Ct Enterography In The Evaluation Of Small Bowel Pathologies

by

DR.Suhas C.N

Dissertation submitted to

In partial fulfillment for the degree of

MASTER OF DEGREE

IN

RADIO-DIAGNOSIS & IMAGING

Under the guidance of

DR. R. C. PATTANSHETTI M.B.B.S M.D.,
PROFESSOR

DEPARTMENT OF RADIO-DIAGNOSIS & IMAGING

BLDE (DEEMED TO BE UNIVERSITY)

SHRI B. M. PATILMEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE

VIJAYAPUR – 586103

2019

ABSTRACT

BACKGROUND & OBJECTIVES

Small bowel diseases are among the ones that have been on rise in recent times and the timely diagnosis plays an important role. They are the most difficult to diagnose endoscopically owing to the length and tortuosity of the small bowel.[1]A house to house survey in Haryana state revealed a prevalence of Inflammatory bowel disease alone was $45.5/10^5$ population. In a later study conducted in Punjab the crude incidence and prevalence of ulcerative colitis was found to be $6.02/10^5$ and $44.8/10^5$ population which was the highest in Asia.[2]

Furthermore the intestinal tuberculosis accounts for 11–16% of extrapulmonary tuberculosis cases.[3]

A study shows that up to 5% of patients with gastrointestinal (GI) bleeding are not diagnosed by gastroscopy and colonoscopy, the source of which is usually the small bowel.[1]It is usually referred to as the black box of obscure bleeding because identifying the source of bleeding is a huge task. Accompanying that, the diagnosis of other small bowel diseases like Crohn's disease, tumors, polyps are also challenging.

Increased speed and resolution has made CT a first-line modality in the diagnosis of small bowel diseases.[4] It is very useful for differentiating active and fibrotic bowel strictures in patients with Crohn's disease. It can be used to visualize the entire thickness of the bowel wall and also to visualize the extra-enteric involvement.[5] Other advantages of CT enterography include assessment of deep ileal loops in the pelvis without superimposition and assessment of solid organs and overview of the entire abdomen.[4]

In the American College of Radiology appropriateness criteria, CT enterography is rated as the most appropriate imaging modality for the diagnosis of

small bowel diseases. The other modality for diagnosis of small bowel diseases include capsule endoscopy. But capsule endoscopy does not provide visualization of the extra-enteric tissue. And also, capsule endoscopy cannot be performed when a stricture is suspected because it gets lodged at the site of the disease and can cause obstruction.[5] CT enterography has the ability to depict subtle findings such as mucosal hypervascularity or mild wall thickening.[6]

AIMS & OBJECTIVES OF THE STUDY:

- To study the mucosal patterns, bowel wall thickness, luminal distension and blood vessels in various diseases of the small bowel.
- To study the CT enterography findings of pathological processes occurring in the small bowel and to discuss the radiological features.

SOURCE OF DATA:

All patients referred to the department of Radio-diagnosis and Imaging, _____ with the clinically suspected / diagnosed cases of small bowel diseases.

PERIOD OF COLLECTION OF DATA:

The study was done on patients, who visited the Department of Radio Diagnosis during the period from NOVEMBER 2017 to JUNE 2019 with prior consent.

RESULT:

CT enterography is an excellent diagnostic tool of the study of small bowel disorders with additional benefit for assessing abdominal and pelvic structures.

INTERPRETATION:

“MDCT enterography” has largely replaced the “small-bowel follow-through (SBFT)” as the chosen technique in the evaluation of small bowel and is vital in

various other clinical scenarios where bowel is the primary source of pathology or secondary to other process.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The small intestine is a complex organ with several functions. It is capable of digestion, absorption and secretion, endocrine function and protects the internal environment against noxious ingested substances and luminal bacteria and their toxins. There are wide numbers of pathologies which involve the small bowel and remains a challenging anatomical site to image accurately. Nonspecific clinical presentation from a wide range of localized and systemic disorders confound successful imaging approaches. Radiologic technique have been a mainstay in the diagnosis of small bowel pathology.

Over recent year, there have been significant advances in a number of new radiological technique, which combine with more established approaches to define small bowel lesions.

A successful imaging strategy is dependent on using the most appropriate radiologic modality to answer the clinical questions. A number of conventional imaging strategies, such as barium follow through, have been successfully used to characterized small bowel pathologies, but newer techniques, including CT enterography, CT enteroclysis, or MR enterography has been introduced and are gaining popularity, moreover, the development of enteric agents to distend the bowel have led to routine visualization of the small bowel lumen, wall, and perienteric tissue using CT & MR modalities.

For these reasons, CT & MR enterography have been shown to offer improved sensitivity and are replacing the barium studies as the preferred diagnostic tests. Cross sectional imaging technique overcomes the principal disadvantage of conventional enteroclysis that are the limited indirect information on the state of the bowel wall and

extramural extension of crohn's disease and its effectiveness may be hindered owing to overlapping bowel loops.

CT & MR have become widely accepted at centers dedicated to the diagnosis and treatment of inflammatory bowel disease, due to the method's diagnostic efficacy; CT & MR can help to confirm the diagnosis; localize the lesion and asses their severity, extent and inflammatory activity and identify the presence of extraintestinal complications and other entities that requires surgical intervention.

In concert with new endoscopic development, multidetector CT technology allow for rapid, accurate and minimally invasive examination of the small bowel and adjacent tissue. Contrast enhancement enable the detection of inflammation, tumor, and vascular lesions of small bowel wall, lumen, and vasculature as well as adjacent structure with high image quality.

Increased speed and resolution of multidetector computed tomography have made CT as a first line modality for examination of small bowel disease. CT enterography differs from routine abdominopelvic CT in that it makes use of thin sections and large volume of neutral enteric contrast material to better display the small bowel lumen and wall. The use of neutral enteric contrast agent such as mannitol, combine with the use of intravenously administered contrast material, permits excellent assessment of vascular lesions and hyper enhancing segments.

Compared with the traditional small bowel follow through examination, CT enterography has several advantages. It displays the entire thickness of the bowel wall, allows examination of deep ileal loops in the pelvis without superimposition and permits evaluation of the surrounding mesentery and perienteric fat. CT enterography also allow assessment of solid organs and provide a global overview of the abdomen.

AIMS AND OBJECTIVES

- To study the mucosal patterns, bowel wall thickness, luminal distension and blood vessels in various types of small bowel diseases.
- To study in detail about CT enterography findings of the pathological processes occurring in the small bowel and to discuss the radiological features.

METHODOLOGY

Source of data:

All patients referred to the department of Radio-diagnosis and Imaging, _____ with the clinically suspected / diagnosed cases of small bowel diseases.

Period of study:

Nov 2017 - June 2019.

Study design:

A hospital based cross-sectional study.

Sample size:

A sample size of 50 subjects will allow the study to determine the role of CT enterography in evaluation of small bowel diseases.

Statistical analysis:

All characteristics were summarized descriptively. For continuous variables, the summary statistics of mean± standard deviation (SD) were used. For categorical data, the number and percentage were used in the data summaries and diagrammatic presentation. Data were analyzed using SPSS software v.23.0. and Microsoft office 2007.

Method of collection of data:

Male and female patients of all ages who are referred to _____ _____ with the clinically suspected / diagnosed cases of small bowel diseases are selected based on the inclusion and exclusion criteria as study subjects. Total 50 subjects will be recruited for the study.

Inclusion criteria:

- Patients with clinically suspected / diagnosed small bowel diseases of all age groups and both genders.

Exclusion criteria:

- Suspected perforation.
- Upper GI obstruction.
- Pregnant women.
- Patients with abnormal renal function tests.
- Post-operative cases.
- Allergy to IV contrast agent.

Ethical clearance

Prior to the commencement, the ethical clearance was obtained from institutional ethical committee of _____

_____

Method of collection of data (including sampling procedure, if any)

- Informed written consent of the participant.
- A detailed history, brief physical examination, laboratory parameters, previous imaging of the participant.

PRE-PROCEDURAL PREPARATION

- Patients are instructed to be on low residue diet 24 hours prior to the exam and completely abstain from all food and drink for 4 hours prior to scanning.
- Antecubital vein IV line (18G) is secured & checked for patency before scanning.

INFORMED CONSENT

Patients fulfilling the selection were briefed about the nature of the study and a written informed consent was obtained

ORAL CONTRAST PROTOCOL [5]

- 0.1 % w/v suspension of barium sulphate mixed with sorbitol/mannitol is given orally in divided doses as follows :
  - → 450 ml at starting of the scan with 10 mg metaclopromide oral suspension is administered to promote gastric emptying.
  - → 450 ml after 20 mins.
  - → 225 ml after 40 mins.
  - → 225 ml after 50 mins.
  - → Following above, 200 ml water is given on table to distend stomach.

IV CONTRAST PROTOCOL [5]

- Iohexol is administered (300 mg/mL) intravenously at a rate of 4 mL/sec, at a dose of 1 to 1.5 ml/kg body weight.
- Scanning (Single, double or triple phase depending upon the clinical suspicion) is performed by32 slice Siemen's MDCT machine.
  - Arterial phase: Images are taken after 15 – 20 seconds of IV contrast administration.
  - Enteric phase: Images are taken after 40 – 50 seconds of IV contrast administration.
  - Delayed phase: Images are taken after 06 - 10 mins of IV contrast administration.
- Images are acquired with a section thickness of 5 mm and a reconstruction interval of 1.0-1.5 mm.

- Coronal & sagittal reformatted images are generated at the workstation from the axial images.

REVIEW OF LITERATURE

Because the small bowel is relatively inaccessible to conventional endoscopy, Radiologic techniques have been the mainstay for evaluation of small bowel pathologies. The newer developments like MDCT – multidetector computed tomography, allows for more accurate, rapid and minimal invasive examination of small bowel and other adjacent tissues. Contrast enhancement with negative oral contrast also enables detection of inflammation, vascular lesions and tumors of the small bowel wall, lumen and vasculature as well as adjacent structures.[10]

ANATOMY OF THE SMALL INTESTINE

The small bowel is a tubular structure in the peritoneal cavity that extends from the pyloric antrum of the stomach to the ileocecal valve.[13] The length of the small intestine grows with age from about 6.5 feet in a newborn to almost 20 feet in an adult. The main functions of the small intestine are to help in digestion, absorption of nutrients and elimination of waste.[14]

The small intestine is comprised of three segments: the duodenum, the jejunum and the ileum.[13,14] The duodenum is the widest segment of the small bowel, has no mesentery and is partially covered by the peritoneum. It consists of 4 portions: superior, descending, horizontal, and ascending. The jejunum is the center segment of the small intestine with a mean diameter of approximately 3 cm. The ileum is narrower, thinner and is less vascular as compared to jejunum, but its aggregated lymph nodules (payer's patches) are larger and more in number.[13,14]

The blood supply to the proximal duodenum includes the superior pancreatico-duodenal branch of the gastroduodenal artery. The branches of the superior mesenteric veins drain the duodenum while the superior mesenteric vein drains the jejunum and ileum. The parasympathetic nerve activity to the duodenum is supplied

by vagus nerve and the greater and lesser splanchnic nerves supply sympathetic nerve activity. The superior mesenteric plexus supply both sympathetic and parasympathetic nerves to the jejunum and ileum.[13]

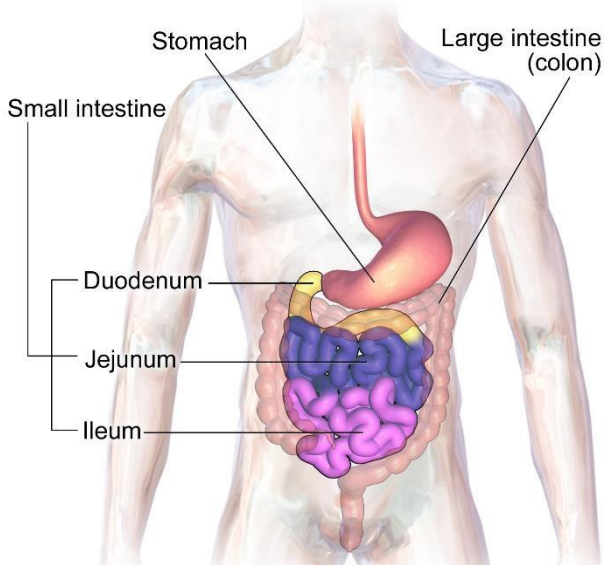


Figure 01: Anatomy of small intestine.

The wall of the small bowel is comprised of an inner mucosa layer, submucosa layer, smooth muscular with inner circular and outer longitudinal layers and the serosa layer.[13] The inner walls show mucosal folds called the plicae circulares (also called valves of kerckring). The plicae are more in number in the proximal jejunum, less in numbers towards the distal jejunum and are completely absent in the ileum. These folds slow the passage of the bolus along the intestines and increase surface area for absorption. The plicae are covered with fingerlike projections called villi, which are covered with microvilli. The microvilli absorb fat and nutrients from the partially digested semi-liquid food from the stomach.

The small bowel is a complex organ in itself as it is involved in a variety of functions like digestion, absorption, secretion, protection of internal environment against harmful ingested materials and luminal bacterial toxins and endocrine function. The surface area for its functions like digestion and absorption is increased

600 times by the circular mucosal folds, villous mucosal architecture and microvillus epithelium. Few definite portions of small bowel have definite characteristic properties, like bile acid absorption is a property of distal ileum, and, because of the compensatory adaption of intestine, resections are possible without a significant morbidity. The length of small bowel is 1.2 metres from pylorus to ileocecal valve. Jejunum begins from ligament of treitz and ileum is suspended by a visceral peritoneum covered mesentry. This extends to the external surface of the bowel to form serosa. Superior mesenteric artery (SMA)supplies jejunum and ileum. Major branch of SMA occlusion results in segmental intestinal infarction. Venous drainage is by superior mesenteric vein, which joins splenic vein behind the neck of the pancreas to form portal vein. Lymphoid aggregates called Peyer's patches are present on the antimesenteric border of distal ileum. Smaller follicles are present throughout the small bowel. Intestine has abundant lymphatic drainage. Regional lymph nodes follow the vascular arcades and then drain toward the cysterna chili. The layers of jejunum and ileum are serosa, muscularis, submucosa and innermost mucosa.[15]

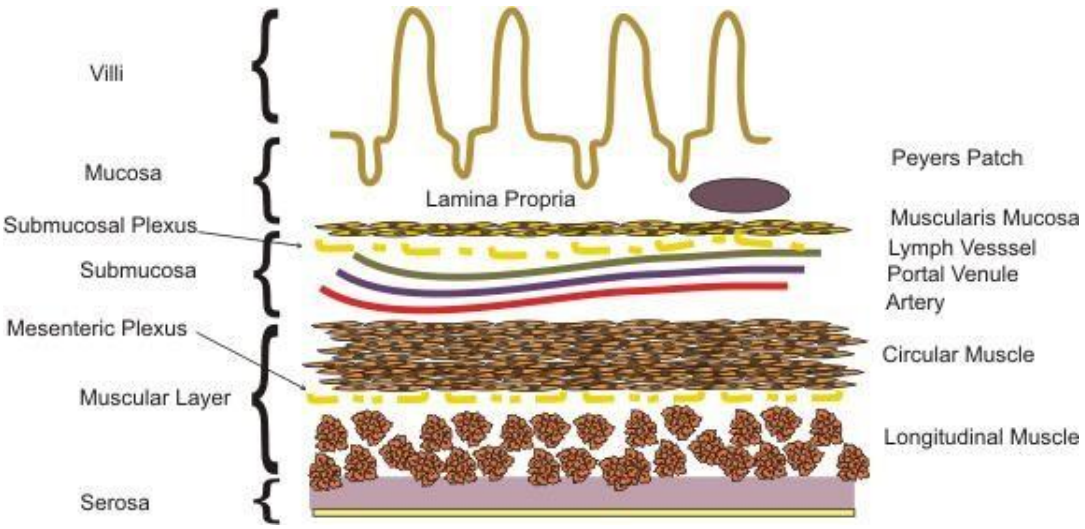


Figure 02: Layers of small intestine.

SMALL BOWEL IMAGING

It is a tedious site to image precisely. The presence of nonspecific presentations ranging from localized or systemic disorders can confound successful imaging approaches. However, the small bowel lesions can be better defined by using advanced newer radiological techniques.

A desired imaging process is reliant on using an apt radiological modality to accurately answer the clinical question. To characterize small bowel pathologies, several conventional radiological imaging studies, like barium meal follow-through, have been used, but newer techniques have been introduced that are attaining popularity, such as CT enterography, CT or MR enteroclysis (CTE or MRE). The advancements in enteric contrast agents, which distends the bowel, has led to better visualization of the bowel lumen wall and assessment of peri-enteric tissues.[4]

So, CT and MR Enterography have shown increased sensitivity and have replaced barium studies as the diagnostic modality of choice for small bowel imaging.

The primary disadvantage of conventional studies is limited information of bowel wall and extramural disease extension are overcome by cross – sectional imaging studies.[5-9]

Because of the diagnostic efficacy, the study of the small bowel by CT and MRI are widely accepted at many centers which are mainly involved in the diagnosis, treatment and follow up of inflammatory bowel disease (IBD). In addition to confirming the diagnosis; localizing lesions and assessing their severity, extent and inflammatory activity, CT and MRI can also identify the presence of extra-intestinal complications and other entities that may require surgical intervention.[4]

BARIUM STUDIES

For small bowel pathology investigation, Barium studies are still the first line modality in most centers.[2,16] They are well endured by the patient, easily accessible, easy to perform and are reproducible. The contrast follow-through and the small bowel enema (SME) are the two main barium procedures that are practiced. Bowel preparation with fasting orally low-residue diet with or without an oral laxative taken the day before the study, ideally aids the barium procedures.

In a small bowel follow-through procedure, patients must drink approximately 40% weight/volume (w/v) barium suspension and the films are taken every 20-30 interval until barium reaches ileocecal junction. Fluoroscopic spot films of the terminal ileum and ileocecal junction are obtained. Per-rectal air insufflations prevents terminal ileum collapse and may help to distend and better visualize the ileum.[4]

Nasojejunal intubation with a 10 Fr catheter is required for a small bowel enteroclysis and to obtain optimal bowel distension, approximately 20% w/v barium suspension infusion is required. 10 mg metoclopramide orally or intravenously or 10 ml of gastrografin orally, improves the passage of barium through small bowel.[4]

Barium when used, distends the bowel and provides good mucosal detail, in depth visualization of fistula, small bowel obstruction, mural and intraluminal filling defects like small bowel neoplasms during enteroclysis.[2] Barium studies have limited role in acute small bowel obstruction or ileus[3] and in the assessment of extraluminal disease. Additional CT studies are required to characterize small bowel lesions or stage small bowel tumours in these patients. Also, the radiologist must consider a radiation dose of approximately 1 mSv for each barium study[3]. Often patients are young and may require multiple investigations. Low-or no-dose study is required in

this group, which is accurate, reproducible and whole small bowel is visualized.

ULTRASOUND

To evaluate patients with Crohn's Disease, ultrasound is used. Ultrasound is readily available and there is no risk of radiation. The skill and expertise of operator is required for successful evaluation using ultrasonography

In Crohn's disease of small bowel, mural thickening is most common. Mural thickening is concentric and its echogenecity depends on the degree of inflammatory infiltration and fibrosis. I Mural stratification is retained in acute stage of the disease. In longstanding cases, especially in elderly patients, a target or pseudokidney appearance is usually seen. Fat deposition in the submucosa may be present, in inactive long-standing disease. Gut appears rigid and fixed, in actively inflamed stage and there may be decreased or absent peristalsis. Color Doppler finding is hyperemia. Spectral Doppler analysis shows increased superior mesenteric and/or inferior mesenteric artery blood flow and increased portal vein velocity.[4]

Ultrasound findings are nonspecific in small bowel diseases but usually used to guide further studies and evaluate the effects of treatment. The sensitivity and specificity of ultrasound in detection of IDBs range from 78% to 90% and 83% to 95% respectively when per oral techniques are used to distend the bowel.[18]

Ultrasound is most effective in detecting IDBI in the terminal ileum and less effective in other parts of small and large bowel. For focal bowel wall thickening demonstration in inflammatory bowel disease (IBD), ultrasound is useful and radiation free, but it depends on the operator skills and experience, and may not fully delineate complications and exclude diseases in deep abdominal loops.[4]

A meta-analysis studies, to diagnose Crohn's disease by using ultrasound, reported sensitivity and specificity between 75%-94% and 67%-100%, respectively.[17]

A combination of clinical and conventional enteroclysis findings, the specificity and sensitivity of ultrasound in diagnosing CD have been reported to be 88.4% and 93.3%, respectively. Reference standard is used for comparison.[17]

In patients with early stage CD of the small bowel ultrasound was less reliable (sensitivity 66.7%). Therefore, further evaluation is necessary for negative result, if ultrasound is used as the initial modality to examine the small bowel in patients with suspected CD.

Using Doppler ultrasound, Differentiation between inactive disease and normal small bowel was not possible, making this technique unsuitable for diagnosis of CD. It is not possible to ascertain which segment of bowel is associated with this sign of inflammation. It is not frequently used in evaluation of CD because it has partial role in the management of complications.[4]

MAGNETIC RESONANCE IMAGING

MRI is best in the imaging of small bowel disorders because of the exceptional soft tissue contrast, capabilities of direct multiplanar imaging, and availability of a variety of oral contrast agents.

The preference of MRI versus CT is based on public policy and expertise. There has been a more global interest in implanting techniques that either reduce or eliminate radiation exposure. This is especially important in patients with chronic diseases such as inflammatory bowel disease who may require multiple studies over a lifetime. Or, in studies, such as in assessment of GI motility, which requires sequential imaging time points.

MRI has better soft tissue resolution as compared to other radiological modalities.

Using MRI, two major techniques are used to achieve bowel distention: MR enteroclysis (MRE) with infusion of the contrast through a nasojejunal tube and MR enterography with oral contrast administration.[4,21,22]

Many enteric contrast agents have been investigated for MR entreography & enteroclysis. These are classified into one of three types: negative contrast agents (low signal intensity on T1-and T2-weighted images), positive contrast agents (high signal intensity on both T1and T2 weighted images).[4,22-25]

The biphasic category has largest number of available agents. Most of these agents are low signal intensity on T1-weighted images and high signal intensity on T2-weighted images. The low signal intensity of these agents on T1-weighted imaging improves the contrast between bowel lumen and hyper enhancing wall inflammation (water mixture, polyethylene glycol, and volume).[26-28]

In pathologies of small bowel, MR enteroclysis offers a good small bowel distention and optimal distention of bowel loops properly because collapsed bowel loops can hide lesions or mimic disease by suggesting pathologically thickened bowel wall in collapsed segments. The visualization of small polypoid masses that do not produce obstruction is difficult.[4]

In patients with CD, MR enteroclysis delineates superficial changes better than MR enterography, and this aspect has to influence the revealing and localization of the disease in patients with only superficial manifestations. In an early stage of small bowel neoplasm, evaluation of superficial abnormalities is of particular importance. To determine the distensibility of narrowed areas and to improve the differentiation between a fixed and an unfixed stenosis, MR enteroclysis with fluoroscopic sequence may be helpful.[4]

The non usage of radiation and the inherent excellent soft tissue contrast make

MRE a good choice in the diagnosis of inflammatory bowel disease with the pattern of enhancement and the presence of enhancing lymph nodes potentially capable of predicating disease activity.[4]

COMPUTED TOMOGRAPHY

Advancement in MDCT scanners technology in using imaging workstations that permit multiplanar and 3D evaluation of isotropic data sets, oral contrast agents and administration techniques that improve small bowel distention have better detection and characterization of small bowel pathology.[29-31]

It is used in the investigation of nonspecific abdominal symptoms. In addition, asymptomatic small bowel abnormalities may be identified on CT. Commonly identified abnormalities include inflammatory and neoplastic diseases. For mucosal detail of small bowel barium studies, conventional CT is not useful, but can recognize thickening of small bowel wall and is best in recognizing related extraluminal diseases like inflammatory change, wrapping, fistulae, abscess formation, lymphadenopathy or local metastatic tumour spread from small bowel neoplasms.[4]

CT has proven to be highly sensitive (81%-94%) and specific. It is the investigation of choice for the indication.[32]Those values are also improved in the detection of partial small bowel obstruction and intraluminal small bowel lesions.[4]

For small bowel disorders, CT Enteroclysis is a well-known examination. The technique uses the advantage of an enteral volume challenge with the multiplanar reformatting capabilities of cross-sectional imaging.[4]

A nasojejunal tube which is 8 or 10 Fr is inserted under fluoroscopic guidance and enteral contrast is infused at the rate of 120-200m1/min using an enteroclysis pump, until 1500-2000m1 has been delivered. Increasing the rate of infusion to 150-200m1/min after 500-1000 m1 brings about a reflex atony in the bowel, thereby causing

increased distension. Before scanning, an anti-peristaltic agent is given. Either 20 mg buscopan or 10 mg glucagon IV. Slice acquisition at 2.5 mm with a pitch of 1.5 for a four-row multidetector CT (MDCT) and 1 mm with pitch of 0.8 for a 64-row MDCT is standard.[31]

For evaluation of intraperitoneal adipose tissues, dilute iodinated positive oral contrast agents are optimal.[4] However, positive oral contrast agents obscure mucosal enhancement, which impairs the pattern of enhancement which is considered in the differential diagnosis of an abnormal small bowel segment.

