ROLE OF ULTRASONOGRAPHY, CONVENTIONAL ANGIOGRAPHY, CT AND CT ANGIOGRAPHY IN ASSESSMENT OF MESENTERIC ISCHAEMIA

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ABSTRACT

AIM

The aim of the study was to evaluate efficacy, sensitivity, specificity of ultrasonography, conventional angiography, CT Angiography in mesenteric ischaemia.

MATERIALS AND METHODS

Prospective study was performed. 35 patients with clinically suspected mesenteric ischaemia were included in the study. The study was conducted from month of November 2013 to August 2015. The patients age ranged from 35 to 70 years (Mean age was 57±11.2 years). All cases met the criteria of acute nontraumatic or chronic abdominal pain and suspected mesenteric vascular ischaemia. All 35 cases were evaluated in surgery department, then underwent USG, conventional angiography, CTA. Out of 20 patients, 2 patients were inconclusive and 4 patients had other findings of abdominal pain. USG and CT angiographic findings were correlated with surgical findings in acute mesenteric ischaemia (AMI) cases & conventional angiography in chronic mesenteric ischaemia (CMI) cases.

RESULT

Ultrasonography has lower sensitivity and high specificity. Conventional angiography has moderate sensitivity and high specificity. CT angiography is highly sensitive and specific in detecting mesenteric ischaemia.

CONCLUSION

Conventional angiography is considered as the gold standard test for patients with acute and chronic mesenteric ischaemia except for hemodynamically unstable patients with acute mesenteric ischaemia. CTA is an emerging diagnostic test with high sensitivity and specificity in the setting of both acute and chronic mesenteric ischaemia 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. 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 ischaemia and therefore is not recommended as the initial examination in evaluating patients with suspected acute mesenteric ischaemia.

KEYWORDS

Acute Mesenteric Ischaemia, CT, Mesenteric Arterial Occlusion, Mesenteric Venous Occlusion, Nonocclusive Mesenteric Ischaemia.

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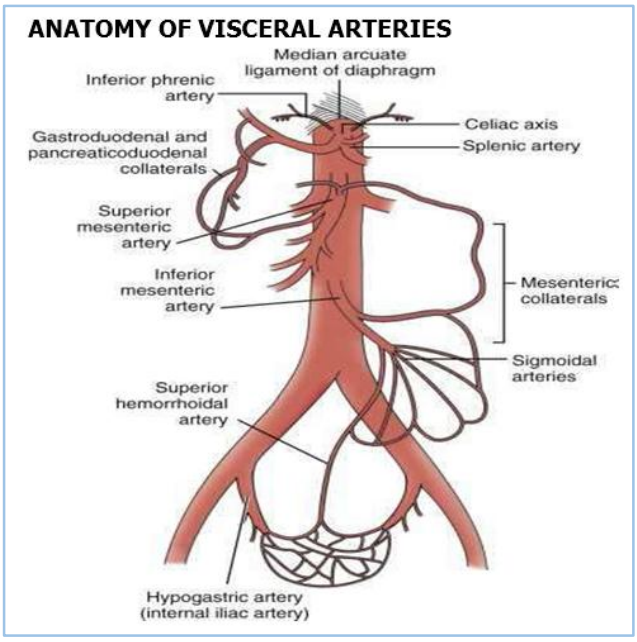
INTRODUCTION: Bowel ischaemia or infarction is a common but complex disorder with various primary causes and clinical presentations and high mortality.

It is caused by insufficient blood flow to the intestine from various causes, including thromboembolism, nonocclusive causes, bowel obstruction, neoplasms, vasculitis, abdominal inflammatory conditions, trauma, drugs (chemotherapy), radiation, and corrosive injury. Imaging findings of bowel ischaemia are similar regardless of the primary cause. Radiographic findings of bowel

ischaemia at plain and barium studies have been well documented and include bowel wall thickening, submucosal focal mural thickening or thumb printing, dilated bowel loops, intramural pneumatosis, and mesenteric or portal venous gas.(1)

Angiography may show arterial or venous occlusion or demonstrate vasospasm and diminished flow in nonocclusive ischaemia.(1) The computed tomographic (CT) or magnetic resonance (MR) imaging findings represent a combination of those seen at plain radiography, barium studies, and angiography. Moreover, CT or MR imaging may be helpful in determining the primary cause of bowel ischaemia as well as allowing direct evaluation of the bowel wall, adjacent mesentery, and vascular structures.



