may be a useful adjunct as a low arterial pH, low serum bicarbonate, and/or high lactic acid level may suggest intestinal ischemia; but the absence of these derangements does not exclude the presence of ischemia.

Initial Management

Irrespective of the underlying cause of the LBO, the tenets of LBO initial management are the same and involve bowel rest with appropriate fluid resuscitation. Patients are kept nil by mouth, and a nasogastric tube can be inserted to decompress the bowel. Nasogastric decompression can potentially reduce the risk of aspiration and provide symptomatic relief by decreasing the volume of gastrointestinal secretions in the proximal bowel. Fluid resuscitation with appropriate electrolyte repletion is required to address fluid and electrolyte losses from third spacing and lack of oral intake. Urine output should be monitored, and regular clinical assessment of fluid requirements should be undertaken in addition to laboratory tests to reassess electrolyte requirements.

Imaging

Imaging plays a crucial role in the evaluation of a patient with suspected LBO. In up to one third of cases where the working diagnosis following history and physical examination is LBO, no mechanical obstruction is found. Conversely, 20% of patients thought to have colonic pseudo-obstruction are actually found to have a mechanical LBO [3, 9]. Abdominal plain films are often the first imaging modality obtained. Supine and nondependent (upright or left lateral decubitus) radiographs can aid in the diagnosis of LBO and evaluate for pneumoperitoneum. Abdominal X-rays have a reported 84% sensitivity and 72% specificity in cases of suspected large bowel obstruction [1]. Normal colonic diameter ranges from 3 to 8 cm with the largest diameter in the cecum; the cecum is typically deemed dilated when its diameter exceeds ~9 cm in an acute presentation, and the remainder of the colon is considered dilated with a diameter greater than ~6 cm [2].

CT is often the imaging modality of choice for eliciting the cause of LBO, with a reported sensitivity and specificity of 96% and 93%, respectively [2, 10]. CT can also accurately identify potential complications of LBO like pneumoperitoneum, pneumatosis, and portal venous gas. Pneumatosis indicates the breakdown of the mucosal integrity of the bowel wall, and while suggestive of intestinal ischemia, it is not pathognomonic, and this finding should be interpreted within the clinical context. The presence of free intraperitoneal air and/or portal venous gas is associated with a higher likelihood of transmural ischemia and necrosis than pneumatosis alone [11]. CT is the superior modality for the detection of intestinal perforation (95% sensitivity and 90% specificity) compared to plain film radiography (53% sensitivity and 53% specificity) and ultrasound (92% sensitivity and 53% specificity) [12, 13].

CT scanning is an integral modality for the assessment of a patient with possible malignant LBO; the two most common sites of obstruction due to colon cancer are the sigmoid colon and splenic flexure [14]. Meanwhile, the most common site of perforation in this setting is at the cecum reflecting Laplace's law, and perforation occurs in about 3–8% of these patients [15]. Typical imaging features of a malignant LBO include dilated large bowel with a transition point across a short segment of colonic thickening with a distally collapsed bowel. An obstructing tumor can often exhibit a shouldering appearance (Fig. 39.1) [2]. The remainder of the colon should also be assessed for synchronous lesions which occur in 2–7% of patients, although conventional CT scanning is not ideal for this purpose. Evidence of local invasion (e.g., into the bladder, small bowel loops, etc.) and metastatic disease should also be assessed as these can impact the therapeutic plan.

Fig. 39.1 CT scan displaying right colon dilation secondary to an obstructing transverse colon cancer. Note the competent ileocecal valve. (Courtesy of Daniel L. Feingold, MD)

While ultrasound can be as accurate as CT in determining the presence of LBO, CT is preferred where available as it provides more information regarding the likely etiology and can inform about relevant clinical factors as described above [16]. MR imaging is comparable to CT in assessing for bowel obstruction and ischemia [17] and is particularly useful in situations that call for omitting ionizing radiation. A water-soluble contrast enema has a 96% sensitivity and 98% specificity in diagnosing LBO but does not commonly elucidate the etiology of the process [18].

Malignant Large Bowel Obstruction

Malignant LBO occurs in up to 20% of patients with colorectal cancer and carries a significant morbidity and mortality. Multiple studies have shown a three- to fivefold higher rate of 30- and 90-day mortality when patients present acutely with colorectal cancer compared with an elective presentation [19, 20]. This reflects the fact that many of these patients are frail with medical comorbidities and present with obstruction often with concurrent sepsis and/or ischemia. Following resuscitation and nasogastric decompression, further management depends on the patient's response to resuscitation and clinical reassessment. Clinical decision-making should incorporate baseline patient medical comorbidities; relevant history; physical examination; presence of sepsis; tumor location (right versus left colon); radiological staging assessment (e.g., primary tumor resectability, presence of metastatic disease, etc.); feasibility of offering endoscopic stenting, if appropriate; and patient treatment goals.

Perforation

Perforation secondary to a colorectal cancer occurs in approximately 2.6–12% of cases [21]. Perforation can occur at the primary tumor site from tissue necrosis or proximal to the tumor due to ischemia related to dilation, most commonly at the cecum, which is referred to as a diastatic perforation [22]. This represents a surgical emergency as patients can rapidly progress to septic shock and multiorgan failure. With concomitant resuscitation underway, the surgical approach typically involves a laparotomy, washout, and identification of the obstructing mass. The site of perforation may be proximal to the obstruction. In some circumstances, damage control surgery principles might need to be applied such as in hemodynamically unstable patients (e.g., septic shock requiring inotropic support, severe metabolic acidosis, hypothermia with coagulopathy, etc.) [12]. In such situations, the surgeon may limit the initial intervention to washout of the abdomen, placement of drains, and possibly a defunctioning ostomy and leaving the abdomen open with a plan for definitive resection once the patient's condition has stabilized. If the patient is hemodynamically stable, then the surgical procedure can address both the obstructing tumor and the proximal perforation, where applicable.

In the case of a right-sided tumor with perforation, an oncological right hemicolectomy with ileocolic anastomosis can be considered, though the increased rate of anastomotic leak in such situations (estimated at 3–15%) should be considered. A right hemicolectomy with ileostomy may be the safest approach in this situation as it avoids the potential risk of an anastomotic leak. In the scenario where there is a left-sided obstruction with perforation, an oncological resection with end colostomy should be considered with the proviso that the proximal colon appears viable with no concern for compromise of the cecum. In the situation where there is left-sided obstruction with a proximal colon perforation or concern for colon viability, a total abdominal colectomy should typically be performed.

Right-Sided Colonic Obstruction (Cecum to Distal Transverse Colon)

While the right colon's wide diameter and typical liquid contents render it less vulnerable to obstruction, right-sided cancers still account for approximately 30–40% of cases of malignant LBO [19, 20]. In contrast to left-sided LBO, oncological resection and anastomosis have been traditionally undertaken for right-sided LBO due to the perceived relative ease of the procedure and relatively low risk of anastomotic complications. However, contemporary studies should temper this perception. Mege reported on a prospective audit of 776 patients who presented with malignant LBO secondary to right-sided colon cancer; 92% had the primary tumor resected, and 82% had an anastomosis formed. The high postoperative mortality rate (10%) and anastomotic leak rate (14%) have been replicated in other studies [19, 20, 23]. While most patients will do well with resection and anastomosis, there is no robust data to guide the surgeon regarding which patient might be better served with resection with some form of ostomy (either end or covering loop). Surgeons' intraoperative judgment (including an assessment of intraoperative blood supply and tissue quality) remains integral to the decision-making pertaining to restoring intestinal continuity or creating an ostomy in these complex situations.

Left-Sided Colonic Obstruction (Splenic Flexure to Rectosigmoid)

There has been an evolution in the approach to managing LBO secondary to left-sided colorectal cancer (CRC) over the past 30 years. Creation of a loop colostomy had traditionally been the first stage of a two- or three-stage approach to LBO under these circumstances. Colostomy creation allows decompression of the colon with subsequent tumor resection (second stage) followed by colostomy closure (third stage). The downside of this approach is that the tumor is not resected at the time of the first surgery; several studies have shown equivalence in outcomes between patients undergoing defunctioning colostomy alone and primary tumor resection. A randomized, controlled trial comparing defunctioning loop colostomy and primary resection reported no significant differences in terms of morbidity rate or overall survival between the two approaches [24], a finding endorsed by a Cochrane systematic review [25]. Thus, one would advocate for oncological resection when feasible and reserve loop colostomy formation for very frail patients where an expeditious, palliative procedure to relieve the obstruction is required or in those with unresectable disease.

