International Journal of Radiology and Diagnostic Imaging

E-ISSN: 2664-4444
P-ISSN: 2664-4436
www.radiologypaper.com
IJRDI 2021; 4(3): 91-97
Received: 09-04-2021
Accepted: 16-06-2021

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CECT Abdomen imaging findings in patients having intestinal ischemia detected per-operative and/or histo-pathologically: A retro-prospective study.

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DOI: http://dx.doi.org/10.33545/26644436.2021.v4.i3a.223

Abstract
Acute mesenteric ischemia (AMI) is rare life-threatening condition. The mortality rate for AMI is as high as 50%– 69%; this rate has gradually improved but has not changed remarkably during the past decade, despite progress in diagnostic and treatment options. The high death-rate related to AMI is due to delay in of early detection and subsequent delays in appropriate management. Generally, severe, constant, diffuse, or periumbilical abdominal pain out of proportion to the physical examination creates a high index of clinical suspicion for acute mesenteric ischemia (AMI). In addition, there are currently no specific laboratory tests for early detection of acute mesenteric ischemia (AMI). The serum lactate level is usually overestimated, and increased d-dimer levels aren't specific. Mesenteric ischemia is often chronic or acute at clinical manifestation. Chronic mesenteric ischemia is comparatively rare and is taken into account imminent AMI, which is most commonly caused by atherosclerotic stenosis or occlusion of two or more major visceral arteries. Single arterial occlusion usually doesn't cause symptoms due to rich mesenteric collaterals that develop during progression of the disease. In this study we studied about the CECT abdomen imaging findings in 30 patients which were proved to be case of intestinal ischemia detected per-operative and/or histo-pathologically.

Keywords: Intestinal, histo-pathologically, abdominal, mesenteric

Introduction
Intestinal ischemia, which refers to insufficient blood flow to the bowel, may be a potentially catastrophic entity which will require emergent intervention or surgery within the acute setting. Although the clinical signs and symptoms of intestinal ischemia are nonspecific, CT findings are often highly suggestive within the correct clinical setting. In the setting of an acute abdomen, early evaluation is necessary to identify intra -abdominal processes that require emergent surgical intervention. Mesenteric ischemia also referred as intestinal ischemia, which refers to insufficient blood flow to the bowel. Initial imaging evaluation for intestinal ischemia is usually obtained with CT. Accurate diagnosis depends on understanding the vascular anatomy, epidemiology, and pathophysiology of mesenteric ischemia and their corresponding radiological findings on MDCT. At imaging, not only is inspection of the bowel itself important, but evaluation of the mesenteric fat, vasculature, and surrounding abdominal structures also helps improves accuracy of diagnosis of bowel ischemia. In this study the features of CECT-Abdomen in patient having intestinal ischaemia detected per -operative and/or histo-pathologically are studied.

Aims and Objectives
Study of the spectrum of CECT abdomen imaging findings in all consecutive cases of Small and Large intestinal ischemia detected per-operative and/or histo-pathologically, AMC MET Medical College, L.G hospital, Maninagar, Ahmedabad.

Subjects
30 cases with small and large intestine ischaemia detected per-operative and/or histo-pathologically and who had underwent prior CECT-Abdomen imaging in the Radiology department, AMC MET Medical College, L.G hospital, Maninagar, Ahmedabad served as the subjects for this study.

Materials and methods:

Source of Data: patients with small and large intestine ischemia detected per-operative and/or histo-pathologically and who had underwent prior CECT-Abdomen imaging in the Radiology department, AMC MET Medical College, L.G hospital, Maninagar, Ahmedabad.

Method of data collection

Duration of study: From July 2019 till 30 cases.
Sample size: 30 cases.

Study type

Retro-prospective study Informed consent had taken.

Inclusion Criteria

Patient who underwent operative procedure after CECT Abdomen imaging and detected intestinal ischemia per-operative and/or histo-pathologically. Cases included irrespective of age/sex.

Exclusion Criteria

Contraindications to CECT studies, such as patients with known allergy to contrast material, pregnant females. Patients with known case of nephropathy with altered renal function test. (Serum creatinine >1.5 mg/dl) Claustrophobia or anxiety disorders exacerbated by MDCT. Inability to provide consent.

Equipment used: 16 SLICE MDCT SCAN

Source of data

Hospital based study, patients were enrolled in study after obtaining informed consent, Patients coming to radio-diagnosis department in seth L.G hospital, AMCMET medical collage for CECT abdomen imaging and those who underwent operative procedure and found intestinal ischemia per-operative and/or histo-pathologically.

