Multi-slice CT angiography in assessment of patients with mesenteric ischemia

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Abstract: Purpose: Our work aiming to assess the role of MDCT angiography in patients with mesenteric ischemia. **Patients and methods:** This a cross sectional study was conducted on 30 patients who fulfilled the criteria for suspected bowel ischemia from October 2013 to July 2015. The cases included in the study were 18 males and 12 females, with a mean age 55 years (ranging from 22 to 68 years old). All patients were referred from vascular surgery and emergency departments to radiology department of Zagazig University hospitals. All patients underwent multi-slice CTA of the abdomen and pelvis, using 128-multi-detector row CT scanner. **Results:** The patients were divided into two groups based upon the rapidity of symptoms and clinical presentation; acute mesenteric ischemia group (no=10 patients) and chronic mesenteric ischemia group (no=20 patients). Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of MSCT angiography in mesenteric ischemia were 96.2%, 75%, 70%, 94% and 93.3% respectively. **Conclusion:** Multi-slice CT mesenteric angiography is an accurate, safe, non-invasive and valuable imaging modality for fast diagnosis of suspected ischemic bowel disease patients. Hence, it should be used as a first imaging tool in cases of suspected mesenteric ischemia, particularly acute cases, for early fast diagnosis and better management.

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Key words: Multislice CT; acute mesenteric ischemia; intestinal angina; thromboembolism.

1. Introduction

Mesenteric ischemia is a rare disease associated with high morbidity and mortality. It is caused by insufficient blood flow of the intestine from various causes, including thromboembolism, non-occlusive causes such as bowel obstruction, neoplasms, vasculitis, abdominal inflammatory conditions, trauma, drugs, radiation and corrosive injury[1]. Acute mesenteric ischemia is most commonly secondary to embolism followed by arterial thrombosis, non-occlusive ischemia, and less commonly venous thrombosis. Chronic mesenteric ischemia is almost always caused by atherosclerotic disease, with a rare causes including fibromuscular dysplasia and vasculitis. Acute and chronic intestinal ischemia must be distinguished. Patients with mesenteric ischemia usually present with nonspecific abdominal symptoms such as postprandial abdominal pain, sito-phobia and loss of weight[2].

Abdominal radiographs and ultrasound are commonly the first ordered tests in patients with abdominal pain and may diagnose more common pathologies[3]. On plain radiographs dilated bowels with air-fluid levels, pneumatosis and portal venous gas can be seen, whereas Doppler ultrasound can demonstrate mesenteric thrombus, but its accuracy may be limited by presence of extensive gas within bowels and patients incompliance[4].

While catheter-based angiography has been considered the reference standard and enables diagnosis and treatment, advances in computed tomography with the introduction of multi-detector technology have made it a first-line test in many patients because it is fast, widely available, and non-invasive study[5]. MDCT became a powerful diagnostic modality in patients with suspected mesenteric ischemia, as it provides direct visualization of the mesenteric vessels, bowels and mesentery[3,6].

Nonspecific MDCT common findings in patients with mesenteric ischemia include bowel dilatation, bowel wall thickening, mesenteric edema, and ascites. MDCT specific findings in acute mesenteric ischemia patients include splanchnic vascular occlusion, intramural gas, lack of bowel-wall enhancement, and multi-organ infarctions[6,7].

Due to its high spatial resolution and 3-D reconstructions, multi-detector CT angiography allows noninvasive direct visualization of the mesenteric ischemia causes and its insults on the intestines, and associated pathologic findings[8].

The purpose of this study is to assess the value of multi-slice CT angiography in early diagnosis and management of patients with suspected mesenteric ischemia.

2. Patients and methods

This study was conducted on 30 patients who fulfilled the criteria for suspected bowel ischemia from October 2013 to July 2015. The cases included in the study were 18 males and 12 females, with a

mean age 55 years (ranging from 22 to 68 years old). All patients were referred from vascular surgery and emergency departments to radiology department of Zagazig University hospitals. All patients underwent multi–slice CTA of the abdomen and pelvis, using 128-multi-detector row CT scanner (Phillips Inguinity Core 128 TM). The study was approved by the ethical committee of our institution and a written consent was obtained from patients or their relatives.

All patients in our study were subjected to the following:

A- Plain x-ray:

Twenty two cases were imaged in erect position, 3 patients in sitting position and the remaining 5 patients in lateral decubitus position.

B-Ultrasonography:

Pelvi-abdominal US was done for all patients using Toshiba machine with curved array probe (3.5 MHz frequency).

C-Multi-slice CT:

All patients in this study were examined in axial planes, using 128-multi-slice CT scanner using an automatic injector**.**

Technique of examination:

Patients were kept fasting for at least 3 hours. Oral administration of 750 ml water over a 30-90 minutes period before scanning and 250 ml immediately prior to it. Twenty six patients were able to drink the entire amount of water without any difficulty, 2 patients received the same amount through a naso-gastric tube, and water intake was contraindicated in the remaining 2 patients suspected to have bowel perforation (plain x-ray revealed free air under diaphragm).

