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ACR appropriateness criteria® imaging of mesenteric ischemia

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Abstract

Mesenteric ischemia is a rare disease associated with high morbidity and mortality. Acute mesenteric ischemia is most commonly secondary to embolism followed by arterial thrombosis, nonocclusive ischemia, and less commonly venous thrombosis. Chronic mesenteric ischemia is almost always caused by atherosclerotic disease, with rare causes including fibromuscular dysplasia and vasculitis. The American College of Radiology Appropriateness Criteria are evidence-based guidelines for specific clinical conditions that are reviewed every 2 years by a multidisciplinary expert panel. The guideline development and review include an extensive analysis of current medical literature from peer reviewed journals and the application of a well-established consensus methodology (modified Delphi) to rate the appropriateness of imaging and treatment procedures by the panel. In those instances where evidence is lacking or not definitive, expert opinion may be used to recommend imaging or treatment. Patients with mesenteric ischemia usually present with nonspecific abdominal symptoms and laboratory findings. This document evaluates and rates the appropriateness of imaging to evaluate patients with clinically suspected mesenteric ischemia. While catheter-based angiography has been considered the reference standard and enables diagnosis and treatment, advances in computed tomography have made it a first-line test in many patients because it is a fast, widely available, and noninvasive study. Abdominal radiographs and ultrasound have a limited role in diagnosing mesenteric ischemia but are commonly the first ordered tests in patients with abdominal pain and may diagnose more common pathologies.

Key words: Appropriateness criteria—Mesenteric ischemia—Acute abdomen—Abdominal pain—Bowel ischemia

Summary of literature review

Mesenteric ischemia is a rare disease associated with a high mortality rate, especially in the acute setting. This disease is responsible for fewer than one in 1,000 hospital admissions, but its mortality rate ranges between 30% and 90% [1]. It is more prevalent in the elderly population

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with comorbidities largely influencing the mortality rate. Another factor associated with the high mortality rate is the clinical presentation with nonspecific symptoms and relatively benign physical examination, which leads to a low index of suspicion and therefore delays in the diagnosis. Most of the data in the incidence of this disease are based on autopsy studies, with the largest epidemiological study conducted in Malmö, Sweden, demonstrating an incidence estimated at 1.2/100,000 person-years between 1970 and 1982 [2]. Most cases of mesenteric ischemia are due to an acute event leading to decreased blood supply to the splanchnic vasculature. Chronic mesenteric ischemia is uncommon, accounting for $<5\%$ of cases of mesenteric ischemia, and is almost always associated with diffuse atherosclerotic disease [3].

Pathophysiology

Acute mesenteric ischemia is most commonly secondary to embolism to the superior mesenteric artery (SMA), which accounts for approximately 40%–50% of all episodes. Acute mesenteric artery thrombosis is the second most common cause of acute mesenteric ischemia (20%–30%) followed by nonocclusive mesenteric ischemia (25%) and less commonly mesenteric and portal venous thrombosis (5%–15%). In the chronic setting, mesenteric ischemia is almost always caused by severe atherosclerotic disease, with rare causes including fibromuscular dysplasia, median arcuate ligament syndrome, and vasculitis [4].

Acute embolization of the SMA involves the distal aspect of the vessel, usually beyond the origin of the middle colic artery. Acute mesenteric artery thrombosis is typically associated with chronic atherosclerotic disease and, given its more insidious course, a well-developed collateral circulation is commonly present [4]. Nonocclusive mesenteric ischemia is seen in the setting of hypoperfusion. In these cases, there is no evidence of vascular occlusion, and the ischemia is distributed over a wider area of the bowel in a nonconsecutive manner [5]. Mesenteric and portal venous thrombosis is the least common cause of acute mesenteric ischemia. Most common risk factors are hypercoagulable states, portal hypertension, and recent surgery [6]. Bowel ischemia occurs if there is no adequate collateral circulation to drain the intestinal mucosa, leading to edema and subsequent arterial hypoperfusion [4].

Chronic mesenteric ischemia occurs due to occlusive or stenotic atherosclerotic disease and most commonly involves at least two or three main vessels [6]. It is more prevalent in the elderly population and in patients with major risk factors for atherosclerosis such as hypertension, hyperlipidemia, and smoking history [7].

