

# Reliability of Multi-Detector CT in the Assessment of Mesenteric Ischemia Using Basic Images

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## Abstract

**Background:** Mesenteric ischemia is caused by drop of blood flow in intestinal vasculature to a degree that compromise the viability of target part and according to the time and amount of reduction, it can be classified into acute mesenteric ischemia and chronic mesenteric ischemia.

**Aim of Study:** To assess the value of Multidetector CT (MDCT) and CT Angiography (CTA) in the diagnosis of different causes of mesenteric ischemia using the source images and routine reformat.

**Material and Methods:** This prospective study included 58 consecutive patients (30 males and 28 females), with age range (52-77 years) during the period from October 2017 to Dec. 2018. They were referred for CT angiography of the mesenteric vessels with clinical suspicious of (acute or chronic) mesenteric ischemia. Four patients were excluded due to contraindication to IV contrast, so finally the study was conducted for 54 patients, all underwent CT angiography and the results of CT angiography were collected and tabulated.

**Results:** Twenty four subjects had CTA findings of mesenteric ischemia (acute=14 and chronic=10). Thickening of bowel wall was the commonest finding in Acute Mesenteric Ischemia (AMI) in 85.7%. Bowel wall non-enhancement was noted in 11 patients of 14 with AMI (78.57%). CTA pointed out the cause of AMI in 14 patients (dominant cause was arterial thromboembolism, (n=10 (71.4 %)), the most frequent site was Superior Mesenteric Artery (SMA). CTA diagnosed and found out the reason of pain in Chronic Mesenteric Ischemia (CMI) patients (atherosclerosis of the splanchnic arteries with significant stenosis or occlusion was the dominant reason (n=7, 70%). Among the 24 patients with mesenteric ischemia, MDCT and CTA provided the reason for mesenteric ischemia in all patients which represents accuracy, sensitivity and specificity of 100%.

**Conclusion:** MDCT and CTA are noninvasive tools that can be the optimum choice in imaging of cases with suspicious mesenteric ischemia.

**Key Words:** Mesenteric – Ischemia – MDCT – CTA.

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## Introduction

**MESENTERIC** ischemia is a complex of heterogeneous diseases that is characterized by insufficient bowel blood supply, it is considered as an abdominal emergency which represents about 2% of gastrointestinal illnesses and up to 2% of admitted cases to abdominal pain in USA [1-4]. The increased incidence can be explained by the advancement of imaging tools as well as raised health and clinical awareness and increased average life age. Because of the variability and non-specificity of both clinical and radiological findings of mesenteric ischemia, the rapid diagnosis and management needs a high index of clinical and imaging suspicion [5-7]. However the reported high mortality (50-90%) necessitates a more need for better diagnostic imaging modalities especially when the clinical diagnosis is difficult as the presentation is non-specific (as pain in abdomen, vomiting or diarrhea). The pathogenesis of ischemic injury is started by a reduction of blood supply in the mesenteric vasculature leading to inadequate oxygen transferred to the wall of bowel resulting in injury of cells and subsequent necrosis. On clinical base mesenteric ischemia can be classified to acute (AMI) or chronic (CMI) while on pathological base, it can be classified into occlusive (venous or arterial) or non-occlusive pathologically [8-13].

The conventional angiography is considered the gold standard tool in the diagnosis; however it is invasive and expensive and unable to provide

### List of Abbreviations:

CT : Computed Tomography.  
MDCT : Multi-Detector Computed Tomography.  
CTA : CT Angiography.  
AMI : Acute Mesenteric Ischemia.  
CMI : Chronic Mesenteric Ischemia.  
SMA : Superior Mesenteric Artery.

proper assessment of extra-vascular changes associated with mesenteric ischemia. Computed tomography is considered as the first imaging option which can suggest acute mesenteric ischemia especially with using of multidetector CT and CT angiography. Advancement of CT allowed improving of its resolution (spatial and temporal) with diminished scanning time and ability of reconstruction in multiple plans and three dimensional (3D) thus can be alternative for conventional angiography in detection of mesenteric ischemia [13-23].

#### *Aim of the work:*

The purpose of current study is to assess the value of MDCT and CTA in the diagnosis of different causes of mesenteric ischemia using the source images and routine reformat.

### **Material and Methods**

This prospective study included 58 consecutive patients (30 males and 28 females), their average age was 65 years (range: 52-77 years). They were referred from Emergency Department, clinics of General Surgery or Internal Medicine Departments to the CT Unit at our institution for CT angiography of the mesenteric vessels with clinical suspicious of (acute or chronic) mesenteric ischemia in the study group patients.

