Colonic ischemia

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INTRODUCTION

Intestinal ischemia is caused by a reduction in blood flow to a level that is insufficient for the delivery of oxygen and nutrients required for cellular metabolism [1]. It can be related to acute arterial occlusion (embolic, thrombotic), venous thrombosis, or hypoperfusion of the mesenteric vasculature causing nonocclusive ischemia. The incidence is estimated at 16 cases per 100,000 person-years, which has increased over time [2].

Colonic ischemia is the most frequent form of intestinal ischemia, most often affecting older adults [3]. Colonic ischemia may be more prevalent in women. Colonic ischemia should be suspected in patients with lower abdominal pain and bloody diarrhea or hematochezia; however, these symptoms are nonspecific.

Approximately 15 percent of patients with colonic ischemia develop necrotic bowel, the consequences of which can be life-threatening, making rapid diagnosis and treatment imperative. Most cases of colonic ischemia are usually transient and resolve without sequelae [4]. However, some patients will have a more prolonged course or develop long-term complications, such as stricture or chronic ischemic colitis.

The diagnosis and treatment of colonic ischemia can be challenging since it often occurs in patients who are debilitated and have multiple medical problems.

The clinical features, diagnosis, and treatment of ischemia affecting the colon, including acute colonic ischemia and chronic ischemic colitis (which sometimes affects the rectum), will be

reviewed here. Acute and chronic intestinal ischemia of the small intestine are discussed separately. (See "Overview of intestinal ischemia in adults" and "Chronic mesenteric ischemia".)

COLON ANATOMY AND PATHOPHYSIOLOGY

Colonic ischemia is usually the result of a sudden, but usually transient, reduction in blood flow, the effects of which are particularly prominent at the "watershed" regions of the colon, where collateral blood flow is limited.

Blood supply of the colon — The circulation to the large intestine and rectum is derived from the superior mesenteric artery (SMA), inferior mesenteric artery (IMA), and internal iliac arteries (figure 1). The colorectal circulation is relatively constant excepting relatively rare anatomic variations [5,6]. The mesenteric veins parallel the arterial circulation, draining into the portal venous system (figure 2). An extensive collateral circulation (figure 3) protects the intestines from transient periods of inadequate perfusion [7,8]. However, the "watershed" areas of the colon, which have limited collateral blood flow, such as the splenic flexure and rectosigmoid junction, are at risk for ischemia particularly related to hypoperfusion [9-11].

Etiology of hypoperfusion — The colon is relatively vulnerable to hypoperfusion since it receives less blood flow compared with the rest of the gastrointestinal tract. In addition, the microvascular plexus of the colon is less developed and is embedded in a relatively thick wall compared with the small bowel. Prolonged severe ischemia causes necrosis of the villous layer, which can lead to transmural infarction within 8 to 16 hours [12].

Perfusion to the colon can be compromised by changes in the systemic circulation or by anatomic or functional changes in the local mesenteric vasculature. Three main mechanisms are responsible for intestinal ischemia.

- **Nonocclusive colonic ischemia** – Nonocclusive or low blood flow ischemia is the predominant mechanism (95 percent of cases) causing colonic ischemia [1]. Nonocclusive colonic ischemia is typically transient, although prolonged nonocclusive ischemia can lead to transmural necrosis [12]. Nonocclusive colonic ischemia most commonly affects the "watershed" areas of the colon that have limited collateralization, such as the splenic flexure and rectosigmoid junction [6,10]. In a study of more than 1000 patients, the left colon was involved in approximately 75 percent of patients, with approximately one-quarter of lesions affecting the splenic flexure [11]. The rectum was involved in only 5 percent of patients, which can be explained because of collateralization of the inferior mesenteric artery with the systemic circulation through the hemorrhoidal vessels. Low

flow states can also reduce perfusion causing ischemia of the distal ileum and right colon related to their greater distance from the aorta. (See "Nonocclusive mesenteric ischemia".)

- **Embolic and thrombotic arterial occlusion** – Colonic ischemia can be due to spontaneous emboli from a proximal source to the mesenteric vessels, or emboli can result iatrogenically from aortic instrumentation. These patients rarely have colonic ischemia without concomitant small bowel ischemia. A case-control study involving 60 patients with segmental colonic ischemia suggested that a potential cardiac source of embolism was present in up to one-third of patients [13]. In patients with mesenteric atherosclerotic occlusive disease, colonic ischemia can occur with progressive superior mesenteric artery stenosis in the setting of an occluded inferior mesenteric artery due to insufficient collateral flow (figure 3). Colonic ischemia can also be related to inferior mesenteric artery ligation during open surgical repair of the aorta. (See "Acute mesenteric arterial occlusion".)

- **Mesenteric vein thrombosis** – Mesenteric vein thrombosis rarely affects the colon; when present, it almost always affects the distal small intestine/proximal colon [14]. Phlebosclerotic colitis is a rare form of ischemic colitis that results from venous obstruction caused by fibrotic sclerosis and calcification of the walls of the mesenteric veins [15]. (See "Mesenteric venous thrombosis in adults".)

The injury to the colon following an ischemic event is due to hypoxia and the sequelae of reperfusion. The hypoxic component causes detectable injury in the superficial part of the mucosa within one hour. With prolonged ischemia, irreversible damage with full-thickness ischemia leading to transmural necrosis can occur. The reperfusion component of intestinal injury is mainly seen following partial ischemia with reperfusion. It is initiated by an increased release of oxygen free radicals, other toxic byproducts of ischemic injury, and neutrophil activation [16]. Reperfusion injury can lead to multisystem organ failure.

Uncertain role of hypercoagulability — The degree to which acquired or hereditary hypercoagulable states contribute to the pathogenesis of colonic ischemia is uncertain [17-21]. The observed prevalences of thrombophilic abnormalities in these studies must be reconciled with the generally later presentation (mean age 65) of colonic ischemia and that recurrence of colonic ischemia is uncommon [17]. This suggests that other factors must be involved in precipitating an ischemic event (a "two-hit" hypothesis). It is also possible that specific types of thrombophilic disorders may predispose to particular forms of colonic ischemia, such as chronic ischemic colitis and stricture formation.

However, one report from Greece compared the prevalence of a variety of hypercoagulable states among 36 patients with colonic ischemia, 18 patients with diverticulitis, and 52 healthy controls [21]. The prevalence of antiphospholipid antibodies was significantly higher among patients with colonic ischemia compared with those with diverticulitis or controls (19.4 versus 0 and 1.9 percent, respectively). Factor V Leiden mutations were also found more frequently in patients with colonic ischemia (22.2 versus 0 and 3.8 percent, respectively). One of several prothrombotic abnormalities was present in 26 patients (72 percent). Another study focused on 19 patients with nonocclusive colonic ischemia who were younger than 55 years. Compared with a group of 52 matched healthy controls, patients with colonic ischemia were significantly more likely to have polymorphisms in factor V Leiden and plasminogen activator inhibitor that may predispose to thrombophilia.

RISK FACTORS

Colonic ischemia typically occurs in well-defined clinical settings in patients with risk factors for mesenteric ischemia. However, colonic ischemia can also develop insidiously without identifiable risk factors. Nonpharmacologic and pharmacologic risk factors associated with colonic ischemia are given in the tables (table 1 and table 2). The main risk factors for colonic ischemia are discussed below [22,23]. Older patients are more likely to have these risk factors [1].

- **Myocardial infarction** – Myocardial infarction appears to predispose to colonic ischemia. Colonic ischemia was described in 14 of 100 patients who underwent a colonoscopy within a mean of 15 days after a myocardial infarction [24]. The indications for colonoscopy were overt or occult bleeding in most patients. One report suggested that ischemic colitis developing in the setting of myocardial infarction was associated with more complications and a worse in-hospital prognosis compared with other causes of ischemic colitis [25].

- **Hemodialysis** – Colonic ischemia in the setting of hemodialysis is typically nonocclusive and is due to underlying diabetes and hemodialysis-induced hypotension [26-29]. (See "Unique aspects of gastrointestinal disease in patients on dialysis".)

- **Drugs** – Constipation-inducing drugs, immunomodulators, and illicit drugs may be best supported as etiologic agents (table 2) [1]. There is also support for a contributing role for many different drug classes, mostly from case reports or small case series [23,30-35]. The mechanism can be related to the known action or effect of the offending drug. Patients with prior colonic ischemia should probably avoid any implicated drug unless the cause of their ischemia was clearly related to another condition.

- **Aortoiliac instrumentation/surgery** – Aortic surgery, such as repair of abdominal aortic aneurysm, particularly ruptured aneurysm; other forms of aortoiliac reconstruction including endovascular therapies; and aortic catheterization can lead to colonic ischemia [17,36-39]. With aortic surgery, subsequent ischemia almost always affects the distal left colon and is related to loss of collateral flow due to inferior mesenteric artery ligation, iliac artery ligation, embolic events, vascular compression with surgical instruments, or hypotension.

  Endovascular intervention and other forms of aortic instrumentation (eg, cardiac catheterization, valve implantation) can also be complicated with colonic ischemia [40-42]. (See "Complications of endovascular abdominal aortic repair", section on 'Intestinal ischemia' and "Complications of diagnostic cardiac catheterization", section on 'Atheroembolism' and "Access-related complications of percutaneous access for diagnostic or interventional procedures", section on 'Atheroembolism'.)

- **Cardiopulmonary bypass** – Colonic ischemia after cardiopulmonary bypass occurs in less than 0.2 percent of patients but is a lethal complication with a mortality rate of up to 85 percent [43,44]. Risk factors include older age, end-stage kidney disease, valve surgery, emergency bypass surgery, and low postoperative cardiac output [45,46]. In addition to the low flow state of bypass perfusion, the procedure exposes the patient's blood to foreign surfaces, which may lead to hypercoagulability, microemboli, alterations in cells and proteins, release of vasoactive substances, and activation of the complement cascade [47]. Long bypass times, use of inotropic agents, and an intra-aortic balloon pump are associated with increased severity of colonic ischemia [48].

- **Extreme exercise** – Extreme exercise (eg, marathon running, triathlon competition) has been associated with intestinal ischemia. The ischemia is probably triggered by shunting of blood flow away from the splanchnic circulation accompanied by dehydration, hyperthermia, and electrolyte abnormalities including hyponatremia and hypokalemia.

- **Mesenteric arteriovenous fistula or malformation** – This rare etiology leads to venous hypertension in the colonic wall that can lead to chronic ischemic colitis [49].

- **Acquired or hereditary thrombophilia** – The reported prevalence of thrombophilic abnormalities (eg, antiphospholipid antibodies, factor V Leiden) is increased in some studies [17-21,50]. (See 'Uncertain role of hypercoagulability' above.)

- **Following colonoscopy** – Ischemic colitis has rarely been associated with diagnostic colonoscopy possibly related to barotrauma from insufflation, sedating medications, or

dehydration associated with bowel preparation [51]. (See "Overview of colonoscopy in adults", section on 'Adverse events'.)

- **Severe COVID-19 infection** – Colonic and small-bowel ischemia have been reported in patients with severe coronavirus disease 2019 (COVID-19) infection usually related to thrombophlebitis and hypoperfusion [52]. (See "COVID-19: Gastrointestinal symptoms and complications", section on 'Mesenteric ischemia'.)

CLINICAL FEATURES

The clinical manifestations of colonic ischemia vary depending upon the clinical setting and onset, duration, and extent of the ischemia. It is important to carefully assess the patient for risk factors associated with colonic ischemia by careful review of the medical and surgical history, including medications and other drug use in each patient. (See 'Risk factors' above and 'Colon anatomy and pathophysiology' above.)