With the patient supine, the scan direction was cranio-caudal, taken from the dome of the diaphragm to the perineum. The patients were instructed to hold breath during scanning. Otherwise, they were instructed to breathe as quietly as possible to minimize respiration artifacts.

Technical parameters of multi-slice CT were:

Slice thickness: 128x0.75-1.5 mm. Reconstructed thickness: 1.75 mm. Reconstructed interval: 0.7 mm. Collimation: 1.25-5 mm. Table movement per gantry rotation: 7.5 mm. Rotation time: 0.8 second/rotation. Pitch: 1.35-2. KV: 100-140, mAs: 80-140 and scan time: 20-30 sec.

Steps of the multi-slice CT examination include:

1-Unenhanced CT:

The role of unenhanced CT in mesenteric ischemia is to identify hyper-attenuating intravascular clotting, and intramural hemorrhage. In assessing chronic mesenteric ischemia, the presence of atherosclerotic calcified plaque at or near the origins of proximal splanchnic arteries is also easily shown on unenhanced CT. This phase was done for all cases.

2-Post-contrast (enhanced) CT:

Nonionic iodinated contrast media (Ultravist) was used as 1-2 ml/Kg BW. Initially, 2-5 ml of the contrast was given to test patient's sensitivity. Then, contrast media was injected at a rate of 4ml/sec in a total dose of 80-120 ml with an automatic injector through a catheter or a cannula (18-20 gauge) via the cubital or the antecubital vein, followed by 20 ml saline flush. Scanning was begun 8-25 sec after the initiation of injection for arterial phase and 60-70 seconds for venous phase acquisition.

3-Interpretation and data recording:

Image interpretation of axial images and reformatted images was done using independent workstation. Images were evaluated for the presence of vascular causes and intestinal manifestations of ischemia as well.

All axial CT image data were sent via local area network to a freestanding available picture archiving and communication system workstation. It is possible to measure the size of the lesion and the attenuation value (measured in Hounsfield units) in a particular region of interest (ROI).

Sagittal and coronal images are reconstructed from the stack of axial image data called multi-planar reformations (MPR). It helps to define the location and extent of the lesions shown on axial CT images.

4-MDCT Post Processing Techniques:

Three dimensional reformations (3D), maximum intensity projection (MIP) and volume rendering images (VR) was done. Two dimensional and three dimensional images were interpreted in combination with axial cuts such that all informations about the GIT abnormality were available in all imaging planes to confirm the diagnosis.

The radiological data describing the vascular & intestinal findings of acute and chronic mesenteric ischemia were collected systematically.

Statistical analysis

The collected data were presented, summarized, tabulated & analyzed by using computerized software statistical packages (EPI-info Version 6.04 & SPSS version 19).P <0.05 was statistically significant. Chi square & Fisher exact tests were used to compare different proportions. Sensitivity, specificity, positive

predictive value, negative predictive value and accuracy of multi-slice CTA were done compared with surgical and follow up findings.

3. Results

The thirty patients included in the study were divided into two groups based upon the rapidity of symptoms and clinical presentation; acute mesenteric ischemia group (no=10 patients) and chronic mesenteric ischemia group (no=20 patients) (table1).

Clinical presentation of acute and chronic mesenteric ischemia were summarized in table2.

Multislice CTA findings of acute and chronic mesenteric ischemia and its significant *p* value were summarized in table3.

Table (1): Demographic data and the risk factors.

	Studied Group
	N (30)
AGE mean± (SD)	22-68 (55)
Sex Male Female	18 (60 %) 12 (40%)
Risk factors:	**No of patients**
-Ischemic heart disease. -Senility -Diabetes -Smoking -Liver cirrhosis -Cerebrovasculat stroke -Malignancy -Hypovolemia -Coagulation disorder -Post-abdominal surgery	22 20 16 17 5 5 2 3 3 3

Table (2): Clinical presentation of acute and chronic mesenteric ischemia.

Clinical presentation of all cases			
Acute mesenteric ischemia	*No.*	*Chronic mesenteric ischemia*	*No.*
Sudden abdominal pain	10	Postprandial abdominal pain	20
Abdominal distension	8	Sitophobia	16
Vomiting	7	Weight loss	17
Diarrhea	6	Constipation	5
Fever	6	Diarrhea	2
Constipation	3		
Hematemesis	1		
Shock	2		

The sensitivity, specificity, PPV, NPV and accuracy of MSCT angiography in mesenteric ischemia compared with surgery and clinical follow up were summarized in table 4.

Table (3): Shows multi-slice CT individual Findings among acute and chronic mesenteric ischemic cases.

