DISSERTATION ON

ROLE OF CT ENTEROCLYSIS IN THE EVALUATION OF SMALL BOWEL DISEASES

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BONAFIDE CERTIFICATE

This is to certify that this dissertation entitled **"ROLE OF CT ENTEROCLYSIS IN THE EVALUATION OF SMALL BOWEL DISEASES"** submitted by **Dr. R. Kumaran,** appearing for M.D. RADIODIAGNOSIS IN MARCH, 2008 is a bonafide record of work done by him under my direct guidance and supervision during the academic period from March, 2005 to March, 2008, in partial fulfillment of University rules regulations for the award of M.D. Degree Branch-VIII, Radiodiagnosis.

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INTRODUCTION

The mesenteric small intestine is the most challenging segment of the alimentary tube to examine diagnostically because of its length, caliber and overlap of loops within the peritoneal cavity. Barium enteroclysis examination has been shown to overcome most of the inherent limitations of the small bowel to follow through and is the more reliable of the conventional contrast methods of radiographic examination [1]. Experience with Computed tomography (CT) has shown that the enteroclysis method of examination fails to show important extra-intestinal manifestations of small bowel disease [2].

Computed tomography enteroclysis (CTE) is a method of examining the small intestine, which combines the advantages of enteral volume challenge and the ability of cross-sectional imaging and reformatting to depict extra intestinal manifestations of the disease [3]. It is used selectively to answer specific questions concerning the small bowel. The ability of multislice CT machines to image larger volumes at a faster speed with the ability to perform reconstruction after the examination, has made CTE a more feasible extension of the conventional barium enteroclysis and CT methods of examining the small intestine.

REVIEW OF LITERATURE

To our knowledge, the first report in Europe on CT enteroclysis focused on patients with inflammatory bowel diseases [4]. This investigation showed CTE to be highly accurate in depicting mucosal abnormalities, bowel thickening, fistulae, and extra-intestinal complications. In addition, the detection rate of conglomerated bowel loops and skip lesions were significantly higher using CTE. Patients who develop abscesses, conglomeration of bowel loops, skip lesions, fistulas are often candidates for elective surgery.

Strictures, sinus tracts, fistulae or abscesses are readily diagnosed with CTE using water soluble enteral contrast. Inflammatory disease activity can be better shown when neutral enteric contrast with IV contrast enhancement is administered.

The first report in North America on CT enteroclysis focused on patients with partial small-bowel obstruction [5]. The infusion technique overcomes the low reliability of conventional CT for the diagnosis of low-grade small bowel obstruction and adds to the ability of CT to reveal the cause of obstruction, particularly adhesions. CTE has been reported to have greater sensitivity and specificity (89% and 100% respectively) than conventional CT (50% and 94% respectively) in patients suspected of

having a partial small bowel obstruction, and this difference was even greater when abdominal malignancy is known or suspected.

Conventional CT has high sensitivity in diagnosing high grade obstruction and is of value in confirming the presence or absence of strangulation [6-9] contrast examination is not indicated in these cases [10]. There is a subset of patients in whom surgeons prefer conservative management. This includes early post-operative obstruction; Crohn's disease, carcinomatosis and patients with a complex history (history of radiation and multiple operations). In these circumstances, further characterization of the severity and nature of the obstruction is of value.

The precise localization and classification of adhesions, the most common cause of small bowel obstruction, is readily made with CTE. Analysis Of axial images aided by reformatted images allows categorization of small bowel adhesions into parietal and visceral adhesions.

Obstruction secondary to stenosis, deformity and fixation of small bowel to the parietal peritoneum is classified as a parietal peritoneal small bowel adhesion. Adherence of small bowel to another loop of small bowel, colon, urinary bladder or other visceral organ is categorized as a visceral peritoneal adhesion. Obstruction from primary malignancy or

metastasis is also readily diagnosed with CTE. Deformity and fixation of small bowel without demonstration of transition point indicates non obstructive adhesions.

The use of an optimal infusion rate is critical in differentiating obstructive from non obstructive adhesions involving the small bowel. The differentiation of early postoperative small bowel obstruction from severe ileus can be made more conclusively with CTE.

Orjollet *et al*, using a beam collimation of 5 mm, a pitch of 1 and reconstructed slices of 3 mm, revealed 25 small bowel tumours in 48 patients, among them 22 histologically proven, measuring between 0.8 to 6 cm [11]. CTE, because of the large surface rendering with a volume challenge, allows delineation of lesions as small as 0.5 cm in size [12]. CTE should be the modality of choice for the detection and localization of small bowel tumours [13].

Very recently, there is study that involves a more general population of patients who were suspected of having small-bowel diseases [14]. Their findings include that the multi–detector row helical CTE was well tolerated in almost all the patients; it allowed the diagnosis of small-bowel masses, active Crohn disease, small-bowel tuberculosis, small bowel lymphoma complicating celiac disease, and confirmed low-

grade small-bowel obstruction in some cases in addition to the normal findings. Sensitivity, specificity, accuracy, positive predictive value, and negative predictive value of multi–detector row helical CT enteroclysis were 100%, 95%, 97%, 94%, and 100%, respectively.

Small Intestine – Anatomy and Normal Appearances:

The small intestine measures ~5 m in length and extends from the DJ flexure (ligament of Treitz) to the ileocaecal valve. It is attached by its mesentery to the posterior abdominal wall and this allows it to be mobile. The proximal $2/5^{th}$ constitutes the jejunum and the distal $3/5^{th}$ the ileum. The jejunum lies mainly in the left upper and lower quadrants and the ileum in the lower abdomen and the right iliac fossa. The jejunal and ileal branches of the superior mesenteric artery provide the blood supply.

Normally the small intestine is in a collapsed or partially collapsed state. The calibre diminishes as it passes distally. During enteroclysis (small bowel enema) the maximum diameter of the jejunal loops is 4 cm and the ileal loops 3 cm. The valvulae conniventes have a circular configuration and are ~2 mm thick in the distended jejunum, becoming more spiral shaped and ~1 mm thick in ileum. They may be absent in the distended terminal ileum, resulting in a rather featureless outline.

A typical feature of mesentery is its fan-shaped arrangement and the vessel contained in it. The fat in the mesentery has the same attenuation as fat elsewhere in the body. Major arteries and veins are identifiable as branching structures within mesenteric fat and do not exceed 3 mm in diameter. Mesenteric lymph nodes are occasionally observed within mesenteric fat and do not exceed 3 mm in diameter. The omentum, located just underneath the anterior abdominal wall, lateral and anterior to the small bowel, appears as a homogenous structure, with the attenuation of fat, crossed by vessels.

Normal Small Bowel Parameters for enteroclysis

	Jejunum	**Ileum**
Folds per inch length	4-7	2-4
Thickness of folds	1-2 mm	1-1.5 mm
Diameter of Lumen	upto 4 cm	upto 3 cm
Wall thickness	1-1.5 mm	1-1.5 mm

ENTEROCLYSIS (SMALL BOWEL ENEMA)

The terms enteroclysis and small bowel enema denote either the intubation based contrast study of the small bowel or studies with minor differences in this technique. Small bowel enema is the term most widely used in Europe and enteroclysis predominates in the United States.