Colonic ischemia can present acutely or chronically. Acute manifestations can range from mild to severe and may include colonic edema or bleeding, diarrhea, ischemic ulceration that can be severe enough to cause stricture, pancolitis, colonic gangrene, or sepsis [17,53]. It may be difficult to identify symptoms in patients who are unconscious, such as those in an intensive care unit, or who are cognitively impaired, such as those with delirium or dementia [54]. A systematic review suggested that a lack of rectal bleeding, peritonitis, or renal dysfunction were predictors of low severity, whereas right-sided colitis was the most significant predictor of severe disease [55].

Acute colonic ischemia

Symptoms and signs — Patients with acute colonic ischemia usually present with rapid onset of mild cramping abdominal pain and tenderness over the affected bowel, most often involving the left side (figure 4) [56]. The pain can be associated with an urgent desire to defecate [6,56]. Compared with ischemia affecting the small intestine, the cramping pain that accompanies colonic ischemia is usually felt laterally rather than periumbilically and is often associated with hematochezia. (See "Overview of intestinal ischemia in adults", section on 'Clinical features' and 'Large versus small bowel ischemia' below.)

Mild-to-moderate amounts of rectal bleeding (bright or maroon blood) or bloody diarrhea usually develops within 24 hours of the onset of abdominal pain, though bleeding without prior abdominal pain also occurs frequently. Bleeding may be more common with ischemia of the left

compared with the right colon (83.8 versus 36.4 percent, in one study [57]). Approximately 15 percent of patients have abdominal pain without evidence of bleeding.

Three progressive clinical stages have been described [58,59]:

- Hyperactive phase – Soon after occlusion or hypoperfusion, severe pain dominates with frequent passage of bloody, loose stools. Blood loss is usually mild without the need for transfusion.
- Paralytic phase – The pain usually diminishes, becomes more continuous, and diffuses. The abdomen becomes more tender and distended without bowel sounds.
- Shock phase – Massive fluid, protein, and electrolytes start to leak through a damaged, gangrenous mucosa. Severe dehydration with shock and metabolic acidosis may develop, requiring rapid surgical intervention. Fortunately, this most severe form affects only 10 to 20 percent of patients.

Passage of bloody stools, unexplained failure of postoperative progress, lactic acidosis, fever, leukocytosis, or thrombocytopenia should raise suspicion for colonic ischemia following aortoiliac instrumentation or surgery [60,61].

Transmural necrosis as a consequence of severe hypoperfusion presents as colon perforation with localized or generalized peritonitis or as sepsis, which is less common. In a review of 364 patients, peritoneal signs were present in only 7.4 percent of patients [57].

Laboratory studies — Laboratory studies are routinely obtained during the initial evaluation of the patient with abdominal pain or gastrointestinal bleeding, including complete blood count, metabolic panel, and coagulation studies. Although these are not diagnostic for colonic ischemia, they may aid the assessment of disease severity [62]. (See "Overview of intestinal ischemia in adults", section on 'Laboratory studies'.)

There are no specific laboratory markers for ischemia, although an increased serum lactate, lactate dehydrogenase (LDH), creatine phosphokinase (CPK), or amylase may indicate advanced tissue damage. Decreased hemoglobin levels may reflect intestinal blood loss. White blood count above 20,000 cells/microliter and metabolic acidosis in a patient with signs and symptoms of colonic ischemia are highly suggestive of intestinal ischemia with infarction. In a multicenter review, albumin levels below 2.8 g/dL were present on admission in 23.2 percent and were more common in those with gangrenous changes [57].

Fecal polymerase chain reaction testing for pathogens should be ordered to rule out an infectious etiology of bloody diarrhea. *Clostridioides difficile* infection uncommonly presents with

bloody diarrhea, but occasionally *C. difficile* superinfection may be superimposed on colonic ischemia. (See "*Clostridioides difficile* infection in adults: Clinical manifestations and diagnosis".)

Plain abdominal radiography — A plain abdominal radiograph is frequently obtained in the evaluation of abdominal pain but is nonspecific. (See "Evaluation of the adult with abdominal pain" and "Overview of intestinal ischemia in adults".)

Distension or pneumatosis (image 1) are typically seen only with advanced ischemia. In one series of 23 cases, signs such as thumbprinting (indicating submucosal edema) (image 2) and hemorrhage could be identified in only 30 percent of patients with mesenteric infarction [63]. However, when present, radiographic findings suggesting ischemia may portend a worse prognosis, as illustrated in one study in which patients with an abnormal abdominal radiograph had a higher mortality rate compared with those without such findings (78 versus 29 percent) [64].

Chronic ischemic colitis — Patients with episodes of chronic recurrent colonic ischemia can present with recurrent abdominal pain, bloody diarrhea, weight loss from protein-losing enteropathy, recurrent bacteremia, persistent sepsis, or symptomatic colonic strictures [65]. Approximately 20 percent of patients with recurrent ischemia develop chronic ischemic colitis [65].

Chronic ischemia may develop into segmental ulcerating colitis or strictures, typically apparent within three to six months. For lesions that manifest with symptoms, colonoscopy may be required to confirm persistent colitis or stricture.

Ischemic strictures that produce no symptoms should be observed. Some strictures will resolve in 12 to 24 months without specific therapy. If symptoms of partial obstruction develop, segmental resection is indicated [66]. Endoscopic dilation or stenting, which is primarily used to palliate malignant obstruction, may be an alternative for patients who are poor surgical candidates [67,68]. However, the efficacy of this approach has not been established in this population of patients. (See "Enteral stents for the management of malignant colorectal obstruction".)

Chronic ischemic colitis can occur in long-distance runners and presents with pain in the lower abdomen, diarrhea, and mild bleeding. Treatment with rehydration and correction of metabolic abnormalities is usually sufficient [69]. (See "Exercise-related gastrointestinal disorders".)

Phlebosclerotic colitis is a rare form of ischemic colitis that results from venous obstruction caused by fibrotic sclerosis and calcification of the walls of the mesenteric veins [15]. It usually involves the right colon. Linear calcifications in the region of the right colon can be seen on

plain abdominal radiographs, while computed tomography (CT) scan may reveal colonic wall thickening associated with mesenteric venous calcifications. Symptoms usually resolve spontaneously.

DIAGNOSIS

Suspicion for colonic ischemia should be increased in patients (particularly in older adults) with any of the risk factors discussed above (see 'Risk factors' above) and with lower abdominal pain and bloody diarrhea or hematochezia; however, these symptoms are nonspecific. In a multicenter study from Spain that included 364 patients, the condition was initially suspected in only approximately 25 percent of patients [57]. In another review, the presence of four or more risk factors (ie, older than 60, hemodialysis, hypertension, hypoalbuminemia, diabetes mellitus, constipation-inducing medications) was 100 percent predictive of colonic ischemia [70]. The diagnosis of colonic ischemia is usually suspected based upon such history, together with physical examination, and clinical setting. It is confirmed with imaging, when possible, typically with CT of the abdomen.

For patients who present with fulminant gangrenous colonic ischemia with peritonitis and/or colon perforation, a definitive diagnosis will necessarily be made in the operating room. In certain acute settings and for those with chronic symptoms, lower endoscopy (sigmoidoscopy or colonoscopy) is the best diagnostic test to identify colonic ischemia and differentiate it from other causes of abdominal pain and bloody stools. (See 'Abdominal exploration' below and 'Abdominal imaging' below and 'Lower endoscopy' below.)

Abdominal imaging — CT of the abdomen with intravenous contrast (and oral contrast if tolerated by the patient) is typically the first imaging study obtained in patients presenting acutely with features of intestinal ischemia (algorithm 1). CT findings are nonspecific, and scans can initially be normal [71-73]. Typical findings include edema and thickening of the bowel wall in a segmental pattern (thumbprinting (image 3) or "target" or "double-halo" appearance from hyperdensity of the mucosa and muscularis). These changes typically reflect the initial episode of transient ischemia and subsequent reperfusion injury rather than ongoing ischemia. But they are not specific for ischemia and can be seen in infectious colitis such as from *C. difficile* or Crohn colitis. Other findings on CT scan may include irregular bowel contours, mesenteric inflammation with stranding of the fat, or free peritoneal fluid [74,75].

Nevertheless, CT can differentiate colonic ischemia from nonischemic causes of abdominal pain or may suggest irreversible ischemia/transmural infarction (eg, colonic necrosis, perforation, extramural or portomesenteric venous gas) that indicates the need for colon resection [74-76].

Pneumatosis coli (image 3), gas in the mesenteric or portal veins, or pneumoperitoneum indicating perforation may be seen in the more advanced stages but these findings are not specific to colonic ischemia. Hepatic portal venous gas is a rare radiographic finding that has been associated with bowel necrosis, particularly in patients with additional clinical and radiographic evidence of necrotic bowel [77]. However, pneumatosis coli and portal venous gas can also be detected in benign situations (eg, after surgical or endoscopic manipulation). Standard CT imaging may also identify major arterial embolic or venous obstruction more consistent with acute mesenteric ischemia (eg, colonic involvement isolated to the right side). If major vascular occlusion is suspected, CT angiography may be the more appropriate initial imaging study. (See 'Large versus small bowel ischemia' below and "Acute mesenteric arterial occlusion".)

Conventional catheter-based arteriography is much less useful in the diagnosis of colonic ischemia. Ischemic changes are typically limited to the arteriolar vessels and are rarely seen since nonocclusive ischemia is more common etiology and because with resuscitation colonic blood flow has often returned to normal levels. In the absence of instrumentation or aortoiliac surgery, the major mesenteric vessels and vascular arcades are usually patent. Nevertheless, catheter-based arteriography may be necessary if the diagnostic evaluation cannot exclude concomitant right colonic small bowel ischemia and lower endoscopy is not revealing. A subset of patients in whom the presentation of colonic ischemia is a heralding sign of acute mesenteric ischemia (eg, severe pain without bleeding with risk factors for arterial mesenteric occlusion) may require catheter-based arteriography to establish the diagnosis. (See 'Large versus small bowel ischemia' below and "Acute mesenteric arterial occlusion", section on 'Presentation and evaluation'.)

Lower endoscopy — Colonoscopy or sigmoidoscopy confirms the diagnosis of colonic ischemia and should be performed in all patients suspected with colonic ischemia, if possible (algorithm 2). Lower endoscopy should be performed with minimal air insufflation to avoid excessive distention that could lead to colon perforation [78]. If colonic ischemia is suspected, the study should be performed earlier (within 48 hours) rather than later following initial presentation [4,79] but should not be performed in patients with acute peritonitis on physical examination or evidence of irreversible ischemic damage on imaging studies. (See "Overview of colonoscopy in adults".)

Colonoscopy is sensitive for detecting mucosal lesions, permits biopsy of suspicious areas, and does not interfere with subsequent arteriography. Colonoscopy may disclose ischemic colitis but cannot separate transmural from the clinically less important mucosal ischemia [79]. Some vascular surgeons recommend serial sigmoidoscopic examinations in patients in whom the

bowel was considered to be at risk following aortic surgery [79]. However, no study has demonstrated that this approach is associated with improved survival [39,60,79].

Colonoscopic findings in the acute setting frequently include edematous, friable mucosa; erythema; and interspersed pale areas (picture 1) [80]. Bluish hemorrhagic nodules may be seen representing submucosal bleeding; these are the equivalent to "thumbprints" detected on radiologic studies. More severe disease is marked by cyanotic mucosa and scattered hemorrhagic erosions or linear ulcerations. Occasional patients have pseudomembranous colitis with yellowish round plaques or confluent membranes not related to *C. difficile* infection [81]. Ischemia rather than inflammatory bowel disease is suggested by segmental distribution, abrupt transition between injured and noninjured mucosa, and rectal sparing. A single linear ulcer running along the longitudinal axis of the colon (the "single-stripe sign") may also favor an ischemic cause of colitis (picture 1) [82].

