

CTA and MRA in Mesenteric Ischemia: Part I, Role in Diagnosis and Differential Diagnosis

Ming-Chen Paul Shih^{1,2}
Klaus D. Hagspiel¹

OBJECTIVE. CT angiography and MR angiography are the main techniques for the noninvasive diagnosis of mesenteric ischemia. High clinical suspicion and knowledge of the differential diagnostic possibilities in this clinical setting are essential for the correct interpretation of the scans.

CONCLUSION. CT angiography and MR angiography are well suited for the workup of patients when mesenteric ischemia is suspected.

Multidetector CT angiography (CTA) is probably the most frequently used technique for the diagnosis of mesenteric ischemia [1]. Contrast-enhanced 3D MR angiography (MRA) is also widely used [2]. In this pictorial essay we review the roles of CTA and contrast-enhanced MRA for the detection and differential diagnosis of mesenteric ischemia (part 1) and for treatment follow-up (part 2) [3]. All scanning was performed on 4-, 8-, or 16-MDCT scanners and 1.5-T high-performance MR scanners. Image reconstruction was performed on MediPrime workstation PACS (Eastman Kodak) and Aquarius (TeraRecon) workstations.

Acute Mesenteric Ischemia

Acute interruption of the blood supply to the gastrointestinal tract is a catastrophic event, with a mortality rate exceeding 60% [4]. The four major causes of acute mesenteric ischemia are superior mesenteric artery (SMA) embolus, SMA thrombosis, mesenteric venous thrombosis, and nonocclusive mesenteric vasoconstriction [4]. Aortic dissections have also been reported to cause acute mesenteric ischemia on rare occasions [5].

Acute SMA Embolism

Acute emboli to the SMA have accounted for approximately 40–50% of all episodes of acute mesenteric ischemia. Most emboli in the SMA lodge just beyond the origin of the middle colic artery. The angiographic hallmark of an embolic occlusion is the abrupt termination of the vessel (cutoff sign). Nonocclusive emboli are usually visualized as filling defects in the vessel lumen. Both CT angiography (CTA)

and contrast-enhanced MRA can show these acute occlusions [6] (Fig. 1). Typically, no or only a paucity of collateral vessels are present. In patients with prior embolic events, recanalized vessels may be seen.

Acute Mesenteric Artery Thrombosis

Acute mesenteric artery thrombosis is typically associated with a preexisting atherosclerotic lesion. It is estimated to be responsible for 20–30% of all cases of acute mesenteric ischemia [1, 4, 5]. In up to 50% of cases, a history of intestinal angina is present [1]. In contrast to the abrupt catastrophic onset of symptoms associated with an embolus to the SMA, the abdominal pain and symptoms associated with acute mesenteric artery thrombosis may be more insidious because of the development of collateral circulation. Occlusion of the SMA is typically within the first 2 cm of its origin, in contrast to acute embolic occlusions, which occur more distally. Usually no defined meniscus or intraluminal filling defect (Fig. 2) is seen. Both CTA and contrast-enhanced MRA can show these findings in addition to visualizing collateral vessels.

Mesenteric and Portal Venous Thrombosis

Mesenteric vein thrombosis accounts for 5–15% of all cases of acute mesenteric ischemia [1, 4, 5]. The most common associated risk factors are portal hypertension; hypercoagulation; trauma; intraabdominal inflammatory diseases; and recent surgery, especially splenectomy, affecting the portomesenteric venous system [1]. Many cases are idiopathic. Acute mesenteric ischemia develops when mesenteric vein thrombosis is associated with a

Keywords: abdominal imaging; angiography, CT; angiography, MR; gastrointestinal imaging; ischemia; mesentery

DOI:10.2214/AJR.05.1167

Received July 6, 2006; accepted after revision December 7, 2005.

¹Division of Non-invasive Cardiovascular Imaging, Department of Radiology, University of Virginia Health System, 1215 Lee St., PO Box 800170, Charlottesville, VA 22908. Address correspondence to K. D. Hagspiel (kdh2n@virginia.edu).

²Present address: Department of Medical Imaging, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan.

AJR 2007; 188:452–461

0361–803X/07/1882–452

© American Roentgen Ray Society

lack of adequate venous collaterals, which results in the development of intestinal mucosal edema and subsequent arterial hypoperfusion. Both CTA and contrast-enhanced MRA have been shown to be highly accurate for the evaluation of superior mesenteric vein and portal vein thrombosis [2, 7] (Fig. 3).

