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Original Research Article

Is Future of CT Enterography Promising: A Cross-Sectional Observational Study to Assess the Accuracy of CT Enterography in Evaluation of Small Bowel Pathologies

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Abstract:

Purpose: To evaluate the accuracy of CT Enterography in evaluation of small bowel pathologies.

Methods: this is a prospective observational study carried in Department of Radiodiagnosis in a Medical college in Maharashtra, India with a sample size of 100; after ethical committee clearance with Study duration of 2 years. The patient's with suspected small bowel pathologies were subjected to CT enterorrhaphy study. Patients were followed for a period of 2 months following the CT Enterography study. The final clinical, intra-operative, or histopathological diagnosis was correlated with the CT Enterography findings.

Results: Diagnostic accuracy of CT Enterography in evaluation of small bowel pathologies was found to be 93% (86.11% to 97.14%). Sensitivity was found to be 90.77% (85.08% to 99.93%), Specificity was found to be 97.14% (90% - 100%), Negative likelihood ratio was 0.1 (0.04 to 0.20), Positive predictive value was 98.33% (89.51% to 99.76%), Negative predictive value was 85 % (72.51% to 92.41%).

Conclusion: CT Enterography is a reliable and accurate imaging modality for diagnosis of various small bowel pathologies.

Keywords: Small bowel, tuberculosis, obstruction, neoplasm, CT Enterography.

Introduction

Small intestine, consisting of duodenum, jejunum and ileum; plays a critical physiological role in nutrient absorption. Through the passive and active transport of water and the ions Na+ and Cl-, it also plays a secondary role in controlling the water balance and ion concentrations. [1] As the small bowel is relatively inaccessible to conventional endoscopy, radiological methods have been the mainstay for the diagnosis for small bowel pathologies. [2] Conventional radiological techniques such as barium follow-through provide inadequate assessment of enteric lesion. Hence In 1997, Raptopoulos et al. developed CT Enterography technique which combines neutral oral contrast and intravenously administered contrast with the enhanced spatial and temporal resolution of Multi-Detector Computed Tomography (MDCT) to specifically examine small bowel. [3]. In addition, the evolution of enteric agents to attain adequate distension of the bowel has led to better visualization of the small bowel lumen and wall on cross-sectional imaging.

The CT enterography has several benefits over the conventional small bowel follow- through examination: (a) It shows the entire thickness of the bowel wall; (b) It enables examination of deep ileal loops in the pelvis without superimposition; and (c) It enables evaluation of the mesentery and perienteric fat in the area. It also helps in evaluation of small bowel tumours, mesenteric ischemia, bowel strictures, and obscure gastrointestinal tract bleeding. When compared to other conventional imaging, CT Enterography has a clear advantage in that it can detect both luminal and extraluminal pathology [3]. Like CT Enterography, MR Enterography was introduced for assessment of small bowel. However, despite the associated radiation exposure, CT Enterography continues to be a preferred imaging modality for small intestine

assessment amongst the gastroenterologists as well as the radiologists.

This study was conducted with an aim to assess the diagnostic accuracy of CT Enterography in evaluation of small intestinal pathologies.

Material and methods:

We conducted a prospective observational study in Department of Radiodiagnosis in a Medical college in Maharashtra, India with a sample size of 100; after ethical committee clearance. Study duration was of 2 years.

Patients with acute intestinal obstruction suspected intestinal perforation, immediate post-operative scans, suspected anastomotic leak, and patients with contraindication to intravenous iodinated contrast were excluded from the study.

Patients were asked to fast for 3-4 hours. Oral neutral contrast i.e., mannitol mixed with 1 to 1.5 litres of water was given to the adult patients slowly over a period of 30-60 minutes. Paediatric patients were required to ingest 20ml/kg of 20% mannitol solution. If the patient could not ingest the oral contrast agent, naso-gastric tube was placed for administration of neutral contrast. CT acquisition was done after 45-70 minutes of start of contrast intake on a 128 slice multidetector CT (Philips Incisive).

A contrast enhanced CT was performed in all the patients using the automatic bolus tracking technique. Patients were scanned in the supine position through the abdomen and pelvis. The perineum was included in patients with suspected perianal fistulas and abscesses (in patients with known or suspected Crohn's disease) and in patients with inguinal hernias. Approximately 60-80 cc of 300% water soluble iodinated intravenous contrast was administered to adult patients through a pressure injector. In paediatric patients, 1.5- 2 ml/kg of contrast was administered on case-to-case basis.

A Biphase (Late Arterial and Venous phases) or triple Phase CT (Arterial, Portal and Venous phases) was performed depending on the indication of the study. Patients were followed for a period of 2 months following the CT Enterography study. The final clinical, intra-operative, or histopathological diagnosis was correlated with the CT Enterography findings.

Results:

Out of the 100 cases included in our study, the youngest patient was 6 years of age and the oldest patient was 90 years old. 52 males and 48 were females were included in our study. 82 subjects had optimal distension of jejunal and ileal loops, 3 had optimal distension of ileum only whereas 3 had optimal distension of jejunum only.

Around 50% subjects showed involvement of small bowel loops. 5% subjects had duodenal involvement, 19% had ileal involvement and in 9% subjects, jejunum was involved and 19 % had involvement of both ileum and jejunum**.**

Stricture or stenosis of the bowel loops was present in 22 subjects with 19 patients having dilatation of proximal small bowel loops.30 subjects had unifocal involvement and 24 subjects had multifocal involvement. 45 subjects had mesenteric fat stranding and 28 subjects had associated lymphadenopathy. Out of the 60 cases showing small bowel pathologies on CT Enterography, 25 had enteritis out of which 1 had ulcerative and 3 had crohn's disease. Further, we identified 15 cases of bowel infection; 3 cases of bowel neoplasm and 7 cases were miscellaneous pathologies (which included ileo-colic intussusception, mid gut volvulus, concealed perforation, duodenal rupture and Wilkie's syndrome.

Diagnostic accuracy of CT Enterography in evaluation of small bowel pathologies was found to be 93% (86.11% to 97.14%). Sensitivity was found to be 90.77% (85.08% to 99.93%), Specificity was found to be 97.14% (90% - 100%), Negative likelihood ratio was 0.1 (0.04 to 0.20), Positive predictive value was 98.33% (89.51% to 99.76%), Negative predictive value was 85 % (72.51% to 92.41%).

Age distribution (Table 1 and Figure 1):

Mean age of study population was found to 42.28 years, Standard deviation was 19.46 years, minimum age was 6 years and maximum age of study participant was 90 years.

Table 1: Age distribution

Age distribution					
	N	**Minimum**	**Maximum**	**Mean**	**SD**
Age	100	6	90	42.28	19.46

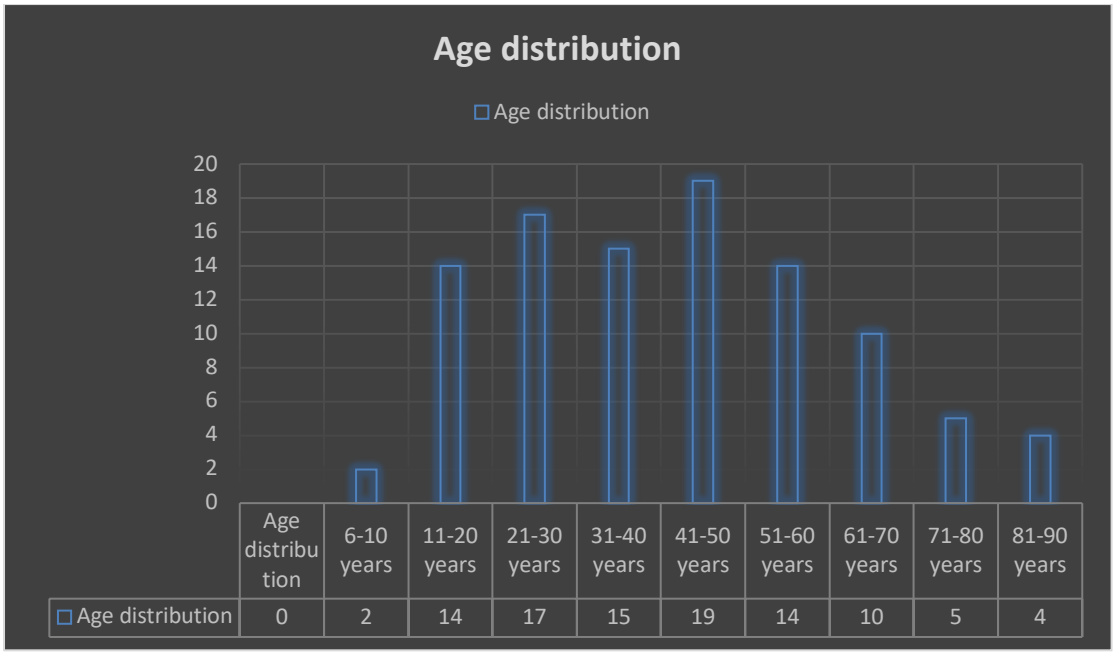

Figure 1: A bar graph illustrating the age distribution among the subjects

Gender distribution (Table 2 and figure 2): 52 subjects were males and 48 were females.