Biopsies taken from affected areas may show nonspecific changes such as hemorrhage, crypt destruction, capillary thrombosis, granulation tissue with crypt abscesses, and pseudopolyps, which may mimic Crohn disease [83,84]. In the chronic phase of ischemic colitis, mucosal atrophy and areas of granulation tissue may be found. Biopsy of a postischemic stricture is marked by extensive transmural fibrosis and mucosal atrophy.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis of colonic ischemia is broad and includes small bowel ischemia, infectious colitis, inflammatory bowel disease, and a myriad of other causes for abdominal pain and lower gastrointestinal bleeding. (See "Etiology of lower gastrointestinal bleeding in adults" and "Causes of abdominal pain in adults".)

Large versus small bowel ischemia — Several clinical features distinguish **acute** colonic ischemia from acute mesenteric ischemia involving the small bowel (table 3) [6,10,56]. The distinction may also be apparent on imaging studies. (See "Overview of intestinal ischemia in adults".)

- Severe pain is more likely for acute ischemia involving the small bowel compared with the colon, for which extreme pain is usually not as prominent a feature.
- The onset of pain is sudden when ischemia is caused by embolic disease. In contrast, the pain may occur more insidiously (hours to days) in patients with thrombotic causes, vasculitis, or nonocclusive ischemia.

- In patients with small bowel obstruction leading to ischemia, pain often precedes vomiting.
- Hematochezia is more commonly a sign of colonic ischemia compared with small bowel ischemia.

Chronic ischemic colitis is rarely confused with chronic mesenteric ischemia. (See "Chronic mesenteric ischemia".)

Other — The differential diagnosis of colonic ischemia also includes infectious colitis, inflammatory bowel disease, diverticulitis, radiation enteritis, solitary rectal ulcer syndrome, and colon carcinoma [85,86]. (See "Approach to the adult with acute diarrhea in resource-abundant settings".)

Infection with *Klebsiella oxytoca* has been associated with right-sided hemorrhagic colitis that can mimic ischemic colitis. This rare infection occurs in patients exposed to antibiotics, particularly penicillin derivatives [87,88]. Diagnosis is established by culture. (See "Microbiology and pathogenesis of Klebsiella pneumoniae infection".)

C. difficile infection should be excluded in hospitalized patients exposed to antibiotics. This infection produces marked thickening of the colon on CT scan as well as very high total white blood cell counts, which resemble the findings of ischemic colitis. Although occult blood may be detected in diarrheal stool of symptomatic patients, grossly bloody stools are quite rare in *C. difficile* infection. (See "*Clostridioides difficile* infection in adults: Clinical manifestations and diagnosis".)

Patients with chronic ischemic colitis who are misdiagnosed as having inflammatory bowel disease will respond poorly to immunosuppressive therapy and have an increased risk of perforation on steroids.

TREATMENT

Treatment overview — Treatment of acute colonic ischemia depends upon its etiology, severity, and the clinical setting (algorithm 2). Most patients with colonic ischemia will resolve with supportive care and do not require specific therapy. For patients who do progress to irreversible ischemia, timely diagnosis and treatment can significantly decrease the morbidity and mortality of the postoperative clinical course. Surgical intervention is best performed before the onset of hemodynamic instability, colon perforation, or frank colon necrosis.

The American College of Gastroenterology has proposed a risk stratification that may assist with determining the appropriate treatment [1]. The risk factors associated with a poor outcome include male sex, hypotension (systolic blood pressure <90 mmHg), tachycardia (heart rate >100 beats/minute), abdominal pain without rectal bleeding, blood urea nitrogen (BUN) >20 mg/dL, hemoglobin (Hb) <12 g/dL, lactate dehydrogenase (LDH) >350 units/L, serum sodium <136 mEq/L (mmol/L), and white blood cell count >15,000 cells/microliter. The risk categories are:

- Mild colonic ischemia – Suspected colonic ischemia based upon typical symptoms and advanced abdominal imaging or lower endoscopy consistent with colonic ischemia but with no risk factors associated with a poor outcome. The patient has no clinical signs that would indicate the need for immediate exploration. (See 'Supportive care' below.)

- Moderate colonic ischemia – Suspected colonic ischemia based upon typical symptoms and advanced abdominal imaging or lower endoscopy consistent with colonic ischemia **and** up to three risk factors associated with a poor outcome. The patient has no clinical signs that would indicate the need for immediate exploration. (See 'Antibiotics' below and 'Antithrombotic therapy' below.)

- Severe colonic ischemia – Suspected colonic ischemia based upon typical symptoms and more than three of the criteria for moderate disease or any of the following: peritoneal signs on physical examination; pneumoperitoneum, pneumatosis, or portal venous gas on radiologic imaging; gangrene on colonoscopic examination. Chronic hemodialysis or poor Eastern Cooperative Oncology Group status are also independent risk factors for severe disease [89]. (See 'Abdominal exploration' below.)

Supportive care — Supportive care with bowel rest and observation is appropriate provided there is no evidence of colon perforation, necrosis, or gangrene. Intravenous fluids should be given to ensure adequate colonic perfusion.

A nasogastric tube should be inserted if an ileus is present. Any precipitating conditions should be treated, and medications known to promote intestinal ischemia (eg, vasopressors, digitalis) should be promptly discontinued (table 1) if feasible. Cardiac function and oxygenation should be optimized.

Most patients with nonocclusive colonic ischemia improve within one or two days and have complete clinical and radiologic resolution within one to two weeks. Patients with a prolonged course may require nutritional support.

The patient should be monitored for persistent fever, leukocytosis, peritoneal irritation, protracted diarrhea, or gastrointestinal bleeding. If clinical deterioration is evident despite conservative therapy, abdominal exploration is indicated. (See 'Abdominal exploration' below.)

Severe ischemia can cause ulceration and inflammation, which over time may develop into a stricture or chronic ischemic colitis. These lesions may be asymptomatic, but they should be followed to document healing or the development of persistent colitis or stricture, which can cause symptoms of partial bowel obstruction.

Antibiotics — There is no strong evidence supporting the routine use of antibiotics for the treatment of all patients with colonic ischemia. However, we agree with major society guidelines that suggest empiric broad-spectrum antibiotics for most patients with colonic ischemia, except possibly those with mild disease and no evidence for bleeding from ulceration (table 4) [1,90-92]. (See "Antimicrobial approach to intra-abdominal infections in adults".)

This recommendation is based mainly upon an experimental model showing reduced intestinal inflammation and injury with depletion of gut bacteria [93] and upon older studies in which antibiotics reduced the severity and extent of experimental bowel damage when given prior to an ischemic event [94-96]. In addition, some studies suggest that antibiotics theoretically protect against bacterial translocation occurring from loss of mucosal integrity, and animal studies have suggested a potential survival advantage with antibiotics [97-99].

Antithrombotic therapy — Antithrombotic therapy is not indicated for most patients with colonic ischemia, as the majority have nonocclusive ischemia. However, anticoagulant therapy is indicated for patients who develop colonic ischemia due to mesenteric venous thrombosis or related to mesenteric thromboembolism (eg, cardiac source). (See "Mesenteric venous thrombosis in adults", section on 'Anticoagulation' and "Acute mesenteric arterial occlusion", section on 'Management'.)

Recanalization of thrombosed mesenteric veins has been described following long-term anticoagulant therapy [100,101]. In addition to systemic anticoagulation, patients with mesenteric vein thrombosis should be evaluated for hypercoagulability. (See "Evaluating adult patients with established venous thromboembolism for acquired and inherited risk factors" and "Mesenteric venous thrombosis in adults", section on 'Anticoagulation'.)

Antiplatelet agents have not been well studied in this setting and are generally not indicated in those without known peripheral vascular disease. (See "Chronic mesenteric ischemia", section on 'Management'.)

Ongoing monitoring and counseling — Close follow-up is important for preventing recurrent episodes of ischemic colitis. The patient should be counseled to avoid dehydration, constipation, and overly aggressive treatment of hypertension, particularly in the setting of illness or exercise, to maintain normal blood pressure for optimal colon perfusion. Medications should be reviewed. Recurrent episodes of bacteremia or sepsis associated with unhealed areas of segmental colitis should be referred for elective segmental colon resection.

It remains unclear which, if any, patients with colonic ischemia should undergo evaluation for hypercoagulability. Routine evaluation for hypercoagulability is **not** necessary but may be reasonable in younger patients (<40 years of age) and those with recurrent colonic ischemia. For those identified with hematologic abnormalities, management must be individualized, taking into consideration the specific abnormality, the course and severity of colonic ischemia, and whether colon resection was performed. (See 'Uncertain role of hypercoagulability' above.)

Abdominal exploration — Surgery is required in up to 20 percent of cases [17]. Patients with colon infarction and necrosis require urgent surgical intervention, which can be life-saving [102]. Clinical suspicion of ischemia (eg, ongoing pain that is out of proportion to clinical examination, hemodynamic instability) is a common indication for surgical exploration. Other indications for abdominal exploration include radiologic evidence of bowel necrosis, or lesser degrees of ischemia in patients who do not respond appropriately to nonsurgical supportive care [17]. (See 'Supportive care' above.)

Prior to abdominal exploration (open or laparoscopic), bowel preparation should **not** be used, as it can precipitate perforation or toxic dilation of the colon.

For patients in whom imaging and colonoscopy have not clearly defined the extent of ischemia and who do not have contraindications, laparoscopic exploration may be appropriate to confirm the diagnosis prior to open exploration [103]. In experienced hands, laparoscopic colectomy, if indicated, is an option and can be done quite efficiently and avoids major wound complications. A concern about laparoscopy is the effect of pneumoperitoneum on mesenteric blood flow [104]. The intraperitoneal pressure should be lowered (approximately 10 mmHg) in those suspected with suspected mesenteric ischemia. (See "Overview of colon resection" and "Complications of laparoscopic surgery", section on 'Related to pneumoperitoneum'.)

Once the abdomen is exposed (open or laparoscopic), the bowel should be systematically inspected from the ligament of Treitz to the peritoneal reflection overlying the rectum. The serosal surface of the intestines may appear normal in early or mild ischemia. With more advanced ischemia, dark peritoneal fluid may be present in the paracolic gutters or within the pelvis. Overtly ischemic bowel will appear edematous with patchy areas of serosal hemorrhage

or gangrenous changes with or without perforation. Intraoperative colonoscopy can be used to assess the extent of ischemia.

Specific surgical management depends upon the location of the affected colon. (See "Overview of colon resection".)

- Right-sided colonic ischemia and necrosis is managed with resection of the ischemic segment. A decision for ileostomy and transverse colon mucous fistula versus primary ileocolonic anastomosis depends upon the patient's general condition and assessment of the transected ends of the ileum and colon [105].

- Depending upon the extent of the ischemia, left-sided colonic ischemia is managed with sigmoid resection or left hemicolectomy, with either a proximal stoma and distal mucous fistula or Hartmann's procedure (figure 5).

- The rare patient with a fulminating type of colonic ischemia involving most of the colon and rectum may require subtotal colectomy with terminal ileostomy.

Adequate surgical margins that are beyond macroscopically involved regions should be ensured. Primary anastomosis should be avoided in patients with severe colitis or those with hemodynamic instability. Among patients with an open aortic or iliac vascular graft, primary colonic anastomosis is also contraindicated in those who require bowel resection because any subsequent anastomotic leak would contaminate the graft [106].

When the need for colectomy is identified during laparoscopic exploration, laparoscopic colectomy can be performed by those facile with the technique. (See "Overview of colon resection", section on 'Minimally invasive colon resection'.)

