Mesenteric ischemia: can multidetector computed tomography angiography be a one-stop diagnostic solution?

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Received: 23 July 2019
Revised: 4 August 2019
Accepted: 21 August 2019
Published: 4 March 2020

Kasr Al Ainy Medical Journal 2019, 25:45–52

Background
Mesenteric ischemia is a medical condition in which inflammation and injury of the small intestine result from inadequate blood supply. Mesenteric ischemia is caused by a reduction in intestinal blood flow and is classified as acute (sudden onset of intestinal hypoperfusion) or chronic depending on the time course of symptoms. Multi Detector Computed Tomography MDCT has high sensitivity and specificity for diagnosing acute primary mesenteric ischemia.
Aim and objectives
Our objective was to evaluate the role of MDCT angiography in evaluation of patients with suspected mesenteric ischemia as regards vascular and intestinal abnormalities.
Patients and methods
This prospective study was performed on 60 patients clinically suspected of having mesenteric ischemia, referred to the radiology department of Cairo University hospitals from the emergency hospital and the out-patient clinics and in-patient departments of general surgery and of Endemic Infectious diseases and Hepatogastroenterology. Patients suspected clinically to have mesenteric ischemia were initially examined by Doppler and if showed mesenteric vascular suspicious findings by Doppler, they were referred to CT angiography examination.
Results
In our study we found that 40 patients (66.7%) out of 60 patients showed abnormal MDCT findings which explained the cause of mesenteric ischemia in these patients. The most prevalent CT findings in 40 patients with positive CT angiographic findings in acute mesenteric ischemia (AMI) were bowel wall thickening in 12 patients (30%), bowel distension in 8 patients (20%) and lack of mural enhancement in 10 patients (25%). Computed tomography angiography (CTA) detected accurately the cause of AMI where arterial thrombo-embolism was common cause of AMI (62.5%) and the SMA was the most frequent site in patients with AMI than mesenteric venous thrombosis with AMI (37.5%). 50% of patients with AMI showed pneumatosis intestinalis and surgical exploration revealed bowel infarction and resection anastomosis was done.
Conclusion
MDCT is fast, safe, accurate and non-invasive imaging modality of choice in patients with suspected mesenteric ischemia which is able to evaluate not only mesenteric vascular structures but also evaluate bowel wall changes and adjacent mesentery, thus detecting the primary cause of mesenteric ischemia that can lead to earlier diagnosis and intervention, also confirmation or exclusion of various other differential diagnoses of acute abdominal conditions.

Keywords:
acute abdominal pain, multidetector computed tomography, mesenteric ischemia

Kasr Al Ainy Med J 25:45–52

1687-4625

Introduction

Mesenteric ischemia is a medical condition in which inflammation and injury of the small intestine result from inadequate blood supply. Causes of the reduced blood flow can include changes in the systemic circulation (e.g. low blood pressure) or local factors such as constriction of blood vessels or a blood clot, which is common in the elderly [1].

Mesenteric ischemia is caused by a reduction in intestinal blood flow and is classified as acute (sudden onset of intestinal hypoperfusion) or chronic depending on the time course of symptoms [2]. Chronic mesenteric ischemia, also called intestinal angina, refers to episodic or constant hypoperfusion of the small intestine that can occur, typically in

 DOI: 10.4103/kamj.kamj_16_19

patients with multivessel mesenteric stenosis or occlusion [3].

Multidetector computed tomography (MDCT) has high sensitivity and specificity for diagnosing acute primary mesenteric ischemia [4]. MDCT findings vary widely depending on the cause and underlying pathophysiology. MDCT findings of mesenteric ischemia should be characterized on the basis of the cause [5].

In addition, the severity of bowel ischemia (i.e. superficial mucosal or transmural bowel wall necrosis), the location (i.e. small or large bowel), and the presence and degree of hemorrhage or subsequent superinfections may affect MDCT appearance [6].