Clinical presentation

Patients with acute mesenteric ischemia present with abdominal pain out of proportion to the physical examination [1]. A high index of suspicion is necessary to achieve early diagnosis. The main challenge is to differentiate acute mesenteric ischemia from other more common causes of acute abdominal pain such as appendicitis, peptic ulcer disease, acute pancreatitis, nephrolithiasis, and cholecystitis. Early in the course of disease, laboratory findings are of little value in differentiating among these causes, with the results usually demonstrating leukocytosis, hemoconcentration, elevated amylase levels, abnormal liver enzymes, and/or metabolic acidosis [8].

In the setting of chronic mesenteric ischemia, patients classically present with the clinical triad of postprandial abdominal pain, weight loss, and food avoidance [6]. Nausea and vomiting, postprandial diarrhea, and signs of malabsorption may also be present [7].

Overview of imaging modalities

Conventional angiography has been the reference standard test to assess mesenteric ischemia in both acute and chronic settings, as it allows diagnosis and treatment with a single procedure [9, 10]. Recently with the advances in computed tomography technique, angiography has become an alternative study. Early angiography remains associated with increased survival rates [9] but has a controversial role in the acute setting when the patient has already developed peritoneal signs, with some authors favoring immediate surgery and others advocating the important role of angiography in the preoperative surgical planning [11]. Angiography should not be considered in patients with significant hypovolemia and hypotension, where immediate surgery is the treatment of choice.

Computed tomography angiography (CTA) is a fast and noninvasive test with high sensitivity and specificity in diagnosing acute and chronic mesenteric ischemia and should be considered the first-line test in most cases [7, 12–16]. CT imaging of the abdomen also allows accurate evaluation of the entire gastrointestinal and genitourinary tract, helping to exclude most of the other causes of acute and chronic abdominal pain, including cholelithiasis, cholecystitis, pancreatitis, appendicitis, diverticulosis with or without diverticulitis, and nephrolithiasis.

Magnetic resonance angiography (MRA) has high sensitivity and specificity for high-grade stenosis and occlusions at the origins of the celiac axis and SMA but has a limited role in evaluating distal arterial stenosis and nonocclusive mesenteric ischemia. As this is a long test and is not often available promptly, it has a limited role in the acute setting where it may delay treatment [17]. It also has a limited role in the evaluation of the inferior mesenteric artery due to its ability to reveal anatomic characteristics [18]. MR of the abdomen and pelvis without contrast can be used in patients with contraindications for intravenous administration of iodinated

and gadolinium contrast, but the lack of opacification of the mesenteric vessels markedly decreases the sensitivity and specificity of this test.

Radiography is usually the initial test ordered in patients with acute abdominal pain but has a limited role in the diagnosis of mesenteric ischemia, especially in the chronic setting. A negative radiograph does not exclude mesenteric ischemia. Plain radiography only becomes positive late in the course of acute disease when bowel ischemia and infarction have developed [19, 20]. It also has a limited role in assessing for other causes of acute abdominal pain, being only helpful in a few cases of nephrolithiasis and bowel obstruction.

Ultrasound (US) can demonstrate proximal mesenteric vasculature occlusion via Doppler mode with high sensitivity but low specificity [21, 22] and has a limited role in the diagnosis of distal occlusion [7, 23]. US may be helpful in diagnosing other causes of acute and abdominal pain such as cholecystitis, cholelithiasis, nephrolithiasis, pancreatitis, and sometimes appendicitis.

Please refer to the variant tables for acute and chronic mesenteric ischemia with ratings and comments for each imaging modality (Tables 1, 2).

Acute mesenteric ischemia

Radiographs. Radiography is usually the first imaging modality ordered for patients with acute abdominal pain but has a limited role in demonstrating primary and secondary signs of acute mesenteric ischemia. Radiography findings in patients with acute mesenteric ischemia are usually nonspecific, late, and associated with a high mortality rate, as they often first appear when bowel infarction has already occurred [3, 20]. A radiograph typically shows bowel dilatation in the elderly patients and a gasless abdomen in younger patients with acute mesenteric ischemia [24]. Hepatic portal venous gas is a rare but important radiographic finding associated with several pathological processes, including bowel necrosis secondary to acute mesenteric ischemia. When associated with pneumatosis intestinalis, it usually indicates the presence of advanced mesenteric ischemia. Abdominal CT appears to be superior to radiographs for detecting pneumatosis intestinalis and hepatic portal venous gas, and their underlying cause. Therefore, CT should be used as the primary diagnostic tool rather than radiography [25].