Nonocclusive Mesenteric Ischemia

Nonocclusive mesenteric ischemia is thought to be responsible for approximately 25% of cases of acute mesenteric ischemia, and its mortality rate has been reported to be as high as 70% [8]. Nonocclusive mesenteric ischemia usually develops during an episode of cardiogenic shock or a state of hypoperfusion in which excessive sympathetic activity results in secondary vasoconstriction of the mesenteric arteries. The contrast-enhanced MRA appearance of this entity, to our knowledge, has not been described in humans, but there is one published report of the CTA findings, which included normal mesenteric arteries and veins associated with bowel wall thickening and pneumatosis [7]. We diagnosed one case in which the diagnostic findings consisted of abnormally small mesenteric arteries and extremely delayed filling of the mesenteric veins (no filling at 70 seconds after injection).

Aortic Dissection

Approximately 5% of patients with aortic dissection develop acute mesenteric ischemia as a complication of the dissection process. Both CTA and contrast-enhanced MRA are excellent techniques to assess these patients by clarifying the dissection, defining entry and re-entry points, differentiating thrombus from slow flow, and evaluating branch vessel involvement (Fig. 4). Isolated dissections of the visceral arteries usually occur in association with cystic degeneration or as a complication of catheter angiography and are extremely rare, but they are well shown with CTA and contrast-enhanced MRA [9] (Figs. 5 and 6).

Chronic Mesenteric Ischemia

Atherosclerotic Chronic Mesenteric Ischemia

Chronic mesenteric ischemia is almost always caused by severe atherosclerotic disease and is characterized by a classic clinical triad of postprandial abdominal pain, weight loss, and food avoidance that is present in nearly half the patients with chronic mesenteric ischemia [1]. With advanced age, the abdominal aorta and mesenteric arteries are frequently involved with atherosclerosis. Although atherosclerosis of the mesenteric

branches is frequent, chronic mesenteric ischemia is relatively uncommon, mainly because of the rich mesenteric collateral circulation. It is generally thought that at least two of the three main vessels must be affected either by occlusive or stenotic disease to produce clinical symptoms, although exceptions to this rule exist [1, 10] (Figs. 7–9).

Chronic mesenteric ischemia in the setting of proximal or segmental mesenteric artery stenosis or occlusion in only one affected vessel is rare but can occur (Fig. 10). On the basis of our personal experience with thousands of abdominal CTA and MRA examinations, the inferior mesenteric artery and the periphery of the other splanchnic vessels are currently better assessed with CTA than with contrast-enhanced MRA because of the higher spatial and temporal resolution of the former. No direct comparison has been published for the mesenteric vessels, but the superiority of CTA over contrast-enhanced MRA has been shown for the renal arteries [11].

Nonatherosclerotic Causes of Chronic Mesenteric Ischemia

Fibromuscular dysplasia—Fibromuscular dysplasia is a rare but well-recognized cause of chronic mesenteric ischemia. The CTA and contrast-enhanced MRA appearances of the mesenteric circulation are identical to the renal manifestation [12] (Fig. 11). Accuracy of these imaging techniques is unknown, but it is likely higher for CTA.

Median arcuate ligament syndrome—Median arcuate ligament syndrome is caused by extrinsic compression of the celiac artery or the celiac neural plexus by the central tendon of the crura of the diaphragm [2]. The angiographic findings are best seen on a lateral aortogram and consist of a smooth indentation of the superior aspect of the proximal celiac artery. This indentation is classically more marked on expiration than on inspiration. This entity has been shown with both CTA and contrast-enhanced MRA, both of which also allow identification of the ligament causing the compression (Fig. 12). The ligament can compress the celiac artery and the SMA and, in rare cases, even the renal arteries. CTA may be superior in this setting to catheter angiography [13]. Because this finding can be seen in many patients without symptoms, clinical correlation is important.