Objective

To evaluate the role of MDCT angiography in the evaluation of patients with suspected mesenteric ischemia as regards vascular and intestinal abnormalities.

Patients and methods

Patients

This prospective study was performed on 60 patients clinically suspected of having mesenteric ischemia, referred to the Radiology Department of Cairo University Hospitals from the emergency hospital and the out-patient clinics and in-patient Departments of General Surgery and of Endemic Infectious Diseases and Hepatogastroenterology.

The clinical suspicion of mesenteric ischemia is based on the following: pain out of proportion to clinical findings, weight loss, laboratory findings characteristic of ischemia such as metabolic acidosis, previous abdominal angina, atrial fibrillation, and severe vascular disease. Patients suspected clinically to have mesenteric ischemia were initially examined by Doppler and if showed mesenteric vascular suspicious findings by Doppler, they were referred to CT angiography examination. Patients with contraindication to intravenous contrast material as history of severe allergic reaction or renal impairment were excluded.

Imaging protocol

All eligible patients were well informed regarding the procedure; written consent was taken before CT angiography and they were submitted to the following:

(1) History taking: patient's age, sex, chronic illness, history of allergies, asthma, history of hypersensitivity reactions to radiograph contrast agents, and complaint analysis. Clinical examination and laboratory investigations: renal function tests.
(2) All patients underwent Doppler examination.
(3) MDCT angiography: All patients underwent multidetector row CT angiography of the abdominal aorta.

All patients were examined with the 64-row MDCT system (Toshiba, Aquilion Scanner; Toshiba Medical Systems, Tokyo, Japan).

A volume of 80–100 ml of iodinated contrast material will be administered through a 20-G cannula in an antecubital vein at a rate of 4 ml/s. The scan start is synchronized with the arterial passage of contrast material using a real-time bolus tracking technique. With this technique, a region of interest will be positioned in the lumen of the proximal abdominal aorta, and a triggering threshold of 150 HU above the baseline attenuation value will be set. Once the contrast material has been injected, a series of dynamic low-dose monitoring scans will be obtained, and as soon as the attenuation value inside the region of interest reaches the triggering threshold the scan will be automatically started, with an additional 4-s delay to allow the table to be repositioned and the patient to receive breath-hold instructions.

Reconstruction

The reconstruction parameters are as important as the scanning parameters. To exploit isotropic resolution and to achieve optimal visualization of the vessels, proper parameters must be used. The most important elements are the use of a thin effective section width with a 30–50% overlapping increment to improve the spatial resolution along the *z* axis (the longitudinal plane). The choice of convolution filter depends on image noise (e.g. obese patients will likely require smooth filters) and the degree of vessel calcification (heavily calcified vessels will be better assessed with sharp filters). The use of filters will also affect the quality of postprocessing and 3D reformatted images.

Postprocessing

The nature of spiral CT and the modality of reconstruction will result in a massive number of axial sections being obtained (300–800 sections, depending on the scanner and the reconstruction parameters). Postprocessing tools are mandatory for handling and reviewing this huge amount of data.

There are two possible approaches at this level. The first approach is based on the interaction of the radiologist with the dataset using the full range of postprocessing tools; the second approach is based on standardization of the protocol to limit interaction with the dataset to the targeted problem-solving task. The first approach is more accurate and comprehensive but also more time consuming. The second approach has several advantages and relies on the ability of the technician to provide high-quality preprocessed material.

Image interpretation

CT scans were evaluated for

(1) CT angiography finding:
Atherosclerotic changes, collaterals, significant stenosis or thromboembolic occlusion of the celiac trunk, superior mesenteric artery, and inferior mesenteric artery also for evidence of portomesenteric venous thrombosis.
Chronic mesenteric ischemia was considered in the presence of atherosclerosis and collaterals.
(2) Other secondary signs of mesenteric ischemia (intestinal findings):
Evidence of bowel wall thickening (defined as a wall thickness>3 mm in the noncollapsed small bowel), mesenteric fat stranding, free fluid, pneumatosis intestinalis, bowel distention (focal or diffuse and disproportionate), and lack of mural enhancement.