Methodology

Study protocol consists of unenhanced and enhanced scans from the diaphragmatic dome to the pubic symphysis with the patient in supine position. After the injection of contrast material scans were performed with a biphasic technique with the arterial (40-45 s mean delay) and venous (65-75 s mean delay) phases, with different technical parameters consistent with the CT device. Unenhanced CT is reportedly required for the diagnosis of intestinal ischemia so as to imaging submucosal hemorrhage, hyper-dense/calcified thrombi and atherosclerotic plaque and to get a baseline attenuation measurement of the bowel wall for the assessment of the enhancement. The arterial phase is performed for evaluating arterial stenosis, thrombi/emboli and occlusion, while the venous phase is for evaluating venous patency and abdominal organs which are affected by ischemia.

Etiology and pathophysiology

The causes of intestinal ischemia are often occlusive or non-occlusive. Occlusive causes are the embolic or thrombotic occlusion of arterial or venous vessels and account for about 80% of all cases of intestinal ischemia. Venous-thrombosis accounts for about 10%-15% of all cases of intestinal ischemia. Non occlusive causes account for about 20%-30% of all intestinal ischemia. In these forms, there is a major reduction in blood flow within the arteries and veins. Shock, severe cardiopathy, abnormal blood concentration, episodes of neurogenic vasodilation and vasoconstriction secondary to drugs are the causes of non-occlusive bowel infarction in most cases.

Anatomy

To accurately diagnose mesenteric ischemic disease, interpreting physicians must be familiar with both mesenteric arterial and venous anatomy of the bowel.. The celiac artery generally supplies the distal esophagus to the second portion of the duodenum. The superior mesenteric artery (SMA), located at the extent of first lumbar vertebral body, supplies the third and fourth portions of the duodenum via the superior and inferior pancreaticoduodenal arteries, and supplies the jejunum, ileum, and colon to level of the splenic flexure. The inferior mesenteric artery (IMA), located at the extent of the third lumbar vertebral body, supplies the distal colon from the extent of distal transverse portion to the upper rectum. Branches of the internal iliac arteries, middle and inferior rectal arteries, supply the distal rectum.

There are numerous important mesenteric collateral pathways that provides vascular safety-net for mesenteric blood supply. The gastrodudoenal artery is the first branch of the common hepatic artery and provides a collateral pathway between the celiac trunk and the SMA. The marginal artery of Drummond and arcade of Riolan connect the SMA and IMA. Four arcades of anastomosis are formed between the IMA and lumbar arteries arising from the aorta, sacral, and internal iliac arteries. Additionally, the peripheral small mesenteric vessels are anatomically arranged in a parallel series configuration that supplies the mucosa, submucosa, and muscularis propria of bowel.

The superior and inferior mesenteric veins run parallel to the arteries and drain the res pectize a part of the bowel. The inferior mesenteric vein (IMV) joins the superior mesenteric vein (SMV) after emptying into the splenic vein to make hepatic portal vein. Numerous collateral venous pathways exist or can form between mesenteric and systemic veins including, gastric and esophageal, renal, lumbar and pelvic veins.

Non-occlusive mesenteric ischemia (NOMI)

Within the setting of septic or hemorrhagic shock, a profound drop of systemic blood pressure results in reflexive mesenteric arterial vasoconstriction with diversion of blood flow to the brain and heart. Other causes of reduced mesenteric blood flow include blunt abdominal trauma, overdose of digitalis, use of amphetamines, cocaine and ergotamine or other agents resulting in vasoconstriction. Classic CT findings of “shock bowel” include diffuse small bowel wall thickening and mural hyper enhancement with relative sparing of the colon and mesenteric ascites.

CT scan is able to detect direct and indirect signs of intestinal ischemia, SMA and SMV thrombosis/occlusion and lack of contrast enhancement of bowel wall are direct CT scan sings of bowel ischemia. Bowel dilatation, hallo/Target sign, pneumatosis intestinalis, pneumoporta, bowel wall congestion, mesenteric fat stranding, ascites, associated organ ischemia and changes in bowel wall thickness are indirect signs.

Results and Analysis

The records of 30 patients admitted to AMCMET medical college, Seth L.G. Hospital, Ahmedabad between july 2019 and May 2021 and diagnosed with mesenteric ischemia are evaluated. CT imaging was obtained in the arterial, venous and portal phases.