Vasculitis, Connective Tissue Disorders, and Other Rare Causes

Chronic mesenteric ischemia has been described as one of the protean manifestations

of vasculitides and connective tissue disorders. The most frequent disease in this respect is Takayasu's arteritis [14] (Fig. 13), but other vasculitides, such as polyarteritis nodosa and segmental mediolytic arteriopathy, can also cause both acute mesenteric ischemia and chronic mesenteric ischemia [1, 13] because of the stenotic and occlusive processes involving the mesenteric arteries. Connective tissue diseases such as Ehlers-Danlos syndrome can also cause mesenteric ischemia [15] (Fig. 14). Both CTA and contrast-enhanced MRA are well suited for imaging when these diseases are suspected because of their ability to assess both luminal and vascular wall changes. Stenosis, occlusion, aneurysm formation, vascular wall thickening, and wall enhancement have been reported in vasculitides. Abdominal coarctation, neurofibromatosis, postirradiation arteritis, and idiopathic fibrosis (Fig. 15) are less common causes of mesenteric ischemia.

Summary

CTA and contrast-enhanced MRA are excellent noninvasive screening techniques for patients suspected of having mesenteric ischemia of all causes. CTA has higher spatial resolution and faster acquisition times, allowing assessment of the peripheral visceral branches and the inferior mesenteric artery with greater accuracy than contrast-enhanced MRA. In addition, it allows the identification of calcified plaques. Contrast-enhanced MRA is therefore our clear second choice in this clinical setting, but the lack of radiation and iodinated contrast agents make it the technique of choice for children and patients with azotemia.

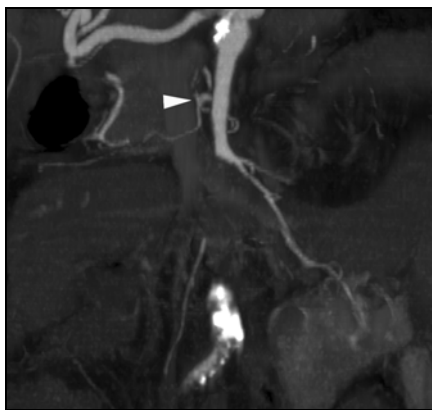
References

1. Hagspiel KD, Angle JF, Spinosa DJ, Matsumoto AH. Mesenteric ischemia: angiography and endovascular interventions. In: Longo W, Peterson GJ, Jacobs DL, eds. *Intestinal ischemia disorders: pathophysiology and management*. St. Louis, MO: Quality Medical Publishing, 1999:105–154.
2. Hagspiel KD, Leung DA, Angle JF, et al. MR angiography of the mesenteric vasculature. *Radiol Clin North Am* 2002; 40:867–886.
3. Shih M-CP, Angle JF, Leung DA, Cherry KJ, Hagspiel KD. CTA and MRA in mesenteric ischemia. Part 2. Normal findings and complications after surgical and endovascular treatment. *AJR* 2007; 188:000–000.
4. Oldenburg WA, Lau LL, Rodenberg TJ, Edmonds HJ, Burger CD. Acute mesenteric ischemia: a clin-

- ical review. *Arch Intern Med* 2004; 164:1054–1062
5. Lock G. Acute mesenteric ischemia: classification, evaluation and therapy. *Acta Gastroenterol Belg* 2002; 65:220–225
 6. Sato O, Okamoto H, Matsumoto H. Emergency CT scan for the diagnosis of superior mesenteric artery embolism: report of 2 cases. *Int Angiol* 2003; 22:438–440
 7. Wildermuth S, Leschka S, Alkadhi H, Marinecek B. Multislice CT in the pre- and postinterventional evaluation of mesenteric perfusion. *Eur Radiol* 2005; 15:1203–1210
 8. Bassiouny HS. Nonocclusive mesenteric ischemia. *Surg Clin North Am* 1997; 77:319–326
 9. Leung DA, Schneider E, Kubik-Huch R, Marinecek

- B, Pfammatter T. Acute mesenteric ischemia caused by spontaneous isolated dissection of the superior mesenteric artery: treatment by percutaneous stent placement. *Eur Radiol* 2000; 10:1916–1919
10. Ruehm SG, Weishaupt D, Debatin JF. Contrast-enhanced MR angiography in patients with aortic occlusion (Leriche syndrome). *J Magn Reson Imaging* 2000; 11:401–410
11. Bhatti AA, Chugtai A, Haslam P, Talbot D, Rix DA, Soomro NA. Prospective study comparing three-dimensional computed tomography and magnetic resonance imaging for evaluating the renal vascular anatomy in potential living renal donors. *BJU Int* 2005; 96:1105–1108
12. Hamed RM, Ghandour K. Abdominal angina and