- Mesenteric ischaemia is characterised by inadequate blood flow to and from the involved mesenteric vessels particularly supplying a particular segment of bowel particularly the small bowel or colon.
- Rare disease with high mortality (30%-90%).
- More prevalent in elderly population.
- Can be acute or chronic and can be occlusive or nonocclusive.
- Causes of Acute Bowel Ischaemia and/or Ischaemic Colitis.

Cause	Mechanism
Mesenteric arterial occlusion (proximal or distal)	Thrombosis, thromboembolism, atherosclerosis, dissection, cholesterol embolisation, aortic surgery, stent placement, etc. Therapeutic embolisation for gastrointestinal haemorrhage, fibromuscular dysplasia (rare), various types of vasculitides, thrombotic microangiopathies, small vessel diseases
Mesenteric venous occlusion (proximal or distal)	Venous thrombosis (primary and secondary), phlebitis of intramural veins (rare)
Mechanical	Strangulation with or without mesenteric venous thrombosis, pronounced overdistention (prestenotic, distention colitis), ischaemic colitis due to endoscopy or enemas (rare)
Inflammation	Pancreatitis, appendicitis, diverticulitis, peritonitis, etc.
Low flow or vasospasm	Haemorrhagic, cardiogenic, septic shock, cardiac failure, cardiac arrhythmia, nonpulsatile cardiopulmonary bypass, dehydration, stress (high-endurance athletes), chronic renal failure requiring haemodialysis, use of various legal and "illegal" drugs, phaeochromocytoma, familial dysautonomia (rare)
Other	Irradiation, trauma, corrosive injury, immunosuppression, chemotherapy adjacent to intestinal tumours (focal), carcinoids, carcinomas, leiomyomas, etc.

AIM: The Efficacy, Sensitivity and to evaluate Specificity of Ultrasonography, Conventional Angiography, Computed Tomography and CT Angiography in evaluation of Mesenteric Ischaemia.

MATERIALS AND METHODS:

Prospective Study: 35 patients with clinically suspected Mesenteric Ischaemia were included in the study. Age Range of Patients: 35 to 70 yrs. All cases met the criteria of acute nontraumatic or chronic abdominal pain and suspected mesenteric vascular ischaemia. All cases were evaluated in surgery dept. followed by ultrasonography, conventional angiography, CT and CT Angiography. USG, Angiography and CT findings were correlated with surgical findings. Out of 35 patients, 2 patients were inconclusive and 4 had other findings of abdominal pain.

Inclusion and Exclusion Criteria: Only those cases were included in the study who underwent surgery.

DISCUSSION: Acute Mesenteric ischaemia (AMI) is most commonly secondary to acute embolism particularly Sup. Mesenteric artery embolism.[1] Other causes are acute Mesenteric artery thrombosis, nonocclusive Mesenteric ischaemia, Mesenteric and portal vein thrombosis. Chronic Mesenteric ischaemia (CMI) is most commonly secondary to severe atherosclerotic disease[1] with rare causes including fibromuscular dysplasia, median arcuate ligament syndrome

and vasculitis. Nonocclusive ischaemia is a condition in which the mesenteric arteries and veins are patent, but flow through them is too slow to deliver enough oxygenated blood to the intestine. The cause is usually decreased cardiac output from any cause, including primary cardiac disease, infarction, arrhythmia, and hypovolemia.