The effected intestinal segment, thickness of bowel wall, dilatation of bowel, halo or target sign, increased or decreased contrast in bowel wall enhancement, faeces sign, pneumatosis intestinalis, bowel obstruction, congestion, distortion and stranding of mesenteric fat, contributing solid organ ischemia, ascites, superior mesenteric arterial thrombus, SMV thrombus and air in portal vein were reported. The bowel wall thickness is thick if it measures as > 3 mm. it's related with reperfusion. In mesenteric arterial occlusion, bowel wall becomes thinner if there's no hemorrhage or intestinal wall edema. Bowel wall thickness isn't related with the severity of ischemia. Dilatation of bowel means > 2.5 cm for small intestines, > 6 cm for colon, > 8 cm for cecum. it's related with decreased peristalsis. Lack of contrast enhancement is very specific for acute arterial ischemia.

Contrast enhancement is seen with venous ischemia and reperfusion. Delayed contrast enhancement is seen with arterial perfusion and differences in venous return. Pneumatosis intestinalis shows transmural ischemia. Mesenteric fat stranding, congestion and distortion are related with strangulation and venous ischemia. Distortion is additionally related with arterial ischemia and transmural infarction. Pneumoporta and free intraabdominal gas are signs of transmural infarction.

Table 1	Present	Absent
Bowel Dilatation	24/30P	6/30P
Percentage	80%	20%

Table 2	Present	Absent
Halo/target sign	11/30	19/30
Percentage	36.67%	63.33%

Table 3	Present	Absent
Faces sign	12/30P	18/30P
Percentage	40%	60%

Table 4 And 5	Present	Absent
Bowel wall contrast uptake	12/30P	18/30P
Percentage	40%	60%
Lack of contrast enhancement	18/30P	12/30P
Percentage	60%	40%

Table 6	Present	Absent
Pneumatosis intestinalis	21/30	9/30P
Percentage	70%	30%

Table 7	Present	Absent
Obstruction	24/30	6/30P
Percentage	80%	20%

Table 8	Present	Absent
Bowel wall congestion	24/30	6/30P
Percentage	80%	20%

Table 9	Present	Absent
Fat Stranding	27/30	3/30P
PERCENTAGE	90%	10%

Table 10	Present	Absent
Associated solid organ Ischaemia	1/30P	29/30P
Percentage	3%	97%

Table 11	Present	Absent
Ascites	23/30	7/30P
Percentage	77%	33%

Table 12	Present	Absent
Superior mesenteric artery Thrombus	7/30P	23/30P
Percentage	23%	77%

Table 13	Present	Absent
Superior mesentric vein Thrombus	2/30P	28/30P
Percentage	6%	94%

Table 14	Small Bowel	Large bowel	Both
Small bowel/ large bowel	19/30	5/30P	6/30P
Percentage	63%	16%	20%

Table 15	Present	Absent
Pneumo-porta	7/30P	23/30P
Percentage	23%	77%

Table 16	Present	Absent
CT S/o mesentric ischaemia	24/30P	6/30P
Percentage	80%	20%
CT sensetivity	80%	

Table 17	Present	Absent
Bowel wall thickness	27/30P	3/30P
Percentage	90%	10%

Bowel wall thickness wasn't correlated with the degree of ischemia, especially in colon.

In our study we've found that in almost every patient had bowel wall thickness over 3mm, the average bowel wall thickness is 5.2mm. Which shows that nearly all patient with mesenteric ischemia shows thickening of bowel wall. Very few patient shows paper thin bowel wall, those patient who were in the late stage of mesenteric ischaemia shows paper thin bowel wall, this finding of thinning of bowel loop shows late stage of ischaemia (Table 17).

The dilatation of bowel did not correlate with the ischemic segments. In our study the result shows that 80% of the patients show dilatation of bowel loops. Mechanical obstruction /dilatation of bowel loops were present in 24 out of 30 patients, in 80% patients. (TABLE 1) and (Table 7).

Halo or target sign was generally negative, only 36% of patient shows halo/target sign, thus not a frequent finding in patient having intestinal ischemia (Table 2).

Most patients had lack of contrast enhancement of bowel walls (60%), 40% of patient showed good contrast uptake (Table 4 and 5).

Faces sign was not correlated with the necrosis, not specific. But it had been seen mostly in large intestinal ischemia in our patients, faces sign was present in 40% of patients, thus not a frequent finding in patient having intestinal ischemia (Table 3).

Bowel wall congestion is present in almost 80% of patients having intestinal ischemia, though frequent finding, as many cases are there which can show bowel congestion, thus not specific finding in patient having intestinal ischemia (Table 8). Pneumatosis intestinalis – it was present in 70% of the patients (Table 6).

