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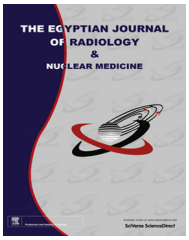

RESEARCH PAPER

Acute and chronic mesenteric ischemia: Multidetector CT and CT angiographic findings

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KEYWORDS

Multidetector CT;
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Abstract *Aim of the work:* To assess the role of multidetector CT (MDCT) and CT angiography (CTA) in the diagnosis of acute and chronic mesenteric ischemia.
Patients and methods: This prospective study was performed on 57 consecutive patients clinically suspected of having mesenteric ischemia, they were examined with 16-row multidetector CT, MDCT and CTA were evaluated for evidence of bowel wall changes and abnormal mesenteric vascular changes.
Results: Twenty one patients of studied 57 patients had an abnormal CTA finding diagnostic of mesenteric ischemia and they constituted the material of this study, the most prevalent MDCT findings were bowel wall thickening, bowel distension and non-enhanced bowel wall. MDCT and CTA gave an accurate diagnosis of the cause of mesenteric ischemia as proved by the final diagnosis based on surgical exploration, conventional angiography, laboratory investigations and clinical follow up with 100% sensitivity and specificity.
Conclusion: MDCT and CTA are fast, safe, accurate and non-invasive imaging modalities of choice in patients with suspected mesenteric ischemia which are 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.

1. Introduction

Mesenteric ischemia is a complex and devastating disease that has been increasing in incidence over the past decade and constitutes 1–2% of admissions for abdominal pain in the USA (1). The increase in incidence can be attributed to various factors, including increased clinical awareness, aging population and improvement in diagnostic imaging techniques (2). The mortality rate is very high, ranging between 50% and 90% and hence timely diagnosis is essential in trying to improve the outcome (3).

Abbreviations: MDCT, multidetector CT; CTA, CT angiography; AMI, acute mesenteric ischemia; CMI, chronic mesenteric ischemia.

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Mesenteric ischemia can be acute or chronic based on clinical presentation and occlusive or non-occlusive based on pathogenesis. The etiology of mesenteric ischemia can be grossly divided as those due to arterial occlusion or compromise, due to venous occlusion or compromise or from low flow states (non-occlusive mesenteric ischemia) (4).

Conventional angiography is the gold diagnostic standard, but is invasive, costly, can rarely cause morbidity, and does not allow the evaluation of the bowel and other related findings (5,6).

Cross sectional imaging with computed tomography can be the first imaging study obtained that can suggest the diagnosis of acute mesenteric ischemia through the evaluation of bowel wall changes and assessment of vascular patency, recent advances in multidetector computed tomography (MDCT) and the use of CT angiography, including improved spatial and temporal resolution, shorter scan time, and the multiplanar and three dimensional (3D) reconstruction, has replaced conventional catheter angiography for the diagnosis of mesenteric ischemia (7,8).

So, the aim of this study was to assess the role of multidetector CT (MDCT) and CT angiography (CTA) in the diagnosis of acute and chronic mesenteric ischemia.

2. Patients and methods

This prospective study was performed between February 2013 and February 2014 on 57 consecutive patients clinically suspected of having mesenteric ischemia (either acute or chronic), they were referred from the emergency hospital and the outpatient clinics of general surgery and general medicine departments of our institution.

The clinical suspicion of mesenteric ischemia is based on the following findings, pain out of proportion to the clinical findings, post-prandial pain, weight loss, laboratory findings characteristic of ischemia such as elevated lactate level, metabolic acidosis, leucocytosis, previous abdominal angina, previous mesenteric ischemia, atrial fibrillation, severe vascular disease and hypercoagulable states.

Patients with contra-indications to intravenous contrast material as history of severe allergic reaction or renal impairment were excluded.

The institutional ethics committee approved the study protocol and written consent was taken from all patients.

All patients were examined with 16-row multidetector CT system (Toshiba, Aquilion scanner, Toshiba Medical Systems, Tokyo, Japan), images were obtained during both arterial and portal venous phases using the scan delay technique, images were obtained 20 s and 55–60 s after initiation of intravenous contrast injection respectively.

Negative (water) or no oral contrast was used to allow visualization of the bowel (water 750–1000 ml as tolerated by the patient). Non-ionic contrast medium (Iopromide 300 mgI/ml) was used according to the body built (1.5 ml/kg body weight), in a dose of 80–130 ml, through a 18-guage antecubital intravenous line at a rate 4 ml/s by automatic injector, from the xiphoid process down to symphysis pubis, slice thickness = 0.5 mm, kV = 120, mAs = 350, 0.4 s gantry rotation and pitch 1.4.