Surgical dogma has dictated that to undertake a primary anastomosis in the setting of colectomy for a left-sided LBO is too hazardous, as a combination of bowel wall edema and an unprepared colon made fashioning an anastomosis ill-advised. Hence, a Hartmann procedure with resection of the obstructing mass, stapling off the distal segment, and creation of an end colostomy has been one of the most common procedures performed in this setting. Intraoperative colonic irrigation or lavage was developed to address the concerns over anastomosis creation in the setting of an unprepared colon. The system can be accessed via an enterotomy or through the base of an amputated appendix to allow for decompression alone or decompression with antegrade, on-table lavage (OTL) of the colon. Lim randomized 49 patients with malignant left-sided LBO to either intraoperative colonic decompression alone or OTL [26]. There was a significant difference in time taken for OTL (31 minutes) versus that for decompression alone (13 minutes, $p = 0.005$). There was no significant difference in overall morbidity between the groups. In the decompression group, 2 of 25 patients developed an anastomotic leak (8%) requiring reoperation, but none (0/24) in the OTL group leaked. However, this difference was not statistically significant [26].

Segmental Versus Total Colectomy

An extended colectomy with either ileosigmoid anastomosis (subtotal colectomy) or ileorectal anastomosis (total colectomy) has been proposed as an alternative to segmental colectomy and stoma creation as a way to avoid creating an anastomosis in a distended, stool-filled colon. This is a preferable approach in the presence of proximal colonic ischemia, cecal serosal tearing not amenable to primary repair, or a synchronous colon lesion. Multiple case series report outcomes after total colectomy and anastomosis with anastomotic leak rates of 0–10% and mortality rates of 0–11% [27, 28]. One major concern raised about this approach is that of medium- and long-term bowel function after a total colectomy and ileorectal anastomosis compared to that of patients undergoing a segmental colectomy. This question was addressed in the SCOTIA randomized trial where 91 patients with LBO were randomized to either segmental colectomy (SC) with or without on-table lavage (OTL) or subtotal colectomy (STC) [29]. No significant differences in anastomotic leak or overall mortality rates were observed between the SC and STC groups. However, patients in the STC group were significantly more likely to report increased bowel frequency (defined as ≥3 bowel motions per day) compared to the SC group (41% versus 9%, respectively, $p = 0.01$), and this difference persisted at 4-month follow-up [29].

Multiple prospective case series show that primary resection with anastomosis for malignant LBO can be performed with reported anastomotic leak rates of 2–12% [20, 30, 31] which is not dissimilar to outcomes reported after elective left-sided resections (2–8%) [28, 32–34]. However, it should be stressed that non-randomized studies are inherently subject to confounding bias, in that surgeons are more likely to fashion an anastomosis when intraoperative parameters are favorable (e.g., no or minimal contamination, healthy proximal colon, good mesenteric blood supply, negative leak test, etc.) in a physiologically stable patient and are more likely to divert when these factors were not present. The potentially disastrous consequences of an anastomotic leak in such a setting cannot be overstated and may lead to life-threatening sepsis and the inability to proceed with adjuvant chemotherapy in a timely fashion. Thus, risk stratification and surgical judgment are crucial in such cases. The Association of Coloproctology of Great Britain and Ireland (ACPGBI) Malignant LBO audit identified that patient age, American Society of Anesthesiologists (ASA) grade, operative urgency, and cancer stage were all significantly associated with in-hospital postoperative mortality [20].

To date, there is no randomized, controlled trial examining whether a diverting loop ostomy is efficacious after resection and anastomosis for malignant LBO. Kube reported the outcomes of 743 patients who underwent resection for malignant LBO; 58% had primary resection and anastomosis, 30% had a Hartmann procedure, and 12% had a primary resection and anastomosis with diverting loop ileostomy [35]. No significant differences were observed between groups who underwent primary anastomosis with or without a diverting ileostomy in terms of anastomotic leak rate (7% and 8%, respectively) or reoperation (5.6% and 5.7%, respectively).

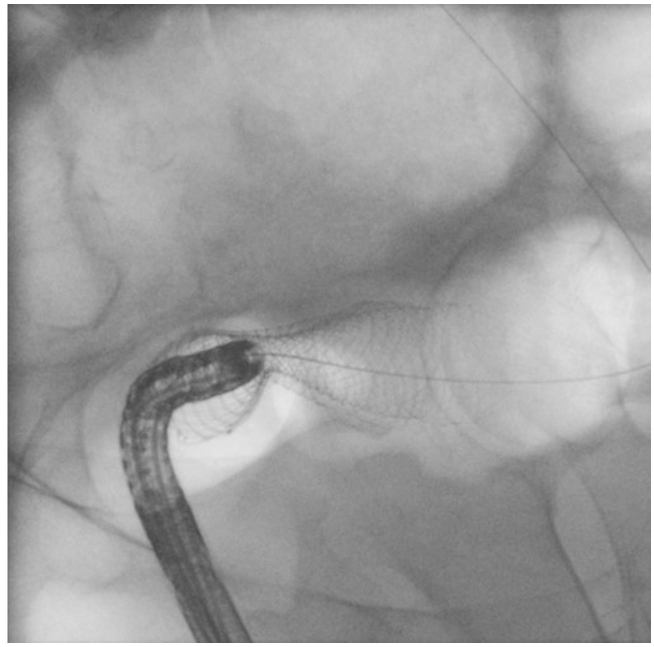

Fig. 39.2 Fluoroscopic image after deploying a self-expanding metallic stent over a guidewire. Note the waist in the mid-portion of the stent signifying the point of the obstructing cancer. (Courtesy of Daniel L. Feingold, MD)

As an alternative to operation, self-expanding metallic stents (SEMS) were originally developed to palliate obstructive symptoms from unresectable tumors or in patients deemed too frail to undergo surgical resection. SEMS involves the endoscopic deployment of a guidewire across the obstructing mass, often facilitated by fluoroscopy, followed by deployment of a stent delivery system (Fig. 39.2). The historically high rate of ostomy formation and morbidity associated with emergent resection for patients with malignant LBO led to studies exploring the deployment of SEMS in these patients to decompress the colon and to act as a bridge to a subsequent elective or semi-elective colonic resection, allowing time for patient optimization before surgery (Fig. 39.3a, b). Observational studies supported the concept that SEMS placement was associated with a reduction in stoma and morbidity rates compared to historical cohorts undergoing surgical resection [36]. However, concerns have been raised about possible tumor cell dissemination after stenting, especially in cases complicated by iatrogenic perforation (Fig. 39.4) [37].