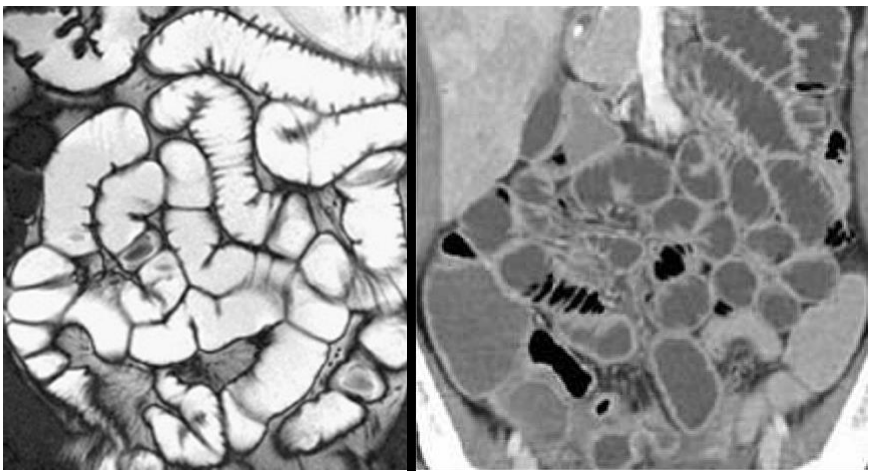


Figure 03: Enterography image showing obscured wall of bowel with positive oral contrast and well appreciated with negative oral contrast.

The use of MDCT, neutral (attenuation values between 10-30 HU) oral contrast agents to distend the small bowel and multiplanar thin section data evaluation has come to be known as CT enterography.[33]

CT enterography was presented for the first time by Raptopoulos et al in 1997 as a modification to "standard" abdomino-pelvic CT examination. It is specific to examine the small bowel, mainly to assess the extent and severity of Crohn's disease.[11,34] They combined neutral low-density oral contrast with "enteric phase" CT to optimize contrast resolution between mucosa and lumen, thereby maximizing

conspicuity of abnormalities arising from the small bowel wall.

For small bowel disorder assessment, CT enterography is emerging as an alternative to conventional imaging procedures. Better spatial and temporal resolution provided by multidetector CT scanners with good luminal distention by negative oral contrast agents have made CT enterography the imaging modality not only in investigating bowel diseases but also in detecting occult GI bleeding, mesenteric ischemia, small bowel neoplasms, and other small bowel pathologies.[35]

Along with the best visualization of the bowel wall thickness, CT enterography also shows extra-enteric involvement and provides more in depth and complete information about the extent and severity of disease.[35]

Neutral oral contrast agents have better visualization the analysis of the degree and pattern of small bowel enhancement.[36] "Neutral contrast" are agents with attenuation value like that of water (10-30HU). For the effectiveness of neutral contrast agents, they must be used with IV contrast material and the small bowel distention should be optimal.[33]

Many neutral contrast agents are being evaluated for small bowel distention including water, water with methylcellulose, polyethylene glycol solutions (PEG) and other low-density barium solution (Volumen) which are commercially available.[36] Volumen and polyethylene glycol solutions are slowly absorbed as compared to water and they achieve a better small bowel distention.[33]

Peroral CT enterography differs from CT enteroclysis tube because the latter technique is performed after placing a nasojejunal tube in combination with active small bowel distention. Neutral enteral contrast agent is administered orally (enterography), although the degree of small bowel distension achieved may be more variable than with enteroclysis.PEG produces better small bowel distension than water

or methycellulose whan taken orally but may induce abdominal cramps and diarrhea. Volumen seems to be better tolerated by patients whilst achiving reasonable distenson. Though CT entrerography is inferior to CT enteroclysis in achieving small bowel distension, the noninvasive nature and speed of CT enterography make it best as a first-line technique for the evaluation of small bowel diseases.[11,36]

PET/CT is emerging in the evaluation patients with IBD.

Advantages of PET-CT with FDG are improved spatial localization compared to PET-FDG without CT; reduced FDG uptake in fibrous strictures indicating failure of medical therapy, compared to nonfibrous areas; and improved performance in detection as compared to CT and MR enterography.[4]

Physiologic uptake of FDG by the intestine leads to false positive results and low radiation dose of the corrective CT restricts evaluation of the collapsed small bowel and mesentery. Combination of PET and CT entrerography might improve bowel distension, anatomic detail, and potential to predict failure of therapy.[4]

CT ENTEROGRAPHY INTERPRETATION [33,38]

Normal imaging considerations and pitfalls

Diameter of 30.0 mm in the jejunum and 30.0 mm in the ileum, with a mean bowel loop diameter of 20mm were considered normal. The usual parietal thickness ranging from 1.0 to 2.0 mm. On an average the jejunum presents four to seven folds and ileum three to five folds every 2.5 cm.

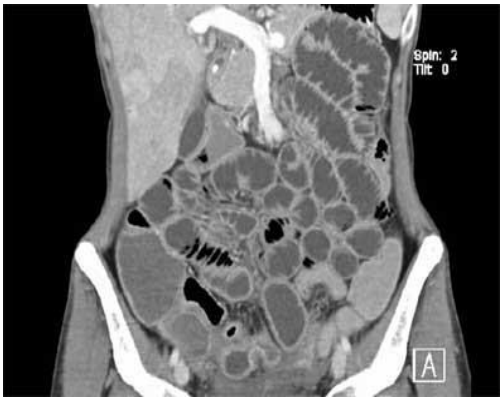


Figure 04: CT Enterography image showing normal difference in enhancement and fold pattern of jejunal and ileal bowel loops.

An abnormal segment will initially be seen because of hyper enhancing mass or wall thickening focus. During the enteric phase of enhancement, jejunum enhances more than the ileum. This should not be mistaken for pathology. Enhancement will be more in the collapsed bowel loops than in the distended loops of the same segment. Small bowel spasm is commonly seen, in spite of buscopan use, it can mimic short strictures.

To overcome this difficulty, pathology should be diagnosed using other signs of the disease, such as, changes in the adjacent small bowel mesentery, hypervascularity, fat stranding or lymphadenopathy.

PATTERN OF APPROACH TO SMALL BOWEL ON MDCT ENTEROGRAPHY

Macari et al[33] described criteria to help to characterize abnormal small bowel segments, including, location in duodenum/jejunum/ileum, degree and symmetry of wall thickening, pattern of contrast enhancement, length of involvement, site of pathological small bowel wall (mucosal/submucosal/serosal) and associated abnormalities in the adjacent mesentery or vessels.

ENHANCEMENT PATTERN

Small bowel wall enhancement pattern has been classified into "target" appearances, homogenous, heterogeneous and diminished.

Target appearances in the small bowel wall (mural stratification) is commonly seen with benign conditions like vasculitis, Crohn's diseases, venous thrombosis associated with bowel edema or ischemia and intramural hemorrhage (as denoted in figure 8).[33]

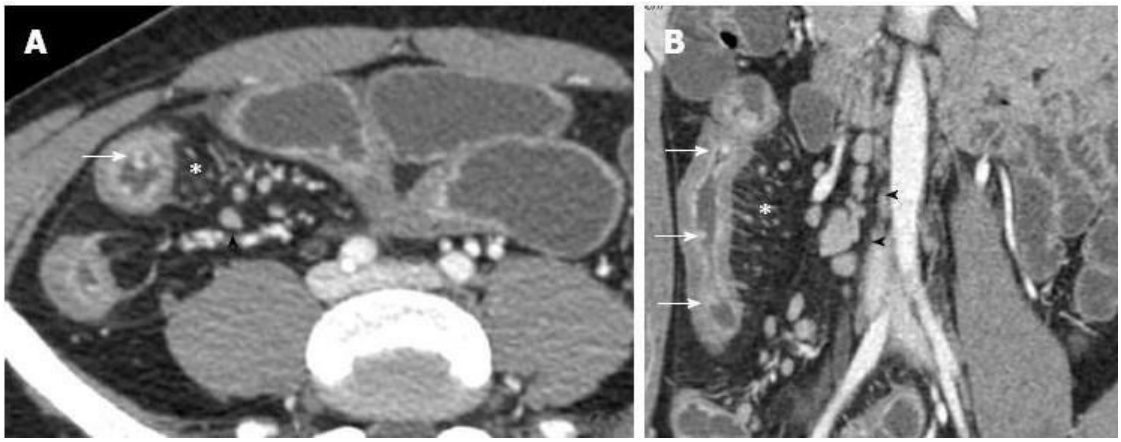


Figure 05: CT enterography image shows thickened jejunal loops with submucosal edema and target enhancement.

In chronic inflammatory conditions, wall enhancement is homogeneous and mild (like muscle), (as denoted in figure 6), particularly in those bringing about fibrosis within the small bowel wall (Crohn's disease, ischemia and radiations).[10] In active Crohn's disease, homogenous hyperenhancement is common, it is commonly in association with enchanced density in the surrounding mesenteric fat. It has been proposed by Bodily et al that a cut-off of 109 HU can be used with reasonable accuracy to diagnose activity in Crohn's-afflicted small bowels.[39]

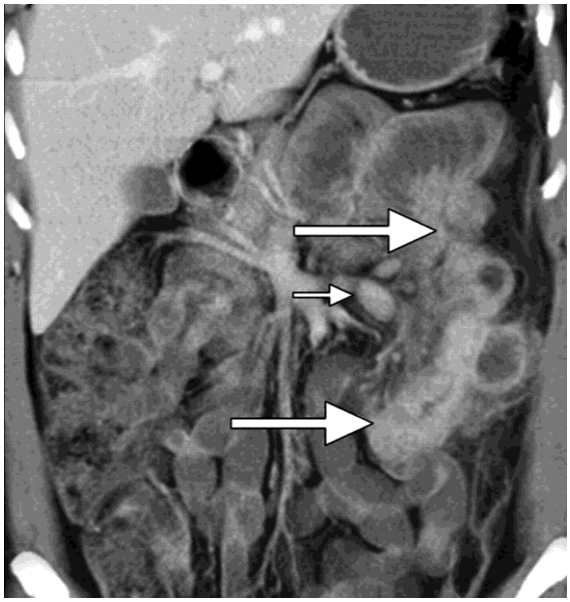


Figure 06: CT enterography showing homogeneous wall enhancement in the jejunal loops on right side (long arrows) and lymphadenopathy (short arrow).

In small bowel neoplasms, including gastrointestinal stromal tumors, adenocarcinomas, metastases and peritoneal deposits, heterogenous enhancement is seen (as denoted in figure 7).[10]

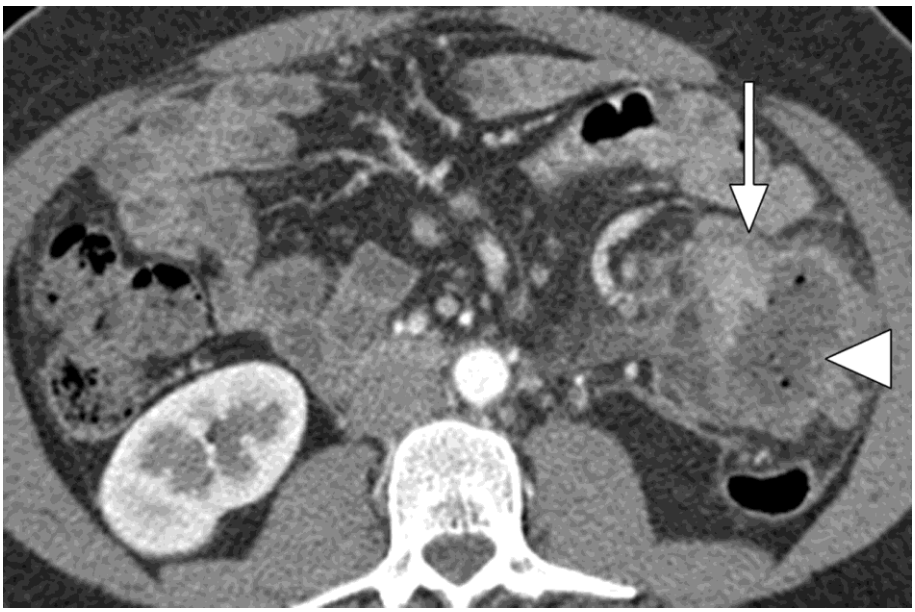


Figure 07: CT enterography showing homogeneous wall enhancement (arrow) in the jejunal loops on right side with areas of necrosis (arrow head).

In bowel ischemia, diminished enhancement is seen and usually precedes the development of intramural gas and subsequent perforation. (as denoted in figure 8)[10]

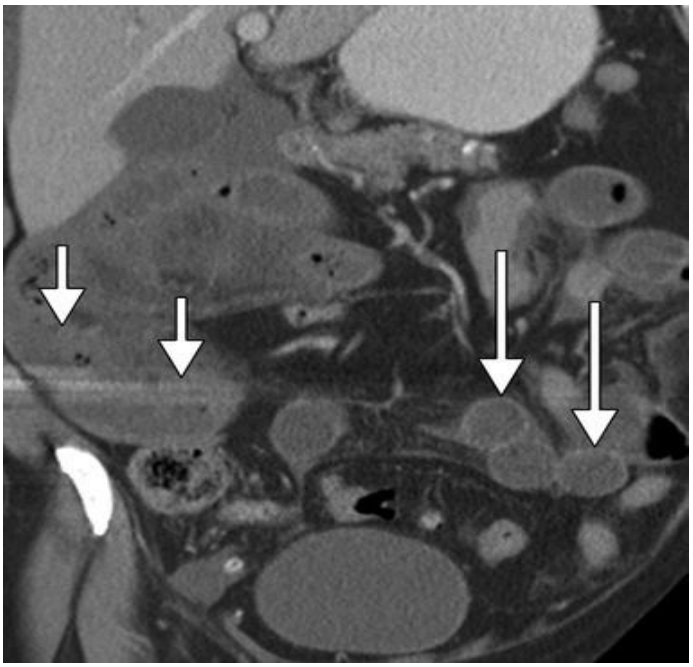


Figure 08: CT enterography showing diminished wall enhancement in the ileal loops.

LENGTH OF SMALL BOWEL INVOLVEMENT

The length of small bowel involvement can be classified into three for differential diagnosis: focal (<5 cm), segmental (6-40 cm) and diffuse (>40 cm). In neoplasms, endometriosis, small bowel ulcers which are secondary to NSAID's, focal small bowel thickening is seen. Focal thickening is occasionally seen even in granulomatous diseases like tuberculosis and Crohn's disease. Segmental involvement is found with intramural hemorrhage, Crohn's disease, lymphoma, infectious enteritis and ischemia, mainly to superior mesenteric artery (SMA) embolus or superior mesenteric vein thrombosis.

Diffuse involvement of the small bowel is usually seen in hypoalbuminemia, low-flow intestinal ischemia, vasculitis, GVHD and infectious enteritis.[10]

MURAL THICKENING AND SYMMETRY

For characterization of small bowel pathology, depends on site, degree and symmetry of mural thickening. Tabels 3-5 summarize mural thickening [33,39-43] symmetry of small bowel thickening [33,41,44] and sites of abnormality in the small bowel [33,43] respectively. By identifying predominantly affected layer of the small bowel, diagnosis can be reached easily. In inflammatory conditions like Crohn's disease, tuberculosis and neoplasms like adenocarcinoma, the mucosa is predominantly affected. Even though mucosa is affected predominantly in infectious conditions and vasculitidis, mucosal disruption is obvious on MDCT.[33] In intramural hemorrhage, vasculitis, ischemia, hypoalbuminemia and angioedema, predominant abnormality is seen in submucosa. The equivalent barium follow-through appearance is classically described as stacked coin- or picket fence- like, in conditions where there is thickening of submucosa. In metastases, endometrosis, carcinoid and other inflammatory conditions in the peritoneum, serosa is predominantly affected.

Table 01: Characterization of mural thickening.

Mild (3-4 mm)	Moderate (5-9 mm)	Severe (>10 mm)
Infectious enteritis Hypoalbuminemia Mild Crohn's disease Ischemia occasionally	Crohn's disease Intestinal ischemia Vasculitis Angioedema Intramural hemorrhage Early adenocarcinoma Lymphoma	Malignancies like lymphoma, Vasculitis Crohn's disease Intramural hemorrhage Infectious colitis(rarely) Most cases of thickening >20mm are due to neoplasms or intramural hemorrhage.

Table 02: Sites of abnormality in the small bowel.

Proximal	Distal
Adenocarcinoma Celiac disease	Lymphoma and carcinoid tumors Crohn's disease (most commonly affects the terminal ileum with skip lesions elsewhere)

Table 03: Affected layer of the small bowel.

Mucosa	Submucosa	Submucosa
Crohn's disease Tuberculosis Neoplasms (adenocarcinoma) Infectious conditions and vasculitidis	Ischemia, Hypoalbuminemia Intramural hemorrhage, Vasculitis, Angioedema	Metastasis Endometriosis Carcinoid Other inflammatory conditions of peritoneum

Table 04: Symmetry of small bowel thickening.

Symmetrical	Asymmetrical
Benign conditions some cases of lymphoma	Crohn's disease Tuberculosis Adenocarcinomas Gastro intestinal stromal tumors

EXTRALUMINAL FINDINGS

CT and additional cross-sectional techniques can visualize extra-luminal soft tissues. Assessment of mesenteric blood vessels should be done to exclude vascular pathologies like arterial embolism or venous thrombosis. Lymphadenopathy in the mesentery, if present, suggests presence of underlying disease which can be both benign and malignant. There is central low attenuation in lymph nodes in intestinal tuberculosis where as in lymphoma and Crohn's disease the nodes are soft tissue density. Mesenteric edema, fluid, fibro-fatty proliferation, abscess and fistula, which are extra luminal findings should also be carefully assessed.[10]

Table 05: Specific indications for CT enterography.

Small bowel disorder	Indication	Advantages	Disadvantages
Crohn's disease	Assessment of extent, severity and luminal/extraluminal complications.	Allows Simultaneous diagnosis of extraluminal disease and complications. Preferred Examination in suspected small bowel stricture	Less sensitive than capsule endoscopy in detecting early mucosal abnormalities. Radiation concerns prevent use of CT enterography in pediatric patients. Frequent examination in adults, ultrasound and MR Enterography are preferred in these situations.
Small bowel tumor	Detection, characterization and staging	Permits simultaneous detection and staging	Less sensitive than capsule study for detection of small mucosal lesions

Small bowel disorder	Indication	Advantages	Disadvantages
Occult gastrointestinal bleeding	Detect and characterize vascular/neoplastic origin	Better visualization of lesions compared to conventional CT and fluoroscopy allowing improved lesion	CT enterography does not permit prolonged imaging times unlike nuclear medicine techniques, which are essential for detection

		directed planning.	of intermittent bleeding, Limiting the detection of active bleeding is done by pre-exiting high attenuation material within the bowel. Conventional barium follow through study is more sensitive in the assessment of adhesional obstruction than CT enterography
Partial small bowel obstructions	Locate site and detect cause	Improved visualization of mucosal lesions compared to conventional CT	
Celiac disease	Assessment of complications mainly lymphoma	CT enterography may show typical mucosal pattern and lymph node involvement	Unlike endoscopic techniques does not depict subtle mucosal changes
Ulcerative colitis	Excludes extraluminal complications and small bowel inflammation like Crohn's disease	Simultaneous assessment of the small and large bowel, extraluminal Disease with CT enterography.	Usually undervalues the disease extent and severity.

COMMON PATHOLOGIES ON CT ENTEROGRAPHY

INFLAMMATORY BOWEL DISEASE

In most cases, inflammatory bowel disease may be classified as either ulcerative colitis or Crohn's disease. Diagnosis is challenging mainly in cases with mild inflammation confined to the small bowel. Aside from the clinical findings, an imaging has become the method of choice for assessing the intestinal wall and extraintestinal lesions.[45]

CROHN'S DISEASE

Crohn's disease is a discontinuous, segmental, often multifocal inflammation that may affect any part of the gastrointestinal tract from mouth to anus. Proximal GI tract involvement is rare and if it is involved, it is always associated with lower gastrointestinal tract involvement. CD is seen both in small bowel and large bowel in most of the cases. Inflammation is confined to small bowel mainly terminal ileum in one third of the cases, and to colon in 20% of patients.[46,47]

Features of active small bowel Crohn's disease on CT are - bowel wall thickening, mural hyperenhancement, and mural stratification and submucosal fatty deposition .[47]

Some studies have reported that the thickness of the bowel wall associates with disease activity, so, noticeably thickened segments indicate active disease rather than chronic disease.[47]

The varieties of appearances of mural hyperenhancement seen with CD are:

1) The entire bowel wall is thickened and enhanced.

2)There will be mural stratification representing the layers of the bowel wall.[47]

Mural stratification is a reliable indicator for active Crohn's disease and one study found that it was more likely than a homogenously enhancing bowel wall to

indicate histologically active Crohn's disease. This finding, determined by increased mucosal enhancement, low attenuation of the submucosa and increased muscularis enhancement, create the "bull's eye sign" or mural stratification sign. Different Mural stratification patterns are 1) bilaminar appearance with mucosal hyperenhancement and decreased intramural attenuation. 2) trilaminar appearance with mucosal and serosal hyperenhancement and decreased intramural enhancement. Increased wall enhancement after the administration of intravenous contrast is considered indicative of active disease and it may even correlate with the degree of disease activity.[48]

Depending on the pathological process, the intramural portion of the bowel wall attenuation can vary. Intramural edema or water attenuation indicates active inflammation, intramural soft tissue attenuation indicates an inflammatory infiltrate, and intramural fat represent past or chronic inflammation.[47]

In CD luminal narrowing is a common finding and is reversible or fixed. Mucosal edema and associated spasm cause luminal narrowing of small bowel. The bowel wall is thickened and displays mural stratification in acute non cicatrizing stage. Acute narrowing is reversible with conservative measures and anti-inflammatory medications. The submucosa and smooth muscle layers become fibrotic, and strictures become fixed with disease progression. This chronic fibrosis is demonstrated by homogenous enhancement of the bowel wall[49] or focal narrowing without significant wall thickening on CTE.[47]

In patients with luminal narrowing less than 1 cm, capsule endoscopes are contraindicated, because of risk of retention of capsule. These cases require surgical intervention. One study stated that capsule retention was present in 13% of patients who had known Crohn's disease and results in intestinal perforation and intestinal obstruction.[47]

EXTRA-ENTERIC FINDINGS

Extraenteric findings that are commonly seen in Crohn's disease include comb sign, fibro- fatty proliferation, fistulas, and abscesses. Abscesses are connected to inflamed bowel loops by a sinus tract and are found in the retroperitoneum or within the leaves of the mesentery. Other extra-enteric complications that are intrinsic to Crohn's disease but unrelated to the inflammation of bowel wall include sacroiliitis, renal calculi, cholelithiasis, primary sclerosing cholangitis, and lymphoma.[47]

ULCERATIVE COLITIS

CT enterography is not used in the diagnosis or staging of ulcerative colitis, since it is less sensitive than endoscopy. They are often nonspecific, even if radiological findings are present.[11]

In both Ulcerative colitis and Chron's disease, mural stratification, dilatation of the vasa recta, colonic wall thickening, and inflammatory pseudopolyps are seen. Crohn's disease is more likely, when there are findings in the right colon and terminal ileum. Fistulas, abscesses, or discontinuous colonic or small bowel inflammation, are extraenteric complications that support the diagnosis of Crohn's disease. The principal role of CT enterography in patients with suspected ulcerative colitis is to help exclude findings of Crohn's disease such as small bowel inflammation, as sensitivity of CT enterography is more for Crohn's disease.[11]

INTESTINAL TUBERCULOSIS

Intestinal TB is equally prevalent in men and woman and can occur in any age group . The chest radiograph may show active disease in only 15% to 20% of patients with intestinal TB may arise by several mechanisms.[50]

Intestinal TB manifests three gross pathologic types: (1) ulcerative, (2) hypertrophic, and (3)ulcerohypertrophic. The highest incidence of abdominal TB has

been noted in the gastrointestinal tract and in the peritoneum, followed by the mesenteric lymph nodes. The ileo-cecum is the most common site of disease, because tubercle bacillus has more affinity for lymphoid tissue.[50]

Bowel wall thickening is the most common CT finding of tuberculus enteritis, ranging from 1 to 2 cm in thickness. There may be homogeneous attenuation on CT because of thickened bowel, but mural stratification may be seen sometimes. Multiple sites of involvement with skipped areas are common. Bowel loop separation can be caused by mesenteric lymphadenopathy or lymphadenitis, intraperitoneal fluid collection or abscess and rarely, fibrofatty proliferation in the mesentery. It is also uncommon to see hypervascularity of mesentricvessels (comb sign) in TB, unlike in active crohn's disease. The nodal involvement patterns are somewhat characteristic in intestinal TB , enlarged lymph nodes commonly larger than 1 cm, and may have low-attenuation center caused by caseating necrosis in a every third patient, and may contain calcification.[50]

OBSCURE GASTROINTESTINAL BLEEDING

Obscure gastrointestinal bleeding is defined as recurrent or persistent bleeding for which no obvious etiology has been identified by standard endoscopic examinations.[50]

Although the source of obscure gastrointestinal bleeding is located most commonly in the small bowel, lesions missed or underestimated during initial endoscopic examination comprise a considerable proportion of bleeding sources.[50]

Variable small bowel lesions can cause obscure gastrointestinal bleeding. Among them, angiodysplasias are the most common, followed by small bowel tumor. However, frequencies of these lesions are variable depending on patients' age: Meckel's diverticula are the most common cause of small bowel bleeding in patients

younger than 25 years of age. Tumors are common abnormalities in patients between 30 and 50 years of age. Angiodysplasias predominate in the elderly.[50]

For the investigation of gastrointestinal bleeding, CT is performed with neutral oral contrast agent. Acquisiton of arterial-phase scan is essential to detect active extravasation of contrast material and enhancing vascular lesions. On CT scan, the source of gastrointestinal bleeding can be detected either by depicting extravasation of contrast material or by demonstrating lesions that are expected to be source of gastrointestinal bleeding (i.e., vascular lesions, tumors, and inflammatory bowel disease).[50]

CAUSES OF SMALL BOWEL BLEEDING VASCULAR LESIONS

- Vascular ectasia
- Telangiectasia (hereditary hemorrhagic telangiectasia)
- Hemangioma
- Congenital vascular malformation
- Tumors

Miscellaneous

- Medication related
- Infections
- Aortoenteric fistula
- Meckel's diverticulum
- .Jejunoileal diverticula
- .Ischaemia
- Small bowel polyposis

Yoon and coworkers also found concordant results in their clinical study. They reported the sensitivity, specificity, and accuracy of arterial phase MDCT in the

localization of acute massive gastrointestinal bleeding to be 90.9%, 99%, and 97.6%, respectively, compared with conventional angiography as a reference standard. Therefore, MDCT appears to be a promising tool for the localization of active gastrointestinal bleeding of obscure origin and is potentially helpful to guide further therapeutic approach.[50]

SMALL BOWEL TUMORS

Adenocarcinoma, carcinoid tumor, lymphoma, and gastrointestinal stromal tumor (in decreasing order of frequency of occurrence) are the most common small bowel tumors. Nonmalignant tumors of small bowel include hamartomatous polyps of Peutz-Jeghers syndrome and hyperplastic polys.

