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VALIDITY OF MULTIDETECTOR COMPUTERISED TOMOGRAPHY IN PREDICTING THE SITE OF GASTROINTESTINAL PERFORATION

By

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Dissertation submitted to the

Kerala University of Health Sciences, Thrissur

In partial fulfillment

of the requirements for the degree of

Doctor of Medicine (M.D)

In

RADIODIAGNOSIS

Under the guidance of

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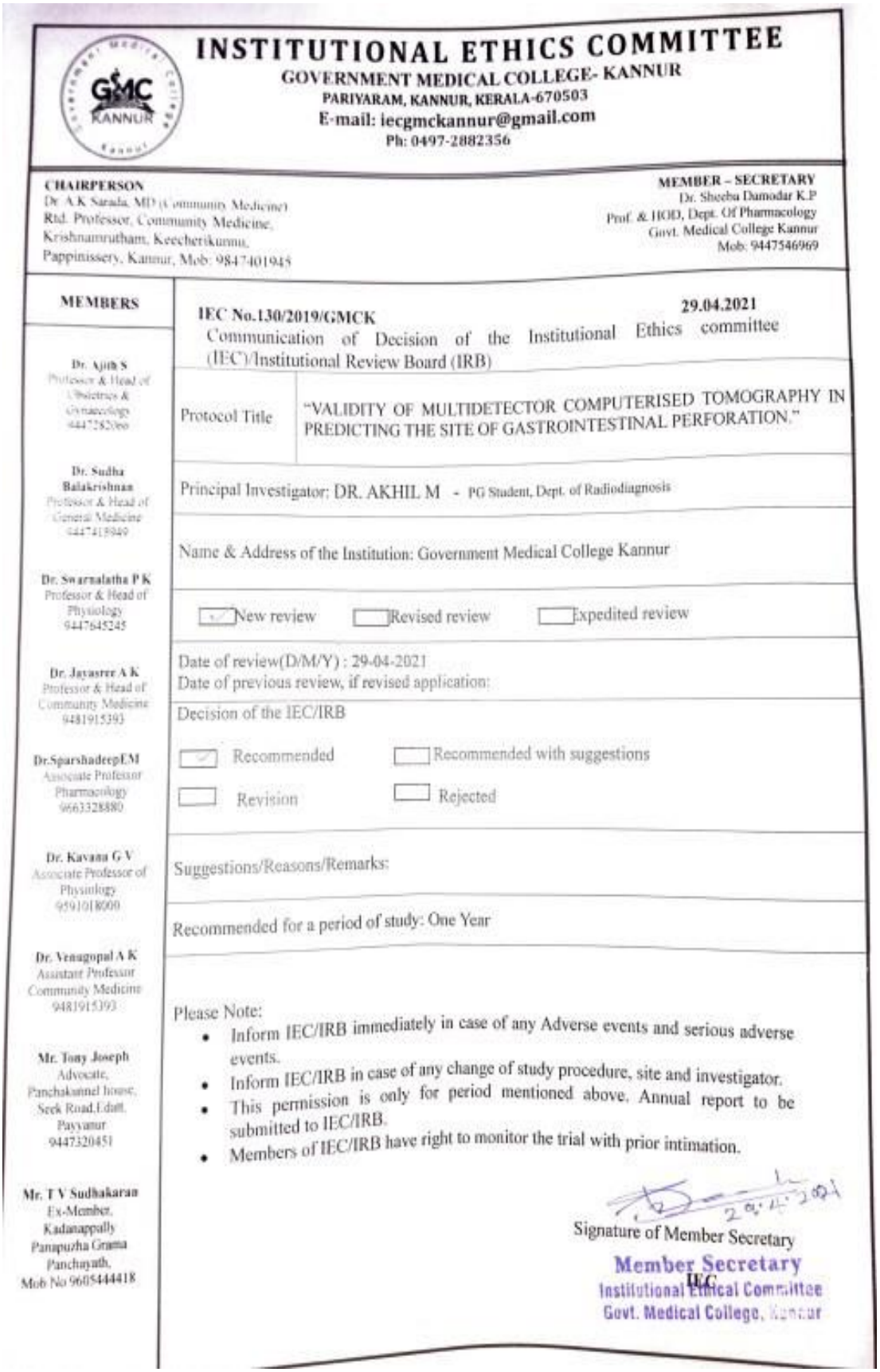

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STRUCTURED ABSTRACT

BACKGROUND:

Gastrointestinal perforations are one of the frequent causes of acute abdomen cases presenting to the casualty. The early diagnosis of this condition is important, but poses a diagnostic dilemma due to the inaccuracy of physical examination findings. The importance of CT scan lies in its accuracy in diagnosing the condition and predicting the site of perforation which helps in guiding management.

OBJECTIVES:

To evaluate the accuracy of MDCT for preoperative determination of the site of gastrointestinal tract perforations by correlating with intraoperative findings and to determine the most predictive findings in this diagnosis

METHODS:

Study Design– Cross sectional study.

Study Setting– Government Medical College, Kannur.

Period Of Study-The study will be conducted over a period of one year (January 2021 to January 2022)

Sample Size - 40

Sampling Method- Consecutive sampling

Study Method-

The study was conducted over a period of one year, 40 patients who were brought with suspicion for hollow viscus perforation, evaluated by MDCT (16 slice TOSHIBA ALEXION CT scanner) from Department of Radiodiagnosis, Govt. Medical College Kannur and confirmed intraoperatively during the period of study were included. The preoperative MDCT findings were recorded as per the proforma, using certain criteria the site of perforation was predicted which was correlated with intraoperative findings. The collected data was analyzed for sensitivity, specificity, positive predictive value and negative predictive value.

Data Analysis: Data was entered using Microsoft Excel and analyzed.

RESULTS & DISCUSSION:

The age of the patients ranged from 15 to 89 years. Majority of the patients were males, 8 0 % . Most number of patients fall into age group 61-70 years; the mean age was 50.65 years. The most common cause of perforation was peptic ulcer disease constitute 40% of the cases. Other causes include inflammatory causes like appendicitis diverticulitis, malignant perforation, traumatic and post-operative bowel injury. The most common site of perforation was found to be gastroduodenal, which together constitutes 50% of the cases and includes twelve cases of duodenal and eight cases of gastric perforation. Preoperative MDCT correctly identified the site of perforation in 35 out of 40 cases. Focal defect in bowel wall, clustering of air bubbles adjacent to bowel wall and segmental bowel wall thickening were strong predictors of the site of perforation. MDCT incorrectly predicted the site of perforation in five cases. Extraluminal fluid and perivisceral fat stranding were consistently observed in cases with hollow viscus perforation and have the highest sensitivity.

CONCLUSION: MDCT is highly accurate in predicting the site of hollow viscus perforation. Focal defect in bowel wall, clustering of extraluminal air bubbles adjacent to bowel and segmental bowel wall thickening have a high predictive value for determining the site.

Key words: Hollow viscus perforation, Multidetector Computed Tomography, Pneumoperitoneum, Bowel perforation

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INTRODUCTION

Pneumoperitoneum means the presence of air within the peritoneal cavity. Gastrointestinal perforations result in pneumoperitoneum or pneumo-retroperitoneum depending upon the location of the bowel. Gastrointestinal perforations present as acute abdomen in day-to-day clinical practice. There are various causes for GIT perforation, the most common causes include perforation of a peptic ulcer, acute appendicitis with perforation, traumatic hollow viscus

injury, diverticulitis with perforation, iatrogenic perforations, post-operative complications and neoplastic perforations. Plain radiography remains the most frequently requested examination performed as an initial imaging procedure in the assessment of patients who presented with acute abdominal pain to the emergency department(1). Plain radiographs may be able to detect pneumoperitoneum, the classical finding beingair under diaphragm. However plain radiographs as a single modality in evaluation can result in both false negative and false positive diagnosis, small amount of pneumoperitoneum may be missed on a plain radiograph, sometimes intraluminal air may be mistaken for pneumoperitoneum.

Abdominal CT is widely available and is very sensitive and specific in diagnosing a case of pneumoperitoneum. Extraluminal air too small to be detected in a plain radiograph can be readily demonstrated by computerized tomography. Spiral and multidetector computerized tomographic scanners has enabled the examination of entire abdomen in a single breath hold by using thin slice sections allowing a precise assessment of the abdomen. Apart from detecting pneumoperitoneum CT plays an important role in the accurate assessment of the perforation site, the pathology causing the perforation and the ensuing complications(2). CT is the most valuable imaging technique for detecting free intraperitoneal air.

Locating the site of perforation, the cause of perforation and any other concomitant intraabdominal pathologies is an important part of preoperative assessment, it helps the surgeon to plan the surgery accordingly(3). Laparoscopic procedure is currently an option instead of open surgery, even for acute conditions like perforated appendix. Therefore, it is beneficial for surgeons to know preoperatively where the bowel tract is perforated. This is also beneficial to the patients, instead of a large laparotomy incision they can undergo a simple laparoscopic procedure through few millimeters sized ports, decreasing the post - operative morbidity, complications to a great extent and also decreasing the duration of hospital stay.

The efficacy of computerized tomography in detecting pneumoperitoneum is well known, many studies have already proven that. But few authors have investigated the sensitivity of computerized tomography in determining the site

of gastrointestinal tract perforation.

Radiology is a constantly evolving field of medicine. With the advent of newer technologies in diagnosis, the role of radiologist has been shifted from just diagnosing the pathology to provide additional details in planning the management. With the invent of Interventional Radiology, radiologists also became the part of management team. New generation CT machines and digital x-ray machines are fast and efficient, images can be acquired within very few minutes without causing any significant delay in patient management. Pre- operative imaging has also gained importance as a documentation in medicolegal disputes.