All data sets were then reconstructed as 0.5 mm section thickness at 0.5 mm intervals, and transferred to a workstation to reformat the axial image data for coronal, sagittal and oblique (30° angulation) multi-planar reformatted images (MPR), curved planar reconstruction (CPR) and volume rendering encompassing the entire bowel. The arterial phase volume was evaluated with maximum intensity projection (MIP), 3D volume rendering, CPR, and MPR.

3. Image interpretation

CT scans were evaluated for evidence of bowel wall thickening (defined as a wall thickness more than 3 mm in non-collapsed small bowel), mucosal attenuation in pre-contrast scans, mucosal enhancement pattern in post-contrast CT scans, mesenteric fat stranding, free fluid, pneumatosis intestinalis, superior mesenteric or portal venous gas, atherosclerotic changes, significant stenosis or thrombo-embolic occlusion of the celiac trunk, superior mesenteric artery (SMA) and inferior mesenteric artery (IMA), also for evidence of porto-mesenteric venous thrombosis.

4. Results

Twenty one patients (15 males and 6 females) out of studied 57 patients had an abnormal CT angiographic (CTA) finding diagnostic of mesenteric ischemia and they constituted the material of this study, their age ranged between 55 and 78 years (mean 67 years), these patients were divided into two subgroups according to their clinical status and the onset of pain into 12 patients with acute mesenteric ischemia (AMI), and 9 patients with chronic mesenteric ischemia (CMI).

Thirty six patients out of 57 patients included in this study showed normal CTA findings, in 30 patients out of these 36 patients, MDCT gave other definitive alternative diagnosis for the cause of the abdominal pain and the patients' clinical status (Table 1), in the remaining 6 patients, both MDCT and CTA were normal with no detectable specific diagnosis.

The MDCT and CTA examinations were performed in most cases within 1–2 h from the request and there were no complications either minor or major.

The most prevalent MDCT findings in 21 patients with mesenteric ischemia, were bowel wall thickening in 12 patients out of 21 (57.1%), 9 patients out of 12 patients (75%) with

Table 1 Distribution of definitive alternative MDCT diagnosis in 30 patients with normal CTA findings.

Definitive MDCT diagnosis	Number of patients
Pancreatitis	3
Gasritis	3
Perforated gastric ulcer	1
Diverticulitis	2
Bowel obstruction	4
Appendicitis	3
Cancer colon	1
Colitis	3
Liver metastasis	2
Choledocholithiasis	2
Ureteric stones	2
Crohn's disease	2
Complicated ovarian cyst	2
Total	30

Table 2 MDCT findings in 21 patients with mesenteric ischemia (12 patients with AMI and 9 patients with CMI).

MDCT finding	AMI (n = 12)	CMI (n = 9)
Bowel wall thickening	9	3
Bowel distension	9	2
Hyperattenuation in NCCT	2	0
Enhanced bowel in CCT	2	2
Non-enhanced bowel in CCT	10	0
Pneumatosis intestinalis	1	0
Stranding of mesenteric fat	7	2
Target sign	3	1
Free fluid	5	0

MDCT, multidetector CT; AMI, acute mesenteric ischemia; CMI, chronic mesenteric ischemia; NCCT, non-contrast CT; CCT, contrast CT.

AMI and 3 patients out of 9 patients with CMI, bowel distension in 11 patients out of 21 patients (52.3%) and non-enhanced bowel wall in contrast-enhanced CT in 10 patients (47.6%) (Table 2).

Computed tomography angiography (CTA) detected accurately the cause of AMI in 12 patients, where arterial thrombo-embolism was the most commonest cause of AMI (75%) and the SMA occlusion was the most frequent site which represents 66.67% in patients with AMI, however in 3 patients out of 12 patients (25%) with AMI, the cause of mesenteric ischemia was porto-mesenteric venous thrombosis (Fig. 1 and Table 3).

Computed tomography angiography (CTA) revealed abnormal findings consistent with CMI and explained the cause of pain in 9 patients, arterial atherosclerosis of the splanchnic arteries with subsequent significant stenosis or occlusion was the most commonest cause (66.67%) and the SMA was involved either by significant stenosis or occlusion with collaterals in all these patients (Figs. 2 and 3), also MDCT revealed superior mesenteric vein thrombosis in two patients (22.22%) and revealed portal vein thrombosis, arterio-venous fistula (between the splenic artery and the superior mesenteric vein) and aneurysm of the superior mesenteric vein in one patient (11.11%) (Fig. 4 and Table 4).