Nonocclusive ischaemia may be caused by a combination of low mesenteric flow and secondary reflex mesenteric arterial vasoconstriction. Mesenteric arterial vasoconstriction is a condition in which arterial vasospasm reduces flow through patent but acutely contracted arteries. The vasoconstriction may occur reflexly because of hypotension or may occur after administration or abuse of medications, such as digitalis, ergot preparations, vasopressin or other pressor agents, amphetamine, and cocaine. Shock bowel is a subtype of nonocclusive ischaemia and involves diffuse small bowel ischaemia in patients with hypovolemia. Hypoperfusion results in increased bowel permeability to macro-molecules and albumin, which leads to diffuse bowel wall thickening, increased enhancement on CT scans due to slowed perfusion and interstitial leakage of molecules of contrast material, and accumulation of intraluminal fluid secondary to failed resorption capacity. However, shock bowel resolves with resolution of hypovolemia; this fact suggests that this finding represents a reversible ischaemic change without clinical significance.

Clinical Presentation: AMI presents as abdominal pain out of proportion to the physical examination whereas CMI presents as clinical triad of abdominal pain, food avoidance and weight loss.[2,3] Abdominal angina, which was first described at the beginning of the 20th century, is defined as postprandial abdominal pain with weight loss and anorexia.[4] Changes in bowel habits and vomiting are less common. Cachexia suggesting a malignancy can occur if there is severe malabsorption or if the patient eats less to avoid triggering the pain. Because abdominal pain and weight loss are common symptoms and CMI is an uncommon condition, the diagnosis of CMI is often made late. The symptoms usually develop insidiously. This contributes to the diagnostic delay. Thus, in all age groups, many patients are seen late, at a stage when they have severe weight loss. The prevalence of CMI seems to increase with age, in agreement with the age-related increase in the prevalence of visceral artery occlusion in autopsy studies. However, CMI can occur in younger patients and the weight loss can suggest a malignant disease.

Clinical Features and Typical CT Findings of Mesenteric Ischaemia in Various Conditions

Characteristic	Arterial Occlusion	Venous Occlusion	Strangulation	Nonocclusion
Incidence	60–70% of PMI	5–10% of PMI	10% of SBO	20% of PMI
Presentation	Acute	Subacute	Acute	Acute or subacute
Risk factors	Arrhythmia, myocardial infarction, valve disease, atherosclerosis, prolonged hypotension	Portal hypertension, venous hypercoagulopathy, right-sided heart failure	Previous abdominal surgery, internal and external hernia, intestinal malrotation	Hypovolemia, hypotension, low cardiac output, digoxin, α-adrenergic agonists
Bowel wall	Thinning, no change, or thickening with reperfusion	Thickening	Thickening	No change or thickening with reperfusion
Attenuation of bowel wall on unenhanced CT	Not characteristic	Low with oedema; high with haemorrhage	Low with oedema; high with haemorrhage	Not characteristic
Enhancement of bowel wall on contrast-enhanced CT	Diminished, absent, target appearance or high with reperfusion	Diminished, absent, target appearance, or increased	Diminished, absent, target appearance, or increased	Diminished, absent, heterogeneous in distribution
Bowel dilatation	Not apparent	Moderate to prominent	Prominent (filled with fluid)	Not apparent
Mesenteric vessels	Defect or defects in arteries, arterial occlusion, SMA > SMV in diameter	Defect or defects in veins, venous engorgement	No defect, venous engorgement	No defect, arterial constriction
Mesentery	Not hazy until mesenteric infarction occurs	Hazy with ascites	Hazy with ascites, "whirl sign", or "spoke wheel sign"	Not hazy until mesenteric infarction occurs

Note: PMI = primary mesenteric ischaemia (i.e., arterial or venous occlusive or nonocclusive bowel ischaemia), SBO = small-bowel obstruction, SMA = superior mesenteric artery, SMV = superior mesenteric vein.

Ultrasonography: Preprandial and Postprandial Doppler Examinations are typically performed. Findings: Fasting Peak Systolic Velocity more than 275 cm/s in the SMA and 200 cm/s in celiac artery. An increase in PSV of less than 20% is considered an abnormal and blunted postprandial response.

Postprandial decrease in End Diastolic Velocity is also considered abnormal. Other findings like thickening of bowel wall, free fluid, etc. are seen.

USG also helps in excluding other causes of abdominal pain such as cholecystitis, pancreatitis, nephrolithiasis, appendicitis etc.

