Acute mesenteric arterial occlusion

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INTRODUCTION

Acute mesenteric ischemia refers to the sudden onset of small intestinal hypoperfusion, which can be due to reduction or cessation of arterial inflow. Ischemia due to acute mesenteric arterial occlusion can be caused by embolic obstruction of the intestinal blood supply, most commonly to the superior mesenteric artery. Acute ischemia can also occur due to acute thrombotic obstruction, often in the setting of an already diseased mesenteric vessel (eg, atherosclerosis).

Acute mesenteric ischemia due to acute arterial obstruction involving the small intestine is reviewed. Other forms of acute mesenteric ischemia, including mesenteric venous occlusion and nonocclusive mesenteric ischemia; chronic mesenteric ischemia; and colonic ischemia are reviewed elsewhere. (See "Mesenteric venous thrombosis in adults" and "Nonocclusive mesenteric ischemia" and "Chronic mesenteric ischemia" and "Colonic ischemia".)

MESENTERIC ARTERIAL OCCLUSION

Thromboembolic occlusion of the superior mesenteric artery is the most common cause of acute mesenteric ischemia. Acute mesenteric arterial occlusion accounts for 67 to 95 percent of cases of acute mesenteric ischemia [1-8]. In one review, there has been a significant decrease in the percentage of embolic events since 2000 [1].

Ischemic injury to the intestine develops when there is insufficient delivery of oxygen and nutrients required for cellular metabolism. The intestines may be able to partially compensate for occlusion of the mesenteric arteries because of increased oxygen extraction as well as the presence of collateral flow pathways (figure 1) [9]. The status of the collateral circulation is particularly important in determining the severity of symptoms [10]. The arterial anatomy of the intestinal circulation is shown in the figures (figure 2 and figure 3 and picture 1). An overview of intestinal anatomy, normal intestinal vascular physiology, and the response to acute ischemia are discussed in detail separately. (See "Overview of intestinal ischemia in adults", section on 'Intestinal vascular anatomy'.)

The two major causes of acute mesenteric arterial occlusion are mesenteric arterial embolism and mesenteric arterial thrombosis. In one autopsy study, the ratio of superior mesenteric embolus to thrombus was 1.4:1 [2].

Arterial embolism — Embolism to the mesenteric arteries, which may partially or completely occlude the arterial lumen, is most frequently due to dislodged thrombus from the left atrium, left ventricle, cardiac valves, or proximal aorta.

Emboli tend to lodge at points of normal anatomical narrowing, usually at a branching point of an artery. The large diameter and narrow takeoff angle of the superior mesenteric artery (SMA) (picture 1) make it anatomically most susceptible to embolism. The inferior mesenteric artery is rarely affected due to its small caliber [3]. The embolus usually lodges 3 to 10 cm distal to the origin of the SMA, in a tapered segment distal to the takeoff of the middle colic artery and sparing the first few jejunal branches, but approximately 15 percent of emboli lodge at the origin of the SMA [4].

The middle segment of the jejunum, which is furthest from the collateral circulation of the celiac and inferior mesenteric arteries, is most often involved in the ischemic process, whereas the proximal jejunum is usually spared. Jejunal sparing suggests embolic occlusion rather than acute-on-chronic occlusion of the SMA related to atherosclerotic disease as the underlying cause of acute mesenteric ischemia (picture 2).

Acute superior mesenteric arterial occlusion in the absence of preexisting stenosis (eg, embolism) causes a greater reduction in blood flow compared with other causes of intestinal ischemia, often leading to bowel infarction (picture 3). This is due to the presence of relatively normal arterial vasculature and lack of collateralization. Concomitant arteriolar vasoconstriction also occurs, further impairing intestinal blood flow and exacerbating the ischemia.

Arterial thrombosis — Arterial thrombosis occurs at areas of severe narrowing most typically due to atherosclerosis. However, mesenteric arterial thrombosis can also occur in the setting of vascular injury related to abdominal trauma, mesenteric dissection (eg, spontaneous, related to instrumentation), hypercoagulable states, and infection. Septic embolization from infected heart valves to the visceral arteries can cause mycotic aneurysm, which can also thrombose. Thrombosis of a previously placed mesenteric stent can also occur.

Acute thrombosis of the mesenteric circulation often occurs as a superimposed phenomenon in patients with a history of chronic mesenteric ischemia from progressive stenosis due to atherosclerotic aortic plaque that involves the origins of the celiac axis and SMA, also referred to as acute-on-chronic ischemia. Therefore, thrombosis of the SMA or celiac axis usually occurs at the origin of the vessel. Abrupt thrombosis of even a modest mesenteric arterial stenosis due to inciting factors such as dehydration or low cardiac output states can cause typical signs and symptoms of acute mesenteric ischemia even in the absence of a known history or prior symptoms of chronic mesenteric ischemia. Involvement of at least two major mesenteric arteries is generally needed for the patient to have significant symptoms because of the development of the collateral circulation (figure 1), which provides some degree of perfusion even in the setting of complete occlusion [11]. However, for some patients, progression from stenosis to occlusion over a sufficient time course can be asymptomatic largely due to development of collaterals.

Etiologies — Etiologies for acute mesenteric arterial occlusion include any process that increases the potential for embolism from the heart or proximal arterial vasculature or that increases the risk for arterial thrombosis. (See "Overview of intestinal ischemia in adults", section on 'Risk factors'.)

- The risk of embolism is increased in patients with cardiac arrhythmias and valvular disease, infective endocarditis, recent myocardial infarction, ventricular aneurysm, cardiac surgery, cardiopulmonary bypass, cardiogenic shock, intra-aortic balloon pump placement, aortic atherosclerosis, and aortic aneurysm. Although the incidence is rare following cardiac surgery (1 percent), mortality remains high (87 percent) [12,13].

- The risk of thrombotic occlusion is increased in patients with atherosclerotic burden such as coronary artery, cerebrovascular and peripheral artery disease (with or without prior mesenteric stenting), advanced age, and low cardiac output states [4]. Traumatic injury can also lead to visceral artery thrombosis [14].

- There does not appear to be a significant association between inherited coagulation defects and mesenteric arterial thrombosis [15,16]. However, acquired hypercoagulable states can contribute. In patients with coronavirus disease 2019 (COVID-19), thrombotic mesenteric occlusion with atypical clinical features can occur suggesting mechanisms specific to COVID-19 [17-25]. (See "COVID-19: Hypercoagulability".)

- Less frequently, acute mesenteric ischemia may also be observed in the setting of an underlying vasculitis, most commonly polyarteritis nodosa. Vasculitis affects the small- and medium-diameter arteries and can lead to acute segmental intestinal infarction, but it may be difficult to determine if acute symptoms are due to arterial occlusion or spasm (ie, nonocclusive ischemia). Fibrous intimal thickening is typically seen histologically [26,27]. In most cases, stenoses and/or microaneurysms are detected on arteriography without obstruction of the main mesenteric arteries. (See "Nonocclusive mesenteric ischemia" and "Overview of gastrointestinal manifestations of vasculitis" and "Clinical manifestations and diagnosis of polyarteritis nodosa in adults".)

PRESENTATION AND EVALUATION

Early symptoms and clinical signs, including laboratory studies and plain radiographs, are nonspecific, but any patient with acute onset abdominal pain, minimal findings on abdominal examination (classically described as pain out of proportion to the exam), and metabolic acidosis should be regarded as having intestinal ischemia until proven otherwise. Risk factors for mesenteric arterial occlusion may be present. (See 'Etiologies' above.)

Plain films and cross-sectional abdominal imaging do not make the diagnosis of mesenteric ischemia but may identify complications related to mesenteric ischemia (eg, necrosis, perforation) that indicate the need for immediate abdominal exploration, while also helping to exclude other obvious causes of abdominal pain (eg, volvulus, small bowel obstruction) [28-39]. Routine laboratory evaluation for abdominal pathology is performed, including complete blood count, arterial blood gas, and lactate. Classically, patients have leukocytosis, acidosis, and elevated lactate; however, this occurs in a minority of patients. Normal laboratory findings do not exclude the diagnosis of acute mesenteric arterial occlusion. (See "Overview of intestinal ischemia in adults", section on 'Clinical features'.)