*Inclusion criteria:* Included patients with abdominal pain not in proportion of the clinical signs, post-prandial pain, weight loss, history of abdominal angina, and laboratory criteria of ischemia as raised level of lactate, acidosis and leukocytosis.

*Exclusion criteria:* Renal impairment and allergy to contrast medium.

According to the exclusion criteria; 4 patients who could not be subjected to contrast CT study due to severe allergy (n=2) and renal dysfunction (n=2) were excluded. So finally the study was conducted for 54 patients (29 males and 25 females).

This study was conducted from October 2017 to Dec. 2018 and approval of the medical research ethics committee of our institution was obtained and all patients gave a written consent. All patients included in this research gave written informed consent to publish the data contained within the study. If the patient was decreased consciousness or comatosed; written informed consent for the publication of this data was given by the legal guardians.

All patients were subjected to CT angiography study using 16 slice multi-detector CT scanner. The exam included: Non-contrast, arterial and portal venous phases at scan delay of 30 and 60 seconds respectively following the start of automatic injection of IV contrast. Oral contrast was not given so as not interfere with vascular reconstruction and to verify the bowel enhancement. Non-ionic (Iopromide 300mg/ml) IV contrast was injected automatically through 18-gauge IV antecubital line at a rate of 3-4ml/s and a dose of (1.5ml/kg body weight).

*Image parameter:* Slice thickness=0.5mm, kV/mAs=120/350, 0.625-mm collimation, a pitch of 1.4, scan was done from the diaphragmatic dome to symphysis pubis.

Images were then reconstructed at 2.5mm thickness and reformatted on a dedicated workstation to have coronal, sagittal and oblique Multi-Planar Reformatted images (MPR) for the arterial and venous phases.

#### *Image interpretation:*

Analysis of the source and reformatted images was done by experienced GIT radiologists with more than 10 years' experience in abdominal imaging. The aim was to assess reliability of the source images and routine reformat in the diagnosis in busy centers trying to answer can we rely on source images and basic reformat?

#### *CT images were assessed for:*

- Bowel wall thickening (>3mm in non-collapsed small bowel).
- Mucosal attenuation (non-contrast images) and its enhancement (post-contrast).
- Mesenteric fat stranding, pneumatosis intestinalis, free fluid.
- Venous assessment (Superior Mesenteric Vein (SMV) and Portal Vein (PV)) for any gas or thrombosis.
- Arterial evaluation is also done of the celiac trunk, superior and inferior mesenteric arteries (SMA and IMA) for stenosis, atherosclerosis and thrombo-embolic disease.

#### *Data analysis:*

The data were collected, tabulated and statistically analyzed. All statistical analyses were computed with the Statistical Package for the Social Sciences (SPSS) Version 21. Descriptive statistic was performed in a form of number and percentage for qualitative data. Sensitivity, specificity and

diagnostic accuracy were calculated for diagnostic evaluation.

**Results**

Of the 54 patients included in this study, we had 24 (16 males and 8 females) with CT angiographic (CTA) findings of mesenteric ischemia and they represented the final subjects in current study (Table 1). Acute Mesenteric Ischemia (AMI) was found in 14 patients and Chronic Mesenteric Ischemia (CMI) was found in 10 patients. Absent bowel enhancement (78.6%), thickened bowel wall (85.7%) and distended bowel loops (71.4%) were the most common CT abnormality in AMI.

Their average age was 65 years (range: 52-77 years). These patients were classified into 2 groups based on the clinical state and pain onset.

- Group A (acute mesenteric ischemia (AMI), n= 14 (Table 2), Figs. (1,2).

- Group B (Chronic Mesenteric Ischemia (CMI), n=10 (Table 3), Fig. (3).

The most common site of the arterial thrombo-embolism was proximal part SMA (50% of AMI group).

The most common cause of CMI detected by CT angiography was atherosclerosis found in (70%) of the case of CMI (Table 3).

Table (1): MDCT abnormalities in 24 subjects with mesenteric ischemia.