Conventional Angiography:

Findings: Fillings defects, narrowing or stenoses/blockages (String of sausages sign), arc of Riolan.[5] In SMA embolus, generally no collaterals are seen while in SMA thrombosis, collaterals are generally formed.[2] Angiography has added advantage of being therapeutic as well as diagnostic.

CT and CT Angiography Findings:

CT Examination:

Preparation: Oral and rectal administration of contrast material is recommended for accurate CT and assessment of acute bowel ischaemia. A variety of contrast materials providing positive, neutral, or negative contrast are available. Whether contrast material is indicated should be carefully considered for patients with bowel obstruction; materials containing barium are contraindicated in patients with bowel leak or perforation. However, in the acute state, particularly in patients with life-threatening conditions, indication of transoral contrast may not be possible or may not be significant because of an adynamic ileus preventing contrast material from moving through the intestine.

Luminal contrast material may be useful in relatively stable patients, and neutral contrast material should be used for the correct assessment of bowel enhancement after IV contrast administration. The use of neutral contrast material is also beneficial in the formation of multiplanar images and in CT angiography because neutral contrast material does not interfere with image quality. Positive contrast material may be advantageous in assessing patients with ischaemic colitis by showing thickened bowel wall and revealing the presence of bowel obstruction or in evaluating patients with a contraindication for IV contrast administration. When contrast material is applied, oral administration of 600–750 mL of luminal contrast material 30–120 minutes before scanning and rectal administration of 400–800 mL of luminal contrast material are used.

CT Technique: CT images are obtained from the dome of the liver to the level of the perineum to cover the entire course of the intestine. With MDCT scanners, a collimation of 0.5–2.5 mm and a detector pitch of 1.0–2.0 are used. Images with a 5- to 7 mm section thickness are usually constructed for image interpretation; however, thinner sections of contiguous 1–2 mm should also be constructed for multiplanar image reformations and CT angiography. Sagittal images are helpful in assessing the origin of the mesenteric arteries and their variations. Acquisition of both unenhanced and contrast-enhanced CT scans is always necessary.

The role of unenhanced CT is to identify vascular calcification, hyperattenuating intravascular clotting, and intramural haemorrhage; the role of contrast-enhanced CT is to identify thrombi in the mesenteric arteries and veins, abnormal enhancement of the bowel wall, and the presence of embolism or infarction of other organs. For contrast-enhanced CT, 100–150 mL of iodinated contrast material is administered at a rate of 2–5 mL/s, and scanning starts with delay times of 30 and 60 seconds for dual acquisition and 40– 60 seconds for single acquisition.

Finding:

- Large mesenteric vessels.[6,7,8]
- Free fluid.
- Mesenteric venous gas.
- Mesenteric Fat Stranding: Specify of 79%.

Abnormal enhancement,[4] hyperaemia and hyperperfusion of the bowel wall are two other factors that may cause hyperattenuation of ischaemic bowel walls on contrast-enhanced CT scans, where it manifests as hyperenhancement. Also, if unenhanced CT is not performed prior to contrast-enhanced CT, differentiation between acute intramural haemorrhage and hyperaemia and/or hyperperfusion may be difficult. Hyperaemia of ischaemic bowel segments without hyperperfusion typically occurs in cases of mesenteric venous occlusion and subsequent outflow obstruction, whereas hyperperfusion of ischaemic bowel segments typically occurs during reperfusion following occlusive or nonocclusive bowel ischaemia or as a result of super infection and subsequent inflammation.

Thrombus in Vessels[3,4,5,6]: Superior mesenteric artery (SMA) embolus associated with cardiovascular problems is the most common cause of acute mesenteric ischaemia, accounting for approximately 50% of cases. Thrombosis in the SMS or superior mesenteric vein (SMV) is a less common cause. SMV thrombosis can be confidently detected with CT, even in the peripheral branches, if good enhancement of the mesenteric vessels is achieved.