To date there have been eight relatively small randomized, controlled trials comparing SEMS as a bridge to elective surgery compared to emergent surgery. Three of these trials were terminated prematurely due to a higher than anticipated event rate (two in the stenting arm and the third in the surgery arm). The Dutch Stent-In 2 trial was stopped when

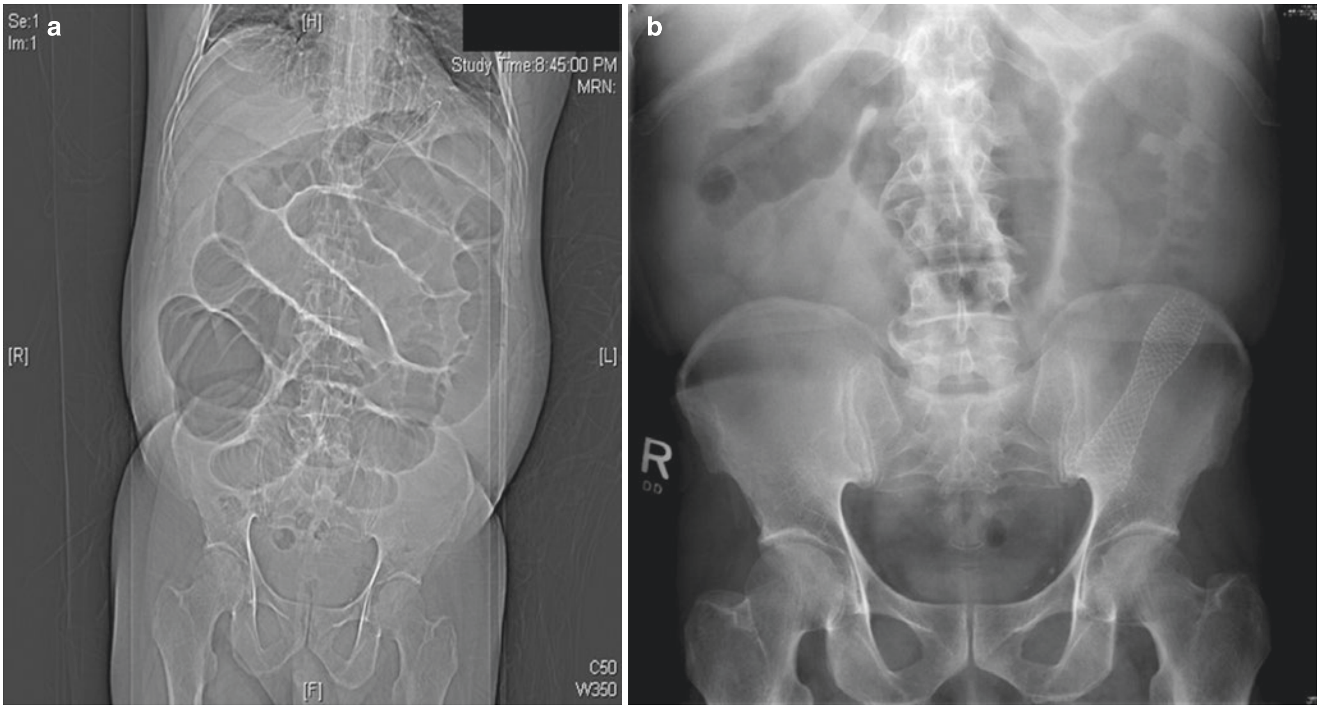

Fig. 39.3 (**a**) CT scan topogram demonstrating small bowel obstruction secondary to a large bowel obstruction in a patient with an obstructing left colon cancer with an incompetent ileocecal valve. (**b**) Abdominal radiograph demonstrating successful decompression after stenting. (Courtesy of Daniel L. Feingold, MD)

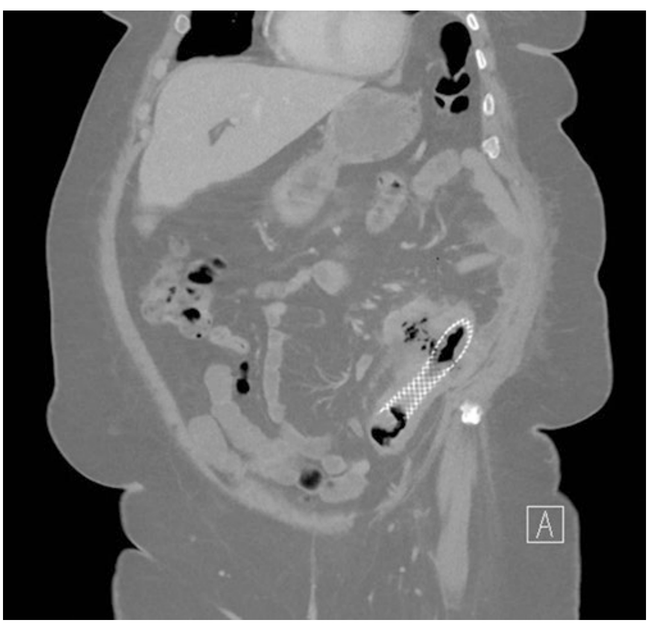

Fig. 39.4 Coronal CT scan image showing a left-sided stent with evidence of perforation. (Courtesy of Daniel L. Feingold, MD)

an interim analysis revealed a higher than anticipated morbidity rate in the SEMS arm, mainly driven by a high rate of perforation (13%) [38]. The relatively high rate of failure to pass a guidewire across the mass (17%) raised the question whether or not appropriate advanced endoscopic personnel were staffing the trial sites. A second randomized, controlled trial by Pirlet was closed early when an analysis found that the primary outcome of decreased ostomy rate was not achieved in the SEMS group compared to the straight-to-surgery group [39]; this was due to the low rate of successful stent deployment. These studies highlight the advanced endoscopic skill level required to safely and effectively deploy this intervention on a consistent basis. Meanwhile, Alcantara prematurely closed their randomized trial due to a high rate of morbidity in the emergent surgery arm [40]. Arezzo [41] undertook a meta-analysis of eight randomized, controlled trials comparing SEMS as a bridge to surgery to straight to emergent surgery (ES). 497 patients were included, and there was no significant difference in 60-day mortality between the SEMS arm (9.6%) and the ES arm (9.9%, RR = 0.99, $p = 0.97$). However, there was a significant difference in the temporary ostomy rate favoring the SEMS arm (33.9%) compared to the ES arm (51.4%, RR = 0.67, $p < 0.001$).

The United Kingdom-based CREST randomized, controlled trial, the largest to date, randomized 246 patients to SEMS as a bridge to surgery versus straight to emergent surgery and was published in abstract form in 2016 [42]. Stenting workshops were held prior to the trial to standardize technical aspects of SEMS deployment. There was no significant difference in 30-day mortality between the SEMS arm (5.3%) and the surgery arm (4.4%) though the overall ostomy formation rates were markedly lower in the SEMS arm (45%) compared to the surgery arm (69%, $p < 0.001$).

Covered Versus Uncovered Stents

Uncovered stents were traditionally associated with increased rates of stent occlusion due to overgrowth through the stent interstices, while covered stents were thought to inhibit the rate of tumor ingrowth. However, covered stents may not anchor to the bowel well as effectively as an uncovered stent and may migrate more easily [43]. Mashar undertook a meta-analysis of a single randomized trial and nine observational studies comparing the outcomes of uncovered and covered stents. In this study, rates of successful stent deployment, perforation, and bleeding did not differ between the uncovered and covered stent groups, but the uncovered stent group was associated with a lower risk of tumor overgrowth (RR = 0.29, 95% CI 0.09–0.93, $p = 0.04$), decreased risk of stent migration (RR = 0.29, 95% CI 0.17–0.48, $p < 0.001$), and lower need for stent reinsertion (RR = 0.38, 95% CI 0.17–0.86, $p = 0.02$) [43].

Obstructing Rectal Cancer

It is rare for an extraperitoneal rectal cancer to cause LBO, and a locally advanced tumor is usually encountered. In this situation, emergent resection should be avoided, if possible, due to the higher risk of suboptimal surgical resection leading to poor oncological outcomes. Emergent management should focus on relieving the obstruction to facilitate appropriate clinical staging and neoadjuvant therapy followed by definitive surgical management in the form of a TME. SEMS placement in the extraperitoneal rectum is problematic due to the risk of stent migration and tenesmus [44]. A loop colostomy offers effective decompression under these circumstances but may compromise a future elective restorative procedure by damaging the marginal blood supply to the left colon. A loop ileostomy can be employed instead, though one must be circumspect about its use especially if the ileocecal valve is competent, as proximal colonic distension can persist.

Unresectable Disease

Approximately 10–15% of patients with malignant LBO may have unresectable disease at presentation due to local tumor infiltration [28] or metastatic disease or owing to a debilitated state such that it is not prudent to undertake an oncological resection. In the event there is no evidence of bowel ischemia or perforation, a diverting ostomy or a self-expanding metallic stent can be considered to effectively palliate.