MDCT abnormalities	AMI (n=14)	CMI (n=10)
Thickened bowel wall	12 (85.71%)	4 (40%)
Distended bowel	10 (71.42%)	3 (30%)
Hyperattenuation in non-contrast	2 (14.28%)	0 (0%)
<i>Post contrast enhancement:</i>		
Positive	3 (21.42%)	10 (100%)
Negative	11 (78.57%)	0 (0%)
Target sign	3 (21.48%)	1 (10%)
Mesenteric fat stranding	8 (57.14%)	3 (30%)
Free fluid	6 (42.85%)	0 (0%)
Bowel wall air	2 (14.28%)	1 (10%)

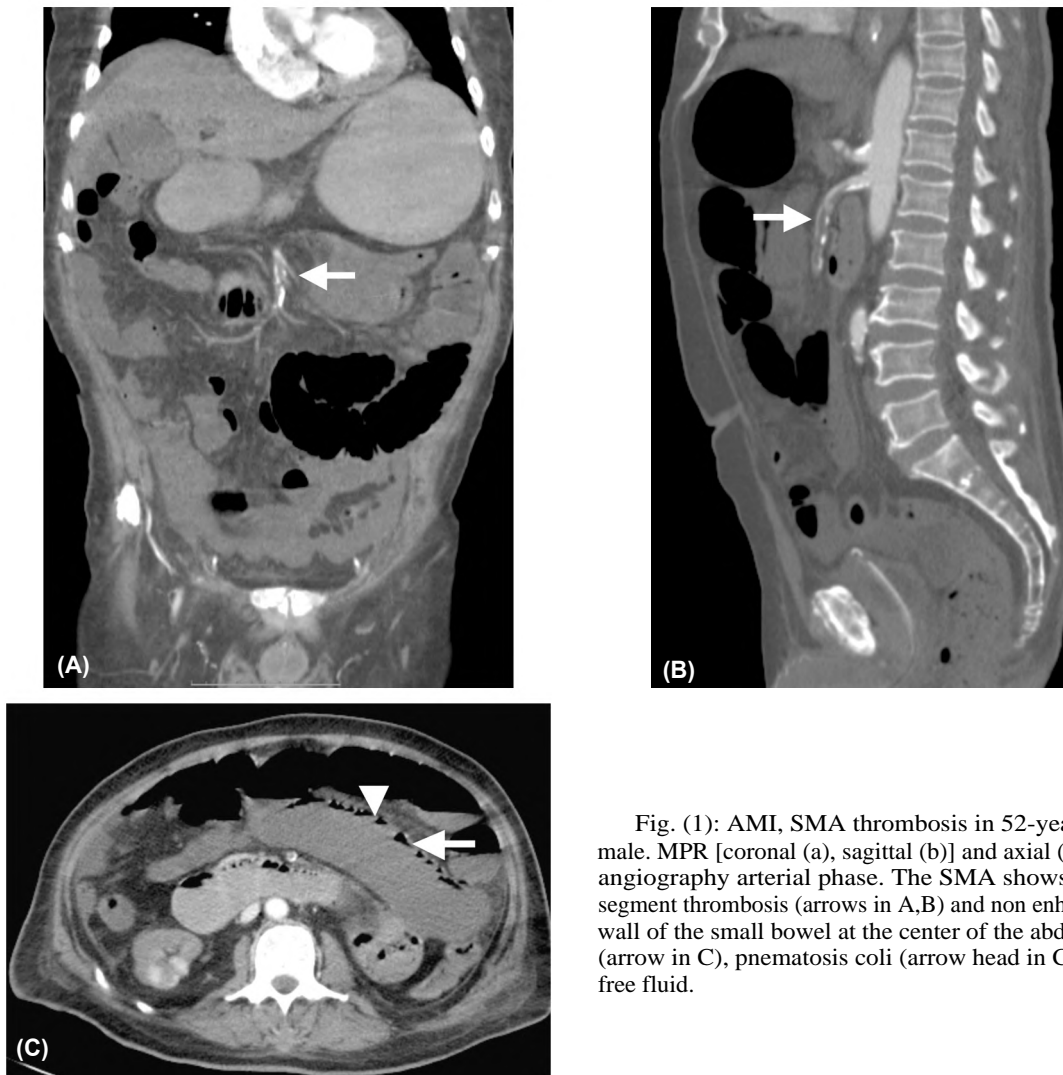


Fig. (1): AMI, SMA thrombosis in 52-year-old male. MPR [coronal (a), sagittal (b)] and axial (c) CT angiography arterial phase. The SMA shows long segment thrombosis (arrows in A,B) and non enhanced wall of the small bowel at the center of the abdomen (arrow in C), pneumatosis coli (arrow head in C) and free fluid.

Table (2): Findings at CTA in patients with acute mesenteric ischemia (n=14).

CTA	Site	Number (n=14)
• Arterial thrombo-embolism (n=7)	Proximal part of SMA	7 (50%)
	Distal part of SMA	2 (14.29%)
	Main trunk IMA	1 (7.14%)
• Porto-mesenteric venous thrombosis (n=3)	SMV and PV	1 (7.14%)
	SMV	2 (14.29%)
• Shock bowel syndrome (n=1)	Small bowel	1 (7.14%)

Table (3): Findings at CTA in patients with chronic mesenteric ischemia (n=10).