Second-look procedure — Rarely, following exploration or colonic resection, repeat exploration (ie, "second-look" operation [open or laparoscopic]) should be performed within 12 to 24 hours to assess the viability of the remaining bowel and integrity of any anastomoses [105,107].

Leaving the abdomen open may be needed if abdominal closure will lead to increased intra-abdominal pressure and facilitates the second-look procedure. (See "Management of the open abdomen in adults".)

Vascular intervention — Local infusion of vasodilators (such as papaverine) can attenuate vasospasm, but systemic side effects often limit its use in patients with nonocclusive colonic ischemia. Vasodilatory therapy is discussed in more detail elsewhere. (See "Nonocclusive mesenteric ischemia", section on 'Vasodilator infusion'.)

Among patients with embolic or thrombotic arterial occlusion, pharmacomechanical thrombolysis with or without mesenteric angioplasty, and stenting may be indicated. (See "Surgical and endovascular techniques for mesenteric revascularization".)

As a general rule, unlike mesenteric ischemia, embolectomy, bypass graft, or endarterectomy is not performed in cases of primary colonic ischemia, which is not generally related to large artery obstruction.

Handling the inferior mesenteric artery during aortic surgery is reviewed separately. (See "Open surgical repair of abdominal aortic aneurysm", section on 'Handling the inferior mesenteric artery'.)

POSTOPERATIVE CARE AND FOLLOW-UP

Following abdominal exploration or colon resection, the patient should be returned to an intensive care setting for hemodynamic support and monitoring.

For patients who have undergone colectomy requiring ileostomy or colostomy, ostomy closure should be delayed for four to six months. Given the risk factors that lead to colonic ischemia, it is apparent that this subgroup of patients is older and likely frailer with a higher risk for subsequent surgery. Up to two thirds of patients never proceed to reversal because of comorbid conditions [17,108]. In-hospital mortality related to elective ostomy reversal was 18 percent in one study, with 35 percent of patients requiring prolonged postoperative intensive care admission [109].

MORTALITY

The prognosis of patients with ischemic colitis depends upon the etiology, disease severity, distribution, and comorbidities [2,6,25,89-92,109]. Most patients have self-limiting ischemia that typically resolves completely [4]. As a general rule, nongangrenous colonic ischemia is associated with a low mortality (<5 percent) [17,110]. The need for surgery increases the rates for morbidity and mortality. Approximately 10 to 20 percent of patients develop colonic necrosis and gangrene, which is associated with high mortality rates [57,92,109].

A systematic review of 11 studies included 1049 patients [55]. Medical management used in 80 percent of patients was associated with a mortality rate of 6 percent. Medically managed patients had only mucosal and submucosal injury, for which symptoms resolved with conservative measures and no long-term sequelae. Surgical intervention was associated with a

40 percent mortality rate. The difference in mortality reflected predominantly the severity of illness in those who required surgery.

In another study of 4548 patients undergoing emergent colectomies for ischemic colitis, 30-day postoperative mortality was 25.3 percent. Preoperative risk factors associated with a higher rate of mortality included older age, poor functional status, multiple comorbidities, septic shock, blood transfusion, acute renal failure, and the duration of time from hospital admission to surgery [111].

In a retrospective review of 273 patients with colonic ischemia, patients with involvement isolated to the right colon had a worse outcome, with a fivefold higher rate of surgery and a twofold higher mortality, compared with those with ischemia involving other areas of the colon [112]. Similarly, in a study of 313 patients with biopsy-proven ischemia, patients with left colon ischemia were less likely to require surgery and had a shorter length of stay compared with any other pattern of ischemic colitis [6]. Mortality is higher because colonic ischemia affecting the right side is due to superior mesenteric artery insufficiency and associated with diffuse small intestinal ischemia and shock; by contrast, left colon ischemia is more likely to be isolated to the inferior mesenteric artery distribution with less associated shock unless there is perforation.

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Intestinal ischemia".)

INFORMATION FOR PATIENTS

UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Basics topic (see "Patient education: Ischemic bowel disease (The Basics)")

SUMMARY AND RECOMMENDATIONS

- **Colonic ischemia** – Colonic ischemia is the most frequent form of intestinal ischemia, most often affecting older adults. It is due to a reduction in blood flow to a level that is insufficient for the delivery of oxygen and nutrients needed for cellular metabolism. The majority of patients have transient, nongangrenous ischemia, which resolves without sequelae. Some patients develop colonic necrosis and gangrene, which can be life-threatening. Long-term complications include persistent segmental colitis and the development of a stricture. (See 'Introduction' above.)

- **Risk factors** – A number of conditions predispose the patient to colonic ischemia (table 1 and table 2); however, colonic ischemia can also develop insidiously with no specific inciting cause identified. (See 'Risk factors' above.)

- **Clinical features** – The clinical manifestations of colonic ischemia vary depending upon the clinical setting and the extent and duration of the ischemia. Patients with acute colonic ischemia usually present with rapid onset of mild abdominal pain and tenderness over the affected bowel, most often the left colon. Mild-to-moderate amounts of rectal bleeding or bloody diarrhea usually develop within 24 hours of the onset of abdominal pain. Approximately 20 percent of patients develop chronic ischemic colitis. (See 'Clinical features' above.)

- **Diagnosis** – Suspicion for colonic ischemia should be increased in patients with risk factors for colonic ischemia and lower abdominal pain and/or blood per rectum. A diagnosis of colonic ischemia can often be made clinically based upon history, physical examination, and clinical setting. Lower endoscopy, typically colonoscopy, can confirm a diagnosis of colonic ischemia. CT of the abdomen is useful for excluding alternative diagnoses for abdominal pain. Arteriography is rarely needed but may be useful when the diagnosis is unclear. (See 'Diagnosis' above.)

- **Differential diagnosis** – The differential diagnosis includes acute mesenteric ischemia affecting the small intestine, infectious colitis, inflammatory bowel disease, diverticulitis, radiation enteritis, solitary rectal ulcer syndrome, and colon carcinoma. Stool polymerase chain reaction testing for pathogens and *Clostridioides difficile* should be considered in the appropriate clinical situation. (See 'Differential diagnosis' above.)

- **Treatment** – Treatment of acute colonic ischemia depends upon its severity and the clinical setting. Supportive care with hemodynamic monitoring in an intensive care unit is appropriate in the absence of colonic gangrene or perforation. Empiric broad-spectrum antibiotics should be given for patients with moderate-to-severe disease. Medications that can promote ischemia should not be given. (See 'Treatment' above.)

- **Prognosis** – The prognosis of patients with nonocclusive colonic ischemia depends upon the disease severity, distribution, and comorbidities. Most patients improve within one or two days and have complete resolution within one to two weeks. Patients with underlying comorbidities and those with right-sided ischemic colitis have a worse prognosis. Severe or recurrent ischemia can lead to chronic ischemic colitis or intestinal stricture. (See 'Mortality' above.)

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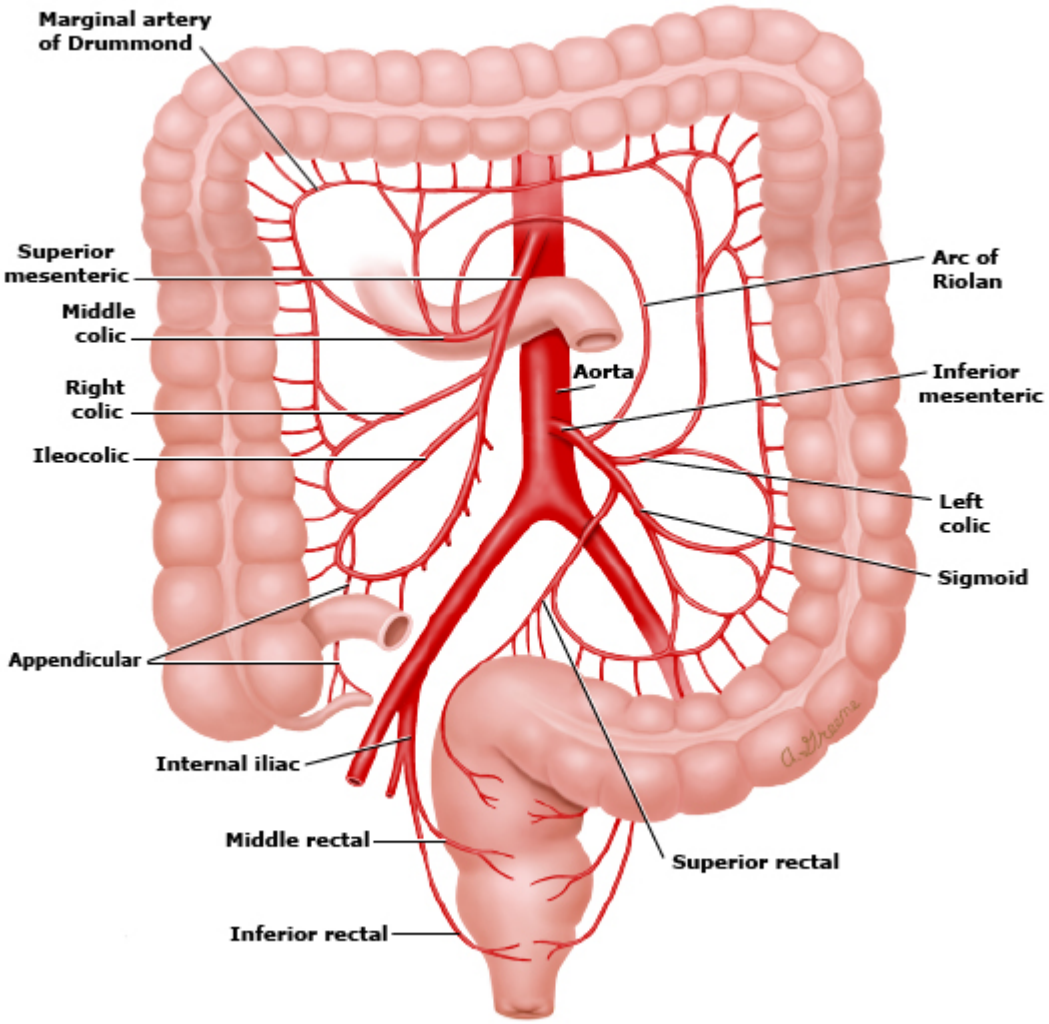
Topic 2564 Version 41.0

GRAPHICS

Blood supply to the colon and rectum



The blood supply to the colon originates from the SMA and the IMA. The SMA arises approximately 1 cm below the celiac artery and runs inferiorly toward the cecum, terminating as the ileocolic artery. The SMA gives rise to the inferior pancreaticoduodenal artery, several jejunal and ileal branches, the middle colic artery, and the right colic artery.

As a general rule, the middle colic artery arises from the proximal SMA and supplies blood to the proximal to midtransverse colon. However, it occasionally provides the predominant blood flow to the splenic flexure.

The right colic artery supplies blood to the mid-distal ascending colon. In anatomical studies, the right colic artery arises independently from the SMA in 28% of individuals, which is depicted in this figure. More frequently, the right colic artery arises with, or as a branch of, the middle colic, ileocolic, or left colic arteries. The right colic artery is absent in 13% of individuals.[1]

The ileocolic artery supplies blood to the distal ileum, cecum, and proximal ascending colon.

The IMA arises approximately 6 to 7 cm below the SMA. The IMA gives rise to the left colic artery and sigmoid arteries continuing as the superior rectal (hemorrhoidal) artery. It is largely responsible for supplying blood distal to the transverse colon.