OBJECTIVES OF THE STUDY

1. To evaluate the validity of Multidetector Computerized Tomography as a diagnostic tool for the preoperative determination of the site of gastrointestinal tract perforations.

REVIEW OF LITERATURE AND BACKGROUND

Acute abdomen accounts for up to 40% of all the surgical emergency cases requiring hospital admissions and large percentage of these cases are secondary to gastrointestinal perforation (4). Gastrointestinal perforation is a major life-threatening condition which requires emergency surgery. Despite improvements in surgical and medical treatments, the overall mortality rate of a gastrointestinal perforation ranges from 30 to 50%(4)(5). Multidetector computerized tomography of the abdomen is the modality of choice in evaluating suspected pneumoperitoneum. MDCT has made it possible to acquire images in high resolution in all planes with greater speed of acquisition. Post- processing techniques like multiplanar reconstructions (MPR), maximum intensity projection (MIP), shaded surface display (SSD) and volume rendered (VR) images helps to read the images in different planes and improves diagnostic accuracy.

The high diagnostic accuracy compared to plain radiographs and the easy availability makes it the investigation of choice in GIT perforations. In a study done by Styliani Pouli et al. stated that the diagnostic accuracy of MDCT in localizing the site of gastrointestinal perforation ranges from 82 to 90%(5). In a similar study done by Bernard Hainaux et al. analysis of MDCT images was predictive of the site of

gastrointestinal tract perforation in 73 out of 85 patients that is 86% of the total cases studied(6). The study showed that concentration of extraluminal air, segmental bowel wall thickening and focal defect of the bowel wall were strong predictors of the site of bowel perforation.

In a study done by Savitha Bhagvan et al. the sensitivity and specificity of CT scan in predicting hollow viscus injury was found to be 55.33% and 92.06% respectively, the positive predictive value was 61.53% and negative predictive value was 89.23%, out of the 1,250 patients evaluated for blunt abdominal injury with CT, 78 patients who underwent laparotomy was included in the study group, the study concluded that the specific findings for hollow viscus injuries on CT scan were free intraperitoneal air, retroperitoneal air, contrast extravasation, bowel wall defect, patchy bowel enhancement and mesenteric abnormality(7).

Maniatis et al. reported a sensitivity of 85.5% in a series of 76 patients presenting with bowel perforation, there were 65 true-positive and 11 false-negative cases, levels of perforation were the esophagus, stomach, duodenum, small bowel, appendix and colon and the causes were peptic ulcer, foreign body, trauma, iatrogenic appendicitis, diverticulitis, Crohn disease, carcinoma and ischemia, level and cause were correctly predicted in 55 and 51 instances, respectively. The sensitivity was 85.5%.(8)

Kim et al. evaluated the abdominal CTs of 57 patients with bowel perforation, retrospectively analyzed to determine the diagnostic accuracy of the perforation site, and reported an overall accuracy of 82% (9)

A study was performed by Bernard Hainaux et al. where 85 patients with pneumoperitoneum on CT was studied, the patients underwent laparoscopic procedure within 12 hours of the study. The prediction of site of perforation was done using the following eight MDCT findings: concentration of extraluminal air bubbles adjacent to the bowel wall, free air in supramesocolic or inframesocolic compartments, extraluminal air in both abdomen and pelvis, focal defect in the bowel wall, segmental bowel-wall thickening, perivisceral fat stranding, abscess, and extraluminal fluid(6). In a similar study done by Hyun Cheol Kim et al. the MDCT findings observed include: free air location, mottled extraluminal air bubbles, focal bowel wall discontinuity, segmental bowel wall thickening, perivisceral fat stranding

and localized fluid collection(10)

In a study done by Alessandro Michele Bonomi et al. six CECT scan criteria were used for diagnosis free fluid without solid organ injury, free intraperitoneal air, gastrointestinal wall alteration (any focal anomaly of the bowel wall, including focal defect, thickening or thinning, abnormal or lack of enhancement with contrast), mesenteric alteration (mesenteric hematomas and fat stranding), intra-mesenteric fluid (accumulating between mesenteric layers and assuming a typical triangle aspect), mesenteric blushing (active leak of intravenous contrast)(11). The following CT scan findings, concentration of extraluminal air bubbles, segmental bowel wall thickening, and focal defect of the bowel wall were found to be the strong predictors of the site of bowel perforation(6). Among specific air distributions, periportal free air and subphrenic free air were statistically significant in differentiating upper gastrointestinal tract peroration. Whereas free air in the minor pelvis, right lower quadrant free air, left lower quadrant free air, and air in the mesentery were statistically significant in differentiating the lower gastrointestinal perforation(12).

RELEVANT ANATOMY:

Gastrointestinal tract includes the esophagus, stomach, duodenum, jejunum, ileum, appendix and the large bowel. The whole GI tract is about 9meters in length. Although the esophagus is a part of the GI tract, in this study we focus on the intraperitoneal and retroperitoneal structures. The stomach, first segment of the duodenum, ileum, jejunum, cecum, transverse colon, and the sigmoid colon are intraperitoneal structures. Second, third, and fourth duodenal segments, and the ascending and descending colon are retroperitoneal structures. The upper two-thirds of the rectum are intraperitoneal, whereas the remainder is extraperitoneal.

Transverse mesocolon is a broad fold of mesentery that suspends the transverse colon from the posterior abdominal wall. The root of transverse mesocolon extends across the descending duodenum, head of pancreas, and continues along the inferior border of body and tail of pancreas. The transverse mesocolon divides the abdominal cavity into supramesocolic and inframesocolic compartments.

STOMACH:

The stomach is a sac like muscular organ located in the left upper quadrant of the abdomen that digests food. It has capacity to hold food and is comprised of 4 main regions, the cardia, fundus, body, and pylorus, the cardia is the first part of

stomach and is connected to the esophagus, the fundus is a bulbous, dome-shaped, superior portion of the stomach, followed by the fundus is the body of stomach which is the largest portion and is bounded on the right by the relatively straight lesser curvature, and on the left by the more curved greater curvature, final part is the pylorus, which joins the first segment of duodenum(13). The gastric wall consists of an outer serosa followed by muscularis, submucosa and the innermost mucosa.

The columnar mucosal epithelium, is thick and thrown into multiple folds called as rugae. The outer serosal layer is continuous with the peritoneum. Stomach contains parietal cells, which produce hydrochloric acid and intrinsic factor, and chief cells, which produce pepsin precursors.