Multi-sliceCT findings	**AMI. (No.=10)**		**CMI. (No.=20)**		**Statistical Significant**
	No.	%	No.	%	*P.value*
Bowel wall thickening*	6	60	14	70	<0.45
Bowel dilatation**	5	50	5	25	<0.17
NCCT bowel wall hyperattenuation	1	10	1	5	<0.65
PCCT bowel wall enhancement	2	20	1	5	<0.15
PCCT bowel wall non-enhancement	5	50	0	0	<0.02
Intestinal pneumatosis	4	40	1	5	<0.05
Portal venous gas	4	40	1	5	<0.05
Free intra-peritoneal air	2	20	0	0	<0.15
Ascites/free fluid	5	50	4	20	<0.22
Mesenteric fat stranding	5	50	8	40	<0.59
Pancreatic pseudocyst	1	10	0	0	<0.39
Chronic duodenal ulcer	0	0	1	5	<0.59
Inflammatory bowel disease.	0	0	1	5	<0.59

*Bowel wall>3-5mm thickness depending on degree of bowel distention.
** Small bowel diameter >2.5cm & large bowel diameter >8cm.
NCCT (Non-contrast CT). PCCT(post-contrast CT).

In table (3), the bowel wall thickening was the most frequent sign, found in 20 out of 30 patients representing (66.7%).There was a significant statistical difference in non-enhanced bowel wall among acute and chronic ischemic groups.

Table(4): Shows sensitivity, specificity, PPV, NPV and accuracy of MSCT angiography in mesenteric ischemia compared with surgery and clinical follow up.

	Sensitivity	Specificity	PPV	NPV	Accuracy
MSCTA vs surgery and follow up	96.2%	75%	70%	94%	93.3%

PPV (positive predictive value). NPV (negative predictive value)

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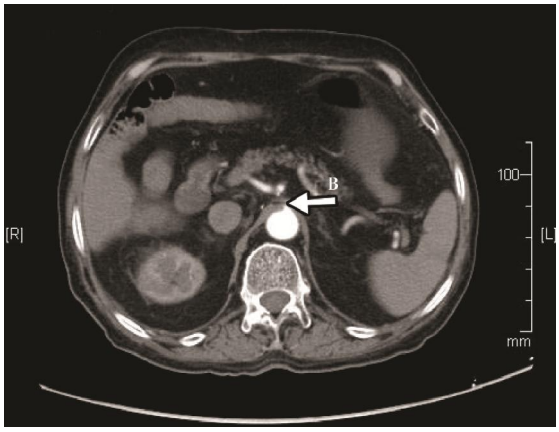

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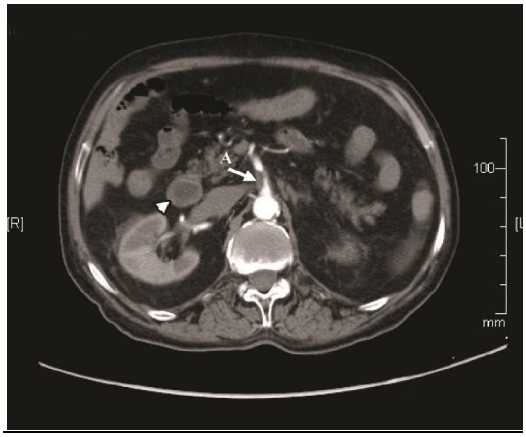

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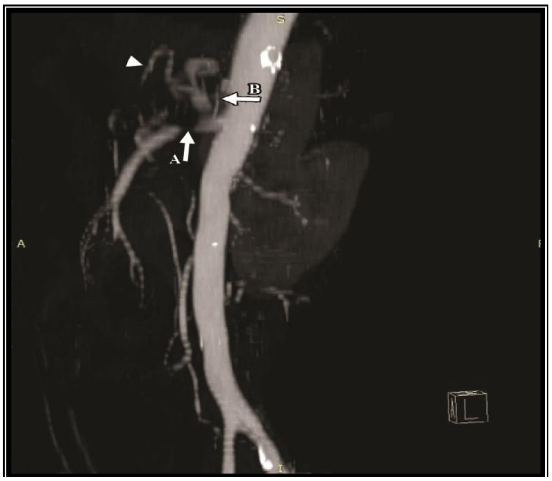

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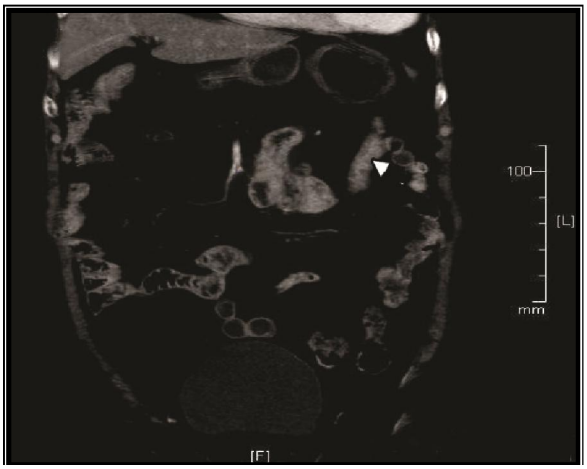


(E)

Figure (1): Sixty years old male, known case of ischemic heart disease presented with a recurrent post prandial abdominal pain & sitophobia **(A, B):** axial CT arterial phase shows marked stenosis of proximal part of celiac artery (arrow B) & incomplete occlusion of **SMA** (arrow A), which is also detected in **3D** sagittal MIP & VR images **(C,D).** Also collateral artery of Buhler seen connecting celiac artery with SMA **image C**(arrow head). (**E):** Coronal reformatted CT image shows thickened wall of the duodenum and jejunum (arrow head). Patient referred to surgery for arterial stenting.