Clinical features that suggest mesenteric arterial embolism or mesenteric arterial thrombus as a cause of acute mesenteric ischemia are as follows:

- **Mesenteric arterial embolism** – The typical patient with acute embolic mesenteric artery occlusion is an older adult patient with atrial fibrillation (or other source for embolism) and severe abdominal pain out of proportion to the physical examination. This presentation is present in one-third to one-half of patients. Bowel emptying, nausea, and vomiting are also common, but bloody bowel movements are less common unless advanced ischemia is present. The patient may be subtherapeutic on previously prescribed antithrombotic therapy. A prior embolic event is present in approximately one-third of patients. In an autopsy series, 19 percent had an acute myocardial infarction, 48 percent had remnant cardiac thrombus, and 68 percent had a synchronous embolus [2]. It is particularly important in these patients to perform a complete vascular examination, examining the carotid, upper extremity, and lower extremity pulses for evidence of reduced perfusion related to synchronous embolism [40].

Systemic embolization occurs in 22 to 50 percent of cases of infected endocarditis, with embolization to the viscera second only to cerebral embolism [41,42]. Most emboli occur within the first two to four weeks of antimicrobial therapy and may be more common in patients with mitral valve involvement, staphylococci independent of vegetation size, larger vegetation size (the largest are associated with streptoccocal infection), and increasing vegetation size while on treatment [41,42]. (See 'Etiologies' above and "Clinical manifestations and evaluation of adults with suspected left-sided native valve endocarditis".)

- **Mesenteric arterial thrombosis** – The typical patient with acute thrombotic mesenteric occlusion is a patient with risk factors for atherosclerosis and possibly known peripheral artery disease who may or may not have an established diagnosis of chronic mesenteric ischemia based upon symptoms of chronic postprandial abdominal pain (ie, intestinal angina), adapted eating pattern, and weight loss. However, in contrast to the classic description, one study noted that patients may not be cachectic, possibly due to earlier diagnosis or a relatively high proportion of patients who were overweight before the onset of symptoms. However, obtaining an antecedent history of chronic mesenteric ischemic symptoms may be helpful for differentiating thrombotic versus embolic occlusion and may potentially influence the choice of initial treatment [8,43]. (See 'Management' below.)

  Patients with COVID-19-related mesenteric arterial thrombosis are often critically ill and may not exhibit classic symptoms (eg, severe abdominal pain or tenderness) [17,24,44]. (See "COVID-19: Gastrointestinal symptoms and complications", section on 'Mesenteric ischemia'.)

DIAGNOSIS

As with all forms of mesenteric ischemia, the diagnosis of acute mesenteric arterial occlusion depends upon a high level of clinical suspicion, particularly in patients with known risk factors for peripheral embolization (eg, atrial fibrillation, recent myocardial infarction, valvular disease) or a history of atherosclerotic disease with or without a history of chronic abdominal pain. Rapid diagnosis is essential to prevent the catastrophic events associated with intestinal infarction [45]. (See "Overview of intestinal ischemia in adults", section on 'Diagnosis'.)

For patients who present with advanced ischemia (bowel perforation and peritonitis) and hemodynamic instability, the diagnosis will necessarily be made in the operating room. (See 'Management' below.)

For patients without indications for immediate surgery, a diagnosis of mesenteric arterial occlusion relies upon demonstration of the occlusion within the mesenteric arteries on vascular imaging studies. High-resolution computed tomographic (CT) angiography (without oral contrast) is highly diagnostic for acute mesenteric ischemia [46-48]. In addition, based upon the appearance of vessels in the abdomen, it is possible to differentiate between embolic and thrombotic etiologies.

- Embolic mesenteric occlusion – Embolic occlusion often appears as an oval-shaped thrombus surrounded by contrast in a noncalcified arterial segment located in the middle and distal portion of the proximal superior mesenteric artery (SMA) (image 1). The occlusion classically occurs in the proximal SMA while preserving the first few jejunal branches (image 2).
- Thrombotic mesenteric occlusion
  - Thrombotic occlusion in association with atherosclerosis usually appears as thrombus superimposed on a heavily calcified occlusive lesion at the ostium of the SMA (image 3).
  - Thrombotic occlusion in association with hypercoagulable states (eg, COVID-19) or associated with shock can have a variable distribution (picture 4).

In addition to determining the type of mesenteric arterial occlusion (ie, embolus versus thrombus), CT angiography identifies the collateral circulation and potential sources of inflow and sites with extensive atherosclerotic lesions to avoid in cases that might require revascularization. In the setting of equivocal CT angiography findings, catheter-based angiography may be needed.

In the critically ill patient, obtaining CT angiography may not be practical, and a proven diagnosis of mesenteric ischemia can be elusive. The clinical evaluation alone may need to be acted upon.

DIFFERENTIAL DIAGNOSIS

Acute mesenteric arterial occlusion needs to be differentiated from other causes of abdominal pain, and from mesenteric ischemia due to nonocclusive mesenteric ischemia or mesenteric venous thrombosis, for which management differs. These distinctions are reviewed elsewhere. (See "Causes of abdominal pain in adults" and "Overview of intestinal ischemia in adults", section on 'Differential diagnosis'.)

MANAGEMENT

Initial medical management for all patients with acute mesenteric ischemia includes the following [49,50], which are discussed in detail separately (algorithm 1) (see "Overview of intestinal ischemia in adults", section on 'Initial management'):

- Nothing by mouth, nasogastric decompression
- Fluid therapy to maintain adequate intravascular volume and visceral perfusion and monitored as normal urine output
- Avoidance of vasopressors, which can exacerbate ischemia
- Therapeutic anticoagulation (unfractionated heparin, weight-based protocol or alternative agent if heparin is contraindicated) to limit thrombus propagation and help alleviate associated arteriolar vasoconstriction, with or without antiplatelet therapy
- Empiric broad-spectrum antibiotic therapy
- A proton pump inhibitor
- Supplemental oxygen

Revascularization options — Clinical evaluation and vascular imaging determine whether the patient is a candidate for vascular intervention and whether the occlusion is embolic or thrombotic, which has a bearing on the type of intervention that can be offered.

The goal of vascular intervention is to restore intestinal blood flow as rapidly as possible. The specific form of revascularization depends upon the clinical status of the patient and the etiology and location of the occlusion. Optimal treatment may include open, endovascular, or a combined (hybrid) approach. Specifically, these include:

- For acute mesenteric embolism
    - Open surgical embolectomy (See "Surgical and endovascular techniques for mesenteric revascularization", section on 'Superior mesenteric artery embolectomy'.)
    - Percutaneous thrombus aspiration with or without pharmacologic thrombolysis (See "Surgical and endovascular techniques for mesenteric revascularization", section on

'Mechanical thrombectomy and lysis'.)

- For acute mesenteric thrombosis (ie, acute-on-chronic mesenteric ischemia)
  - Open mesenteric bypass (See "Surgical and endovascular techniques for mesenteric revascularization", section on 'Mesenteric artery bypass'.)
  - Retrograde open mesenteric stenting (See "Surgical and endovascular techniques for mesenteric revascularization", section on 'Retrograde open mesenteric stenting'.)
  - Percutaneous angioplasty and stenting (See "Surgical and endovascular techniques for mesenteric revascularization", section on 'Mesenteric stenting'.)

The ability to offer an endovascular (percutaneous, hybrid) approach requires the availability of vascular specialists and other local resources. A hybrid interventional suite/operating room may be the ideal setting to manage acute mesenteric arterial occlusion, but these are generally available only at larger vascular centers. (See 'Diagnosis' above and 'Endovascular versus surgical revascularization' below.)

Endovascular versus surgical revascularization — Percutaneous intervention remains somewhat controversial for acute mesenteric ischemia because the bowel is not inspected. No randomized trials are available to guide treatment, but there are a growing number of observational studies that have compared open with endovascular mesenteric revascularization [43,47,51-65].

In a review of the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) database, a total of 439 patients with acute mesenteric ischemia underwent treatment using an open approach in 88.6 percent, a hybrid approach in 5.2 percent, and an endovascular approach in 6.2 percent [55]. There was a trend toward lower transfusion requirements and complications, in particular pneumonia and sepsis, in the minimally invasive group; however, among the 27 patients in the endovascular group, 13 patients required subsequent laparotomy. In a review from Sweden, endovascular treatment surpassed open surgery in 2009 [43]. The authors noted that this shift in treatment has not yet taken place in other countries [51].

Systematic reviews have demonstrated that endovascular revascularization may be as effective as traditional surgical approaches [66-69]. Following endovascular intervention, the requirement for laparotomy ranges from 13 to 69 percent [67]. Rates of bowel resection and length of bowel resection have varied but may be related more so to the underlying etiology (ie, embolic versus thrombotic) rather than the type of revascularization.