5. Final diagnosis

*Acute mesenteric ischemia (AMI) was surgically proven in 11 patients out of 12 patients, in whom 9 patients were with arterial thrombo-embolism and 2 patients with porto-mesenteric venous thrombosis, however one patient presenting with porto-mesenteric venous thrombosis was treated conservatively and serial CT scans showed improved bowel appearance as the venous thrombosis decreased in size after anticoagulant therapy and the diagnosis of AMI was done on this basis.

*In 6 patients of 9 patients with CMI (patients with arterial atherosclerosis), both MDCT and CTA findings were confirmed by conventional angiography, however in 2 patients with superior mesenteric venous thrombosis and one patient with portal vein thrombosis, arterio-venous fistula and aneurysm of the superior mesenteric vein were treated conservatively by anticoagulant therapy and clinical follow up.

*In 30 patients with normal CTA findings, and positive definitive alternative MDCT diagnosis, these CT findings were later proven either by surgery or laboratory and clinical findings, however in the remaining 6 patients with normal both MDCT and CTA findings, they improved spontaneously without any specific treatment and therefore were presumed not to have mesenteric ischemia.

Both multidetector CT (MDCT) and CTA gave an accurate diagnosis of the cause of mesenteric ischemia in 21 patients, which constitutes the material of this study as proved by the final diagnosis based on surgical exploration, conventional angiography, laboratory investigations and clinical follow up with 100% sensitivity and specificity.

6. Cases

The figures (from Fig. 1 to Fig. 4) demonstrate a sample of selected cases of our study, each figure outlines one case.

A 62 year old male patient presented with colicky abdominal pain with vomiting and constipation with history of splenectomy 15 years ago, axial CT scans (A and B) showed bowel wall thickening (arrows) and distension with no enhancement, mesenteric fat stranding (*), free fluid (F) and engorged venous collaterals (arrow head), sagittal reformatted contrast-enhanced image (C) showed target sign (arrows), portal phase curved coronal reformation (D) showed thrombosis of both superior mesenteric vein (SMV) and portal vein (PV).

A male patient aged 74 years with history of hypertension, diabetes mellitus and coronary heart disease presented with recurrent post-prandial abdominal pain and weight loss, axial contrast-enhanced CT scan (A), sagittal reformatted image (B) and sagittal MIP (C and D) showed thrombosis and total occlusion of the proximal superior mesenteric artery (SMA) with distal re-filling from collaterals, with advanced atherosclerotic changes of the SMA and aorto-iliac arteries.

A male patient aged 71 years, diabetic and hypertensive, presented with chronic abdominal pain and history of myocardial infarction. Axial non-contrast and contrast-enhanced CT scans (A and B), showed calcified atheromatous plaque (arrow in A) at the ostium of the superior mesenteric artery (SMA) with thickened and enhanced bowel wall (arrow in B), coronal (C) and sagittal (D) 3D volume rendering (VR) demonstrate significant osteal stenosis of the SMA and atherosclerotic plaques are seen also at the ostium of the celiac trunk (arrows).

A 58 year old male patient presented with abdominal pain with a past history of splenectomy 1 month before CT examination. Axial MIP (A and B), sagittal and coronal reformatted MIP (C and D), axial CT scan (E), 3D volume rendering (VR) (F and G) demonstrate arterio-venous shunting between the splenic artery (SA) and the superior mesenteric vein (SMV) with early opacification of both SMV and portal vein (PV) in the arterial phase (the site of shunt is seen as a jet of flow of contrast) and aneurysmal dilatation of celiac trunk (C), SMV and SA, partial PV thrombosis, bowel wall thickening and enhancement together with congested and engorged venous collaterals.

7. Discussion

Mesenteric ischemia is caused by a reduction in blood flow for intestinal circulation of sufficient magnitude to compromise the viability of the affected portion (9–13).

The disease can be classified into acute or chronic based upon the rapidity and the degree to which blood flow is