Volvulus

Acute colonic volvulus (from the Latin *volvere* meaning to turn or twist) involves axial torsion of a redundant segment of the colon along its mesentery that results in a closed loop obstruction. Over time, the volvulized segment and the colon proximal to the volvulized segment can distend to the point of developing ischemia and perforation unless the patient experiences reduction of the volvulus either spontaneously or due to therapeutic intervention. While any mobile segment of the colon can volvulize, the condition most commonly occurs in the sigmoid colon (~60% of cases) and the cecum (~40% of cases). For unknown reasons, the twisting of sigmoid volvulus most commonly occurs in counterclockwise fashion, while cecal volvulus tends to twist in a clockwise direction. Volvulus of the transverse colon, splenic flexure, or other segments of the colon is rare.

Risk factors for developing colon volvulus include having amenable anatomy (e.g., redundant colon with a relatively narrow mesentery), constipation or colonic dysmotility, prior abdominal surgery, and prior volvulus. While sigmoid volvulus is more common in patients who are male, > 70 years of age, African American, diabetic, and institutionalized or have neuropsychiatric comorbidities, patients with cecal volvulus are typically younger and more likely female [45]. Colonic volvulus is relatively uncommon in the United States where only about 10–15% of large bowel obstructions and about 3–5% of all bowel obstructions are due to volvulus [45, 46]. In areas like Africa, the Middle East, India, Brazil, and South America (the so-called volvulus belt), volvulus is more endemic and may account for as many as 40% of bowel obstructions. The geographic variability in the incidence of volvulus is thought to be multifactorial and due in part to differences in diet, altitude, cultural factors, and certain kinds of infections [45].

Patients with volvulus often present with abdominal distension, decreased bowel function or obstipation, nausea, and abdominal pain. They may develop a secondary small bowel obstruction due to decompression of the colon through an incompetent ileocecal valve and can also present with vomiting. In cases where volvulus progresses to colonic ischemia and perforation, patients present with an abdominal catastrophe and sepsis. While patients presenting with signs and symptoms consistent with volvulus may have a differential diagnosis that includes the spectrum of etiologies for large bowel obstruction, imaging typically confirms the diagnosis. In emergency cases and cases where the imaging is not clear enough to establish the diagnosis, volvulus is confirmed at the time of exploration.

Given the constellation of symptoms and signs that patients can present with, abdominal radiographs and/or CT scan imaging are usually obtained as part of standard evaluation. Plain radiographs or CT topograms can demonstrate

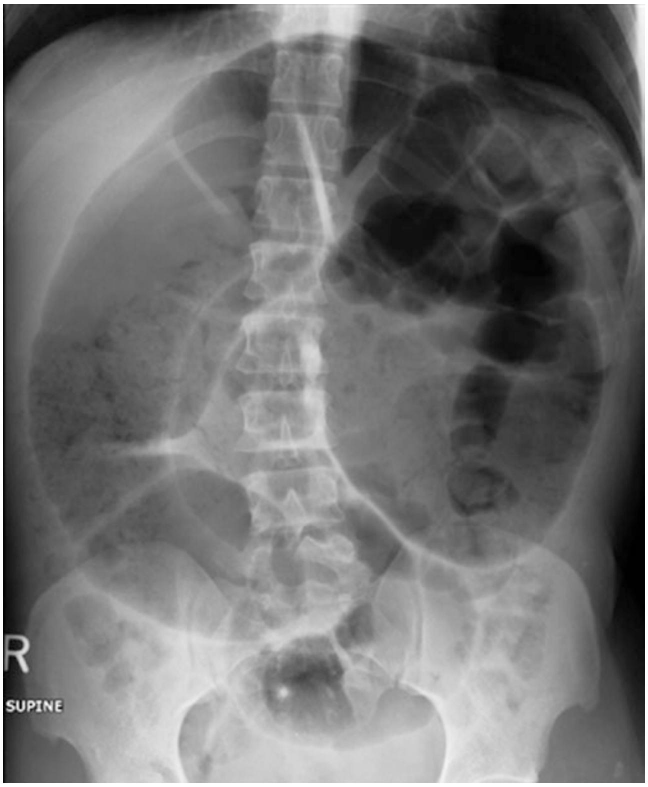

Fig. 39.5 Abdominal radiograph showing a typical sigmoid volvulus prior to decompression. (Courtesy of Daniel L. Feingold, MD)

Fig. 39.6 Abdominal radiograph showing typical cecal volvulus. (Courtesy of Daniel L. Feingold, MD)

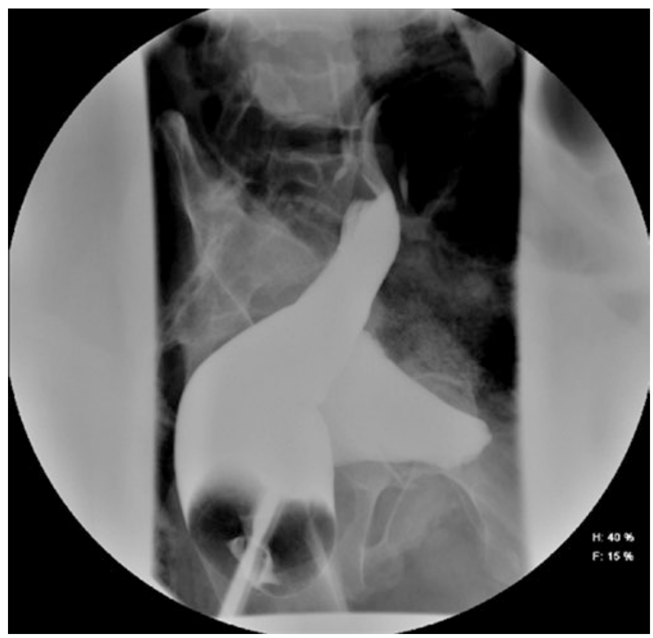

Fig. 39.7 Water-soluble contrast enema demonstrating a bird's beak sign from a sigmoid volvulus. (Courtesy of Daniel L. Feingold, MD)

classic findings consistent with volvulus such as a "coffee bean" or "bent inner tube" which describe the appearance of a massively dilated segment of volvulized colon (Figs. 39.5 and 39.6). The "northern exposure sign" describes the apex of the volvulized sigmoid loop cranial to the transverse colon. Water-soluble contrast enemas can reveal a "bird's beak" sign that reflects the tapering of the colon lumen due to the twisted distal limb of a sigmoid volvulus (Fig. 39.7). CT imaging may also reveal a "swirl" or "whirl" sign depicting the torsed mesenteric vessels due to the presence of a volvulus.

While historically plain radiographs and contrast enemas were used to investigate a possible volvulus, these modalities have effectively been supplanted by CT scanning with multiplanar reconstruction, which can diagnose volvulus with nearly 100% sensitivity and a specificity rate over 90% [47]. Importantly, CT imaging can also identify signs of complicated volvulus related to ischemia or perforation such as intravenous enhancement defects related to arterial occlusion, colon wall thickening related to venous occlusion, pneumatosis intestinalis, free peritoneal fluid, mesenteric or portal venous gas, and pneumoperitoneum. While CT scanning is the preferred modality to diagnose volvulus, depending on the degree of proximal bowel dilation, cross-sectional imaging can be challenging to interpret and may explain why some patients are not diagnosed until the time of exploration.

A cecal bascule is a rare entity distinct from volvulus in that there is no axial torsion across the mesenteric axis; in this situation, the caput of the cecum is displaced anteriorly and folds over the ascending colon closing off the cecum

[48]. In the setting of a competent ileocecal valve, this configuration can cause a closed loop obstruction. Cecal bascule may be demonstrated on cross-sectional imaging but is commonly diagnosed at the time of operative exploration. The evaluation and treatment for a patient with cecal bascule mirror those for cecal volvulus.

Another related anatomic variant that does not meet the criteria for volvulus, mobile cecum syndrome, is a poorly defined entity and postulated to be due to an embryologic abnormality whereby the lateral peritoneal attachments of the ascending colon are absent [49]. It is hypothesized that the resulting mobility of the cecum permits a degree of obstruction that can cause related symptoms. While the proposed treatment for this condition is laparoscopic cecopexy, it is not clear what the criteria are for intervening under these circumstances or what the outcomes are after cecopexy.