- In one systematic review, an endovascular first approach was associated with a reduced in-hospital mortality (pooled prevalence 19 versus 34 percent; risk ratio 0.68, 95% CI 0.59-0.79) [66]. However, there is an inherent selection bias since an endovascular approach is used for patients who are less ill. Several studies have reported higher serum lactate measurements for open compared with an endovascular approach, which is consistent with selection criteria that explicitly exclude patients with signs of peritonitis from undergoing an initial endovascular approach [67]. One retrospective review of patients treated over a 20-year period reported no significant difference in mortality between open and endovascular approaches [51].

- In a study from Sweden, the perioperative (ie, 30-day) mortality rate was similar after open versus endovascular surgery for embolic occlusions (37 versus 33 percent), whereas for thrombotic occlusion, the mortality rate was significantly higher for open compared with endovascular (56 versus 23 percent) [43]. Differences in disease severity may have existed between the treatment groups, but the authors speculated that it is possible that the endovascular approach is better for thrombotic occlusions, which typically occurs in older and more frail patients. Similarly, in another single-center study, lower mortality rates were reported for patients with acute thrombotic occlusions who underwent endovascular intervention [52].

- Several reviews have reported a lower frequency of bowel resection with endovascular therapy for acute thrombotic occlusion [53,54,56-58]. The long-term survival at five years after endovascular treatment and open vascular surgery was 40 and 30 percent, respectively [56]. Independent risk factors for decreased long-term survival were short bowel syndrome and advanced age.

Approach by clinical scenario — The approach is individualized based upon the clinical scenario, including patient anatomy, duration of ischemia, and medical comorbidities. As noted above, there are no high-quality data to guide treatment. Our preferred approach is provided below. (See 'Endovascular versus surgical revascularization' above.)

Acute abdominal findings — Patients who are good-risk surgical candidates with indications for immediate laparotomy such as peritonitis or radiologic features of advanced bowel ischemia (free air, extensive pneumatosis) should be taken directly to the operating room for exploration. While laparotomy should also be viewed as a diagnostic modality of last resort, for some patients, it may be the only possible method for making the diagnosis. At laparotomy, findings suggestive of intestinal ischemia should then prompt evaluation of vascular status (if it remains unknown). Techniques for evaluating the vasculature and mesenteric perfusion (eg, fluorescein, Doppler) are reviewed separately. (See "Surgical and endovascular techniques for mesenteric revascularization", section on 'Adjunctive procedures'.)

- **Mesenteric embolism** – The traditional treatment and our suggested approach for mesenteric embolism, which is typically associated with acute abdominal findings, is open surgical embolectomy, which, in addition to expeditiously clearing the thrombus, allows direct assessment of bowel viability. (See "Surgical and endovascular techniques for mesenteric revascularization", section on 'Superior mesenteric artery embolectomy'.)

- **Mesenteric thrombosis** – Revascularization of mesenteric artery thrombosis due to an underlying atherosclerotic lesion is principally managed with open surgical mesenteric bypass. Thrombectomy alone is unlikely to offer a durable solution due to the presence of thrombogenic atherosclerotic plaques. Intraoperative retrograde open mesenteric stenting (ROMS) is an alternative, particularly in the presence of gross contamination where surgical bypass can be more problematic. (See "Surgical and endovascular techniques for mesenteric revascularization", section on 'Mesenteric artery bypass' and "Surgical and endovascular techniques for mesenteric revascularization", section on 'Retrograde open mesenteric stenting'.)

Mesenteric arterial revascularization is preferably performed before bowel resection. In the setting of acute mesenteric ischemia, the phrase "time is bowel" remains a driving principle for a favorable outcome. Certainly, in the setting of bowel perforation or gangrenous changes, there is very little to debate, and areas of the small or large intestine that are clearly nonviable can be quickly resected using a damage control approach. However, because reversal of ischemia can be very difficult to ascertain with any degree of certainty even with the available methodologies to assess bowel viability, it is prudent to generally err on the side of bowel preservation.

Bowel of questionable viability is preserved and reassessed with a second-look operation. Thus, we advocate delayed re-evaluation of ischemic bowel within 24 to 72 hours corroborated with an adjunctive intraoperative technique to assess viability prior to definitive closure. (See "Surgical and endovascular techniques for mesenteric revascularization", section on 'Second-look laparotomy'.)

No acute abdominal findings — Patients who are hemodynamically stable **and** who do **not** have clinical or radiologic signs of advanced intestinal ischemia may be candidates for a primary endovascular approach.

- **Mesenteric embolism** – Although we prefer open surgical thrombectomy for patients with acute embolism, percutaneous aspiration of the clot or catheter-directed thrombolytic therapy is another approach that has been used successfully with reasonable outcomes in those with no immediate indications for surgery. (See "Surgical and endovascular techniques for mesenteric revascularization", section on 'Superior mesenteric artery embolectomy' and "Surgical and endovascular techniques for mesenteric revascularization", section on 'Mechanical thrombectomy and lysis'.)

- **Mesenteric thrombosis** – For patients with acute mesenteric thrombosis, a primary endovascular approach is reasonable along with close clinical monitoring. (See "Surgical and endovascular techniques for mesenteric revascularization", section on 'Mesenteric stenting'.)

  Some patients with evidence of good collateral blood flow on vascular imaging studies can be observed while anticoagulated. Additional antiplatelet therapy may be justified in this setting if the risk of progressive ischemia appears to be greater than the risk of bleeding [49,70]. The patient should have serial clinical assessment (laboratory, physical examination) with a low threshold to repeat abdominal imaging studies or perform laparoscopic evaluation if abdominal symptoms progress, and surgical or endovascular intervention, as indicated). For those who undergo endovascular intervention, there should be a low threshold to convert to open surgical exploration at any time if problems arise or the patient's clinical condition deteriorates. (See 'Endovascular versus surgical revascularization' above.)

High-risk patient — A palliative approach (ie, comfort measures only) may be the best option for high-risk patients with extensive transmural infarction (eg, small bowel up to the midtransverse colon). Extensive bowel resection would be inappropriate for a subset of patients with limited life expectancy (eg, malignancy), or in those who might otherwise be expected to tolerate the procedure but in whom lifelong parenteral nutrition would be unacceptable (picture 5). A discussion with the patient or other caregivers regarding the immediate and long-term risks/benefits is critical to appropriately manage this population. (See "Palliative care: The last hours and days of life".)

In one review, 64 of 104 (62 percent) patients with embolic/thrombotic occlusion who did not undergo mesenteric revascularization died within 30-days compared with 36 out of 85 (42 percent) patients who were revascularized [1]. Predictors of mortality included a preoperative white blood cell (WBC) count ≥25,000/microL, lactate ≥2.3 mmol/L. Predictors of nonsurvivable bowel necrosis included WBC ≥24,000/microL and lactate ≥3.8 mmol/L.

MORTALITY AND LONG-TERM MANAGEMENT

Mortality from acute mesenteric ischemia remains high, with most series not showing appreciable improvement despite aggressive treatment, regardless of approach [1,45,50,51,62,70-78]. Time to diagnosis and treatment is paramount to survival for acute mesenteric ischemia patients. Advanced mesenteric ischemia (picture 3) requiring bowel resection is associated with a 15-fold increase in mortality, and overall mortality for mesenteric ischemia requiring surgical intervention exceeds 50 percent [2,76]. In a systematic review that included 51 studies, factors associated with an increased risk for death included older age, chronic kidney disease, diabetes, patient dependency, arrhythmia, heart failure, hypotension, small and large bowel involvement, increased lactate, and delay to surgery [79].

Short bowel syndrome — Patients who require extensive bowel resection are at risk for lifelong complications. Patients with less than 200 cm of small bowel are at risk of developing some variation of short bowel syndrome (SBS). In general, having less 100 cm of small bowel renders a patient dependent on parenteral nutrition support regardless of colon status. For patients with between 100 and 200 cm, the expected outcome becomes dependent on colon status, but some deviation from normal can be expected. (See "Management of short bowel syndrome in adults".)

Medical management — Long-term medical management is aimed at the prevention of future embolic events, typically with the use of vitamin K antagonists or novel oral anticoagulants [49]. (See "Atrial fibrillation in adults: Use of oral anticoagulants".)

Following revascularization of thrombotic arterial occlusion due to atherosclerosis, medical management of peripheral artery disease includes antiplatelet therapy and statin therapy as part of a cardiovascular risk reduction strategy. (See "Overview of lower extremity peripheral artery disease", section on 'Risk factor modification'.)

Surveillance imaging — Following mesenteric revascularization, patients should have periodic surveillance either using duplex ultrasound or CT angiography. There are few data by which to guide a specific surveillance interval. Our approach is discussed separately. (See "Surgical and endovascular techniques for mesenteric revascularization", section on 'Postoperative imaging and surveillance'.)