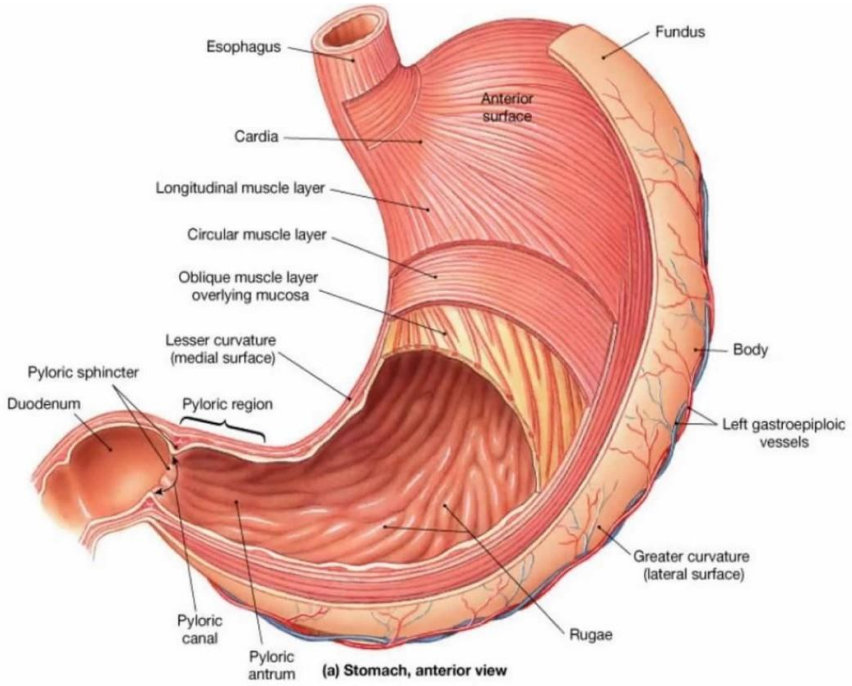


Figure 1: Anatomy of the Stomach

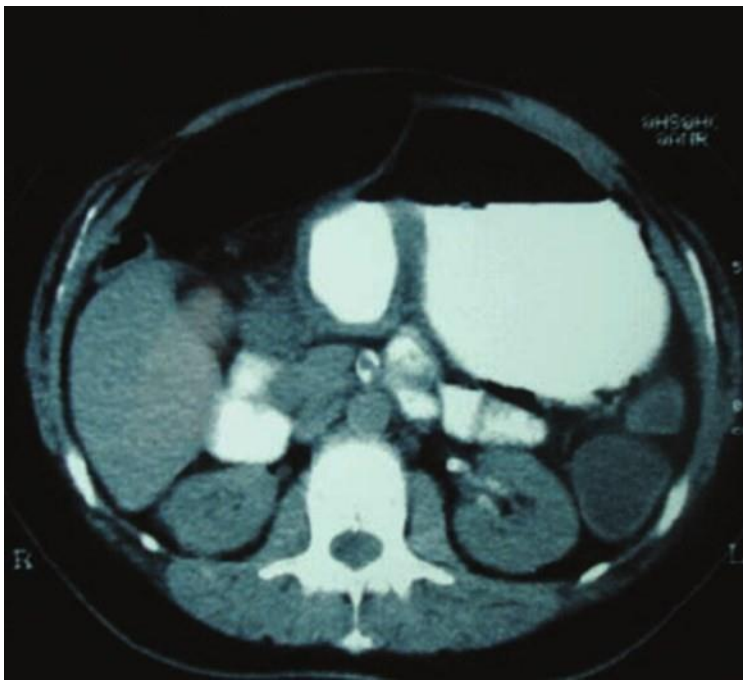


Figure 2: Axial CT image of stomach distended with oral contrast

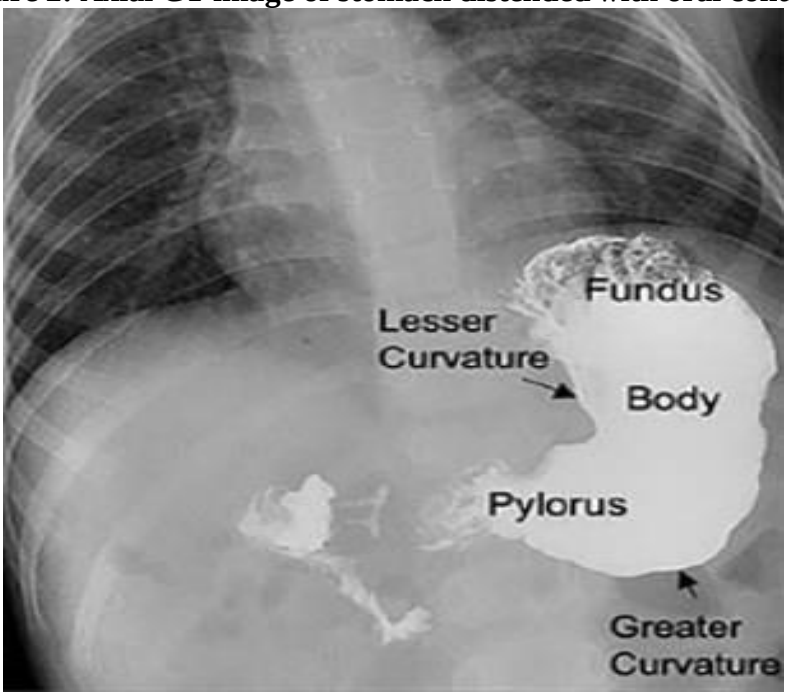


Figure 3: Barium meal showing normal anatomy of stomach

SMALL INTESTINE:

The small intestine is the longest part of the digestive system. The small intestine is divided into the duodenum, jejunum, and ileum. Together these can extend up to six meters in length. The duodenum has both intraperitoneal and retroperitoneal parts, while the jejunum and ileum are entirely intraperitoneal. Small intestine function

includes digestion and absorption of nutrients and water. The duodenum is a C shaped bowel distal to the pylorus and is about 25 cm in length and is divided into four segments: superior (duodenal bulb/ampulla), descending, horizontal and ascending parts(14). The (superior) portion is about 2.5 cm in length, from the pylorus and is the only part of the duodenum that is intraperitoneal. Sheet like fold of mesentery called as lesser omentum is attached to the superior border of duodenum, whereas the greater omentum is attached to its inferior border. The gastroduodenal artery runs posterior to the first part of the duodenum. An ulcer on the posterior wall of first part of duodenum will erode this artery leading to massive bleeding.

The ligament of Treitz form the anatomical demarcation between duodenum and jejunum. The jejunum and ileum are intraperitoneal in location suspended by the mesentery. Jejunum is the proximal two-fifths of small bowel and ileum being distal with no clear line of demarcation between the two. The wall of the jejunum is thicker and its lumen is wider than in ileum. Ileum is the last and longest part of the small intestine. The ileum terminates at the ileal orifice (ileocecal junction) where the cecum of the large intestine begins.

LARGE INTESTINE:

The large intestine extends from the ileocecal valve up to the anus and measures up to 1.5meters. It is distinguished further from the small intestine by the presence of omental appendices, haustra, and teniae coli(15). It consists of caecum, colon, rectum and anal canal. The colon is divided into ascending colon, transverse colon and descending colon. The important functions of the colon include absorption of water, nutrient and some of the vitamins, feces compaction, secretion of potassium and chloride secretion.

The cecum marks the beginning of the colon and is the widest and proximal most part of the large intestine and has the thinnest wall. The small intestine opens into the cecum through the ileocecal valve on its side. The end of the cecum is actually closed like a pouch. Caecum is also the widest portion of the large intestine. Caecum functions as a reservoir where food from the small intestine arrives in the large intestine. When the cecum is full, it triggers the muscle movements of the colon.

The appendix is a blind ending, tubular, aperistaltic loop extending from the caecum measuring about 8- 10 cm in length and < 6mm in thickness. It normally contains intraluminal gas. Appendix is thought to be a vestigial organ

The ascending colon and descending colon are retroperitoneal structures and relatively fixed in position. The transverse colon is intra- peritoneal and is mobile.

The rectum measures about 12 to 15 cm, and is characterized by a lack of taenia coli. The anal canal is the distal- most 2 to 4 cm, from the anorectal junction to the anal verge. The large bowel has three outer longitudinal muscular layers called taenia coli, which are about 30 cm shorter than the length of the large bowel causing sacculations called haustra.

The cecum to the distal transverse colon develops from the midgut, the distal transverse colon till the dentate develops from hindgut, below the dentate line develops from the proctodeum. The derivatives of midgut receive blood supply from superior mesenteric artery (SMA), whereas the derivatives of hindgut receive blood supply from the inferior mesenteric artery (IMA).

Figure 4: Contrast distended small bowel loops axial CT image.

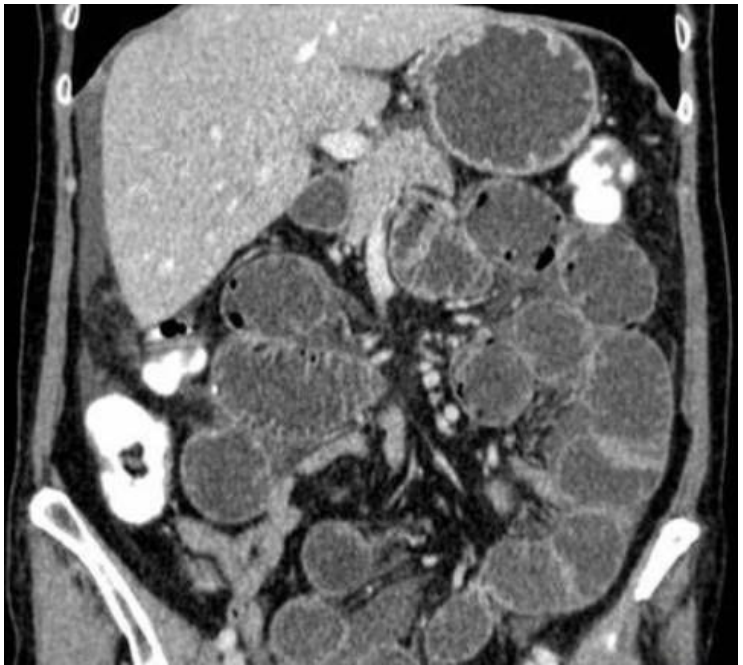


Figure 5: Fluid distended small bowel loops coronal CT image

Figure 6: Ascending and descending colon coronal CT

Figure 7: Transverse colon coronal CT

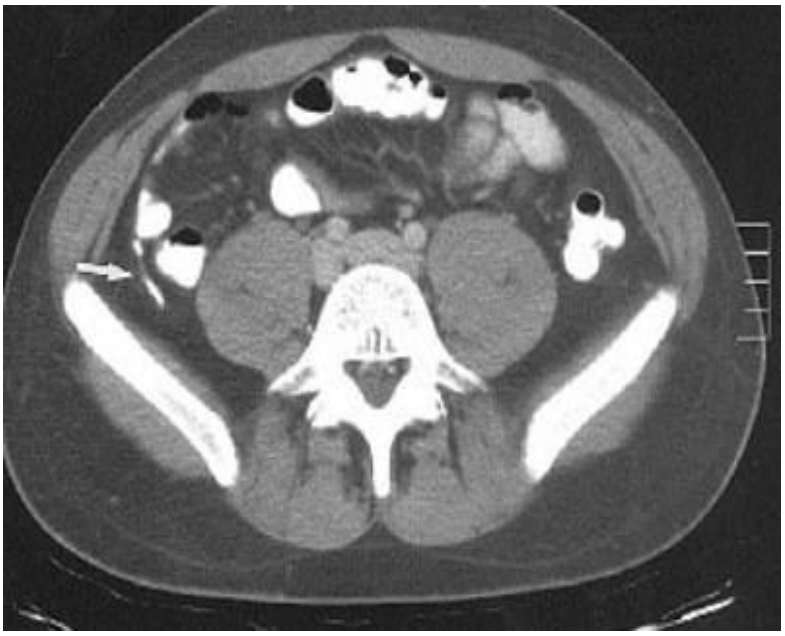


Figure 8: Appendix axial CT image

ETIOLOGY OF HOLLOW VISCUS PERFORATION

Perforated hollow viscus means the focal loss of gastrointestinal wall integrity with subsequent leakage of the intraluminal contents into the peritoneum or retroperitoneum. Perforation depending upon the etiology can occur at any site of the gastrointestinal tract. The size and site of perforation are important determinants of patient morbidity and mortality. The treatment plan also depends upon the age of the patient the general condition of the patient, site of perforation, omental adhesions, features of peritonitis and varies from a conservative management to immediate laparotomy.