Mesenteric fat stranding is not specific. But it's present in almost every patient, in 90% patients, though frequent finding, as many cases are there which can show mesenteric fat stranding, thus not specific finding in patient having intestinal ischemia (Table 9).

In only 1 patient there was accompanying solid organ ischemia, only 3% (Table 10). Segmental infarction of the left kidney is seen in one patient with SMA thrombosis.

Ascites is not considered specific, but present in many patients, in 77% (Table 11). Superior mesenteric arterial occlusion/thrombosis was present in 23% of patient, thus not a frequent finding in patient having intestinal ischemia, though specific (Table 12).

Mesenteric vein thrombosis was present in just 2 (6%) patients, thus not a frequent finding in patient having intestinal ischemia, though specific (Table 13).

The small intestines were affected more than colonic segments. In 63% of patient small intestine was affected, in 20% of patient both small and large intestine was involved and in just 16% of patient the large intestine was affected (Table 14).

Pneumoporta is seen in the 23% of the patients, thus not a frequent finding in patient having intestinal ischemia, many causes are there which present with pneumoporta, so the pneumoporta is not specific si gn for the small bowel ischemia (Table-15).

In our study 24 patients (80%) had CT findings which were suggestive of small intestinal ischemia, and they were operated and bowel loop was found to be ischaemic per-operative and/or histo-pathologically, while 6 patients who had other signs of ischemia but no definitive diagnosis of small intestinal ischemia is given on the CT report found to have ischemic bowel on per-operative/histopathological study, so the study shows that while taking the all direct-indirect CT signs of intestinal ischaemia during CT evaluation the probability of detecting true positive cases on CT scan is very high. The CT sensitivity for detection of small intestinal ischaemia in this study is 80% (Table-16).

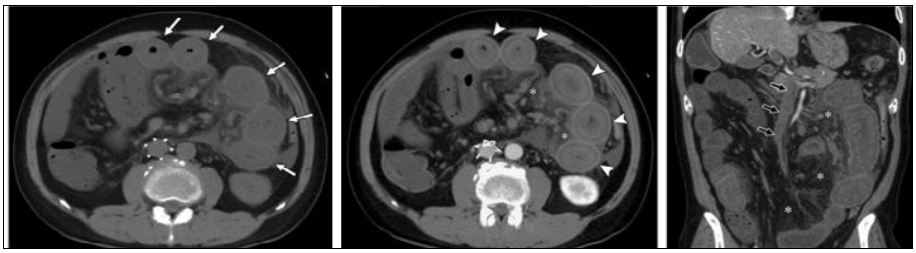


Fig 1: Portomesenteric venous thrombosis in a 51-year-old man. (a) Axial nonenhanced CT image shows prominent bowel wall thickening (arrows). (b) Axial contrast-enhanced CT image shows a thickened bowel wall and a target or halo appearance (arrowheads). Mesenteric stranding and vascular engorgement also are seen. (c) Coronal contrast-enhanced CT image shows thrombi (arrows) within the SMV and portal vein

Fig 2: SMA embolism and arterial reperfusion, 63-year-old man who experienced severe abdominal pain while undergoing treatment of fibrillation. (a) Axial contrast-enhanced CT image of the upper abdomen shows a filling defect like an embolus (arrow) within the SMA. Segmental infarction of the left kidney (arrowheads) is additionally seen. (b) Axial contrast-enhanced CT of the lower abdomen shows a thickened small bowel, with the wall showing a halo or target pattern (arrowheads) of contrast enhancement, which is compatible with the ischemic bowel after arterial reperfusion.

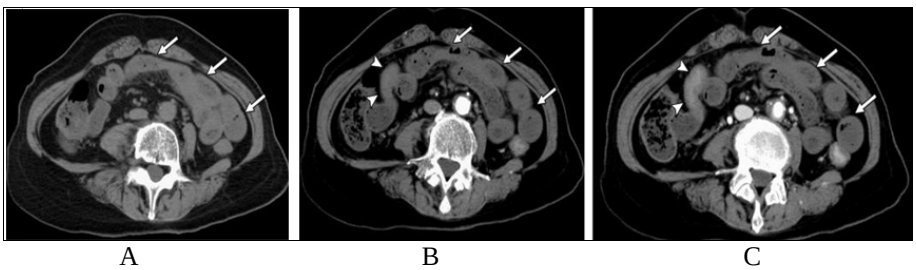


Fig 3: Transmural small bowel infarction because of SMA thrombosis in a 73-year-old woman with a history of atrial fibrillation. (a) Axial nonenhanced CT image of the abdomen shows a rather high-attenuating bowel wall (arrows) over long segments. (b, c) Axial contrast-enhanced arterial phase (b) and venous phase (c) CT images of the abdomen show that the wall of the involved bowel segments (arrows) lacks contrast enhancement. However, the uninvolved segments of the small bowel (arrowheads) show contrast enhancement