In CT enterography, a pedunculated or an exoenteric mass recommends a gastrointestinal stromal tumor. Lymphoma is exoenteric mass in combination with adjacent lymphadenopathy or aneurismal ulceration. Carcinoid tumors arising from neuroendocrine precursors in the mucosa or small bowel wall manifest as enhancing polyps mainly in the ileum or as enhancing carpet lesions, representing the wall thickening of Crohn's disease. Mesenteric carcinoid metastases are desmoplastic reaction and contain eccentric calcification or are clustered near the mesenteric root, while hepatic carcinoid metastases are hyper vascular and necrotic. Adenocarcinomas have variety of shapes but are located in the proximal small bowel.[11]

CELIAC DISEASE

Patients with Celiac disease present with nonspecific symptoms. Similarly, conventional barium studies are frequently nondiagnostic. The characteristic findings of celiac disease on CT are, small bowel dilatation, fold separation, non-obstructing small bowel intussusception, and extraintestinal diseases such as adenopathy and celiac-associated T-cell lymphoma. In CT enterography Reversal of the jejuno-

ilealfold pattern with villous atrophy in the proximal small bowel can be visualized. On coronal reformatted images jejunization of the ileum can be noticed.[11]

MESENTERIC ISCHAEMIA

Mesenteric ischemia is a devastating disease process. It may be acute or chronic and may be of venous or arterial origin. Vascular occlusion due to arterial or venous disease and hypo-perfusion associated with non-occlusive vascular disease, may lead to mesenteric ischemia. Bowel obstruction, vasculitis, inflammatory conditions , neoplasm, trauma and iatrogenic causes like drug or radiation therapy also lead to vascular changes. [50]

Among a variety of diagnostic methods, CT enterography is considered as a best noninvasive tool, because it helps in detecting changes in the bowel and the vessels and also reveals other accessory abdominal findings.[50]

Of the multiphase dynamic sequences in CT enterography, inclusion of non-enhanced CT in addition to both arterial and portal phase CT is recommended because non- enhanced CT has advantages not only in differentiating the hyper-attenuating bowel wall caused by intramural hemorrhage from that caused by hyperemia but also in easy detection of atherosclerotic vascular wall calcification or blood clot occluding the mesenteric vessels. In addition, acqusition of arterial-phase CT scans should be included, as one of the significant CT findings of bowel wall enhancement (i.e., hyperattenuation or hypoattenuation) in establishing mesenteric ischemia diagnosis and in differentiating it from other non-ischemic conditions (i.e., hypoatttenuation; ischemia versus hyperattenuation; infection) is appreciated.[50]

CT enterography signs for diagnosis include thromboembolism in the mesenteric vessel, lack of bowel wall enhancement, intramural gas, portal venous gas and ischemia of other organs; nonspecific signs are bowel dilatation, bowel wall

thickening, bowel obstruction, mesenteric edema and vascular engorgement and ascities.[50]

Considerarion of the length of involved bowel segment will help localize thromboembolism in the mesenteric vessels; if the ischemia develops at the proximal mesenteric artery, a larger small bowel segment may be involved, and in cases of peripheral branches, the involved bowel segment is relatively very short.[50]

In cases of mesenteric arterial occlusion, on arterial phase CT enterography, both reversible mesenteric ischemia (stage 1) and mesenteric infarction (stage 3) show hypoattenuation in the involved bowel segments but on portal or enteral phase CT scans, the involved bowel shows persistence of hpoattenuation in mesenteric infarction (stage 3) and nearly isoattenuation in the reversible mesenteric ischemia (stage 1) in stage 2 type of mesenteric ischemia, the involved bowel appears as hypoattenuation on arterial phase and slight hyperattenuation on portal phase.[50]

MESENTERIC ISCHEMIA OF VENOUS ORIGIN

Acute mesenteric venous thrombosis (MVT) is an uncommon but often lethal form of bowel ischemia, accounting for 5% to 15% of all mesenteric ischemia events. The important predisposing factors for developing superior mesenteric venous thrombosis include inherited or acquired conditions causing hypercoagulable state such as protein S or C deficiency, or anti-phospholipid antibody syndrome. Other causes include portal hypertension, abdominal inflammatory disease, previous surgery, trauma and oral contraceptive use. But many cases are idiopathic.[50]

Noticeable thickening of bowel wall with severe mesenteric haziness or edema is the hallmark of mesenteric ischaemia caused by superior mesenteric venous thrombosis, on CT enterography. There may be substantial collateral vasculature in the mesentery and in the retroperitoneum. The thickened bowel wall displays a target

appearance with hyperattenuating inner layer, an isoattenuating or hypattenuating middle layer and a hyperattenuating outer layer. Pathologically, the inner and middle layers correspond to alternating areas of hemorrhage and edema in submucosa of the intestinal wall and the outer layer represents the change mainly in the serosal layer of the intestine. Because of these unique findings, the diagnosis is usually made easily by CT enterography. CT enterography findings of hypoattenuation in the involved bowel on arterial phase and hyperattenuation on portal phase favor the diagnosis of mesenteric infarction.[50]

NON-OCCLUSIVE MESENTERIC ISCHEMIA

The mesenteric arteries and veins are patent, in patients with non-occlusive mesenteric ischemia, but enough oxygenated blood is not delivered to the bowel. This condition is relation to primary cardiac dysfunction, such as cardiac failure, myocardial infarction, arrhythmia, vascular insufficiency, sepsis and trauma. Progressive vasoconstriction and persistent splanchnic vasculature vasoconstriction results in decreased blood flow to the viscera and causes intestinal hypoxia.[50]

Prolonged hypoperfusion due to hypovolemic shock causes shock bowel, and it is a subtype of non-occlusive mesenteric ischemia and is transient. With hypovolemia restoration, it resolves. On CT enterography diffuse bowel wall thickening and contrast enhancement in the small intestine can be seen. Other manifestations are diminished caliber and increased enhancement of the inferior vena cava , aorta and intestine and contrast enhancement of the kidneys and mesentery.[50]

INTUSSUSCEPTION

Intussusception is the leading cause of intestinal tract obstruction occurring in young children but is uncommon in adults. 5% of all intussusceptions occur in adults and it accounts for up to 5% of all cases of bowel obstruction in adults. In contrast to

childhood intussusception, which is idiopathic in 90% of cases almost half of adult cases may be idiopathic.[50]

As the intussusceptum enters the intussuscepien, the mesentery is carried forward and trapped between the overlapping layers of bowel. Constriction or twisting of mesenteric vessels lead to vascular compromise and edematous thickening of the involved bowel. If intervention is not done, ischemic necrosis may develop.[51]

Types of Intussusceptions are enteroenteric, ileocolic, and colocolic .In general, most lead points in the enteroenteric intussusceptions are benign, including benign neoplasms, Meckel's diverticula, adhesions, lymphoid hyperplasia and adenitis, trauma ,celiac disease, duplications and inflammatory lesions; small bowel malignancy (either primary or metastatic) may account for about less than one third of adult intussusceptions.8% to 20% of enterenteric intussusceptions may be idiopathic. It should be noted that proximal small bowel intussusceptions are likely to be transient and non-obstructive and are unlikely to have significant lead point. Pathognomonic appearance of intussusption on imaging is bowel –within-bowel configuration , with or without contained fat and mesenteric vessels.[50,51]

Intussusception may have three different CT appearances, based on severity and orientation to the scanning axis: 1) a target lesion representing an intraluminal soft tissue mass with mesenteric fat; 2) a sausage shaped mass with alternating layers of low and high attenuation; 3) reniform mass associated with focal ischemic changes.[50]

VASCULAR COMPRESSION SYNDROME

SUPERIOR MESENTERIC ARTERY SYNDROME

Described originally by Rokitansky in 1861, SMA syndrome also known as cast syndrome or arteriomesenteric duodenum compression syndrome comprises of obstruction of third portion of duodenum due to compression between SMA and

aorta. Wilkie described it as a chronic duodenal ileus in 1927. SMA syndrome is one of the rare cause of proximal duodenal obstruction.[53]

ANATOMY AND PATHOGENESIS

The SMA arises at the level of L1-2, courses anteriorly and inferiorly and forms an angle with the aorta known as aortomesenteric angle. At the level of L3, the third portion of the duodenum crosses between aorta and proximal SMA. The third portion of the duodenum is normally surrounded by retroperitoneal fat which provides a "cushion" for duodenum between the anterior SMA and posterior aorta which maintains a wide aortomesenteric angle and aortomesenteric distance. Many studies have shown the normal range of the aortomesenteric angle and aortomesenteric distance to be 28^-65^ and 10-34 mm, respectively.[53]

Conditions with rapid and severe weight loss result in a loss of retroperitoneal fat, which lead to decrease in aortomesenteric angle and aortomesenteric distance and causes compression of duodenum. These are wasting conditions like, malabsorption, acquired immunodeficiency syndrome, cancer and other cachexia associated conditions, catabolic states like major surgery and burns, drug abuse, eating disorders and after weight loss surgeries are more prone to this syndrome.[53]

Females have more incidence of SMA syndrome with two-thirds of patients in age group of 10 and 39 years of age. They usually present with symptoms like postprandial epigastric pain and fullness, nausea, vomiting, weight loss, and anorexia.[53]

CTE after of IV contrast material injection permits evaluation of the mesoaortic vascular anatomy, transverse duodenal compression, proximal dilation. Therefore, used in SMA as the diagnostic of choice.[53]

MEDIAN ARCUATE LIGAMENT SYNDROME

MALS is also known as celiac artery compression syndrome or Dunbar syndrome which was first described in 1963 by Harjola. It is rare condition characterized by narrowing of the proximal celiac trunk by the median arcuate ligament causing symptoms like epigastric pain and weight loss.[8]

The median arcuate ligament is an arch like fibrous band connecting right and left diaphragmatic crura at level of the aortic hiatus, crossing aorta anteriorly superior to the celiac artery at the level of the L1 vertebral body.[53]

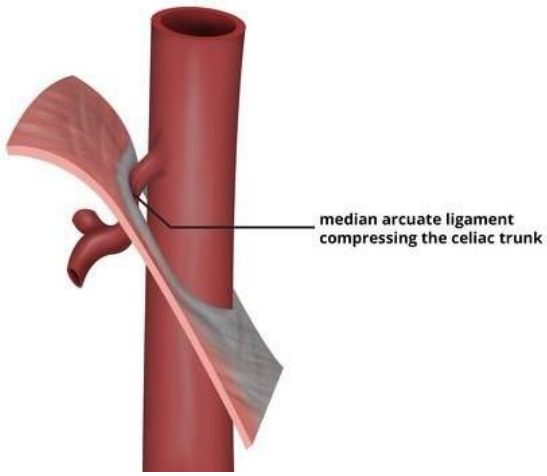


Figure 09: Median arcuate ligament syndrome.

Incidence is most common in young women and presents with epigastric pain and weight loss.[53]

Typically, findings can be seen at CT enterography in arterial phase. Focal narrowing is seen in proximal celiac artery. Hooked appearance is seen in the narrowed segment. This with no atherosclerotic changes in the adjacent aorta and proximal celiac segment helps differentiate MALS from atherosclerotic narrowing. In severe stenosis, post-stenotic dilatation is seen. In some cases, hemodynamic compensation is present in the form of collateral vessels between branches of the celiac axis and the SMA, normally via the pancreatico-duodenal arcade.[53]

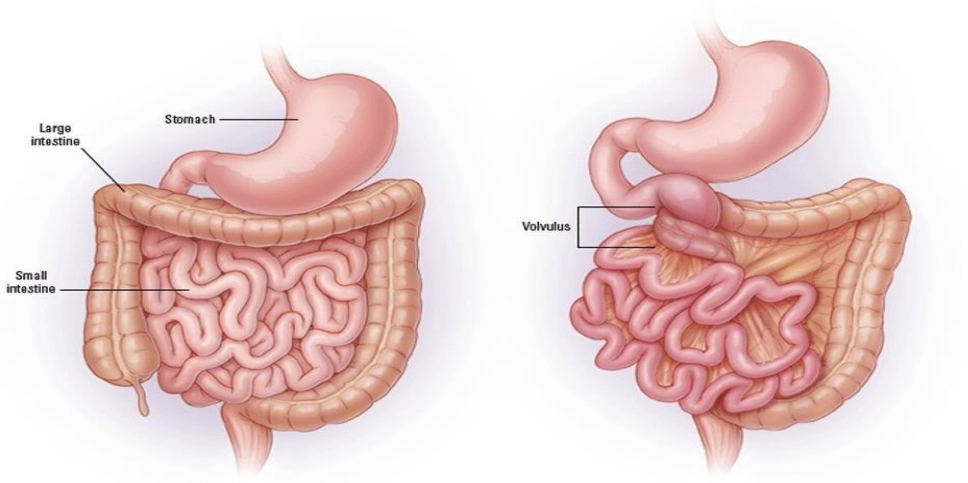


Figure 10: Normal & malrotated gut.

MIDGUT MALROTATION

Intestinal malrotation is defined broadly as any deviation of the midgut from normal 270^{o} counterclockwise rotation during embryologic development. Types: [54]

1. Non rotation of gut
2. Malrotation of gut
3. Reversed rotation of gut

Malrotation does not result only in the malposition of the bowel. It also results in the malfixation of the mesentery. Normally broad mesenteric attachment is shortened to a narrow pedicle which predisposes the patient to complication of midgut volvulus. Another complication of malrotation in adults is internal hernia in relation to the abnormal peritoneal fibrous bands of ladd that attach to the right colon.[54]

ROLE OF CT ENTEROGRAPHY IN IMAGING MALROTATION

Conventional radiography cannot be used for malrotation as it is neither sensitive nor specific. Right sided jejunal markings and absence of stool-filled colon in the right lower quadrant may indicate in some cases. Barium series of upper gastrointestinal tract is accurate in detection. The rules of pediatric radiology apply to adults also which states duodenal-jejunal junction fails to cross the midline and lies

below the level of the duodenal bulb.[54]

In adults, Quiescent malrotation are nowadays being detected on cross sectional imaging (especially in CT enterography) performed for many conditions. In addition to intestinal malpositioning depicted by barium studies, CT also depicts other associated extraintestinal findings not depicted on conventional examinations. For instance, change in the normal relationship between the superior mesenteric artery (SMA) and superior mesenteric vein (SMV) is a useful indicator of malrotation. In most patients with quiescent malrotation, the SMA and SMV will show a vertical relationship or show left-right inversion.[54]

A complication of malrotation is midgut volvulus. There is clockwise twisting of the bowel around the SMA axis because of narrowed mesenteric attachment. This life-threatening condition requires emergency surgery. Repeated episodes of colicky abdominal pain with vomiting lasting for months or years are typical symptoms leading to imaging.[54]

Upper gastrointestinal examination shows the typical corkscrew appearance of the proximal small bowel in neonates. CT findings of midgut volvulus with malrotation are characteristic.

The swirling of bowel and mesentery twist around SMA axis is described as CT whirl or whirlpool sign. Other CT findings are duodenal obstruction, congestion of the mesenteric vasculature and underlying malrotation. [54]

INTERNAL HERNIAS

Internal hernias are formed due to viscus herniating through a normal or abnormal aperture within the peritoneal cavity. 50% internal hernias are comprised of paraduodenal hernias. Other internal hernias include transmesenteric, transomental, pericecal, intersigmoid, and retro anastomotic hernias; herniation through the foramen

of winslow or broad ligament; and supravesical hernias. [55]

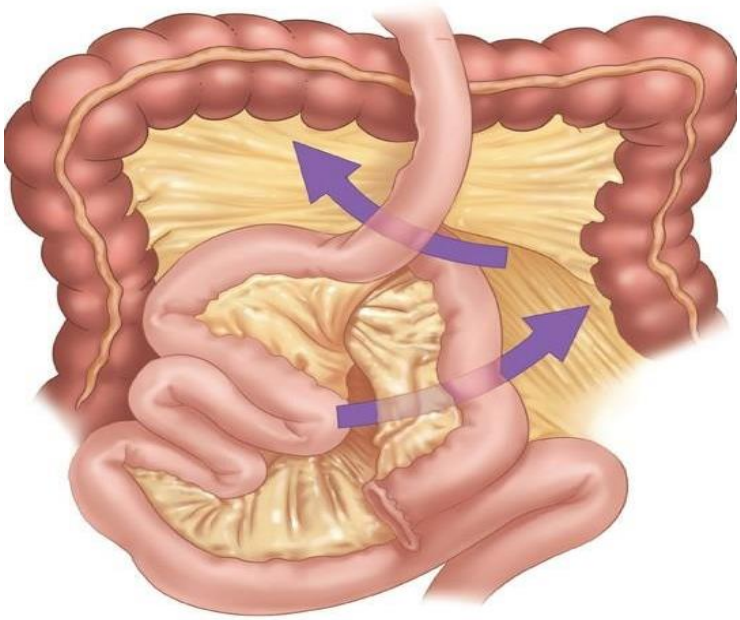


Figure 11: Internal hernia.

CT enterography may play an important role in establishing the diagnosis. The most important CT finding reported in the literature is a saclike mass of clustered small bowel loops with converging of engorged mesenteric vessels toward its orifice; the converging point of the mesenteric vessels and/or intestinal loops may indicate the site of hernia defect.[55]

Paraduodenal hernias are the most common type of internal hernia and are usually left sided. They often cause acute intestinal obstruction, but can also lead to chronic intermittent postprandial abdominal pain. A right paraduodenal hernia results from incomplete rotation of the duodenum during development. They usually contain single small bowel. The anterior wall of the sac is formed by transverse colon and mesentery of the ascending colon. The entrance into the hernia sac is most commonly through mesentericoparietal fossa of waldeyer, which is in the first part of the jejuna mesentery immediately behind the superior mesenteric artery (SMA)and inferior to the

third part of the duodenum.[55]

Left paraduodenal hernias also involve an anomaly of gut rotation. The bowel becomes entrapped behind the descending mesocolon in a hernia sac created by the fossa of landzert. CT enterography may show abnormal cluster of normal caliber or dilated bowel loops in an abnormal position either behind the body of the pancreas or between stomach and body of pancreas. There is usually a mass effect causing displacement of the posterior wall of the stomach, duodenojejunal flexure and transverse colon. The inferior mesenteric vein and ascending left colic artery are located anterior to the sac.[55]

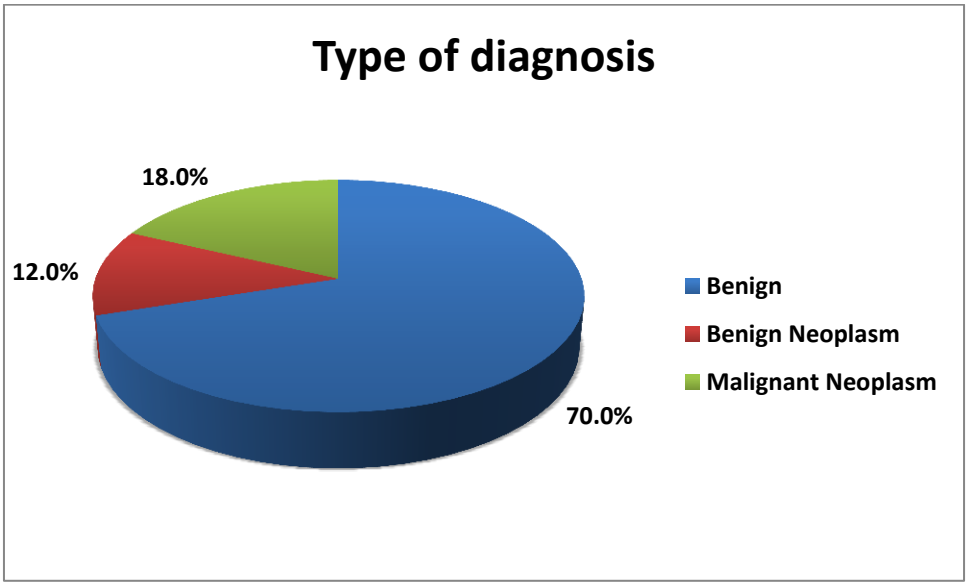
RESULTS AND ANALYSIS

The hospital based cross sectional study was done in the _____ _____ A total of 50 patients with the clinically suspected / diagnosed cases of small bowel diseases based on the inclusion and exclusion criteria from November 2017 to June 2019 were studied. The data obtained was coded and entered into the Microsoft excel spreadsheet. The data was analyzed and the final findings were tabulated as below.

Table 06: Type of diagnosis.

Type of diagnosis	No.	%
Benign	35	70
Benign Neoplasm	6	12
Malignant Neoplasm	9	18
Total	50	100

Figure 12: Type of diagnosis.

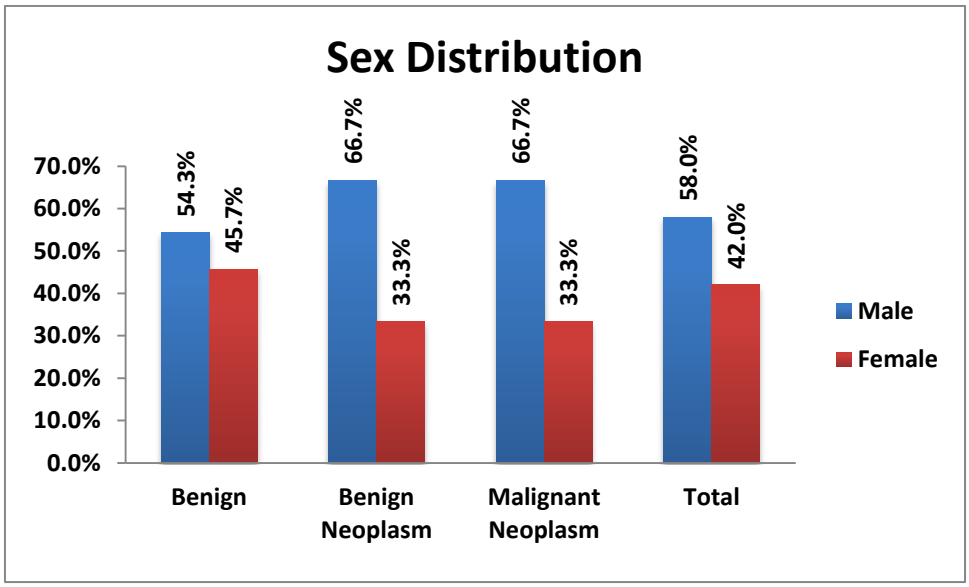


In the present study majority of the patients were diagnosed to have benign lesions (70%) followed by neoplastic lesions (30%). Out of these neoplastic lesions, majority was malignant neoplasm (18%) and rest were benign neoplasms (12%).

Table 07: Distribution of lesion according to sex

Sex	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
Male	19	54.3	4	66.7	6	66.7	29	58.0
Female	16	45.7	2	33.3	3	33.3	21	42.0
Total	35	100.0	6	100.0	9	100.0	50	100.0

Figure 13: Distribution of lesion according to sex

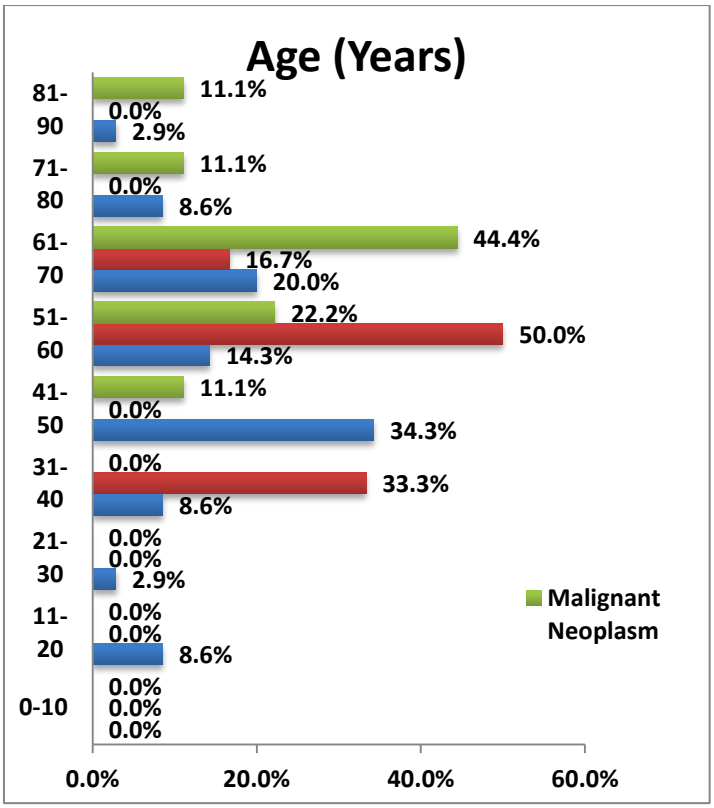


In this study, most of the patients were males (58%). The male to female ratio was 1.38:1. In benign, benign neoplasm and malignant neoplasm majority of the patients were males (54.3%, 66.7% and 66.7%) respectively.