- intestinal gangrene: a catastrophic presentation of arterial fibromuscular dysplasia: case report and review of the literature. *J Pediatr Surg* 1997; 32:1379–1380
13. Kopecky KK, Stine SB, Dalsing MC, Gottlieb K. Median arcuate ligament syndrome with multivesel involvement: diagnosis with spiral CT angiography. *Abdom Imaging* 1997; 22:318–320
 14. Mehta R, Deepak, John A, Shine, Raj, Balakrishnan. Takayasu arteritis presenting as chronic mesenteric ischemia. *Indian J Gastroenterol* 2004; 23:73–74
 15. Cormier F, Cormier JM. Thirty-eight cases of dysplasia of the superior mesenteric artery [in French]. *J Mal Vasc* 2005; 30:150–161

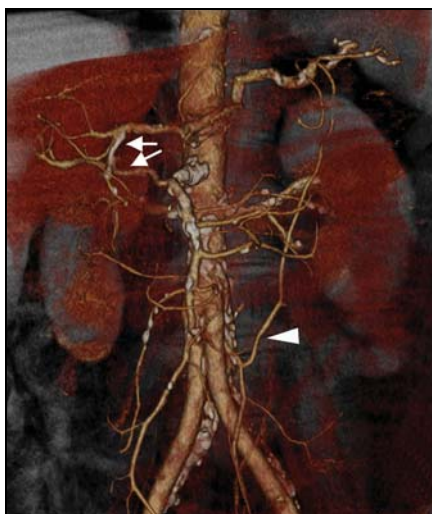


A

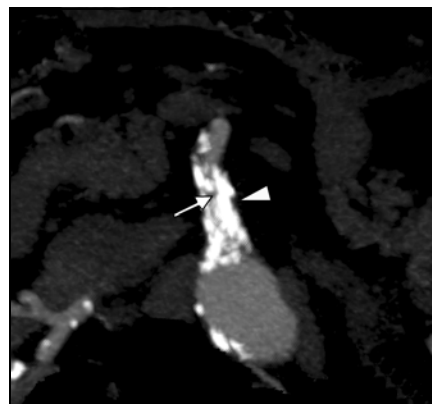


B

Fig. 1—76-year-old woman with severe abdominal pain and diarrhea. **A**, MDCT angiography (CTA) shows acute embolic occlusion of superior mesenteric artery (SMA) distal to origin of middle colic artery (arrowhead). Pathologic thickening of multiple small-bowel loops of jejunum was present (not shown). **B**, Source image of CTA shows filling defect in SMA (arrowhead) and patent superior mesenteric vein. Patient underwent emergent embolectomy with SMA bypass and small-bowel resection and made full recovery.