Statistical analysis

Our data were collected, coded, and processed by the statistical software (SPSS) Software program, version 23 (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.) and the following statistical tests were applied:

(1) Collecting results.
(2) Tabulating result data numbers.
(3) Statistical analysis, descriptive, for example, percentage.

Results

This study enrolled 60 (48 men and 12 women) patients with an age range of 36–81 years (mean age 59 years).

All patients included in this study were initially clinically examined and then radiologically investigated by Doppler and were proved or suspected to have mesenteric vascular abnormality, after which they were referred to CT angiography examination.

Table 1 MDCT intestinal findings in 40 patients with mesenteric ischemia (16 patients with AMI and 24 patients with CMI)

MDCT finding	AMI (*n*=16)	CMI (*n*=24)	*P* value
Bowel wall thickening	12 (75%)	4 (16.7%)	<0.01 (S)
Bowel distension	8 (50%)	0	<0.01 (S)
Pneumatosis intestinalis	8 (50%)	0	<0.01 (S)
Stranding of mesenteric fat	16 (100%)	4 (16.7%)	<0.01 (S)
Free fluid	6 (37.5%)	2 (8.3%)	0.06
Lack of mural enhancement	10 (62.5%)	0	<0.01 (S)

AMI, acute mesenteric ischemia; CMI, chronic mesenteric ischemia; MDCT, multidetector computed tomography.

From 60 patients with clinical and Doppler suspicion for mesenteric ischemia, 40 (66.7%) patients showed MDCT abnormal findings conforming with secondary signs of mesenteric ischemia. The examination was performed in most cases within 1–2 h from the request and there were no major or minor complications.

From 40 patients, 16 (40%) patients were diagnosed with acute mesenteric ischemia acute mesenteric ischemia (AMI) while 24 (60%) patients were diagnosed with chronic mesenteric ischemia chronic mesenteric ischemia (CMI). AMI showed more CT findings than CMI as shown in Table 1.

In AMI patients, CT angiography showed arterial thromboembolism in 10 patients 62.5% (Fig. 1) and SMV thrombosis in 6 patients 37.5%, as shown in Table 2 and Fig. 2.