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

- **Acute mesenteric ischemia** – Acute mesenteric ischemia refers to the sudden onset of small intestinal hypoperfusion. Risk factors for acute mesenteric arterial occlusion include any process that increases the potential for embolism from the heart or proximal arterial vasculature or increases the risk for mesenteric arterial thrombosis. Common etiologies include (see 'Introduction' above and 'Etiologies' above):
  - **Embolism** – Emboli to the mesenteric arteries most commonly arise from the heart and lodge 3 to 10 cm distal to the origin of the superior mesenteric artery (SMA) in a tapered segment distal to the takeoff of the middle colic artery and sparing the first few jejunal branches.
  - **Thrombosis** – Thrombosis of the mesenteric arteries is often superimposed on a preexisting stenosis due to atherosclerotic plaque. Mesenteric arterial thrombosis can also occur in the setting of vascular injury related to abdominal trauma, mesenteric arterial dissection (spontaneous, related to instrumentation), a previously placed mesenteric stent, hypercoagulability, and infection.
- **Clinical presentations** – Early symptoms and clinical signs are often nonspecific. Specific clinical features that suggest mesenteric arterial embolism or mesenteric arterial

thrombus as a cause of acute mesenteric ischemia include (see 'Presentation and evaluation' above):

- For acute embolic occlusion, the typical triad is an older adult patient with atrial fibrillation (or other source for embolism) and severe abdominal pain out of proportion to the physical examination.

- For thrombotic occlusion, the typical patient has atherosclerotic risk factors and known peripheral artery disease and may or may not have an established diagnosis of chronic mesenteric ischemia based upon symptoms of intestinal angina, adapted eating pattern, and weight loss.

- **Diagnosis** – For patients who present with acute abdominal findings on exam indicative of bowel infarction and peritonitis, the diagnosis will necessarily be made in the operating room at the time of emergency exploratory laparotomy. For those with clinical features suggestive of acute mesenteric ischemia, but without indications for emergency laparotomy, the diagnosis of mesenteric arterial occlusion relies upon demonstration of the occlusion within the mesenteric arteries on imaging studies. CT angiography (without oral contrast) is the initial study of choice. (See 'Diagnosis' above and "Overview of intestinal ischemia in adults", section on 'Diagnosis'.)

  - Embolic occlusion appears as an oval-shaped thrombus (image 1 and image 2) surrounded by contrast in a noncalcified arterial segment located in the middle and distal portion of the proximal SMA.

  - Thrombotic occlusion often appears as thrombus superimposed on a calcified occlusive lesion at the origin of the SMA (image 3). Thrombotic occlusion in association with hypercoagulable states or associated with shock can have a variable distribution.

- **Treatment** – For patients with acute mesenteric ischemia, the goal of treatment is to restore intestinal blood flow as rapidly as possible after initial management that includes systemic anticoagulation and empiric broad-spectrum antibiotic therapy. The approach to revascularization depends upon the clinical status of the patient and the etiology and location of the occlusion. A palliative approach may be the best option for poor-risk patients with extensive transmural infarction in whom the consequences of extensive bowel resection (eg, small bowel up to the midtransverse colon) would be unacceptable. (See 'Management' above.)

  - **Acute abdominal findings** – Patients who are good-risk surgical candidates with indications for immediate laparotomy should be taken directly to the operating room for exploration. Mesenteric arterial revascularization is preferably performed before bowel resection, but areas of the small or large intestine that are clearly nonviable can be quickly resected using a damage control approach. Bowel of questionable viability (not perforated, not gangrenous) is preserved and reassessed with a second-look operation. (See 'Acute abdominal findings' above.)

  - For patients with acute embolic ischemia due to SMA embolism, we suggest open embolectomy, rather than percutaneous techniques (**Grade 2C**). SMA embolectomy is a relatively straightforward procedure to perform that rapidly restores blood flow. In selected patients, percutaneous aspiration of the clot or catheter-directed thrombolytic therapy are acceptable alternative approaches. (See 'Acute abdominal findings' above and 'Endovascular versus surgical revascularization' above.)

  - For patients with acute thrombotic mesenteric ischemia (ie, acute-on-chronic disease), we suggest open surgical revascularization, rather than alternative methods of revascularization (**Grade 2C**). Surgical bypass provides the benefits of exploratory laparotomy and a durable revascularization. Retrograde open mesenteric stenting is an alternative that allows inspection of the bowel while providing rapid revascularization. (See 'Acute abdominal findings' above and 'Endovascular versus surgical revascularization' above.)

- **No acute abdominal findings** – Some hemodynamically stable patients with thrombotic occlusion (ie, acute-on-chronic disease) who do not have clinical signs of advanced bowel ischemia can be observed while maintained on systemic anticoagulation, provided there is evidence of good collateral blood flow on vascular imaging studies. The patient should have serial clinical assessment with a low threshold to repeat abdominal imaging studies or perform laparoscopic or open surgical evaluation if abdominal symptoms progress, and surgical or endovascular intervention as indicated. Such patients may be candidates for a primary endovascular revascularization, which may include pharmacomechanical thrombectomy and balloon angioplasty (typically with arterial stent placement). For those who undergo endovascular intervention, the threshold is low for conversion to open surgical exploration if there are any problems or there is deterioration of the patient's clinical condition. (See 'No acute abdominal findings' above.)

- **Long-term management** – Long-term management is aimed at preventing future embolic events with anticoagulation, reducing risk reduction for progression of disease in those with thrombotic arterial occlusion related to atherosclerosis, management of any bowel-related consequences, and periodic surveillance of the revascularization. For recurrent stenosis, which can lead to recurrent symptoms, reintervention may be necessary. (See 'Medical management' above and 'Surveillance imaging' above.)

- **Mortality** – Mortality from acute mesenteric ischemia remains high, with most series not showing appreciable improvement despite aggressive treatment regardless of approach, especially if concomitant bowel resection is required. For open surgical approaches to revascularization, perioperative mortality ranges between 31 and 62 percent. The causes of perioperative death include ongoing mesenteric ischemia with intra-abdominal sepsis and multiorgan failure, cardiac causes, hemorrhage, and termination of care. (See 'Mortality and long-term management' above.)

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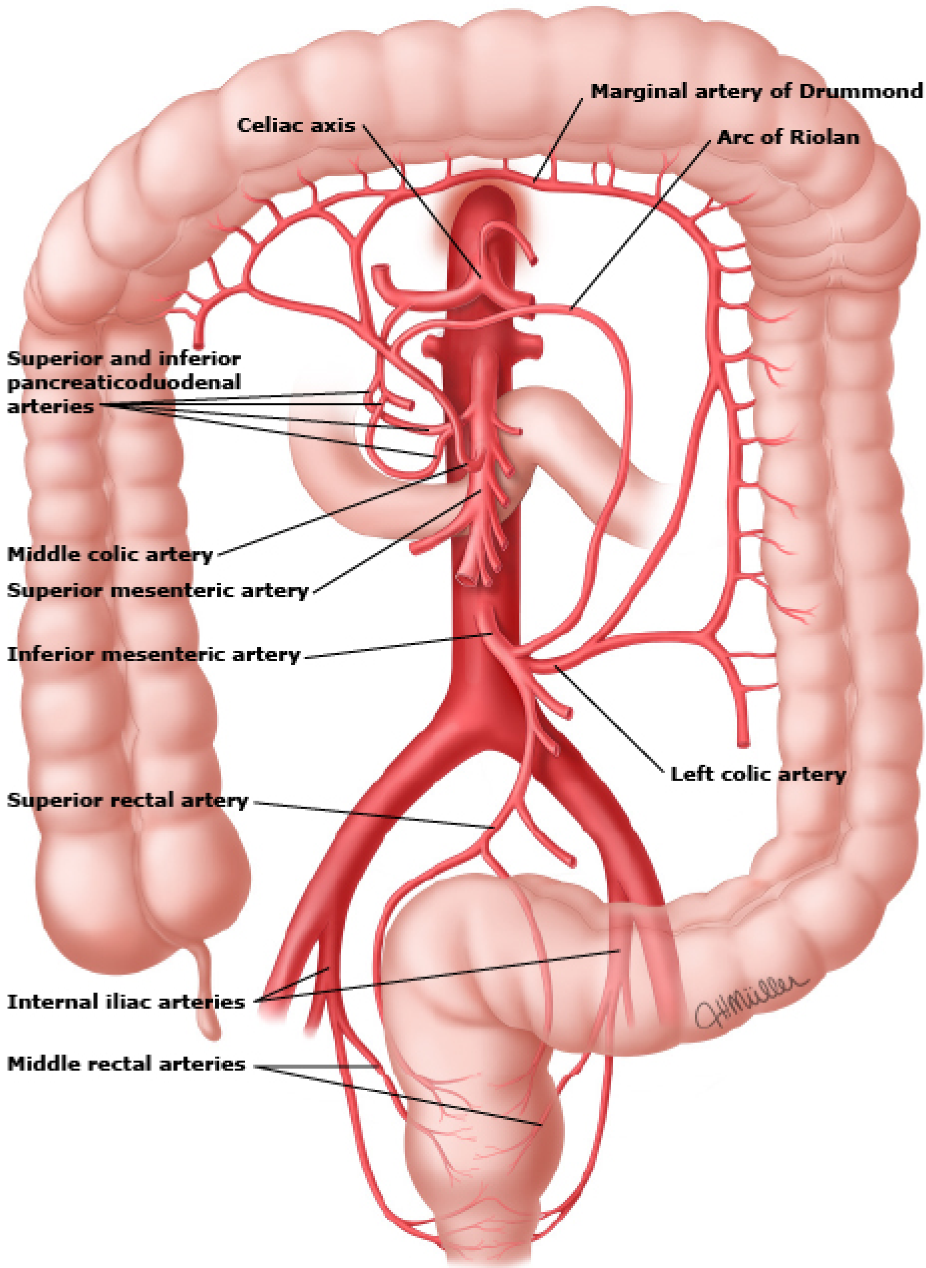
Topic 96754 Version 18.0