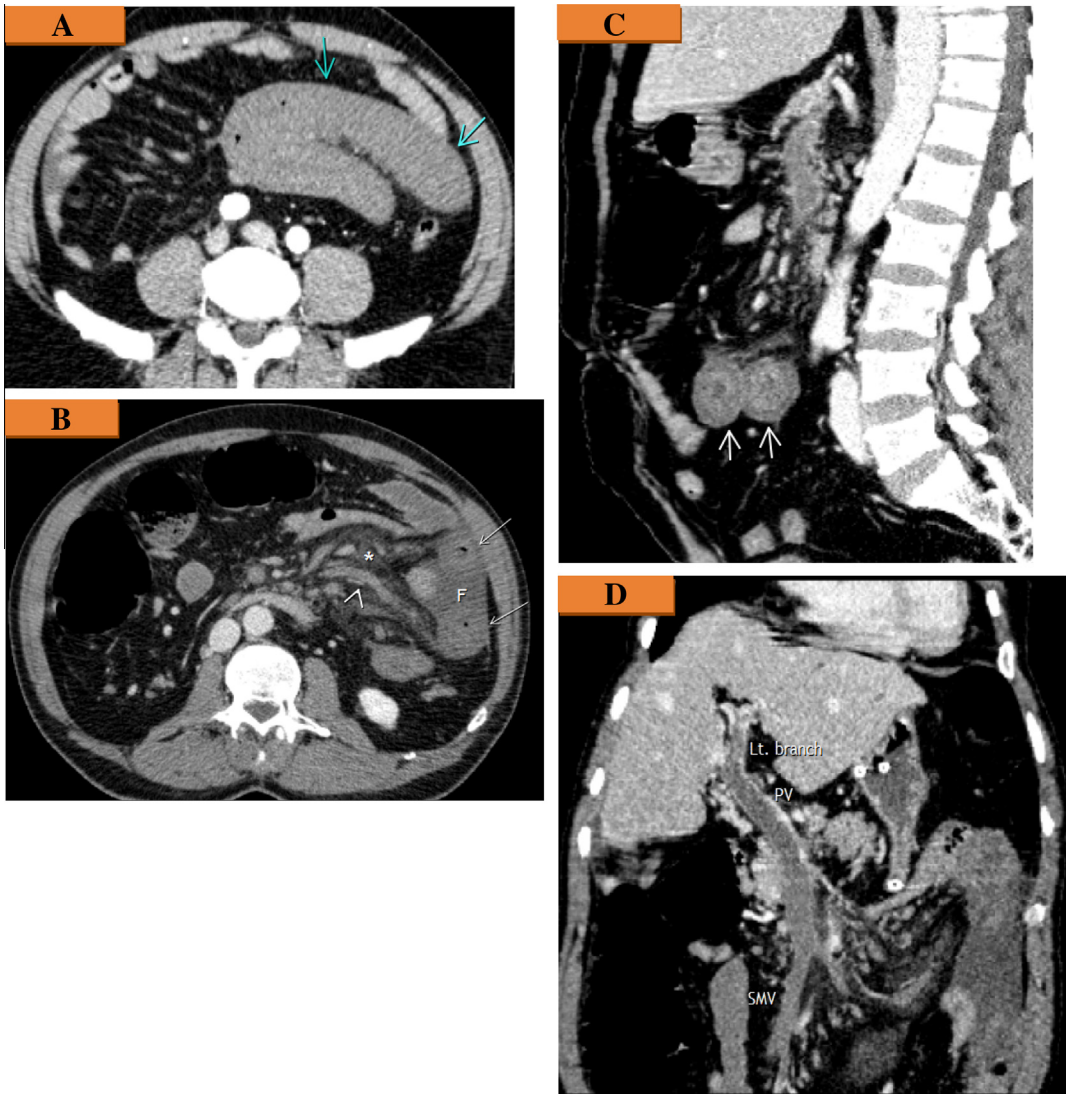

Fig. 1 A 62 year old male patient presented with colicky abdominal pain with vomiting and constipation with history of splenectomy 15 years ago, axial CT scans (A and B) showed bowel wall thickening (arrows) and distension with no enhancement, mesenteric fat stranding, (*), free fluid (F) and engorged venous collaterals (arrow head), sagittal reformatted contrast-enhanced image (C) showed target sign (arrows), portal phase curved coronal reformation (D) showed thrombosis of both superior mesenteric vein (SMV) and portal vein (PV).

Table 3 CTA findings in 12 patients with acute mesenteric ischemia.

CT angiographic findings	Number of patients (%)
*Arterial thrombo-embolism	9 (75%)
-SMA proximal part	5 (41.67%)
-SMA distal part	3 (25%)
-IMA main trunk	1 (8.33%)
*Porto-mesenteric venous thrombosis	3 (25%)
-SMV and PV thrombosis	2 (16.67%)
-SMV thrombosis	1 (8.33%)

CTA, CT angiography; SMA, superior mesenteric artery; IMA, inferior mesenteric artery; SMV, superior mesenteric vein; PV, portal vein.

compromised and the duration of the symptoms (9–11), the lack of an accurate and readily available diagnostic imaging tool has played a role in the high morbidity and mortality of the disease (3,14).