CTA	Number (n=10)	%
<i>Atherosclerosis (n=7):</i>		
Stenosis proximal SMA	2	70%
Stenosis proximal SMA and IMA	1	
Stenosis proximal SMA and celiac trunk	1	
Occlusion of proximal SMA with collateral	2	30%
Stenosis distal SMA	1	
<i>Thrombosis (N=3):</i>		
SMV	2	30%
PV and SMV thrombosis	1	

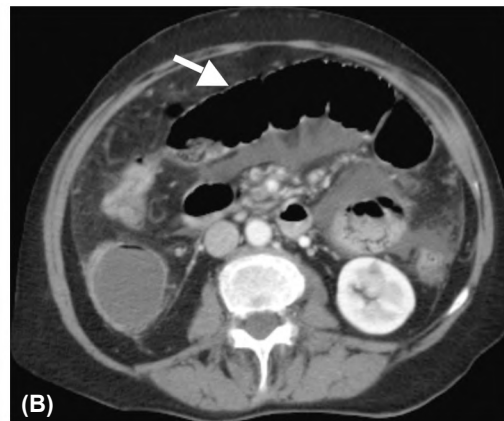
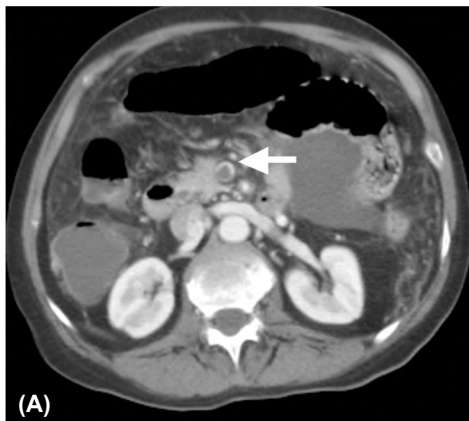


Fig. (2): AMI, Porto-mesenteric venous thrombosis in 79-year-old male. Axial (a,b), coronal (c) venous phases, sagittal (d,e) arterial phase reveals. SMV and PV thrombosis (arrow in A,C,E), patent SMA (curved arrow in D), small bowel ischemia non enhanced wall, (arrow in B), mesenteric congestion, stranding and free fluid (arrow head in C). Note the halo sign (arrow head in D).