GRAPHICS

Collateral circulation to the intestines

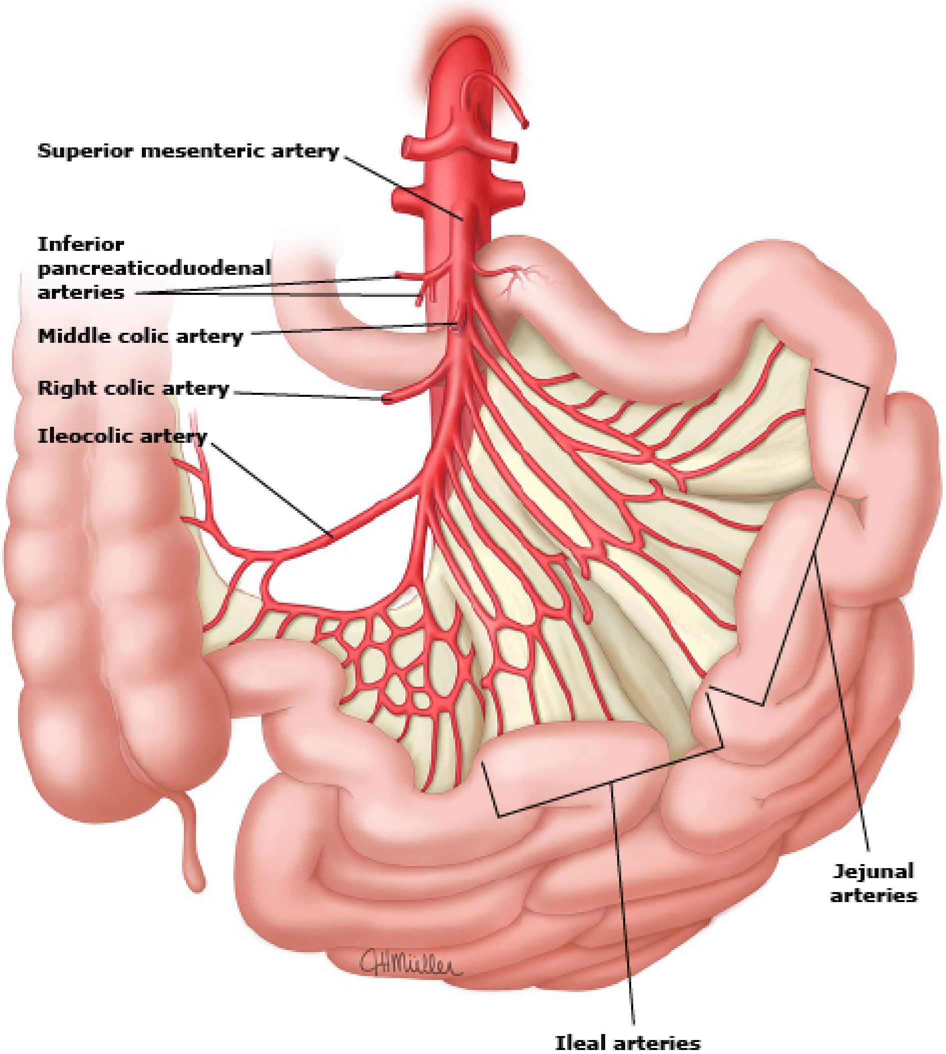


An abundant collateral blood supply exists between the SMA and IMA and the IMA and internal iliac arteries. The arcades of the SMA and IMA interconnect at the base and border of the mesentery. The connection at the base of the mesentery is called the arc of Riolan, whereas the connection along the mesenteric 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

Blood supply to the small intestine

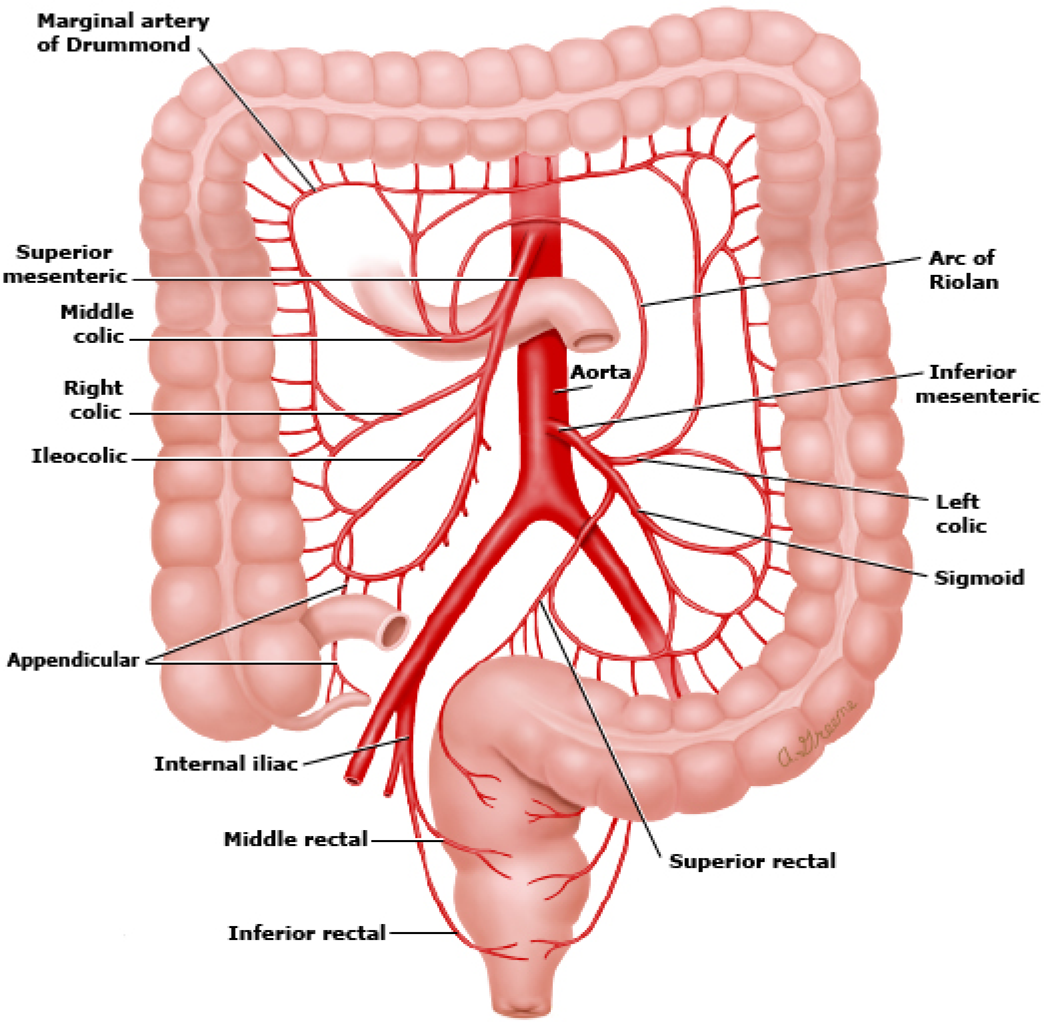


The blood supply to the small and large bowel is derived from the celiac artery and SMA. The celiac axis primarily provides blood flow to the stomach, liver, spleen, and pancreas but is also a source of collateral flow when blood flow in the SMA is reduced. The SMA gives rise to the inferior pancreaticoduodenal artery, the middle colic artery, right colic artery, and many jejunal and ileal branches. The jejunal and ileal branches supply the jejunum and ileum, respectively. The ileocolic artery supplies the distal ileum, cecum, and proximal ascending colon.