In our study, 21 patients out of 57 patients, showed abnormal CT angiographic findings which explained the cause of mesenteric ischemia in these patients, and the examination was performed in most cases within 1–2 h from the request and there were no complications either major or minor complications, so, this method is considered highly accurate, fast and safe, these findings agree with Ofer et al. (15) who performed a study on 93 patients with clinically suspected acute mesenteric ischemia.

In the current study, the most prevalent MDCT findings in 21 patients with positive CT angiographic findings were bowel wall thickening in 12 patients (57.1%), bowel distension in 11 patients (52.3%) and non-enhanced bowel in contrast-enhanced CT in 10 patients (47.6%), these findings more or less matched with those reported by Al-Azzazy et al. (16) who in their study found that bowel wall thickening, bowel

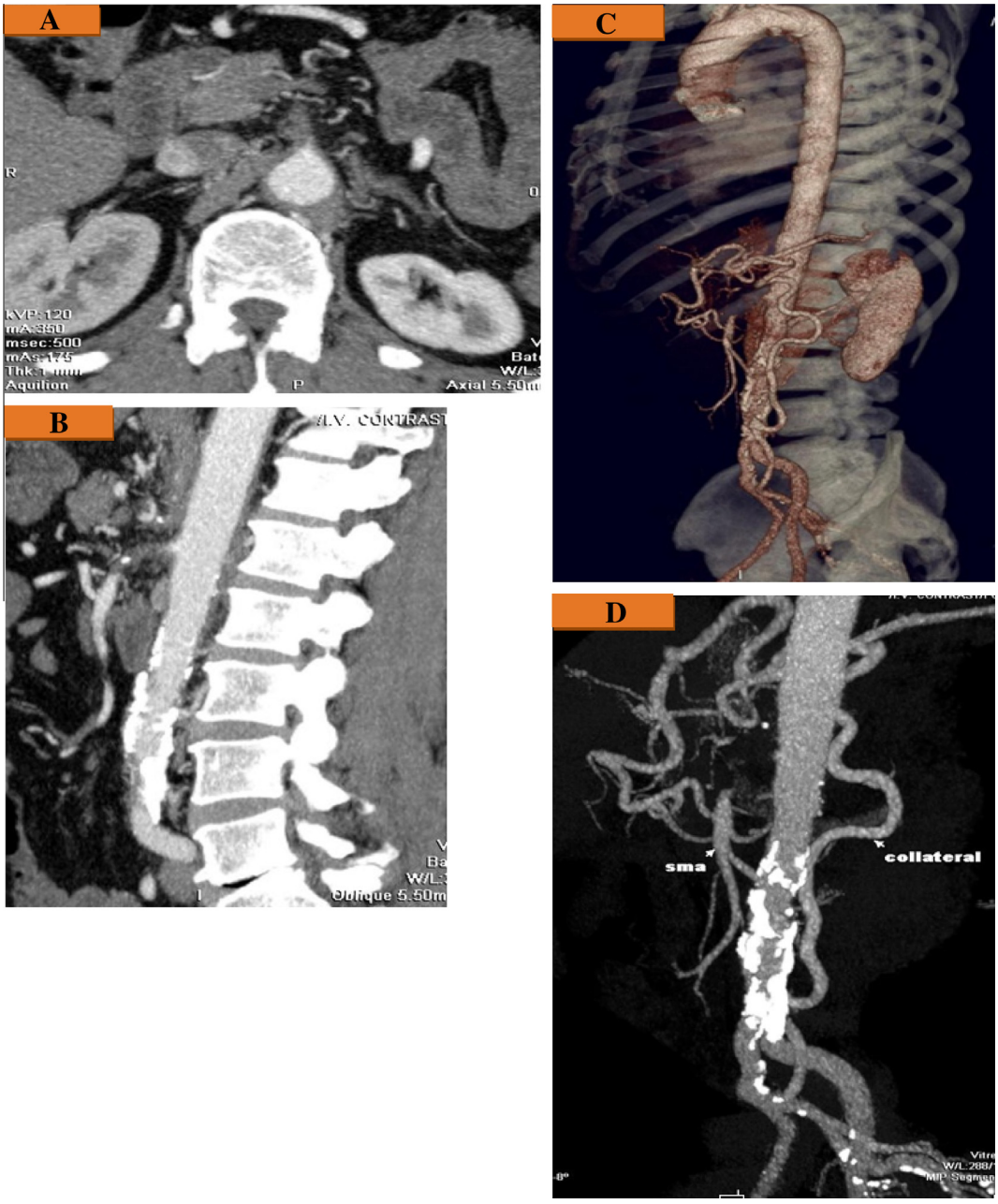

Fig. 2 A male patient aged 74 years with history of hypertension, diabetes mellitus and coronary heart disease presented with recurrent post-prandial abdominal pain and weight loss, axial contrast-enhanced CT scan (A), sagittal reformatted image (B) and sagittal MIP (C and D) showed thrombosis and total occlusion of the proximal superior mesenteric artery (SMA) with distal re-filling from collaterals, with advanced atherosclerotic changes of the SMA and aorto-iliac arteries.

distension and also non-enhanced bowel wall in post-contrast CT are the most frequent MDCT findings in patients with mesenteric ischemia.