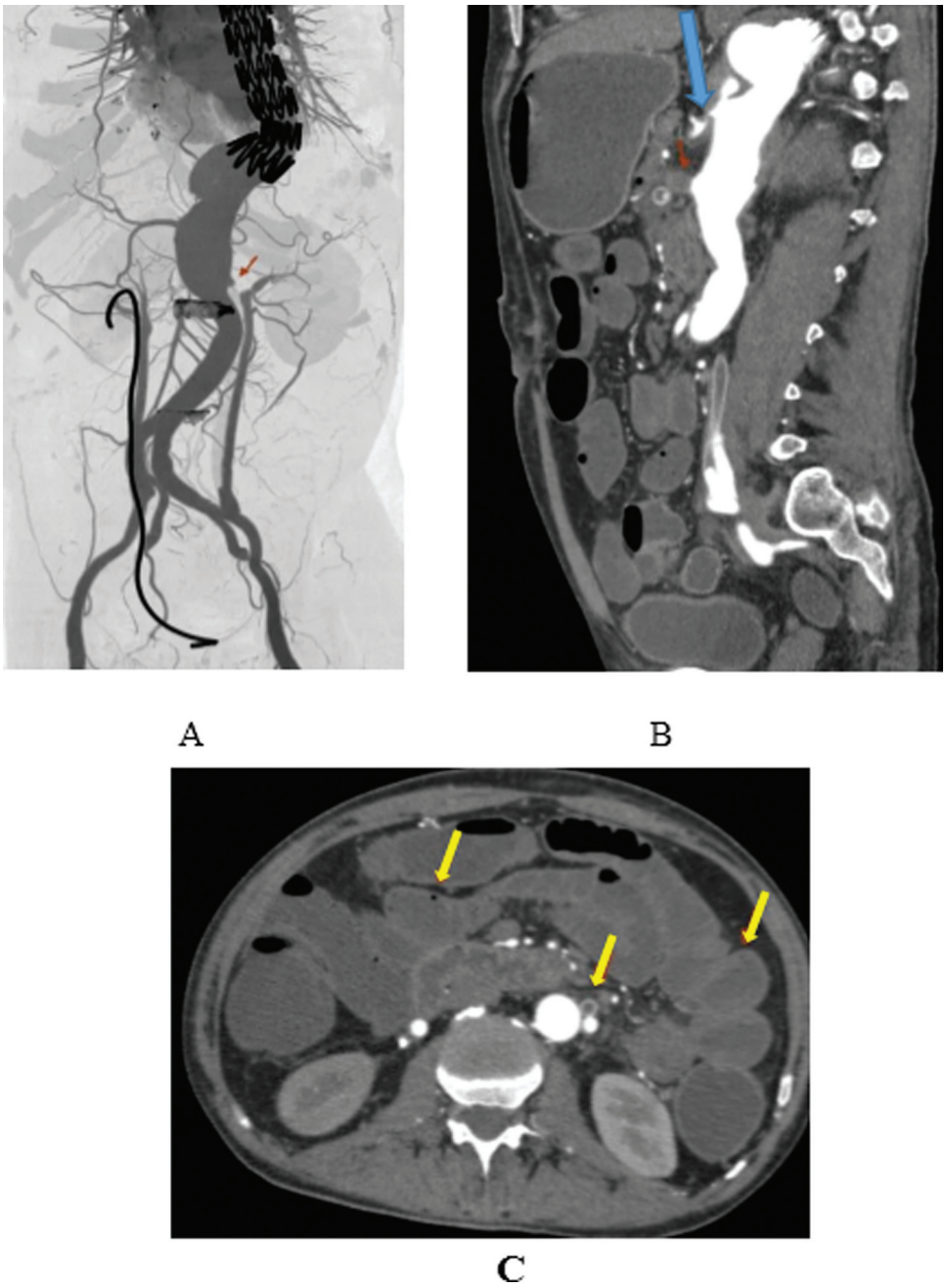
While in CMI CT angiography findings, all 24 (100%) patients had atherosclerosis and collaterals, and variable degrees of stenosis and occlusion as shown in Table 3.

Discussion

Mesenteric ischemia is caused by a decrease in blood flow for intestinal circulation of adequate magnitude to compromise the viability of the affected portion [7]. Mortality associated with acute mesenteric arterial occlusion remains very high. Patient survival and prognosis depends on prompt diagnosis and revascularization before intestinal gangrene development [8]. MDCT angiography is the prime diagnostic tool due to its capability to define accurately the arterial anatomy and assessment of secondary signs of mesenteric ischemia [9].

In this study, 40 (66.7%) patients out of 60 patients showed abnormal MDCT findings

Figure 1



A 51-year-old man. Status postoperative for a case of thoracoabdominal aneurysm repair presented by colicky abdominal pain, vomiting, diarrhea. (a) MIP, (b) multiplannar reconstruction (MPR), and (c) axial computed tomography abdomen showed status postoperative (thoracoabdominal aneurysm repair) with superior mesenteric artery occlusion (red arrows) and celiac artery stenosis. Pneumatosis intestinalis, luminal dilatation, and mesenteric congestion (yellow arrows). Diagnosis: findings are those of acute mesenteric ischemia due to superior mesenteric artery occlusion.