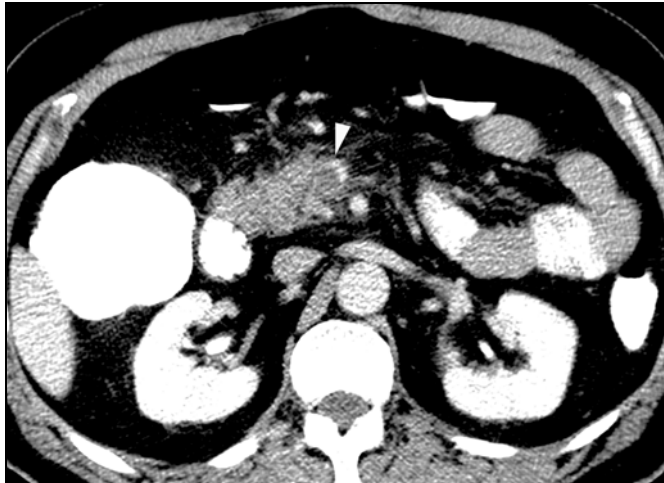
A



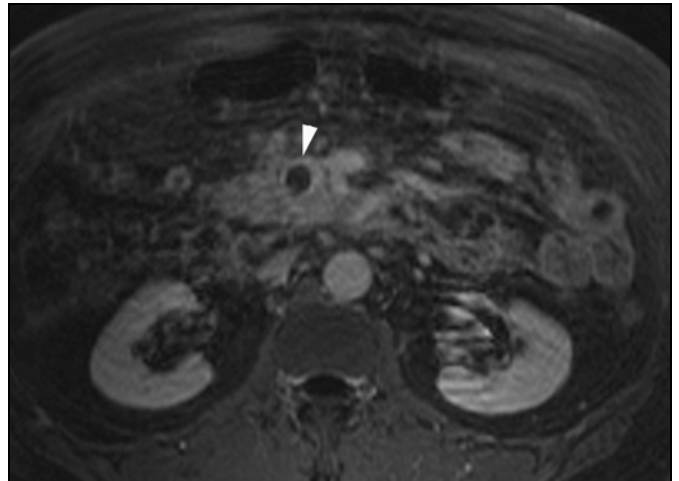
B

Fig. 2—64-year-old man with syncopal episode and abdominal pain. Patient had history of coronary artery disease after aortocoronary bypass graft and aortobifemoral bypass surgery for aortic occlusive disease. **A**, Volume-rendered MDCT angiogram shows aortobifemoral graft as well as severe calcified plaque burden in native vasculature. Note moderate enlargement of ascending branch of inferior mesenteric artery (arrowhead) as well as pancreaticoduodenal arcades (arrows). **B**, Subvolume maximum intensity projection shows significant vascular wall calcifications in superior mesenteric artery origin (arrowhead) causing high-grade stenosis and acute thrombus seen as a small hypodense filling defect (arrow).

CTA and MRA of Mesenteric Ischemia



A



B

Fig. 3—58-year-old man with history of hypercholesterolemia and nephrolithiasis who presented with severe abdominal pain that began approximately 6 days previously. **A** and **B**, Axial images of MDCT angiography (**A**) and gadolinium contrast-enhanced axial T1-weighted image (**B**) show acute thrombus in superior mesenteric vein (arrowheads) as evidenced by round nonocclusive filling defect.

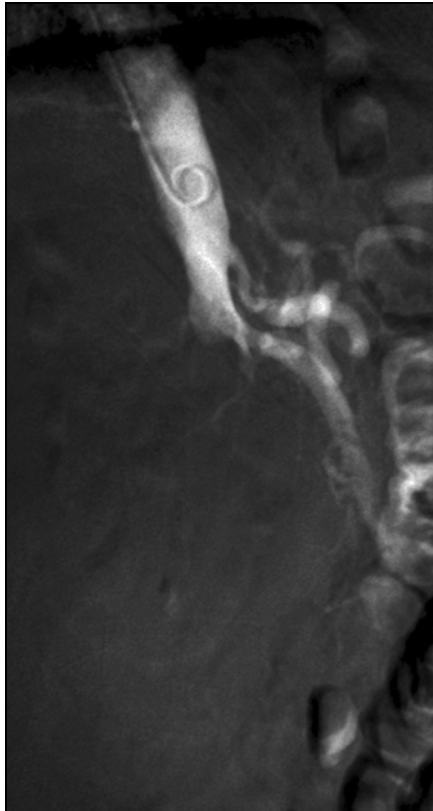


A



B

Fig. 4—58-year-old man with acute onset of severe excruciating back and abdominal pain due to type II aortic dissection. **A** and **B**, Contrast-enhanced MR angiograms show type II dissection with extension of dissection flap (arrow, **A**) downward below origin of superior mesenteric artery (SMA) and occlusion of right renal artery (not shown). There is an occlusion of ileocolic artery (arrowhead, **B**). (Fig. 4 continues on next page)



C

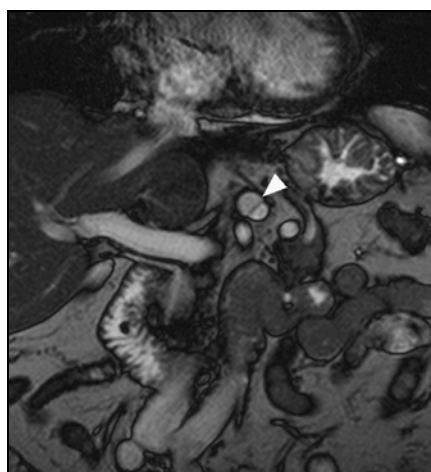


D

Fig. 4 (continued)—58-year-old man with acute onset of severe excruciating back and abdominal pain due to type II aortic dissection. **C and D**, Catheter angiograms in lateral (**C**) and anteroposterior (**D**) projections with catheter in anterior false lumen show that dissection ends just below SMA and filling of distal aorta is via nonopacified (from this catheter position) distal aorta. Note also embolus in ileocolic artery (**arrowhead, D**) of SMA seen on both subvolume maximum intensity projection (**B**) and catheter angiogram (**D**).