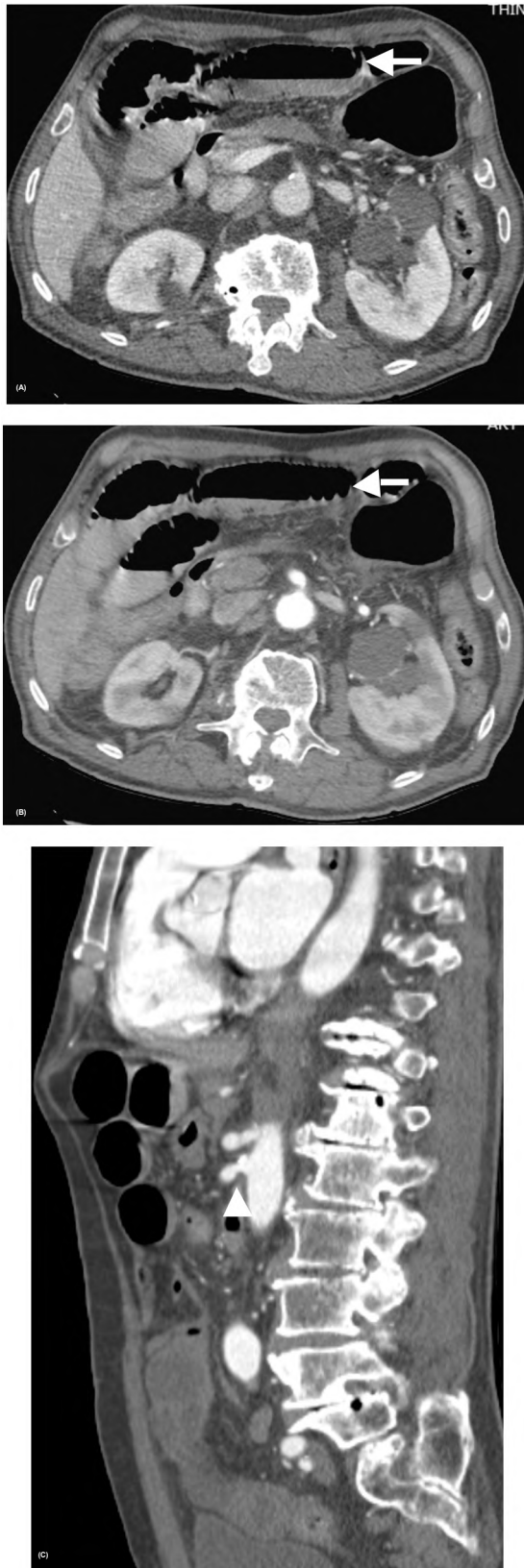


Fig. (3): CMI, atherosclerosis of SMA in 75-year-old male. CTAaxial venous (a), axial arterial (b) and sagittal arterial (c) showing atheromatous plaque at the origin of the SMA causing significant stenosis (arrow heads) and small bowel ischemia (fluid filled non enhanced wall, arrows).

Table (4): Findings at MDCT in patients with unremarkable CTA study (n=30).

MCT findings	Number
Pancreatitis	4
Colitis	3
Bowel obstruction	2
Gastritis	1
Diverticulitis	3
Appendicitis	4
Gall bladder stone	3
Ureteric stone	3
Complicated ovarian cyst	2
Unremarkable/nonspecific findings	5

The rest of patients (n=30) involved in the current study had unremarkable CTA results, but 25 of which had an alternative diagnosis based on MDCT findings while the other 5 patients had unremarkable results at both MDCT and CTA.

Thickening of bowel wall was noted at MDCT and was seen in 12 patients with acute mesenteric ischemia (85.7%) and in 4 patients with CMI (40%).

Bowel wall non-enhancement was noted in post-contrast study of 11 patients of 14 with acute mesenteric ischemia (78.57%).

*For AMI:* CTA pointed out the cause of AMI in 14 patients (dominant cause was arterial thromboembolism which was detected in 10 patients (71.4%), the most frequent site was SMA (n=7, 70% of thromboembolic cases) while 3 cases with AMI had porto-mesenteric venous thrombosis (21.4%). One case had shock bowel syndrome 2ry to perforated stomach Fig. (4) showed thickened hyper enhanced bowel wall. This patient had also associated rectal mass Fig. (4).

*For CMI:* CTA diagnosed relevant signs and found out the reason of pain in 10 patients (atherosclerosis of the splanchnic arteries with significant stenosis or occlusion was the dominant reason (n=7, 70%) and the SMA showed significant stenosis or occlusion with collateralization among those patients. On the other hand MDCT showed SMV thrombosis in 2 patients (20%) and PV and SMV thrombosis in one patient (10%).

AMI was surgically confirmed in 13 of the 14 patients (10 arterial thrombo-embolism, 2 porto-mesenteric venous thrombosis and one case shock bowel syndrome) while one patient was with porto-mesenteric venous thrombosis was unfit for surgery and received conservative management and follow-up CT revealed improvement (bowel abnormalities and venous thrombosis size regressed) after anti-coagulant therapy.

In 7 of the 10 patients with CMI (arterial atherosclerosis), MDCT and CTA diagnosis were matching with conventional angiography, while 2 patients with SMV thrombosis and one patient with portomesenteric venous thrombosis were managed conservatively by anticoagulant treatment and follow-up clinically.

Patients with unremarkable CTA but with alternative diagnostic criteria at MDCT (n=25) other than mesenteric ischemia were confirmed by clinical, laboratory or post-operative findings (Table 4).

The rest of patient (5 patients) with unremarkable and non-specific MDCT and CTA findings were followed-up and showed spontaneous improvement suggesting of not to be mesenteric ischemia.

Among the 24 patients with mesenteric ischemia, MDCT and CTA provided the reason for mesenteric ischemia in all patients and confirmed by final diagnosis (surgical, conventional angiography, laboratory findings and follow-up) which represents accuracy, sensitivity and specificity of 100%.