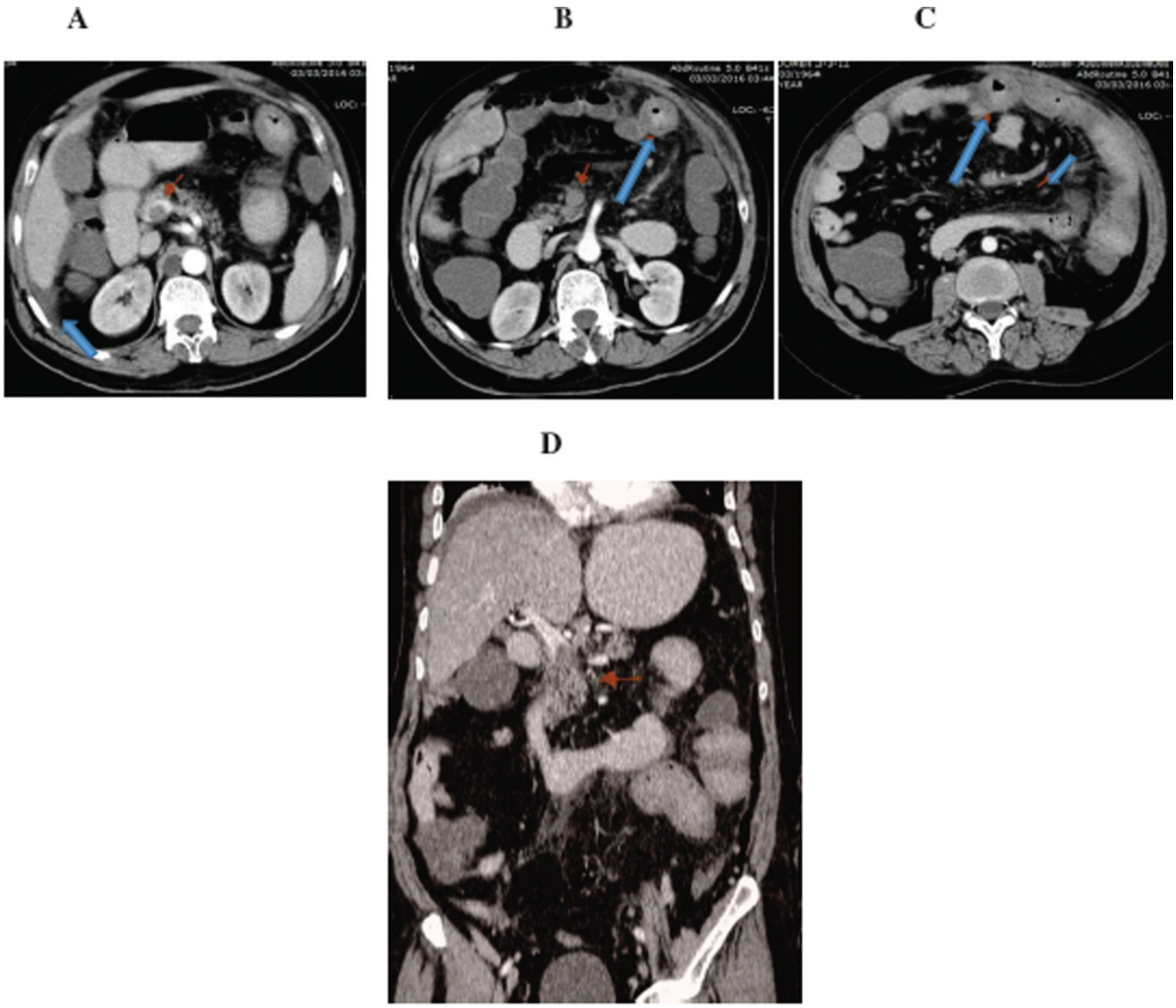
Table 2 CTA findings in 16 patients with acute mesenteric ischemia

CT angiographic findings	*N* (%)
Arterial thromboembolism	10 (62.5)
SMA proximal part	6 (60)
SMA distal part	4 (40)
SMV thrombosis	6 (37.5)

CT, computed tomography; SMA, superior mesenteric artery.

which explained the cause of mesenteric ischemia in these patients. These findings agree with Barmase *et al.* [10], who performed a study on 31 patients with clinically suspected mesenteric ischemia and report that 16 (53.3%) patients out 31 patients showed abnormal CT angiographic findings which explained the cause of mesenteric ischemia (Figs 3 and 4).