A



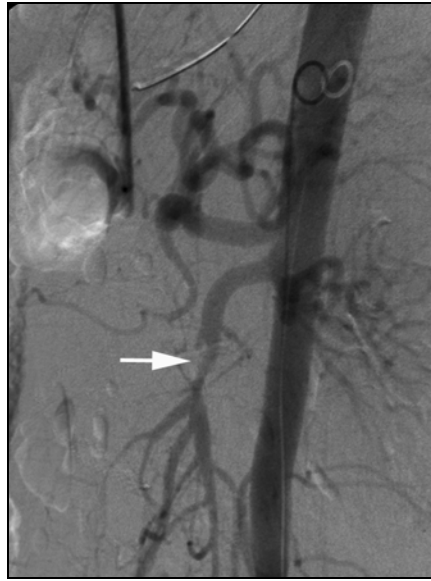
B

Fig. 5—59-year-old man with spontaneous dissection of celiac artery. **A and B**, Contrast-enhanced MR angiogram (**A**) shows ectasia of celiac artery (**arrow**), and coronal steady-state free precession image (**B**) shows dissection flap (**arrowhead**).

CTA and MRA of Mesenteric Ischemia



A

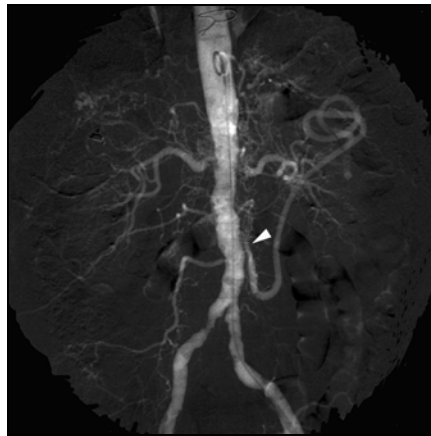


B

Fig. 6—36-year-old woman with acute onset of abdominal pain and bowel perforation.
A, Axial source image of MDCT angiography shows focal dissection of superior mesenteric artery (SMA) (solid arrowhead). Patient also had free air in peritoneum (arrow) due to bowel perforation as well as air in mesenteric veins (open arrowhead).
B, Lateral aortogram confirms focal dissection of SMA (arrow).



A



B

Fig. 7—73-year-old woman with 2-year history of postprandial abdominal pain and 50-lb (22.5-kg) weight loss.
A and B, Contrast-enhanced MR angiogram of abdomen (**A**) and abdominal aortogram (**B**) show atherosclerotic occlusion of celiac trunk and superior mesenteric artery. Collateralization is maintained via inferior mesenteric artery (arrowhead).



Fig. 8—60-year-old woman with clinical symptoms of chronic mesenteric ischemia and severe bilateral claudication.

A, Lateral subvolume maximum intensity projection of MDCT angiogram shows occlusion of celiac artery and superior mesenteric artery and high-grade stenosis of inferior mesenteric artery (IMA) (*arrow*).

B, Volume-rendered image shows that collateral flow to iliac and superior mesenteric arteries was through IMA via Riolo's arch (*arrowhead*).

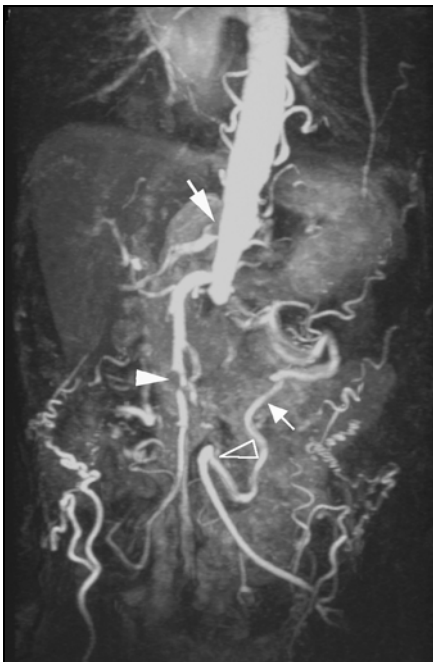


Fig. 9—67-year-old man with vasculopathy and history of left hemispheric stroke, chronic claudication, and clinical signs of mesenteric ischemia. Contrast-enhanced MR angiogram shows total occlusion of infrarenal abdominal aorta, high-grade stenosis of celiac artery origin (*solid arrow*), and segmental superior mesenteric artery stenosis (*arrowhead*). Inferior mesenteric artery (*open arrowhead*) was reconstituted via Riolo's arch (*arrow*).