There is a paucity of high-quality or population-based evidence detailing the management of this condition. In practice, patients present or are referred in by primary care providers and gastroenterologists with episodic bloating, distension, and pain that resolve after an explosive, decompressive movement and with imaging demonstrating colon dilation but without evidence of volvulus. The concept of a "pre-volvulus" condition is not well described, and operative intervention under these circumstances, despite the insistence of patients or referring doctors, is not generally supported.

Sigmoid Volvulus

Nonoperative Methods for Devolvulizing a Sigmoid Volvulus

Patients with radiographic evidence of sigmoid volvulus without peritonitis, perforation, clinical instability, or sepsis are typically managed with an attempt at detorsion using endoscopy. Patients should be aware that procedures attempting to reduce a sigmoid volvulus risk failure as well as perforation. After obtaining appropriate consent, rigid proctoscopy can be performed at the bedside with the patient in the usual left decubitus position and without sedation. Proctoscopic detorsion is usually well tolerated. The rigid proctoscope is passed under direct visualization to the level of the torsion using air insufflation, as needed. The volvulized mucosa has a typical appearance one would expect from a twisting across the longitudinal axis of the colon which has been described as a pinwheel (Fig. 39.8). With continued insufflation and gentle manipulation of the colon lumen using the tip of the proctoscope, it is usually feasible to untwist the colon and intubate the more proximal sigmoid colon. Once the scope is advanced into what had been the volvulized segment of the colon, the window of the proctoscope is opened to vent the gas and liquid that had been trapped in the obstructed colon. The endoscopist should anticipate this maneuver to produce a dramatic decompression with efflux of the colon contents.

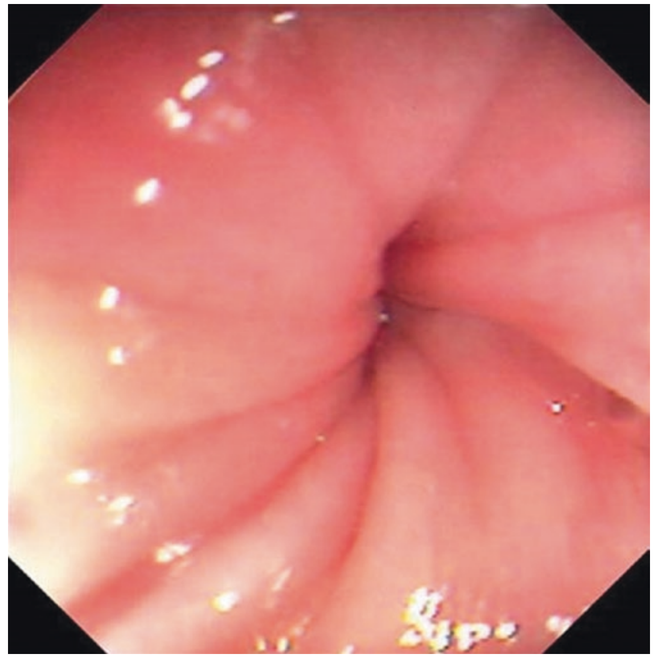

Fig. 39.8 Endoscopic appearance of the mucosa at the level of a sigmoid volvulus. Notice the classic pinwheel appearance of the mucosal folds

Upon successful intubation of the previously volvulized segment, the mucosa of the decompressed colon should be evaluated, and signs of ischemia should prompt a plan for colectomy. In the absence of concerning proctoscopic findings, a transrectal decompression tube should be placed not so much to allow for venting through the tube (this typically clogs with stool) but to stent the previously volvulized segment so that the volvulus does not recur immediately; this affords the patient the ability to continue to decompress and, depending on the individualized plan, to undergo a bowel preparation in anticipation of semi-elective colectomy in the following days. A semi-rigid chest tube passed through the proctoscope and sutured to the perianal skin can adequately function in this capacity. After an apparently successful detorsion, it may be helpful to obtain abdominal radiographs to document the location of the rectal tube and the degree of decompression, as well as to confirm the absence of free air (Fig. 39.9).

As an alternative to rigid proctoscopy or in uncommon cases where the level of the sigmoid volvulus is more proximal than the reach of a proctoscope, flexible sigmoidoscopy can be performed. This procedure may be performed with a water immersion technique or using gas insufflation, as needed, and the rectal tube that is passed is usually thinner and more flexible than rectal tubes that are passed through a proctoscope [50]. In some situations, fluoroscopic guidance

Fig. 39.9 Abdominal radiograph demonstrating the patient in Fig. 39.5 after successful proctoscopic detorsion and rectal tube insertion. (Courtesy of Daniel L. Feingold, MD)

can aid in successfully advancing the flexible scope under these circumstances. Nonoperative detorsion is relatively straightforward and is successful in 60–95% of cases and carries a low morbidity rate [51, 52]. Nonetheless, there is an estimated 3% mortality rate associated with detorsing a sigmoid volvulus which is considered to be a reflection of the patient population typical for volvulus rather than the actual procedure for reducing the volvulus [47].

After successful nonoperative detorsion, patients are observed as they decompress. In general, sigmoid colectomy should be considered after resolution of the acute phase of sigmoid volvulus, specifically in order to prevent recurrent volvulus [52]. The risk of recurrence after a first admission for sigmoid volvulus is estimated at 45–70% or even higher, depending on the length of follow-up, with a majority recurring within the first few months after successful nonoperative decompression [47, 51, 53, 54]. A common teaching and practice is to proceed with semi-elective resection during the same hospitalization, though patients may prefer to return on a more elective timeline, ideally soon after the index hospitalization [52]. Given that the sigmoid volvulus patient population is typically elderly with comorbidities, the decision to proceed with elective, interval sigmoidectomy under these circumstances should be individualized. In addition, it is important to consider the need for colonoscopy, or possibly CT colonography, prior to proceeding with colectomy in the non-emergent setting [55].

Surgery for Sigmoid Volvulus

Patients with evidence of perforation or concern for ischemia should be treated with broad-spectrum antibiotics and intravenous fluid resuscitation as the operating room is being mobilized and typically undergo exploratory laparotomy. Colon ischemia and peritonitis are the main risk factors for mortality related to volvulus; the mortality of volvulus presenting as an emergency may be as high as 33% or even higher [45, 47]. As with elective or semi-elective surgery for sigmoid volvulus, a laparoscopic approach may be utilized depending on the specific patient circumstances and the available expertise. However, even after endoscopic detorsion and decompression, the redundant sigmoid colon typically remains dilated to some degree and has a much larger diameter than a typical otherwise normal sigmoid colon. This anatomy can be difficult to negotiate within the domain of a laparoscopy, and the nature of the redundant colon is such that it usually prolapses out readily, if not spontaneously, through a relatively short midline laparotomy (Fig. 39.10). In addition, the splenic flexure does not typi-