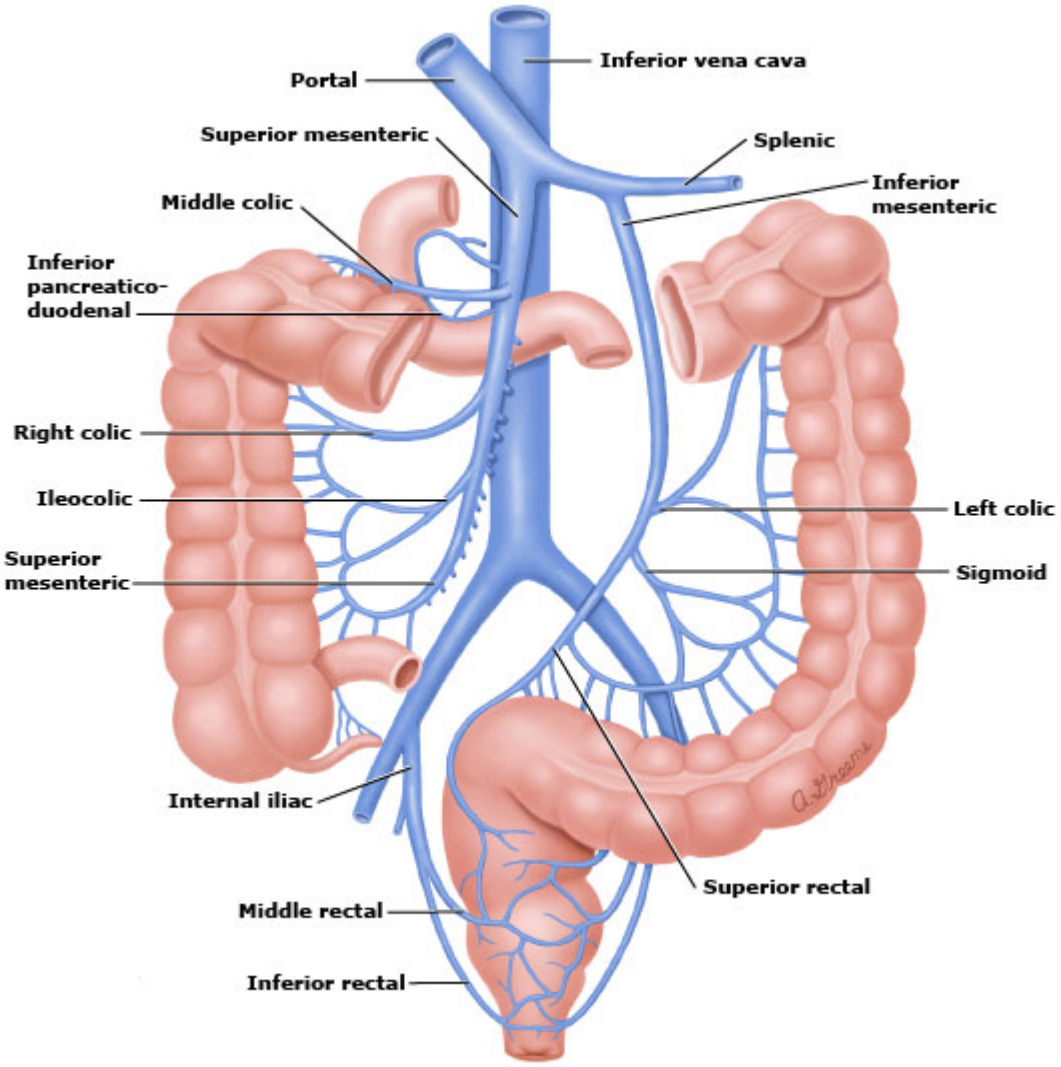
SMA: superior mesenteric artery; IMA: inferior mesenteric artery.

Reference:

1. *Bergman RA, Thompson SA, Afifi AK, Saadeh FA. Compendium of Human Anatomic Variation: Text, Atlas, and World Literature, Urban & Schwarzenberg, Baltimore, MD 1988.*

Graphic 73756 Version 12.0

Venous drainage of the colon and rectum

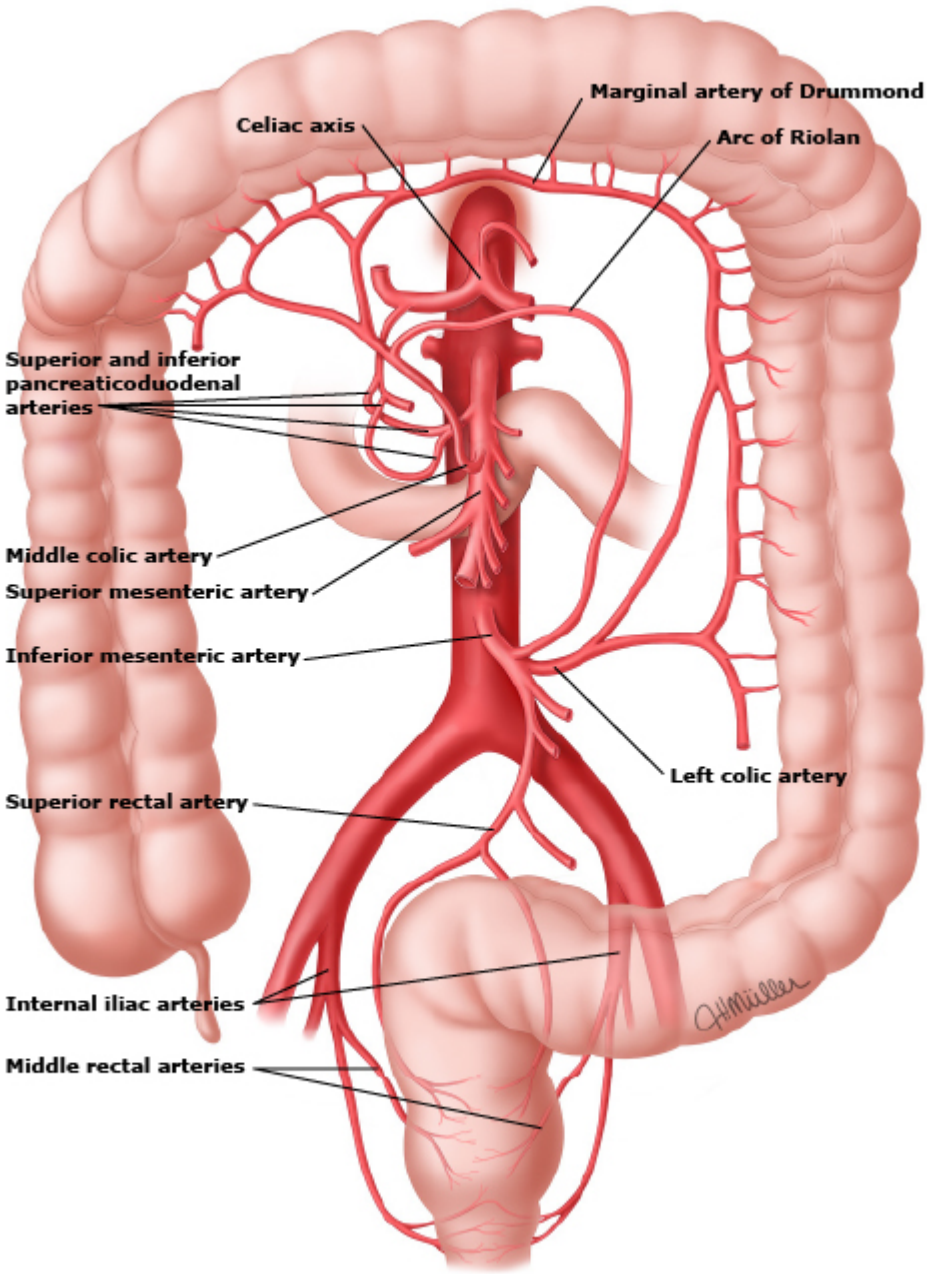


The mesenteric veins parallel their corresponding arteries. The SMV drains the small intestine, cecum, and ascending and transverse colon via the jejunal, ileal, ileocolic, right colic, and middle colic veins. The IMV drains the descending colon through the left colic, the sigmoid through the sigmoid vein, and the rectum through the superior rectal vein. The IMV fuses with the splenic vein, which then joins the SMV to form the portal vein.

SMV: superior mesenteric vein; IMV: inferior mesenteric vein.

Graphic 81960 Version 4.0

Collateral circulation to the intestines



An abundant collateral blood supply exists between the SMA and IMA and the IMA and internal iliac arteries. The arcades of the SMA and IMA interconnect at the base and border of the mesentery. The connection at the base of the mesentery is called the arc of Riolan, whereas the connection along the mesenteric border is known as the marginal artery of Drummond. Ischemic damage to the rectum is rare since the rectum has a dual blood supply from the IMA and iliac arteries. Collateral flow between the IMA and iliac arteries occurs via the superior and middle/inferior rectal vessels. Despite the presence of collaterals, the colon circulation has two watershed areas that are vulnerable to ischemia during systemic hypotension: the narrow terminal branches of the SMA supply the splenic flexure, and the narrow terminal branches of the IMA supply the rectosigmoid junction.

SMA: superior mesenteric artery; IMA: inferior mesenteric artery.

Graphic 89911 Version 5.0

Nonpharmacologic etiology of colonic ischemia

Mesenteric venous thrombosis
Hypercoagulable state
Lymphocytic phlebitis
Portal hypertension
Pancreatitis
Small vessel disease
Diabetes
Vasculitis
Polyarteritis nodosa
Lupus erythematosus
Takayasu arteritis
Granulomatosis with polyangiitis (Wegener's)
Anticentromere antibodies
Buerger's disease
Antiphospholipid antibodies
Amyloidosis
Rheumatoid arthritis
Radiation
Shock
Cardiac failure
Hemodialysis
Pancreatitis
Anaphylaxis
Mechanical obstruction
Strangulated hernia
Colon cancer
Adhesion
Rectal prolapse
Fecal impaction or pseudo-obstruction

Blood dyscrasia
Hypercoagulable state
Sickle cell disease
Iatrogenic
Surgical
Aortoiliac reconstruction
Cardiopulmonary bypass
Renal transplant
Colonoscopy
Barium enema
Others
Long-distance running
Dialysis
Neurogenic
Spontaneous in young adults
Infections (COVID-19, CMV, *Escherichia coli* O157:H7)
Airplane flight
Major vascular occlusion
Mesenteric artery thrombosis
Cholesterol emboli
Colectomy with IMA ligation
Aortic dissection
Aortic reconstruction

The table provides nonpharmacologic causes for colonic ischemia. Pharmacologic causes are presented in a separate UpToDate table.

COVID-19: coronavirus disease 2019; CMV: cytomegalovirus; IMA: inferior mesenteric artery.