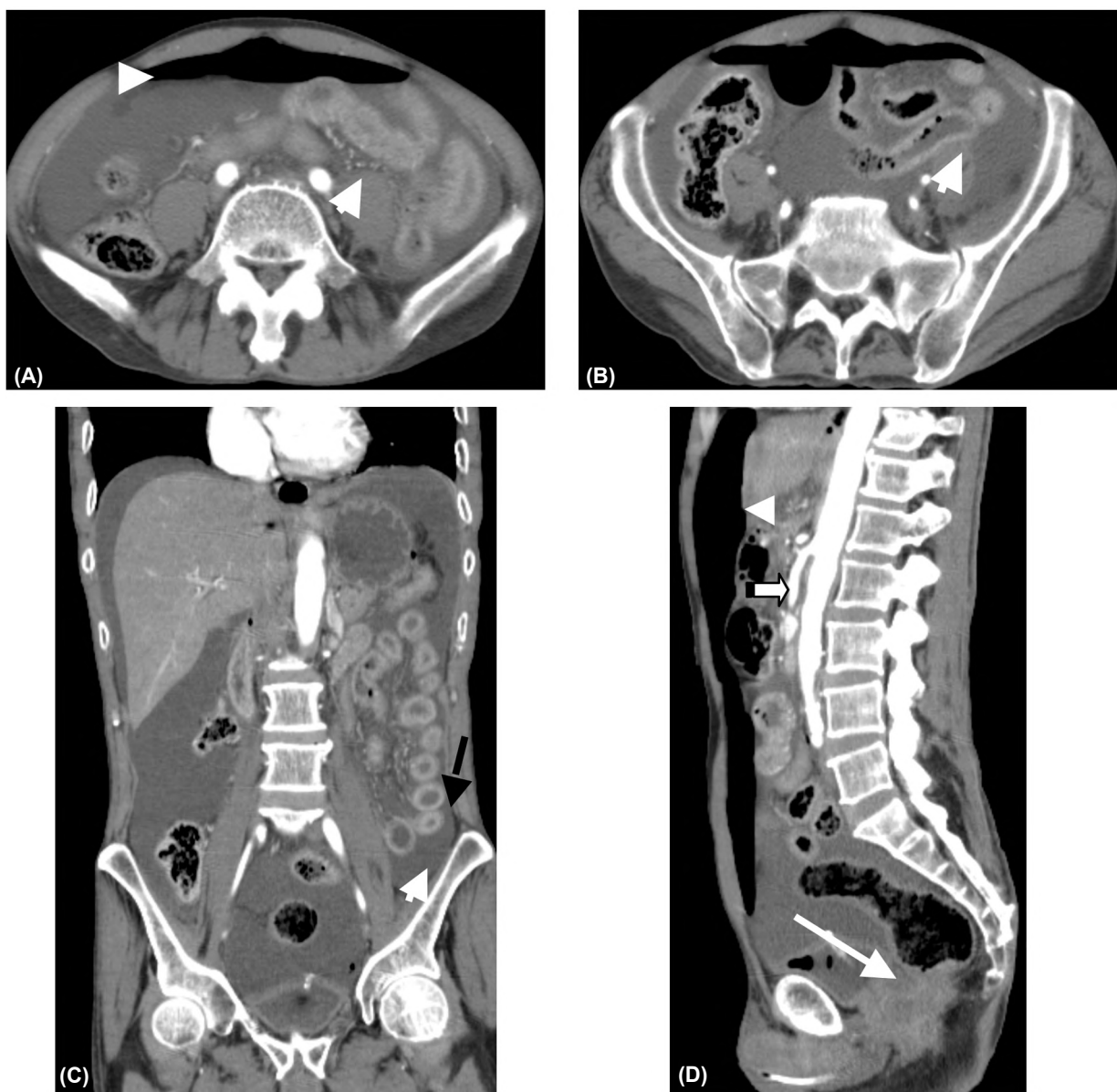


Fig. (4): Shock bowel syndrome in 39-year-old male secondary to perforated stomach. CTA arterial phase, axial (a,b), coronal (c) and sagittal (d) showing pneumoperitonium (arrow heads a,d), hyperenhancement of the small bowel (short arrows), patent SMA (filled arrow in D) and rectal mass causing shouldering (long arrow in D), note the halo sign (back arrow).



## Discussion

Mesenteric ischemia is attributed to drop of blood flow in intestinal vasculature to a degree that compromise the viability of target part [8, 11-15] and according to the time and amount of reduction, it can be classified into acute mesenteric ischemia and chronic mesenteric ischemia [25].

Bowel wall thickening, distension of bowel and non-enhanced bowel wall in CT contrast study are the most dominant findings in mesenteric ischemia cases at CT and MDCT studies, in earlier study [16] bowel wall thickening was noted in 7 of 9 cases with AMI while distended bowel and high bowel wall attenuation in post-contrast study was noted in 44% and 55% of AMI case respectively, they considered these as non-specific reaction of bowel to various pathogenesis.

Bowel wall thickening is the commonest CT intestinal abnormality in mesenteric ischemia [26], typically circumferential and more in cases of venous thrombosis [11]. The segment of bowel showing wall affected is related to cause of ischemia so in SMA or SMV blockage, the thickening will involve small intestine as well as right and proximal transverse colon, while in embolic disease affection can be multi-segments [26].