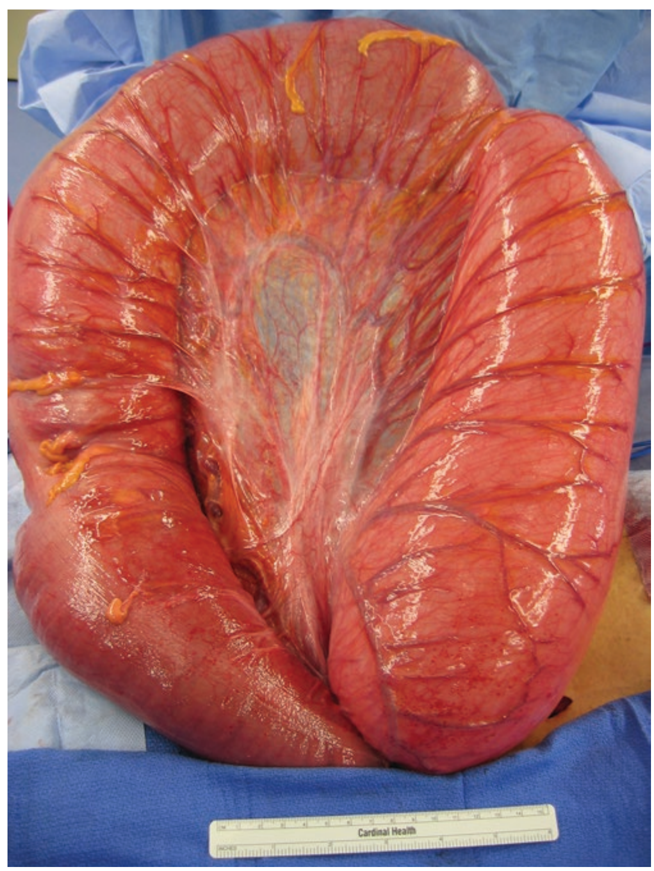

Fig. 39.10 Typical appearance of a sigmoid volvulus prolapsing through a laparotomy incision. (Courtesy of Daniel L. Feingold, MD)

cally need to be released for this operation, obviating the need for operative access to the left upper quadrant. Commonly there is fibrosis observed along the peritoneum overlying the mesocolon which is not thought to be a causative factor in volvulus, but rather a result of prior episodes. While it is relatively common to observe redundancy in other segments of the colon upon exploration, elongation in and of itself is not generally considered an indication for extended resection under these circumstances.

The most common operation performed for sigmoid volvulus is colectomy with the goal of resecting the redundant sigmoid colon in order to minimize the risk for recurrent volvulus [45, 46, 54]. In cases of cecal perforation complicating sigmoid volvulus, a subtotal colectomy is typically performed in order to address the different sites of pathology. Another indication for extended resection is when the colon proximal to the volvulized loop is ischemic due to the colonic obstruction; in these cases, the distribution of the ischemia is often patchy and diffuse, again requiring subtotal colectomy. In patients with sigmoid volvulus and concomitant megacolon, subtotal colectomy can effectively prevent recurrent volvulus at an otherwise retained segment of the colon [52].

The general recommendation for dealing with patients with a gangrenous, volvulized segment of the colon is to resect the loop without reducing the twist in order to try to prevent a load of potassium, bacteria, and endotoxin from entering the circulation and to minimize manipulation of the colon which can lead to perforation of the diseased segment. In practice, the anatomy of a volvulized segment folds the mesentery over itself, making it difficult to control coming across the mesentery without untwisting the colon, though modern-day energy devices are usually capable of coming across this thickness of tissue. While an oncologic operation with a nodal catch is not required under these circumstances, it is usually technically helpful to ligate the main mesenteric pedicle rather than repeatedly come through the mesentery closer to the colon wall. Meanwhile, an unwieldly sigmoid loop can impede dissecting the base of the mesentery and identifying the left ureter. The surgeon should be aware of these options, and it may be preferable to avoid dissecting near the retroperitoneum and use a mid-mesenteric plane of dissection. As with operations for other causes of large bowel obstruction, it may be helpful to decompress the colon in a controlled fashion to facilitate mobilization.

Once the diseased colon has been resected, a decision can be made regarding whether or not to restore bowel continuity. In emergency volvulus operations, the decision is based on individualized risk assessment and the clinical status of the patient. Ideally, patients will have been sited and marked for stoma location preoperatively. In semi-elective or elective operations for previously detorsed sigmoid volvulus, patients will commonly have an anastomosis created. It is common to have a wide diameter end of the colon coming down to the anastomosis which can be suboptimal when seating the anvil of an end-to-end mechanical stapler. In this situation, it may be particularly helpful to close the end of the colon with a linear stapler and perform a side-to-end Baker-type anastomosis.

Non-resectional operations that are alternatives to sigmoidectomy include simple operative detorsion alone, mesosigmoidoplasty, and sigmoidopexy [52]. These approaches spare the risk of morbidity related to stoma creation or creating an anastomosis but are associated with much higher rates of recurrent volvulus [45–47].

Another potential alternative option for treating patients with sigmoid volvulus is percutaneous endoscopic colostomy (PEC) or sigmoidopexy to restrict the mobility of the colon and reduce the risk of recurrent volvulus [56]. Patients considered to have a prohibitive operative risk or who otherwise decline to undergo abdominal surgery may be candidates for endoscopic fixation of the sigmoid colon to the anterior abdominal wall which is usually done under conscious sedation. This procedure can also be combined with laparoscopy to ensure proper alignment of the colon prior to fixation, to guide where along the length of the colon fixation is performed, and to decrease the risk of injury to nearby structures related to the endoscopic procedure [57]. While the approach is relatively straightforward and may even be performed at the time of endoscopic detorsion, there is no universally accepted PEC technique, and questions remain regarding how many points of fixation are used (typically one versus two) and when to remove the devices from the abdominal wall, as early removal has been associated with recurrent volvulus. Furthermore, although this approach is considered minimally invasive, minor and even major complications have been reported, ranging from infection or bleeding at the PEC site to peritonitis from PEC migration or dislodgement due to recurrent volvulus. Given that patients treated with PEC typically have significant comorbidities that preclude abdominal surgery, even minor complications related to an endoscopic procedure can have severe consequences. In reports of PEC that provide follow-up data, this particularly vulnerable patient population has a significantly high mortality rate after PEC from unrelated causes.

Cecal Volvulus

In contrast to sigmoid volvulus, the success of nonoperative detorsion of a cecal volvulus is low, and the general consensus is not to delay operation and risk ensuing ischemia, necrosis, and perforation. Patients diagnosed with cecal volvulus are considered to have a surgical emergency even in the absence of overt sepsis and are typically given broad-spectrum antibiotics and intravenous fluid resuscitation as the operating room is mobilized. As with cases of sigmoid volvulus, the surgical approach, open versus laparoscopic, depends on the specific clinical circumstances and the available expertise; but the typical size of a cecal volvulus specimen is such that a meaningful extraction incision is usually unavoidable. In addition, as with a sigmoid volvulus, it can be difficult to laparoscopically negotiate the dilated, displaced, and elongated colon.

The most common operation performed to treat and prevent recurrent cecal volvulus is ileocolectomy with anastomosis [54]. In cases where creating an ileocolic anastomosis is considered too high risk, an end ileostomy with or without mucous fistula is performed. In certain circumstances, unstable patients may be resected, left in discontinuity, and brought back for a “second look” with possible anastomosis at that time. As with sigmoid volvulus, there are a number of non-resectional alternatives like simple detorsion alone, cecopexy, or cecostomy that may be considered in cases of cecal volvulus, but these approaches carry risks of morbidity including recurrent volvulus. While there is a role for individualizing the operative treatment in cases of volvulus, consideration of the risks and benefits will most commonly favor resection-based therapy [52, 55].

Ileosigmoid Knotting

While rare in the United States, this entity is more common in areas where volvulus is endemic, such as countries in the volvulus belt. Multiple configurations of knotting have been described, but all involve the ileum and sigmoid colon wrapping around each other in some fashion causing obstruction and frequently progressing to ischemia in one or both segments. This “double-loop” obstruction is associated with a poor prognosis, and patients present commonly with an abdominal catastrophe; the mortality in these cases can be as high as 73% [47, 58]. The diagnosis of ileosigmoid knotting can be made by cross-sectional imaging but is often made at the time of surgical exploration. The combination of imaging demonstrating sigmoid volvulus with a secondary small bowel obstruction and inability to reduce the sigmoid volvulus endoscopically may raise the suspicion of ileosigmoid knotting. Operative treatment depends on the specific anatomic variant encountered and often involves a double resection of the involved anatomy with or without restoration of bowel continuity depending on the anatomy and the circumstances.

Acute Colonic Pseudo-obstruction

Acute colonic pseudo-obstruction (ACPO) is generally considered to result from an imbalance or derangement of parasympathetic inhibition and/or sympathetic stimulation that impairs colonic motility leading to colon dilation in the absence of a mechanical source of obstruction. The prevailing hypothesis is that overall decreased parasympathetic tone in the area of the splenic flexure colon results in a relatively atonic segment that functions like an obstruction [59]. This condition may be referred to by a variety of terms including Ogilvie’s syndrome, colonic ileus, acute megacolon, etc. The exact pathophysiologic mechanism underlying ACPO remains unclear, but the autonomic dysregulation involved is likely multifactorial and occurs most often in the setting of predisposing factors [59]. ACPO is rarely a primary diagnosis and is most commonly diagnosed in the setting of patients with some other active illness or state [60]. The dysregulation of the autonomic impulses in the enteric nervous system of the colon is likely part of a syndrome manifesting a more global process as described below [61].