Both blunt and penetrating trauma results in hollow viscus perforation. Blunt trauma of the abdomen usually results from RTA, fall from height, blast injuries or assault. Penetrating injuries can be due to stab injuries, bullet injuries, fall on sharp objects or iatrogenic. Blunt trauma can result in an irregular relatively larger defect in the wall of hollow viscus and is usually associated with trauma of other intraabdominal organs, whereas penetrating trauma usually results in a relatively smaller clear sharp marginated focal defect in the wall of hollow viscus. The parts of GIT that are fixed by ligaments are prone to shear injuries during trauma. Both blunt and penetrating trauma can result in multifocal perforations and can be associated with other organ and vascular injuries as well.

Other causes can be due to inflammation or ischemia, both can result in mural full thickness necrosis and focal disruption of the wall. Exposure of the normally sterile peritoneal cavity to intraluminal contents results in peritoneal irritation and inflammation.

The pattern of imaging findings also differs according to the site of perforation. Gastroduodenal and large bowel perforation results in abundant extraluminal air and a variable amount of fluid, whereas small bowel perforations are generally associated with a paucity of extraluminal air and a larger amount of fluid. The location of leaked intraluminal content (intraperitoneal vs retroperitoneal) can help localize the site of perforation.

The clinical presentation of gastrointestinal perforation consequently varies by the location, extent, and the cause of the injury and can range from subacute mild to acute severe abdominal pain with or without sepsis (16). A patient's physiologic state can also affect the severity because immunosuppressed states, for example, can impair inflammatory response and increase the risk of free perforation (17)

Gastroduodenal perforations can result in the leak acidic gastric secretions or caustic biliary pancreatic secretions causing severe form of chemical peritonitis and may cause rapid clinical deterioration due to systemic inflammatory response (SIRS).

The most common cause of gastroduodenal perforation is peptic ulcer disease. Perforation is the most serious complication of peptic ulcer and may also be the first definite evidence of ulceration (18). The most common locations of gastroduodenal ulcers include the anterosuperior wall of the duodenum and stomach near the pylorus.

Perforation is more commonly seen in younger than in older patients, duodenal than in gastric ulcers (18). Duodenal perforation is a rare but lethal condition, the mortality rate ranges reported from 8% to 25% in the literature (19). Duodenal perforation is potentially life-threatening injury and is a surgical emergency that requires immediate attention. Any delay in diagnosis or management will increase the mortality and morbidity (20).

Etiology	Examples
Foreign body	Ingestion of sharp or magnetic object, rectal foreign body
Iatrogenic	Colonoscopy, laparoscopy, laparotomy, nasogastric tube insertion, paracentesis, percutaneous tissue biopsy or fluid drainage, endoscopy
Infection	Clostridium difficile, Cytomegalovirus, Mycobacterium tuberculosis, Salmonella typhi
Inflammation	Diverticulitis, inflammatory bowel disease, peptic ulcer disease, solitary colonic ulcer
Ischemia	Embolic occlusion, severe arterial stenosis, systemic hypotension, venous outflow obstruction
Neoplasm	Metastatic cancer, primary gastrointestinal malignancy
Obstruction	Large-bowel obstruction, small-bowel obstruction, stercoral ulcer
Trauma	Blunt hollow viscus injury, penetrating hollow viscus injury

Table 1: Common etiology of hollow viscus perforation

Causes of gastroduodenal perforation:

- Blunt trauma
- Penetrating trauma
- Peptic ulcer disease
- Caustic ingestion
- Foreign body ingestion
- Malignancy
- Iatrogenic
  - Balloon dilation
  - Esophagogastroduodenoscopy (EGD)
  - Endoscopic retrograde cholangiopancreatography (ERCP)
  - Myotomy
  - Nasogastric tube insertion
- Crohn's disease
- Zollinger-Ellison syndrome

Table 2: Causes of gastroduodenal perforation

Intestinal perforations cause the leakage of intraluminal contents with high bacterial load but chemically inert to cause a purulent peritonitis or fecal peritonitis in case of large bowel perforations and result in formation of intra-abdominal abscess or phlegmon. Their clinical course may be more insidious than the gastroduodenal perforation.

Patients with hollow viscus perforation needs to undergo rapid clinical assessment, stabilization and early surgical consultation to maximize the chances of a successful outcome. Small intestinal perforations are difficult to diagnose clinically hence imaging plays an important role in early diagnosis and localization of the site of perforation. CT is often the investigation done in a tertiary care center in a case of acute abdomen and radiologist may be the first to suggest such a diagnosis of perforation. Surgical treatment of perforation varies for different person depending on the cause of perforation and extent of injury and includes omental patching to resection anastomosis. Traumatic perforation is usually large and irregular, may be multiple site perforation, the patient can rapidly deteriorate.

Causes of small intestinal perforation:
• Blunt trauma • Crohn's disease • Foreign body ingestion, esp. fish bones, chicken bones, or toothpicks • Iatrogenic • Intestinal malperfusion due to vascular occlusion • Jejunal diverticulitis • Meckel's diverticulitis • Neoplasm • Penetrating trauma • Strangulated bowel obstruction (Internal hernia, ventral hernia, malrotation, adhesions)

Table 3: Causes of small intestinal perforation

Causes of colonic perforation:
• Appendicitis • Blunt trauma • Colorectal cancer • Diverticulitis • Iatrogenic • Intestinal malperfusion due to vascular occlusion, scleroderma • Ogilvie's syndrome • Penetrating trauma • Stercoral perforation • Strangulated bowel obstruction

Table 4: Causes of colonic perforation

Blunt abdominal trauma:

Blunt abdominal trauma may be due to fall from height, assault, road traffic accidents or due to blast injuries. Hollow viscus injury following blunt trauma is difficult and challenging to diagnose clinically because most of the time only minimal or nil external findings will be present. There comes the role of CT in its early detection by identifying extraluminal oral contrast extravasation and pneumoperitoneum. Detection of bowel and mesenteric injury can be challenging in patients after blunt abdominal trauma but early diagnosis and treatment are critical to decrease patient morbidity and mortality(11). Fast diagnosis and treatment is important for preventing complications in patients with intestinal perforation caused by blunt abdominal trauma, a delay exceeding 8 h and an injury severity score more than 15 were related to significant septic complications(16).

Penetrating abdominal trauma:

Abdominal penetrating injuries usually results in bowel injuries which may be clinically occult at the time of admission. In contrast to blunt trauma, the presence of free intraperitoneal air alone is not considered diagnostic of bowel injury following penetrating trauma because small amount of air can enter the peritoneal cavity along the tract of wound with a breech in peritoneum. Extraluminal spillage of oral contrast can be taken as confirmatory to diagnose a bowel perforation. Other findings include bowel wall thickening with adjacent mesenteric contusion, hematoma, extraluminal free fluid, the wound tract may be identified on CT images.

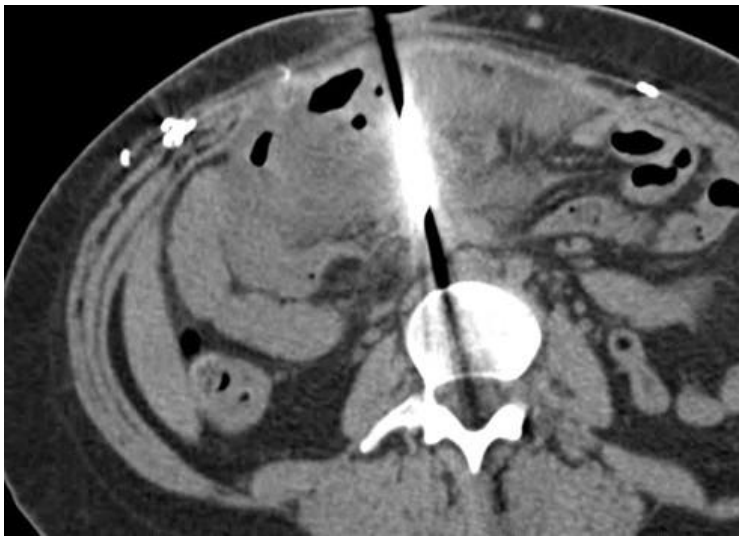


Figure 9: CT image of penetrating bowel injury with knife (17)

Iatrogenic injury:

Duodenal perforation can occur during endoscopic procedures including endoscopic ultrasound and endoscopic retrograde cholangiopancreatography or gastroduodenoscopy. Duodenal perforations are commonly retroperitoneal and rarely, intraperitoneal. The spillage of acidic intraluminal contents results in rapid development of peritonitis with severe abdominal pain and progresses to sepsis if treatment is delayed. Factors that increases the risk of perforation during endoscopy include degenerative changes of cervical spine with anterior osteophytes, presence of any diverticulum, preexisting stricture or malignancies of the UGI tract(18)

Peptic ulcer disease:

The current trend of declining prevalence of Helicobacter pylori infection and widespread use of anti-H pylori regimen resulted in decreased prevalence of PUD than two decades before(19). Peptic ulcer disease occurs due to the disruption of mucosal defense barriers or due to hypersecretion of the acidic secretions. Gastrointestinal haemorrhage and perforation is considered as a serious complication of PUD which presents as acute abdomen(20). Perforated peptic ulcer carries a high risk for morbidity and mortality if treatment is delayed. Perforated peptic ulcer is a common emergency condition worldwide, with associated mortality rates of up to 30% (21). Peptic ulcers can occur in the stomach as well as the duodenum.

Figure 10: Pneumoperitoneum in gastric ulcer perforation

Tobacco smoking, long term use of drugs like NSAID's or steroids, Helicobacter pylori infection, alcohol are considered as risk factors. Other causes include excessive acid production due to gastrinomas and Zollinger-Ellison syndrome. The patient presents with abdominal pain, upper abdominal discomfort, nausea, vomiting.