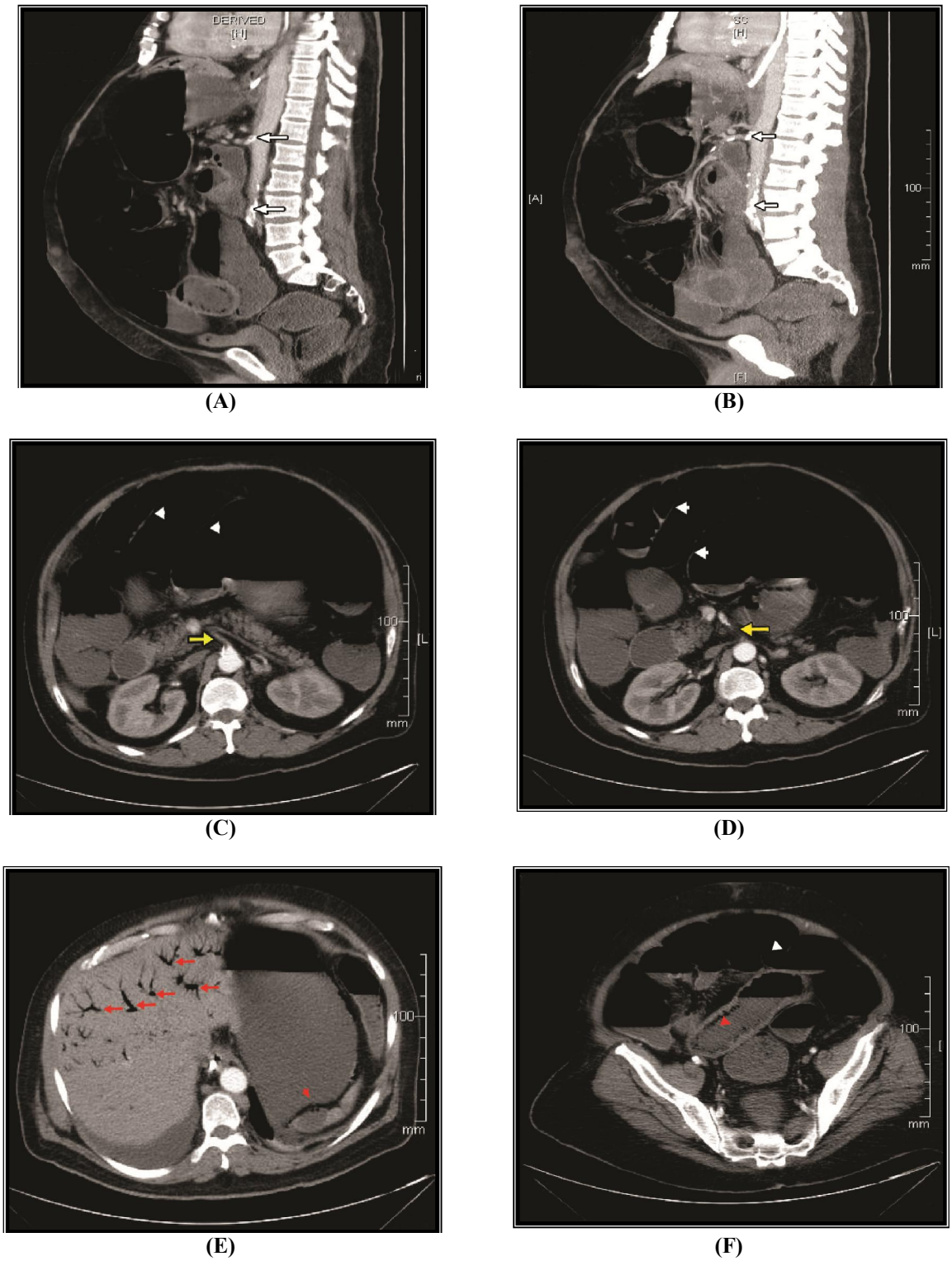
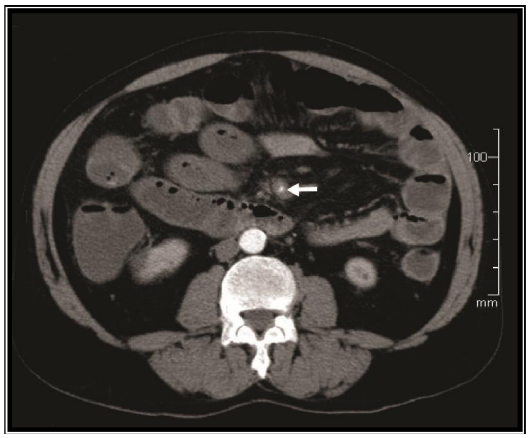


Figure (2): Fifty eight years old male with rheumatic heart disease complaining from abdominal pain and abdominal distention. (**A, B):** Non contrast sagittal reformatted & sagittal MIP images show multiple calcified atherosclerotic plaques in the aorta and &origin of SMA (arrows). (**C, D, E& F)**: Axial CT arterial phase shows hypodense thrombus in SMA completely occludes its lumen at its origin from the aorta (yellow arrow). Also Extensive portal venous gas (red arrows), gastric/intestinal pneumatosis (red arrow heads), diffuse small bowel dilatation with thin wall & intermittent areas of non-enhancement (arrow heads). All are features of arterial occlusive mesenteric ischemia. Patient referred to surgery for thrombo-embolectomy.