Air in Bowel Wall: Specificity almost reaches 100%.[9]

Intramural gas, also known as pneumatosis intestinalis, refers to gas within the wall of the bowel. There are different terminologies in the medical literature, such as pneumatosis intestinalis, pneumatosis coli. Gas tracks along the wall, either located submucosally or subserosally appearing as either linear (usually submucosal) or rounded cystic collections (Usually subserosal).

Air in Portal Venous System: Specificity almost reaches 100%.[9]

Portal venous gas is merely the accumulation of gas in the portal vein and its branches. It needs to be distinguished from pneumobilia, although this is usually not too

problematic, when associated findings are taken into account along with the pattern of gas.

Helpful in ruling out other causes of abdominal pain.

Limitations in Mesenteric Ischaemia Imaging:

Ultrasonography: Presence of extensive gas within the loops of bowel limits the accuracy of this imaging modality, time consuming, operator dependent.

Duplex US has a limited role in detecting distal arterial emboli or in diagnosing nonocclusive mesenteric ischaemia.[8] Non-specific findings can lead to false positive results (other inflammatory and infectious aetiologies can mimic mesenteric ischaemia).

Conventional Angiography: An invasive test, consuming, radiation exposure. Failure to demonstrate nonocclusive disease due to hypovolemia or low output cardiac failure. Should not be considered in patients with significant hypovolemia and hypotension.[3] Contrast agents should be used with caution in patients with renal disorders, heart disorders and other allergic conditions etc.

CT and CT Angiography: Non-specific findings can lead to false positive results (other inflammatory and infectious aetiologies can mimic mesenteric ischaemia).

Radiation Exposure: Contrast agents should be used within caution in patients with renal disorders and other allergic conditions, etc.[8]

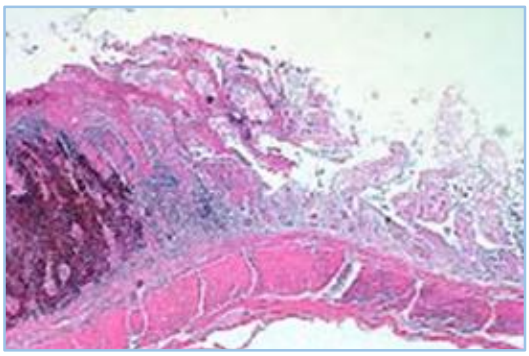
RESULT:

Statistics:

Imaging Procedure	Specificity	Sensitivity	Accuracy
Ultrasonography	93%	78%	92%
Conventional Angiography	99%	86%	98%
CT and CT Angiography	94%	96%	94%

Ultrasonography has lower sensitivity and high specificity. Conventional angiography has moderate sensitivity and high specificity. CT angiography is highly sensitive and specific in detecting mesenteric ischaemia.

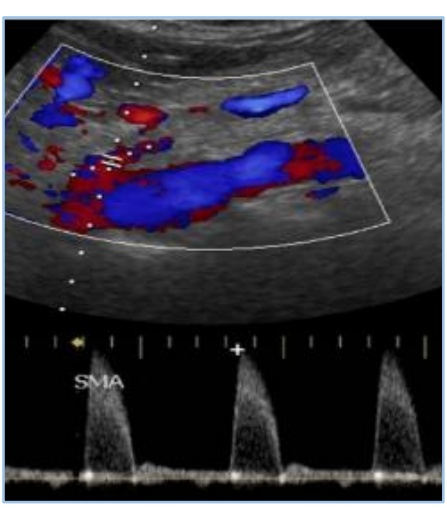
CONCLUSION: Conventional angiography is considered as the gold standard test for patients with acute and chronic mesenteric ischaemia except for hemodynamically unstable patients with acute mesenteric ischaemia. CT is an emerging diagnostic test with high sensitivity and specificity in the setting of both acute and chronic mesenteric ischaemia and should be considered the first-line imaging test. US of the abdomen with Doppler waveform analysis is limited in the diagnosis of distal occlusions/stenosis and nonocclusive mesenteric ischaemia and therefore is not recommended as the initial examination in acute conditions, but can be done in stabilised patients.



