Helical CT Findings in Mesenteric Ischemia

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Ischemic bowel disease is one of the common causes of acute abdomen, which results from insufficient blood flow to the small bowel and colon caused by arterial or venous occlusion or mesenteric vasoconstriction. Early diagnosis by clinical, laboratory, and radiologic findings is often difficult and delay in adequate therapy results in substantial morbidity and mortality. CT is known to be useful for the evaluation of patients with suspected bowel ischemia or infarction. This study describes the spectrum of helical CT findings in acute and chronic mesenteric ischemia due to various causes, and explains the value of CT findings for specific diagnosis.

Index words: Intestines, ischemia

Intestines, CT

Ischemic bowel disease is one of the common causes of acute abdomen and has a wide spectrum of clinical courses, ranging from the transient reversible form to catastrophic necrosis (1). The condition results from decreased blood flow to the small bowel and colon caused by arterial or venous occlusion or mesenteric vasoconstriction (1, 2). Early diagnosis by clinical, laboratory and radiologic findings is often difficult, and delay in initiating adequate therapy results in substantial morbidity and mortality.

CT is known to be useful for the evaluation of patients with suspected bowel ischemia or infarction. This study describes the spectrum of helical CT findings in acute and chronic mesenteric ischemia due to various causes and explains the value of CT findings for specific diagnosis.

Etiologies and Classification

Mesenteric ischemia may be caused by occlusion of splanchnic vessels (celiac artery, mesenteric artery and vein) or non-occlusive diseases. The most common cause of arterial occlusion is embolism, while thrombosis, extrinsic compression and infiltration are less common etiologies. Thrombosis is the usual cause of mesenteric venous occlusion. Hypovolemia, radiation therapy, and other causes of vasculitis may result in non-occlusive ischemia. According to the etiology, clinical presentation, and prognosis, mesenteric ischemia can be classified in four groups: 1) acute mesenteric ischemia 2) focal segmental ischemia 3) chronic mesenteric ischemia and 4) colonic ischemia (1).

Pathophysiology and Pathology

The earliest physiologic response to acute bowel ischemia is spasm of the muscularis propria which causes cramp. The muscle loses its contractility and the spasm will cease if ischemia is sustained. Integrity of the vessel wall will lose and blood is extravasated. Bowel wall thickening is produced by the submucosal collection of extravasated blood and edema. The serosa has the least metabolic activity of all layers of the bowel wall and it remains viable longest, and this initially prevents bowel perforation. Finally, full-thickness transmural infarction occurs, and the bowel perforates. In the early stage of infarction, the involved bowel wall appears intensely congested, and with time, the bowel wall becomes edematous, thic-
kened, and hemorrhagic. Histological findings include obvious edema, interstitial hemorrhage, and sloughing necrosis of the mucosa (4).

In the case of focal segmental ischemia, collateral circulation can supply the ischemic segment. Therefore, ischemic segment would be completely recovered. Focal infarction or ulcer will heal with fibrosis and/or stricture (2).

If there is chronic vascular insufficiency, submucosal chronic inflammation and fibrosis may lead to stricture (Fig. 1)(3).

**CT Techniques**

CT scans of the abdomen and pelvis were obtained using both oral and intravenous contrast materials; the former is essential for adequate distension of bowel loops. A total of 120ml of non-ionic intravenous contrast material (Ultravist 300®, Schering AG, Berlin, Germany) was injected automatically at a rate of 3ml/sec and the whole abdomen and pelvis were scanned at a slice thickness of 7mm.

For CT angiogram, an 18 or 20 gauge angiocatheter was inserted in the antecubital vein and a mini-test bolus was used to determine precise scanning delay before the initiation of spiral CT acquisition. For the mini-test bolus, a total 20ml of contrast material was injected at a rate of 4ml/sec. After determination of scan delay time (maximal enhance time of celiac axis on mini-test), a total 120ml of non-ionic contrast material was delivered at a rate of 4 ml/sec to maximize superior mesenteric artery (SMA) and celiac artery perfusion. We used 3mm collimation and 3mm table speed (pitch=1); thus a segment of approximately 9cm including origin of the SMA and celiac axis was helically scanned. Images were reconstructed at 1mm intervals and for three-dimensional assessment, both shaded surface display (SSD) and maximum intensity projection (MIP) were made.