Single Contrast Enteroclysis

An empty colon is desirable for single contrast enteroclysis (the Sellink technique) [15]. The tube is passed through the mouth and positioned in the distal duodenum. After intubation, a barium suspension is infused with a concentration varying from 28% in thin patients to 42% in obese patients. About 600 mL of barium suspension is infused at an optimal rate of 75 mL/min. More barium is required if the cecum has not been reached. Water may be infused after the barium suspension to achieve better filling of the distal ileum, to provide a brief double contrast effect in the jejunum, to produce prestenotic distention, and to outline the colon in patients in whom a barium enema cannot be performed.

Biphasic Enteroclysis with Methylcellulose

Maglinte infuses 400 to 450 mL of a 50% w/v barium suspension and usually completes the single contrast examination of all bowel loops before infusing methylcellulose. The study may be terminated at this point if the clinical objective has been achieved. In contrast, Herlinger infuses 180 to 240 mL of an 80% suspension of barium filling only about half the small bowel. Infusion of methylcellulose then propels the denser barium toward the terminal ileum, gradually converting the examination

from single to double contrast [16]. Thus, all bowel loops are studied as lumen distention and transradiancy increase.

Purpose of Methylcellulose

Methylcellulose has the following functions in enteroclysis:

1. It propels the barium column into the distal ileum and the colon.

2. It gradually distends the small bowel lumen, straightens the circular folds, and tests the distensibility of individual segments. Nondistended bowel loops can give misleading information (eg. A false impression of nodularity).

3. It has low diffusivity with compatible barium suspensions and thus preserves an interface between the density of the barium coating the mucosa and the water density of the distended lumen. Provided than vigorous abdominal compression has been avoided during this stage, double contrast develops throughout the small bowel and persists for 15 to 20 minutes. Even with the best technique, however, there is some diffusion of barium into methylcellulose, which becomes more noticeable in the ileum. The double contrast density difference between barium and methylcellulose is therefore greatest in the jejunum.

4. As a result of the double contrast effect or even dilution and transradiancy, intestinal surface detail can be studied even when two or three bowel loops overlap. This is important because lumen distention within the limited space of the peritoneal cavity increases the frequency of overlapping bowel loops.

5. On entry into the colon, methylcellulose promotes evacuation of barium.

Air double-contrast Enteroclysis

The primary indication for this technique is to show subtle intraluminal surface details (i.e. erosions small ulcers, or small non-obstructing neoplasm).

With the balloon of the enteroclysis catheter in the proximal duodenum, we turn the patient to a right lateral position and gradually inject carbon dioxide or air through large syringes (up to a total of 2500 mL) or a mechanical insufflation system. The head is lowered 5 to 10 degrees. When all jejunal and pelvic loops are filled with air, double-contrast views in supine and prone positions with mild compression in different obliquities are obtained to clear the jejunum. Similar to the methylcellulose double-contrast technique, the jejunum is the easiest segment of the small bowel to evaluate but should be cleared first before

degradation of coating or superimposition by contrast-filled transverse colon occurs. Following jejunal filming, double-contrast views of the pelvic segments of ileum are obtained with the patient supine and prone. If hyperperistalsis of small bowel loops are present, 1 mg IV glucagons is administered. Following radiography of the pelvic segments of the ileum, the patient is brought semiupright and views of the distal ileum distended with gas are obtained in supine and prone positions. In patients with slow transit and not enough barium coating and distending the distal small bowel, 0.5% methylcellulose suspension is infused next to air insufflation. Diagnostic double-contrast radiographs of the distal small bowel are usually produced, because the methylcellulose will push the barium distally although subtle surface details may be effaced.

However, as air does not distend the intestine as well as dilute barium, sinuses and fistulas are often demonstrated, stenosis may be overlooked.

Advantages of Enteroclysis

Advantages of the enteroclysis include the following:-

1. By introducing contrast beyond the gastric outflow regulating action of the pylorus, contrast materials can be administered directly into the small bowel as rapidly as necessary.

2. Lumen distention of the small bowel can be controlled by the rate of infusion. By testing lumen distensibility, diseases associated with focal or segmental reduction of distention are more easily detected.

3. Distention of the jejunum induces small bowel hypotonia, enabling display of all dilated bowel loops simultaneously at the end of the examination.

4. Lumen distention is the most important aspect of enteroclysis and is more important than double contrast. It straightens the circular folds and makes it possible to determine morphologic normality on the basis of measurable parameters.

5. The examination is normally completed within 20 to 30 minutes.

AIM AND OBJECTIVE

- The purpose of this study is to evaluate the role of CT Enteroclysis in a symptomatic patient population with a clinical suspicion or previous diagnosis of small bowel disease.

MATERIALS AND METHODS

This study was performed at the Barnard Institute of Radiology, Madras Medical College, Chennai.

Duration of this study

From October 2005 to October 2007

Inclusion criteria

Study group included 30 patients of age ranging from 18 years to 62 years, suspected of having low-grade small intestinal obstruction, small bowel tumours, small bowel tuberculosis, inflammatory bowel disease, unexplained abdominal pain with a h/o abdominal surgery, malabsorption, entero-enteral fistula.

Exclusion criteria

Exclusion criteria consisted of acute complete small bowel obstruction, perforation, general contraindications for helical CT (including pregnancy, acute or chronic renal failure, and hemodynamic instability) and an inability to tolerate a sufficient breath hold for adequate helical CT study. In addition, patients with a history of allergy were excluded from the study group.

In patients referred for CT enteroclysis or barium enteroclysis for unexplained gastrointestinal bleeding, anemia, or workups for small bowel neoplasm who have a history of prior colectomy and ileosigmoidostomy or ileoproctostomy, a retrograde (per rectum) enteroclysis or small bowel enema is preferred over antegrade infusions. This is because of the difficulty of distending the small bowel from above without the sphincter mechanism of the ileocecal valve.

If only a segment of the right colon has been removed, infusion should be antegrade, because the long length of the remaining colon prevents adequate infusion pressure to challenge the distensibility of the entire small bowel and duodenum. Even with a background of prior colon surgery, if the indication is for small bowel obstruction, an antigrade approach is preferred. A long decompression tube can be used for suction if the small bowel is obstructed.

Nasoenteric tube was positioned into duodenojejunal flexure under fluoroscopic guidance and positive contrast/neutral contrast about 1.5 – 2 *l* was infused at a rate of 55 -150 ml/min. Buscopan 20 mg injected intravenously and after administration of intravenous contrast (40 ml) CT enteroclysis [15 with helical CT (Toshiba Asteion) and the rest with 4-slice CT (Toshiba Asteion 4)] were obtained with 3 mm collimation and

reconstructed with 1.5mm analyzed. Results compared with surgical, histopathological findings and clinical follow-up.

The steps involved in multislice CTE are described via the following block diagram [Fig. 1].