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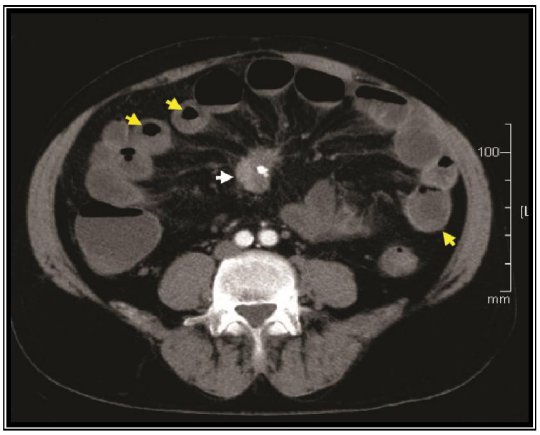

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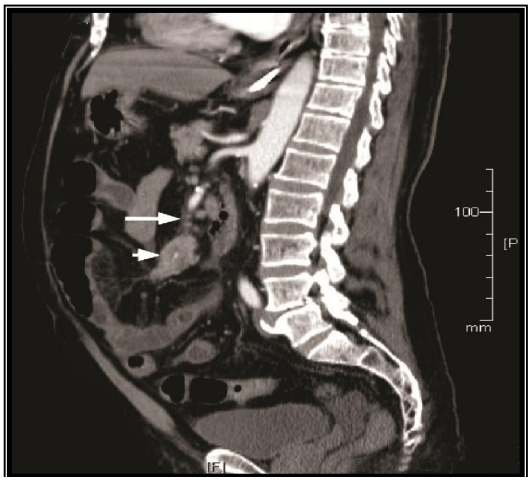

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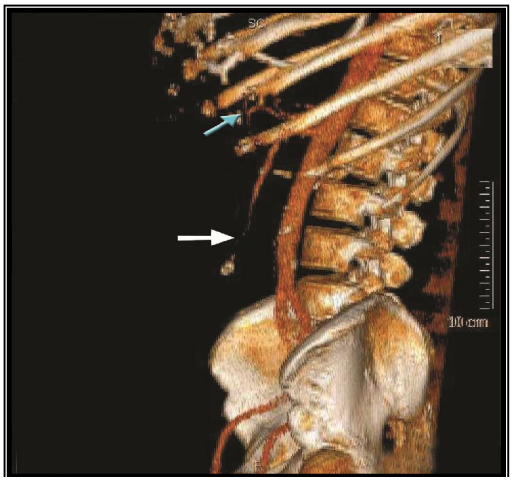

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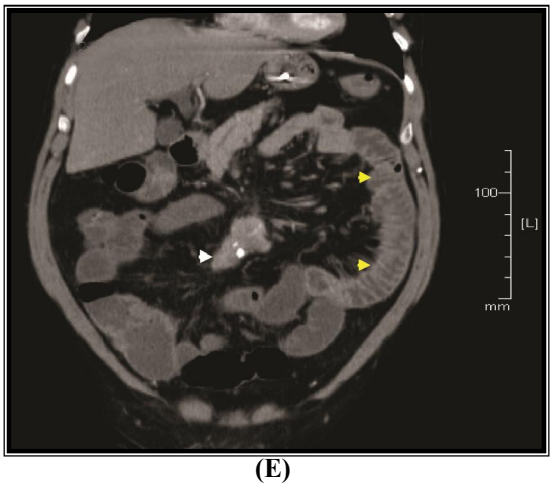

(E)

Figure.(3): Sixty four years male patient, known case of hypertension complaining from abdominal distension & diarrhea. **Image A, B:** Contrast enhanced axial CT images in the arterial phase at the level of mid abdomen, demonstrate enhancing soft tissue mass in the root of the mesentery with coarse calcification and desmoplastic reaction in the surrounding mesentery causing tethering of the surrounding bowel loops (sclerosing mesenteritis) (arrow head). This mass seen encasing the middle portion of SMA markedly attenuating its lumen (arrow). **Image C & D:** Arterial enhanced sagittal reformatted image C & 3D sagittal VR image D show SMA encasement. Also demonstrate collateral artery of Buhlar (blue arrow). **Image E**: Coronal reformatted enhanced CT image demonstrate a circumferential wall thickening of jejunal loops (yellow arrow heads) with surrounding misty mesentery, representing ischemic changes. Patient surgery confirmed our diagnosis.