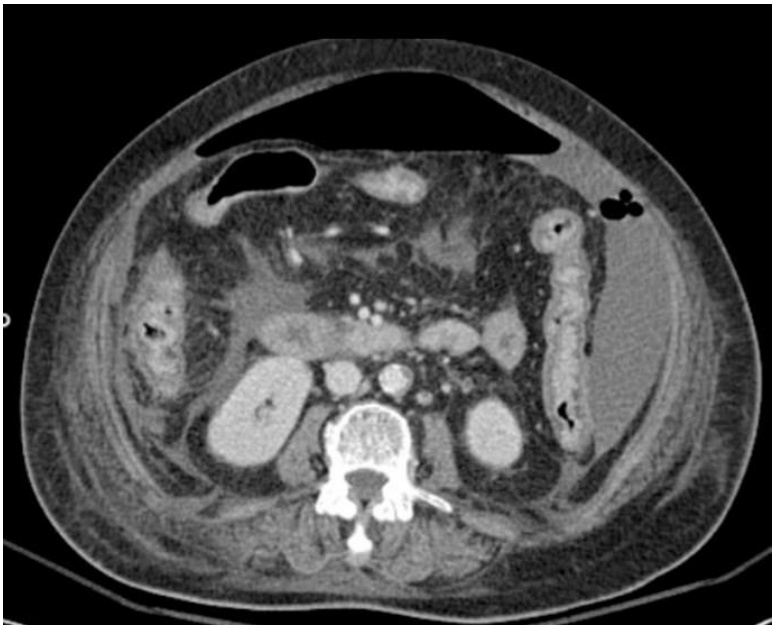


Figure 11: Large volume pneumoperitoneum and free fluid in perforation

Perforation peritonitis results in sudden onset of severe abdominal pain or acute deterioration of the ongoing abdominal pain and is characterized by triad of sudden onset of abdominal pain, tachycardia and abdominal rigidity.

Neoplasm:

GI perforation, obstruction, ischemia, and intussusception are common bowel related emergency in patients with cancer. Colorectal cancer in old age patient can present with perforation and is seen with more advanced stages of the disease. Patients presenting with perforations also have higher mortality, increased local recurrence rate, and risk of peritoneal spread of malignancy. Adenocarcinoma, lymphoma, and GI stromal tumors, can ulcerate and cause perforations. Malignancy can cause bowel ischemia by direct invasion of the vessels, mechanical obstruction, or by inducing hypercoagulable states. Chemotherapy for lymphoma also increases the risk for perforation. Perforated gastric cancer occurs in less than 5% of all gastric cancer patients and is an oncologic emergency after major bleeding, usually associated with advanced disease stage (22)**.** Malignant lesions appear on CT images

as mass forming lesions with irregular heterogeneously enhancing eccentric or circumferential stenosing bowel wall thickening associated with lymphadenopathy.

Figure 12: Axial CT image of gastric malignancy

Perforation is more likely to occur at the primary site than metastatic sites or other nontumor sites. The CT manifestations of cancerous and inflammatory colorectal perforations overlap(23). Perforation of colonic cancer is a serious but rare complication. It represents 0.8%–3.7% of all surgically treated and 10%–26% of those operated on in emergency(24). Lymphoma of the GIT presents as non-stenosing circumferential enhancing bowel wall thickening. Aneurysmal dilatation of the bowel may be seen. Synchronous multifocal lesion and generalized lymphadenopathy may be seen. Perforation is a life-threatening complication of lymphoma. In a study made by Vaidya et al, 9% (92 of 1062) of bowel lymphoma patients developed a perforation, of which 55% (51 of 92) occurred after chemotherapy, they also concluded that the most common site for perforation was small intestine(25).

Infectious causes:

GI perforation from infection occur as a result of typhoid, tuberculous, schistosomiasis, or amebic infection. In developing country like India, infectious causes of gastrointestinal perforation carries a high mortality rate ranging from 10% to 43%, and can occur as a result of typhoid, tuberculous, schistosomiasis, or amebic infection(26). Typhoid most commonly affects children and young adults. Wall injury

from the infection or the host's inflammatory response leads to formation of ulcers and eventually necrosis and perforation. Salmonella typhi have a tendency to involve the peyer's patches of the terminal ileum, where most of the perforations are seen, and Clostridioides causes infection of the colon. The overall frequency of intestinal perforation in typhoid fever was 3% with an overall mortality rate of 39.6%(27). On imaging, enteritis and colitis show hyperenhancement of the bowel wall with circumferential bowel wall thickening, which can be focal or diffuse. Perienteric fat stranding and free fluid in abdomen are associated findings.

Acute inflammatory disorder:

Acute appendicitis is the most common cause of acute abdomen presenting to the casualty department. Prevalence is higher in younger populations. The risk of perforation is higher in men, young children, elderly, with appendicolith, greater distention of the appendix. The complications of appendicitis like gangrenous changes, phlegmon formation, perforation, abscess formation, peritonitis, and sepsis increase the risk of morbidity and mortality(28). Appendicular perforation may be free or contained. Perforation can result in the formation of right iliac fossa abscess. Acute non-perforated appendicitis can be treated successfully with antibiotics, however, there is a risk of recurrence in cases of acute appendicitis, and this risk should be compared with the risk of complications after appendectomy(29). The incidence of perforated appendicitis was found to be low in males as compared to females, also the incidence of appendicular perforation was found to be higher in the extreme of ages(30).

Acute diverticulitis is a complication of diverticulosis usually seen in old age group. Perforation of an inflamed diverticulum can occur with or without the formation of diverticular abscess. Both disorders develop with initial obstruction causing stasis of fecal contents within the appendix or the diverticular sac, leading to bacterial proliferation that leads to bowel wall injury. CT and USG are able to diagnose appendicitis, diverticulitis and perforation. CT shows inflamed appendix with diameter greater than 6 mm, wall thickening (>3 mm), mural hyperemia, peri appendiceal fat stranding, and free fluid. Appendicolith may be seen. Inflamed diverticulum is seen as a small outpouching from the sides of bowel wall with hyperemia, wall thickening, peripheral fat stranding and free fluid. Perforation can be identified as focal wall defect or focal area of non enhancing wall. Peripherally

enhancing collection or abscess may be visualized. There will be increased peripheral fat stranding. Appendicolith visualized outside the lumen of appendix will be confirmatory.

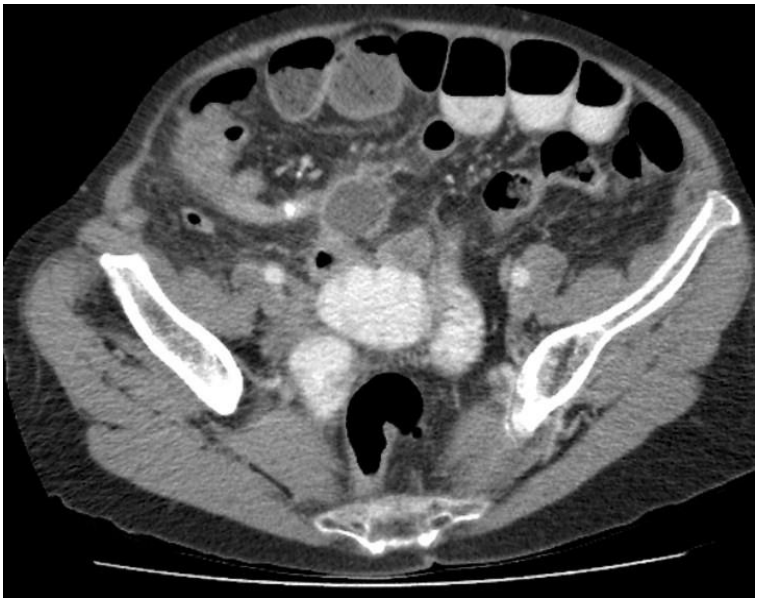


Figure 13: Perforated appendix with collection, no pneumoperitoneum

Figure 14: Axial CT showing colonic diverticulitis with perforation (31)

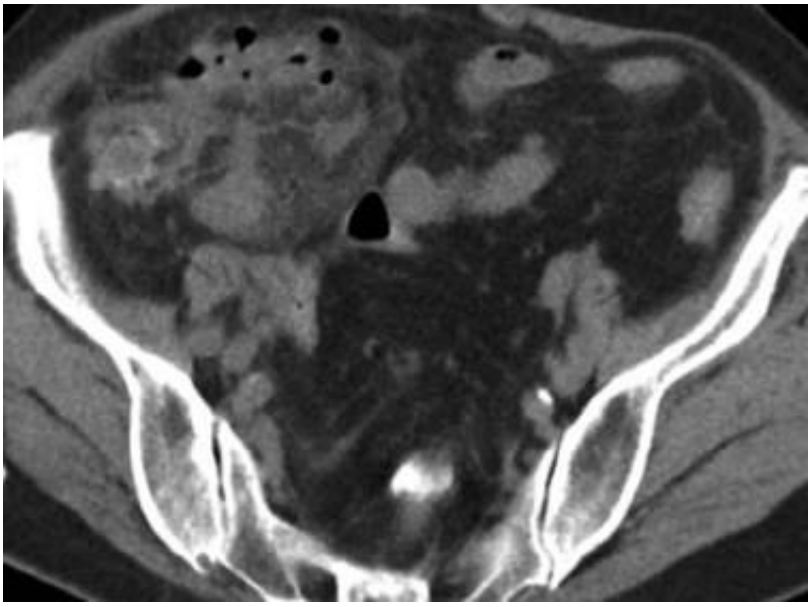


Figure 15: Axial CT showing perforated ileal diverticulitis (32)

DIAGNOSIS OF HOLLOW VISCUS PERFORATION

Perforated hollow viscus usually presents to the casualty as a case of acute abdomen. The clinical suspicion for perforated hollow viscus begins with the patient presenting complaints, history and abdominal examination. The patient complaints of an initial localized, visceral pain that later on became diffuse and severe. The patient may also have nausea, vomiting, anorexia, raised body temperature, chills, syncope, dizziness(33). The initial localized pain usually points to the site of perforation. The diffuse severe pain and raised body temperature can be clues to the developing peritonitis. The abdominal examination of the patient reveals tenderness, guarding and rigidity. Localized tenderness may be elicited initially that may help in localizing the site of perforation. Diffuse tenderness, guarding and rigidity develops later indicate peritonitis. Guarding and rigidity usually indicates a severity of the process. An inflammatory or neoplastic mass may be palpable on abdominal examination; however, it is difficult to elicit due to the tenderness, guarding and rigidity. The vitals may show raised body temperature, tachycardia, tachypnea and hypotension. Tachycardia hypotension and a low urine output suggest the possibility of septic shock and warrants urgent surgical consultation and patient stabilization.