Figure 2



A 52-year-old man presented by colicky abdominal pain (about 2 days) with vomiting and diarrhea. Doppler examination showed superior mesenteric vein thrombosis (a–c) axial computed tomography abdomen and (d) coronal multiplannar reconstruction (MPR) showed superior mesenteric vein thrombosis (red arrows). Bowel wall thickening, lack of bowel enhancement, mesenteric fat stranding, and free fluid collection (blue arrows). Diagnosis: findings are those of acute mesenteric ischemia due to superior mesenteric vein thrombosis.

Table 3 CTA findings in 24 patients with chronic mesenteric ischemia

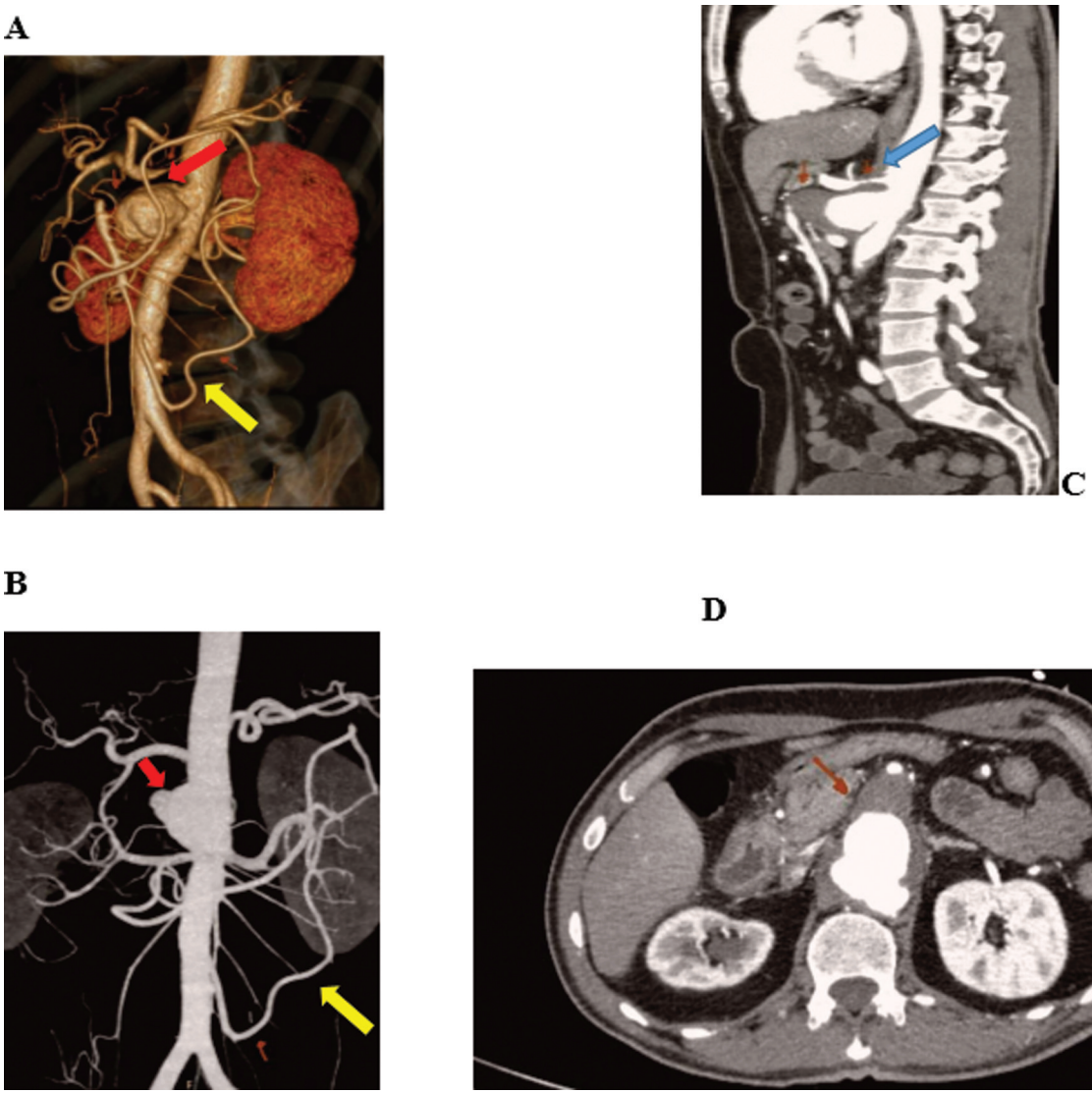
CTA findings	*N* (%)
Atherosclerosis+collaterals*	24 (100)
Stenosis of both SMA and celiac	4 (16.6)
SMA occlusion and celiac stenosis	2 (8.3)
Celiac occlusion and SMA stenosis	2 (8.3)
SMA and celiac occlusion	4 (16.6)
SMA stenosis and IMA occlusion	2 (8.3)
Celiac stenosis and IMA occlusion	2 (8.3)
Occlusion of SMA	2 (8.3)
SMA aneurysm	4 (16.6)
SMA pseoudaneurysm	2 (8.3)