Graphic 61647 Version 9.0

Pharmacologic agents and colonic ischemia

Drug	Evidence	Postulated pathogenesis
Moderate evidence		
Constipation-inducing drugs	▪ Predicted CI in patients with abdominal pain: 2.8 (1.1-7.1)[1] ▪ All drugs C-CS: Risk, 0.68 (0.62-1.27)[2] ▪ Opioids C-CS: Increased risk, 1.96 (1.43-2.67)[3] ▪ Nonopioids C-CS: Increased risk, 1.75 (1.25-2.44)[3]	Reduced blood flow, increased intraluminal pressure[4]
Immunomodulator drugs	▪ Antitumor necrosis factor-alpha inhibitors for rheumatoid arthritis from US FDA AERS: 17 probable, 18 possible cases; median age, 62 years*[5] ▪ Type 1 interferon: • Alpha for hepatitis C: 13 probable, 4 possible cases; median age, 51 years* • 11 other reported cases[6] • Beta for multiple sclerosis: 19 probable, 20 possible cases; median age, 56 years • 10 other reported cases of interferon for hepatitis C (8 cases with age <55 years)[7]	Cytokines affecting thrombogenesis[8]
Illicit drugs	▪ Amphetamines: 5 reported cases; age 42 to 50 years[8,9] ▪ Cocaine: Used by 19 of 97 (20%) CI patients at two inner-city hospitals; age 44 to 56 years; 37% right-sided and 16% small bowel disease; 26% mortality[10] ▪ Many other reported cases of multiple ischemic organs[8]	Vasoconstriction, hypercoagulation, direct endothelial injury[8]
Low evidence		
Antibiotics	▪ Antibiotic-associated colitis resembles CI, usually right-sided[8] C-CS: Increased risk, 3.3 (2.19-4.96)[3]	Altered gut microbiome (eg, *Klebsiella oxytoca*)[11]
Appetite suppressants	▪ Bitter orange (resembles ephedra): 1 reported case[12] ▪ Hydroxycut: 1 probable case*[13]	Vasoconstriction[8]

	▪ Ma huang (mainly ephedrine): 1 reported case[14] ▪ Phentermine: 2 reported cases (1 with fenfluramine)[8,15] ▪ Xenadrine (bitter orange, ma huang, caffeine, salicin): 1 reported case[16]	
Chemotherapeutic drugs	▪ R-CHOP: 1 reported case[17] ▪ Taxanes: 10 reported cases[8,18-20] ▪ Vinorelbine/cisplatin: 1 reported case[8] ▪ C-CS: Increased use of taxanes or vinca alkaloids on univariate analysis[3]	Direct epithelial toxicity, inhibited repair of vascular injury[8]
Decongestants	▪ Pseudoephedrine: 9 reported cases (6 cases with age <50 years)[8,21] C-CS: Risk unaffected, 1.1 (0.3-3.9)[22] ▪ Phenylephrine: 1 reported case[23]	Vasoconstriction[8]
Diuretics	▪ C-CS: Increased risk, 1.6 (1.2-2.1)[22]	Extracellular volume deficit, lower peripheral vascular resistance, vasoconstriction[8]
Ergot alkaloids (often combined with caffeine)	▪ 20 reported cases[8,24]	Vasoconstriction[8]
Hormonal therapies	▪ Predominance of women among young patients[25,26], common use of female hormones by female patients[27] ▪ Female hormones C-CS: Increased risk, 1.88 (1.30-2.73)[3] ▪ Oral contraceptives C-CS: Increased risk, 1.05 (1.00-1.10)[28]; risk unaffected, 0.59 (0.28-1.33)[29]; 0.7 (0.3-1.5)[22] ▪ Estrogen replacement C-CS: Risk unaffected, 0.75 (0.67-1.19)[29]; 1.0 (0.7-1.5)[22]	Hypercoagulability, endothelial injury[8]
Laxatives	▪ Osmotic agents: 2 reported cases[8] ▪ Bisacodyl: 2 reported cases[8] ▪ Bisacodyl/polyethylene glycol: 1 reported case of 2 episodes[30] ▪ Lubiprostone: 1 reported case[31] ▪ All drugs C-CS: Increased risk, 4.73 (3.71-6.02)[28]	Increased motility or rapid intravascular volume deficit, reduced perfusion[8]
Psychotropic drugs	▪ 6 reported cases (2 with hypotension)[8,32,33]	Hypotension, constipation

	▪ 10 cases, clinical/pathological data incomplete[34] ▪ C-CS: Increased risk, 3.7 (1.3-11.0)[22]	
Serotoninergic drugs	▪ 5-hydroxytryptamine1 receptor agonists: 12 cases from US FDA AERS (8 cases with age <50 years)[8,35-37] ▪ 5-hydroxytryptamine3 receptor antagonist: 1 case of CI/1000 patient-years of use[38] ▪ 5-hydroxytryptamine4 partial agonist: 27 reported cases (drug withdrawn)[39]	For 5-hydroxytryptamine1 receptor agonists vasoconstriction[8]; for othe agents various factors[39]
Very low evidence		
Digitalis	▪ 1 reported case (poisoning)[8] ▪ Digoxin C-CS: Increased risk, 3.6 (2.1-6.2)[22]; atrial fibrillation not analyzed; decreased risk, 0.27 (0.083-0.86)[40]	Vasoconstriction
Kayexalate	▪ 1 reported case[41] ▪ 44 cases of colon injury with incomplete pathological data[42]	Direct toxic effect, various non-drug factors[41,42]
NO-Xplode	▪ 1 reported case[43]	Blood shunting to skeletal muscle, hypoperfusion, various non-drug factors[43]
NSAIDs	▪ Reported cases not clearly distinguishable from NSAID-induced colopathy[8] ▪ C-CS: Risk unaffected, 0.9 (0.6-1.2)[22]; 0.68 (0.62-1.27)[44]	Inhibition of vasodilating prostaglandins, vasoconstriction[8]
Statins	▪ 2 reported cases[8,45]	None
Vasopressors	▪ 1 reported case[8]	Vasoconstriction

The table provides the pharmacologic agents associated with colonic ischemia. Nonpharmacologic etiologies for colonic ischemia are presented in a separate table.

CI: colon ischemia; C-CS: case-control study (followed by odds ratio [95% confidence interval]); US FDA AERS: United States Food and Drug Administration Adverse Event Reporting System; R-CHOP: rituximab, cyclophosphamide, vincristine, doxorubicin, prednisolone; NSAID: nonsteroidal anti-inflammatory drug.

* Classified by the criteria of Naranjo et al.[13]

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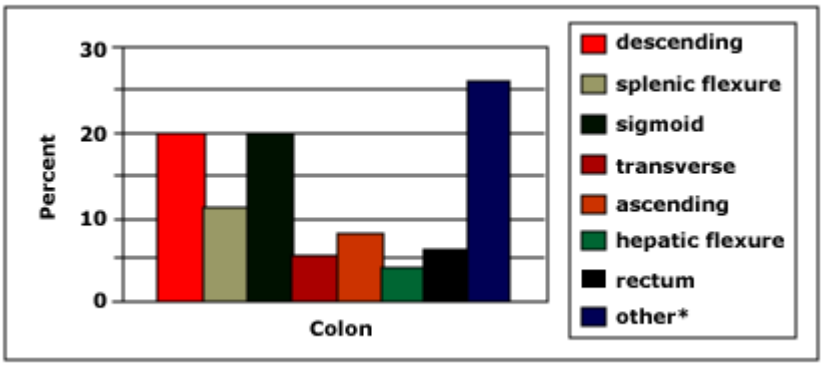
Graphic 115263 Version 1.0

Distribution of colon ischemia

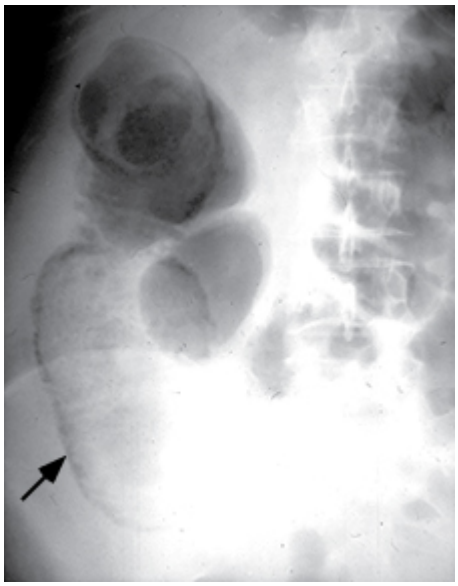


* Other areas refer to combination of different regions.

Data from: Reinus JF, Brandt LJ, Boley SJ. Ischemic diseases of the bowel. Gastroenterol Clin North Am 1990; 19:319.

Graphic 65067 Version 5.0

Pneumatosis intestinalis of the colon on plain film



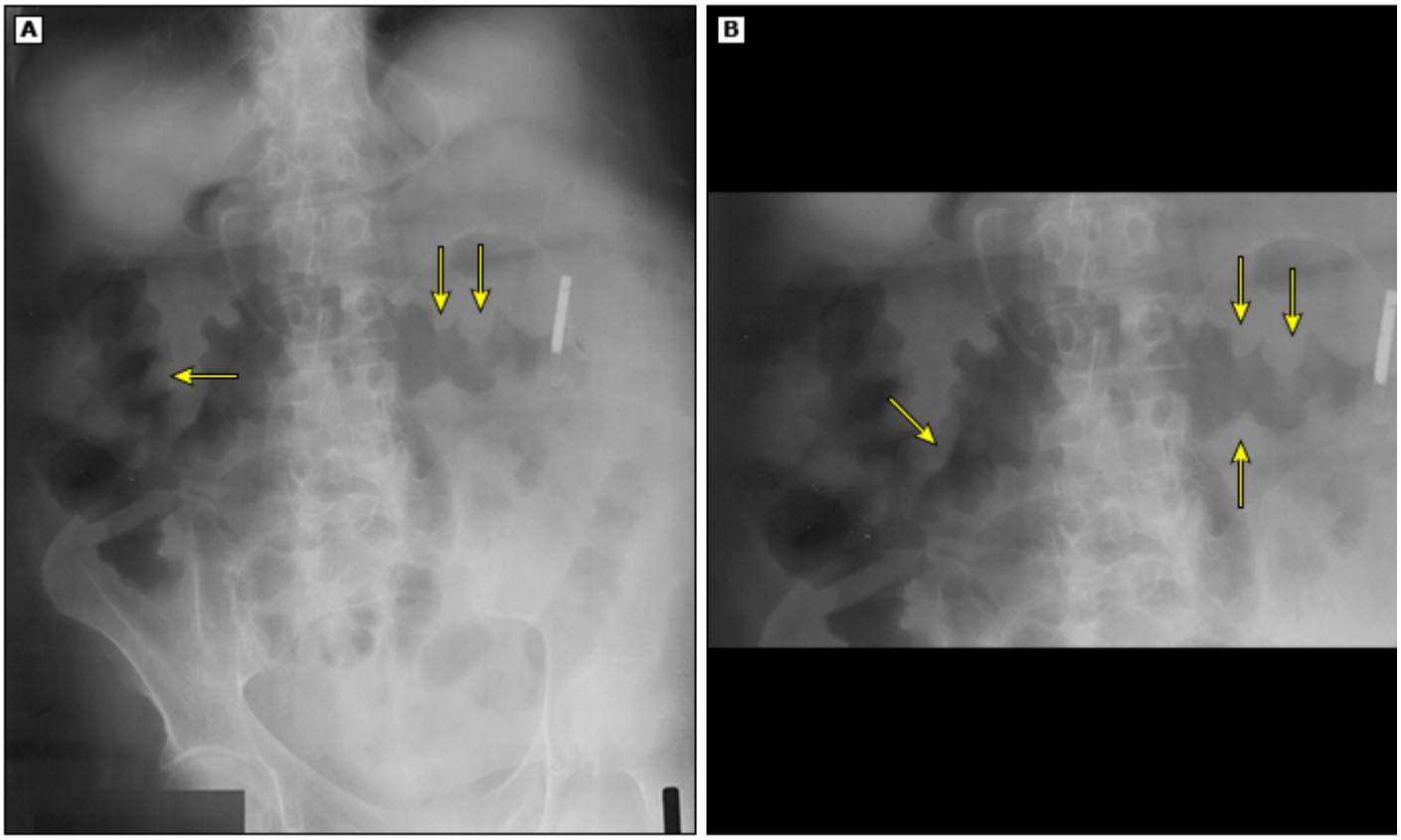
A plain film of the abdomen demonstrates air within the wall of the ascending colon (arrow). This can be seen in ischemic bowel but may also occur after colonoscopy or surgical anastomoses and in patients taking corticosteroids or with HIV infection.