CTA and MRA of Mesenteric Ischemia

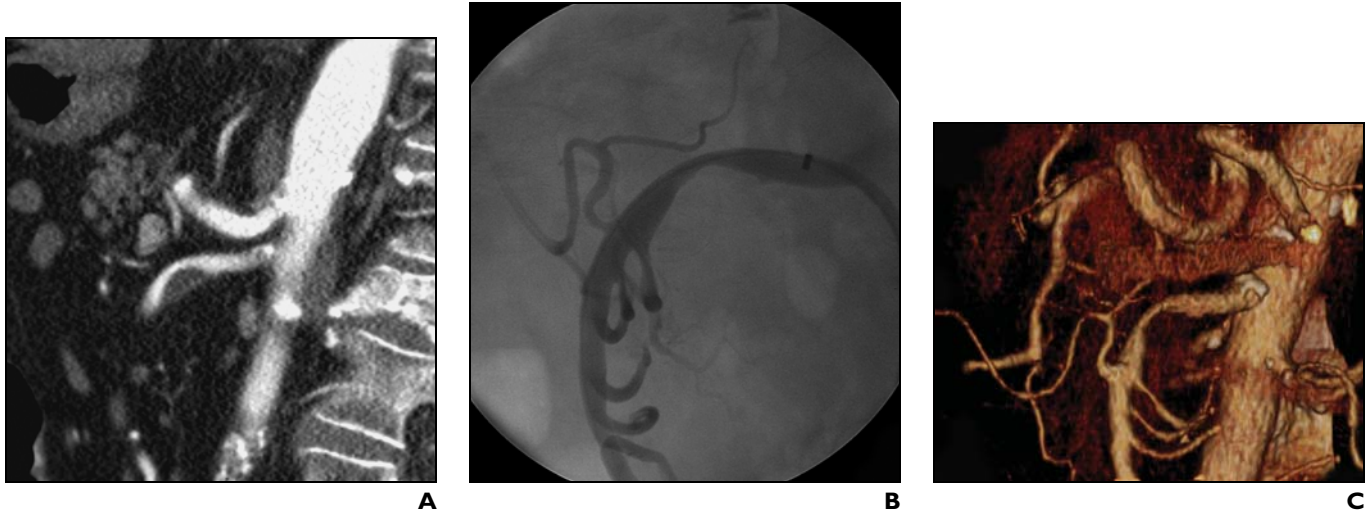


Fig. 10—75-year-old man with peripheral vascular and coronary artery disease who was admitted for postprandial abdominal pain and food avoidance. **A**, Subvolume maximum intensity projection of MDCT angiogram shows 60% stenosis of proximal superior mesenteric artery caused by eccentric noncalcified plaque. **B** and **C**, Selective superior mesenteric arteriogram (**B**) and volume-rendered MDCT angiogram (**C**) both show high-grade stenosis, which was successfully treated with percutaneous transluminal angioplasty (PTA).



Fig. 11—61-year-old woman with history of right nephrectomy and fibromuscular dysplasia of left renal artery that was treated previously with angioplasty. Contrast-enhanced MR angiogram shows beaded appearance typical of fibromuscular dysplasia at origin of superior mesenteric artery (*arrow*). Patient had no symptoms related to this finding, which was confirmed at catheter angiography (not shown).