Table 08: Distribution of lesion according to age

Age (Years)	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
0-10	0	0.0	0	0.0	0	0.0	0	0.0
11-20	3	8.6	0	0.0	0	0.0	3	6.0
21-30	1	2.9	0	0.0	0	0.0	1	2.0
31-40	3	8.6	2	33.3	0	0.0	5	10.0
41-50	12	34.3	0	0.0	1	11.1	13	26.0
51-60	5	14.3	3	50.0	2	22.2	10	20.0
61-70	7	20.0	1	16.7	4	44.4	12	24.0
71-80	3	8.6	0	0.0	1	11.1	4	8.0
81-90	1	2.9	0	0.0	1	11.1	2	4.0
Total	35	100	6	100	9	100	50	100

Figure 14: Distribution of lesion according to age.

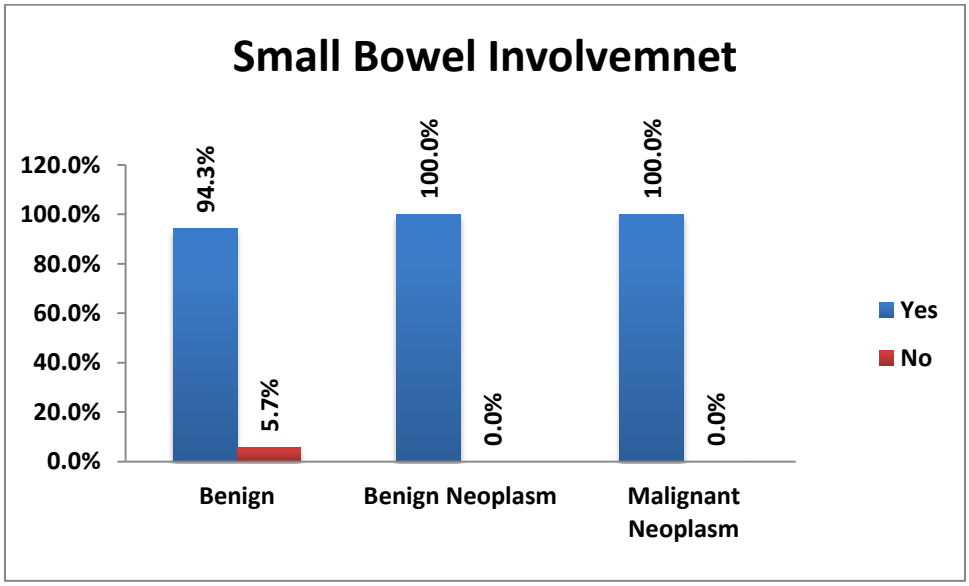


In the present study, the commonest age group was 41 to 50 years comprised of 26% of the patients. Maximum patients with benign lesions were aged between 41 to 50 years (34.3%). Maximum patients with benign neoplasms between 51 to 60 years (50%) and malignant neoplasms between 61 to 70 years (44.4%).

Table 09: Small bowel involvement

Small Bowel Involvement	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
Yes	33	94.3	6	100.0	9	100.0	48	96.0
No	2	5.7	0	0.0	0	0.0	2	4.0
Total	35	100.0	6	100.0	9	100.0	50	100.0

Figure 15: Small bowel involvement.

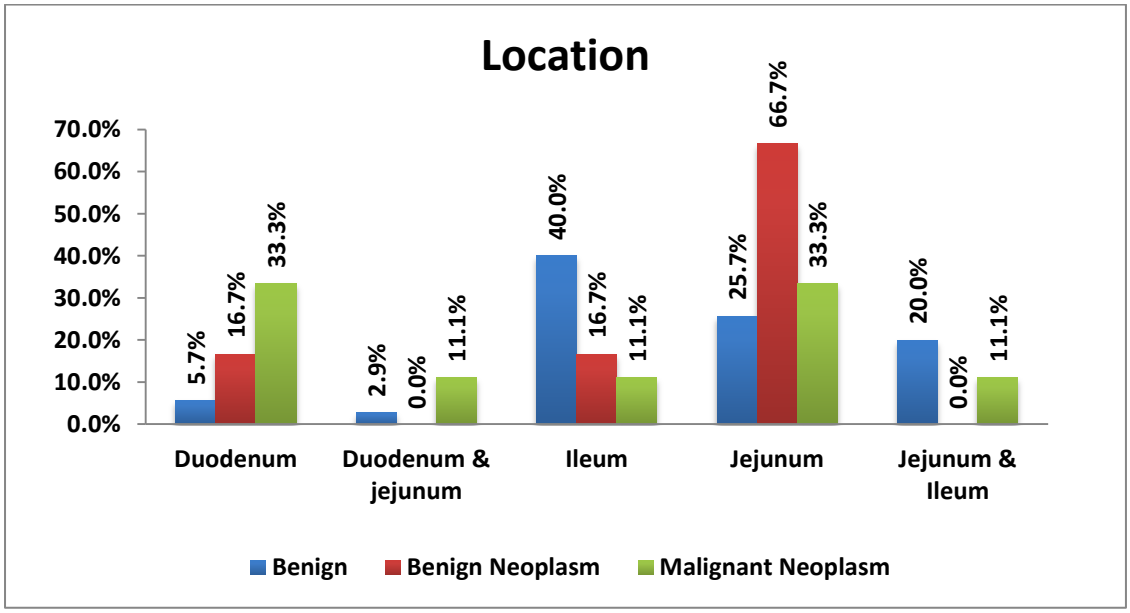


In this study involvement of small bowel loops was noted in the majority of the patients (96%). In 4% of the cases, adjacent mesentery was involved without involvement of bowel loops.

Table 10: Location of pathology in the small bowel

Location	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
Duodenum	2	5.7	1	16.7	3	33.3	6	12.0
Duodenum & jejunum	1	2.9	0	0.0	1	11.1	2	4.0
Ileum	14	40.0	1	16.7	1	11.1	16	32.0
Jejunum	9	25.7	4	66.7	3	33.3	16	32.0
Jejunum & Ileum	7	20.0	0	0.0	1	11.1	8	16.0
Total	35	100.0	6	100.0	9	100.0	50	100.0

Figure 16: Location of pathology in the small bowel

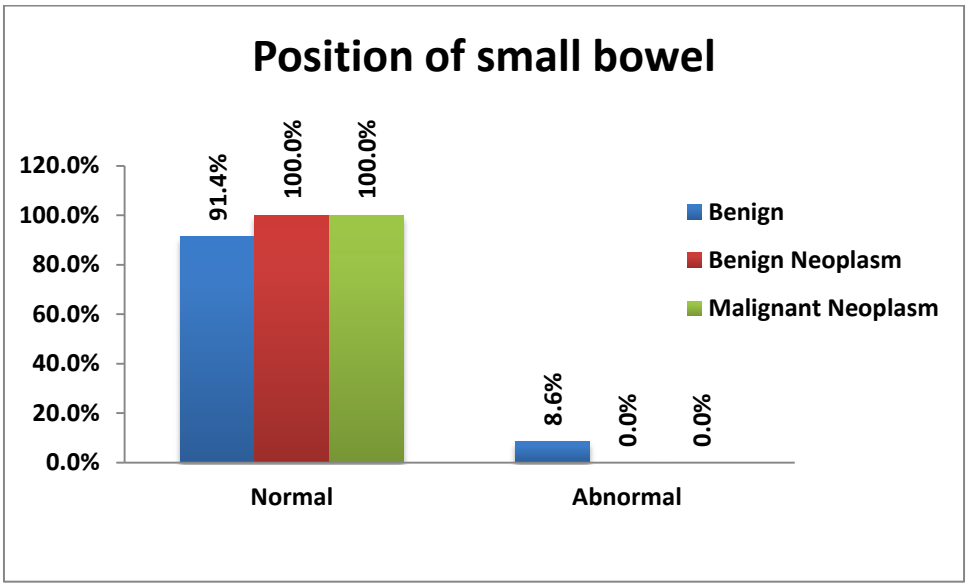


In the present study, the commonest location of the pathology in the small bowel was jejunum & ileum, noted in 32% each. Among the patient with benign lesions, the commonest location was ileum (40%) and in benign neoplastic lesions, 66.7% of the patients were detected in jejunum. Malignant neoplastic lesions were most commonly noted in duodenum & jejunum (33.3% each).

Table 11: Position of small bowel

Position of small bowel	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
Normal	32	91.4	6	100.0	9	100	47	94
Abnormal	3	8.6	0	0.0	0	0.0	3	6
Total	35	100	6	100	9	100	50	100

Figure 17: Position of small bowel

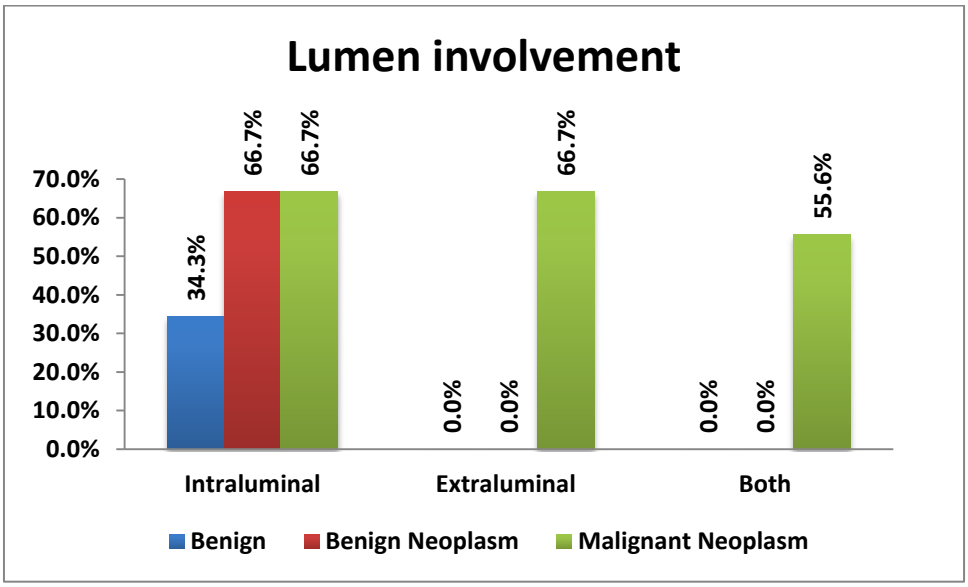


In this study, majority of the patients were found to have normal position of the bowel (94%). In 6% of patients, there was abnormal positioning of small bowel loops which is grouped under benign lesions.

Table 12: Lumen involvement

Lumen involvement	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
Intraluminal	12	34	4	66.7	6	66.7	22	44
Extraluminal	0	0	0	0	6	66.7	6	12
Both	0	0	0	0	5	55.6	5	10

Figure 18: Lumen involvement

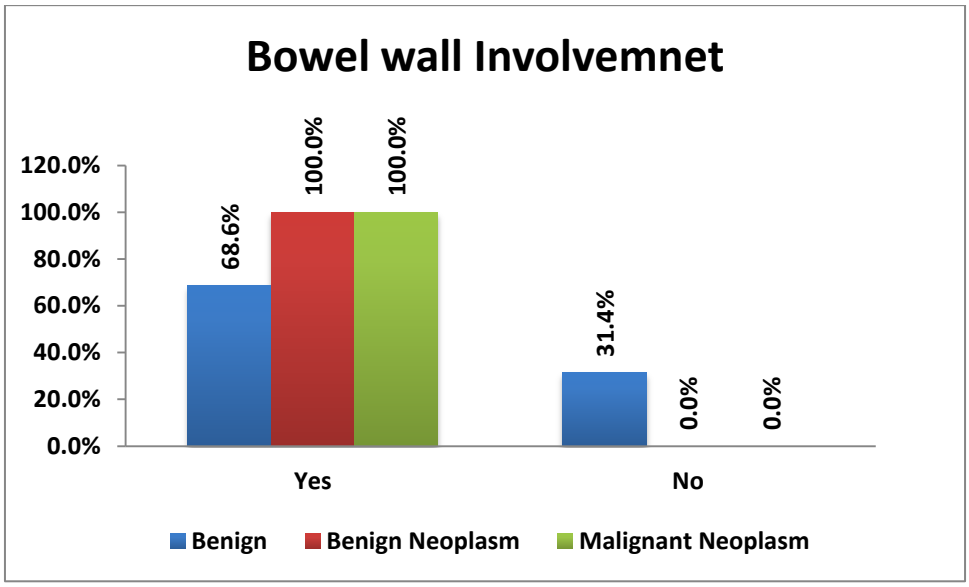


In the present study, intraluminal involvement was noted in 22 cases (44%). Among the patients with benign lesions 34.2% had intraluminal involvement while in cases with benign neoplasms, 66.7% had intraluminal involvement. In malignant lesions, 66.7% of the cases had extraluminal and intraluminal involvement respectively with 55.6% involving both.

Table 13: Bowel wall involvement

Bowel wall Involvemnet	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
Yes	24	68.6	6	100	9	100	39	78
No	11	31.4	0	0.0	0	0.0	11	22
Total	35	100	6	100	9	100	50	100

Figure 19: Bowel wall involvement.

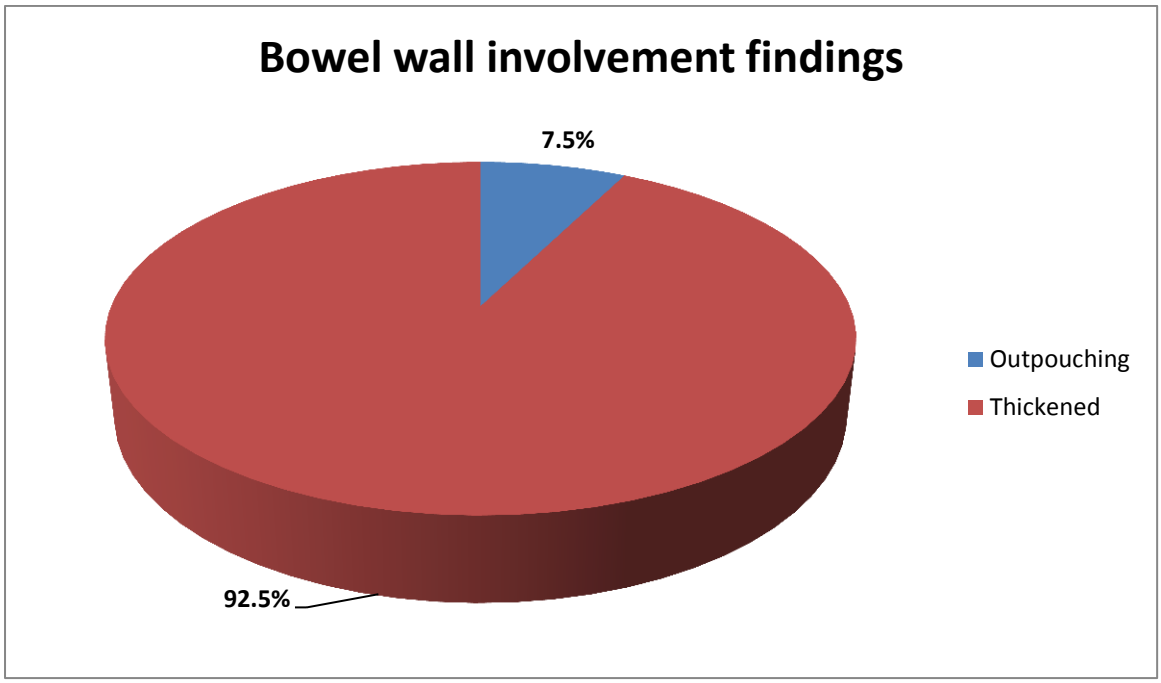


In this study bowel wall involvement was noted in 78% of the patients. In patients with benign group of lesions, the involvement of bowel wall was present in 68.6%. In benign neoplasm & malignant neoplasm group, wall of small bowel was involved in 100% of the cases.

Table 14: Bowel wall involvement findings

Bowel wall involvement findings	Total	
	No.	%
Oupouching	3	7.5
Thickened	37	92.5
Total	40	100.0%

Figure 20: Bowel wall involvement findings

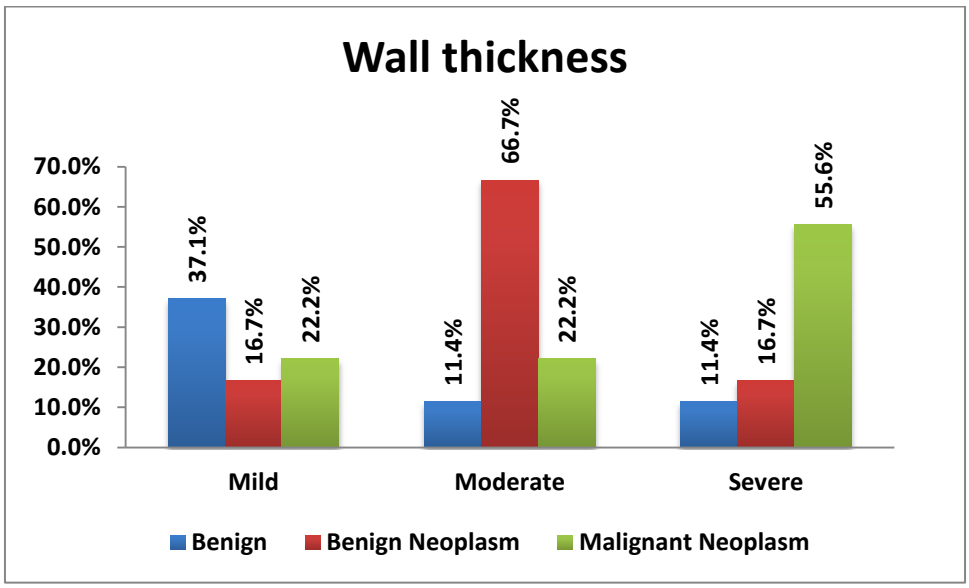


In the present study, out of 40 patients with bowel wall involvement 92.5% of cases were classified as thickened bowel wall. Rest cases (7.5%) were cases of diverticula from the small bowel.

Table 15: Degree of small bowel wall thickness

Wall thickness	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
Mild	13	61.9	1	16.7	2	22.2	16	44.44
Moderate	4	19.04	4	66.7	2	22.2	10	27.77
Severe	4	19.04	1	16.7	5	55.6	10	27.77
Total	21	100	6	100	9	100	36	100

Figure 21: Degree of small bowel wall thickness

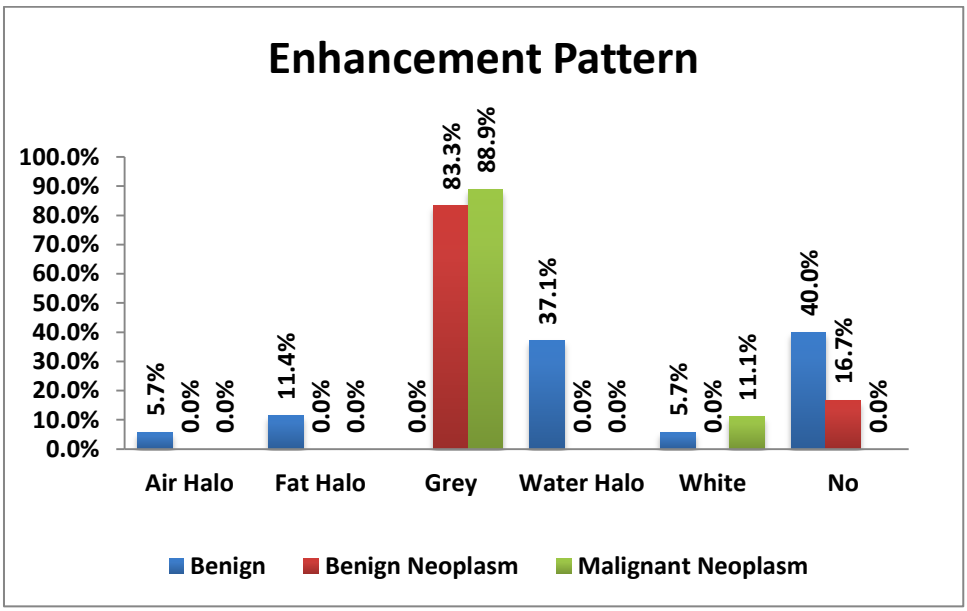


In this study, out of 36 cases that showed thickened walls, majority of the cases (44.44%) had mild bowel thickness out of which most were benign pathologies (61.9%). In those with benign neoplasms majority of cases had moderate bowel thickening (66.7). Severe bowel thickening was seen in most cases of malignant neoplasm (55.96%).

Table 16: Pattern of wall enhancement

Enhancement Pattern	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
Air Halo	2	9.52	0	0	0	0	2	5.71
Fat Halo	4	19.04	0	0	0	0	4	11.42
Grey	0	0	5	100	8	88.9	13	37.14
Water Halo	13	61.9	0	0	0	0.0	13	37.14
White	2	9.52	0	0	1	11.1	3	8.57
Total	21	100.0	5	100	9	100	35	100.0

Figure 22: Pattern of wall enhancement.

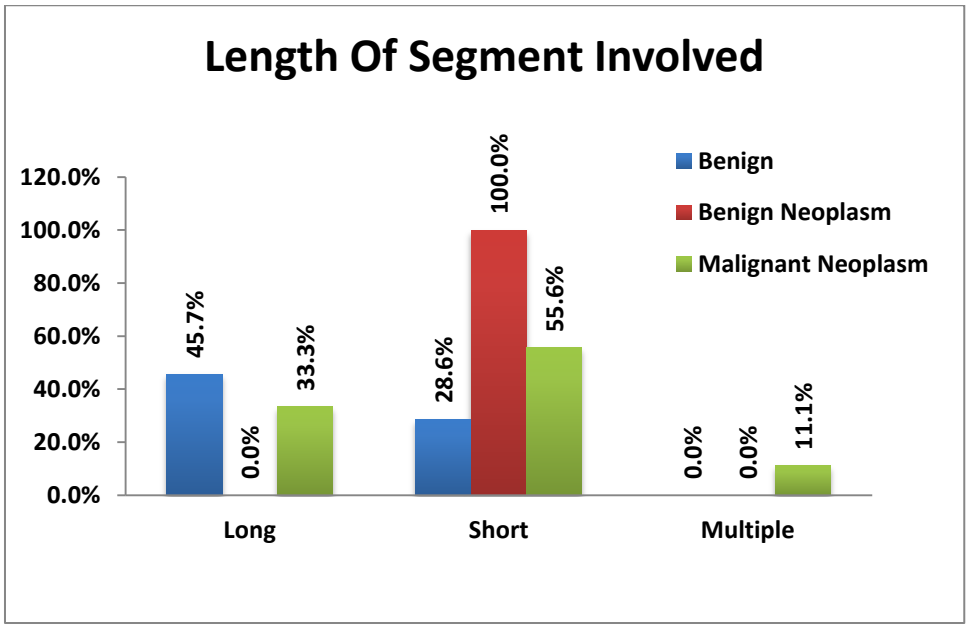


In the present study, cases with small bowel thickening, majority of the patients had grey & water halo pattern of enhancement (37.14% each) followed by fat halo, white & air halo patterns of enhancement (11.42%, 8.57% & 5.71 % respectively). Among the patients with benign lesions, 61.9% had water halo pattern of enhancement whereas in those with malignant neoplasm, grey enhancement pattern was noted in 88.9% of the cases.

Table 17: Length of the thickened segment

Length Of Segment Involved	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
Long	16	61.53	0	0	3	33.3%	19	46.34
Short	10	38.46	6	100	5	55.6%	21	51.21
Multiple	0	0	0	0	1	11.1%	1	2.43
Total	26	100	6	100	9	100.0%	41	100

Figure 23: Length of the thickened segment

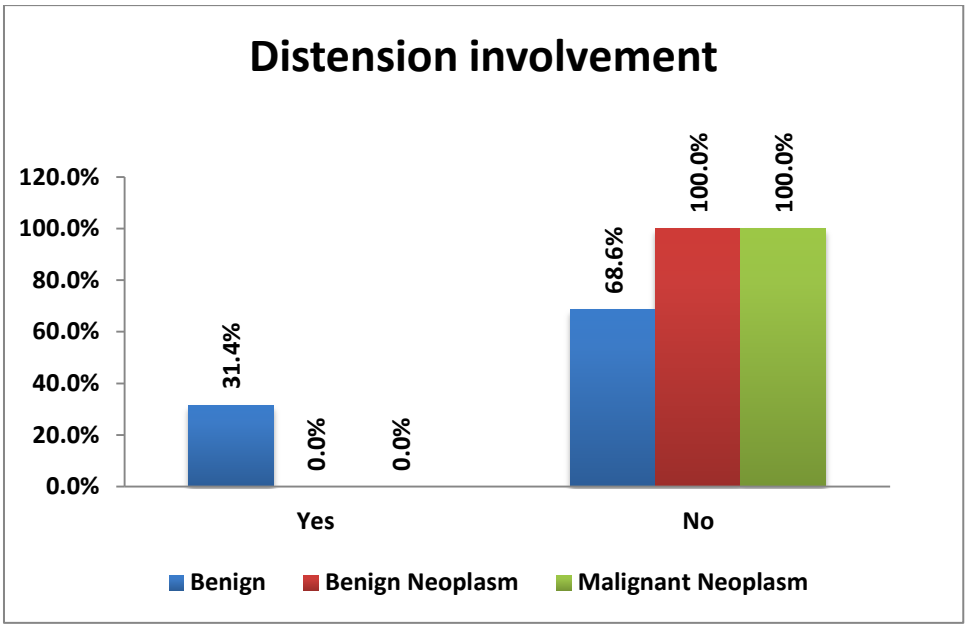


In this study, length of the involved bowel segment were classified under three categories and short segmental type was most commonly noted in 51.21% of the patients. In patient with benign lesions most of the patients had long segment involvement (61.53%). All benign neoplasm had short segment involvement. In malignant neoplasm, 55.6% cases had short segment involvement followed by long segment & multiple segments (33.3% & 11.1% respectively).