Serpa et al. (17) reported that bowel wall thickening was observed in 7 of 9 patients diagnosed with acute mesenteric ischemia and bowel distension was found in 55% of cases, and 4 patients (44%) had a high attenuation of the bowel wall after contrast injection, and reported that these bowel wall changes (bowel wall thickening, bowel distension and bowel enhancement pattern) are non-specific responses of the bowel to a wide variety of pathologies, so, they lack specificity.

In the current work only one patient of 12 patients with AMI showed pneumatosis intestinalis and surgical exploration revealed bowel infarction and resection anastomosis was done, so this MDCT finding is extremely specific and considered late onset finding and this result was in agreement with different published studies (3,9,10).

In the current study, CTA detected accurately the cause of AMI, where arterial thrombo-embolism was the most commonest cause of AMI (75%) and the SMA occlusion was the most frequent site in patients with AMI, however in 3 patients out of 12 patients (25%) with AMI, the cause of mesenteric

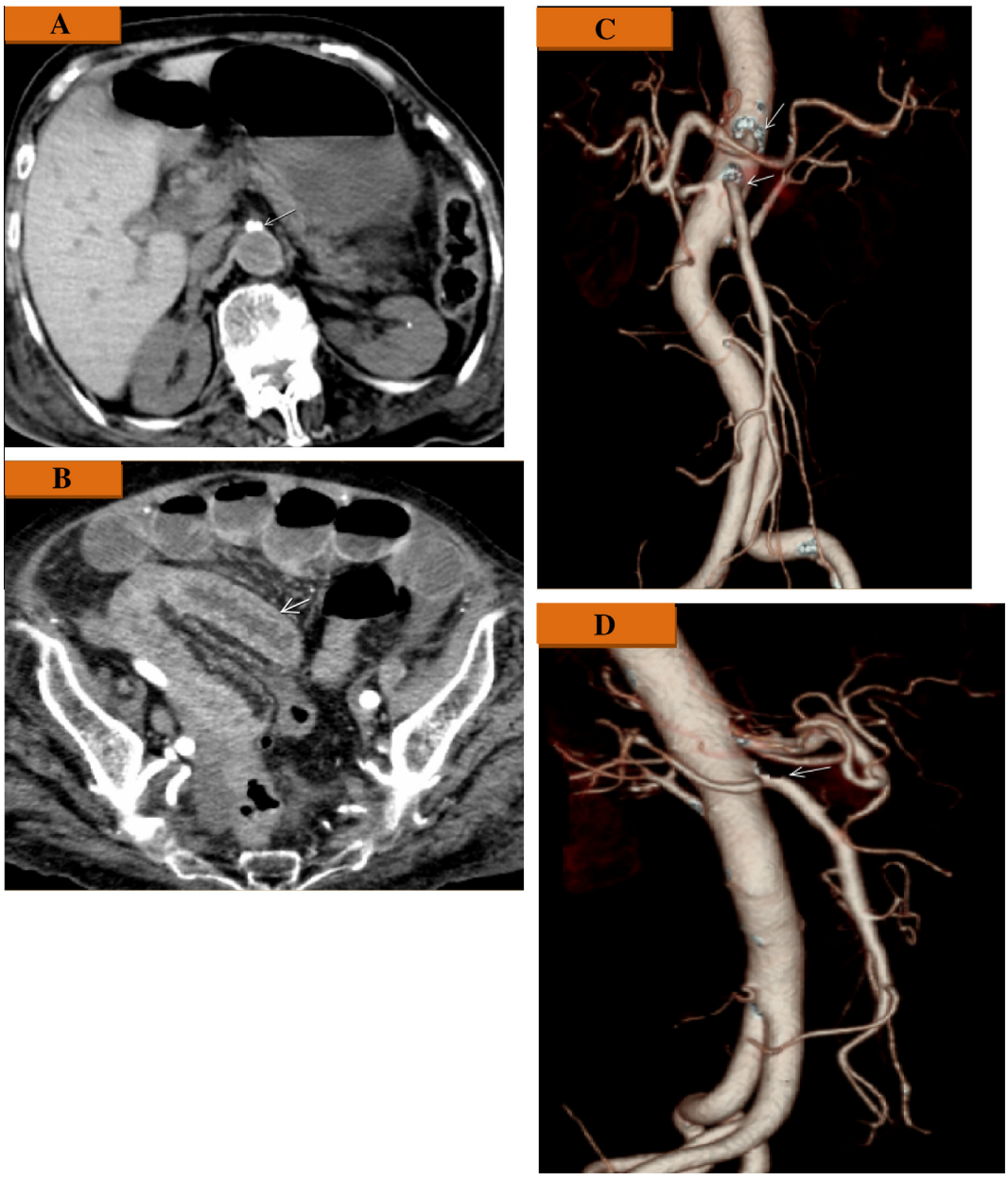

Fig. 3 A male patient aged 71 years, diabetic and hypertensive, presented with chronic abdominal pain and history of myocardial infarction. Axial non-contrast and contrast-enhanced CT scans (A and B), showed calcified atheromatous plaque (arrow in A) at the ostium of the superior mesenteric artery (SMA) with thickened and enhanced bowel wall (arrow in B), coronal (C) and sagittal (D) 3D volume rendering (VR) demonstrate significant osteal stenosis of the SMA and atherosclerotic plaques are seen also at the ostium of the celiac trunk (arrows).

ischemia was porto-mesenteric venous thrombosis, these results were in agreement with Al-Azzazy et al. (16).

Acute bowel ischemia may be caused by occlusions of the arteries or veins as well as by non-occlusive reduction of intestinal perfusion. Acute occlusion of the SMA due to thrombosis or embolization is responsible for approximately 60–70% of causes of acute bowel ischemia, whereas mesenteric venous thrombosis accounts for 5–10% of the total (3).

In our work, CTA revealed abnormal findings consistent with CMI and explained the cause of pain in 9 patients, arterial atherosclerosis of the splanchnic arteries with subsequent significant stenosis or occlusion was the most commonest cause and the SMA was involved either by significant stenosis or occlusion with collaterals in 6 patients, also MDCT revealed superior mesenteric vein thrombosis in two patients and revealed portal vein thrombosis, arterio-venous fistula and aneurysm of the superior mesenteric vein in one patient, these results were in agreement with previous researchers (16–18).

In the current study, mesenteric ischemia was correctly diagnosed using both MDCT and CTA in 21 patients and explained the cause of pain and clinical status of these patients with 100% sensitivity and specificity, these findings matched with Barmase et al. (19) who reported that mesenteric ischemia was diagnosed in all 16 patients using MDCT (100%