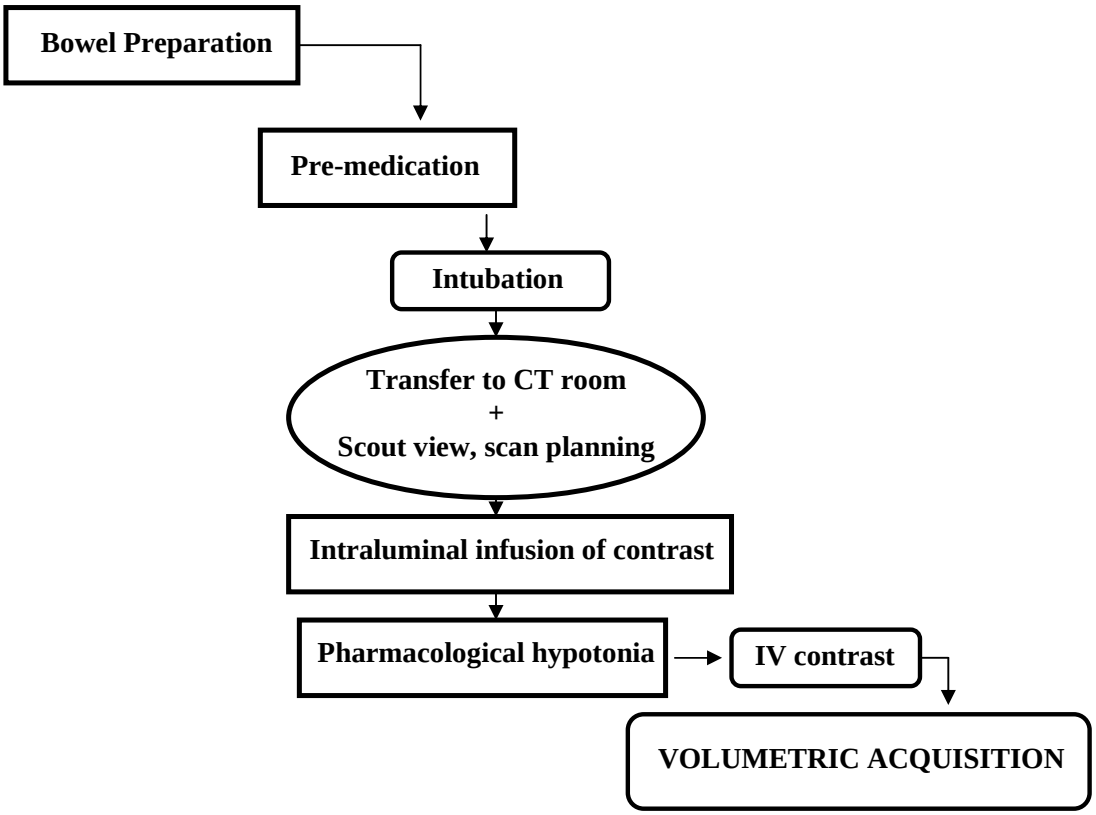
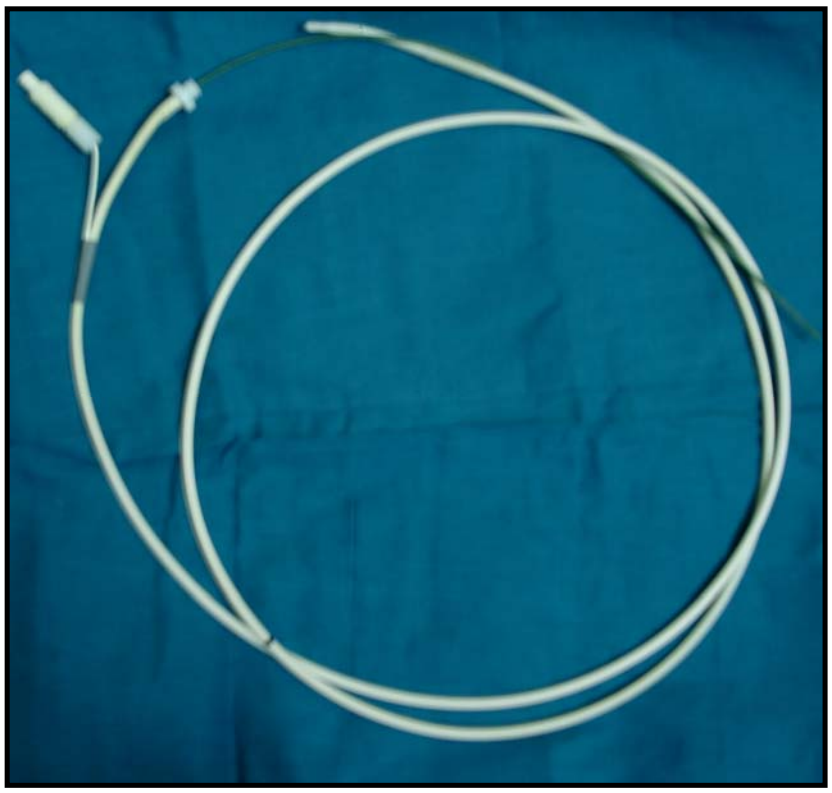