By taking a detailed history the cause of the perforation may be determined. The patient may give history of long-term ingestion of drugs like NSAID’s or steroids. A

well-established association of mucosal ulcers has been found with the use of NSAIDs, immunosuppressants, chemotherapeutic agents, antibiotics, immunotherapies, etanercept and Olmesartan(34). There may be history of peptic ulcers or previous endoscopy reports. Patient may have history of appendicitis or diverticulitis diagnosed on previous imaging. There may be history of neoplastic disease diagnosed previously. Patient may have history of recent GIT instrumentation, surgery or history of trauma. But in most of the case there won't be a proper history, also the clinical scenario is different in case of patients with advanced age, obesity, immunosuppression, late presentation or contained perforation, they can present with minimal symptoms and clinical findings causing diagnostic dilemma where the role of imaging comes to help. Laboratory values may show elevated inflammatory markers, amylase lipase may be elevated, ABG may show metabolic acidosis

Because patients with perforated hollow viscus may present in a moribund state and have the potential for rapid clinical deterioration, the initial assessment focuses on maintaining airway breathing and circulation. At times the clinical symptoms may not be obvious to suspect a bowel perforation, especially in old age patients, debilitated patients or diabetic patients. The field of radiology has evolved in the past years and now we have fast and sensitive imaging modalities for diagnosing a case of hollow viscus perforation. This includes the commonly used x-ray, computerized tomography and ultrasound of the abdomen.

ROLE OF IMAGING IN THE DIAGNOSIS

Today different diagnostic modalities are available for the evaluation of hollow viscus perforation. The field of radiological imaging have evolved from mere confirming the presence of hollow viscus perforation to providing various valuable details to the surgeon like site and cause of perforation, containment of perforation, peritonitis, drainable abscess, anatomical details. This enables the surgeon to plan the surgical procedure and to take the consent accordingly. The radiological investigations had increased the sensitivity of diagnosis by identifying cases of clinically silent perforations, thus increasing the number of perforation cases diagnosed.

RADIOGRAPHY

Plain radiographs are usually the first radiological investigation done in a case of acute abdomen(1). Standard abdominal radiography consists of three views, a supine abdominal view combined with an erect chest film and an upright abdominal view(35). Pneumoperitoneum, if present, will be demonstrated on upright chest radiographsas free air under diaphragm. Free gas under the diaphragm is a classic sign of pneumoperitoneum on the erect chest and abdomen radiographs. The average plain abdominal radiograph exposes the patient to 0.7 mSv and an abdominal CT exposes the patient to 10.0 mSv, with newer techniques, such as automated dose modulation and an iterative reconstruction algorithm, reduce the CT radiation dose(36,37).

Abdominal radiographs can detect other causes of acute abdomen like renal or gall bladder calculus, bowel obstruction, volvulus, emphysematous infections and abscess formations. It can detect any radio dense foreign body swallowed, which may the cause of perforation. Radiographs have a disadvantage of not being able to rule out bowel perforation. This is due to small amount of pneumoperitoneum can go undetected on radiograph, also bowel perforations can occur with no obvious pneumoperitoneum, like in cases of some appendicular perforations.

The overall positivity rate of plain radiography in detecting pneumoperitoneum was 89.20% (47). Xray even though is usually the first line of investigation in a case of suspicious bowel wall perforation, it has disadvantages like not being able to localize the perforation. But it is easily available, fast and low cost. Presence of pneumoperitoneum when identified on x-ray with relevant clinical details are suggestive of hollow viscus perforation. However, x-ray have some drawbacks, small amount of pneumoperitoneum may be missed on an x-ray. X-ray cannot identify the site and cause of perforation; it cannot identify peritonitis. Abscess if any are more likely to undergo undetected on an x-ray. Erect x-rays are required to diagnose pneumoperitoneum, in some cases it may not be possible because of the patient condition. Interposition of large bowel anterior to the liver called as Chilaiditi's syndrome may be mistaken for air under diaphragm. Similarly, the intraluminal air at the fundus of the stomach may be mistaken for air under diaphragm.

Name of sign	Definition
Free gas under diaphragm	Air outlines the undersurface of diaphragm [1].
Rigler sign	Air outline both sides of the bowel wall on abdominal x-ray (38)
Football sign	Abdominal cavity is outlined by gas from a perforated viscus in massive pneumoperitoneum(39)
Telltale triangle sign	Radiolucent triangle of gas formed between three loops of bowel or between two loops of bowel and the abdominal wall [1].
Falciform ligament sign	Falciform ligament being outlined with free abdominal gas in cases of pneumoperitoneum of a large amount [1].
Lucent liver sign	Reduction of hepatic radiodensity on supine radiograph when there is a collection of free intraperitoneal gas located anterior to the liver(40).
Cupola sign	Free air within the peritoneal cavity can be recognized on supine abdominal films by identification of the median subphrenic space(41)

Table 5: Important x-ray signs of pneumoperitoneum

The presence of pneumoperitoneum is also not specific for hollow viscus perforation because recent surgery, laparoscopy, bladder injury, penetrating peritoneal injury without hollow viscus perforation can also result in pneumoperitoneum. Pneumoperitoneum remains a reliable sign of viscus perforation; however, lack of this finding does not rule out perforation(42). Pneumoperitoneum may be absent in very early stages of perforation, in very tiny focal perforations as in case of appendicular perforation and in cases of sealed off perforation.

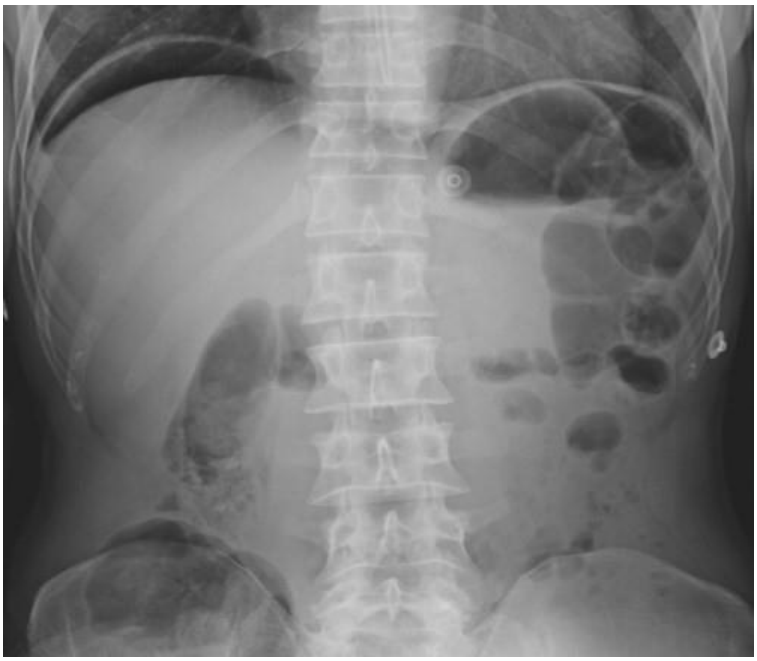


Figure 16: Air under diaphragm (1)

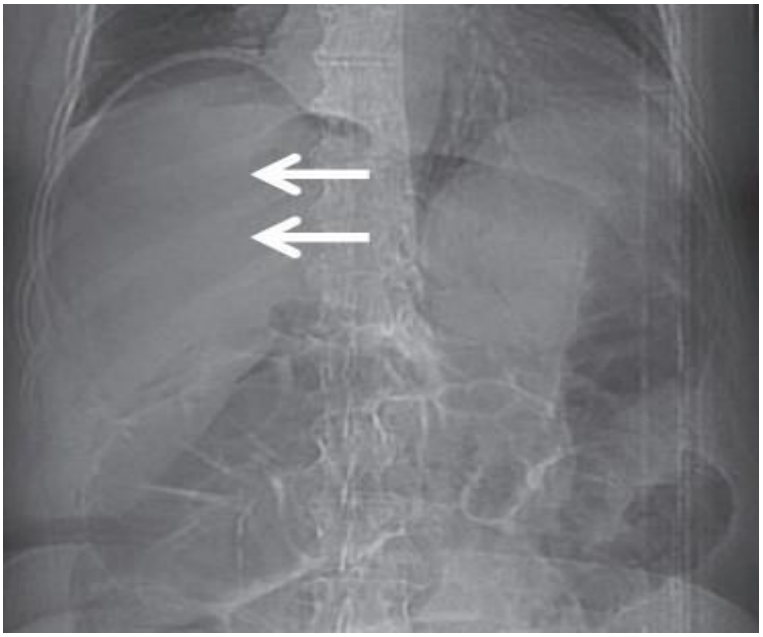


Figure 17: Hyper lucent liver sign (1)