Table 18: Distension of bowel loop

Distension	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
Yes	11	31.4	0	0	0	0	11	22
No	24	68.6	6	100	9	100	39	78
Total	35	100	6	100	9	100	50	100

Figure 24: Distension of bowel loop

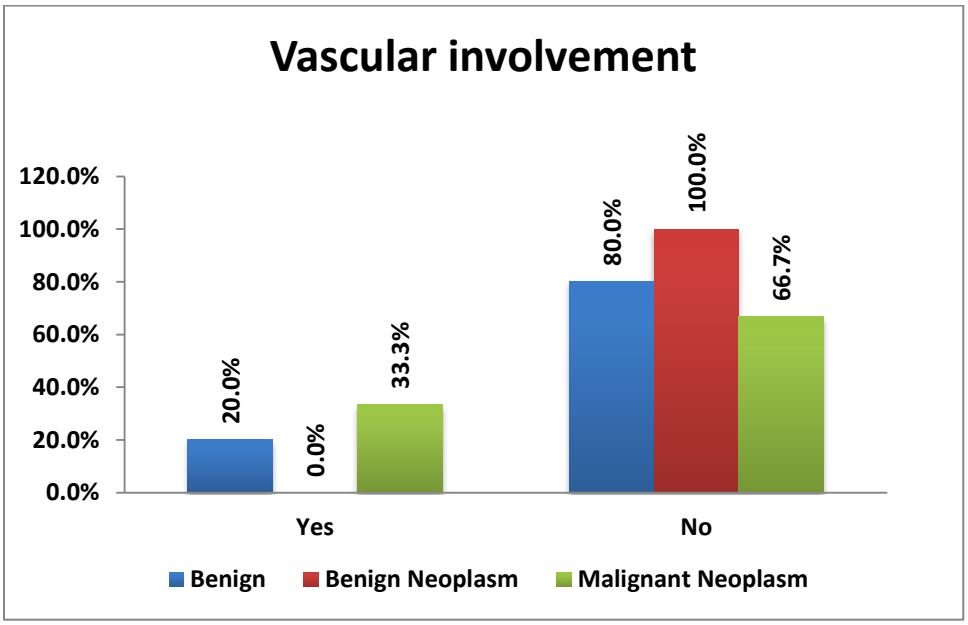


In the present study 22% of the patient had bowel distension out of which all were benign pathologies majority including bowel obstruction. There was a case of superior mesenteric artery syndrome involving distension of duodenum. There was no evidence of bowel distension in benign & malignant neoplasm.

Table 19:Vascular involvement

Vascular involvement	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
Yes	7	20	0	0	3	33	10	20
No	28	80	6	100	6	66.7	40	80
Total	35	100	6	100	9	100	50	100

Figure 25: Vascular involvement

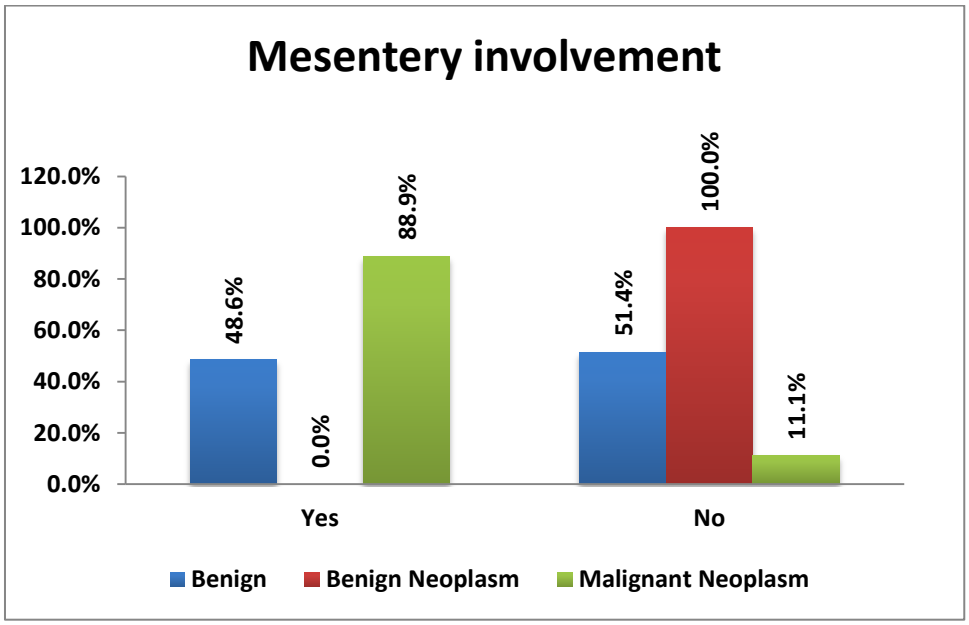


In the present study, vascular involvement was present in 20% of the patients. The vascular involvement was present in 20% of the benign lesion out of which majority were cases of bowel ischemia. 33.3% cases of malignant neoplasm had vascular involvement which were cases of GIST, adenocarcinoma & metastasis. There was no vascular involvement in benign neoplasms.

Table 20: Mesentery involvement

Mesentery involvement	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
Yes	17	48.6	0	0	8	88.9	25	50
No	18	51.4	6	100	1	11.1	25	50
Total	35	100	6	100	9	100	50	100

Figure 26: Mesentery involvement

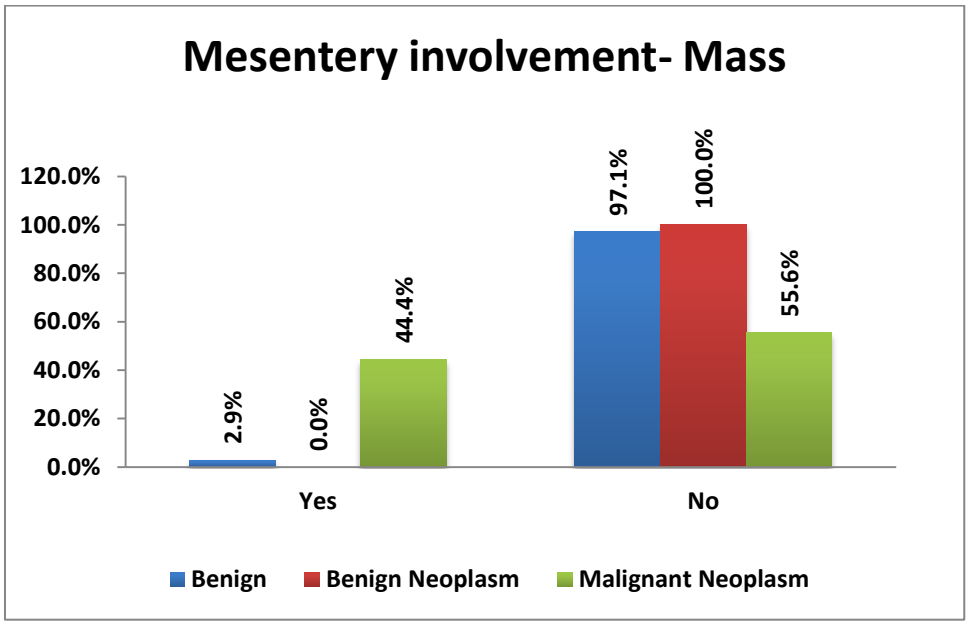


In the present study, involvement of mesentery was present in 50% of the patients. The involvement of mesentery was present in 48.6% of the benign lesions and 88.9% cases of malignant neoplasm.

Table 21: Mesenetry involvement –mass

Mesentery involvement- Mass	Benign		Benign Neoplasm		Malignant Neoplasm		Total	
	No.	%	No.	%	No.	%	No.	%
Yes	1	2.9	0	0.0	4	44.4	5	10
No	34	97.1	6	100	5	55.6	45	90
Total	35	100	6	100	9	100	50	100

Figure 27: Mesentery involvement –mass



In the present study mass in the mesentery was present in 10% of the patients and the same was present in 2.9% of the benign lesion and 44.4% of the patient with malignant neoplasm.

Table 22: Diagnosis of benign lesions

Final Diagnosis	No.	%
Infectious Enteritis	8	22.9
Intestinal Obstruction	7	20
Ischemic Bowel	5	14.3
Koch'S	4	11.4
Crohn'S	3	8.6
Diverticulum	2	5.7
Intussusception	1	2.9
Koch'S Peritonitis	1	2.9
Meckel'S Diverticulum	1	2.9
Mesenteric Panniculitis	1	2.9
Midgut Volvulus	1	2.9
Superior Mesenteric Artery Syndrome	1	2.9

Figure 28: Diagnosis of benign lesions

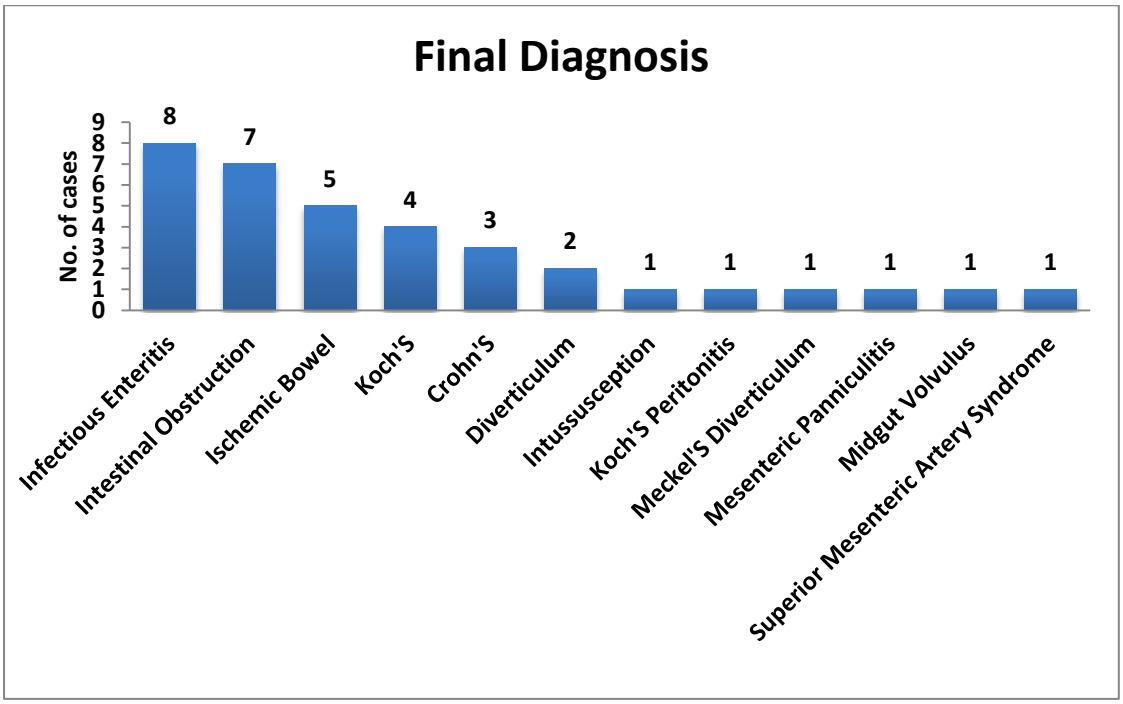


Table 22 and figure 28 shows the diagnosis of benign lesion based on CT enterography. The commonest diagnosis among benign pathologies were infectious enteritis (22.9%) followed bowel obstruction (20%).

Table 23: Diagnosis of Benign Neoplasm

Final Diagnosis	No.	%
Adenoma	4	66.7
Leiomyoma	1	16.7
Lipoma	1	16.7

Figure 29: Diagnosis of Benign Neoplasm

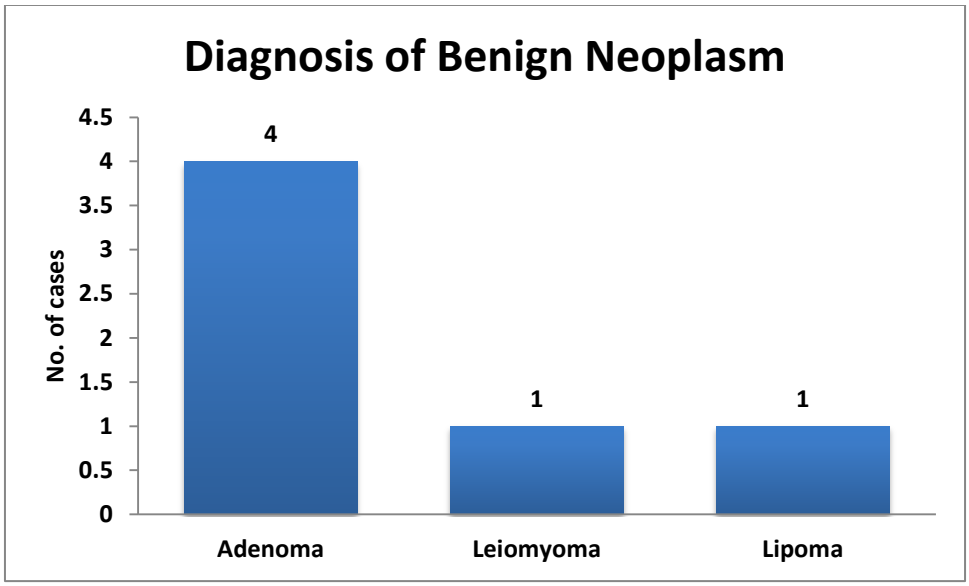


Table 23 and figure 29 shows the diagnosis of benign neoplasm based on CT enterography. The commonest diagnosis in benign neoplasm were adenomas (66.7%).

Table 24: Diagnosis of Malignant Neoplasm

Final Diagnosis	No.	%
Adenocarcinoma	4	44.4
Gist	2	22.2
Carcinoid	1	11.1
Lymphoma	1	11.1
Metastatic	1	11.1

Figure 30: Diagnosis of Malignant Neoplasm

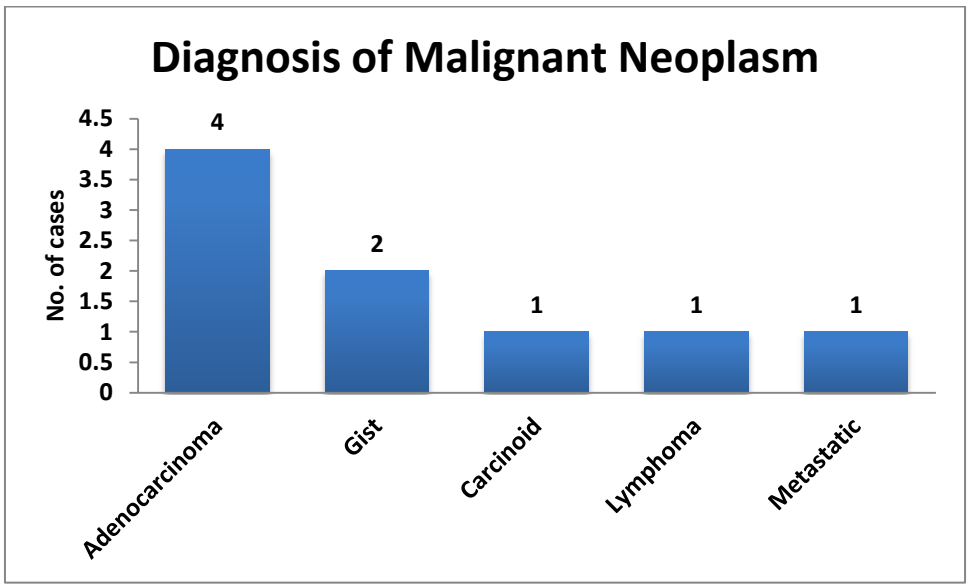


Table 23 and figure 30 shows the diagnosis of malignant neoplasm based on CT enterography. The commonest diagnosis in malignant neoplasm were adenocarcinomas (44.4%).

Table 25: Diagnosis of Total cases

Final Diagnosis	No.	%
Infectious Enteritis	8	16
Intestinal Obstruction	7	14
Ischemic Bowel	5	10
Adenocarcinoma	4	8
Adenoma	4	8
Koch'S	4	8
Crohn'S	3	6
Diverticulum	2	4
GIST	2	4
Carcinoid	1	2
Intussusception	1	2
Koch'S Peritonitis	1	2
Leiomyoma	1	2
Lipoma	1	2
Lymphoma	1	2
Meckel'S Diverticulum	1	2
Mesenteric Panniculitis	1	2
Metastatic	1	2
Midgut Volvulus	1	2
Superior Mesenteric Artery Syndrome	1	2

Figure 31: Diagnosis of Total cases

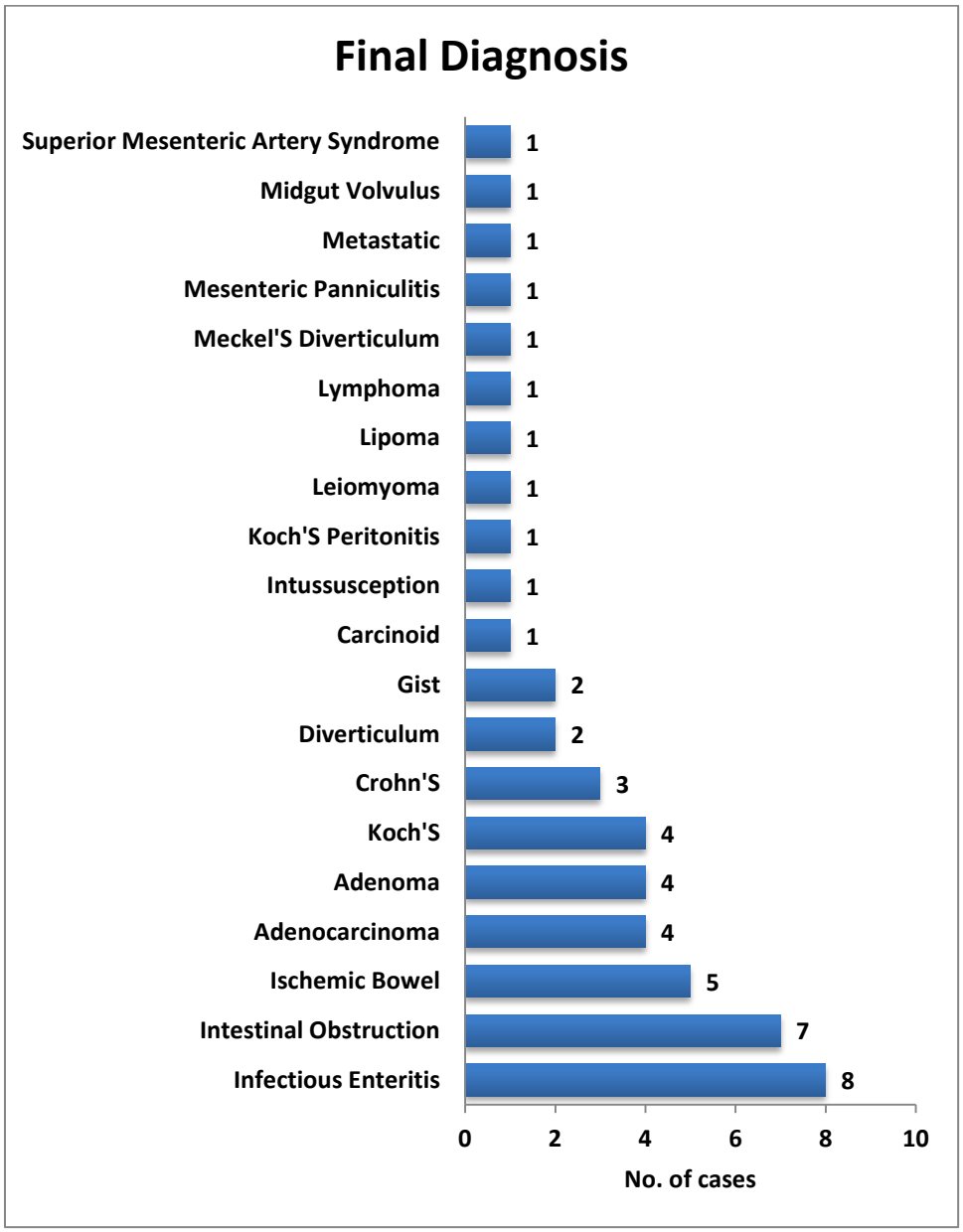


IMAGE GALLERY

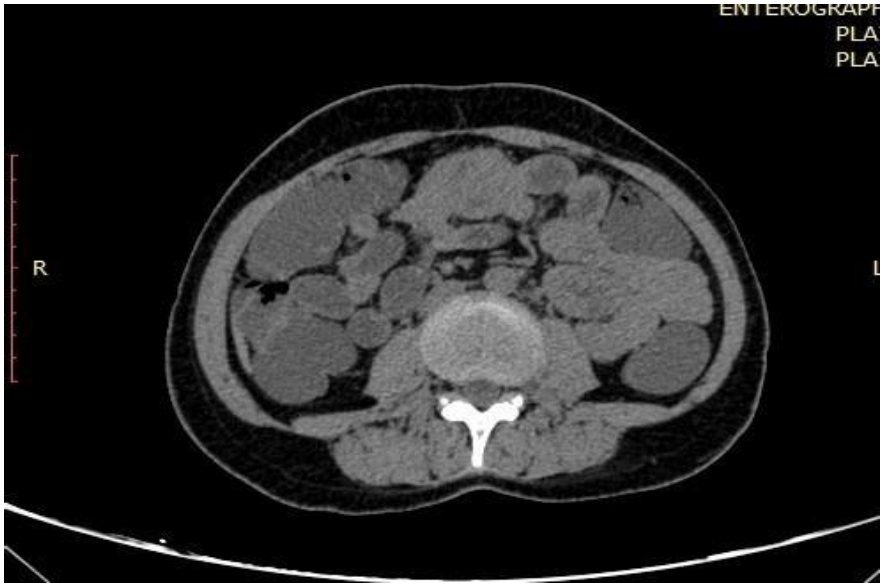


Figure 32: CT ENTEROGRAPHY; AXIAL VIEW

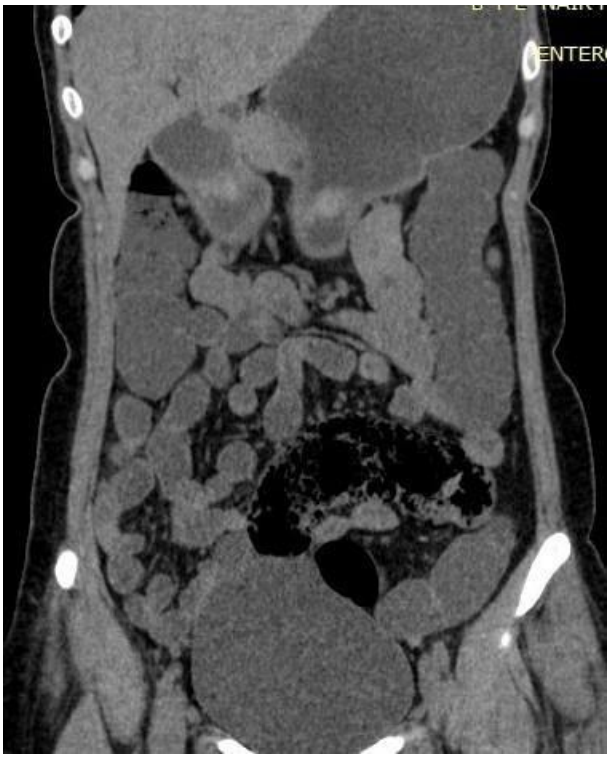


Figure 33: CT ENTEROGRAPHY; CORONAL VIEW

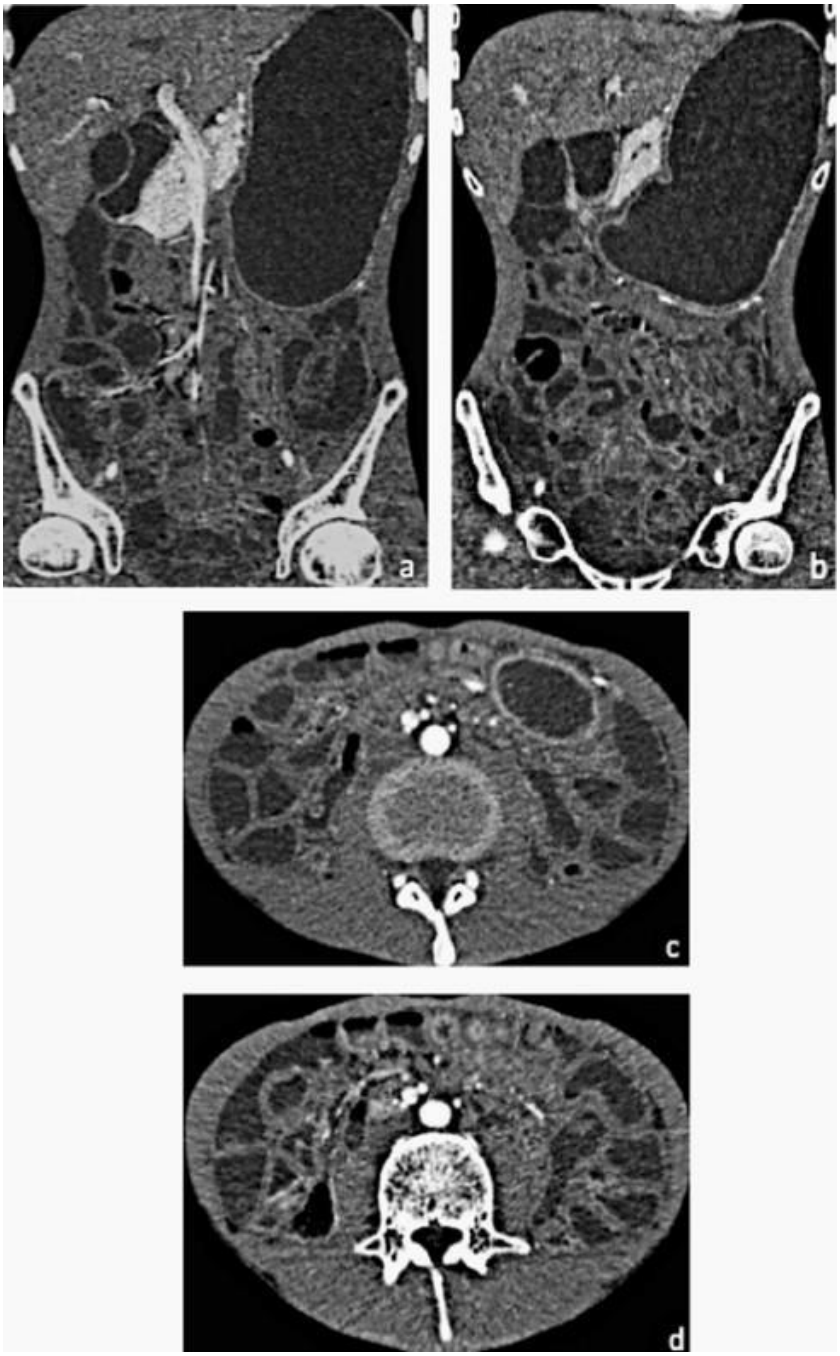


Figure 34: (a,b,c,d) CT enterography image showing homogenously enhancing mildly thickened bowel walls (arrow) in duodenum along with adjacent fat stranding. Diagnosis: Inflammatory / Infectious enteritis.