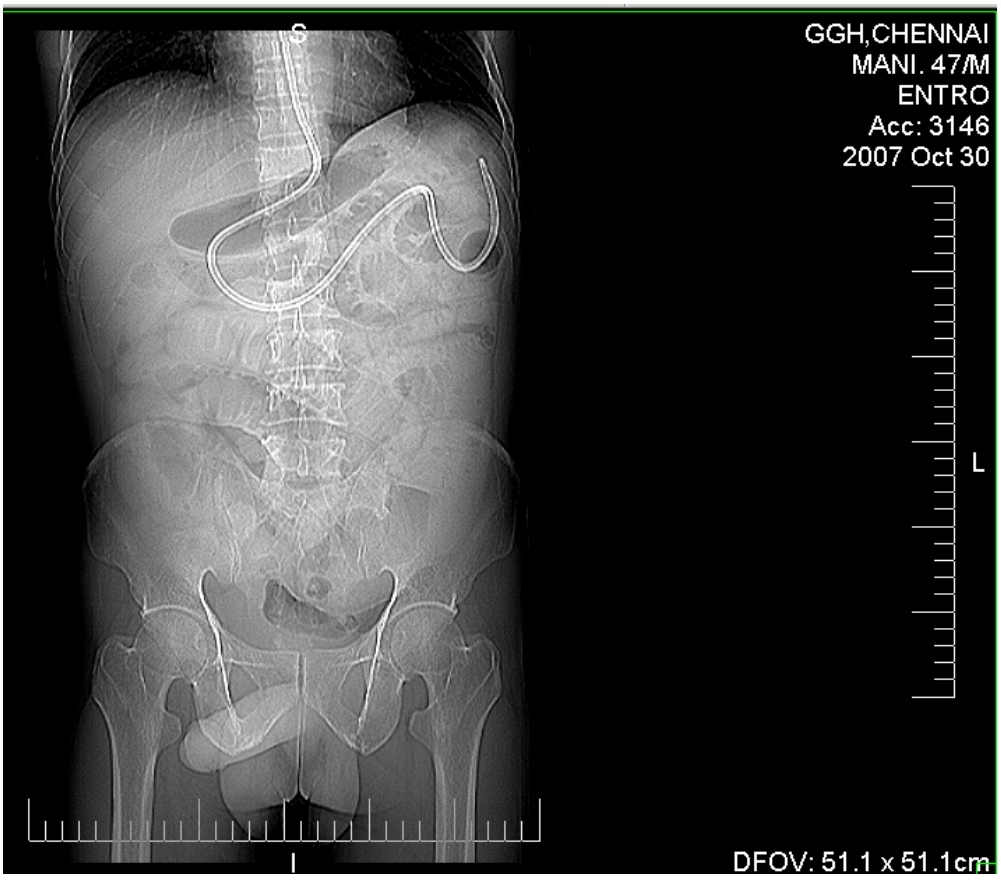
Fig. 1

BILBAO DOTTER TUBE

MAGLINTE ENTEROCLYSIS TUBE



SCOUT VIEW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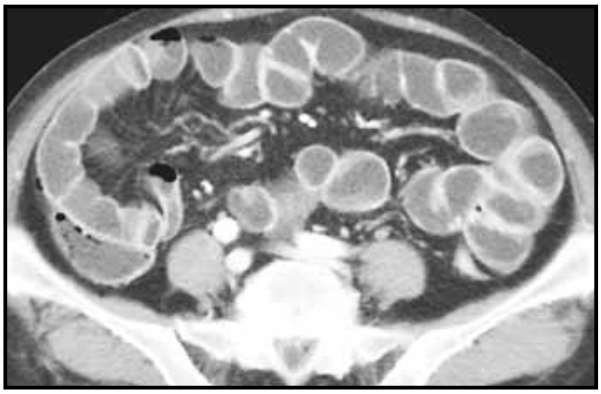
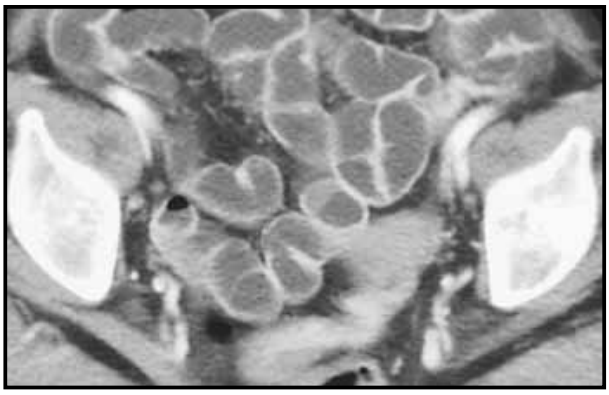
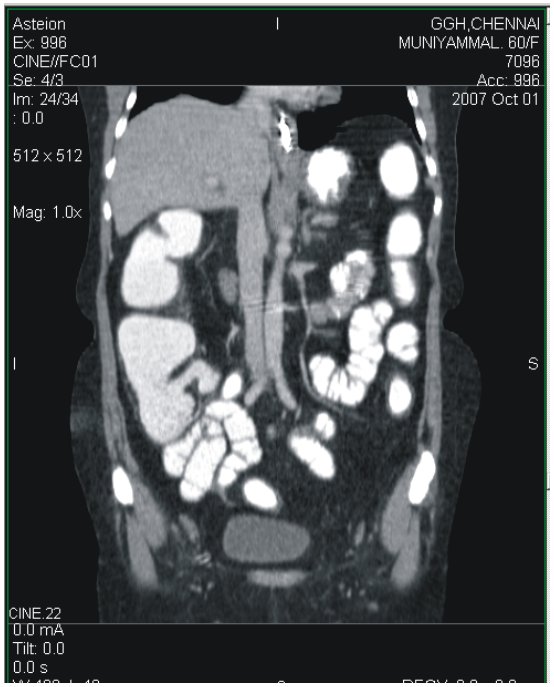
Normal Anatomy





Ileocaecal valve



Mesentery

Bowel Preparation

24 hour small bowel preparation

- low-residue diet
- Ample amount of fluids
- laxative with Bisacodyl

8- 12 hours fast

Pre-medication

Metoclopromide 10mg IV facilitates transpyloric intubation, allows for faster contrast infusion rates and reduce procedure time.

Intubation

Transnasal intubation: - allows better catheter control and faster intubation, better tolerated than the trans-oral approach, a 2% lidocaine jelly used as a surface anaesthetic slowly introduced through the nostrils into the nasal passage.

13 Fr, 135 cm long, Bilbao – Dotter tube with 5 side holes,

13 Fr, 155 cm long Maglinte dual lumen catheter with a distal balloon attachment to prevent duodeno-gastric reflux were used for our diagnostic study**.**

With the guide wire approximately 5 inches from the tip, the lubricated catheter is gently introduced while the patient′s neck is maximally extended. Slight resistance is normally felt at the posterior wall of nasophaynx.

When the catheter is beyond this point, patient should be asked to flex the head towards the chest and swallow while the catheter is advanced through the pharynx and oesophagus to facilitate catheter passage through the stomach patient should be turned to the right.

Passage of catheter through the upper duodenal flexure is facilitated by turning the patient to the left, the stomach shifts towards the left taking with it the mobile 1st part of duodenum and thus widening the duodenal flexure.

Passage through the lower duodenal flexure may occur spontaneously or may be facilitated by craniad directed hand pressure.

To negotiate the duodeno-jejunal flexure patient should be turned to left into a semiprone position.

If possible catheter should be far enough into jejunum for the inflated balloon to be positioned beyond the ligament of Treitz.

The balloon can be anchored in the descending duodenum for positive contrast enteroclysis.

Transfer to CT room, Scout view and Planning of CT Scans

Pharmacological hypotonia

20 mg IV buscopan serves to lessen the patient discomfort and reduce intestinal peristalsis and resulting segmentation of loops so that entire small bowel is adequately and uniformly distended during the volumetric scan.

It may be given after infusion of 1000ml of enteral contrast.

Intraluminal contrast infusion

The material used were sodium diatrizoate (4%) / water at a steady flow rate of 100-120 ml/min approximately 2 -2.5 L contrast is infused. There is no fixed optimum infusion rate to ensure that distensibility of entire small bowel is tested. Each patient's small bowel has a different response to different rates that is modified by the medications that the patient has been taking or by administration of a promotility agent. Generally, high rates of infusion abolish peristalsis and produce hypotonia and subsequenty atonicity with reflux of contrast into the stomach. This results in distended loops of jejunum, but collapsed or poorly distended

distal small bowel. Slow rates of infusion result in hyperperistalsis, so that an optimum enteral volume challenge is not produced. Mild gradient (transition point) from adhesions or small nodules may not be appreciated.

Administration of IV contrast: 40 ml of iodinated contrast (Iohexol)

Volumetric acquisition: slice thickness of 3mm was used at the most and then reconstructed at 1.5 mm. Image analysis and documentation were carried out with a soft tissue window (centre 30 HU, width 400 HU).

All CTE images were reviewed in both the axial and reformatted coronal and sagittal planes.

OBSERVATIONS

The present study was carried out on 30 cases with indications of small bowel disorders and the following observations are made.

The results of the CTE examination are listed below.