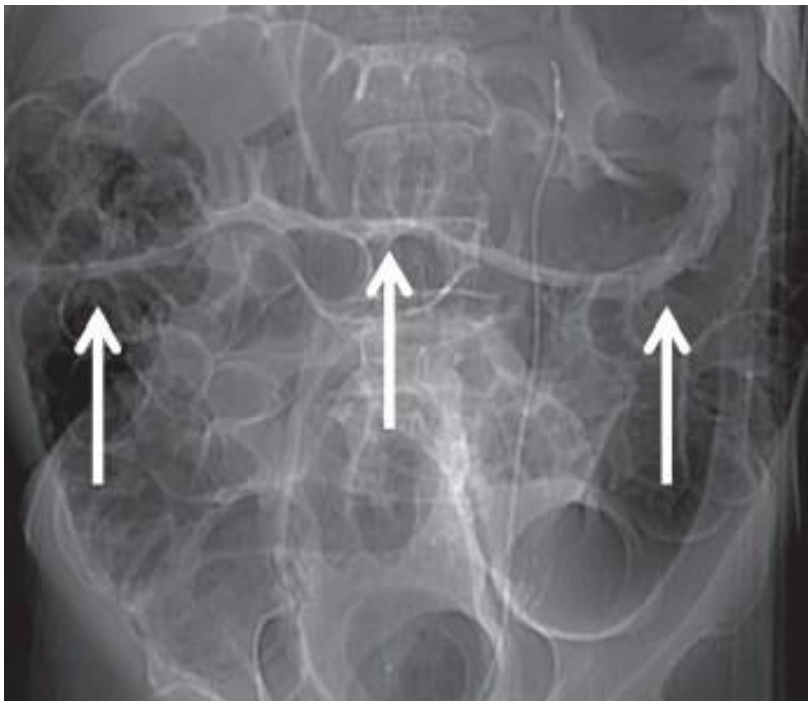


Figure 18: Rigler sign (1)

ULTRASOUND

Ultrasound (USG) is not a primary modality for evaluating pneumoperitoneum, free gas can be detected on ultrasound when gas shadowing is present along the peritoneum. Peritoneal stripe sign is indicative of pneumoperitoneum. Free air in the abdomen will collect in an anti-dependent manner in anterior prehepatic space in the supine patient, creating an unusually reflective interface(43). Intraperitoneal free air is most commonly identified in the right upper quadrant between the anterior abdominal wall, in the prehepatic space with patient in supine position as enhancement of the peritoneal stripe which moves when the patient position changes should raise the suspicion of intraperitoneal free air as opposed to intraluminal gas with a visible peristalsis and a normal wall thickness(44).Varying amount of free fluid with internal echoes may be identified on ultrasound. Ultrasound may be sometimes able to detect the site of perforation by identifying the focal defect in bowel wall, appendix and duodenal perforations may be identified. Ultrasound is useful at times to know if the perforation has been naturally sealed by omental and mesenteric adhesions. Ultrasound can detect and quantify any intraabdominal collection or abscess. Inflammatory or neoplastic mass lesions if any can be identified on ultrasound. Ultrasound may be used to rule out other causes of acute abdomen like

pancreatitis, cholecystitis, abdominal aortic aneurysm or dissection, ovarian torsion, renal or ureter calculus, pyelonephritis. However small amount of pneumoperitoneum may remain undetected on ultrasound and is greatly operator dependent. Intraluminal bowel gas may be mistaken for pneumoperitoneum. Ultrasound most of the times is no able to pinpoint the site of perforation. Ultrasound imaging is greatly influenced by the bowel gas artefacts and patient body habitus. Air creates artifacts on ultrasound resulting in suboptimal evaluation of the bowel. Also in cases of obese patients or in cases with subcutaneous emphysema, the sensitivity of ultrasound in identifying pathologies decreases(45). Some authors demonstrated that US has lower sensitivity than radiography (76% vs. 92%, respectively) (46) Although CT has more accuracy in the detection of the site of perforation, ultrasound may be particularly useful also in patient groups where radiation burden should be limited notably children and pregnant women.(43). The linear array, high frequency transducers (10-12MHz) are more sensitive in detecting extraluminal air than the standard curvilinear abdominal transducers (2-5MHz).

Figure 19: Pneumoperitoneum on ultrasound

COMPUTED TOMOGRAPHY:

Computed tomography (CT) examination has been shown to be more sensitive than abdominal radiographs for the detection of free intraperitoneal air(1). CT has shown promising results in identifying pneumoperitoneum, by detecting even very tiny

extraluminal air pocket that x-ray failed to identify. While x-ray is the most frequently ordered first line investigation, CT continues to be the investigation of choice in diagnosing hollow viscus perforation. CT also provides excellent anatomical details that enables the surgeon to plan the procedures accordingly. CT helps us to understand the cause of perforation and any coexisting pathologies. The extent of peritoneal inflammation, localized or generalized can be readily identified on CT images. CT also detects any intraabdominal collection or abscess formation which is a surgical emergency and need to be drained immediately. CT also helps the clinician to rule out other causes of acute abdomen. Administration of IV contrast agent is necessary while evaluating a case of acute abdomen, especially if suspecting hollow viscus perforation in order to evaluate the bowel thoroughly. Present day CT machines uses multislice helical scanner, with the advent of post processing imaging techniques like multiplanar reconstruction, CT is often able to localize the exact site of perforation. This is a valuable preoperative information to the operating surgeon to plan the surgery beginning with the suitable type of incision. Often oral contrast is administered to identify the site of perforation, with the use of water soluble near inert contrast agents, there is less likely chances of inflammatory peritoneal reaction upon spillage of the contrast material.

CT findings in GIT perforation:
• Concentrated extraluminal air bubbles • Free air in supra- or inframesocolic compartment • Free air in both abdomen and pelvis • Focal bowel-wall defect • Segmental bowel-wall thickening • Perivisceral fat stranding • Abscess • Extraluminal fluid

. **Table 6: CT findings in GIT perforation**

Present day multi detector CT (MDCT) machines improved the diagnostic accuracy by providing excellent quality images in short period of time with increased gantry speed and improved spatial resolution(47).

Unlike single-slice CT, MDCT have the capability to acquire two or more than two slices in a single rotation itself. This improves the scanning speed and allows thinner slices to be obtained which increases the diagnostic accuracy(48).

A low dose CT (LDTCT) has got high diagnostic accuracy for detecting intestinal obstruction and pneumoperitoneum with less exposure to radiation(49).

Abdominal CT findings in hollow viscus perforation includes extraluminal air, focal bowel wall defect, bowel wall thickening, perivisceral fat stranding, free fluid and abscess formation. In a retrospective study done by Chen etal on intraoperatively confirmed cases of bowel perforation, 100% of the patients showed extraluminal air accumulation, and 71% of patients had abnormal fluid accumulation.

In a study done by Ryo Seishima et al, the diagnostic accuracy of CT in identifying the site of bowel perforation improved by 9.8% when the attenuation values of ascites was also taken into consideration(50). A study done by Sessa et al concluded that MDCT is accurate in identifying the site of hollow viscus perforation in approximately 85% cases, by the detection of direct signs and indirect signs, direct signs include focal bowel wall defect, extraluminal air, and extraluminal contrast, the indirect signs are nonspecific and include segmental bowel wall thickening, abnormal wall enhancement, fat stranding, fluid, and abscess(51).

Figure 20: Pneumoperitoneum axial CT image

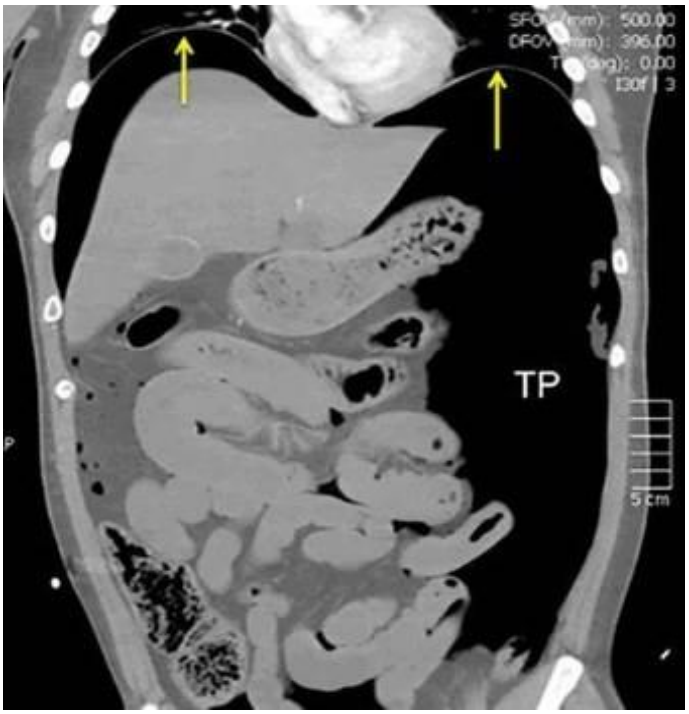


Figure 21: Coronal CT massive pneumoperitoneum with abscess formation(52)