HIV: human immunodeficiency virus.

Courtesy of Jonathan Kruskal, MD.

Graphic 81253 Version 5.0

Thumb printing of the colon on radiograph

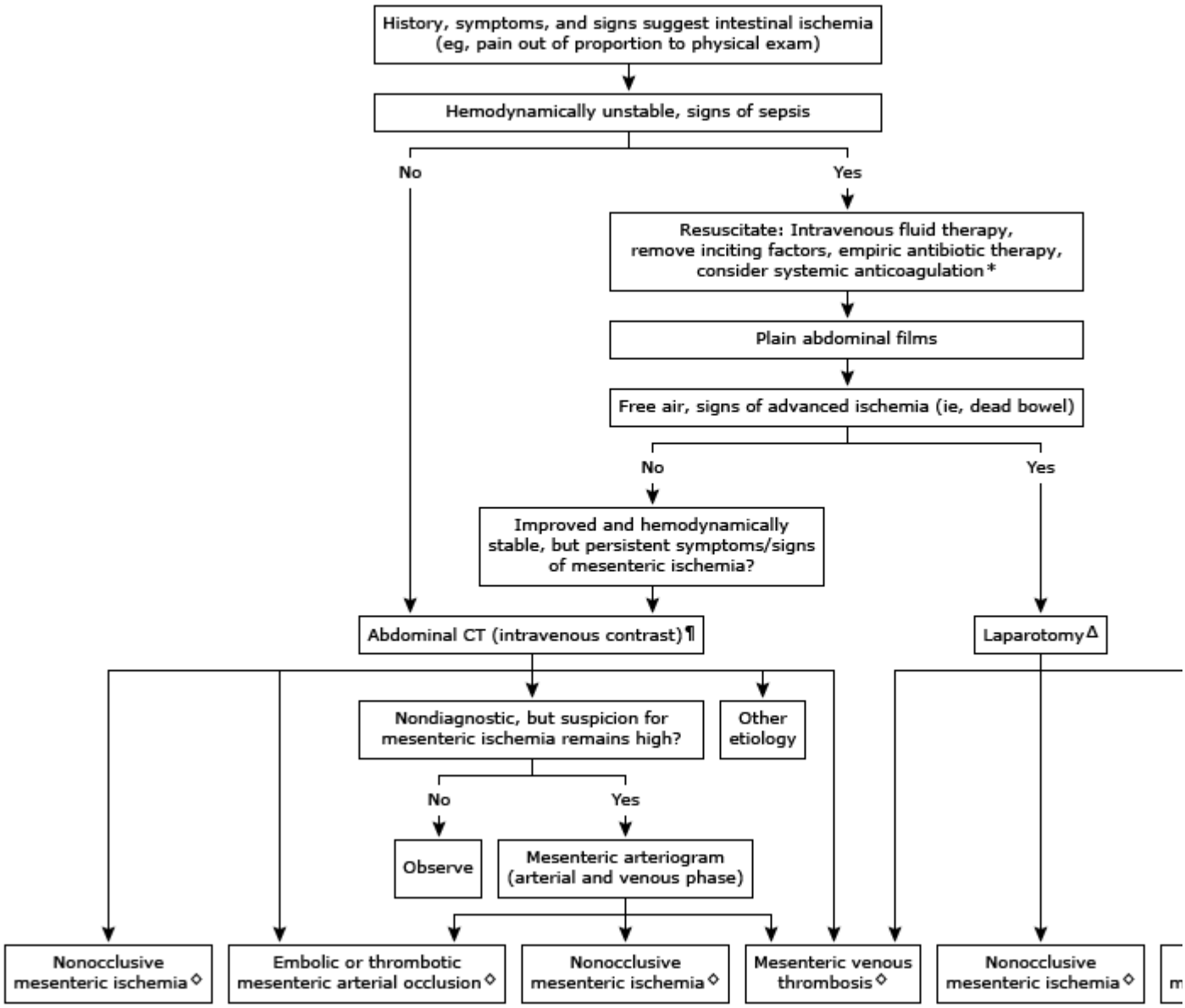


A-P view of the abdomen shows thumb printing of the transverse colon (arrows). Image B is a magnified view and highlights the thumb printing (arrows).

A-P: anteroposterior.

Graphic 99511 Version 1.0

Diagnosis and initial management of intestinal ischemia



CT: computed tomography.

* Patients ultimately identified with nonocclusive mesenteric ischemia will not benefit from anticoagulation, at which point it can be discontinued.

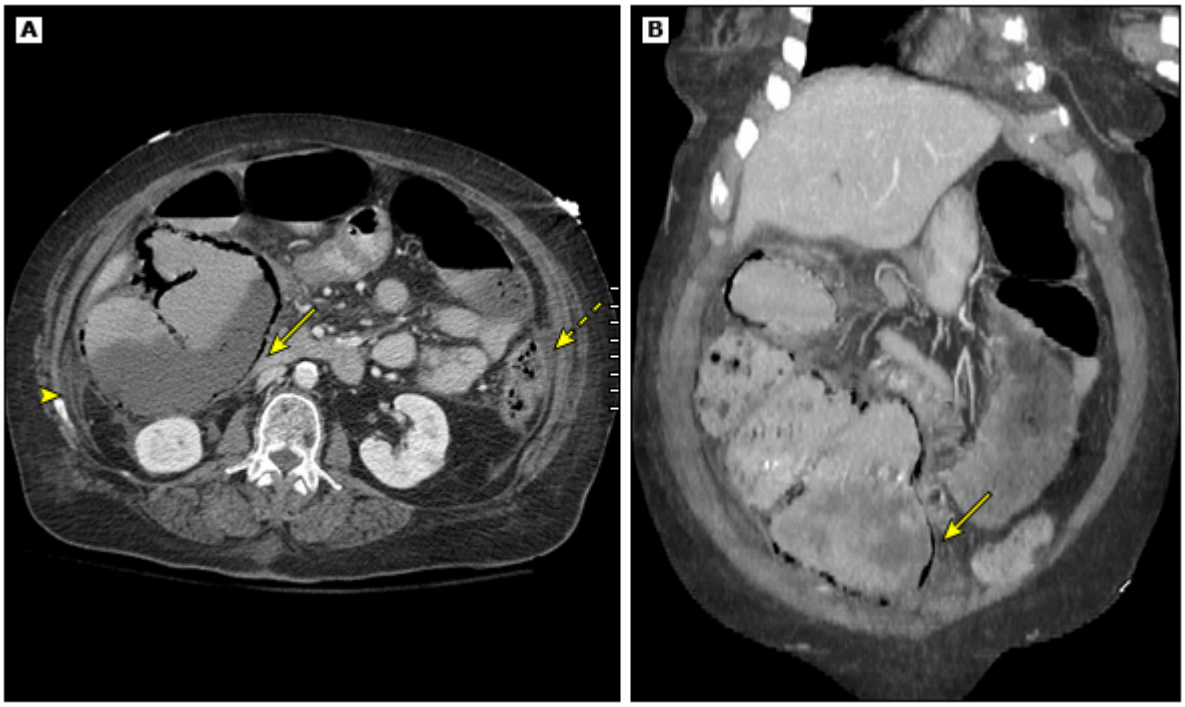
¶ Imaging signs associated with mesenteric ischemia include focal or segmental bowel wall thickening, intestinal pneumatosis, portal vein gas, portomesenteric thrombosis, mesenteric arterial calcification, and mesenteric artery occlusion.

Δ Medically fit patients.

◇ Refer to associated UpToDate algorithms on mesenteric ischemia (acute or chronic, occlusive or nonocclusive, arterial or venous).

Graphic 62760 Version 6.0

Colonic ischemia on computed tomography

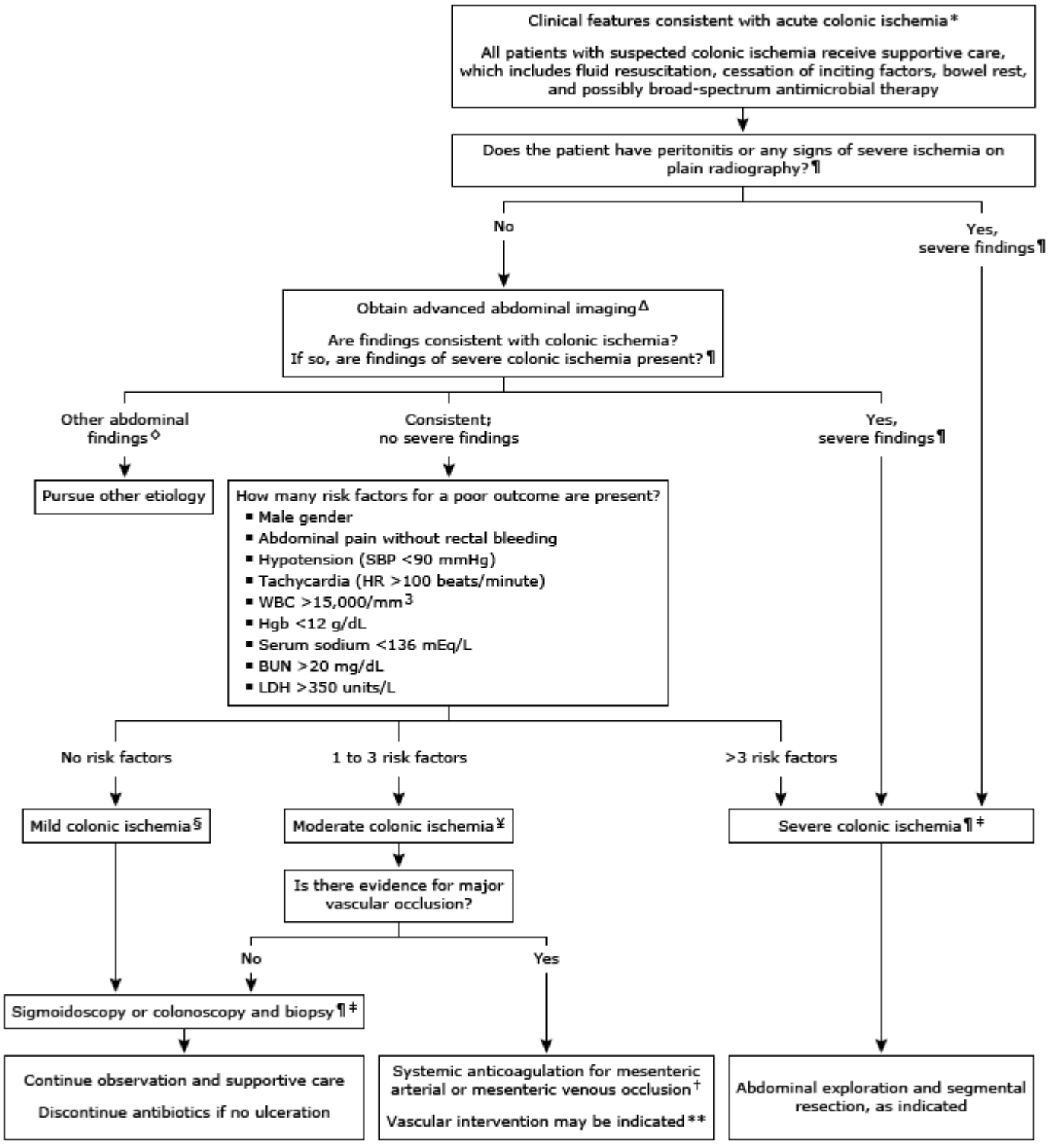


The CT scan of the abdomen is from a 72-year-old female who presented with acute abdominal pain. Image A is an axial projection through the cecum, and image B shows the cecum and ascending colon reformatted in the coronal plane. The images show an accumulation of air within the wall of the cecum (arrows), a finding that is characteristic of pneumatosis coli. Associated radiolologic findings include the lack of formed stool in the colon reflecting loss of mucosal function, thickening of the peritoneum and lateral conal fascia (arrowhead), and ascites (dashed arrow). No portal venous air was evident. In the appropriate clinical setting, the findings are highly suggestive of acute ischemia of the large bowel.