**Acute Mesenteric Ischemia**

Acute mesenteric ischemia is a serious vascular emergency and has a very high mortality rate (60–100%). Early diagnosis and treatment are therefore, critical (2, 4). It is caused by a sudden decrease in SMA blood flow and may affect all parts of the small bowel and the right side of the colon. SMA occlusion is the most common cause and SMA thrombosis, superior mesenteric vein (SMV) thrombosis, and non-occlusive ischemia such as collagen vascular disease, vasculitis, or radiation are less common etiologies (1). Patients usually present with rapid onset of severe cramping abdominal pain but on physical and laboratory examination, the findings are minimal (3). The most common CT findings in patients with acute mesenteric ischemia are dilated fluid-filled bowel loops and bowel wall thickening (Fig. 2)(1, 2). Other CT findings suggestive of acute mesenteric ischemia include lack of bowel wall enhancement due to mesenteric artery occlusion, persistent bowel enhancement, “double-halo” sign, mesenteric edema and infiltration, ascites, engorged mes-
enteric veins, and intramural curvilinear pneumatisa-

(Fig. 3, 4). Most CT findings do not provided a specific
diagnosis of acute mesenteric ischemia (1, 2), though, if
mesenteric and/or portal vein gas and occlusion of mes-
enteric vessel are detected, specific diagnosis can be
made (Fig. 5)(1).

**Focal Segmental Ischemia**

Focal segmental ischemia is defined as an ischemic
insult to a short segment of the small bowel. In this con-
dition, collateral circulation supplies the ischemic seg-

ment and transmural infarction rarely occurs (1, 2).
The symptoms of focal segmental ischemia are less
severe than those of acute mesenteric ischemia and
life-threatening insult is very rare (1). Focal segmental
ischemia is commonly caused by occlusion of branches
of the SMA or SMV, strangulation by obstruction or
volvulus, collagen vascular disease, vasculitis, trauma,
or radiation (1). The most common CT findings are
luminal narrowing caused by segmental concentric
wall thickening and proximal bowel dilatation (Fig. 6):
mesenteric infiltration or fluid, mesenteric vascular
congestion, and multiple infarction of other solid

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**Fig. 2.** CT scans of acute mesenteric ischemia involving entire small and large bowel in a 41-years-old man with polyarteritis

nodosa.

A and B. Contrast enhanced CT scans show dilated fluid-filled bowel loops and bowel wall thickening. Ascites and

“double-halo” sign (arrow) are also present.

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**Fig. 3.** CT scans of SMV thrombosis in a 37-years-old man with autoimmune hemolytic anemia.

A. Contrast enhanced CT scan demonstrates low attenuated thrombus in the SMV (arrow) and multiple collateral vessels.

B. Mesenteric vascular congestion (arrow), mesenteric fluid, ascites, and “double-halo” sign are also seen.

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Fig. 4. CT scans and angiography in a 60-years-old man with atrial fibrillation and SMA embolism.  
A. The SMA is not enhanced due to embolus (arrow) on contrast enhanced CT scan. Note absence of normal bowel wall enhancement of the ascending colon and the small bowel.  
B. Notice the well enhancing sigmoid colon contrast to the non-enhancing ileum at the level of the pelvis.  
C. SMA angiogram demonstrates total occlusion of the proximal SMA just distal to the inferior pancreaticoduodenal artery origin. Sharp round cut-off is characteristic of embolism (arrow).

Fig. 5. CT scans of catastrophic acute mesenteric ischemia due to hypovolemic shock in an 85-years-old woman with pontine hemorrhage.  
A. Contrast enhanced CT scan shows extensive gas in the portal venous system.  
B. Massive curvilinear pneumatosis in the sigmoid colon is well demonstrated on CT scan at the level of the pelvis.
abdominal organ are less common (Fig. 7). Possible outcomes of focal segmental ischemia are complete recovery, fibrosis, or stricture (2).

**Chronic Mesenteric Ischemia**

Chronic mesenteric ischemia is a relatively rare condition characterized by weight loss and abdominal pain after eating (1, 2); atherosclerotic stenosis or occlusion of the orifices of the celiac axis and the SMA accounts for most cases. A clinical diagnosis of chronic mesenteric ischemia has traditionally been one of exclusion and has required angiographic documentation. Coupled with the reluctance of most physicians to request conventional angiography early in the evaluation of patients with abdominal pain, both its rarity and propensity to be mimicked by more frequent gastrointestinal diseases including peptic ulcer, chronic cholecystitis, and pancreatitis, have resulted in the late diagnosis of chronic mesenteric ischemia.

Three-dimensional CT angiography, recently developed, helps to evaluate the abdominal aorta and its branches. When compared with conventional angiography, three-dimensional CT angiography is less expensive and less invasive, and has been proven to be comparable in accuracy (4).