Table no. 1

Total no. of CTE cases	**30**	**Percentage (%)**
Normal	11	36.67
Abnormal	19	63.33

Out of the 30 cases investigated eleven were found to be normal and the rest nineteen were diagnosed to be abnormal. Among the abnormal cases, small bowel obstruction was seen in four: abnormalities of inflammatory origin three: Tumour was encountered in three cases. Fistula in two cases. Abnormalities in large bowel were four and there is one case on follow-up. The results of abnormal cases are tabulated below.

Table no. 2

Abnormality	No. of Cases
Obstruction	4
Inflammatory	3
Tumour	3
Fistula	2
Large bowel	4
Cases on follow-up	1
Others	2

RESULTS AND DISCUSSION

CT Enteroclysis enabled us to diagnose

- low grade intestinal obstruction

  which was associated with adhesions (n=1), stricture [distal jejunum (n=1), proximal jejunum (n=1)]

- Small bowel tumors

  Adenocarcinoma (n=1)

  Lymphoma (n=2)

- Intestinal tuberculosis (n=3)
- Entero colic fistula (n=1)
- Entero cutaneous fistula (n=1)

- CT Enteroclysis identified the site, level and cause of obstruction in 4 of the patients suspected of having low grade small bowel obstruction. Two of the patients had stricture and 1 of them had adhesions, one patient had Crohn's disease.

- In the case of adhesions, at the zone of transition there was no mass / mural thickening, CTE demonstrated the adhesion between ileal loops suggesting visceral peritoneal adhesions.

- In case of distal jejunal stricture, CT enteroclysis demonstrated the stenosis and prestenotic dilated loops, collapsed ileal loops and small bowel faeces sign (SBFS). The small bowel faeces sign on computed tomography images is the appearance of particulate material mixed with gas bubbles within the small bowel, which has the appearance of stools in the colon. This is believed to be due to delayed transit through the small bowel with increased time for fluid absorption across the bowel wall and accumulation of undigested food, as a result of stasis or obstruction.

- Inhomogenous mottled material with small internal air collections in the small intestine may also be found in other conditions, such as cystic fibrosis, infectious or metabolic bowel disease, rapid jejunostomy tube feedings, or, rarely, bezoars. By definition, however, for the diagnosis of the small-bowel feces sign, a dilatation of bowel loops more than 2.5 cm in diameter must be present. Other possible causes of the SBFS include bacterial overgrowth and reflux into the terminal ileum due to an incompetent ileocaecal valve [17, 18, 19].

- In the case of Crohn’s disease, CTE showed circumferential wall thickening of the ileum, prominent mesenteric vessels indicating hyperemia, mesenteric fat stranding, causing low grade ileal obstruction.

- In a known case of inflammatory bowel disease, CTE showed the small fistula between the distal ileal loop and ascending colon and extension of fistula from inflamed ascending colon to small abscess within the adjacent abdominal wall.

- The reported incidence of fistulas in Crohn’s disease ranges from 6 - 33% .Fistulas occur as the result of transmural extension of the disease. Ileocaecal and enteroenteric fistulas are most common and are often multiple . An enterocolic fistula as in our case may lead to bacterial overgrowth and is one of the causes of malabsorption associated with Crohn’s disease.

- CTE demonstrated the following small bowel abnormalities in 3 patients with intestinal tuberculosis.

- long segment wall thickening of ascending colon, terminal ileum with pulled up caecum, paraaortic lymphadenopathy and ascites,

- Asymmetrical wall thickening of the caecum and terminal ileum, low density lymph nodes in the paracaval, paraaortic, aortocaval region.

- Terminal ileum thickening with mesenteric inflammatory changes.

Differentiating imaging features of ileocecal involvement by tuberculosis and Crohn's disease:-

Tuberculosis features

Asymmetric wall thickening, irregular,

No creeping fat,

Omental and peritoneal thickening,

Enlarged lymph nodes with low-density centers.

Crohn's disease features

Circumferential bowel wall thickening +/- mural stratification,

Creeping fat (abnormal quantity of mesenteric fat),

Prominent mesenteric vessels indicating hyperemia,

Normal omentum and peritoneum

- The sensitivity of conventional double contrast barium enteroclysis for Crohn's disease ranges between 98.2% - 100% as was demonstrated on 168 and 143 patients respectively,whereby Maglinte et al had included 43 patients (31%) with early lesions.

- The diagnostic accuracy of cross sectional imaging modalities including CTE remains controversial for the initial stage of Crohn's disease. Their spatial resolution is still inferior to that of conventional double contrast enteroclysis and does not allow detailed analysis of small bowel mucosa.Therefore early mucosal inflammation, histopathologically characterized as aphthoid ulcerations and enlarged follicles is not constantly visualized by CTE even with given improvements of multidetector row technology.

- At intermediate or advanced stages of Crohn's disease however, the value of CTE is well established. The degree of small bowel thickening and intensity of mucosal contrast enhancement correlate with the disease activity at the acute or quiescent phase due to homogenous luminal distension, CTE allows a better analysis of the small bowel wall than conventional CT and thus a more precise and comprehensive recognition of the different pathological enhancement patterns.

- Acute inflammation is characterized by mural stratification mainly explained by strongly contrast enhanced mucosa surrounded by low density submucosa.

- Chronic involvement seen during clinical quiescence is associated with diffuse parietal contrast enhancementand mild thickening, indicating irreversible transmural fibrosis.

- Extraintestinal features of Crohn's disease such as inflammatory extension into the adjacent mesentery, associated abscesses, enteric fistulae or involvement of other organs are simultaneously and readily demonstrated by CTE and not by conventional barium studies.

  The latter only inconsistently showed enteric fistulous tracts which can precisely be demonstrated by multiplanar reformatting views.

  Finally enteral volume challenge of CTE allows the visualization of even moderate segmentary luminal narrowing due to active Crohn's disease which might only appear as collapsed or spasmed small bowel loops on traditional CT.

  The length of these strictures might then be more accurately demonstrated on multiplanar reconstructions, often best appreciated on the coronal plane.

- Furthermore, CTE features allow accurate classification of Crohn’s disease into subtypes that include active inflammatory, fibrostenosing and fistulizing perforating categories.

Radiological classification of small bowel Crohn's disease, according to Maglinte et al :-

Radiological classification	
Active inflammatory subtype	
Minimal changes	Superficial ulceration (aphthae)
	Minimal fold thickening or distortion
Severe changes	Deep ulcers, cobblestone mucosa
	Marked wall thickening
	(mural stratification, target sign)
	Obstruction secondary to spasm, Comb sign
Fibrostenotic subtype	
Minimal stenosis	Minimal decrease in luminal diameter,
	Mild pre-stenotic dilatation, minimal wall thickening, no bowel wall oedema
Severe stenosis	Marked decrease in luminal diameter,
	With pre-stenotic dilatation
	Marked wall thickening, non-mural oedema
Fistulising/perforating	Deep fissuring ulcers, sinus tract
Subtype	Fistulae
	Associated inflammatory mass
Reparative or	Mucosal atrophy, Regenerative
regenerative subtype	polyps
	Minimal decrease in luminal diameter, no mural oedema

- Its clinical utility and influence on further patient's management is certain: broad anti-inflammatory medical treatment is indicated for edematous luminal narrowing due to active Crohn's disease, while fistulous and perforating complications might successfully be managed by specific medical treatment (infliximab). In case of refractory fistulizing disease surgical resection is indicated, which might also be the treatment of choice for the symptomatic fibrostenosing subtype whenever minimally invasive procedures, such as stricturoplasty or endoscopic balloon dilatation, fail or are not possible.