SMA: superior mesenteric artery.

Graphic 89910 Version 5.0

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.

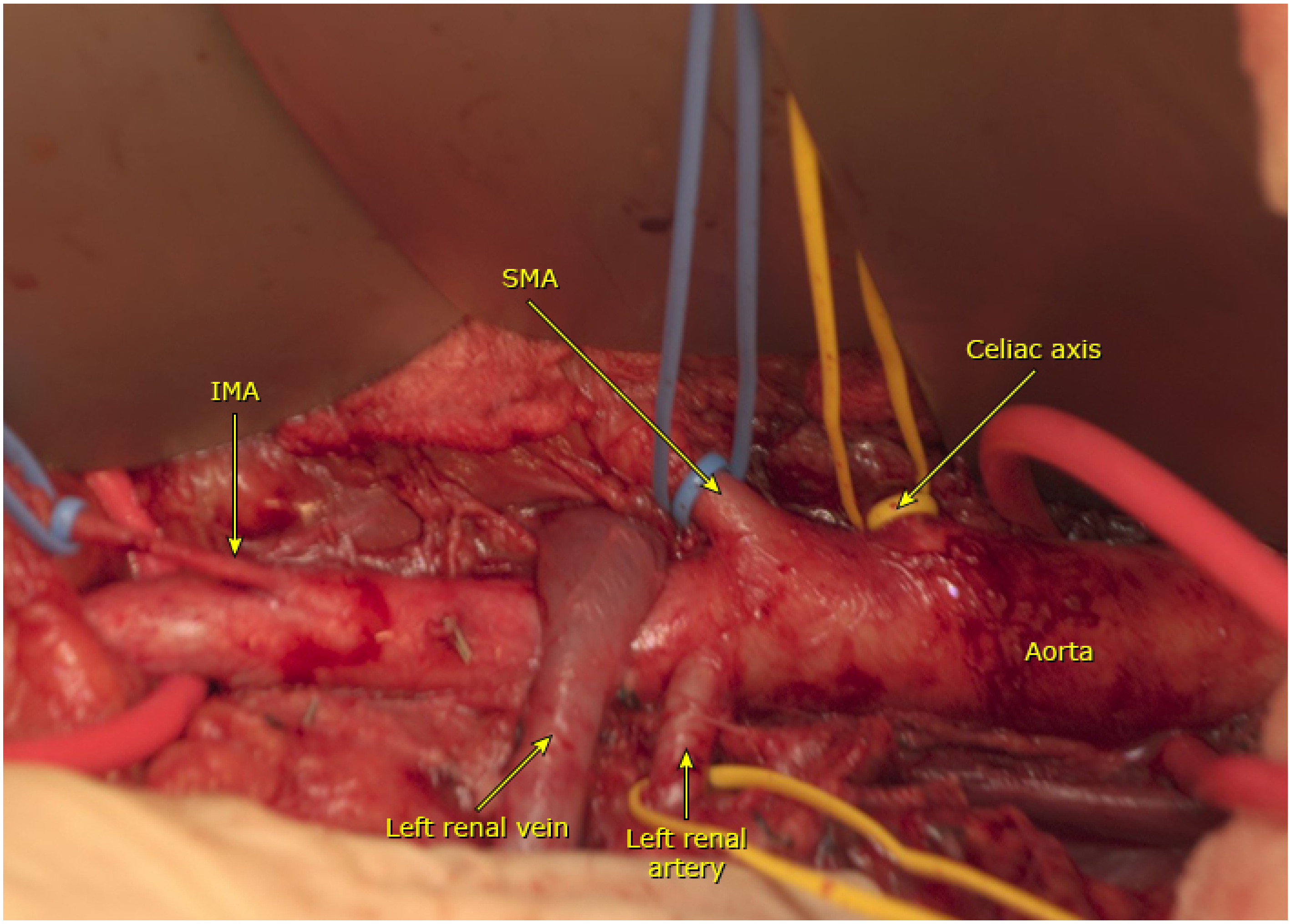
SMA: superior mesenteric artery; IMA: inferior mesenteric artery.

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

Abdominal aorta and its visceral branches

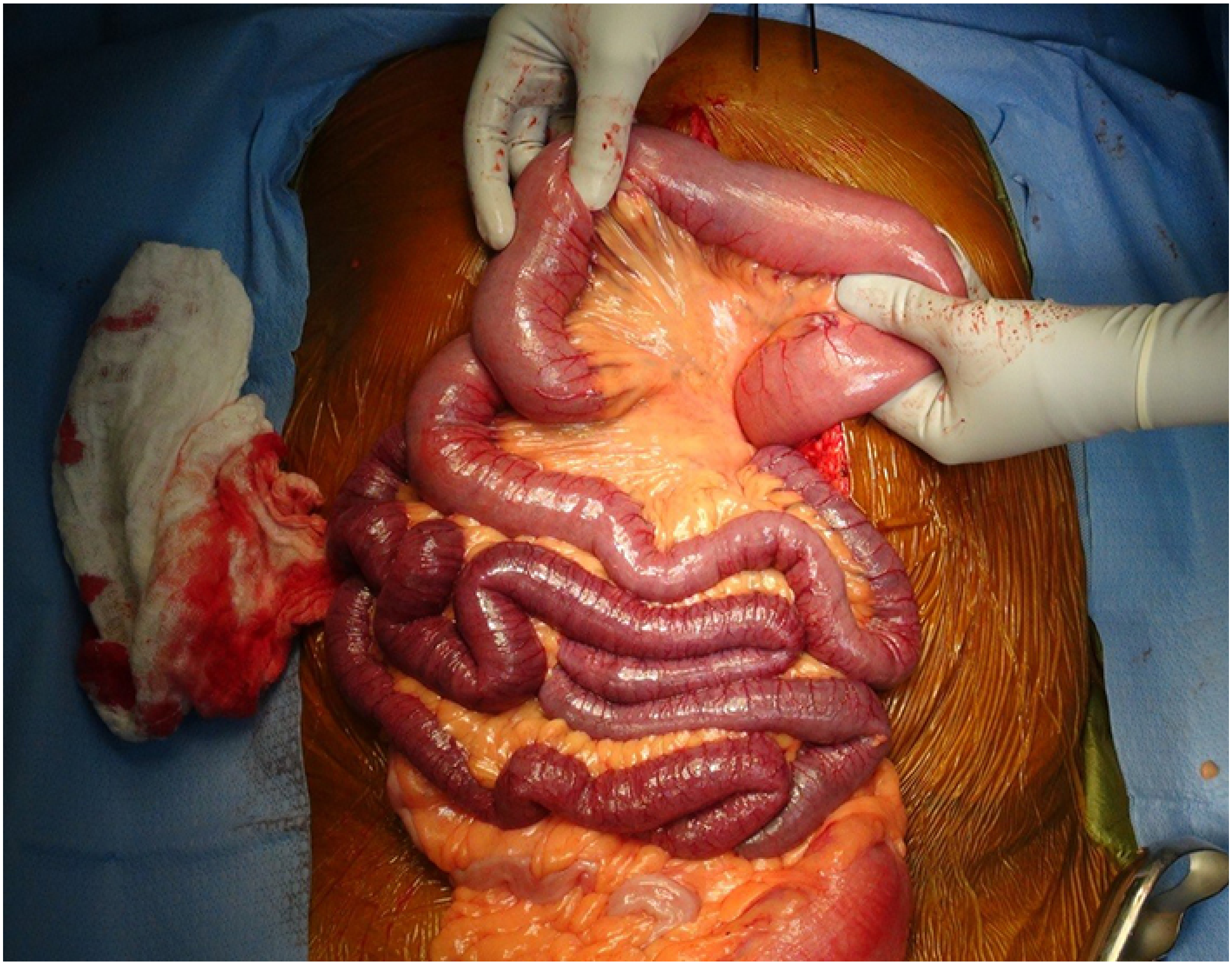


The picture shows the aorta dissected from its bed. The red loops encircle the supraceliac aorta proximally a the left iliac artery distally. From right to left (cranial to caudal) are the celiac axis, SMA, left renal artery, left vein, and IMA.

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

Graphic 110493 Version 1.0

Ischemic bowel from acute embolic occlusion



The picture shows the appearance of the small intestine. The operator's left hand is holding the proximal jejunum, which is relatively spared, suggesting acute embolic occlusion of the superior mesenteric artery ra than acute-on-chronic occlusion. The more distal jejunum and the ileum are dusky and ischemic but appear viable.