The current study was matching with that as the most frequent CT finding in AMI was bowel wall thickening (n=12, 85.7%), while it was detected in 4 of CMI cases (40%).

However absence of bowel wall thickening should not exclude the diagnosis of mesenteric ischemia as in transmural infarction of acute arterio-occlusive, the bowel wall may be very thin [11].

In current study 10 of 14 (71.2%) cases with AMI showed bowel distension, this coincides with earlier study [27] which reported bowel distension as a common finding and attributed to a peristalsis due to ischemic changes or contractility dysfunction in transmural infarction.

In the present study we had two cases of AMI (14.28%) displayed hyperattenuation in pre-contrast study which could be explained by submucosal bleeding while low attenuation could be due to edema and inflammation in agreement with Cognet et al, [28].

Bowel wall enhancement can be increased in cases of damped venous drainage of contrast as in thrombosis of mesenteric vein thrombosis or high reperfusion following arterial occlusion or in cases of diminished arterial perfusion and venous drain-

age, such as shock bowel syndrome. On the other hand reduced or lack of mural enhancement may be a better sign indicating viable loop [28].

In the current study, negative bowel wall post contrast enhancement was detected in 11 patients with AMI (78.57%) which matches with earlier study of Chung et al., [29].

A "target or halo" sign may be seen, corresponding to hypo-attenuated submucosa (due to oedema and inflammation) with enhanced outer and inner mucosa and muscularis propria respectively [26,30, 31], and is considered as an indicative of mesenteric ischemia, however can be seen in various pathologies and considered non-specific by some authors [10,19,26]. In the current study, 3 cases (21.4%) with AMI and 1 patient (10%) with CMI showing the mentioned target signs.

Mural bowel gas (pneumatosis intestinalis) is usually a sign of transmural infarction especially if associated with porto-mesenteric venous gas, however it can also occur with reversible ischemia also it can be encountered after inflammatory or neoplastic bowel wall injury or post-operative [32-34]. In the current study mural bowel gases were detected in 2 cases of AMI cases (14.28%) and in 1 case (10%) of CMI cases which were shown to have bowel infarction at surgery and needed resection with anastomosis.

Acute bowel ischemia can be venous or arterial and occlusive or non-occlusive with drop of intestinal perfusion intestinal perfusion. Acute occlusion of superior mesenteric artery by thrombus or embolus accounts for 60-70% of acute ischemia, while venous thrombosis represents 5-10% [3,23].

SMA embolism appears in CTA as hypodense central intraluminal filling defect while thrombosis is eccentric near to ostium with arterial atherosclerotic changes [35].

In the present study, arterial thrombo-embolism was on the top of causes of AMI (10 of 14 cases of AMI, 71.4%) with the proximal SMA occlusion being the dominant location (7 cases, 70%) in cases with arterial thrombo-embolism which matched with Baris et al., [36] who reported SMA occlusion as the main cause of AMI in acute mesenteric (nearly 40-50%).

SMV thrombosis can be complete or incomplete hypodense filling defect, the thrombosed vein maybe dilated with venous congestion of mesenteric veins [33], and mesenteric venous thrombosis can occur in malignancy especially hepatic and pan-

creatic cancers [33], some authors [37] assumed that SMV thrombosis does not usually cause significant bowel ischemia thanks to rich collateral blood flow. In the current study, 3 of the 14 patients (21.4%) with AMI, the reason of ischemia was thrombosis in porto-mesenteric venous system, these matches with previous results of Sebastia et al., [38].

Non-occlusive mesenteric ischemia as shock bowel syndrome is a systemic disorder, MDCT can show distended bowel with diffuse wall thickening that show marked enhancement and attenuated blood vessels [11]. MDCT can show diffusely thickened hyper-attenuated small bowel loops wall with fluid or gas filled lumen associated with criteria of hypovolaemia as flat IVC [26]. Current study included one patient with shock bowel syndrome showing thickened hyperattenuated bowel wall in agreement with [26].

In the current study, MDCT could diagnose the cause of AMI correctly with high specificity and accuracy (100%) which is matching with Barmase et al., [17] study in which MDCTA had 100% sensitivity. As well as in line with earlier studies [11,17,19,27] as well as with the previous results of Aschoff et al., [9] who could diagnose 27 of 28 cases of AMI in their series (96.4%) with a sensitivity of 93% and specificity of 100%.

On the other hand, Chronic Mesenteric Ischemia (CMI) needs a combination of clinical and imaging signs after exclusion of potential intestinal disorders [26]. CT can detect plaques resulting in occlusion or stenosis, which is more in the proximal celiac artery or SMA as well as other findings including vascular attenuation and collateralization [11].