  The unpredictable and insidious character of Crohn's disease might be especially harmful in the acute postoperative period when early complications occur. Patients might present with unexplained persistent inflammatory syndrome or complain of mild intermittent, recurrent abdominal pain, however, without evident physical findings or the clear pathological features seen on conventional CT, which is usually the first diagnostic procedure to be performed. In these instances, CTE performed with positive enteral opacification and without IV contrast medium is the technique of choice to detect small anastomotic leakages or intestinal fistulae. Due to its enteral volume challenge, CTE is superior to conventional CT in

this regard. The fistuluous tract is shown by opacification with the positive enterally administered contrast medium: sometimes it might only become evident on late phase images.

- CTE performed in a patient with celiac disease demonstrated circumferential wall thickening in proximal jejunal loops with thickened mucosal folds and mesenteric, paraaortic lymphadenopathy, suggestive of complicating lymphoma.

- The role of CT Enteroclysis in celiac disease is to identify its complications such as ulcerative jejunoileitis, lymphoma and jejunal adenocarcinoma.

- In patients with atypical presentations of celiac disease, enteroclysis can be performed to confirm or refute this diagnosis. When mucosal biopsies show characteristic histologic features of celiac disease, enteroclysis can also facilitate differentiation from other disorders with similar mucosal abnormalities, including viral enteritis, bacterial overgrowth, giardiasis, hypogammaglobulinemia, kwashiorkor and lymphoma.

- We have also identified a case with lymphoma in duodenum which was previously operated for jejunal lymphoma. It was a circumferential wall thickening involving the 3rd part of duodenum.

- Small bowel Lymphoma:- Lymphoma accounts for approximately 20% of all small bowel tumours. The small intestine closely follows the stomach as the most frequent site of disease, and multicentric involvement occurs in 10% to 25% of cases. Almost all small bowel lymphomas are non-Hodgkin's lymphoma: most of them are of B-cell origin, but the cases complicating Celiac disease are of T-cell origin. Predisposing conditions include AIDS, Celiac disease, systemic lupus erythematosus (SLE), Crohn's disease and chemotherapy. In children and young adults, lymphoma primarily affects the ileocecal region: in adults, the distal ileum is the most common site of tumour. In lymphoma complicating celiac disease, however, the proximal jejunum is usually involved.

  The most common forms are Circumferential, Cavitary and Mesenteric forms and in our case circumferential form has been observed.

- Out of the six cases referred as small bowel obstruction, negative findings were found in five cases which were concluded as normal as proved by the absence of symptoms at clinical follow-up. One case had anterior abdominal wall hernia containing omentum.

- In two cases referred as enterocutaneous fistula, CTE confirmed its occurrence in one whereas in the other it was diagnosed to be biliary cutaneous fistula with loculated peritoneal fluid collections. Biliary cutaneous fistula was confirmed by a fistulogram.

- In a known case of oesophageal carcinoma which was operated, CTE demonstrated heterogenously enhancing mass lesion of the ileum with areas of necrosis causing low grade small bowel obstruction. Findings from HPE after surgery confirmed it as adenocarcinoma.

- The choice of enteral contrast medium mainly depends on the clinical indication. The inherent advantages of neutral contrast agents is the good delineation of the contrast enhanced small bowel mucosa contrasting well with the hypodense lumen. It allows detection of very small mural lesions, such as polyps or vascular malformations.

  Furthermore, opacified mesenteric vessels can be exactly analysed on multiplanar reformations without being obscured by the high density bowel content. We used water as it was readily available and inexpensive, but it is absorbed by the intestinal mucosa hence distension may be suboptimal.

In search of enteral leakages or fistulae, positive contrast agents are techniques of choice.

Whatever the contrast medium is used it should be heated to 37° C before the administration to decrease the patients discomfort.

SUMMARY AND CONCLUSION

CT enteroclysis allows depiction of small-bowel diseases in patients suspected of having small-bowel conditions.

- ❖ It is highly recommended for

- ➢ advanced and complicated Crohn′s disease or the preoperative assessment of inflammatory extent, stricture, extra intestinal extension of the disease – fistulas ,abscesses.

- ➢ In clinical setting of small bowel obstruction of intermittent /recurrent nature, particularly with a history of abdominal surgery; suspected high grade obstruction in whom surgeons prefer initial conservative management – immediate postoperative small bowel obstruction, h/o abdominal surgery for malignancy.

- ➢ Detection and localization of small bowel tumours.

- ➢ Entero enteral fistula

Other Applications

Unexplained Gastrointestinal bleeding

Angiography and radionuclide studies still have an important primary role in acutely bleeding patients. In patients with an occult gastrointestinal bleed, the conventional nonfluoroscopic SBFT has no place in clearing the small bowel after negative endoscopy, colonoscopy, angiography, or a tagged red cell scan. If clearing of the small bowel is clinically indicated either barium enteroclysis, with 20 % positive rate, or CTE should be used. Thirty eight percent to sixty six percent of patients with gastrointestinal bleeders have potentially identifiable vascular malformations.

Traditional double contrast enteroclysis is estimated to be successful in 21% of such cases. Demonstration of such lesions has been reported using helical CT. Luminal distention with positive or neutral enteral contrast improves diagnosis when imaging with CT by using an easily placed, small – caliber, nasoenteric tube. Four percent to fifteen percent of patients with occult or recurrent gastrointestinal bleeding of the small bowel have tumours. Because neutral enteral contrast is not visualized fluroscopically, adequacy of small bowel distention is difficult to gauge. In obese or elderly patients with anal incontinence, maintaining small bowel distention with infusion during CT acquisition may be

difficult. Tumours can be difficult to identify in collapsed or poorly distended gut using neutral luminal contrast and IV contrast, but easily shown with positive enteral contrast.

Arteriovenous malformations are the most common vascular etiology. They are seen in sixty six percent of patients with positive enteroscopy. Six percent have multiple vascular lesions (10 or more). CTE using methyl cellulose as a neutral contrast material with an IV contrast bolus of 150 mL at 4 mL/second can potentially identify the source of unexplained gastrointestinal bleeding.

Vascular malformation has been diagnosed on helical CT with IV contrast material. Small vascular tumours can be missed in collapsed or poorly distended bowel but are potentially visible with CTE if the small bowel is distended. When using this CTE technique, higher infusion rates (150 ml/minute), and the use of a larger volume of enteral contrast (2 liters) with a hypotonic agent, is recommended. No large data on this indication have yet been reported.

Miscellaneous applications

In therapeutic radiation to the gut, an arteritis of the small mesenteric and gut wall arterioles may result in ischemic and fibrotic changes to the bowel wall over time. At the time of presentation, mural

stratification is present secondary to ischemia with edema separating the inner enhancing mucosal ring from the outer enhancing serosal margin. This can occur within days, weeks, or decades from the time radiation therapy is administered. Because of the propensity to be a chronic, slowly progressing phenomena, considerable lengths of bowel wall may be involved by the time imaging has occurred. With the radiation field being defined by the port, several disparate loops of bowel can be involved.