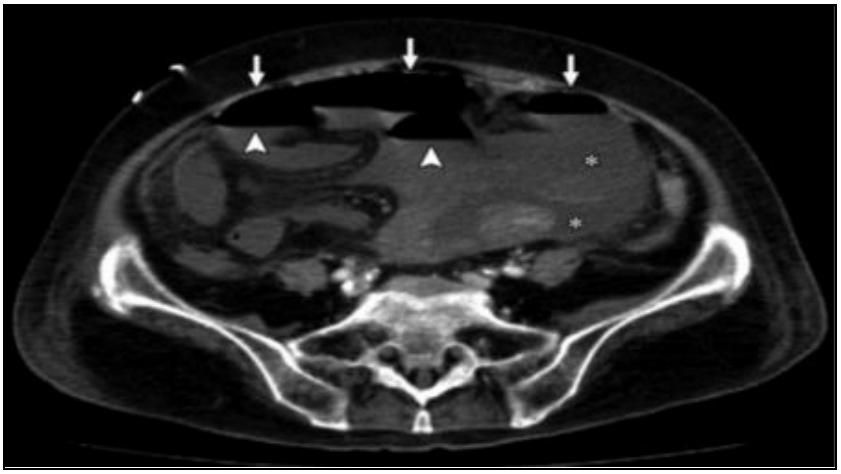


FIGURE-4) SMA embolism in a 76-year-old woman. Axial contrast- enhanced CT image shows dilated bowel loops, air-fluid levels (arrowheads), indicating a state of ileus. The bowel wall (arrows) is thin (paper-thin wall) and lacks contrast enhancement. Mesenteric stranding and ascites (*) also are seen.

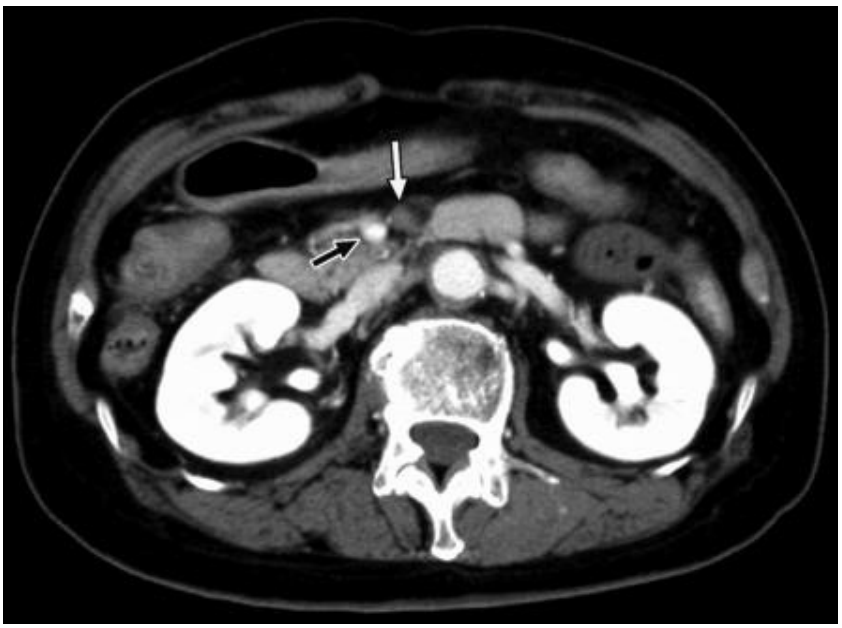
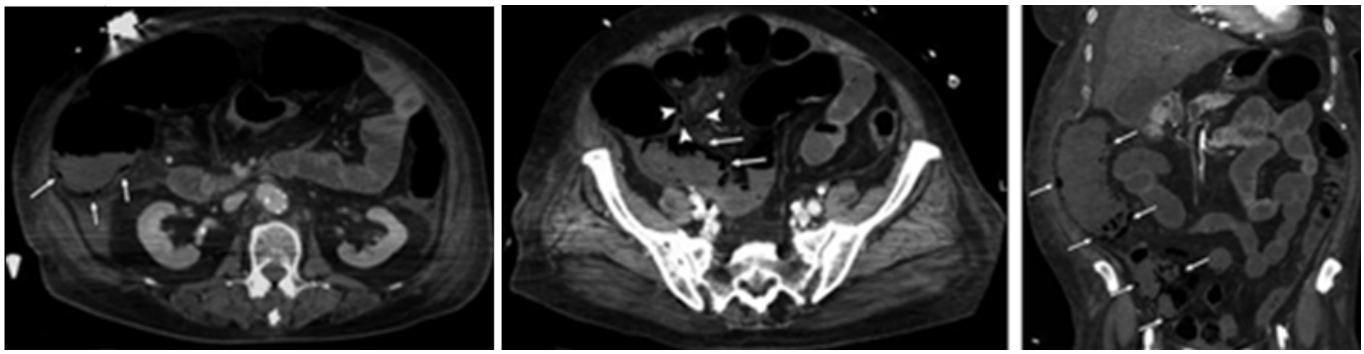