Table 2: Gender distribution

Sex			
		Frequency	**Percent**
	Female	48	48.0
	Male	52	52.0
	Total	100	100.0

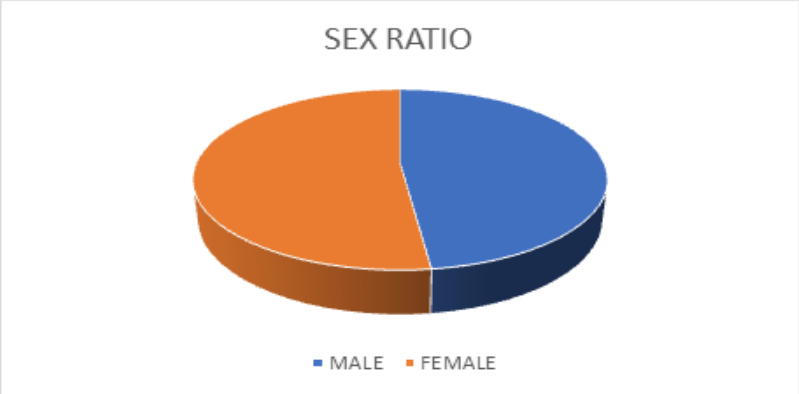

Figure 2: A pie chart depicting the gender distribution

Distribution of study subjects based on optimal distension of bowel loops (Table 3 and Figure 3): Out of 100 subjects, 82 subjects had optimal distension of jejunal and ileal region, 3 had optimal distension of ileum only whereas 3 had optimal distension of jejunum only. 12 subjects did not have any adequate distension of bowel loop**.**

Table 3: Distribution of study subjects based on optimal distension of bowel loops

		Frequency	**Percent**
Optimal distension of bowel loops	Both	82	82.0
	Ileum	3	3.0
	Jejunum	3	3.0
	None	12	12.0
	Total	100	100.0

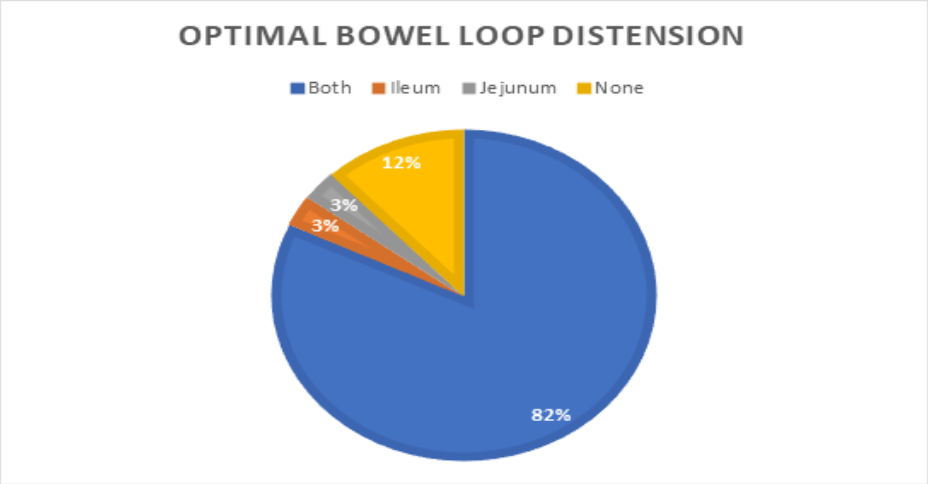

Figure 3: A pie chart depicting the distribution of study subjects based on Optimal distension of bowel loops

Distribution of study subjects based on small bowel wall enhancement (Table 4 and Figure 4): Out of 100 subjects, 80% subjects did not show any abnormal bowel wall enhancement. 19% subjects had increased bowel wall enhancement. 1 subject had reduced bowel wall enhancement.

Table 4: Distribution of study subjects based on small bowel wall enhancement

		Frequency	Percent
Bowel wall enhancement	Decreased	1	1.0
	Increased	19	19.0
	Normal	80	80.0
	Total	100	100.0

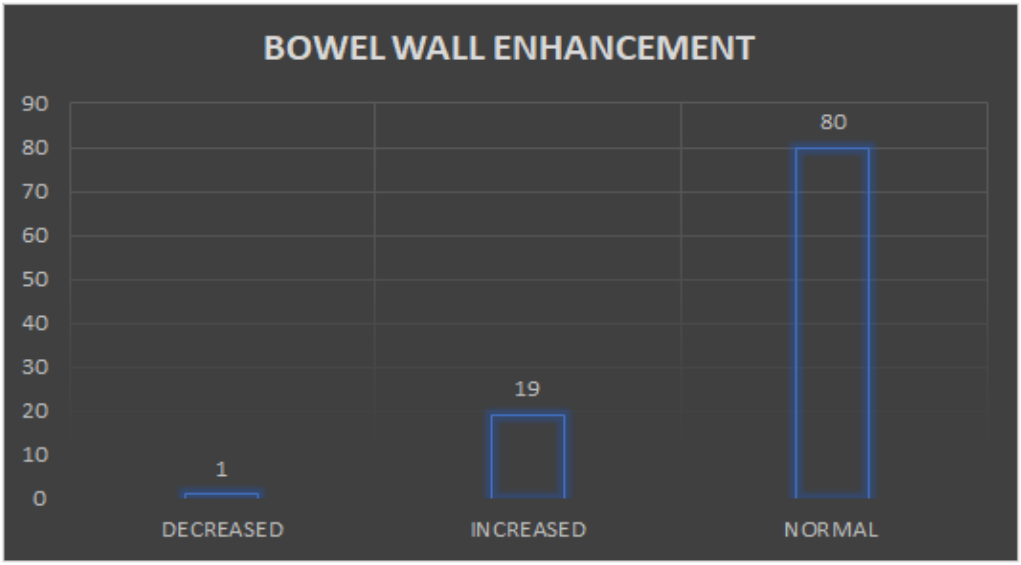

Figure 4: A bar graph depicting Distribution of study subjects based on small bowel wall enhancement

Distribution of study subjects based on gut signature (Table 5 and Figure 5): Out of 100 subjects, 73% subject had maintained gut signature, whereas 27% subjects had lost their gut signature.

Table 5: Distribution of study subjects based on gut signature

		Frequency	Percent
Gut signature	Absent	27	28.0
	Present	73	72.0
	Total	100	100.0

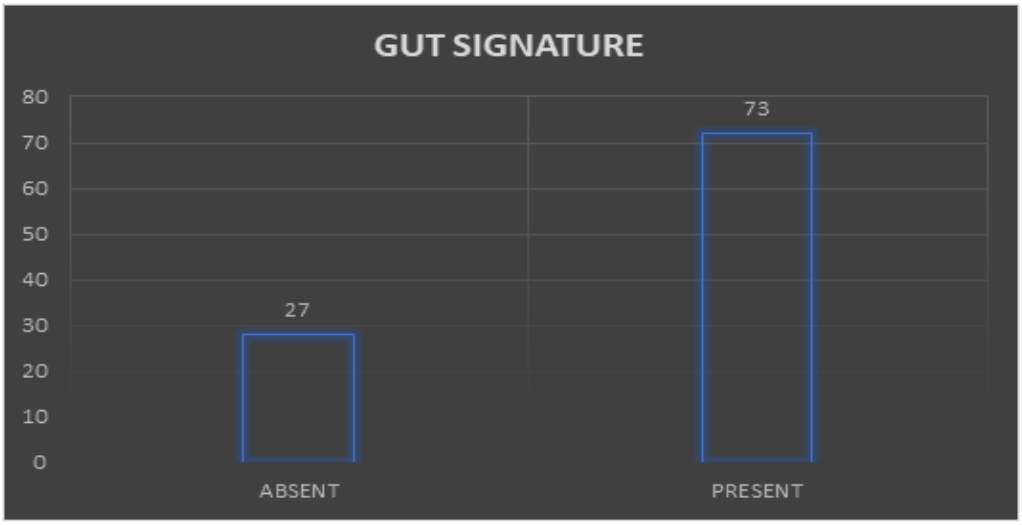

Figure 5: A bar graph depicting Distribution of study subjects based on gut signature

Distribution of study subjects based on involvement of bowel loops (Table 6 and Figure 6 &7): Out of 100 subjects, 50% subjects had involvement of small bowel loops. 5% subjects had duodenal involvement, 19% had ileal involvement and in 9% subjects, jejunum was involved and 19 % had involvement of both ileum and jejunum.