While the exact incidence is unknown, ACPO is considered to be rare and is estimated to occur in 100 of every 100,000 admissions annually in the United States [62, 63]. Patients typically are elderly with medical comorbidities who have been hospitalized for an acute illness, nonoperative trauma, or metabolic disarray or are recovering from a recent surgery (including caesarean section). Many patients predisposed to developing ACPO are also maintained on medications that can affect colonic motility (e.g., opioids, calcium channel blockers, psychotropics, etc.), and these medications may be manipulated to facilitate treatment.

Patients who develop ACPO are typically already hospitalized, have severe or even massive colon dilation, and have symptoms and signs that may include abdominal distension, tympany, nausea, abdominal pain, decreased or absent bowel activity, or diarrhea. The degree of abdominal distension can cause respiratory symptoms by displacing the diaphragm. Right lower quadrant tenderness, signs of sepsis, or diffuse abdominal pain may signify ischemia with impending perforation.

While there is no universally accepted definition or criteria for diagnosing ACPO, patients in the appropriate clinical circumstances with imaging demonstrating a cecal diameter ≥ about 9 cm or other colonic segments ≥ about 6 cm may be classified as having ACPO. Radiologic imaging by way of abdominal radiographs or cross-sectional imaging typically demonstrates dilated, gas-filled colon with cecal dilation and with a transition to more normal colon in the area of the splenic flexure (Fig. 39.11). Interestingly, in this area of the colon (about where the midgut transitions to the hindgut), there is a transition in colonic innervation, supporting the concept of autonomic dysregulation as part of the underlying etiology of ACPO. When considering the diagnosis of ACPO, it is important to confirm there is no mechanical point of obstruction causing a large bowel obstruction (whether intrinsic or extrinsic to the colon) as these patients are treated according to a different algorithm. While it is usually possible to exclude a mechanical obstruction by reviewing CT scan imaging, in certain cases, it may be helpful to verify the anatomy by obtaining a water-soluble

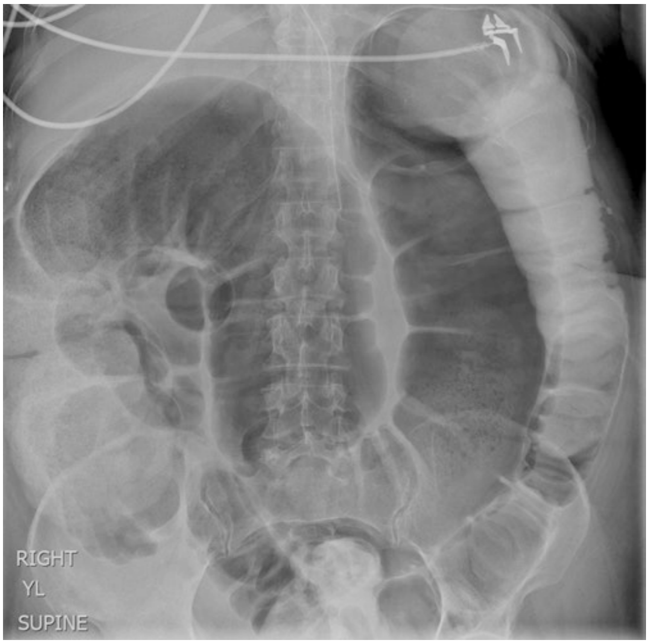

Fig. 39.11 A serial abdominal radiograph of a patient being treated for acute colonic pseudo-obstruction. Notice the dilated right and transverse colon and the relatively decompressed descending colon. Oral contrast has passed through the pseudo-obstructed colon. (Courtesy of Daniel L. Feingold, MD)

contrast enema study. Patients presenting with signs and symptoms consistent with ACPO carry a differential diagnosis similar to other etiologies of large bowel obstruction (Table 39.1). Toxic megacolon from an infectious source or from inflammatory bowel disease should also be considered in appropriate circumstances, as this can mimic the presentation and imaging seen in cases of ACPO. Cross-sectional imaging, as with cases of volvulus, can also reveal signs of colon ischemia that would prompt proceeding with surgery.

Medical Therapy

Patients who develop ACPO can progress to critical colonic distension, which increases the transmural pressure, resulting in ischemia from inadequate perfusion and, ultimately, perforation with peritonitis and even death. As with other etiologies of colon obstruction, the most common site of perforation is the cecum due to its increased diameter as compared to the rest of the colon as predicted by the law of Laplace [63]. The likelihood of experiencing these sequelae increases as the cecal diameter distends beyond about 10 cm and as the duration of distension approaches or exceeds about 6 days (Fig. 39.12) [51]. Although larger-diameter cecal dilation is associated with higher risk of perforation, the duration of distension and the acuity of how quickly the colon distends are important factors and contribute to perforation even in cases with less extreme degrees of dilation [64, 65]. The mortality

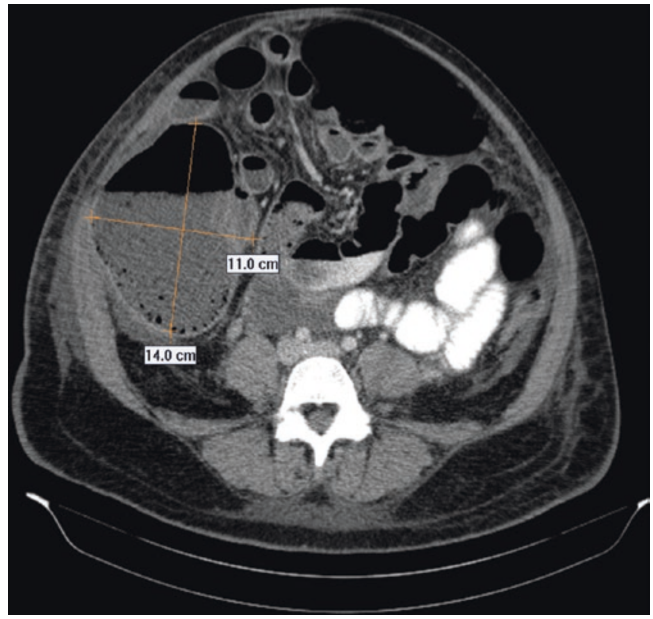

Fig. 39.12 Axial CT scan image measuring the cecal dimensions in the setting of acute colonic pseudo-obstruction. (Courtesy of Daniel L. Feingold, MD)

rate associated with ACPO is higher in cases of perforation, ranges from about 10% to as high as 30–40%, and reflects the potential seriousness of the clinical entity as well as the population of patients prone to develop this unique form of large bowel obstruction [59, 60]. Early recognition and appropriate therapy to decompress the colon under the circumstances are important and clearly influence outcomes.

Patients with ACPO with complicating factors like ischemia, perforation, or signs of sepsis require urgent operation as discussed below. Otherwise, the initial management of a patient diagnosed with ACPO includes instituting bowel rest, eliminating or reducing potentially confounding or causative factors (e.g., narcotics and other medications that may influence colonic motility), encouraging ambulation and patient positioning to potentially facilitate colonic activity, correcting metabolic derangements, and decompressing the system with nasogastric and/or rectal tubes. In general, oral laxatives are contraindicated under these circumstances as these can increase intraluminal pressure [65]. This kind of supportive therapy is successful in resolving ACPO in 77–96% of patients [51]. Serial evaluations with physical examination, blood work, and imaging are important in order to determine the response to therapy and whether or not a patient requires escalation in treatment. The management of patients with ACPO usually requires coordinated, multidisciplinary care from medicine, gastroenterology, and surgery services. Patients who clinically worsen or fail to improve within about 48–72 hours of instituting medical therapy or who have cecal diameter of about 12 cm usually proceed with pharmacotherapy.