Fig 5: SMA embolism. Axial contrast-enhanced CT images shows the SMA trunk (white arrow), which lacks contrast enhancement because of an embolus. The thrombosed SMA is dilated and is as large as the adjacent SMV (black arrow).



A B C

Fig 6: non occlusive mesenteric ischemia with transmural bowel infarction in a 78-year-old woman. Axial (a, b) and coronal (c) contrast-enhanced CT images show gas (arrows) within the bowel wall (pneumatosis intestinalis) at the distal ileum and colon. Gas is seen within the branches of the mesenteric vein (arrowheads in b), and mesenteric stranding (* in a and b) in those areas is additionally seen.

Discussion

Computerized tomography and intraoperative findings were correlated with the aspect of affected bowel segment. Contrast enhancement is critical for the preoperative diagnosis of necrosis, Although halo (target) sign features a high diagnostic value in ischemia, most of our patients with intestinal necrosis has no halo sign. Our patients are generally delayed cases with necrosis requiring resection. So, halo might not be significant finding in patient with bowel necrosis, it's going to be valuable in reversible bowel

ischemia. Lack of contrast enhancement mainly shows bowel necrosis, therefore the importance of contrast CT is confirmed again. While absence of faeces sign isn't significant in necrosis, presence of faeces sign was more significant for colonic necrosis in our patients.

Pneumatosis intestinalis was seen in 70% of patients and found to be more diagnostic for colonic necrosis in our patients. Bowel obstruction was generally present in our patients with bowel necrosis. The etiology of necrosis in our patients were generally both obstructive and non-obstructive in origin. CT sign of bowel obstruction is typically present in mesenteric torsion or volvulus. We had seen that mesenteric fat stranding had no diagnostic value in our patients, as it was found in many patients not proved to be intestinal ischemia (10%). This finding could also be significant in early phases of mesenteric vascular obstruction like reversible ischemia. Accompanying solid organ ischemia was present in patients with small intestinal and colonic ischemia. So, this is often generally related with systemic vascular disease including multiple vessels but in our study it is seen in patient with SMA thrombosis. Ascites is not considered significant for the diagnosis of ischemia or necrosis. Mesenteric vein thrombosis was detected in just two patients. Rest vascular obstructive (7/9) causes of our patients had ischemic bowel disease related with arterial obstruction.

In this study pneumoporta was seen in the 7/30 patients which constitute only 23% of total cases and found to be less specific sign for the intestinal ischemia, many other GIT conditions shows pneumoporta other than intestinal ischemia.

While taking all direct-indirect CT signs into consideration the CT has very high sensitivity for the diagnosis of the Mesenteric Ischemia, this study shows 80% sensitivity of the CT scan for the diagnosis of intestinal ischemia.

Mortality was related with patient's primary disease, age, functional capacity of the vital organs and sepsis; not with the anatomic location of bowel necrosis.

Conclusion

Lack of contrast enhancement of bowel wall and superior mesenteric artery and vein thrombus/occlusion were found as indicators of both small and large intestinal ischemia. Bowel wall thicknesss wasn't correlated with the degree of ischemia, especially in colon. Faeces sign and pneumatosis intestinalis were more specific for large intestinal ischemia. Pneumoporta is less specific for intestinal ischemia. While taking all direct-indirect CT signs into consideration the CECT has very high sensitivity (80%) for the diagnosis of the Intestinal Ischemia.

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