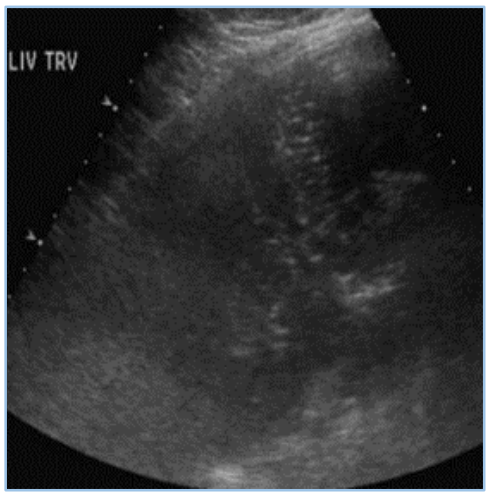
Small Intestine. Demonstrates focal haemorrhage, expanding lamina propria with sloughing & necrosis of mucosal epithelium.

USG Showing Thickening of Bowel Loop:

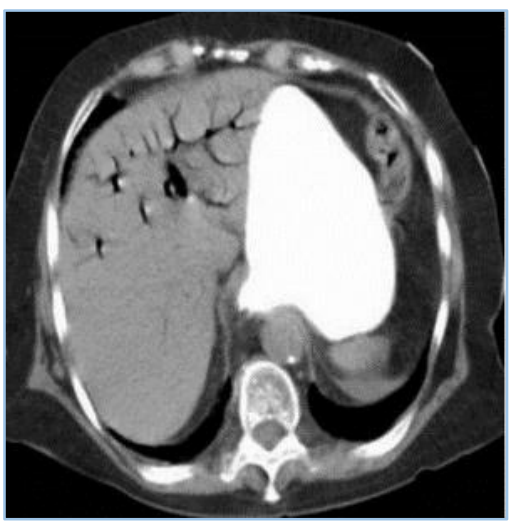
Maximum Peak systolic velocity of 304 cm/s and spectral broadening in the proximal SMA. This velocity exceeds the accepted PSV of 275 cm/s.

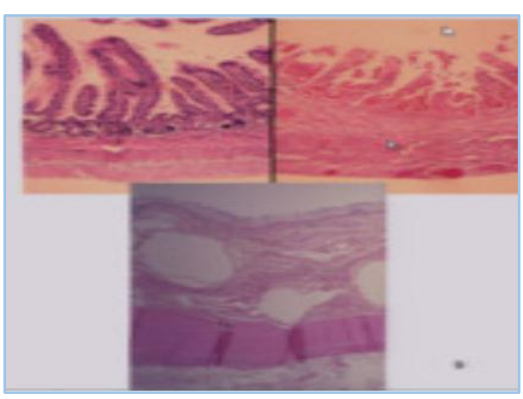


Ultrasonographic evaluation in a 63-year-old woman with abdominal pain reveals multiple echogenic foci within the liver, which are suggestive of portal venous air.



CT Scan in a 63-old-woman, (same patient as in the previous image) obtained after suggestive sonographic findings of portal venous air were observed confirms the presence of air in the portal-venous system.

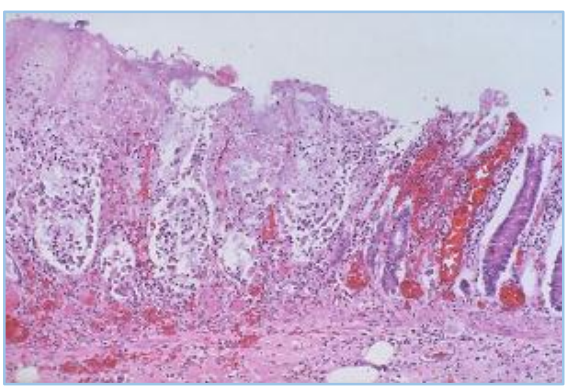




Mucosal Coagulative necrosis extending into and often through the submucosa and muscular layers.