Computed tomography angiography. CTA is a fast and noninvasive diagnostic tool for evaluating bowel and assessing intestinal vasculature. Recently, the application of CTA as the ideal first-step imaging approach in patients with acute bowel ischemia has been advocated [26–29]. CTA can also be helpful in stratifying patients to identify those who would benefit from angiography as opposed to the ones who should undergo emergent surgery. Vascular CT findings include arterial stenosis, embolism, thrombosis, arterial dissection, and mesenteric vein thrombosis; nonvascular CT findings include bowel wall thickening, hypoperfusion and hypoattenuation, bowel dilatation, bowel wall hemorrhage, mesenteric fat stranding, pneumatosis intestinalis, and portal venous gas. Overall, combining vascular findings with the appearance of the bowel wall resulted in a specificity of 94% with a sensitivity of 96% [2, 7, 24].

Magnetic resonance angiography. MRA has high sensitivity and specificity for diagnosing severe stenosis or occlusion at the origins of the celiac axis and SMA. However, it has a limited role in diagnosing distal stenosis as well as nonocclusive mesenteric ischemia, and its use may delay therapeutic options in acute settings because it is a long examination that is not readily available in most practices [18]. MR without contrast has lower sensitivity and specificity but may be used in cases where both iodinated and gadolinium contrast are contra-indicated.

Table 1. Variant 1: Acute mesenteric ischemia

Radiologic procedure	Rating	Comments	RRL
CTA abdomen with contrast	9	Fast noninvasive study that also evaluates other causes of abdominal pain.	☢☢☢
Arteriography abdomen	8	Allows diagnosis and treatment with a single procedure.	☢☢☢
X-ray abdomen	7	Initial study for patients with acute abdominal pain.	☢☢
MRA abdomen without and with contrast	7	Longer when compared to CT. Limited in distal thrombosis/embolism or nonocclusive mesenteric ischemia. See statement regarding contrast in text under "Anticipated Exceptions."	O
US abdomen	6	High sensitivity and specificity for venous occlusion, and can assess other causes of abdominal pain.	O
MRA abdomen without contrast	3	Lower sensitivity and specificity than MRA that incorporates contrast.	O

Rating scale: 1–3 usually not appropriate, 4–6 may be appropriate, 7–9 usually appropriate
RRL relative radiation level

Table 2. Variant 2: chronic mesenteric ischemia

Radiologic procedure	Rating	Comments	RRL
CTA abdomen with contrast	9	Fast noninvasive study that also evaluates other causes of abdominal pain.	☢☢☢
Arteriography abdomen	7	Allows diagnosis and treatment with a single procedure.	☢☢☢
US abdomen	7	High sensitivity and specificity for venous occlusion, and can assess other causes of abdominal pain.	O
MRA abdomen without and with contrast	7	Longer when compared to CT. Limited in distal thrombosis/embolism or nonocclusive mesenteric ischemia. See statement regarding contrast in text under "Anticipated Exceptions."	O
X-ray abdomen	3	A normal examination does not exclude chronic mesenteric ischemia.	☢☢
MRA abdomen without contrast	3	Lower sensitivity and specificity than MRA that incorporates contrast.	O

Rating scale: 1– 3 usually not appropriate, 4–6 may be appropriate, 7–9 usually appropriate
RRL relative radiation level

Angiography. Angiography has been the gold standard to aid in diagnosis and preoperative planning in acute mesenteric ischemia, with sensitivity in the range of 74%–100% and specificity of 100%. Early angiography has shown to be associated with increased survival in patients with mesenteric ischemia and allows for initiation of therapeutic maneuvers [7]. Whether angiography should precede surgical intervention in the presence of peritoneal signs is controversial. Some would favor immediate surgery in this setting as signs of peritonitis usually indicate infarcted bowel. However, others advocate early angiography because of the importance of determining the etiology of bowel ischemia and providing a "roadmap" for revascularization procedures [5]. Nonetheless, angiography should not be considered in patients with significant hypovolemia or hypotension.

Ultrasound. US can demonstrate proximal mesenteric vessel thrombosis via Doppler mode. It was shown that US is highly specific for identifying vascular occlusions (92%–100%) but has a lower sensitivity (70%–89%) [28, 30]. Unfortunately, the presence of extensive gas within the loops of bowel limits the accuracy of this imaging modality. Moreover, duplex US has a limited role in detecting distal arterial emboli or in diagnosing nonocclusive mesenteric ischemia. US might be helpful in excluding other causes of acute abdominal pain such as cholelithiasis, cholecystitis, nephrolithiasis, acute pancreatitis, or even appendicitis, but it is not recommended for initial evaluation of patients with suspected acute mesenteric ischemia because timing of the diagnosis is very critical [7, 9].