Table 6: Distribution of study subjects based on involvement of bowel loops

Involved loops		
	Frequency	**Percent**
Absent	50	50.0
Duodenum	5	5.0
Ileum	17	17.0
Jejunum	9	9.0
Ileum and Jejunum	19	19.0
Total	100	100.0

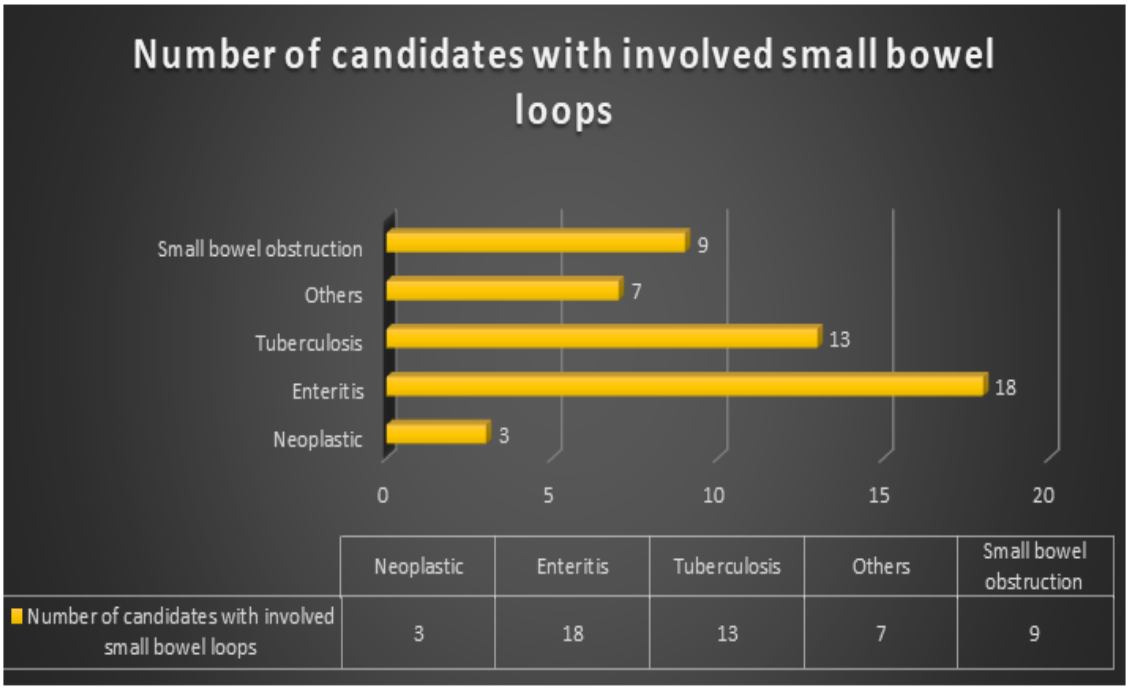

Figure 6: A bar graph depicting the distribution of small bowel pathologies

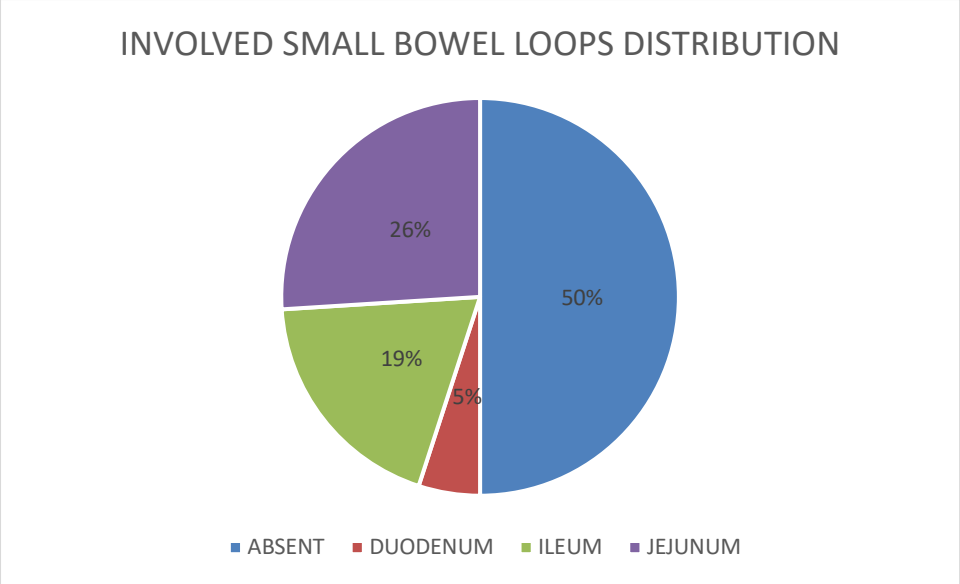

Figure 7: A pie chart depicting distribution of study subjects based on involvement of bowel loops

Distribution of study subjects based on presence of stricture/stenosis (Table 7 and Figure 8 &9): Out of 100 subjects, stricture or stenosis of the bowel loops was present in 22 subjects.

Table 7: Distribution of study subjects based on presence of stricture/stenosis

Stricture/Stenosis		
	Frequency	**Percent**
Absent	78	78.0
Present	22	22.0
Total	100	100.0

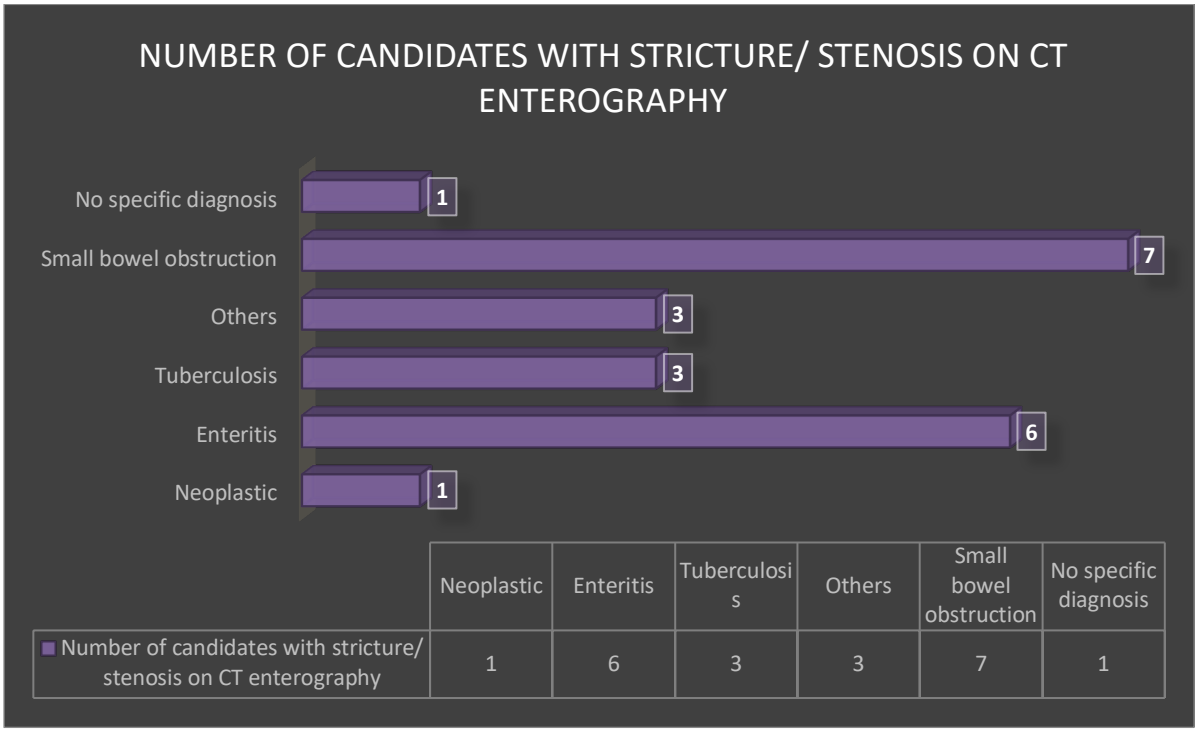

Figure 8: A bar graph depicting the distribution of small bowel pathologies depending on the presence of stricture/stenosis