Graphic 110494 Version 2.0

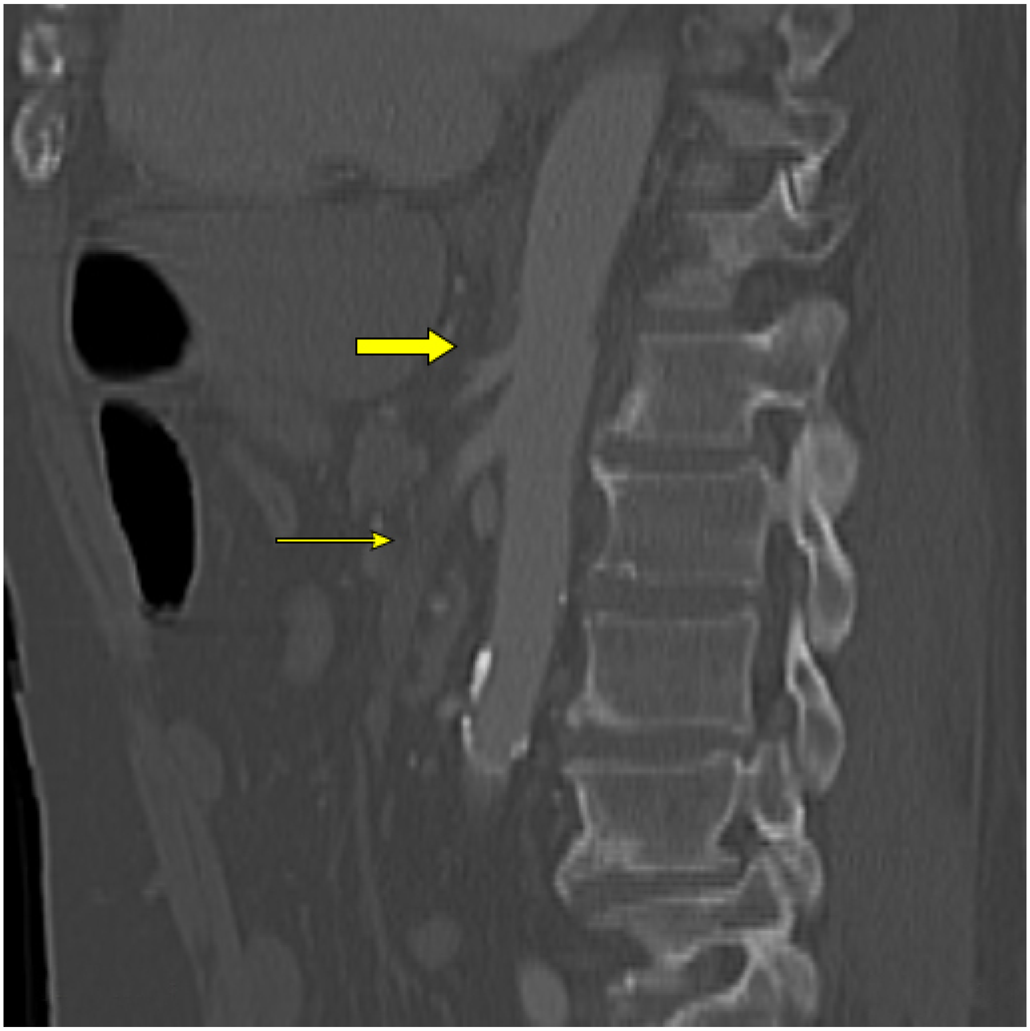
Acute mesenteric arterial occlusion with gangrenous bowel

The picture shows the appearance of the small intestine in a patient who presented with a 12-hour history o
exploration, the bowel was found to be ischemic and a superior mesenteric artery embolism was identified.
minimal improvement in the appearance of the bowel and bowel resection was required; the patient expirec

Courtesy of Ramyar Gilani, MD.

Graphic 128207 Version 1.0

Acute embolic arterial occlusion on CT



The image is a sagittal view of the aorta showing occlusion of the superior mesenteric artery just distal to its takeoff from the aorta (thin arrow) without any associated mural calcifications like those seen in the distal aorta. The origin of the celiac axis (thick arrow) is also without calcification.

Graphic 110495 Version 1.0

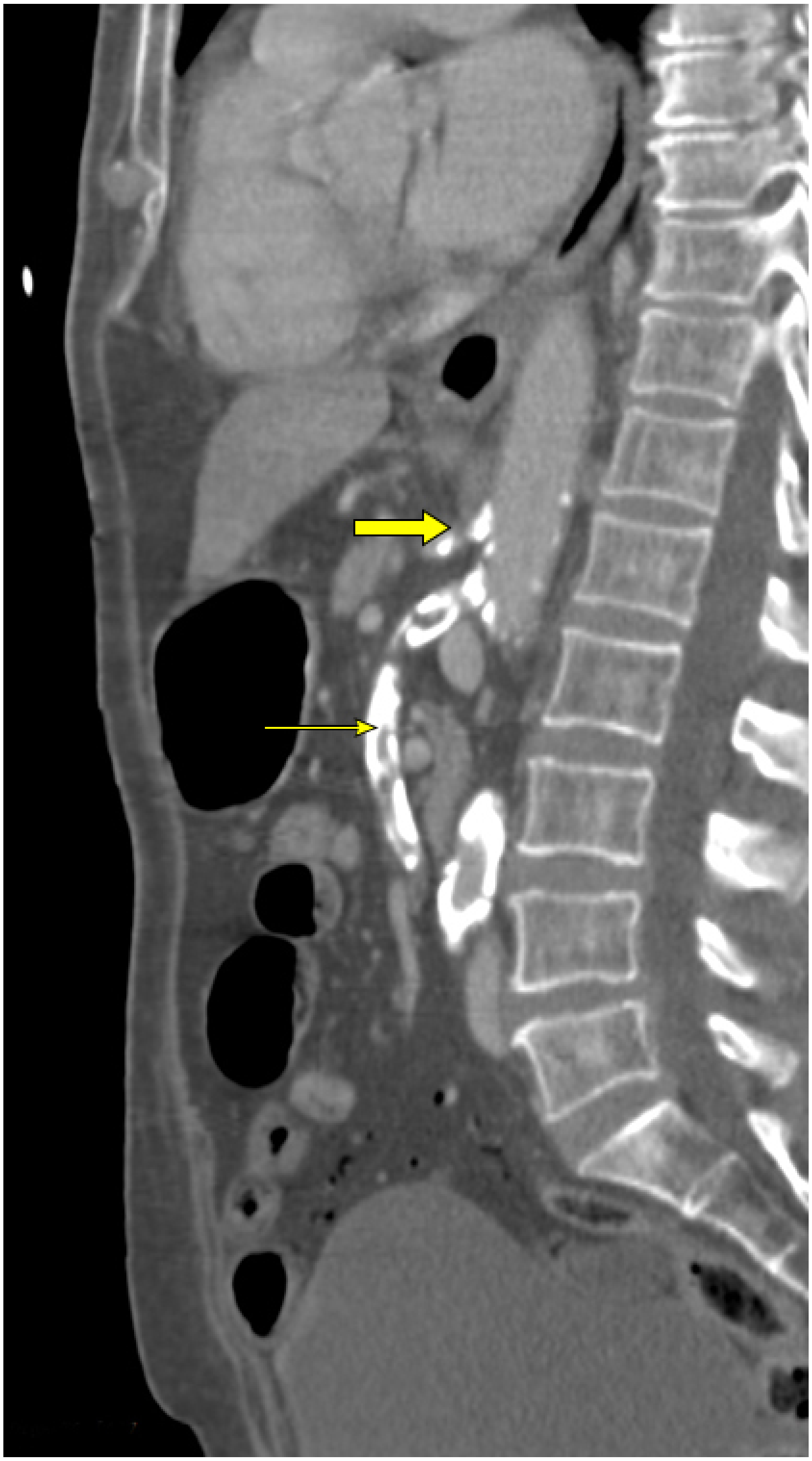
Acute embolic superior mesenteric occlusion on arteriography

The image shows a catheter in the superior mesenteric artery. There is an abrupt cutoff distal to the jejunal branches, typical of a superior mesenteric artery embolism.

RT: right (side of patient); RAO: right anterior oblique; FD: focal distance.

Graphic 110496 Version 1.0

Acute thrombotic mesenteric arterial occlusion



The sagittal image shows calcification at the origins of the celiac (thick arrow) artery as well as calcification distally in the aorta. Diffuse calcifications are also seen along the course of the superior mesenteric artery, and the vessel is thrombosed (thin arrow).