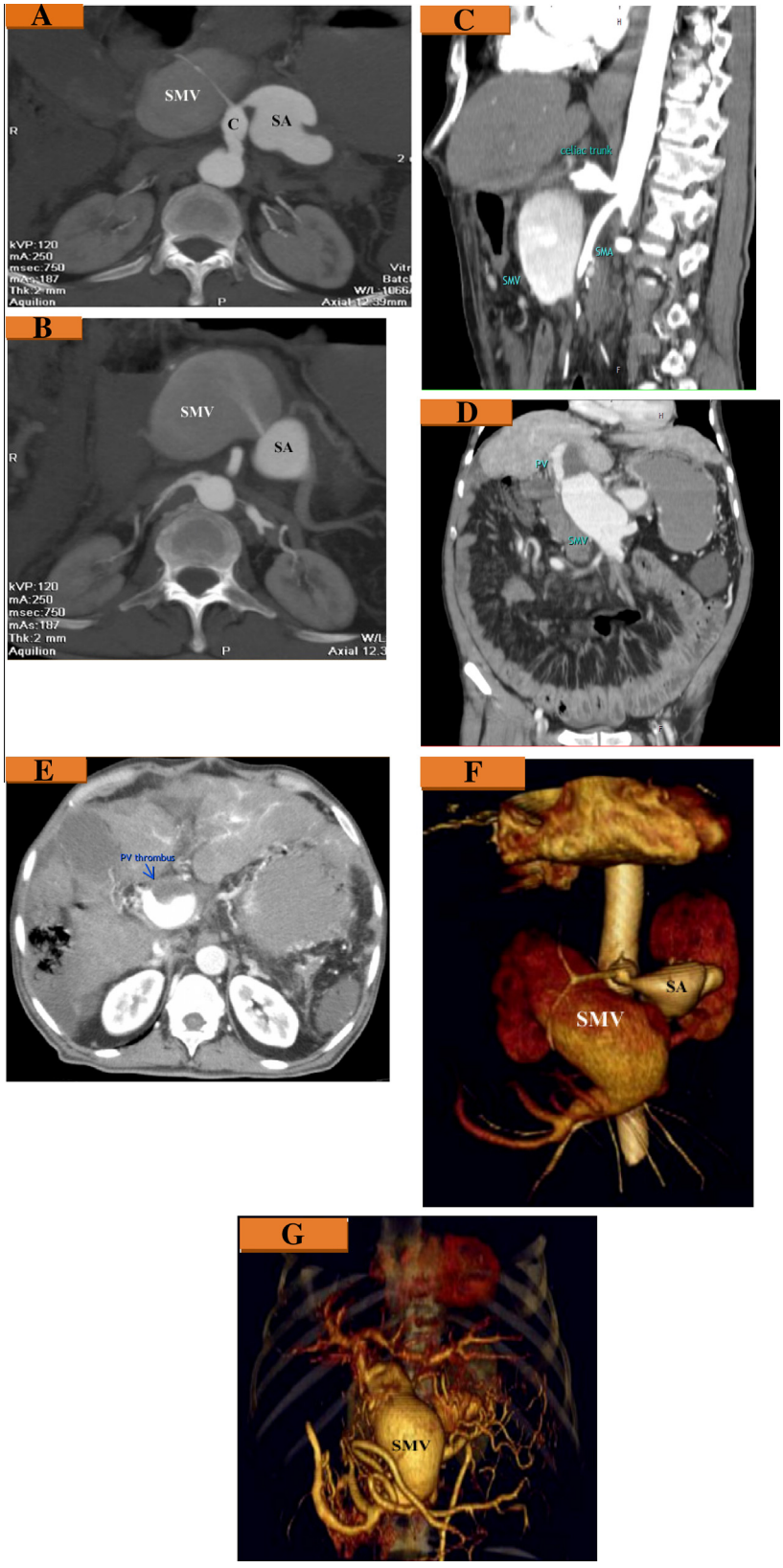

Fig. 4 A 58 year old male patient presented with abdominal pain with a past history of splenectomy 1 month before CT examination. Axial MIP (A and B), sagittal and coronal reformatted MIP (C and D), axial CT scan (E), 3D volume rendering (VR) (F and G) demonstrate arterio-venous shunting between the splenic artery (SA) and the superior mesenteric vein (SMV) with early opacification of both SMV and portal vein (PV) in the arterial phase (the site of shunt is seen as a jet of flow of contrast) and aneurysmal dilatation of celiac trunk (C), SMV and SA, partial PV thrombosis, bowel wall thickening and enhancement together with congested and engorged venous collaterals.

Table 4 CTA findings in 9 patients with chronic mesenteric ischemia.

CTA findings	Number of patients (%)
*Atherosclerosis:	6 (66.67%)
-Stenosis of both SMA & celiac trunk	2 (22.22%)
-Stenosis of proximal SMA	1 (11.11%)
-Stenosis of distal SMA	1 (11.11%)
-Occlusion of proximal SMA + collaterals	1 (11.11%)
-Stenosis of SMA + IMA	1 (11.11%)
*SMV thrombosis	2 (22.22%)
*PV thrombosis, A-V fistula & SMV aneurysm	1 (11.11%)

-CTA, CT angiography, SMA, superior mesenteric artery, IMA, inferior mesenteric artery, SMV, superior mesenteric vein, PV, portal vein, A-V, arterio-venous.

sensitivity and specificity) of whom 9 patients underwent surgical exploration.

In this work, MDCT not only explained the cause of mesenteric ischemia (21/57) but also gave other definitive alternative diagnosis for the cause of the abdominal pain and the patients' clinical status in 30 patients out of 57 patients (52.6%), these results agree with those reported by Ofer et al. (15) who found that MDCT and CTA are able to make an alternative diagnosis in 38 patients (51%) and also agreed with Kirkpatrick et al. (9) who reported that CT was used to make a definitive alternative diagnosis in 21 patients (58%).

There are some limitations in our work, among which and considered the most important one was the small number of cases, since mesenteric ischemia is not a common pathology, also not all cases were surgically confirmed, however specific clinical findings and follow up were considered sufficient for the diagnosis.

Finally, MDCT and CTA are fast, safe, accurate and non-invasive imaging modalities of choice in patients with suspected mesenteric ischemia which are 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 confirmation or exclusion of various other differential diagnoses of acute abdominal conditions.

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