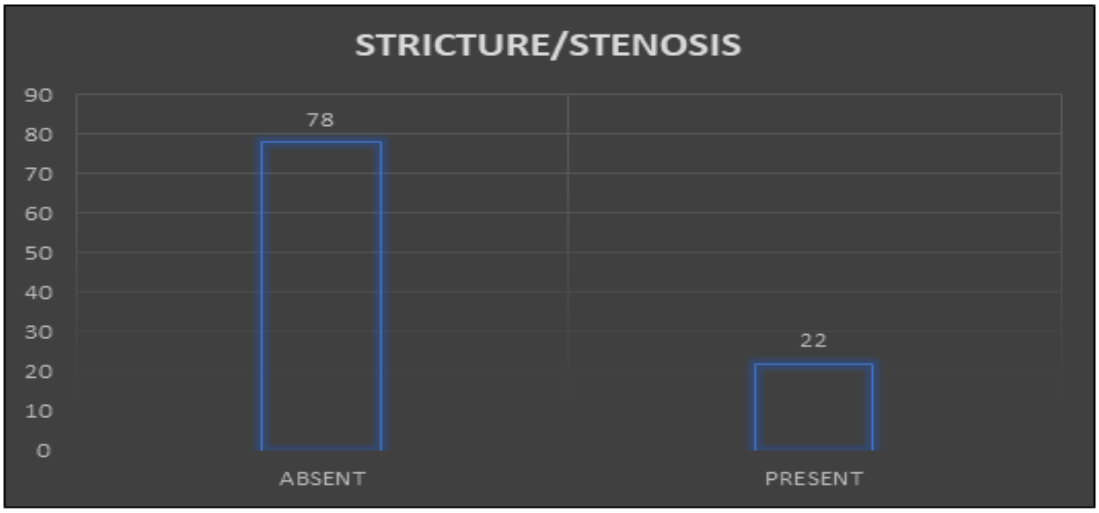

Figure 9: A bar graph depicting distribution of study subjects based on presence of stricture/stenosis

Distribution of study subjects based on dilatation of proximal bowel loops (Table 8 and Figure 10): Out of 100 subjects, 19 patients had dilatation of proximal small bowel loops.

Table 8: Distribution of study subjects based on dilatation of proximal bowel loops

Proximal dilatation of bowel loops		
	Frequency	**Percent**
Absent	81	81.0
Present	19	19.0
Total	100	100.0

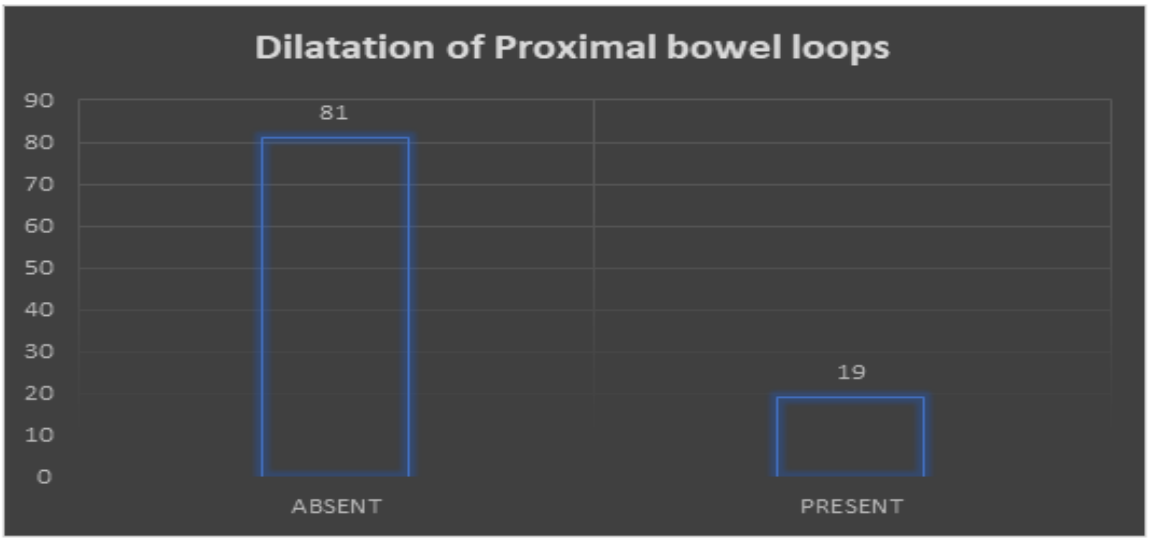

Figure 10: A bar graph depicting distribution of study subjects based on dilatation of proximal bowel loops

Distribution of study subjects based on unifocal/multifocal involvement (Table 9 and Figure 11): Out of 100 subjects, 30 subjects has unifocal involvement and 24 subjects had multifocal involvement

Table 9: Distribution of study subjects based on unifocal/multifocal involvement

Unifocal/Multifocal Involvement		
	Frequency	**Percent**
Absent	46	46.0
Multifocal	24	24.0
Unifocal	30	30.0
Total	100	100.0

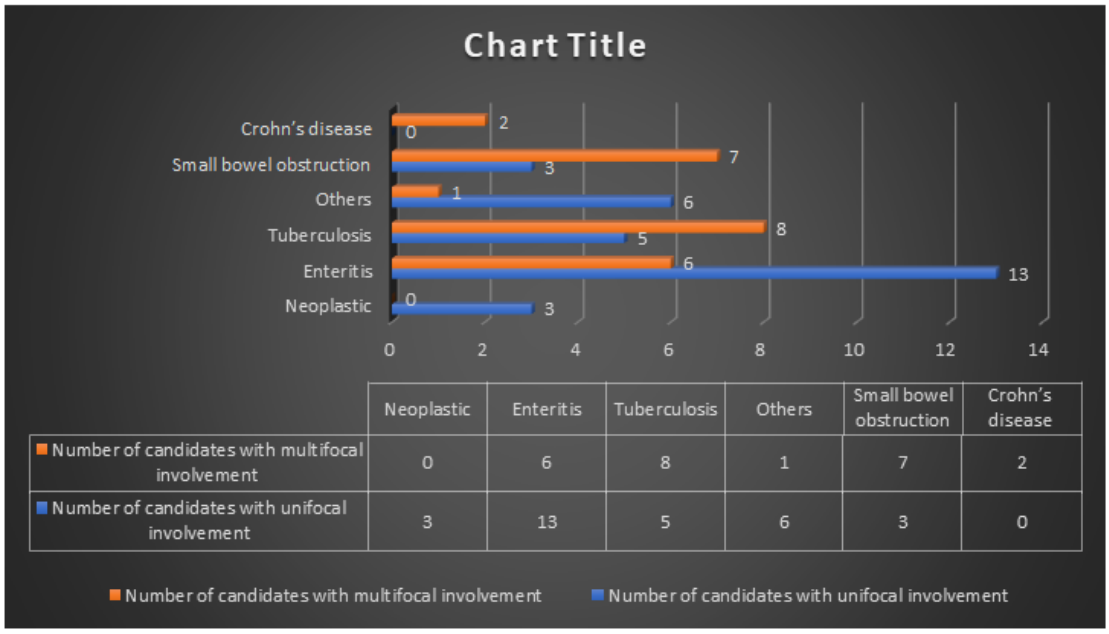

Figure 11: A bar graph depicting the distribution of small bowel pathologies depending on unifocal/multifocal involvement

Distribution of study subjects based on involvement of large bowel loops (Table 10 and Figure 12): Out of 100 subjects, 16 had large bowel involvement.