Graphic 110498 Version 1.0

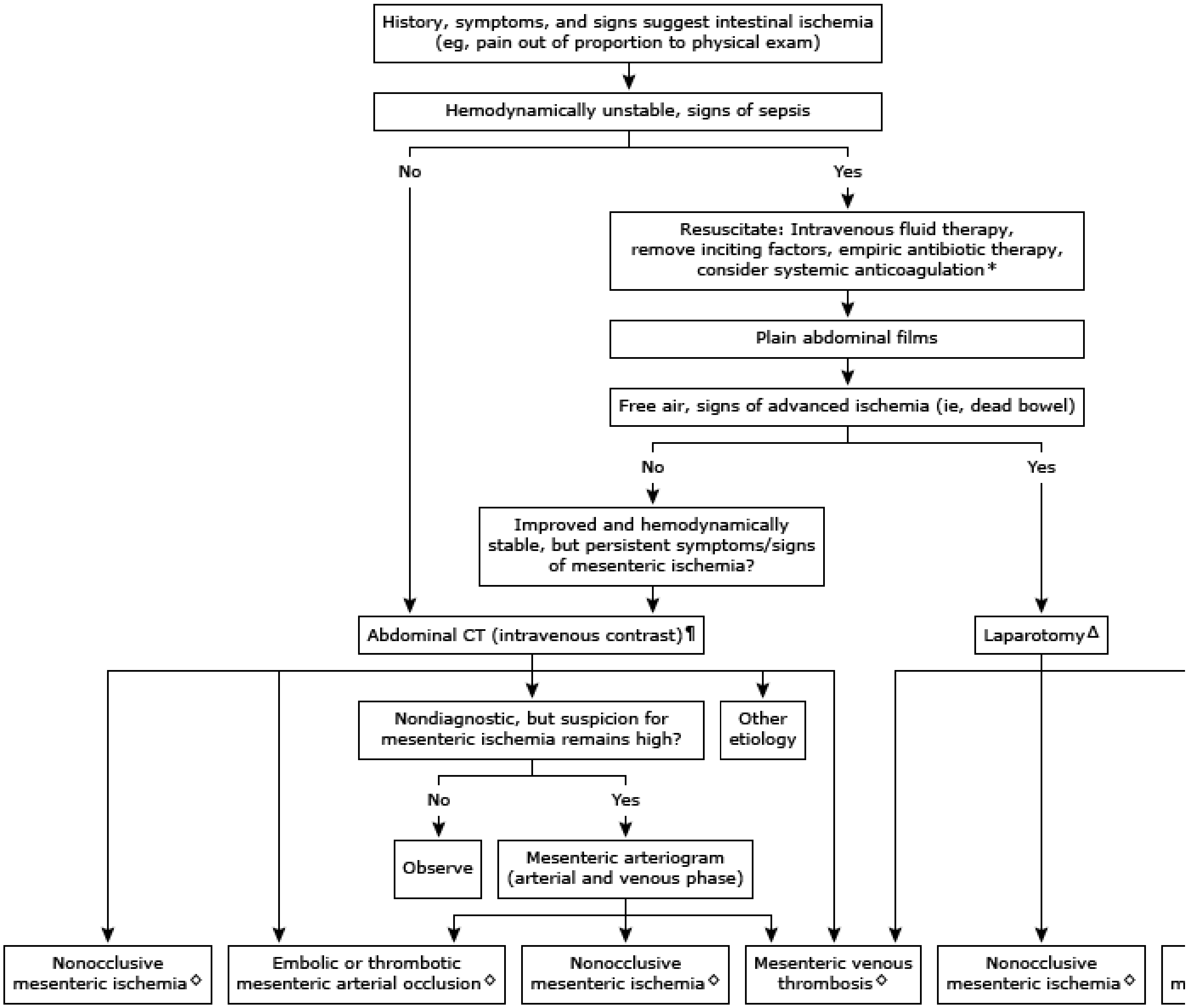
Intraoperative findings in a COVID-19 patient with bowel ischemia

The arrows show the unusually well-demarcated antimesenteric patches of ischemia and necrosis.

From: Kaafarani HMA, El Moheb M, Hwabejire JO, et al. Gastrointestinal complications in critically ill patients with COVID-19. Ann Surg 2020; 272:e61. DOI: 10.1097/SLA.0000000000004004.

Graphic 131026 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, be discontinued.

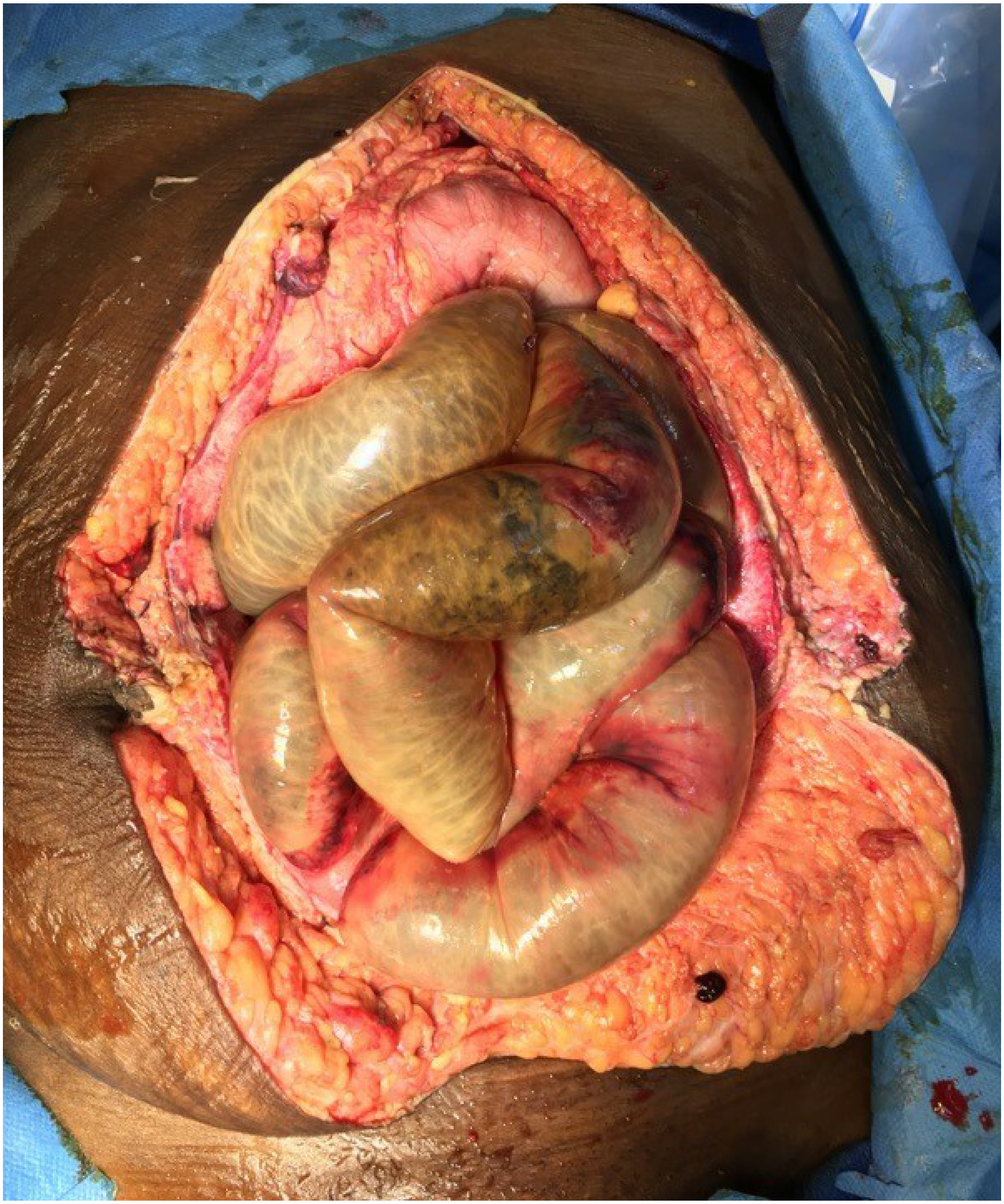
¶ Imaging signs associated with mesenteric ischemia include focal or segmental bowel wall thickening, inte portal vein gas, portomesenteric thrombosis, mesenteric arterial calcification, and mesenteric artery occlusi

Δ Medically fit patients.

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

Graphic 62760 Version 6.0

Acute mesenteric arterial occlusion with nonviable bowel



The picture shows the appearance of advanced mesenteric ischemia with nonviable bowel.

Graphic 110499 Version 1.0

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