CT: computed tomography.

Graphic 86279 Version 4.0

Algorithm for the diagnosis and management of colonic ischemia



SBP: systolic blood pressure; HR: heart rate; WBC: white blood cell count; Hgb: hemoglobin; BUN: blood urea nitrogen; LDH: lactate dehydrogenase; CT: computed tomography; IV: intravenous.

* Abdominal pain, cramping, urgent desire to defecate, lower gastrointestinal bleeding, diarrhea.

¶ Severe colonic ischemia includes any of the following: peritoneal signs on physical examination; pneumoperitoneum, pneumatosis, or portal venous gas on radiologic imaging; gangrene on

colonoscopic examination; pancolonic ischemia or colon involvement isolated to the right side on imaging by colonoscopy or CT; or more than three of the risk factors commonly associated with a poorer outcome (refer to central box of algorithm).

Δ CT with IV (and oral contrast, if tolerated) is the initial imaging study. Multiphase CT angiography is indicated for patients with suspected vascular occlusion (eg, colonic involvement isolated to the right indicating possible superior mesenteric artery occlusion). Bowel findings include mural thickening, edema, and thumbprinting.

◇ Examples include intestinal obstruction or inflammatory bowel disease.

§ Mild disease includes that with typical symptoms of colon ischemia but none of the risk factors commonly associated with a poorer outcome (refer to central box of algorithm).

¥ Moderate colonic ischemia includes those with typical symptoms and one to three risk factors commonly associated with a poorer outcome (refer to central box of algorithm).

‡ Colonoscopy should be performed in suspected cases to confirm the diagnosis. The colon should be insufflated minimally. For moderate-to-severe disease, limited sigmoidoscopy or colonoscopy is appropriate to confirm disease prior to exploration, stopping at the distal-most extent of the disease. Biopsies of the colonic mucosa should be obtained except in cases of gangrene.

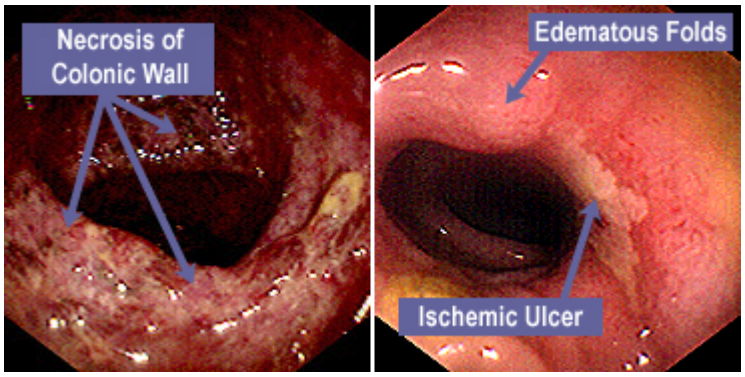
† Conventional catheter-based arteriography may be indicated if vascular occlusion is demonstrated or strongly suspected, such as with colonic involvement isolated to the right side.

** The approach to revascularization, if indicated, may be endovascular or open depending upon the nature of the lesion.

Adapted from: Brandt LJ, Feuerstadt P, Longstreth GF, et al. ACG clinical guideline: epidemiology, risk factors, patterns of presentation, diagnosis, and management of colon ischemia (CI). Am J Gastroenterol 2015; 110:18.

Graphic 108778 Version 3.0

Ischemic colitis on colonoscopy

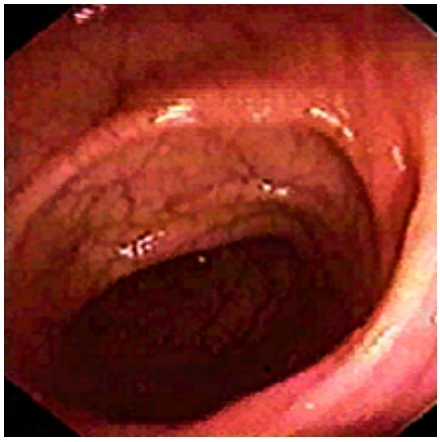


Endoscopy of ischemic colitis may reveal continuous necrosis and mucosal friability that resembles ulcerative colitis (left panel); discrete ulcers with surrounding edema may also be seen (right panel).

Courtesy of James B McGee, MD.

Graphic 59803 Version 2.0

Normal sigmoid colon



Endoscopic appearance of the normal sigmoid colonic mucosa. The fine vasculature is easily visible, and the surface is shiny and smooth. The folds are of normal thickness.

Courtesy of James B McGee, MD.

Graphic 55563 Version 1.0

Features of acute small bowel versus acute colonic ischemia

Acute small bowel ischemia	Acute colonic ischemia
Age varies with etiology of ischemia	90 percent of patients over age 60 years
Acute precipitating cause is typical	Acute precipitating cause is rare
Patients appear severely ill	Patients do not appear severely ill
Pain is usually severe, tenderness is not prominent early	Mild abdominal pain, tenderness present
Bleeding uncommon until very late	Rectal bleeding, bloody diarrhea typical
MRA or MDCT angiography may be considered as the initial diagnostic test; angiography is recommended if there is strong clinical suspicion	Colonoscopy is procedure of choice

MRA: magnetic resonance angiography; MDCT: multidetector row computed tomography.

Data from: Reinus JF, Brandt LJ, Boley SJ. Ischemic diseases of the bowel. Gastroenterol Clin North Am 1990; 19:319.

Graphic 62738 Version 8.0

Empiric antibiotic regimens for low-risk community-acquired intra-abdominal infections in adults

	Dose
Single-agent regimen	
Piperacillin-tazobactam*	3.375 g IV every 6 hours
Combination regimen with metronidazole*	
One of the following:	
Cefazolin	1 to 2 g IV every 8 hours
or	
Cefuroxime	1.5 g IV every 8 hours
or	
Ceftriaxone	2 g IV once daily
or	
Cefotaxime	2 g IV every 8 hours
or	
Ciprofloxacin	400 mg IV every 12 hours or 500 mg PO every 12 hours
or	
Levofloxacin	750 mg IV or PO once daily
Plus:	
Metronidazole¶	500 mg IV or PO every 8 hours

For empiric therapy of low-risk community-acquired intra-abdominal infections, we cover streptococci, Enterobacteriaceae, and anaerobes. Low-risk community-acquired intra-abdominal infections are those that are of mild to moderate severity (including perforated appendix or appendiceal abscess) in the absence of risk factors for antibiotic resistance or treatment failure. Such risk factors include recent travel to areas of the world with high rates of antibiotics-resistant organisms, known colonization with such organisms, advanced age, immunocompromising conditions, or other major medical comorbidities. Refer to other UpToDate content on the antimicrobial treatment of intra-abdominal infections for further discussion of these risk factors.

The antibiotic doses listed are for adult patients with normal renal function. The duration of antibiotic therapy depends on the specific infection and whether the presumptive source of infection has been controlled; refer to other UpToDate content for details.

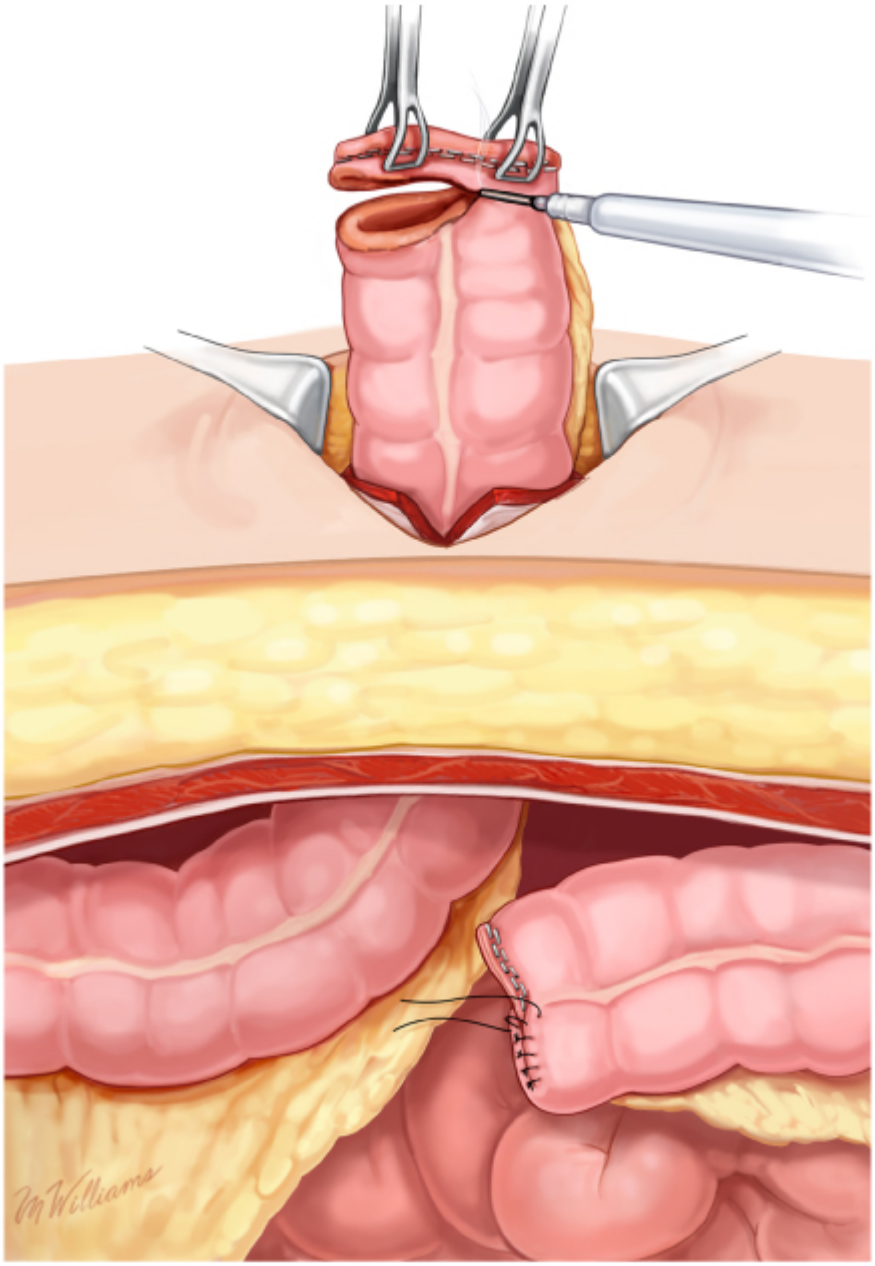
IV: intravenously; PO: orally.

* When piperacillin-tazobactam or one of the combination regimens in the table cannot be used, ertapenem (1 g IV once daily) is a reasonable alternative.

¶ For most uncomplicated biliary infections of mild to moderate severity, the addition of metronidazole is not necessary.

Graphic 106948 Version 13.0

Construction of a colostomy - Hartmann's pouch



This figure depicts the proximal limb of the colon brought onto the abdominal wall. The proximal bowel is opened with electrocautery. The distal limb will remain in the abdominal cavity and the suture line inverted with silk sutures, creating a Hartmann's pouch.

Graphic 67367 Version 1.0

Contributor Disclosures

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