Table 10: Distribution of study subjects based on involvement of large bowel loops

Involvement of large bowel loops		
	Frequency	**Percent**
Absent	84	84.0
Present	16	16.0
Total	100	100.0

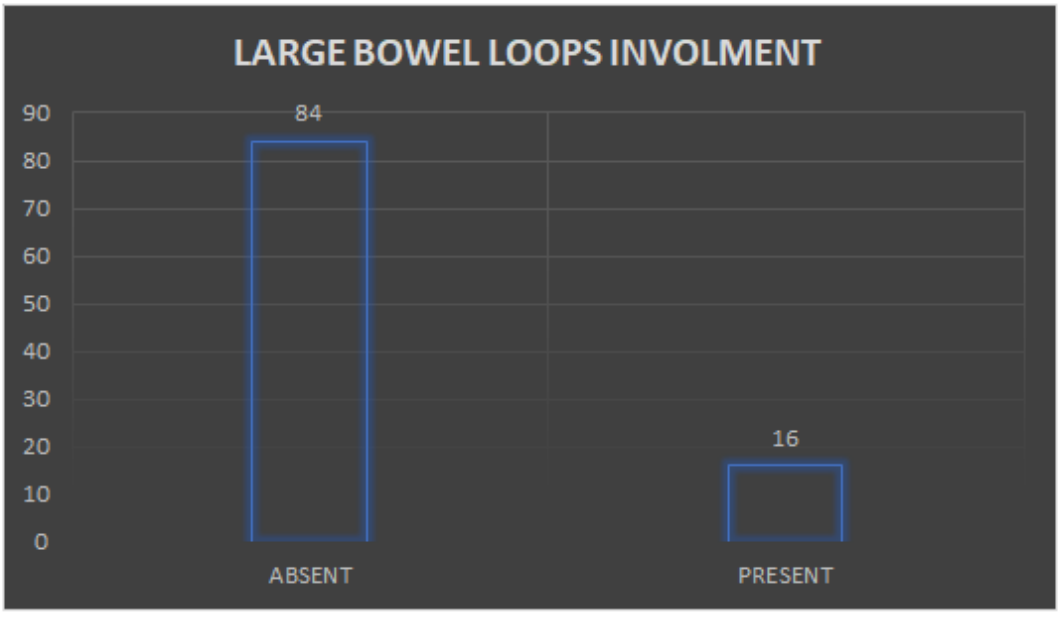

Figure 12: A bar graph depicting Distribution of study subjects based on involvement of large bowel loops

Distribution of study subjects based on presence of mesenteric fat stranding (Table 11 and Figure 13): Out of 100 subjects, 46 had mesenteric fat stranding.

Table 11: Distribution of study subjects based on presence of mesenteric fat stranding

Mesenteric fat stranding		
	Frequency	**Percent**
Absent	55	55.0
Present	45	45.0
Total	100	100.0

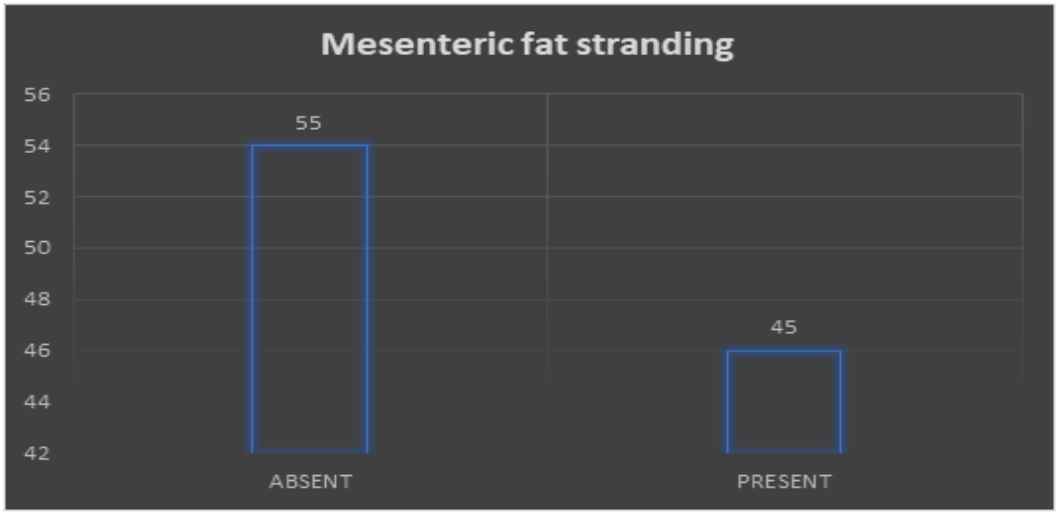

Figure 13: A bar graph depicting distribution of study subjects based on presence of mesenteric fat stranding

Distribution of study subjects based on associated abdominal lymphadenopathy (>1 cm) (Table 12 and Figure 14): Out of 100 subjects, 28 subjects had associated lymphadenopathy.

Table12: Distribution of study subjects based on associated abdominal lymphadenopathy (>1 cm)

Associated lymphadenopathy		
	Frequency	**Percent**
Absent	72	72.0
Present	28	28.0
Total	100	100.0

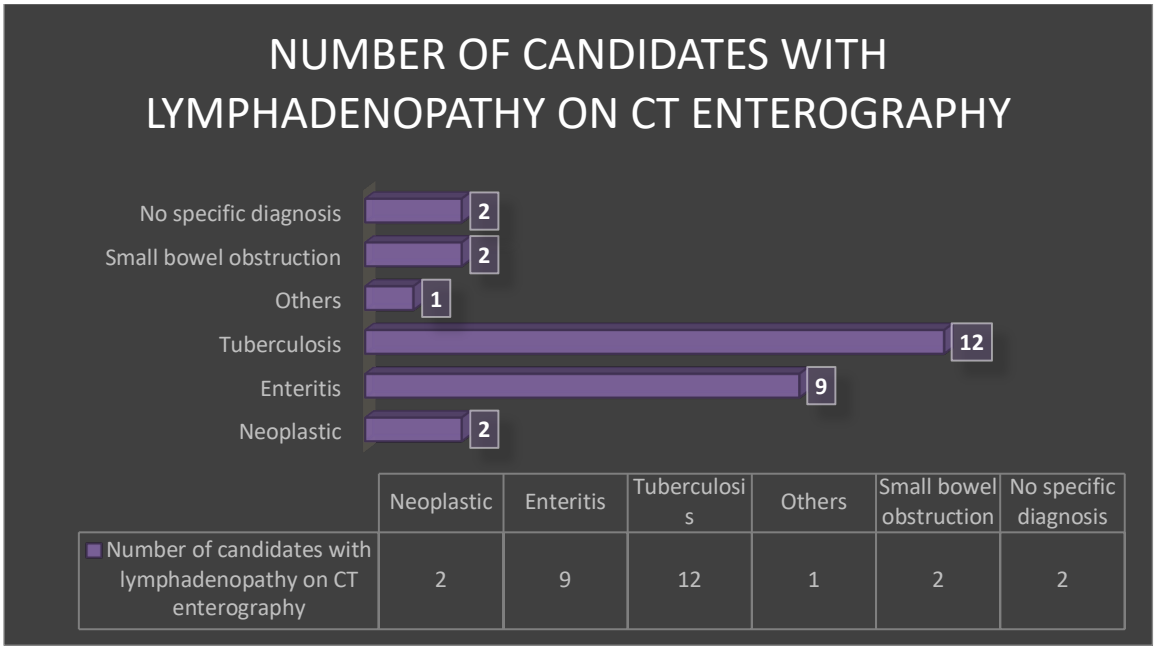

Figure 14: A bar graph depicting distribution of small bowel pathologies based on presence of mesenteric fat stranding

Distribution of study subjects based on presence of mesenteric hypervascularity (Table 13 and Figure 15): Out of 100 subjects, 11 had mesenteric hypervascularity.

Table 13: Distribution of study subjects based on presence of mesenteric hypervascularity

Mesenteric hypervascularity		
	Frequency	**Percent**
Absent	89	89.0
Present	11	11.0
Total	100	100.0