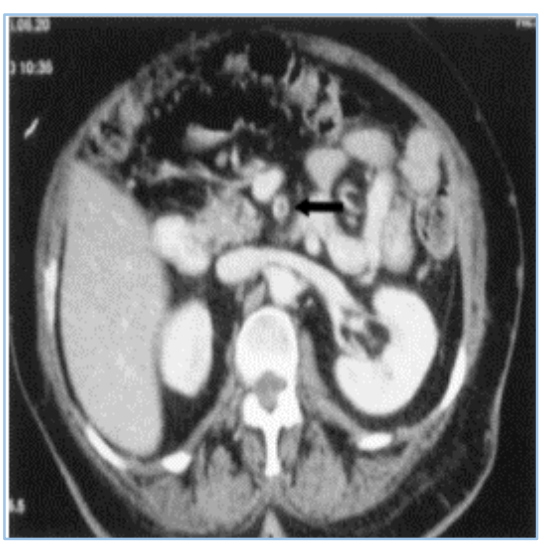
Small air filled spaces beneath mucosa pneumatosis intestinalis.

CT scan in a 52-year-old woman with a 4-day history of abdominal pain and leucocytosis shows congested, oedematous, central small bowel loops.

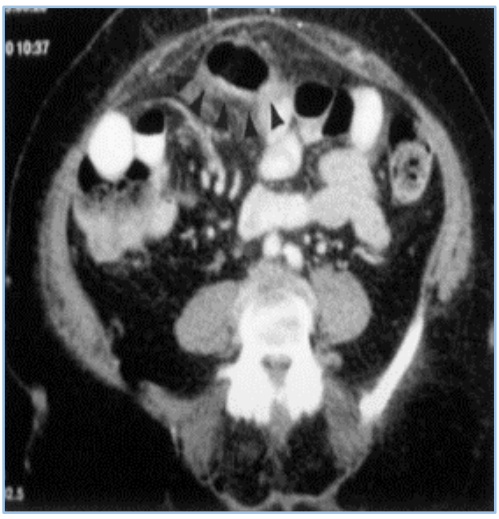


At higher magnification with more advanced necrosis, the small intestinal mucosa shows haemorrhage with acute inflammation in this case of ischaemic enteritis.

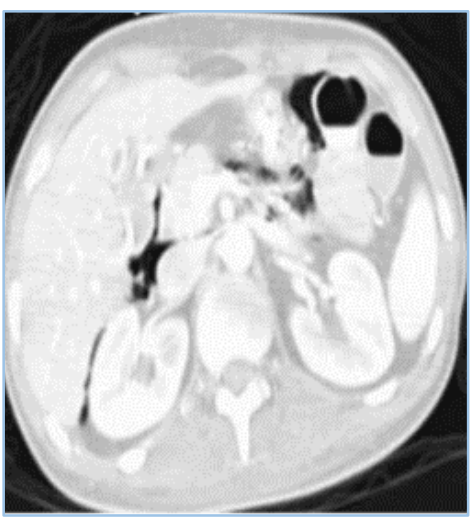
Contrast- enhanced computed tomography (CT) of the abdomen showed a partial filing defect of the SMA.



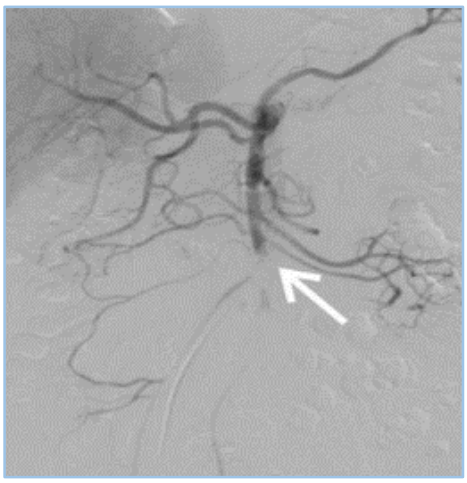
A slight distention of one of the small bowel loops with surrounding mesenteric fat infiltration was also noted, most likely representing ischaemic bowel.



CT Scan obtained by using lung window parameters in a 48-year-old male patient which reveals free retroperitoneal air.



Total occlusion of SMA due to thromboembolism (arrow) is shown in the mesenteric angiography.



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