Over a recent three-year period, we performed three-dimensional CT angiography in 14 patients with clinically suspected chronic mesenteric ischemia. Most three-dimensional CT angiograms successfully demonstrate either normal (n=3) or abnormal splanchnic artery orifices (celiac axis stenosis in five patients, celiac axis occlusion in one, SMA stenosis in four, SMA occlusion in two), and comparable image quality (Fig. 8).

**Colonic Ischemia**

The colon is very susceptible to ischemic change, particularly in the elderly and colonic ischemia is the most common vascular disorder of the gastrointestinal tract. Blood is delivered to the colon by the SMA from the cecum to the splenic flexure, by the inferior mesen-
Fig. 7. CT and small bowel follow-through study of a 66-years-old man with strangulation due to closed loop obstruction after operation.

A. On CT scan, the distal ileum is focally thickened (arrow) and proximal small bowel loops are dilated. Mesenteric fluid and infiltration (arrowheads) may suggest strangulation.

B. Small bowel follow-through study well demonstrates closed loop obstruction (arrows).

Fig. 8. Three dimensional CT angiography and conventional angiography in a 72-years-old man with severe SMA stenosis due to atherosclerosis.

A and B. SSD (A) and MIP (B) images show severe stenosis of the SMA orifice (arrow). The celiac axis orifice is also narrowed (arrowheads). Calcifications (curved arrows) around the SMA orifice are well demonstrated on MIP image.

C. Lateral view of conventional angiogram shows similar findings.

teric artery from the splenic flexure to the distal sigmoid, and by the hemorrhoidal arteries from the distal sigmoid to the anus (1). Any portion of the colon and the rectum can be insulted but the splenic flexure and distal sigmoid colon are most vulnerable. These areas are so-called watershed zones where each supplying vessel is farthest from the aorta and collateral circulation systems are least adequate. Ischemic colitis is commonly caused by arteriosclerosis. Aortic surgery, a cardiac problem, shock, impaired venous drainage, collagen vascular disease, trauma, radiation, or colon cancer may cause colonic ischemia (1, 2). Pheochromocytoma, rarely, provokes vasospasm and may result in colonic ischemia.

Colonic ischemia has wide range of disease spectrum from transient ischemic to gangrenous colitis. In our patients, colonic ischemia caused by systemic lupus erythematosus marked improved after treatment with steroid. Because most patients have no major vascular occlusion, angiography is not usually indicated. Abdominal pain is common symptom of colonic ischemia, and CT examination is performed initially. On CT scan,
symmetrical and circumferential colonic wall thickening due to submucosal hemorrhage and edema is seen in the early stage (1, 2), and some cases, these may produce "double halo" or "target" sign and polypoid filling defects associated with "thumbprinting" may be seen (Fig. 9) (1). Intramural curvilinear pneumatosis may be detected in the advanced stage of colonic ischemia. These findings, however, are not specific to the ischemic colitis; they are also seen in inflammatory disease, infectious colitis, and diverticulitis.

Summary

Even though ischemic insult to the small bowel and colon may produce catastrophic result, early diagnosis of mesenteric ischemia is difficult because of nonspecific symptoms and radiologic findings.

Plain film and barium study findings in mesenteric ischemia have been well documented. Thickening of the bowel wall, "thumbprinting" appearance, dilated bowel loops, and mesenteric and portal vein gas can be detected, but these findings are not specific to mesenteric ischemia. Bowel ischemia can sometimes be con-

![CT, double contrast barium enema in a 80-years-old man with proximal ischemic colitis due to colon cancer.](image1)

A and B. CT scans demonstrate mass (arrow) in the hepatic flexure and symmetric concentric thickening with "double-halo" sign (arrowheads) of the ascending colon.

C. Double contrast barium enema shows total obstruction of colon at the hepatic flexure and polypoid intraluminal filling defect (arrow) is seen.

D. Photograph of resected specimen shows large mass (arrow) in the hepatic flexure and thickened ascending colon (arrowheads).
firmed by angiography, which may demonstrate arterial and venous occlusion, vasospasm or diminished flow in non-occlusive ischemia (5).

CT may demonstrate a combination of the findings seen on plain film, barium study, and angiography: these include symmetrical bowel wall thickening, polypoid lesions representing a “thumbprint”, “double halo” sign, dilated fluid filled bowel loops, ascites, mesenteric infiltration, intramural gas, mesenteric vein and/or portal vein gas, and narrowing or occlusion of mesenteric vessels (5). Moreover, CT can be helpful in evaluating other causes of abdominal pain, fever, and bowel dilatation. Three-dimensional CT angiograms are useful for demonstrating either normal or abnormal splanchnic arteries and their image quality is comparable to that of a conventional angiogram.

Early diagnosis and treatment of bowel ischemia is critical; CT may play an important role in the early diagnosis and recognition of its etiology.

References