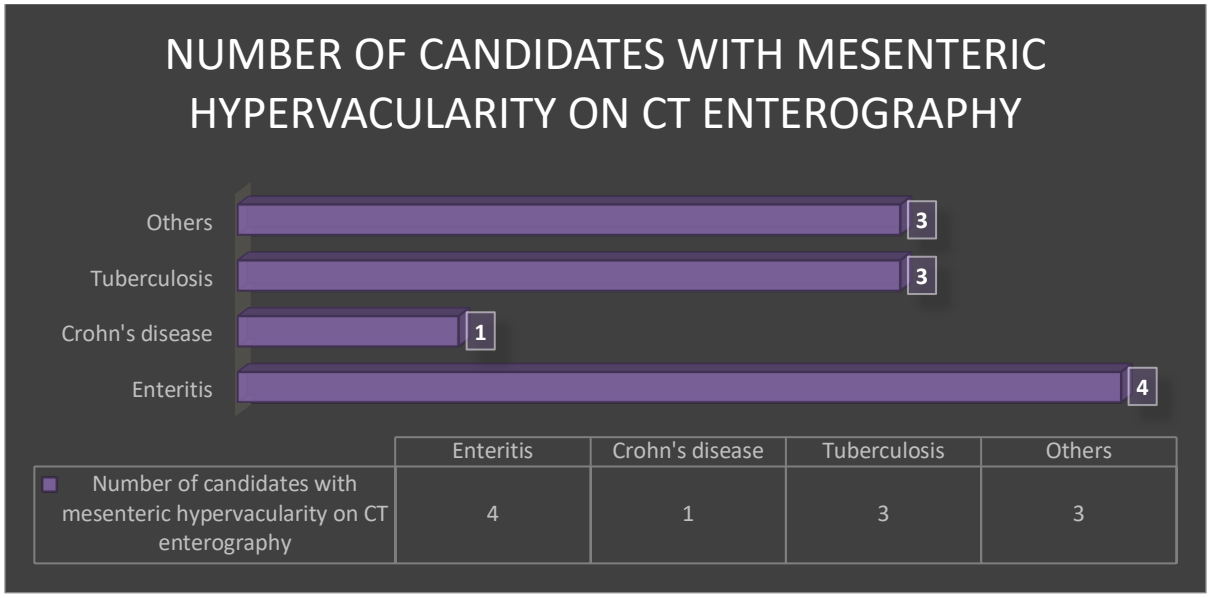

Figure 15: A bar graph depicting distribution of small bowel pathologies based on presence of mesenteric hypervascularity

Distribution of study subjects based on deposits in peritoneum or omentum (Table 14 and Figure 16): Out of 100 subjects, 5 had either peritoneal or omental deposits.

Table 14: Distribution of study subjects based on deposits in peritoneum or omentum

Peritoneal/Omental deposits		
	Frequency	**Percent**
Absent	95	95.0
Present	5	5.0
Total	100	100.0

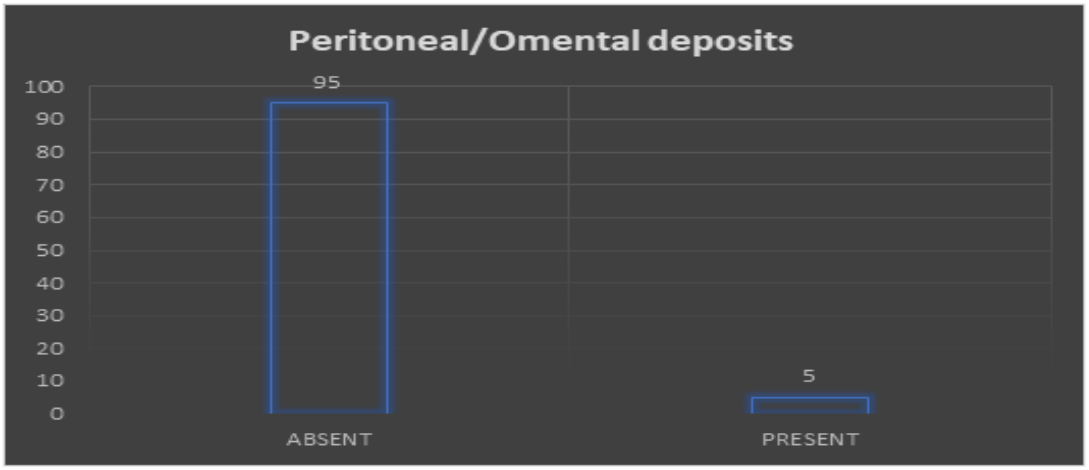

Figure 16: A bar graph depicting distribution of study subjects based on deposits in peritoneum or omentum

Distribution of study subjects based on ascites (Table 15 and Figure 17): Out of 100 subjects, 36 subjects had ascites.

Table 15:

Ascites		
	Frequency	**Percent**
Absent	64	64.0
Present	36	36.0
Total	100	100.0

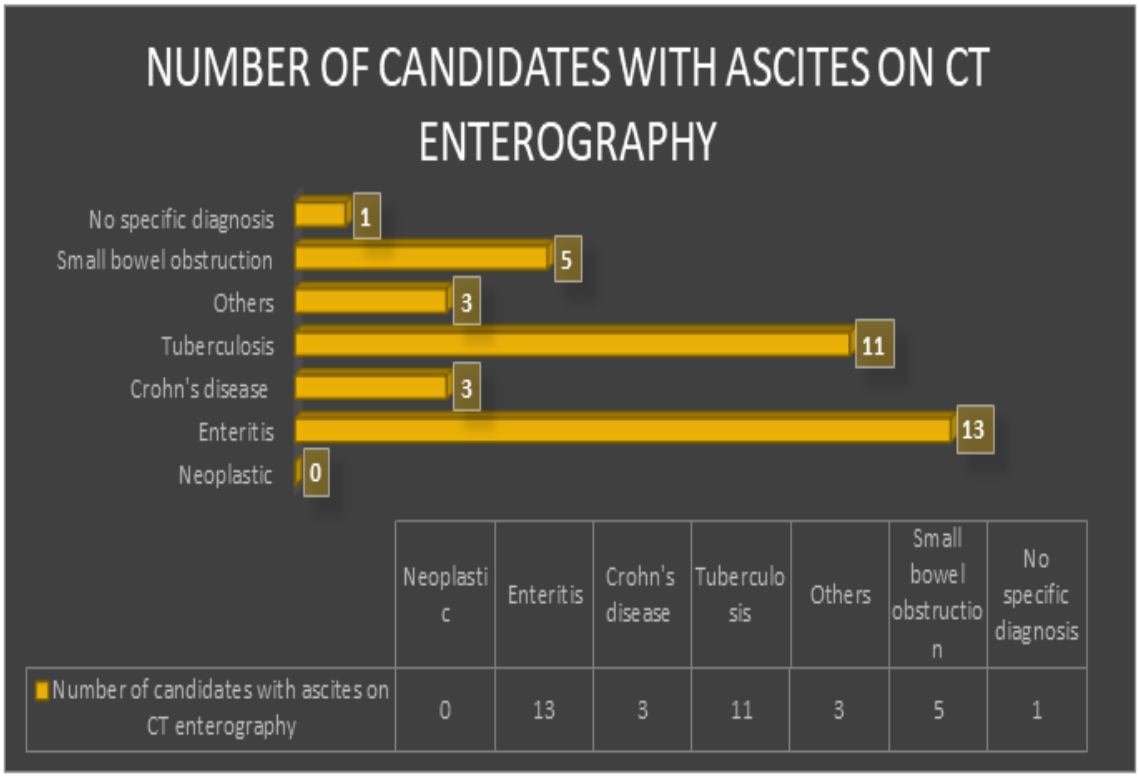

Figure 17: A bar graph depicting distribution of small bowel pathologies based on presence of ascites

Distribution of study subjects based on presence of small bowel abnormality on CT Enterography (Table 16): Out of all 100 subjects, 60 subjects had small bowel abnormality on CT Enterography.

Table 16: Distribution of study subjects based on presence of small bowel abnormality on CT Enterography

CT Final Diagnosis		
	Frequency	**Percent**
Present	60	60.0
Absent	40	40.0
Total	100	100.0

Diagnostic accuracy of CT Enterography**:**

Illustrative cases

Case 1: GIST.