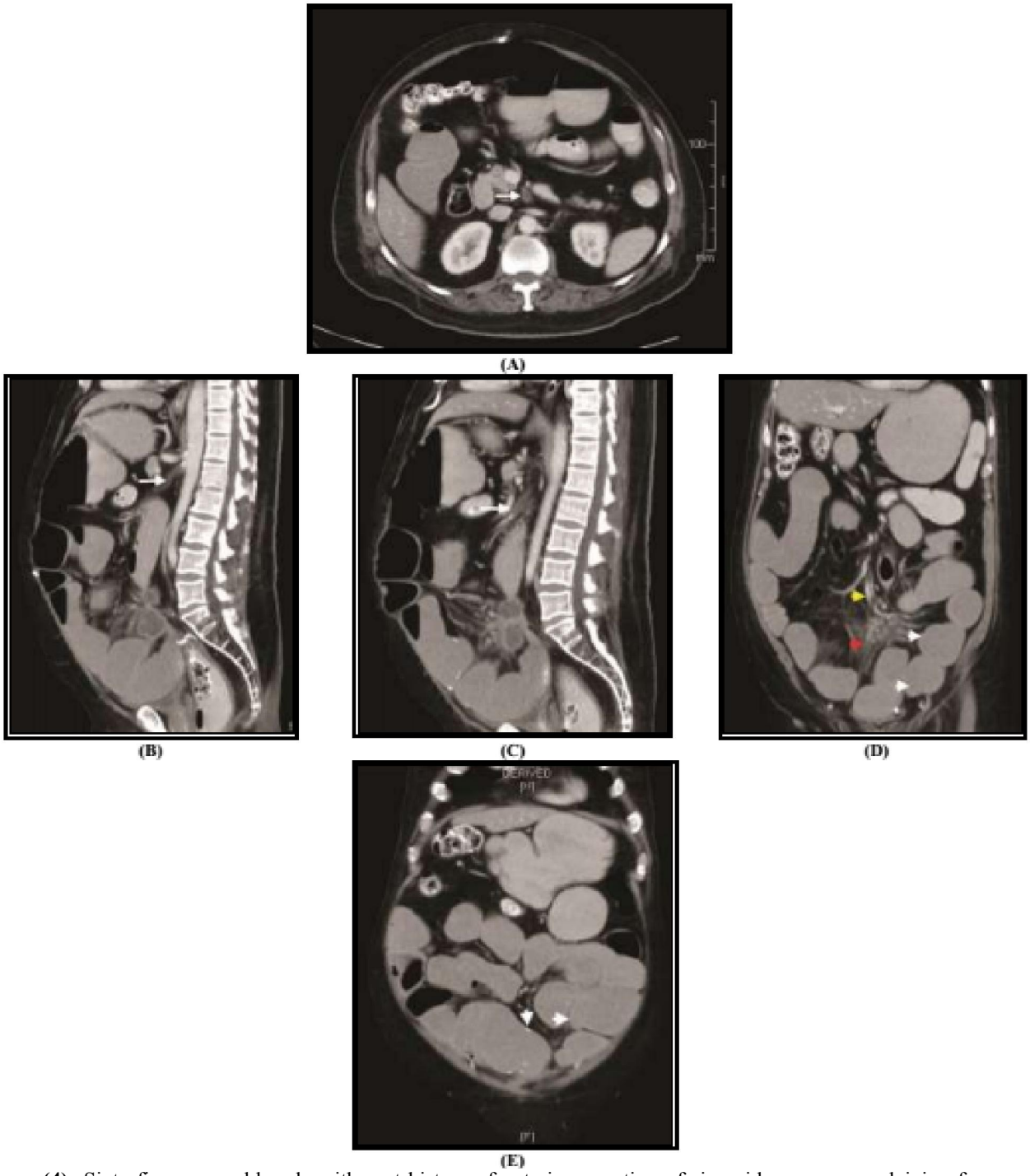

Figure (4): Sixty five years old male with past history of anterior resection of sigmoid cancer, complaining from abdominal pain and absolute constipation. **Image A,B,C:** Abdominal contrast enhanced axial **(A)** and sagittal reformatted images**(B,C)** demonstrate thrombotic occlusion of the proximal SMA extends till the bifurcation of the artery (arrow), however the artery reconstituted peripherally by collaterals as detected in the coronal reformatted **image D** (yellow arrow head). **Image E:** Enhanced coronal reformatted image shows generalized dilatation of small bowel loops with diminished enhancement of its thin wall (arrow heads), surrounded by misty mesentery (red arrow head in image D). Features of early arterial occlusive ischemia.
Patient immediately referred to surgery for urgent thrombectomy.