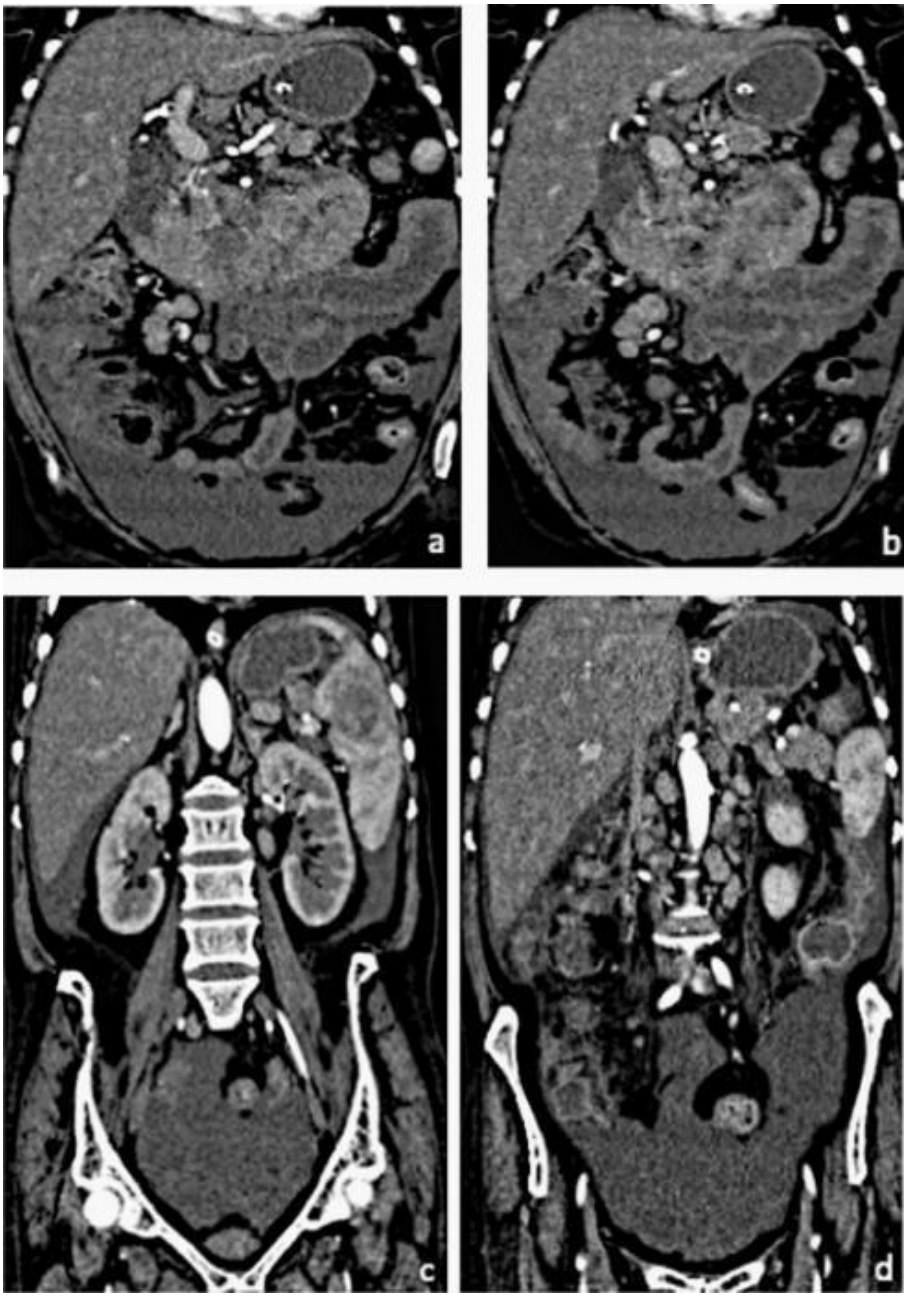


Figure 35: Reformatted CT enterographic images (Coronal) showing focal aneurysmal dilatation of jejunal loop with thickening(circumferential) and hyper-enhancement. Enlarged para-aortic, porta-hepatis, splenic and mesenteric lymph nodes seen (a and b). Reformatted CT enterographic images showing hepatosplenomegaly with focal lesion in spleen (c and d) Diagnosis: Lymphoma.

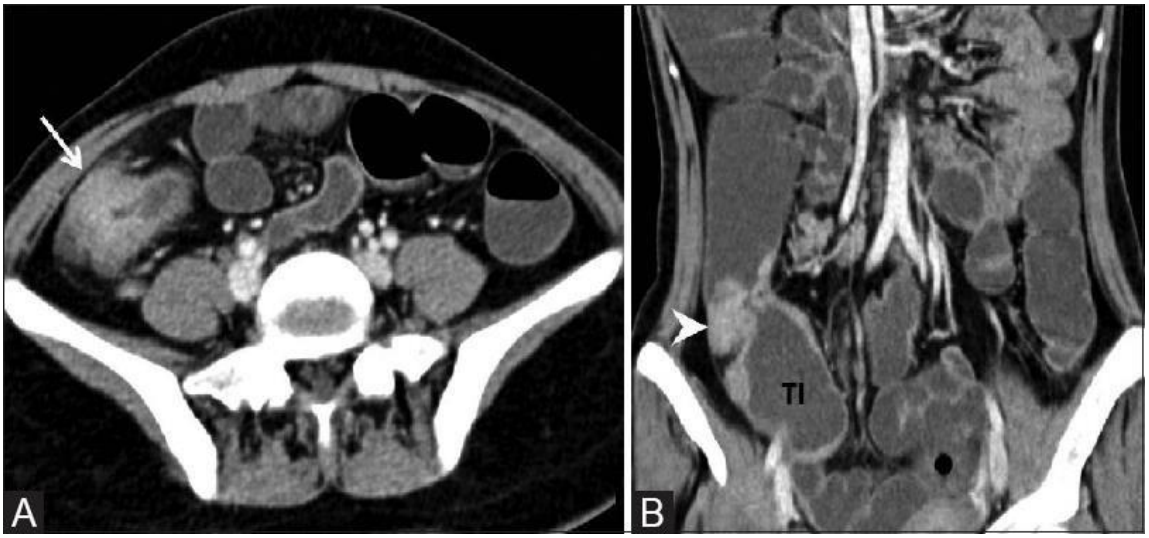


Figure 36: Axial (A) and coronal (B) CT enterography images of ileocecal tuberculosis showing gross thickened ileocecal valve (arrow). Thickening and contraction of cecum (arrow head) with pericecal fat stranding also noted. Dilated terminal ileum (TI) is noted. Diagnosis: Koch's bowel.

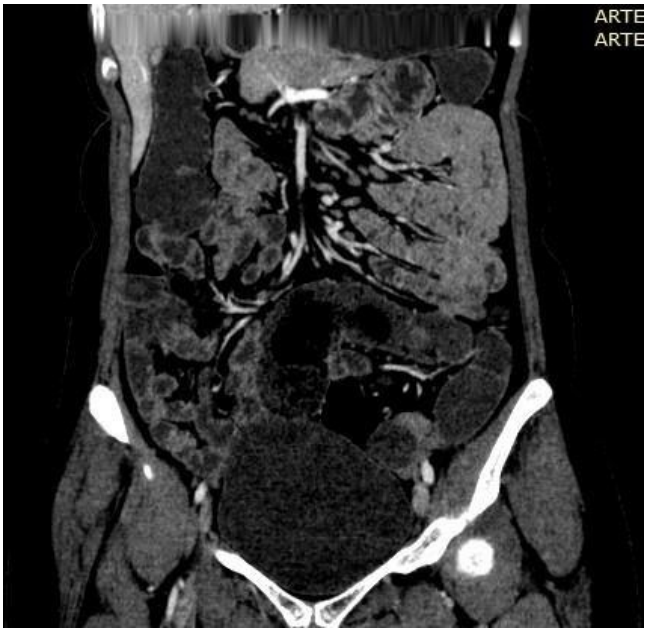
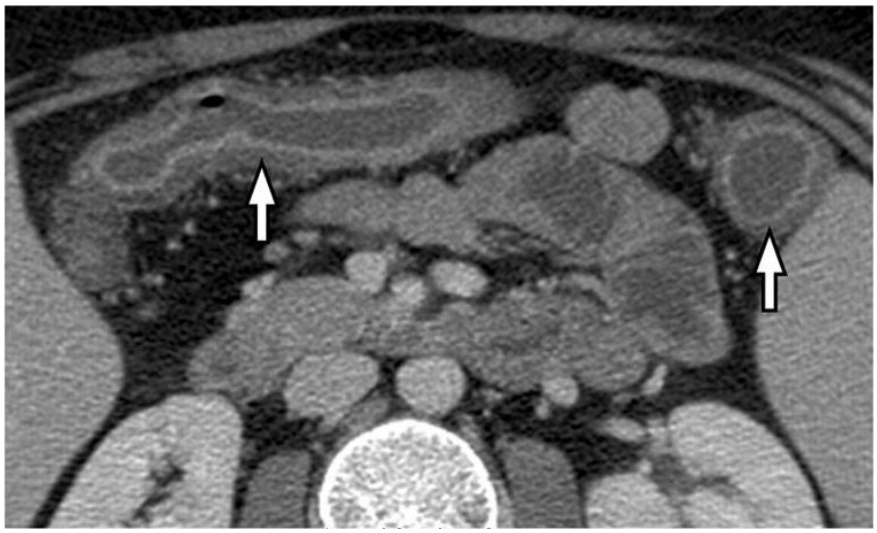


Figure 37: CT enterography image showing mildly thickened diminished enhancing bowel walls in jejunum Diagnosis: Ischemic bowel.

(A)



(B)

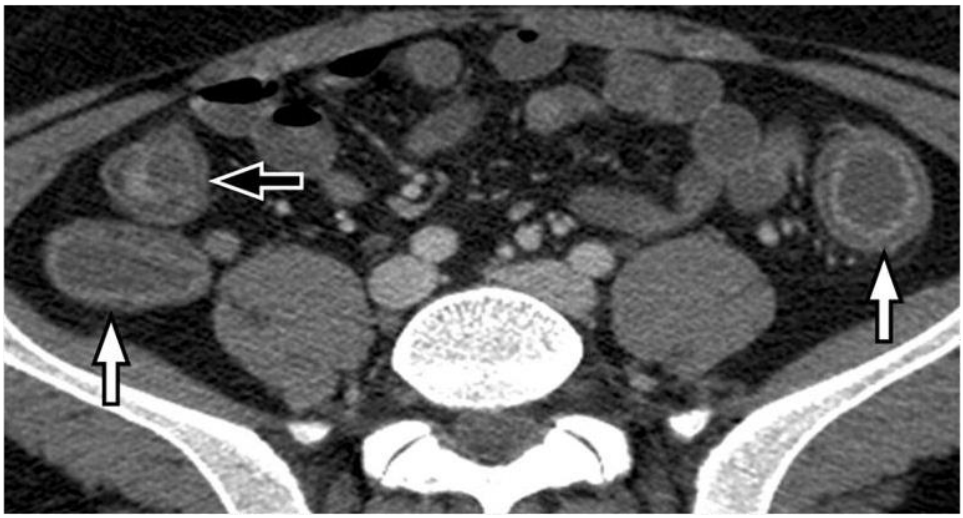


Figure 38: CT enterography image showing mildly thickened bowel loops (arrow) with mucosal enhancement, loss of haustration and submucosal fat proliferation in terminal ileum and large bowel loops.

Diagnosis: Inflammatory Bowel Disease likely to be ulcerative colitis with back wash ileitis.

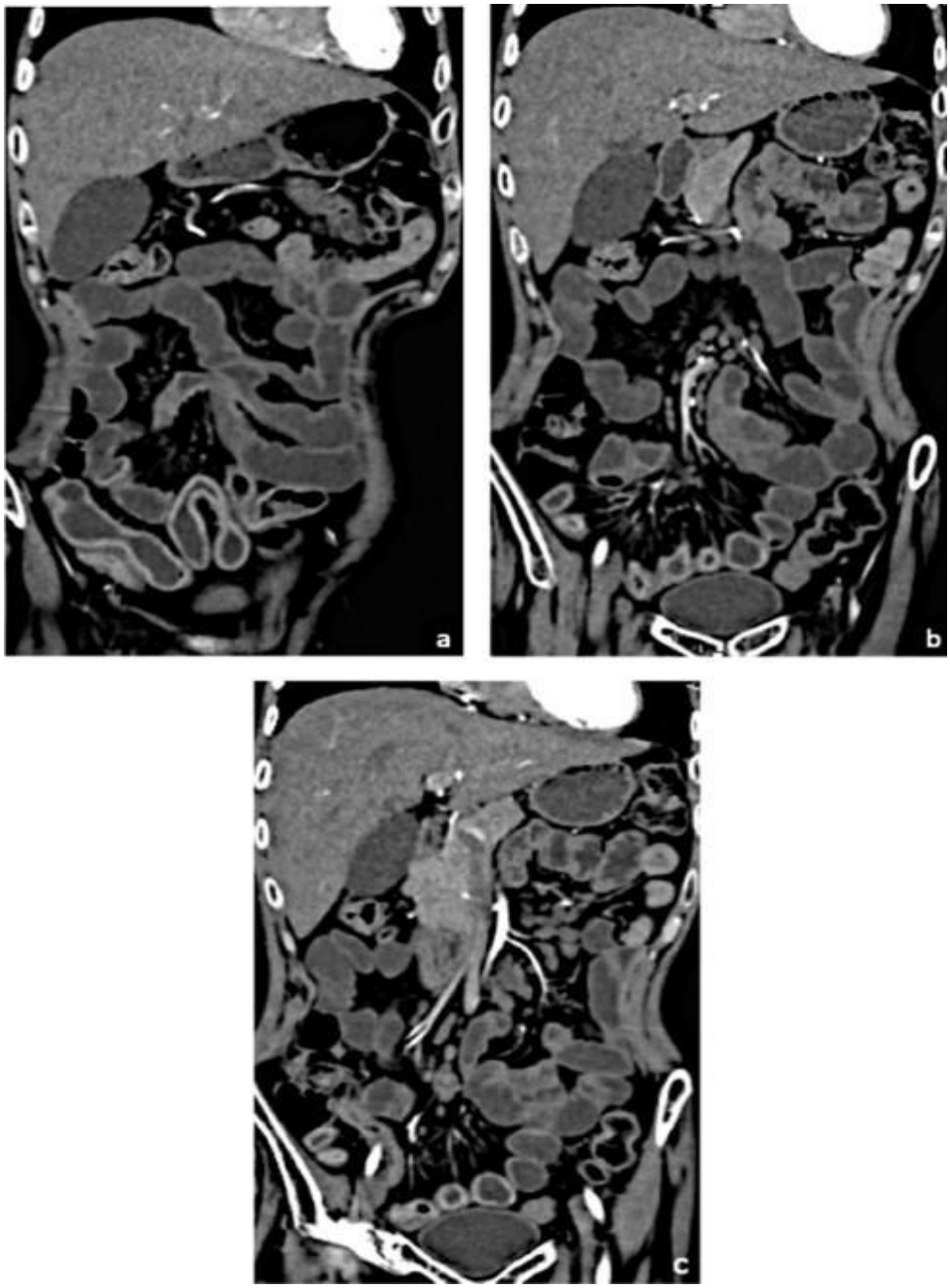


Figure 39: Reformatted CT enterographic images (Coronal) showing uniform intense enhancement of ileal loops with narrowed short segments which is alternating with calibered normal ones (a). Reformatted CT enterographic images (Coronal) showing vasa recta engorgement (positive Comb's sign) and subcentimetric multiple mesenteric lymph nodes (b and c). Diagnosis is Crohn's disease.

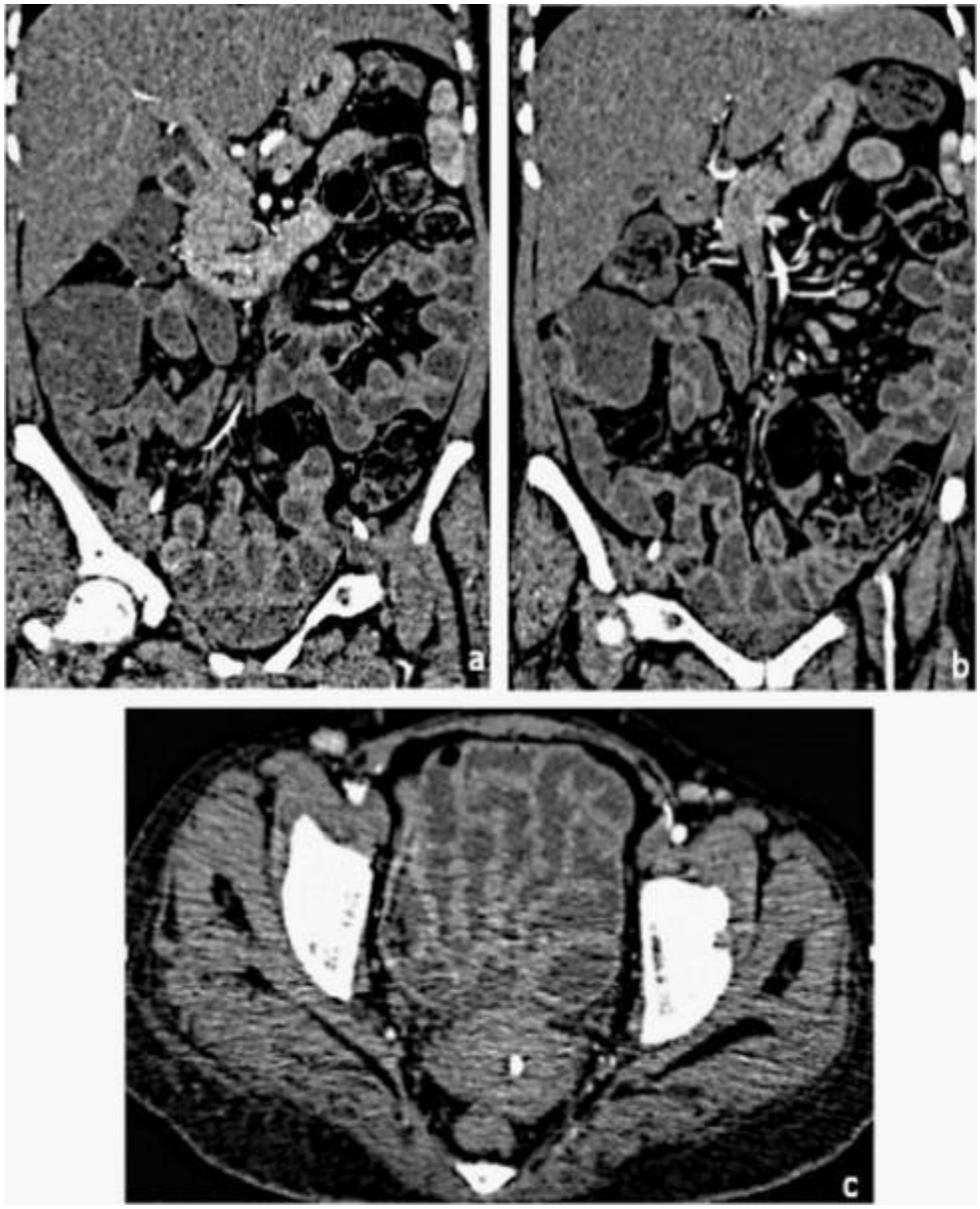


Figure 40: Reformatted CT enterographic images (Coronal) (a and b) and CT enterographic image (axial) (c) showing prominent ileal mucosal folds (reversed fold pattern), reduced jejunal and enlarged multiple mesenteric lymph nodes.

Diagnosis: Celiac disease

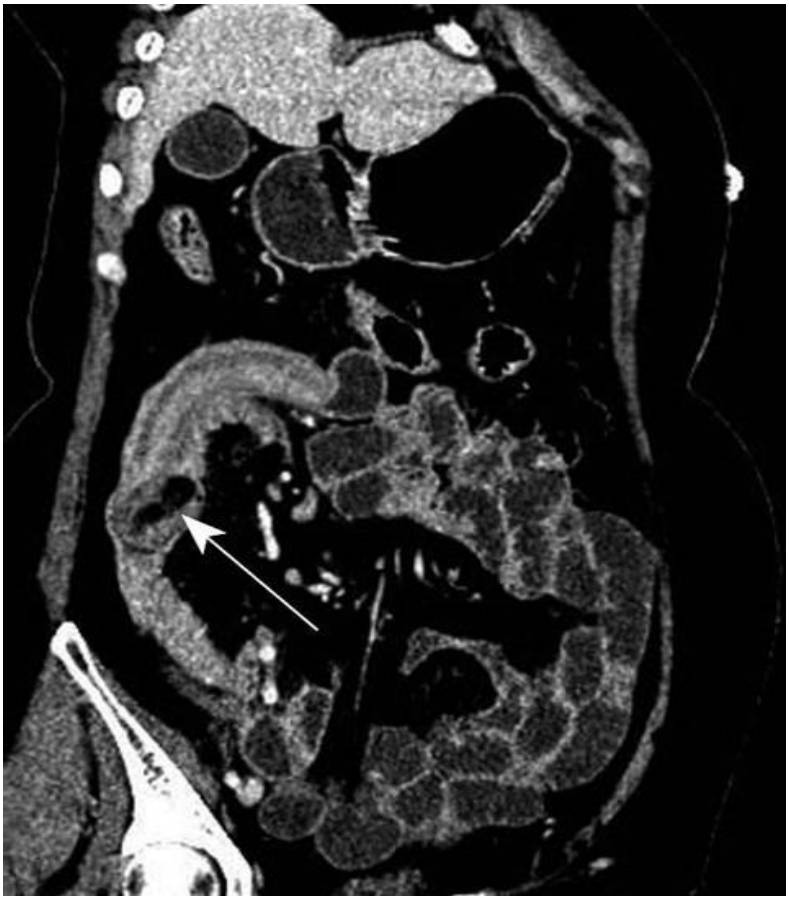


Figure 41: CT enterography image showing intraluminal non enhancing fat attenuating lesion (arrow) in small bowel.
Diagnosis: Small bowel lipoma.

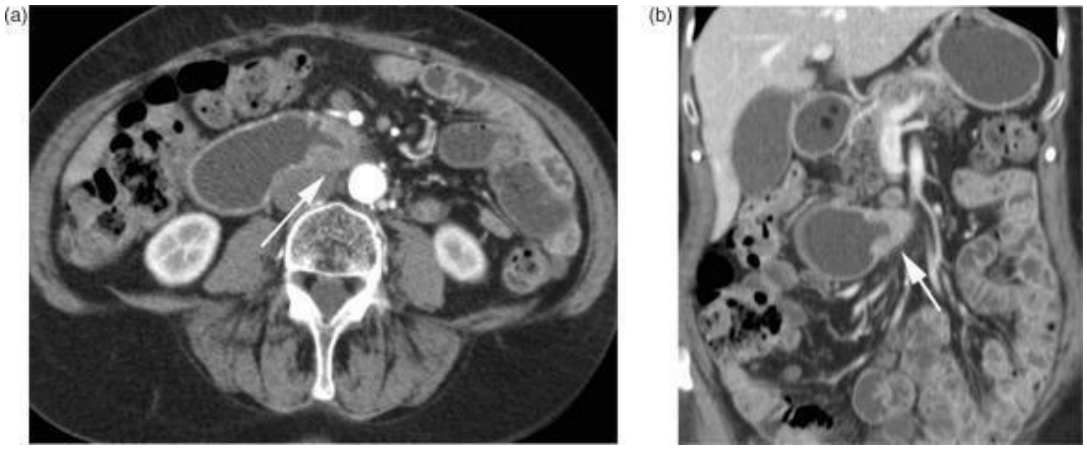


Figure 42: (a) Axial and (b) coronal CT enterography images with contrast-enhanced circumferential wall thickening of the horizontal part of the duodenum (arrow) causing stenosis with prestenotic dilatation.
Diagnosis: Duodenal adenocarcinoma.