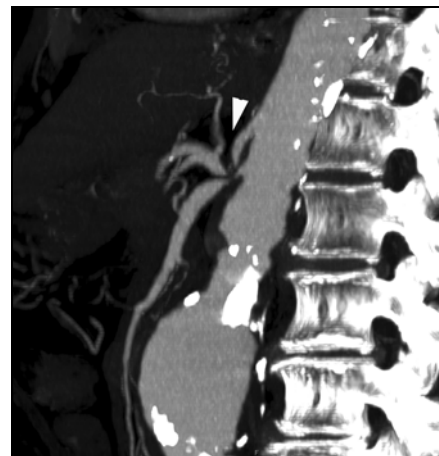
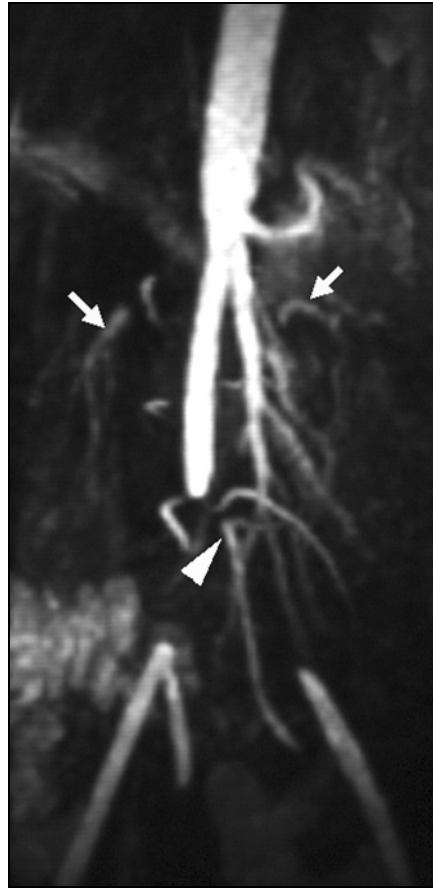


Fig. 12—56-year-old woman with postprandial epigastric pain, weight loss, and abdominal bruit. Patient underwent MDCT angiography and was found to have abdominal aneurysm with both celiac and superior mesenteric artery origin (*arrowhead*) compression caused by median arcuate ligament of diaphragm. This finding on this maximum-intensity-projection image was consistent with classic median arcuate ligament syndrome.



A



B

Fig. 13—22-year-old woman with history of claudication, hypotension, and postprandial pain who was diagnosed with Takayasu's arteritis. **A** and **B**, Conventional abdominal angiogram (**A**) and contrast-enhanced MR angiogram (**B**) show marked narrowing and occlusion of distal abdominal aorta as well as occlusion of both renal arteries, inferior mesenteric artery (IMA) (arrowhead), and both common iliac arteries. Collaterals reconstitute renal arteries (arrows, **B**), IMA (arrowhead), and external iliac artery.



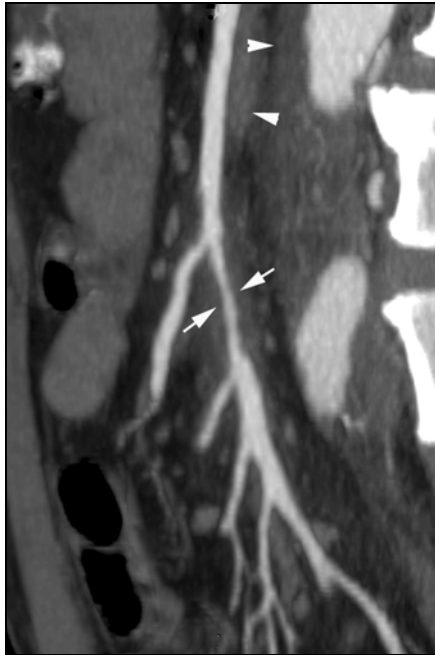
A



B

Fig. 14—69-year-old woman with Ehlers-Danlos syndrome who presented with postprandial epigastric pain. **A** and **B**, Volume-rendered MDCT angiograms of abdomen and pelvis (**A**) and mesenteric artery (**B**) reveal numerous aneurysms of branches of superior mesenteric artery, thrombosed splenic artery aneurysm (arrowhead, **A**), and aneurysms of right profunda femoral branches (arrows, **A**).

CTA and MRA of Mesenteric Ischemia



A



B

Fig. 15—41-year-old man with history of antiphospholipid antibody syndrome and retroperitoneal fibrosis who presented to emergency department with 1-week history of low-grade fever, nausea, vomiting, mild diarrhea, and constant postprandial abdominal pain. **A** and **B**, Oblique sagittal multiplanar reformatted (**A**) and volume-rendered (**B**) MDCT angiograms show ill-defined soft tissue surrounding abdominal aorta and superior mesenteric artery (SMA) roots (*arrowheads, A*) and leading to focal stenosis of distal SMA (*arrows*).

FOR YOUR INFORMATION

The reader's attention is directed to part 2 accompanying this article, titled "CTA and MRA in Mesenteric Ischemia: Part 2, Normal Findings and Complications After Surgical and Endovascular Treatment," which begins on page 462.