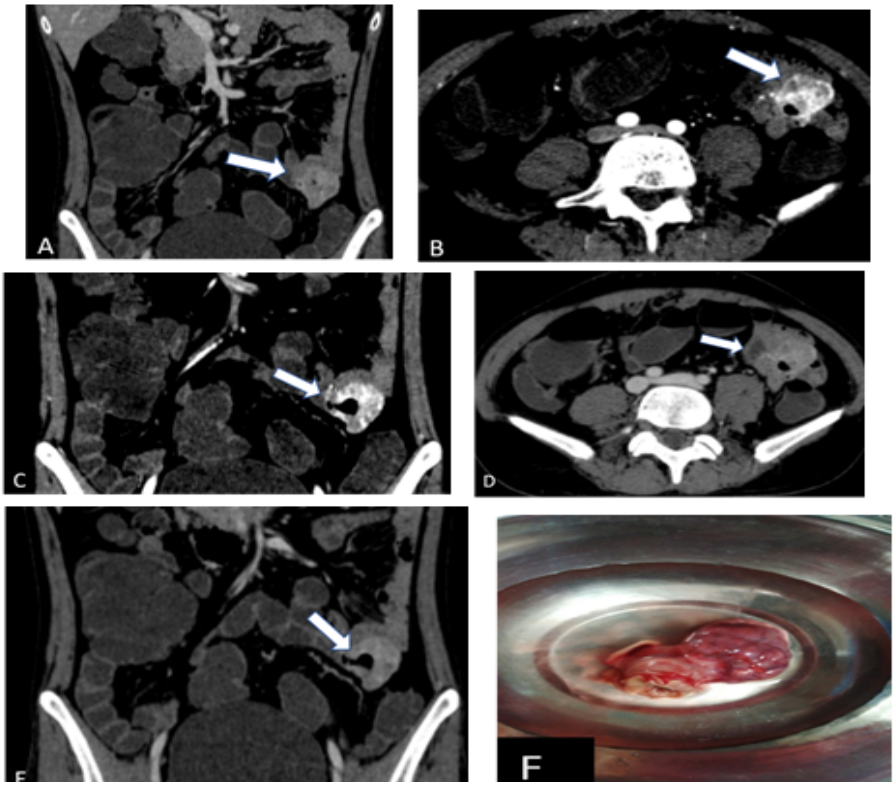

Figure 18: (A) Well defined intensely heterogeneously enhancing predominantly exophytic lesion arising from anti-mesenteric wall from distal jejunal loop in left iliac region. Figure (B) (C) Intense heterogeneous enhancement in arterial phase with arterial supply from jejunal branches from SMA. Figure (D) Few non-enhancing necrotic areas are also noted within the lesion. Figure (E) Central cavitation within the lesion with air foci which appears communicating with the jejunal lumen. Figure (F) Surgical image of the lesion.

Case 2- Tuberculosis.

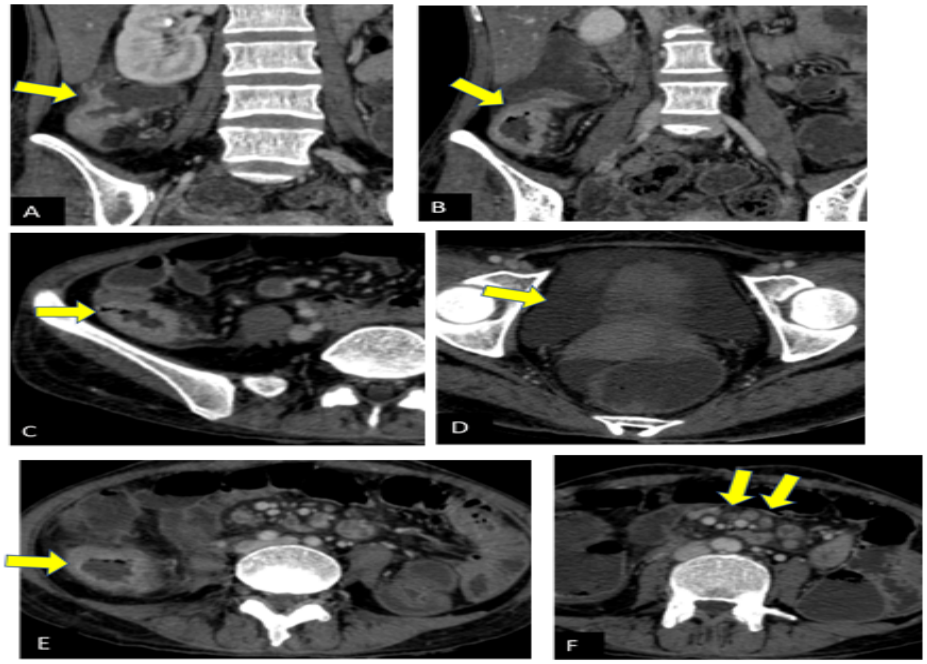

Figure 19: (A-C) CT coronal and axial showing diffuse wall thickening and enhancement of tterminal ileum and caecum with surrounding fat stranding. Figure (D) Moderate ascites. Figure (E& F) Multiple necrotic mesenteric lymph nodes.

Case 3: Post-operative small bowel obstruction due to adhesions.

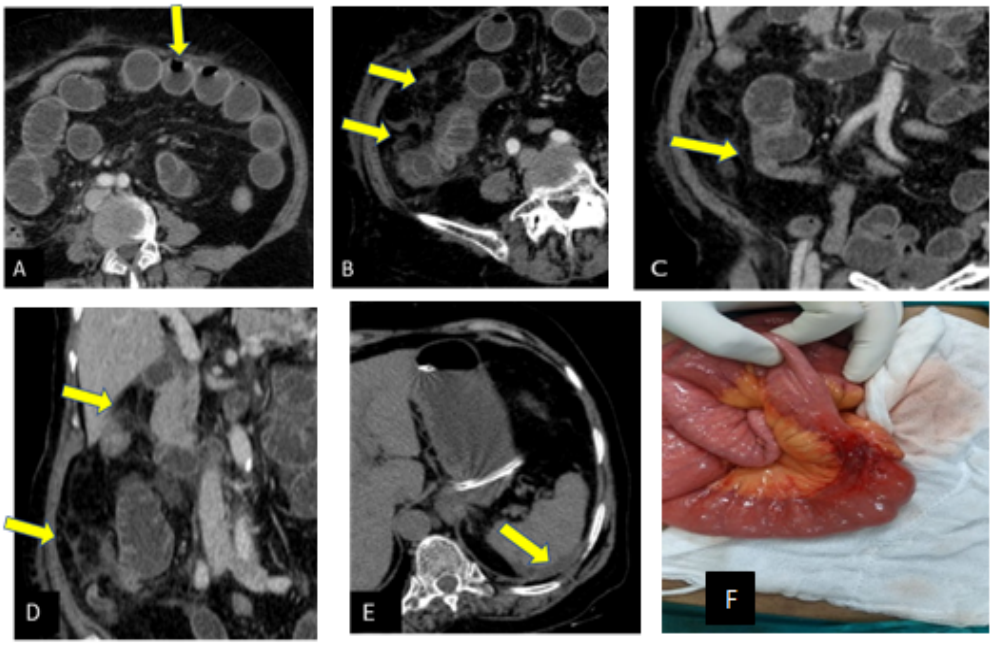

Figure 20: (A) CT axial-Dilated small bowel loops with air fluid levels. Figure (B)Mild fat standing around cecum. Figure (C) Transition point is in ileal loop in ileal loop in in pelvis right inguinal region due to adhesions. Figure (D) Mild fat standing ascending colon and hepatic flexure with mild wall edema. Figure (E) Mild free fluid in peri splenic region. Figure (F) Surgical image depicting adhesion.

Case 4: Adenocarcinoma

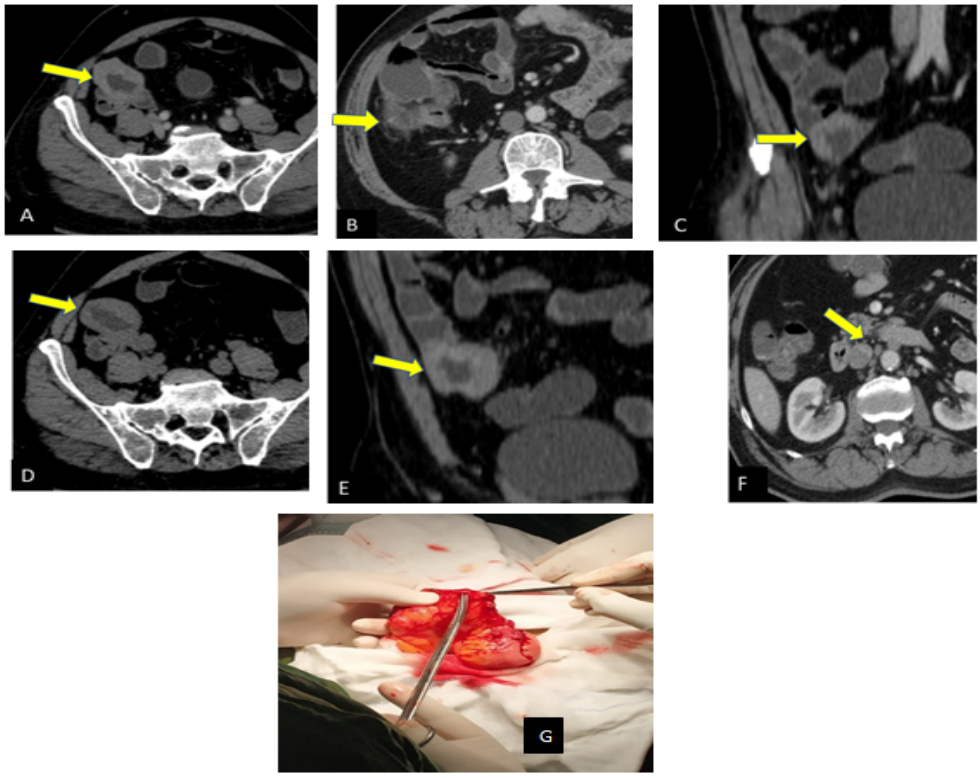

Figure 21: (A-E) Circumferential asymmetrical short segment wall thickening in the distal ileal loop in RIF region with mild enhancement and surrounding mesenteric fat stranding. Figure (F) Sub centimetric lymph nodes in pre and para aortic and pre caval region. Figure (G) Intra-operative image depicting wall thickening.