With long lengths of low-grade, or even high-grade, partial obstruction, intestinal bypass may now be considered in the management of these patients. At surgery, the diffuse mesenteric and small bowel fibrosis throughout the are involved makes identifying potential sites for anastomosis difficult. Long lengths of small bowel cannot be indiscriminately bypassed because they are no longer available for absorption.

CTE can provide reliable imaging in patients with radiation enteritits allowing for clear delineation of areas of involved bowel from surrounding normal gut. Clear definition of areas of high grade partial obstruction can be differentiated clearly from loops with low grade obstruction or encased by peritoneal sclerosis: this is helpful in planning bypass surgery. Internal extra-intestinal fistulae readily can be shown by CTE. This is one of the promising use of multislice CTE.

CTE can be of value in resolving the false positive and false negative interpretation from other small bowel studies that arise from the difficulties associated with nonfilling, poor distention, peristalsis, or simulation of abnormalities through segmentation of the contrast column.

It has been observed that some patients with obstructive symptoms often have their symptoms reproduced at the time of infusion during CTE. In these cases symptoms quickly abate by decreasing the rate of infusion or by simply turning off the infusion pump. With reproduction of symptoms during CTE, there is greater confidence in associating those symptoms with the small bowel and any adhesive processes that are encountered. Patients who have reproduction of abdominal symptoms without obstruction any have visceral hypersensitivity (irritable bowel).

In patients suspected of superior mesenteric artery syndrome, it has been found pain reproduction with a volume challenge of the third portion of the duodenum also of diagnostic help. The same has been true in patients following abdominal aortic aneurysm repair in which a tight oversewing in reperitonealization of the graft has caused a temporary partial obstruction of the duodenum. These patients present with symptoms similar to that of superior mesenteric artery syndrome. Recognition of this self-limiting process can avoid unnecessary reoperation.

In dealing with a suspected SMA syndrome, it is important to demonstrate narrowing of the duodenum. CTE is well suited with the axial imaging showing the duodenum and superior mesenteric artery on one side and abdominal aorta on the other. In this situation, the balloon of the catheter is anchored in the upper descending duodenum before infusion.

- Sprial CTE now combines the inherent advantages of conventional barium enteroclysis, i.e. homogenous luminal distension resulting from volume challenge, with those of cross-sectional imaging, which is the simultaneous detection of intraluminal, mural and extraintestinal pathologies.

  The development of multidetector row technology has allowed data acquisition over the entire abdomen in thin slices within one breath-hold, thus reducing peristaltic and breathing artifacts. This shorter acquisition time and better spatial resolution regarding the z-axis has improved the quality of multiplanar reconstructions, being of particular advantage for the investigation of intestinal pathologies.

Limitations of CTE

CTE versus Conventional Small Bowel Studies

CTE, as a projection modality, provides precise analysis of anatomical details without superimposition of small bowel loops as often seen at fluoroscopy. Nevertheless, the assessment of motility disorders remains difficult in contrast to conventional small bowel studies. Patients with predominantly functional disorders should therefore continue to be investigated with conventional enteroclysis. However, many functional small bowel disorders will sooner or later also cause organic changes and therefore become evident on CTE, such as prestentotic luminal dilatation when segmentary small bowel narrowing is becoming significant. Futhermore, CTE is much less operator dependent than conventional enteroclysis: therefore, results are far more standardized and reproducible than those of conventional enteroclysis.

Spatial resolution of CTE still remains suboptimal compared to conventional double contrast barium enteroclysis, as it does not provide detailed analysis of small bowel mucosa [20] the exclusion of early Crohn’s disease in particular is not reliable.

CTE versus oral CT enterography

Oral administration of enteral contrast medium before CT, even using a large volume, is always associated with less optimal small bowel distension than obtained after nasojejunal intubation [21]. This drawback might not prevent the detection of many small bowel lesions significantly, but it causes diagnostic problems in a small number of difficult cases. Intermittent and low grade small bowel obstruction might be impossible to detect [22]. The lack of complete small bowel distension may simulate segmentary mural thickening and mask small intraluminal lesions of the small bowel.

According to Wold et al, per oral CT enterography does not show any statistically significant difference concerning the assessment of Crohn's disease activity as compared to CTE. However, the small number of eight patients included in the CTE group, among them only four with active inflammation of the terminal ileum, hampers these conclusions [21].

CTE versus MR Enteroclysis (MRE)

Thanks to the multiplanar imaging capabilities and the excellent soft tissue contrast resolution inherent in MR imaging, as well as technical progress concerning fast imaging sequences and the absence of

ionizing radiation, MR Enteroclysis has become a very promising tool for the evaluation of small bowel disorders. The mural contrast enhancement seen in MRE is far more pronounced than that seen with iodinated contrast medium, and is therefore especially useful for the detection of inflamed bowel segments in Crohn's disease or tumours. Dynamic image acquisition, MR fluoroscopy, is possible, provided that the infusion pump is placed in the MR unit, while CT Enteroclysis always reflects a 'snapshot' of the small intestine [23].

Persistent limitations of MR Enteroclysis are the limited availability of MR scanners, and the still long acquisition times associated with a few persistent artifacts due to magnetic susceptibility, chemical shifts or residual peristaltism. The spatial resolution of MR imaging is far inferior to that of CT: small bowel mucosa can therefore not be analyzed in detail, like on CT Enteroclysis. The only direct comparison of MRE and multidetector CT Enteroclysis performed on 50 patients resulted in better sensitivity and inter-observer agreement of CT Enteroclysis for the detection of various small bowel lesions [24].

CTE versus wireless capsule endoscopy (WCE)

Its clinical value is difficult to evaluate because of the lack of a gold standard despite the proven high sensitivity and good diagnostic

yield [24, 25]. The exact localization of lesions can also be difficult with WCE. The high incidence of abnormal findings of about thirty three percent classified as ‘others’ among the forty nine sources for small bowel hemorrhage revealed by Scarpa et al shows the problematic interpretation of non-specific findings and renders treatment options difficult [26].

Upto now, wireless capsule endoscopy has revealed better sensitivity than barium follow-through, conventional enteroclysis, traditional CT and especially CT Enteroclysis. The latter demonstrated fewer positive findings than wireless capsule endoscopy for obscure gastrointestinal bleeding and Crohn’s disease, whereby wireless capsule endoscopy is contraindicated in case of intestinal stenoses. They should therefore be excluded beforehand, which is done best by CT Enteroclysis.

Wireless capsule endoscopy seems therefore an ideal diagnostic modality for early Crohn’s disease wherever the localization is beyond the reach of the endoscope and lesions are superficial without associated luminal narrowing. Wireless capsule endoscopy is certainly the method of choice for obscure gastrointestinal bleeding for which CT Enteroclysis is most likely associated with the same low diagnostic performance as conventional double contrast enteroclysis.