Chronic mesenteric ischemia

Radiographs. Radiography has little to no role in the diagnosis of chronic mesenteric ischemia as these patients have not yet developed bowel necrosis, and therefore the radiograph will likely be normal or demonstrate nonspecific findings. A negative radiograph also does not exclude the diagnosis of chronic mesenteric ischemia.

Ultrasound. US with B-mode and Doppler waveform analysis are a useful initial screening tool for chronic mesenteric ischemia. Visualizing the mesenteric vessels with duplex, US can be technically challenging. The SMA and celiac arteries are visualized in approximately >90% and 80%, respectively. On the other hand, the inferior mesenteric artery can hardly be visualized on transabdominal US studies due to its anatomical location and course [30]. Peak systolic velocity has been widely used for diagnosing stenosis with a cutoff value of 275 cm/s for the SMA and 200 cm/s for the celiac artery. US can also help in excluding other causes of chronic abdominal pain such as cholelithiasis, nephrolithiasis, and chronic pancreatitis.

Computed tomography angiography. CTA with 3D volume reformatting has sensitivity and specificity of 96% and 94%, respectively, for detecting chronic mesenteric ischemia. Therefore, it should be considered as a first-line alternative to angiography for diagnostic purposes [14]. Moreover, CTA is an accurate diagnosing tool for detecting SMA syndrome [15]. CT can also accurately exclude other causes of chronic abdominal pain.

Magnetic resonance angiography. MRA is a noninvasive test that has become increasingly accurate in recent years for diagnosing chronic mesenteric ischemia with sensitivity and specificity of 100% and 95%, respectively [18]. Nonetheless, obtaining high-resolution angiograms is still limited to the inferior mesenteric arteries, where it depicts only 25% of this vessel due to its anatomical course [14]. MR without contrast has lower sensitivity and specificity but may be used in cases where both iodinated and gadolinium contrast are contraindicated.

Angiography. Conventional angiography of the mesenteric arteries remains the gold standard for diagnosing chronic bowel ischemia with its therapeutic role allowing physicians performing endovascular procedures at time of diagnosis. The success rate of angiography is reported to be as high as 88%–100%, with initial relief of symptoms in 82%–100% of cases [31]. Nevertheless, traditional angiography is an invasive test that exposes patients to radiation and is associated with complications related to the procedure itself [32].

Summary

- Literature supports conventional angiography as the gold standard test for patients with acute and chronic mesenteric ischemia except for hemodynamically unstable patients with acute mesenteric ischemia.
- CTA is an emerging diagnostic test with high sensitivity and specificity in the setting of both acute and chronic mesenteric ischemia and should be considered the first-line imaging test. CT can also accurately assess for other causes of acute and chronic abdominal pain, and it provides excellent anatomic mapping of the mesenteric vasculature, which is essential in the preoperative planning.
- MRA is an evolving technique with high sensitivity and specificity for severe stenosis or occlusions at the origin of the celiac axis and SMA, but it has a limited role in the evaluation of distal embolism and nonocclusive mesenteric ischemia and is only able to depict 25% of the inferior mesenteric artery. This is also a long test that is not readily available in most centers, making its use even more limited in the acute setting.
- US of the abdomen with Doppler waveform analysis can depict proximal mesenteric thrombosis and secondary signs of bowel compromise, but it is limited in the diagnosis of distal occlusions/stenosis and nonocclusive mesenteric ischemia and therefore is not recommended as the initial examination in evaluating patients with suspected acute mesenteric ischemia.
- Radiographs remain of limited value, being able to diagnose only late stages of acute mesenteric ischemia when bowel necrosis is already present.

Anticipated exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (i.e., <30 mL/min/1.73 m^2), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73 m^2. For more information, please see the ACR *Manual on Contrast Media* [33].

Table 3. Relative radiation level designations

Relative radiation level	Adult effective dose estimate range (mSv)	Pediatric effective dose estimate range (mSv)
O	0	0
☢	<0.1	<0.03
☢☢	0.1–1	0.03–0.3
☢☢☢	1–10	0.3–3
☢☢☢☢	10–30	3–10
☢☢☢☢☢	30–100	10–30

RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies"

Relative Radiation Level (RRL) Information. Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a RRL indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table 3). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® *Radiation Dose Assessment Introduction* document [34].

Disclaimer The American College of Radiology seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply individual or society endorsement of the final document. This article is a revised version of the American College of Radiology Appropriateness Criteria Imaging of Mesenteric Ischemia. Practitioners are encouraged to refer to the complete version at www.acr.org/ac.

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