Case 5: Small bowel obstruction.

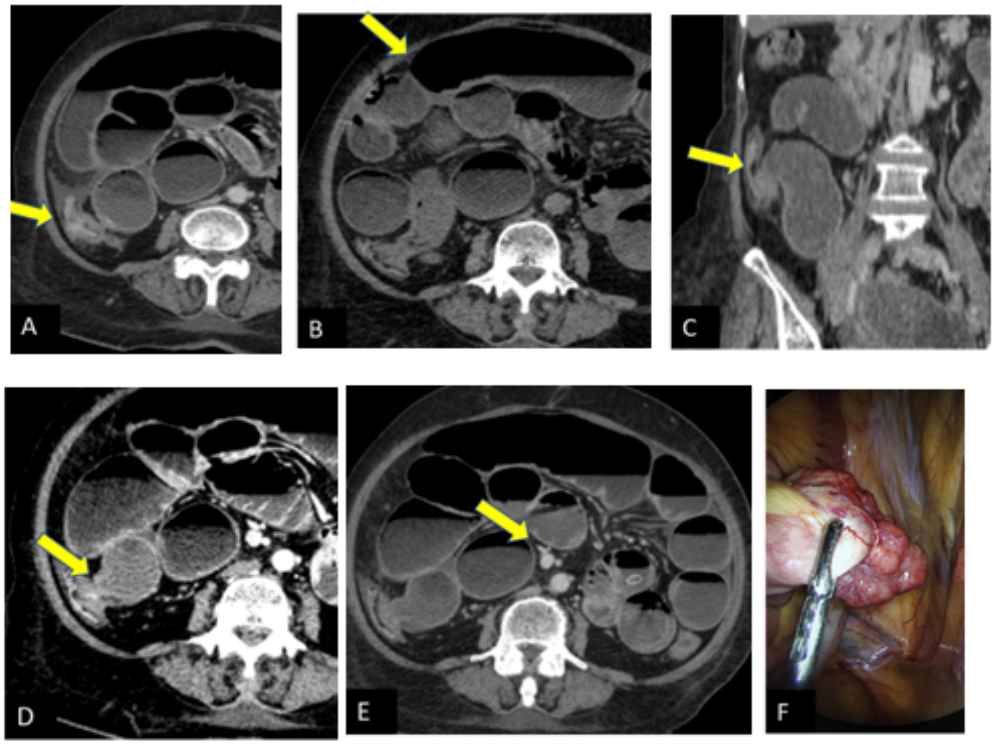

Figure 22: (A-E)The jejunum and ileal loops are dilated with multiple air-fluid levels with the transition point at IC junction. Figure (F) Intera-operative finding depicting the lesion.

Case 6: PNET.

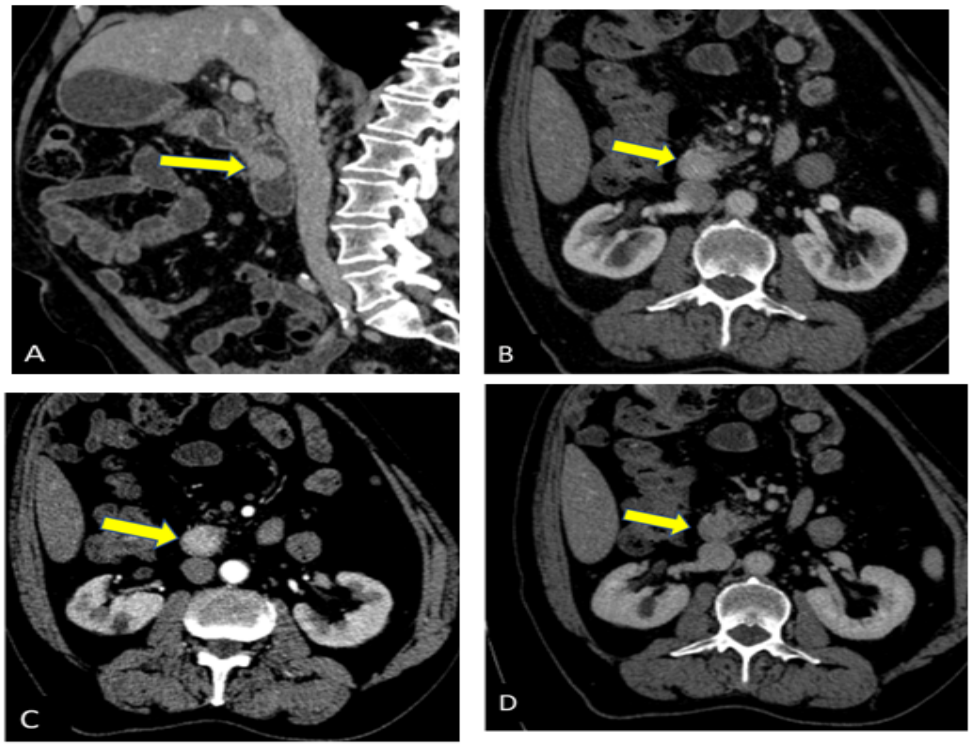

Figure 23: (A-D) A well- defined, lobulated, intraluminal lesion, in second part of duodenum which appears to be arising from the lateral wall abutting the ampulla.

Discussion

The present study was conducted with an aim to assess CT Enterography as a diagnostic modality in diagnosing small bowel pathologies, inaccessible to endoscopic approaches.

This study compared the diagnosis established by CT Enterography against clinical/histopathological diagnosis.

One candidate in this study exhibited decreased bowel enhancement and was confirmed to have bowel ischemia. Out of the 19 candidates with increased bowel wall enhancement on CT, 6 were finally diagnosed with bowel infection, 1 with Crohn's disease, 3 with bowel neoplasms, 2 with subacute bowel obstruction, 6 with intestinal tuberculosis, and 1 with post-traumatic concealed intestinal perforation. Among the 19 patients diagnosed with bowel infection on CT Enterography, 15 were diagnosed with tuberculosis on follow-up. Three patients were diagnosed with typhoid, which is a close mimic of intestinal tuberculosis. To our surprise one case was diagnosed with neuro-endocrine tumour on follow-up.

Although the diagnosis was initially missed on CT, the site of bowel hyperemia correlated with the location of the neuro-endocrine tumor. On CT Enterography 60 subjects had small bowel abnormality, however on follow-up 65 were detected with enteric pathologies. Sensitivity of CT Enterography was found to be 90.77% (85.08% to 99.93%). Specificity was found to be 97.14% (90% - 100%). Negative likelihood ratio was found to be 0.1 (0.04 to 0.20). Positive predictive value of CT Enterography was found to be 98.33% to be (89.51% to 99.76%). Negative predictive value of CT Enterography was found to be 85 % (72.51% to 92.41%). Diagnostic accuracy of CT Enterography was found to be 93% (86.11% to 97.14%).

Mishra RN et al.[4], conducted a study with a study population of 30 patients in February, 2019 to evaluate the role of CT enterography in evaluation of small bowel disease. Our study population of 100 candidates showed a sensitivity of 90.77% against 95.83%. A negative predictive value of 85% against 85.71% and an accuracy of 93% against 96.66% as seen in the study by Mishra RN et al[4],. The accuracy is lower as compared to the Mishra RN et al. as the sample size is significantly more in the conducted study. CT enterography showed a good diagnostic accuracy in assessment of small bowel pathologies. One of the important causes of false-negative scans was suboptimal distension of bowel loops despite mannitol administration. This continues to be a limitation of CT Enterography study. The alternative; CT enteroclysis which entails putting a naso-jejunal tube through which contrast is administered gives better luminal distension.

However, the placement of naso-jejunal tube is a cumbersome technique and not well tolerated by patients. Hence, CT Enterography promises to continue as the preferred imaging method for small intestinal lesions. This is also because MR Enterography, the radiation-less alternative is far more expensive and readily available everywhere.

Conclusion

CT Enterography to be a reliable, easily available, well tolerated non-invasive and fairly accurate imaging modality in diagnosing small bowel pathologies with superior delineation bowel wall and its enhancement as well as extra intestinal manifestations / involvement.

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