Radiation dose

The mean effective dose equivalent of multidetector CTE is 6.2 mSv for each acquisition phase, with an additional 0.5 – 1mSv for nasojejunal intubation guided by fluoroscopy. The radiation dose of CTE is otherwise operator independent, it only depends on chosen acquisition parameters, mainly varying with the patient's body weight. Furthermore, we observe a more efficient dose profile using the most recent multidetector CT. Due to relative reduction of penumbra radiation with an increasing number of channels of CT scanners, the radiation dose necessary for the same slice width and with the same image noise decreases [29].

CONCLUSION

In summary, CT Enteroclysis represents a problem solving modality for well selected patients concerning the detection and characterization of small bowel pathology.

The successful adoption of CT Enteroclysis by the clinical environment depends on how radiologists can educate surgeons, gastroenterologists and other specialists. Using a very small intestinal catheter can show them that this technique does not increase patients' discomfort because of the necessary nasojejunal intubation. CT Enteroclysis also essentially contributes to the diagnostic quality of modern small bowel imaging, and therefore deserves an established place among the other available techniques.

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ABBREVIATIONS

CT Computed Tomography

CTE Computed Tomography Enteroclysis

CVS Cardio Vascular System

DJ duodenojejunal

FU Follow-up

GI Gastrointestinal

Hb Haemoglobin

HPE Histopathological Exam

IV Intravenous

k/c known case

MR Magnetic Resonance Enteroclysis

n number of cases

RS Respiratory System

SBFS Small bowel feces sign

SBFT Small bowel follow through

SMA Superior Mesenteric Artery

USG Ultrasonogram

MASTER CHART

S. No.	Patient details	Clinical Data	CTE findings
1	Rajesh, 40 yrs, Male	Chronic right iliac fossa pain	Asymmetrical wall thickening –ileum and Caecum., low density paracaval ,aortocaval ,paraaortic lymphadenopathy. HPE : Tuberculosis
2	Mani, 47 yrs, Male	Sub-acute intestinal obstruction	Circumferential bowel wall thickening distal ileum causing low grade partial obstruction Mesenteric vascular engorgement HPE : Crohn's disease
3	Muniyammal, 60 yrs, Female	?Sub-acute intestinal obstruction	Anterior abdominal wall hernia
4	Kanniyammal, 28 yrs, Female	Chronic abdominal pain	Proximal jejunal stricture HPE: Gangrenous stricture
5	Chithra, 30 yrs, Female	Faecal fistula	Enterocutaneous fistula
6	Marimuthu, 35 yrs, Male	Sub-acute intestinal obstruction	Proximal jejunal and mid small bowel dilatation. Small bowel faeces sign in distal jejunum.Collapsed ileal loops. Surgical findings : jejunal stricture
7	Prakash, 51 yrs, Male	Chronic Diarrhoea	Asymmetrical wall thickening of ascending colon, pericolonic fat stranding
8	Malaiyappan, 35 yrs, Male	?low-grade small bowel obstruction	normal
9	Balaji, 18 yrs, Male	Chronic abdominal pain. h/o abdominal surgery +	Normal **FU**
10	Venkatesan, 33 yrs, Male	Right iliac fossa mass	Asymmetrical wall thickening >1 cm of caecum, ascending colon, terminal ileum, pericolonic lymphadenopathy
11	Xavier, 35 yrs, Male	Celiac disease	Circumferential bowel wall thickening, proximal and mid-jejunal loops, thickened mucosal folds, mesenteric, paraortic lymphadenopathy. HPE : lymphoma

S. No.	Patient details	Clinical Data	CTE findings
12	Gowri, 40 yrs, Female	k/c of Oesophagal carcinoma operated, lower abdominal pain	Short segment irregular bowel wall thickening in the ileum with areas of cavitation / necrosis causing low grade obstruction multiple pelvic lymphadenopathy (<0.5 cm) HPE :Adenocarcinoma
13	Kabali, 25 yrs, Male	Abdominal pain, vomiting-2 months	Soft tissue density lesion involving the 3rd part of duodenum. HPE:Duodenal lymphoma –B cell type
14	Neelan, 16 yrs, Male	?low-grade small bowel obstruction	normal
15	Sundaramurthy 25 yrs, Male	Abdominal pain and malabsorption	Normal
16	Balashankar, 35 yrs, Male	Post-appendicectomy, lower abdomen pain	Irregular thickening of distal ileum, mesenteric fat stranding HPE: Tuberculosis
17	Narayanan, 42 yrs, Male	Lower abdominal pain	normal
18	Nirmala, 23 yrs, Female	? Sub-acute intestinal obstruction	normal
19	Chandran, 28 yrs, Male	?enterocutaneous fistula	Loculated peritoneal fluid collection, biliary fistula
20	Kannan, 35 yrs, Male	Right lower quadrant pain	normal
21	Perumal, 37 yrs, Male	? intestinal tuberculosis	normal
22	Paranthaman, 36 yrs, Male	? Sub-acute intestinal obstruction	normal
23	Lakshmipathy, 42 yrs, Male	Right lower quadrant mass	Irregular wall thickening of the caecum, pericolonic standing, terminal ileum narrowing, pericolonic lymph adenopathy, **FU**
24	Jeyalakshmi, 35 yrs, Female	Diarrhoea -2 months	Circumferential wall thickening of ascending colon HPE : non-specific colitis

S. No.	Patient details	Clinical Data	CTE findings
25	Shanthi, 35 yrs, Female	abdominal pain and constipation	Multiple peritoneal deposits. Adhesion between ileal loops with distal collapsed loops suggestive of obstructive adhesions.
26	Subramanian, 50 yrs, Male	Lower abdominal pain	Normal
27	Kuppu Gounder, 50 yrs, Male	Altered bowel habits – 1 month	Circumferential long segment wall thickening of ascending colon
28	Krishnan, 62 yrs, Male	k/c of inflammatory bowel diesease	Asymmetrical wall thickening of ascending colon extending to hepatic flexure, pericolonic fat stranding, fistula between ascending colon and distal ileal loop , extension of fistula between inflamed ascending colon to small abscess within adjacent abdominal wall. multiple pericolonic lymphadenopathy
29	Muthupandi, 36 yrs, Male	? Sub-acute intestinal obstruction	Normal
30	Krishnaveni, 50 yrs, Female	Chronic right iliac fossa pain, loss of weight	Irregular thickening of ileum , caecum, ascending colon, pulled up caecum, paraaortic lymphadenopathy, ascites, portal vein thrombosis HPE : Tuberculosis

PROFORMA

Name

Age & Sex

Clinical History:

Past History:

General condition:

Pulse rate: Blood Pressure:

CVS: RS:

Per abdomen:

Provisional diagnosis:

Investigations:

Blood Sugar: Stools - Ova cysts:

Blood Urea:

Serum Creatinine:

Blood Hb %:

TC:

DC:

Colonoscopy-

Upper GI scopy –

USG abdomen –

CT Abdomen –

CT Enteroclysis:

	Prox. Jejunum	Mid Jejunum	Ileum
Lumen diameter			
Wall thickening			
Contour abnormalities			
Obstruction Zone of transition			
Mass lesion			

Extramural abnormalities :

Imaging findings :

Followup :