The current study showed findings coincides with CMI and ruled out the reason of abdominal pain in 10 subjects, the dominant one was SMA stenosis which was noted in 7 out of 10 patients with CMI (70%), it was associated with IMA (1 case, 10%) or celiac trunk stenosis (n=1, 10%), nearly similar results was found in an earlier study carried out by Mark et al., [14] in which SMA stenosis represented 76% of CMI cases. We had 2 (20%) of CMI cases with SMA occlusions and collaterals. On the other hand we had 3 cases of CMI (30%) with porto-mesenteric thrombosis, this agreed with some earlier studies [20,26].

Mesenteric stranding and ascites are nonspecific findings in mesenteric ischemia, because it can be seen in other conditions of acute abdomen [26] and can be attributed to venous congestion thus more in venous than arterial ischemia [33]. It was noted

in 8 in AMI and 3 of CMI in current study (11/24, 45.8%).

In the present study, mesenteric ischemia was correctly detected by MDCT and CTA in 24 patients and could explain the clinical status of those patients. It showed 100% specificity and sensitivity which was in line with Barmase et al., [17] who diagnosed mesenteric ischemia in their all 16 patients by MDCT with sensitivity and specificity of 100%.

In the current study, the accuracy, sensitivity and specificity of CTA in the diagnosis of CMI in comparison to conventional angiography and surgical diagnosis were 100%.

In the current study, MDCT was able to find out the reason of clinical status in 25 patients without mesenteric ischemia of total 54 patients (46.2%), these results matched with two earlier studies in which the MDCT and CTA could find out alternative explanation of clinical status in 38 patients (51%) [16] and in 21 patients (58%) [19].

This study had some limitations, first was small number of patients involved in the study but this can be explained by short study duration, second limitation was surgical confirmation was not possible in all cases as some cases were unfit for surgery, third limitation was regarding the machine as it was 16 slice which is of lower diagnostic capabilities when compared to higher slices machine and this can be in favor as not all centers are able to achieve higher machines but still the study was able to reach the diagnosis.

#### *Conclusion:*

MDCT and CTA are noninvasive tools that have a high rapidity, safety and accuracy putting them as optimum choice in imaging of cases with suspicious mesenteric ischemia with high ability to assess the bowel and mesenteric changes so helping in proper early diagnosis and management.

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## وثوقية الأشعة المقطعية متعددة المقاطع فى تقييم نقص تروية المساريقي باستخدام الصور الأساسية

الخلفية: ينجم نقص تروية المساريقي عن انخفاض تدفق الدم فى الأوعية الدموية إلى درجة تؤدي إلى الإضرار بسلامة الجزء المستهدف وفقاً لوقت وكمية الخفض فى التروية، يمكن تصنيفها إلى نقص تروية المساريقي الحاد ونقص تروية المساريقي المزمن.

الغرض من الدراسة: هو تقييم قيمة التصوير المقطعي المتعدد وتصوير الأوعية الدموية فى تشخيص الأسباب المختلفة لنقص تروية المساريقي باستخدام الصور الأساسية وإعادة التنسيق الروتيني.

النتائج: شملت الدراسة أربعة وعشرون يعانون من نقص تروية المساريقي (حاد=١٤ ومزمن=١٠). كانت سماكة جدار الأمعاء الأكثر شيوعاً فى نقص تروية المساريقي الحاد و لوحظت ف ٨٥.٧٪. لوحظت عدم وجود تروية لجدار الأمعاء فى ١١ من ١٤ مريض يعانون من نقص تروية حاده (٧٨.٥٧٪). أشار التصوير المقطعي المتعدد وتصوير الأوعية الدموية إلى سبب إصابة نقص تروية المساريقي الحاد بـ١٤ مريضاً (كان السبب السائد هو الجلطات الدموية فى الشرايين، (ن=١٠) (٧١.٤٪))، وكان الموقع الأكثر شيوعاً هو الشريان المساريقي العلوي، وتم تشخيص وإكتشاف سبب الألم المزمن كان مرضى نقص تروية المساريقي المزمن (تصلب الشرايين فى الشرايين العنكبوتية مع تضيق كبير أو إنسداد السبب الرئيسى. إستطاع التصوير المقطعي المتعدد وتصوير الأوعية الدموية إكتشاف سبب نقص تروية المساريقي فى جميع المرضى مما يمثل دقة وحساسية وخصوصية ١٠٠٪.

الإستنتاج: التصوير المقطعي المتعدد وتصوير الأوعية الدموية يمكن أن تكون الخيار الأمثل فى تصوير الحالات التى تعاني من نقص تروية المساريقي المشبوه.