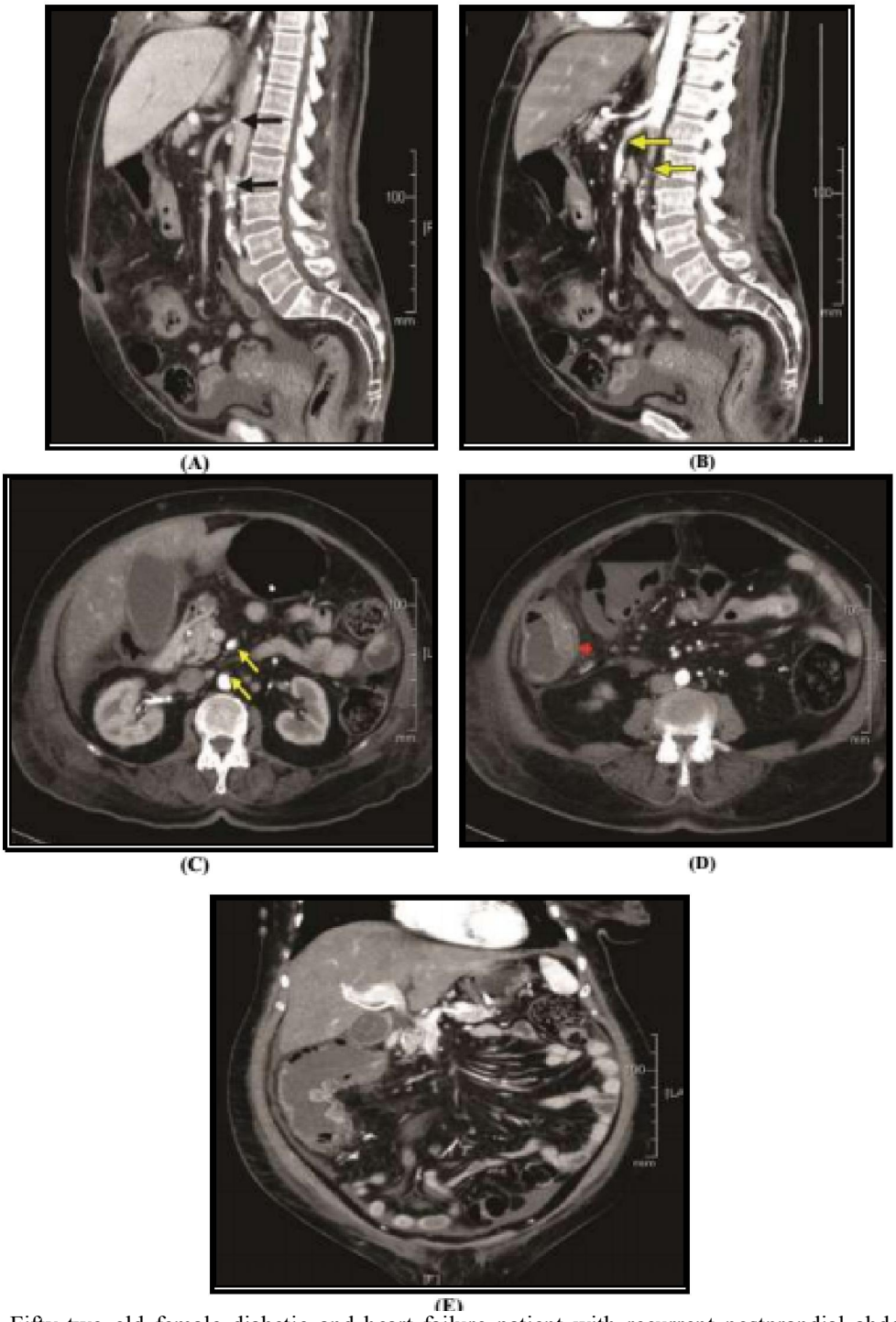

Figure (5): Fifty two old female diabetic and heart failure patient with recurrent postprandial abdominal pain. **Image A:** Non-contrast sagittal image shows calcified atherosclerotic changes of the aorta and its main branches (black arrows). **Image B**: Contrast enhanced sagittal reformatted image in the arterial phase shows atheroma in the aorta and SMA (yellow arrows). **Image C, D:** Contrast enhanced axial cuts in the arterial phase at the level of L2 & L4 shows also hypodense wall thickening of the SMA and aorta (yellow arrows), show significant thickening of the right colon reaching (8.3 mm) with misty mesentery as shown in the coronal enhanced reformatted **image E**. Patient admitted at vascular surgery for clinical follow up. Symptoms relieved and bowel wall thickness returned back to normal on US follow up after anticoagulant therapy.

4. Discussion

Mesenteric ischemia is due to a reduction in blood flow for intestinal circulation of sufficient magnitude to compromise the viability of the affected portion[9].Acute mesenteric ischemia is frequently a lethal vascular emergency, with a mortality rates ranging from 60% to 80%.Patient outcome is dependent on the cause of mesenteric ischemia, and mortality reaches up to 95 % if AMI is due to thrombo-embolic occlusion of the SMA[10]. It is vital to diagnose acute intestinal ischemia before bowel wall infarction occurs to improve clinical outcome [10].

The main risk factors in the 30 patients of our study were ischemic heart disease, old age and smoking, other risk factors included liver cirrhosis, coagulation disorders, abdominal malignancies and hypovolemia. This matched with **Dang et al**.[11] who stated that risk factors for AMI include atherosclerosis, arrhythmias, hypovolemia, CHF, recent MI, valvular disease, advanced age, and intra-abdominal malignancy.