CTA, computed tomography angiography; IMA, inferior mesenteric artery; SMA, superior mesenteric artery.

In this study, the most prevalent CT findings in 40 patients with positive CT angiographic findings in AMI were bowel wall thickening in 12 (30%) patients, bowel distension in eight (20%) patients, and lack of mural enhancement in 10 (25%) patients. These findings nearly matched with those reported by Amin *et al.* [11], who performed a study on 57 patients with clinically suspected mesenteric ischemia and reported that 21 patients out 57 patients with abnormal CT findings; bowel wall thickening in 12 out of 21 (57.1%) patients, bowel distension in 11 out 21 (52.4%) patients, and also nonenhanced bowel wall in postcontrast CT in 10 out 21 (47.6%) patients are the most frequent CT findings in patients with mesenteric ischemia.

In this study eight of 16 (50%) patients with AMI showed pneumatosis intestinalis and surgical exploration showed bowel infarction and resection anastomosis was done, thus this CT finding is extremely specific and is considered late onset finding and this result was in agreement with different published studies as that of Kärkkäinen

Figure 3



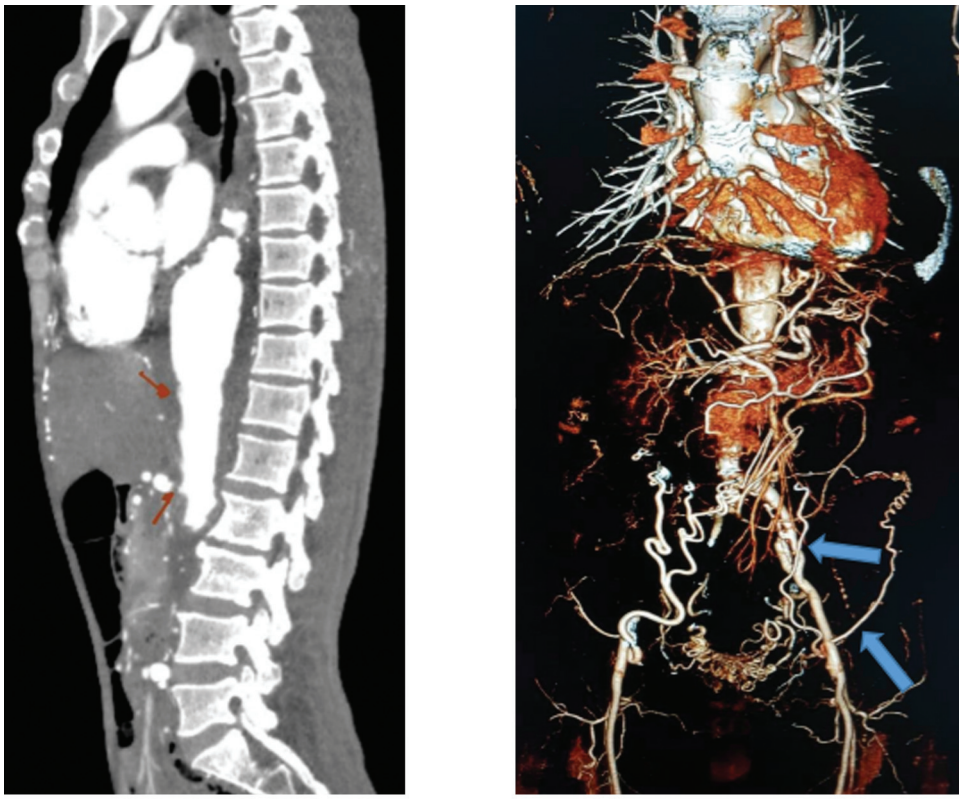
A 65-year-old man (diabetic and hypertensive) complains of postprandial abdominal pain, diarrhea, and weight loss. By Doppler: celiac trunk stenosis and superior mesenteric artery (SMA) aneurysm (a, b) MIP images and (c) multiplannar reconstruction (MPR) and (d) axial computed tomography abdomen showed superior mesenteric artery aneurysm (red) arrows, celiac trunk stenosis (blue arrows), collaterals between SMA and inferior mesenteric artery via the marginal artery (yellow arrow). Diagnosis: findings are those of chronic mesenteric ischemia due to superior mesenteric aneurysm and celiac artery stenosis.

et al. [12]; 67% patients showed ischemia-specific CT findings (decreased bowel wall enhancement and pneumatosis) and Kirkpatrick *et al.* [13] reported that 11 out 26 (42.3%) patients with AMI showed pneumatosis intestinalis.