DISCUSSION

Many types of infections, inflammatory, neoplastic and vascular diseases affect the small bowel resulting in various clinical presentation that usually overlap. Computed tomography (CT) is an essential tool in evaluation of small bowel both in outpatient, inpatient and emergency room settings, replacing the radiographic small-bowel follow-through (SBFT) examination. The development of multidetector CT (MDCT) scanners and associated shorter scan times with them has increased the utility of CT further in the evaluation of vascular abnormalities affecting the small bowel because of the ability to scan multiple acquisitions during different phases of enhancement. The multiplanar capabilities of MDCT, along with the development of CT enterography as an useful tool in the detailed characterization of inflammatory disease and improved detection of small-bowel neoplasms.[56] This study was done to characterize small bowel pathologies on multi-detector computerized tomography enterography.

This one cross sectional study was carried out in the Department of Radio-diagnosis, _____ from Nov 2017 - June 2019. A total of 50 patients clinically suspected or were known to have small intestinal diseases were studied.

In this study, males (58%) outnumbered females and the male to female ratio was 1.38:1. The commonest age group was between 41 to 50 years comprised of 26% of the patients. These findings suggest higher frequency of small bowel disease among males and patients are likely to have small bowel diseases in fourth and fifth decades of life. However there isn't any fixed sex preponderance in small bowel pathologies, results can vary with season or geographical location of the study.

In the present study, out of 50 patients 35 (70%) patients had benign lesions and

15 (30%) had neoplastic lesions. Of the 15 patients 6 were detected to have benign neoplasms (12%). In 35 patients with benign lesions, the commonest diagnosis were infectious enteritis (22.9%) & small bowel obstruction (20%) followed by ischemic bowel (14.3%), Koch's bowel (11.4%), Crohns (8.6%), diverticulum (5.7%), Meckel'S Diverticulum (2.9%), Mesenteric Panniculitis (2.9%) Midgut Volvulus (2.9%) and Superior Mesenteric Artery Syndrome (2.9%).

In this study, out of 50 patients, bowel wall involvement was noted in 39 (78%) of the patients. Out of these 39 patients, 36 patients (92.3%) had thickened bowel wall and 3(7.7%) patients had diverticula from the bowel wall.

Bowel wall thickening may be related to a number of entities including normal variants, inflammatory conditions and neoplastic disease. The CT enterography findings that were analyzed in thickened bowel include pattern of attenuation, degree of thickening; focal, segment, or diffuse involvement and other associated perienteric abnormalities. The solitary CT findings by themselves are not specific, it's association with many abnormal parameters will lead to correct diagnosis or it narrows down the different diagnosis in almost all cases.[38] In this study out of 36 cases that showed thickened walls, majority of the cease (32%) had mild degree of bowel wall thickening. In those with benign pathology which had bowel wall thickening, majority of the cases (37.1%) had mild thickening. In cases with moderate bowel wall thickening, most were benign neoplasm (66.7%).

Small bowel wall enhancement patterns are divided into a air halo, fat halo, grey, water halo, & white patterns. water halo pattern with stratification of the layers of the small bowel wall (mural stratification) is generally found with benign conditions-for example Koch's bowel, Crohn's disease, ischemic bowel venous thrombosis associated with bowel edema. Homogenous hyperenhancement is

commonly seen with active crohn's disease and is frequently associated with increased density in the surrounding mesenteric fat (fat halo).[10] Indeed, it has been proposed by bodily et al[39] that a cut off of 109HU can be used with reasonable accuracy to diagnose activity in crohn's-afflicated small bowels. Heterogenous enhancement is seen in small bowel neoplasms, including gastrointestinal stromal tumours, adenocarcinomas, metastases and peritoneal deposits.

Decreased enhancement is characteristic of bowel ischemia and it usually precedes the intramural gas development and perforation.[10] Majority of the benign & malignant neoplasm had grey pattern of enhancement.

In this study, length of the thickened bowel segment was classified under three categories and short segment type was most commonly noted in 42% of the patients. long segment was seen in 38% of the patients.

Another point which helps in reaching a diagnosis is identification of the layer of small bowel that is mainly affected. The mucosa is mainly affected in inflammatory conditions such as Crohn's disease, TB and neoplasms like adenocarcinoma. Mucosa is affected mainly in infectious conditions. The main abnormality is seen in the submucosa in intramural hemorrhage, vasculitis, ischemia, hypoalbuminemia and angioedema. The serosa is predominantly involved in metastases, endometriosis, carcinoid and other inflammatory conditions in the peritoneum.[10]

Radiation administered along with cancer therapy causes acute and chronic inflammatory changes in any bowel loops included within the radiation port. Segmental areas of abnormal bowel wall thickening are seen in radiation enteritis. Chronic radiation enteritis results in fibrotic changes in chronic Crohn's disease.[38] Given the nonspecific findings, clinical history and note about the abnormal small

bowel location within the site of previous radiation are essential to a confident radiotherapy status had segmental bowel wall thickening with target pattern of enhancement.[56]

"Small-bowel obstruction (SBO)" is a very common cause of abdominal pain which accounts for 4% of all emergency room visits for abdominal pain and 20% of surgical admissions. Rapid diagnosis and identification of complicated cases such as closed-loop obstruction, volvulus or superimposed ischemia are of critical importance as these patients require emergent surgical management.[56]

MDCT findings in small bowel obstruction has dilated small bowel loops measuring >3 cm in diameter transitioning to normal caliber or collapsed bowel loops distally. The "small bowel feces" sign is specific but not a sensitive sign for small bowel obstruction and it defines the presence of solid material intermixed with gas bubbles i.e., the appearance of fecal material within the small bowel, just proximal to the site of obstructions.[57] This finding can be helpful in the identification of "transition point".[58] The fecal material should be within the dilated loops of bowel, however as fecal material can be seen within the small bowel in unobstructed bowel of cystic fibrosis patients as well as individuals with metabolic or infectious enteropathies. Also, fecal material in the distal ileum is seen in patients with an incompetent ileocecal valve, without small bowel obstruction.[57-59]

MDCT facilities the identification of the etiology of a small bowel obstruction be it extrinsic or intrinsic to the bowel. The most common cause of small bowel obstruction in developed countries is adhesions mainly secondary to prior abdominal or pelvic surgery. Adhesions are not visualized on CT with only a beak or sharp angulation in the bowel seen at the transition point from normal to dilated bowel. The diagnosis of adhesions as the cause of small bowel obstruction can be only made

when other causes are excluded and an appropriate clinical history is present.[58] The reported accuracy of CT in the diagnosis of adhesive small bowel obstruction is 70% to 95%.[58] MDCT plays an important role in not just diagnosing the small bowel obstruction and determining the etiology, but also in identifying potential complications, most important being closed loop obstruction. A closed loop obstruction occurs when two points along the same length of small bowel are obstructed at a single point. This is caused by an adhesion, but internal and external hernias are also the common causes. The segment of the bowel between the two obstructed points is predisposed to volvulus, which leads to venous outflow obstruction and strangulation of the incarcerated segment of bowel. Findings on MDCT depends on the length and angle of the incarcerated segment. Characteristically, a C- shaped, U-shaped, or coffee bean-shaped loop of bowel is seen with radiating folds and accompanying mesenteric vessels seen converging to the point of obstruction often called the "beak sign". A "whirl sign" is seen in volvulus, which is twisting of the mesentery and its vessel around the point of obstruction.[60,61]

In our study, 7 patients (14%) were diagnosed to have mechanical small bowel obstruction most commonly due to small bowel strictures followed by adhesions and volvulus.

The second most common cause of small bowel obstruction is hernias which are external and sometimes internal. Internal hernias are less common than external hernias, but they are important in identifying because they are associated with signification morbidity and mortality but difficult to diagnose both clinically and radiographically. Although internal hernias have an overall incidence of less than 1%, they constitute up to 5.8% of all small- bowel obstruction, which, if left untreated, have been reported to have an overall mortality exceeding 50% if strangulation is present.

Under internal hernias there are many main types, as conventionally described by Meyers, [62] based on location. Specifically, these are "paraduodenal (53%), pericaecal (13%), foramen of winslow (8%), transmesenteric and transmesocolic (8%), intersigmoid (6%), and retroanastomotic (5%)". In old literatures, "paraduodenal hernias" were the most common type of internal hernia, which accounts for around 53% of all cases.[63] Unlike most type of internal hernias, this subtype does have a sex predilection, being found more commonly in men by a ratio of 3:1. There are two main types, left and right, with the former(left) having the most (73%) cases.[55]
In our study no case of internal hernias were diagnosed.

A rare cause of small bowel obstruction is intussusception which is responsible for only 1% of cases. A "bowel-within-bowel" on CT is pathognomonic for an intussusception and is described as the telescoping of a small-bowel loop, often with its associated mesenteric fat and vessels into a downstream loop of bowel. Most small-bowel intussusceptions on CT are transient, they cause no obstruction and do not have underlying tumor which acts as a lead point. Most entero-enteric intussusceptions are usually idiopathic. In few cases a mass lesion may be noted which act as the lead-point for intussusceptions. In such cases, the intussusception is more likely to causes signification small bowel obstruction necessitating surgical treatment.[64]

In our study, one patient with intussusception was diagnosed. Age was in 2nd decade of life. None of the patients had features of small bowel obstruction or a lesion at the lead point. The site of telescoping was ileum. Most of the cases involve the ileocecal area, however in adults, entero-enteric intussusception accounts for 40% of the cases. Proximal small bowel invagination, as seen in all our cases is considered uncommon. Only 18 cases were identified among 160 intussusceptions reviewed by Weilbaecher et al.[65]

The appearance of GI wall differs on IV CECT as the bowel wall progresses from ischemia to infarction. When the wall is ischemic, it is circumferentially thickened and has a target or halo configuration of attenuation. In few other cases of ischemic bowel, the wall is thickened, and diminished enhancement is identified. Causes of ischemia and infarction are thromboembolism, low flow which is related to poor cardiac output and strangulation obstruction.[38]

In our study, 5 patients (10%) were diagnosed with ischemic small bowel disease. Majority of the patients were males (60%). Most of the patients had mild bowel wall thickening. 2 patients (40%) had diminished bowel wall enhancement and rest had white & air halo pattern of wall enhancement. Out of these, 2 patients (40%) had intramural air pockets along with submucosal edema. In these patients, 2 patients had gas in the portal vein and 1 patients had thrombus in superior mesenteric artery. 1 patient also showed splenic infarcts.

Hence CT enterography not only can help stage the process of ischemia to infraction according to enhancement of the bowel wall but also shows the pathologies in mesenteric vasculature and ischemic changes in other solid organs thus describing the complete picture of the disease process.

Patients with Crohn's disease who have features like an acute flare show bowel wall thickening with mural stratification resulting in a "target-like" or "halo" appearance of the bowel. Bowel wall thickening is wall thickness >3 mm in a wall-distended loop. The "halo" appearance is alternating layers of hyperdense mucosa, hypodense submucosal edema and hyperdense serosa. The presence of low- density submucosal edema suggests an active inflammatory process. A more sensitive yet less specific indicator of active disease is mucosal hyperemia, which is shown on CT enterography protocol. Luminal narrowing is seen secondary to edema or small bowel

obstruction associated with it.[66] With chronic inflammation, intramural fat deposition is water-density submucosal edema seen with acute disease. Alternatively, chronic inflammation also results in muscular hypertrophy, collagen deposition and fibrosis which lead to strictures causing small bowel obstruction.[56]

Extra-enteric findings cab be useful indicators of active disease. The "comb sign" is engorged vasa rectae within the mesentery that runs perpendicular to the bowel wall and relates to advanced and active disease that warrants aggressive medical therapies. An increased density of mesenteric fat surrounding an abnormal loop of bowel is a highly specific indicator of active Crohn's disease and relates to increased CRP and histopathologic severity of disease.[66] "Fibrofatty proliferation or fatty deposition" along the mesenteric border of inflamed bowel segments is specific for transmural inflammation secondary to Crohn's disease but can also be associated with active and chronic disease. Other extra-enteric findings include abscesses and fistulas, which determine a need for surgical intervention.[56]

In our study, 6% cases were diagnosed as crohn's decease; out of the 3 cases of Crohn's disease, 2 were diagnosed to have active inflammation with mild wall thickening, submucosal edema, target wall enhancement and adjacent fat stranding with abscess and comb sign as extraenteric complication. 1 case with submucosal fat deposition was diagnosed to have chronic crohn's disease. The main diagnostic purpose of CT enterography in Crohn's disease is to differentiate active inflammatory thickening from chronic fibrotic strictures to guide therapy which was successfully achieved in this study.

Duodenal diverticulosis which is common was first described by in 1710 by Chomel. The duodenum is second to colon as the most common site of diverticula in the GI tract. Its prevalence varies depending on the mode of diagnosis. Diverticula are

found in 6% of upper GI series.

23% of ERCP procedures, and in 22% of autopsies. Its occurrence has no sex predilection, and the age range for the detection various from 26 to 69 years. Duodenal diverticula are either congenital or acquired, acquired is more common. The acquired or false types are like pulsion diverticula elsewhere in the GI tract, which is formed by protrusion of mucosa, muscularis mucosa or submucosa through a focal weakness in the duodenal wall. This is mostly near blood vessels, the pancreatic duct & the common bile duct or areas of aberrant growth of pancreatic tissue in the duodenal wall.[67]

In our study, 3 patients were diagnosed with outpouching from the bowel wall (diverticula); out of which one case of meckel's diverticulum was diagnosed. Rest 2 were cases of diverticula & were present in jejunum & ileum respectively. No evidence of fat stranding was noted adjacent to it, thus ruling out the possibility of diverticulitis.

In a study of 208 patients with small-bowel diverticula, smith J et al.[68] showed that jejuno-ileal diverticula were four times more likely to develop complications and nearly 18 times more likely to perforate and develop abscesses than duodenal diverticula which is consistent in our study. About 5% of patients whon have duodenal diverticula will have clinical symptoms. This is commonly caused by perforation and hemorrhage, acute diverticulitis being less common. Other less common reported complications are malabsorption secondary to duodeno-colic fistulas, common bile duct obstruction with or without associated cholangitis,[67] and superior mesenteric vein thrombosis. [68]

Primary neoplasms of the small bowel, both benign and malignant, are rare. They are also difficult to diagnose as direct visualization of most of the small bowel

is not possible with conventional endoscopic procedures. Capsule endoscopy has been increasingly used but its utility is controversial. MDCT particularly with the CT enterography protocol has improved the ability of CT to detect small-bowel tumors and provides the added advantages of characterizing the extraluminal extension of disease.[56]

In the present study 9 patients were diagnosed to have malignant lesions and adenocarcinoma was the commonest diagnosis (44.4%) followed by GIST (22.2%). Carcinoid, lymphoma & metastasis (11.1%each) constituted rest of the malignant neoplastic lesions.

Malignant tumors account for up to 70% of small-bowel neoplasms. Adenocarcinomas being the most common, which occurs mostly in the duodenum, followed by proximal jejunum. Risk factors for adenocarcinoma are "celiac disease, Crohn's disease, and familial adenomatous polyposis". The CT appearance of adenocarcinoma varies, but usually a focal segment of asymmetric bowel-wall thickening is seen, with moderate heterogeneous enhancement and mucosal ulceration. Extension through the serosa into the adjacent mesentery is assessed on CT, and also the identification of metastases to solid organs and lymph nodes. Adenocarcinomas narrow or occlude the bowel lumen and lead to obstruction, which can also be seen on MDCT.[56] Adenocarcinoma in this study presented as most common malignant neoplastic lesion. Adenocarcinomas occurred in 4 cases out of which 3 were males (75%) with age of 70-90 years, most commonly in jejunum (66.6%). All cases of the adenocarcinoma presented with bowel wall thickening with grey pattern of enhancement. Extraluminal findings such as mesenteric lymphadenopathy were also found in 66.6% of the cases, however other solid organ metastases were not found in any case diagnosed as adenocarcinoma.

The second most common malignant neoplasms in the small bowel is the neuroendocrine tumor or carcinoid tumor, which takes its origination from enterochromaffin cells. 50% of neuroendocrine tumors are in the appendix, and the next common site being the ileum. Even though they are hypervascular, these tumors are small and hard to identify on CT, even though CT enterography increases their conspicuity. Nodal metastases elicit a desmoplastic reaction within the mesentery resulting in mass-like density with speculated margins, calcifications and marked tethering of adjacent bowel loops. This desmoplastic reaction is detected easily on CT and assist in the diagnosis. Patients usually present with advanced disease after development of flushing, diarrhea and intermittent hypertension. These symptoms of "carcinoid syndrome" are present when liver metastases represent. Neuroendocrine metastases to the liver are hypervascular lesions that are best detected during the arterial phase of enhancement.[56] In our study, 11.1% of the malignant neoplasms were diagnosed as carcinoid. These lesions were intraluminal homogenously enhancing lesions. Most commonly lesions were intraluminal homogenously enhancing lesions. Most commonly lesions were located in duodenum which isn't concordance with overall incidence for site; however this variation is mainly due to the small sample size and lack of histopathology correction in this study.

Lymphoma is the third most common malignant neoplasm of the small bowel and arises from mucosa-associated lymphoid tissue (MALT). A systemic lymphoma also affects the small bowel. Lymphoma has many appearances on CT from a short segment of symmetric bowel wall thickening to a solitary mass infiltrating the surrounding mucosa to multifocal enhancing mucosal nodules. Secondary obstruction is not so common even though intussusception can be seen.[56] Lymphoma usually affects the ileum. In our study, 11.1% of the cases were diagnosed as small bowel

lymphoma located involving jejunum & ileum. In this case, there was long segment involvement of jejunum & ileum with severe wall thickening and heterogenous grey pattern of enhancement. Extraluminal findings such as mesenteric lymphadenopathy which showed classical encasement of the vessels were observed. Spleen also showed few non enhancing lymphomatous deposits.

While most Gastrointestinal stromal tumors are benign tumors, they can undergo malignant transformation. None of the radiologic imaging findings other than metastatic disease can differentiate between benign and malignant disease and thus in this study GISTs have been classified under malignant category. These mesenchymal tumors are usually seen in the stomach, but can also be seen in the jejunum, where the characteristic appearance is that of an exophytic bulky mass, with "central cavitation and calcification". In contrast to neuroendocrine metastases, metastases to the liver, are usually hypodense.[56] In this study, 22.2% of the neoplastic lesions were diagnosed as GIST most commonly occurring in duodenum. Larger lesions typically showed infiltration of the adjacent mesentery as well as cavitations, necrosis and hemorrhage.

Duodenal lipomas are benign lesions that can be reliably diagnosed on CT enetrography as a smooth-margined mass with a low Hounsfield unit measurement. They usually produce no symptoms and most often occur in men in their 7th decade. There are three types of duodenal adenomas: tubular type, villous adenoma and brunner gland adenoma. Villous adenomas have a malignant potential and are treated with surgical resection, while tubular adenomas and brunner gland adenomas are typically resected for symptomatic reasons.[69]

In the present study, 1 case was diagnosed as intraluminal lipoma presented in 3rd decade of life. Lipoma had occurred at duodenum junction which is harmony with

standard incidence.

Vascular structures in the abdomen and pelvis are compressed by adjacent anatomic structures or they may lead to compression of adjacent hollow viscera. So, compression of the "proximal celiac artery, transverse duodenum, left common iliac vein (CIV), left vein (LRV), uretero-pelvic junction (UPJ), and ureter" is because of their close anatomic relationship to adjacent ligaments, and to bony and vascular structures. When symptomatic, such compression lead to many uncommon syndromes like median arcuate ligament syndrome (MALS), may- turner syndrome, nutcracker syndrome, superior mesenteric artery (SMA) syndrome etc.[53] In the present study, one patient (2%) were diagnosed with vascular compression syndrome. Superior mesenteric artery syndrome was diagnosed in 18 years male patient. The patient presented with persistent vomiting and abdominal discomfort. On CT enterography there was compression on 3rd part of duodenum by superior mesenteric artery. Aorto- mesenteric angle and aorto-mesenteric distance were between 6^{0}- 22^{0} and 2-8 mm respectively with proximal dilatation of duodenum and stomach.

Also in this study; 1(2%) case of midgut malrotation, 1(2%) case of mesenteric panniculitis and 1(2%) case of tubercular peritonitis were also diagnosed. Hence, there is role of CT enterography in diagnosing not only bowel pathologies and mesenteric disorders.

Overall, there are many advantages to CTE. "First, MDCT scanners are readily available and the technique is not complex". The scanning parameters are easy to set up and can be done by a novice technologist. The room time to perform a CTE is 10 minutes or less. An entire CTE from oral contrast ingestion to end of scan, takes 1.5 hours or less. Most standard conventional follow through small bowel series take almost 2 to 3 hours at least. Also, lastly, when compared to a dedicated small bowel

series or an enteroclysis, there is less radiation to patients. Fluoroscopy delivers a significant dose to the patient. Even though CT makes use of ionizing radiation such as fluoroscopy, it is equivalent to pulsed fluoroscopy and often less. Prouder is well tolerated by the patient as compared to CT enteroclysis in which nasojejunal tube insertion is at times not tolerated by the patient. Not just the luminal but extra-luminal extent of the disease also appreciated on CT enterography.

The low level of agreement observed for conventional small bowel studies may reflect inherent disadvantages of techniques, including incomplete evaluation of bowel segments located deep in the pelvic cavity owing to overlapped bowel loops and suboptimal evaluation of the small bowel distal to the tight stricture [69,70,71].

Although triphasic CT enterography was mainly developed to evaluate the small bowel, it can also detect abnormalities in the colon and stomach, largely because of improved distention with low-density oral contrast material in these areas that make lesions more conspicuous.

CONCLUSION

CT enterography is an excellent diagnostic tool of the study of small bowel disorders, including inflammatory bowel disease, in particular, Crohn's disease, mechanical small bowel obstruction and small bowel neoplasms.

CT enterography offers the additional benefit for assessing abdominal and pelvic structures other than the small intestine therefore describing the complete extent of the disease process and also allowing for alternative diagnosis to guide medical and surgical management.

The present study showed higher frequency of benign lesions in the detection of small bowel pathology and small bowel obstruction was the common diagnosis closely followed by infectious/ inflammatory bowel wall thickening, diverse list of differential diagnosis could be narrowed. CT enterography is mainly useful in differentiating between active and fibrotic bowel strictures in patient with Crohn's disease which enables selection of the most suitable treatment, medical management or intervention, for a better outcome.

"MDCT enterography" has largely replaced the "small-bowel follow-through (SBFT)" as the chosen technique in the evaluation of small bowel and is vital in various other clinical scenarios where bowel is the primary source of pathology or secondary to other process.

On comparison with the histopathology diagnosis & patient response to treatment for radiological diagnosis, CT enterography appear to be significantly sensitive, specific and accurate in the identification of pathologies of the small intestine and are capable of depiction of more complications. Therefore, CT enterography are preferred for the comprehensive evaluation the small bowel diseases.

SUMMARY

Enhanced resolution of multi-detector row CT along with better distension by negative oral contrast agent has led to CT enterography being a first-line modality in the examination of small bowel disease which is a complex organ with several functions. This study was undertaken to characterize the small bowel pathologies on multi- detector computerized tomography enterography.

This cross sectional study was carried out in the Department of Radio-diagnosis, _____ from Nov 2017 - June 2019. A total of 50 patients clinically suspected or were known to have small intestinal diseases were studied.

Majority of the patients had benign lesions (70%) and neoplastic lesions were noted in 30% of the patients. Among the neoplastic lesions, 18 % were malignant neoplasms and 12% were benign neoplasms. The commonest diagnosis were infectious enteritis (22.9%) & mechanical small bowel obstruction (20%) in patients with benign lesions and adenoma (8%) & adenocarcinoma (8%) was the commonest diagnosis in patients with neoplastic lesions. Most of the patients were males (58%) with male to female ratio of 1.38:1 and benign lesions were noted in 54.3% of the males, benign neoplasms in 66.7% and malignant neoplasms in 66.7% of the males. Most of the patients were aged between 41 to 50 years (26%). The involvement of small bowel was present in 96% of the patients respectively. Abnormal positioning of small bowel loops was noted in 6% of patients. The extraluminal involvement was detected in 12% of the patients. Involvement of bowel wall was noted in 39 patients (78%) and among them, 94% had thickened bowel wall. Grey & water halo pattern of enhancement was noted in 26% respectively. The short segment bowel involvement was noted commonly (42%). The vascular and mesentery involvement were present in

20% and 50% of the patients respectively.

CT enterography is significantly sensitive, specific and accurate in the identification of pathologies of the small intestine by using histopathology & treatment response as a reference standard. Therefore, CT enterography are preferred for the comprehensive evaluation the small bowel diseases.

Overall CT enterography is an excellent diagnostic tool for the study of small bowel disorders and other abdominal organs and as it has better spatial resolution and helps describing the complete extent of the disease process thereby allowing for prompt diagnoses to guide medical and surgical management.

BIBLIOGRAPHY

1. Costamagna G et al. A prospective trial comparing small bowel radiographs and video capsule endoscopy for suspected small bowel disease. Gastroenterology 2002; 123(4): 999-1005.
2. Ray G. Inflammatory bowel disease in India - Past, present and future. World J Gastroenterol 2016; 22(36):8123-8136.
3. Raju Sharma, Kumble S M, and Vineet Ahuja. Intestinal tuberculosis versus crohn's disease: Clinical and radiological recommendations. Indian J Radiol Imaging 2016 Apr-Jun; 26(2):161–172.
4. Paulsen SR et al. CT enterography as a diagnostic tool in evaluating small bowel disorders: review of clinical experience with over 700 cases. Radiographics 2006; 26(3): 641-657.
5. Elsayes KM, Al-Hawary MM, Jagdish J, Ganesh HS, Platt JF. (). CT Enterography: Principles, Trends, and Interpretation of Findings. Radiographics 2010; 30(7): 1955-1970.
6. Hara AK, Leighton JA, Heigh RI, Sharma VK, Silva AC, De Petris G, Fleischer DE. Crohn disease of the small bowel: preliminary comparison among ctenterography, capsule endoscopy, small-bowel follow-through, and ileoscopy. Radiology 2006: 238(1): 128-134.
7. History of the Stomach and Intestines [Internet]. Web.stanford.edu. 2017 [cited 26 October 2017].
8. Pasha SF et al. Double-balloon enteroscopy and capsule endoscopy have comparable diagnostic yield in small-bowel disease: a meta-analysis. Clinical gastroenterology and hepatology 2008; 6(6): 671-676.
9. Panes J et al. Systematic review: the use of ultrasonography, computed

tomography and magnetic resonance imaging for the diagnosis, assessment of activity and abdominal complications of Crohn's disease. Alimentary pharmacology & therapeutics 2011;34(2), 125-145.