Pharmacotherapy

Neostigmine is the agent of choice for managing ACPO under these circumstances although it is *not FDA approved* for this indication. Neostigmine methylsulfate is a short-acting, competitive acetylcholinesterase inhibitor that reduces the breakdown of acetylcholine, effectively increasing the concentration of acetylcholine in the synaptic cleft (i.e., it is a parasympathomimetic agent). The efficacy of neostigmine supports, to some degree, the proposed pathogenesis of ACPO reviewed above. Placebo-controlled, double-blinded, randomized trials demonstrate that intravenous neostigmine (typically 2 mg over 3–5 minutes) is effective in 85–94% of cases and are the basis for the off-label use of this drug in patients with ACPO [66]. Neostigmine usually results in clinical decompression within about 10–30 minutes and has a half-life of about 60 minutes. Redosing neostigmine in patients who did not respond adequately to a first dose is successful in 40–100% of cases [67]. Risk factors associated with failure of neostigmine include male gender, younger age, postoperative status, and electrolyte imbalances [62]. After successful decompression, daily polyethylene glycol has been demonstrated to decrease the risk of recurrent ACPO [67].

Given the potential side effects of bradycardia and respiratory distress, neostigmine should be administered in a continuously monitored setting with access to the variety of supportive medications (e.g., atropine) and devices in the event cardiac or respiratory support or resuscitation is needed. Administering glycopyrrolate may prevent side effects like bronchospasm and hypersalivation. Neostigmine is contraindicated in patients with intestinal or urinary tract obstruction or known hypersensitivity and should be used with caution in patients with bradycardia, asthma, renal insufficiency, peptic ulcer disease, or recent myocardial infarction.

It is generally believed that rates of endoscopic and operative interventions for the treatment of patients with ACPO have decreased in recent decades because of the wider recognition of the syndrome as well as the efficacy of medical therapy and of appropriate pharmacotherapy [62]. While neostigmine has traditionally been administered via intravenous bolus delivery, subcutaneous and continuous infusion protocols are also effective and may be associated with fewer side effects. Other agents may be tried in cases of refractory ACPO including oral pyridostigmine, a long-acting acetylcholinesterase inhibitor; methylnaltrexone, a peripherally acting μ-opioid receptor antagonist; and prokinetics like metoclopramide and erythromycin.

Colonic Decompression

Patients who do not respond adequately to supportive measures and fail neostigmine therapy may be treated by colonoscopic decompression with a success rate as high as 95% [61]. While colonoscopy in this setting carries the usual risks of the procedure including perforation, typical patients hospitalized with ACPO have comorbidities and have not had a bowel preparation; they may be at higher than usual risk when undergoing colonoscopy in this setting. As with other etiologies for bowel obstruction, these patients require careful attention to protect their airway while undergoing a procedure under sedation. While there is some evidence supporting endoscopic decompression as superior to pharmacotherapy, given the low cost, overall safety, and efficacy of neostigmine and the cost and risks related to endoscopic decompression, colonoscopy is generally reserved as a second-line treatment [68].

In cases of ACPO, colonoscopy is generally performed using water immersion or minimal CO_2 insufflation rather than ambient air with the goal of evacuating as much colonic gas as possible. The sedation for these cases usually relies on benzodiazepines and other non-narcotics, as narcotics can interfere with colonic motility. The goal of insertion, in general, is to reach the ascending colon rather than the cecum, upon which a long intestinal tube can be deployed to effectively stent the colon allowing for continued postprocedure decompression. Repeated colonoscopy may be required in as many as 40% of patients, especially if a long decompression tube is not utilized. Often symptoms of ACPO resolve within about 48 hours after successful colonoscopic decompression [60]. Case reports detail treating patients with endoscopic or CT-guided percutaneous cecostomy to vent and decompress patients with ACPO, but the utility of these approaches is not well documented [65].

Surgical Therapy

While patients with perforation or concern for ischemia require exploration, patients who do not resolve their ACPO should be considered for exploration in order to decompress the colon prior to developing an emergency indication for operation. The timing and circumstances of proceeding with surgery under these circumstances are variable and should be individualized especially in light of the mortality rate associated with surgery in the setting of ACPO, which is variably reported as about 30% and as high as 60% [65]. In a retrospective review of the National Inpatient Sample, ACPO patients treated with medical therapy, colonoscopic decompression, or surgery experienced higher mortality rates with each escalation in therapy documented as 7.3%, 9.0%, and 12.3%, respectively [62]. In practice, patients without a firm indication for operation may undergo continued medical therapy with repeated attempts of pharmacotherapy and/or endoscopic decompression before ultimately moving to a surgical intervention.

In terms of operative options in the setting of medically refractory ACPO, patients with viable colon without perforation most commonly undergo exploration to confirm there is no compromised colon and are then decompressed and vented through a colostomy. The role of colectomy under these circumstances is questionable. Meanwhile, patients with ischemic colon and/or perforation require resection of the diseased segment and are commonly left with an end stoma. The extent of the resection under these circumstances depends on the operative findings and clinical course.

Rare Causes of LBO

Intussusception

Intussusception accounts for only 1–3% of mechanical bowel obstructions in the adult population; a demonstrable lesion can be found in 80% of cases [11]. The classic triad of symptoms seen in pediatric intussusceptions (abdominal pain, vomiting, and red currant stools) is rare in adults who tend to present in a non-specific manner [69]. While the most common cause of large bowel intussusception is malignancy (65–87% of cases), benign processes can be implicated and include adenomatous polyps, GISTs, diverticular disease, and villous adenoma of the appendix [11, 70]. CT scan, the most accurate modality to diagnose an intussusception, has a reporting accuracy of 58–100% and can show a characteristic target or sausage-shaped lesion [71]. While colonoscopy can be a useful adjunct to identify a benign lead point such as an adenomatous polyp, concern has been raised that endoscopic reduction of an intussusception could theoretically result in the dissemination of malignant cells if a cancer is present [72]. Given the high incidence of malignancy as the lead point, there should be a low threshold for surgical exploration and an oncological resection of the affected segment.

Hernia

Abdominal wall hernias are a very rare cause of LBO due to the colon's larger caliber and relatively fixed nature. Femoral, inguinal, umbilical, incisional, Spigelian, lumbar, and diaphragmatic hernias can contain large bowel and cause LBO [11]. The management in these cases should follow principles of bowel rest and fluid resuscitation and typically requires surgical exploration.

Infection

While a rare cause of LBO, infectious causes such as actinomycosis can occur where the infection leads to a desmoplastic reaction with multiple abscesses causing extrinsic compression of the colon and LBO. Treatment in these cases can include defunctioning ostomy, directed antimicrobial therapy, and/or surgical resection [3]. LBO can occasionally be seen with abdominal *Mycobacterium tuberculosis* which is typically treated with antibiotic therapy [73]. LBO can also occur secondary to worms arising from schistosomiasis or helminthic infections.

Endometriosis

While endometriosis is a relatively common condition (affecting 8–15% of women), it accounts for less than 1% of cases of bowel obstruction [74]. Intestinal endometriosis can cause luminal stenosis secondary to serosal infiltration, with the rectosigmoid being the most common site of intestinal endometriosis. Most of the literature pertaining to LBO secondary to endometriosis is comprised of case reports that utilize fecal diversion; stent placement and resection have been reported [3, 75].

Other Malignancies

While colorectal cancer accounts for 50–60% of cases of LBO, other malignancies including ovarian, gastric, pancreatic, and bladder can be responsible. With these pathologies, LBO occurs due to intraluminal obstruction, intramural blockage, or extrinsic compression. Management options should be based on clinical presentation and disease extent. A defunctioning ostomy can help relieve the obstruction and may allow for appropriate staging and cancer therapy. Lymphoma accounts for less than 0.5% of colorectal malignancies but can cause LBO. Perforations of large bowel lymphomas are treated by resection with or without anastomosis. Colonic obstruction secondary to lymphoma may be treated with resection, defunctioning ostomy, stenting, or possibly chemoradiation [76].

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