Pneumatosis intestinalis can be indicated when CT depicts air in the bowel wall. In the setting of mesenteric ischemia, pneumatosis often indicates transmural infarction, particularly if it is associated with portomesenteric venous gas [14].In this study, computed tomography angiography (CTA) detected accurately the cause of AMI where arterial thromboembolism was a common cause of AMI (62.5%) and the superior mesenteric artery was the most frequent site in patients with AMI than mesenteric venous thrombosis with AMI (37.5%); these results were in agreement with Amin *et al.* [11], who reported AMI where the cause was arterial thromboembolism (75%) and mesenteric venous thrombosis (25%).

In this study, CTA showed abnormal findings consistent with CMI and explained the cause in 24 patients; arterial atherosclerosis of the splanchnic arteries with variable degrees and combinations of stenosis or occlusion was the most common cause. These results were in agreement with Amin *et al.* [11],

Figure 4



A B

A 70-year-old man (diabetic and hypertensive) complains of postprandial abdominal pain, diarrhea, and weight loss. By Doppler: celiac trunk and superior mesenteric artery occlusion. (a) Computed tomography angiography sagittal reconstruction (b) MIP images show superior mesenteric artery and celiac trunk occlusion (red arrows) compensated by collaterals (blue arrows). Diagnosis: findings are those of chronic mesenteric ischemia due to superior mesenteric artery and celiac trunk occlusion.

who reported that atherosclerosis of splanchnic arteries with subsequent stenosis or occlusion was the cause of CMI in nine patients.

Conclusion

MDCT is a fast, safe, accurate, and noninvasive imaging modality of choice in patients with suspected mesenteric ischemia which is able to evaluate not only mesenteric vascular structures but also evaluate bowel wall changes and adjacent mesentery, thus detecting the primary cause of mesenteric ischemia that can lead to earlier diagnosis and intervention, and also for confirmation or exclusion of various other differential diagnoses of acute abdominal conditions.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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