Regarding acute bowel ischemia group in our study, the most common clinical presentations were abdominal pain out of proportion to physical examination, abdominal distension, vomiting & diarrhea. Less common presentations were fever, shock and hematemesis. That was going with the same findings as **Horton and Fishman**[12] and **Aschof et al.**[10]

In our study, the most prevalent MDCT findings in AMI patients were bowel wall thickening, found in 6 patients, bowel dilatation in 5 patients, and non-enhanced bowel wall in post-contrast CT in 4 patients, these findings matched with those reported by **Chung et al**[9], who stated that intestinal wall thickening was the most frequent MDCT finding in AMI.

In our study a halo or target appearance was found in one case diagnosed as strangulating small bowel obstruction. It was also indicative of mesenteric ischemia, representing hyper-perfusion associated with surrounding mural edema. This agree with **Furkawa et al**[13], who stated that closed loop obstruction represents 10% of acute mesenteric ischemia.

Assessment of bowel wall enhancement is traditionally made by comparing NECT and contrast-enhanced images. An alternative method, which is routinely used in clinical practice, relies alone on the post-contrast images by using normally enhancing bowel wall as an internal reference [14].

In our study non-enhancement of the bowel wall in post contrast CT was found in 5 cases, which was statistically significant in AMI group compared to CMI group in which bowel wall enhanced in all cases, similar significance was found in the study of **Chung et al.**[9]

Serpa et al[15] reported that bowel wall thickening observed in 7patientsout of 9 patients (77%) acute mesenteric ischemia and bowel dilatation found in 5 cases (55%), and 4 patients (44%) had increased bowel wall enhancement after contrast injection, and reported that these bowel changes alone are non-specific.

Both intestinal pneumatosis and pneumoporta may occur in bowel wall infarction due to mesenteric ischemia, also may complicate neoplastic or post-inflammatory bowel wall damage or occur after gastrointestinal surgery or sepsis. So, detection of intestinal pneumatosis and pneumoporta should not be taken as an ominous signs for mesenteric ischemia and bowel infarction [16,17].

In our study, CT showed arterial occlusion associated with bowel wall pneumatosis and pneumoporta in 4 acute mesenteric ischemia cases, increasing the possibility of embolic occlusion and raising sensitivity and specificity of those combination, that was in agreement with **Kirkpatrick et al**[17], who found that intestinal pneumatosis, portomesenteric venous gas, SMA, IMA or celiac occlusion were 100 % specific for AMI.

In our study, MDCTA detected accurately the cause of AMI, where arterial thrombo-embolism was the commonest cause of AMI (40%). Similar incidence had been reported by other researchers like **Barıs et al**[18], who found that acute mesenteric ischemia due to SMA occlusion was accounting nearly 40–50% of all cases.

In our study, two out of ten patients (20%) with AMI manifestations, the cause of mesenteric ischemia was porto-mesenteric venous thrombosis, the two patients had chronic liver disease as a risk factor, similar incidence was reported by **Aschof et al**[10].

Chronic mesenteric ischemia shows a more indolent course with a recurrent postprandial abdominal pain as a typical presentation. Chronic mesenteric ischemia is mainly due to atherosclerotic plaque, which is formed slowly, consequently, the affected patients develop collateral vessels in an attempt to maintain an appropriate intestinal perfusion. The symptoms appear with insufficient collateral vessels[11]. **Cognet et al**[19] reported that at least two of the three mesenteric arteries should be narrow with flow reduction to cause chronic mesenteric ischemia symptoms.

In our study, CTA revealed abnormal findings consistent with CMI and explained the cause of pain in 18 patients, arterial atherosclerosis of the splanchnic arteries with subsequent significant

stenosis was the most commonest cause of CMI. This also matched with **Cognet et al**.[19]

Our results showed that SMA was the most involved artery by significant stenosis with collaterals in 10 patients, also MDCT revealed superior mesenteric vein thrombosis in one patients and revealed portal vein thrombosis with SMV extension in two patient, these results were in agreement with **Cademartiri et al**.[20]

In CMI, usually there are less morphologic changes in the bowels. So, CMI diagnosis is based on detection of stenotic artery, accompanied by collaterals, and with exclusion of AMI criteria. MDCT can detect calcified plaque in the aorta and mesenteric arteries as well as the presence of collateral vessels in patients with chronic mesenteric ischemia [7].

Comparing MDCTA findings with surgical, endoscopic and follow up results we found that MDCTA sensitivity, specificity and accuracy were 96.2%, 75% & 93.3% respectively. Similarly **Aschoff et al**.[10], correctly found AMI in 27 patients out of 28 (96.4%) with a sensitivity of93% but they had specificity of 100%. Higher sensitivity for MDCTA had reported by **Barmase et al.**[21] in their study for acute MI, which was 100%.

MDCT is the best imaging tool to detect bowel wall necrotic damage, limiting surgery to excision of the irreversibly necrotized intestine only [22].

Conclusion:

Multi-slice CT mesenteric angiography is an accurate, safe, noninvasive and valuable imaging modality for fast diagnosis of suspected ischemic bowel disease patients. Hence, it should be used as a first imaging tool in suspected cases of mesenteric ischemia, particularly acute ones, for fast diagnosis and better assessment to safe patient life.

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