10. Rimola J et al. Magnetic resonance for assessment of disease activity and severity in ileocolonic Crohn's disease. Gut 2009;58(8): 1113-1120.
11. Paulsen SR, Huprich JE, Fletcher JG, Booya F, Young BM, Fidler JL, et al. CT enterography as adiagnostic tool in evaluating small bowel disorders: review of clinical experience with over 700 cases. Radiographics 2006,26(3):641-57; discussion 657-62.
12. Neri E, Caramella D, Baratolozzi C. Image processing in radiology. Germany: Springer-Verlag;2008.
13. Gray H. Anatomy of the Human Body. Philadelphia, PA: Lea & Febiger; 2000.
14. Friedman S, Blunberg, RS. Inflammatory bowel disease. In: Harrison's Principles of Internal Medicine. 17th ed., New York, McGraw-hill companies Inc.; 2008.
15. Noton JA, Bollinger RR, Chang AE, Surgery. Basic science and clinical evidence. Springer-Verlag New York,Inc.;2001
16. Gore R, Masselli G, Caroline D. Crohn's disease of the small bowel. In: Gore R, Levine M, ads. Textbook of Gastrointestinal Radiology. 3rd ed., Philadelphia: Saunders Elsevier; 2008. P. 781-806,
17. Tarjan Z, Toth G, Gyorke T, Mester A, Karlinger K, Mako EK. Et al. Ultrasound in Crohn's disease of the small bowel. Eur J Raiol 2000;35(3):176-82.
18. Di Mizio R, Maconi G, Romano S, D'Amario F, Porro GB< Grassi R. Small

bowel Crohn disease: sonographic features. Abdominal Imaging 2004;29(1):23-35.

19. Young BM, FLetcher JG, Booya F, Paulsen S, Fidler J, Johnson CD, et al. Head- to-head comparison of oral contrast agents for cross-sectional enterography: small bowel distention, timing, and side effects. J Comput Assist Tomogr 2008;32(1):32- 8.
20. Gourtsoyiannis NC, Papanikolaou N.Magnetic resonance enteroclysis. Seminars in ultrasound CT MRI 2005;26(4):237-46.
21. Cronin CG, Lohan DG, Brownie AM, Roche C, Murphy JM. Magnetic resonance enterography in the evaluation of the small bowel. Seminars in Roentgenology 2009;44(4):237-43.
22. Zhu J, Xu JR, Gong HX, Zhou Y. Updating magnetic resonsnce imaging of small bowel: imaging protocols and clinical indications. World J Gastroenterol 2008;14(21):3403-9.
23. Masselli G, Casciani E, Polettini E, Guladi G. comparison of MR enteroclysis with MR enterography and conventional enteroclysis in patients with Crohn's disease. Eur Radiol 2008;18(3):438-47.
24. Tolan DJM, Greenhalgh R, Zealley IA, Halligan S, Taylor SA. MR enterographic manisfestations of small bowel crohn disease. RadioGraphics 2010;30(2);367-84.
25. Wiarda BM, Horsthuis K, Dobben AC, Geenen RW, Heitbrink MA, Moolenaar W, et al. Magnetic resonance imaging of the small bowel with the true FISP sequence: intra_ and interobserver agreement of enteroclysis and imaging without contrast material. Clin Imaging 2009;33(4);267-73.
26. Sharman A, Zealley IA, Greenhalgh R, Bassett P, Taylor SA. MRI of small

bowel Crohn's disease: determining the reproductibility of bowel wall gadolinium enhancement measurements. Eur Radiol 2009;19(8):1960-7.

27. Zappa M, Stefanescu C, Cazals-Hatem D, Bretagnol F, Deschamps L, Attar A, et al., Which magnetic resonance imaging findings accurately evaluate inflammation in small bowel Crohn's disease? A retrospective comparison with surgical pathologic analysis,"Inflamm Bowel Dis 2011;17(4):984-93.
28. Low RN, Sebrechts CP, Politoske DA, Bennett MT, Flores S, Snyder RJ, et al., "Crohn disease with endoscopic correlation: single-shot fast spin-echo and gadolinium-enhanced fat suspressed spoiled gradient-echo MR imaging. Radiology. 2002;222(3):652-60.
29. Taylor A, Punwani S, Rodriguez-Justo M, Bainbridge A, Greenhalgh R, De Vita E, et al., Mural Crohn disease: correlation of dynamic contrast-enhanced MR imaging findings with angiogenesis and inflammation at histologic examination-pilot study. Radiology. 2009;251(2):369-79.
30. Planner AC, Philips A, Bungay HK. The role of imaging in small bowel disease. Imaging 2006;18(4):228-56.
31. Scgmidt S, Felley C, Meuwly JY, Schnyder P, Denys A. CT enteroclysis: technique and clinical applications. Eur Radiol 2006;16(3):648-60.
32. Walsh DW, Bender GN, Timmons H. Comparison of computed tomography-enteroclysis and traditional computed tomography in the setting of suspected partial small bowel obstruction. Emergency Radiol 1998;5(1):29-37.
33. Macari M, Megibow AJ, Balthazar EJ. A pattern approach to the abnormal small bowel: observations at MDCT and CT enterography. AJR AM J Roentgenol 2007;188(5):1344-55.
34. Raptopoulos V, Schwartz RK, Menicholas MM, Movson J, Pearlman J, Joffe

N. Multiplanar helical CT enterography in patients with Crohn's disease. AJR Am J Roentenol 1997;169:1545-50.

35. Elsayes KM, Al-Hawary MM, Jagdish J, Ganesh HS, Platt JF. CT enterography: principles, trends, and interpretation of findings. Radiographics. 2010;30(7):1955- 70.
36. Hara AK, Leighton JA, Sharma VK, Heigh RI, Fleischer DE. Imaging of small bowel disease: comparison of capsule endoscopy, standard endoscopy, barium examination, and CT. Radographics 2005;25(3):697-711.
37. Jaffe TA, Martin LC, Miller CM, et al. Abdominal pain: coronal reformations from isotropic voxels with 16-section CT-reader lesion detection and interpretation time. Radiology 2007;242(1):175-181.
38. Macari M, Balthazar EJ. CT of bowel wall thickening: significance and pitfalls of interpretation. AJR Am J Roentgenol 2001;176(5):1105-16.
39. Bodily KD, Fletcher JG, Solem CA, Johnson CD, Fidler JL, Barlow JM, et al. Crohn Disease: mural attenuation and thickness at contrast-enhanced CT enterography- correlation with endoscopic and histologic findings of inflammation. Radiology 2006;238:505_16
40. Balthazar E, Gordon R, Hulnick D. Ileocecal tuberculosis: CT and radiologic evaluation. AJR Am J Roentgenol 1990;154:499-503
41. Wiesner W, Khurana B, Ji H, Ros P. CT of acute bowel ischemia. Radiology 2003;226:635-50
42. Kirkpatrik I, Kroeker M, Greenberg H. Biphasic CT with mesenteric CT angiography in the evaluation of acute mesenteric ischemia: initial experience. Radiology 2003;229:91-8
43. Rao P, Rhea J, Novelline R. CT diagnosis of mesenteric adenitis. Radiology

1997;202:145-9

44. Buckley J, Fishman E. CT evaluation of small bowel neoplasms: spectrum of disease. Radiographics 1998;18:379-92
45. Leighton JA, Loftus EV. Evolving diagnostic modalities in inflammatoey bowel disease. Curr Gastroenterol Rep 2005;7(6):467-74.
46. Sands BE. Crohn's Disease. In: Feldman M, Friedman L, Sleisenger M, editors. Sliesenger and Fordtran's gastrointestinal and liver disease. Philidelphia: Saunders; 2002. p.2005-38.
47. Paulsen SR, Huprich JE, Hara AK. CT enterography: noninvasive eavaluation of Crohn's disease and obscure gastrointestinal bleed. Radiol Clin North Am 2007;45:303-15.
48. Maccioni F, Bruni A, Viscido A, Colaiacomo MC, Cocco A, Montesani C, et al. MR imaging in patients with Crohn disease: value of T2- versus T1-weighted gadolinium-enhanced MR sequences with useof an oral superparamagnetic contrast agent. Radiology 2006;238:517-30.
49. Gore RM, Balthazar EJ, Ghahremani GG, Miller FH. CT features of ulcerative colitis and Crohn's disease. AJR Am J Roentgenol 1996;167:3-15.
50. Kwonha H, Park SH, Lee SS, Kim AY. Gastrointestinal
51. Abrahams RB, Franco A, Lewis KN. Pediatric Colocolic Intussusception With Pathologic Lead Point: A Case Report 2012;3(1):84-8.
52. Lamba R, Tanner DT, Sekhon S, McGahan JP, Corwin MT, Lall CG. Multidetector CT of vascular compression syndromes in the abdomen and pelvis. Radiographics. 2014;34(1):93-115.
53. Pickhardt PJ, Bhalla S. Intestinal malrotation in adolescents and adults: spectrum of clinical and imaging features. AJR Am J Roentgenol

2002;179(6):1429-35.

54. Martin LC, Merkle EM, Thompson WM. Review of internal hernias: radiographic and clinical findings. AJR Am J Roentgenol 2006;186(3):703-17.
55. Tye GA, Desser TS. MDCT of the small bowel. Appl Radiol 2012;41(8);6-17.
56. Jacobs SL, Rozenblit A, Ricci Z, et al. small bowel faeces sign in patients without small bowel obstruction. Clin Radiol 2007;62:353-7.
57. Desser TS, Gross M. Multidetector row computed tomography of small bowel obstruction. Semin Ultrasound CT MR 2008;29;308-21.
58. Lazarus DE, Slywotsky C, Bennett GL, Megibow AJ, Macari M. Frequency and relevance of the "small-bowel feces" sign on CT in patients with small-bowel obstruction. AJR Am J Roentgnol 2004;183:1361-6.
59. Furukawa A, Yamasaki M, Takahashi M, et al. CT diagnosis of small bowel obstruction: scanning technique, interpretation and role in the diagnosis. Semin Ultrasound CT MR 2003; 24:336-52.
60. Qalbani A, Paushter D, Danchman AH. Multidetector row CT of small bowel obstruction. Radiol Clin North Am 2007;45:499-512.
61. Meyers MA. Dynamic radiology of the abdomen: normal and pathologic anatomy. 4th ed., New York, NY: Springer-verlag;1994.
62. Ghahremani GG. Abdominal and pelvic hernias. In:Gore RM, Levine MS, eds. Textbook of gastrointestinal radiology. 2nd ed., Philadelphia, PA; Saunders; 2000. P. 1993-2009.
63. Lvoff N, Breiman RS, Coakley FV, Lu Y, Warren RS. Distinguishing features of self-limiting adult small-bowel intussusceptions identified at CT. Radiology 2003; 227:68-72.

64. Weibaecher D, Bolin JA, Hearn D, Ogden W. Intususception in adults: review of 160 cases. AmJ Surg 1971;121:531-5.
65. Hara AK, Swartaz PG. CT enterography of crohn's disease. Abdomen imaging 2009;34: 289-95.
66. Pearl MS, Hill MC, Zeman RK. CT findings in duodenal diverticulitis. AJR Am J Roentgenol 2006;187(4):W392-5.
67. Smith J, Carman TL, Fernandez BB Jr. Sesto ME, Portnova R. Superior mesentericvein thrombosis and duodenal diverticulum. Ann Vasc Surg 2000;14: 278-82.
68. Jayaraman M, Mayo-Smith WW, Movson JS, Dupuy DE, Wallach MT. CT of the duodenum: an overlooked segment gets it due. Radiographics 2001;21:S147- 60.
69. Bernstein CN, Greenberg H, Boult I, Chubey S, Leblanc C, Ryner L. A prospective comparison study of MRI versus small bowel follow-through in recurrent Crohn's disease. *Am J Gastroenterol* 2005; 100(11): 2493–2502.
70. Reittner P, Goritschnig T, Petritsch W, et al. Multiplanar spiral CT enterography in patients with Crohn's disease using a negative oral contrast material: initial results of a noninvasive imaging approach. *Eur Radiol* 2002; 12(9): 2253–2257.
71. Horsthuis K, Lavini C, Stoker J. MRI in Crohn's disease. *J Magn Reson Imaging;* 2005; 22(1): 1–12.

ANNEXURE I

ETHICAL CLEARANCE CERTIFICATE

ANNEXURE II

CASE PROFORMA

- **Name:**
- **Age:**
- **Sex:**
- **IP/OP No.:**
- **CLINICAL PRESENTATION:**
- **PAST HISTORY:**
- **Occupation**
- **Chief complaints**
- **RIF Pain**
- **Weight loss Anorexia**
- **Fever**
- **Bleeding PR**
- **Abdominal distension**
- **(Onset, duration and progress.)**
- **Relevant personal history Alcohol,Smoking,Chewing,Weight loss**
- **General physical examination**
- **Systemic examination**
- **Any prevous USG Abdomen**
- **Any prevous Barium meal follow through.**
- **Radiological Findings.**

RADIOLOGICAL DIAGNOSIS:

ANNEXURE III

CONSENT FORM

TITLE OF RESEARCH: "CT ENTEROGRAPHY IN THE EVALUATION OF SMALL BOWEL PATHOLOGIES"

GUIDE :

P.G. STUDENT :

PURPOSE OF RESEARCH:

I have been informed that the purpose of this study is to study the mucosal patterns, bowel wall thickness, luminal distension and blood vessels in various diseases of the small bowel and to discuss its radiological features.

I understand that I will undergo detailed history, clinical examination and investigations.

RISKS AND DISCOMFORTS:

I understand the risks involved (as informed prior to procedure viz allergic reactions, skin dryness, itching & rarely long term effects) and I may experience mild pain during the above mentioned procedures.

There is no other risk involved other than radiation when CT scan is done, which is within permissible limits.

BENEFITS:

I understand that my participation in this study will help in determining role of CT enterography in evaluation of small bowel diseases.

CONFIDENTIALITY:

I understand that the medical information produced by the study will become a part of hospital record and will be subjected to confidentiality and privacy regulations

of hospital. If the data is used for publications the identity of the patient will not be revealed.

REQUEST FOR MORE INFORMATION:

I understand that I may ask for more information about the study at any time.

REFUSAL OR WITHDRAWL OF PARTICIPATION:

I/my ward understand that my participation is voluntary and I may refuse to participate or may withdraw from study anytime.

INJURY STATEMENT

I understand that in the unlikely event of injury to me/my ward, resulting directly to my participation in this study, if such injury were reported promptly, then medical treatment would be available to me, but no further compensation will be provided.

I understand that by my agreement to participate in this study, I am not waiving any of my legal rights.

I have explained to _____ the purpose of this research, the procedures required and the possible risks and benefits, to the best of my ability in patient's own language.

Date:

(Guide) (Investigator)

KEY TO MASTERCHART

m	**–**	**Male**
f	**-**	**Female**
d	**-**	**Duodenum**
j	**-**	**Jejunum**
i	**–**	**Ileum**
dj	**-**	**Duodenum & jejunum**
ji	**-**	**Jejunum & Ileum**
n	**-**	**Normal**
b	**-**	**Benign**
bn	**-**	**Benign neoplasm**
mn	**-**	**Malignant neoplasm**

MASTERCHART

Sl No	age (years)	sex	ip no.	small bowel involvemnet	locati on	position	lumen involvement						
							intraluminal					extraluminal	both
						normal / abnormal	involvement	mass	attenuation	enhancement	calibre	involvement	
1	35	m	180567	yes	j	n	no	no	no	no	no	no	no
2	52	m	203193	yes	i	n	yes	yes	hypo	yes	narrowed	no	no
3	46	f	28660	yes	i	abnormal	no	no	no	no	no	no	no
4	58	m	29765	yes	d	n	no	no	no	no	no	no	no
5	38	m	341994	yes	j	n	no	no	no	no	no	no	no
6	65	m	33940	yes	ji	n	no	no	no	no	no	no	oo
7	25	f	34574	yes	i	n	no	no	no	no	no	no	no
8	18	m	33282	yes	d	n	yes	no	no	no	dilated	no	no
9	55	m	41396	yes	j	n	yes	yes	hypo	yes	narrowed	no	no
10	42	m	42033	yes	d	n	no	no	no	no	no	yes	no
11	54	f	168268	yes	j	n	yes	yes	hypo	yes	narrowed	no	no
12	65	m	190000	yes	i	n	no	no	no	no	no	no	no
13	49	m	26675	yes	ji	n	yes	no	no	no	dilated	no	no
14	75	m	27841	yes	j	n	no	no	no	no	no	no	no
15	50	m	731215	yes	i	n	no	no	no	no	no	no	no
16	43	f	339776	yes	ji	n	no	no	no	no	no	no	no
17	51	f	34439	yes	d	n	no	yes	no	no	dilated	no	no
18	61	m	354809	yes	i	n	no	no	no	no	no	no	no
19	70	m	159632	yes	j	n	yes	yes	iso	white	narrowed	yes	yes
20	20	f	374368	yes	i	n	yes	yes	no	no	dilated	no	no
21	60	f	371323	yes	d	n	yes	yes	hetero	hetero	narrowed	yes	yes
22	32	f	42500	no	-	-	no	no	no	no	no	no	no
23	42	m	42302	no	-	-	no	no	no	no	no	no	no

24	35	m	433166	yes	d	n	yes	yes	hypo	no	narrowed	no	no
25	31	f	5785	yes	j	n	no	no	no	no	no	no	no
26	80	f	6032	yes	dj	n	yes	no	no	no	narrowed	no	no
27	50	f	88027	yes	j	n	no	no	no	no	no	no	no
28	62	f	129404	yes	ji	n	yes	yes	iso	non	narrowed	yes	yes
29	65	m	12607	yes	i	n	yes	no	no	no	dilated	no	no
30	80	m	13930	yes	j	n	yes	yes	hetero	yes	narrowed	yes	yes
31	75	m	440165	yes	i	n	yes	no	no	no	narrowed	no	no
32	65	f	439579	yes	j	abnormal	no	no	no	no	no	no	no
33	50	f	431187	yes	ji	n	yes	no	no	no	dilated	no	no
34	45	f	425363	yes	i	n	no	no	no	no	no	no	no
35	65	m	10308	yes	j	n	no	no	no	no	no	no	no
36	70	m	10170	yes	dj	n	yes	yes	hyper	hetero	narrowed	no	no
37	65	m	40329	yes	j	n	yes	no	no	no	dilated	no	no
38	56	f	10086	yes	i	n	no	no	no	no	no	no	no
39	68	m	405532	yes	ji	n	yes	no	no	no	dilated	no	no
40	45	m	393667	yes	i	n	yes	no	no	no	narrowed	no	no
41	87	m	386068	yes	ji	n	no	no	no	no	no	no	no
42	60	m	37305	yes	i	n	yes	no	no	no	dilated	no	no
43	20	f	37525	yes	ji	abnormal	yes	no	no	no	no	no	no
44	45	m	360313	yes	j	n	no	no	no	no	no	no	no
45	87	m	33877	yes	i	n	yes	yes	iso to hyper	yes	narrowed	yes	yes
46	70	f	33391	yes	j	n	no	no	no	no	no	no	no
47	46	m	33218	yes	j	n	no	no	no	no	no	no	no
48	45	f	338911	yes	j	n	no	no	no	no	no	no	no
49	53	f	31253	yes	i	n	no	no	no	no	no	no	no
50	55	f	301112	yes	i	n	no	no	no	no	no	no	no

SL NO.	distension				bowel wall involvement				
	involvement	location	degree	content	involvement	oupouching / thickened	wall thickness(mild/moderate/severe)	enhancement pattern	length of segment involved
1	no	no	no	no	yes	thickening	mild	water halo	long
2	no	no	no	no	yes	thickening	moderate	grey	short
3	no	no	no	no	yes	thickening	mild	water halo	long
4	no	no	no	no	yes	thickening	severe	grey	short
5	no	no	no	no	yes	oupouching	no	no	short
6	no	no	no	no	yes	thickening	mild	fat halo	long
7	no	no	no	no	yes	oupouching	no	no	short
8	yes	d	severe	fluid	no	no	no	no	no
9	no	no	no	no	yes	thickening	moderate	grey	short
10	no	no	no	no	yes	thickening	mild	grey	short
11	no	no	no	no	yes	thickening	moderate	grey	short
12	no	no	no	no	yes	thickening	mild	water halo	short
13	yes	ji	mild	air fluid	no	no	no	no	no
14	no	no	no	no	yes	thickening	mild	air halo	short
15	no	no	no	no	yes	thickening	moderate	water halo	long
16	no	no	no	no	yes	thickening	mild	water halo	long
17	yes	d	moderate	air fluid	no	no	no	no	no
18	no	no	no	no	yes	thickening	moderate	fat halo	long
19	no	no	no	no	yes	thickening	moderate	grey	short
20	yes	i	mild	bowel	no	no	no	no	no
21	no	no	no	no	yes	thickening	severe	white	short
22	no	no	no	no	no	no	no	no	no
23	no	no	no	no	no	no	no	no	no

24	no	no	no	no	yes	thickening	severe	non	short
25	no	no	no	no	yes	thickening	moderate	grey	short
26	no	no	no	no	yes	thickening	severe	water halo	long
27	no	no	no	no	yes	thickening	mild	air halo	long
28	no	no	no	no	yes	thickening	severe	grey	long
29	yes	i	moderate	air fluid	no	no	no	no	no
30	no	no	no	no	yes	thickening	severe	grey	long
31	no	no	no	no	yes	thickening	severe	water halo	short
32	no	no	no	no	yes	thickening	mild	water halo	long
33	yes	ji	mild	air fluid	no	no	no	no	no
34	no	no	no	no	yes	oupouching	no	no	short
35	no	no	no	no	yes	thickening	mild	grey	short
36	no	no	no	no	yes	thickening	severe	grey	multiple
37	yes	j	mild	air fluid	no	no	no	no	no
38	no	no	no	no	yes	thickened	mild	water halo	short
39	yes	ji	moderate	air fluid	yes	thickened	severe	water halo	long
40	no	no	no	no	yes	thickening	severe	water halo	short
41	yes	ji	mild	air	yes	thickening	mild	white	long
42	yes	i	mild	air fluid	no	no	no	no	short
43	yes	ji	severe	air	no	no	no	no	long
44	no	no	no	no	yes	thickening	mild	fat halo	long
45	no	no	no	no	yes	thickening	moderate	grey	short
46	no	no	no	no	yes	thickening	mild	grey	long
47	no	no	no	no	yes	thickening	moderate	water halo	long
48	no	no	no	no	yes	thickening	mild	white	short
49	no	no	no	no	yes	thickening	mild	water halo	long
50	no	no	no	no	yes	thickening	moderate	fat halo	long

SL NO.	vascular involvement	mesentery			final diagnosis	pathology
	yes / no	involvement	mass	fat stranding		benign / benign neoplasm/ malignant neoplasm
1	no	yes	no	yes	infectious enteritis	b
2	no	no	no	no	adenoma	bn
3	no	yes	no	yes	koch's	b
4	yes	yes	yes	no	GIST	mn
5	no	no	no	no	diverticulum	b
6	no	yes	yes	yes	crohn's	b
7	no	no	no	no	meckel's diverticulum	b
8	yes	no	no	no	superior mesenteric artery syndrome	b
9	no	no	no	no	leiomyoma	bn
10	no	yes	yes	yes	CARCINOID	mn
11	no	no	no	no	adenoma	bn
12	no	no	no	no	koch's	b
13	no	no	no	no	intenstinal obstruction	b
14	yes	yes	no	yes	ischemic bowel	b
15	yes	yes	no	yes	ischemic bowel	b
16	no	no	no	no	infectious enteritis	b
17	no	no	no	no	intenstinal obstruction	b
18	no	yes	no	yes	crohn's	b
19	yes	yes	yes	yes	adenocarcinoma	mn
20	no	no	no	no	intussusception	b
21	no	yes	no	yes	GIST	mn
22	no	yes	no	yes	mesenteric panniculitis	b
23	no	yes	no	yes	koch's peritonitis	b

24	no	no	no	no	lipoma	bn
25	no	no	no	no	adenoma	bn
26	no	yes	no	yes	infectious enteritis	b
27	yes	yes	no	yes	ischemic bowel	b
28	no	no	no	no	lymphoma	mn
29	no	no	no	no	intestinal obstruction	b
30	no	yes	yes	yes	adnocarcinoma	mn
31	no	no	no	no	koch's	b
32	no	no	no	no	infectious enteritis	b
33	no	no	no	no	intestinal obstruction	b
34	no	no	no	no	diverticulum	b
35	no	no	no	no	adenoma	bn
36	yes	yes	no	yes	metastatic	mn
37	no	no	no	no	intestinal obstruction	b
38	no	yes	no	yes	infectious enteritis	b
39	no	no	no	no	intestinal obstruction	b
40	no	no	no	no	Koch's	b
41	yes	yes	no	yes	ischemic bowel	b
42	no	no	no	no	intestinal obstruction	b
43	yes	yes	no	yes	midgut volvulus	b
44	no	yes	no	yes	infectious enteritis	b
45	no	yes	no	yes	adenocarcinoma	mn
46	no	yes	no	yes	adenocarcinoma	mn
47	no	no	no	no	infectious enteritis	b
48	yes	yes	no	yes	ischemic bowel	b
49	no	yes	no	yes	infectious enteritis	b
50	no	yes	no	yes	crohn's	b