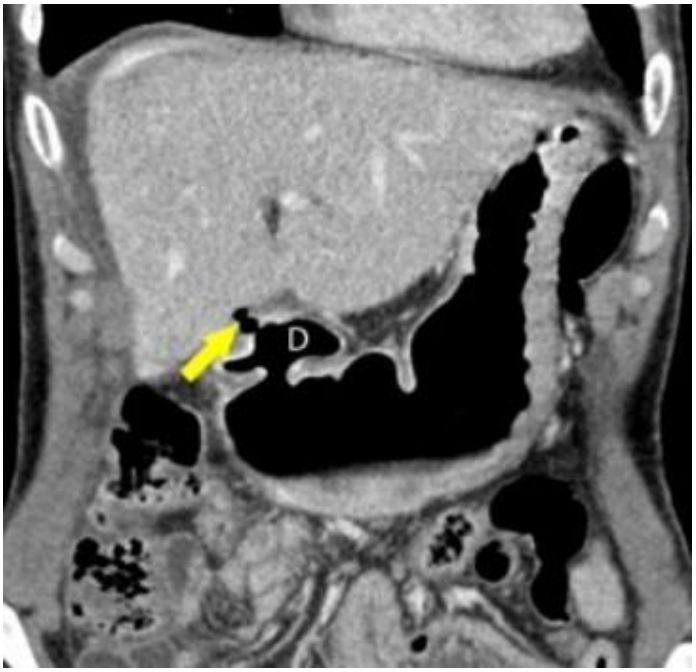


Figure 22: Coronal CT image of focal bowel wall defect (53)

RELEVANCE

Hollow viscus perforation is a serious condition with a mortality rate of up to 20%, and it is the third most common cause of surgical abdomen after appendicitis and intestinal obstruction (33). Clinical examination of the patient combined with relevant history taking usually raises the suspicion for bowel perforation, however other causes of acute abdomen like ovarian torsion, ruptured ectopic gestation can mimic bowel perforation clinically. Clinical examination findings can be unreliable for several reasons like in case of old age patients, chronic debilitated patients, uncontrollable diabetics, or patients with altered mental status. Imaging has an important role as a diagnostic tool in hollow viscus perforation and excluding other differential diagnosis. Erect x-ray of chest and abdomen, an easily available investigation if able to identify pneumoperitoneum, is the first and fastest way of reaching diagnosis, hence treatment can be offered without delay.

Delay in diagnosing a case of hollow viscus perforation puts the patient's life into risk due to peritonitis, this increases the morbidity of the patient. CT scan is considered as the investigation of choice for the diagnosis of hollow viscus perforation because it can detect even small amount of extra luminal air, which is undetectable on x-ray. It can also help to identify the site and cause of perforation most of the times. With the advent of modern technology, present day multislice CT machines take only very few minutes to scan the entire abdomen. Hence CT is a fast, sensitive and excellent diagnostic modality that can provide valuable pre operative information to the treating surgeon.

The surgical procedure for hollow viscus perforation is midline laparotomy which involves a long midline parietal wall incision from the epigastric region to the suprapubic area/ The post operative morbidity associated with this procedure is significant. The large incision takes more time to heal which increases the patient's duration of hospital stay. Also, there is increased risk of surgical site infections in case of inadequate post operative care. There is also risk for wound dehiscence and burst abdomen which is a severe post operative complication. In long period, the patient is also at risk of incision hernia, the long scar also possesses cosmetic issues. In non-traumatic perforation, if the surgeon knows the site of perforation preoperatively, he can plan the procedure accordingly, instead of a long midline incision, incision may be made to expose only the site of perforation. In case of

gastroduodenal perforation, if the surgical site is known, instead of putting midline incision, the surgeon can operate with an upper abdominal incision or he can go for a laparoscopic approach. In cases of appendicular perforation, the surgeon can use laparoscopic approach or can use an open approach with a small incision at the right iliac fossa. These minimal invasive approaches can significantly decrease the postoperative morbidity and hospital stay of the patient. However, this is not the case with traumatic bowel injury. Multi focal bowel injury is expected in cases of trauma and preoperative CT cannot identify all the sites of bowel injury, in such cases the surgeon needs to perform a midline laparotomy and will have to inspect the whole bowel for injury and repair accordingly. Preoperative imaging with CT in cases of bowel perforation can detect additional complications like abscess formation, quantification of the abscess can also be made. CT can also guide the percutaneous aspiration of abscess.

Most published studies focus on the ability of MDCT to identify free gas or pneumoperitoneum and sensitivity of CT scan in diagnosing hollow viscus perforation, only few studies are available that had evaluated the diagnostic accuracy of MDCT abdomen in the preoperative localization of the site of perforation. This study attempts to evaluate the accuracy of MDCT as a diagnostic tool in the preoperative localization of surgically confirmed cases of hollow viscus perforation by corelating the CT findings with intraoperative findings.

METHODOLOGY

STUDY DESIGN– A hospital based cross sectional study.

STUDY SETTING– Department of Radiodiagnosis, Government Medical College, Kannur.

PERIOD OF STUDY-The study was conducted over a period of one year (January 2021 to January 2022)

SAMPLE SIZE CALCULATION -

$$n = \frac{Z^2 pq}{d^2(100\text{-prevalance})}$$

where Z (desired confidence level) = 1.96, corresponding to 5% level of significance

p= 92% **[5].** q=100-p = 8% d (relative precision) = 0.92 (1% of p)

Prevalence is taken as 0.4% of acute abdomen cases. By applying values to the equation, we get a sample size of 35.

SAMPLING METHOD- Consecutive sampling

The study was done on all patients with suspected hollow viscus perforation brought to or referred from other centers to Government Medical College, Kannur, and treated operatively. As per previous records a minimum of at least 3 patients have been evaluated by Computed Tomography for hollow viscus perforation, every month receiving operative management.

STUDY POPULATION–

The data required for this study was collected from patients with clinically suspected hollow viscus perforation or pneumoperitoneum referred to the Department of Radiodiagnosis, Government Medical college, Kannur for MDCT evaluation, with evidence of hollow viscus perforation on CT and managed operatively.

STUDY SUBJECTS:

INCLUSION CRITERIA:

Any patient with clinical suspicion of hollow viscus perforation based on xray findings of pneumoperitoneum or abdominal examination findings evaluated with MDCT and managed operatively at Government Medical College Kannur. All age group patients will be included.

EXCLUSION CRITERIA:

All patients who are clinically or hemodynamically unstable and taken up for emergency surgical intervention without preoperative MDCT evaluation.

PARAMETERS STUDIED:

Information will be obtained about demographic factors like age, sex of the patient, any previous history. Additional investigations like X-rays will be interpreted. CT images will be interpreted for findings like focal defect in bowel wall, segmental bowel wall thickening, clustering of extraluminal air bubbles near bowel wall, free air in supra/infra mesocolic compartments, perivisceral fat stranding, abscess and extraluminal fluid.

METHOD OF STUDY:

Study was conducted over a period of one year (January 2021 to January 2022) and 40 consecutive patients with hollow viscus perforation was evaluated. All the patients underwent surgery within 12 hours after MDCT was performed.

Written informed consent was obtained from individual patients. The entire abdomen from the dome of diaphragm to the pelvic floor was scanned using TOSHIBA ALEXION 16 slice multidetector CT machine. The patient placed in supine position on the CT table and non-contrast images are obtained. Intravenous contrast agent will be given using automated pressure injector. The contrast agent used, Iohexol – Omnipaque is a nonionic water-soluble contrast agent and given at a dose of 2-3ml/kg. In our department we don't prefer giving oral contrast material in emergency CT with suspected cases of pneumoperitoneum. The renal function test will be checked prior to the giving of

intravenous contrast. CT images are taken in the arterial phase by bolus tracking method, region of interest will be kept in descending aorta. Portal venous phase will be taken with a delay of 50 to 70 seconds. The scans are studied in detail on workstation monitor, films will be taken for permanent record. The CT findings will be analyzed and recorded in all patients as per predesigned format. Consensus of the site was made on the basis of seven criteria:

1. Focal defect in bowel wall
2. Segmental bowel wall thickening
3. Clustering of extraluminal air bubbles near bowel wall
4. Free air in supra/infra mesocolic compartments
5. Perivisceral fat stranding
6. Abscess
7. Extraluminal fluid

Results will be compared with intraoperative findings of the operating surgeon and will be analyzed for sensitivity, specificity, positive predictive value and negative predictive value

ANALYSIS PLAN:

Collected data was analyzed by sensitivity, specificity, positive predictive value, and negative predictive value.

ETHICAL CONSIDERATIONS:

The study was performed after getting approval from ethical committee of Government Medical College, Kannur, Kerala. Written informed consent was obtained from every patients/guardian during the study. The data for this study was collected from the case sheet and radiological investigation that was done by the patient for his diagnostic purpose as requested by the treating doctor. No extra investigations were done. All other expenses were borne by the investigator himself.

RESULTS

Data analysis of 40 patients who visited Govt. Medical College Kannur with hollow viscus perforation and fulfill the inclusion criteria.

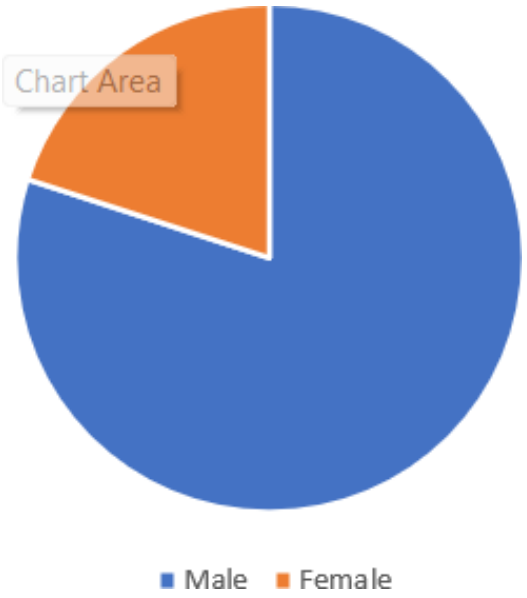
1. AGE DISTRIBUTION OF PATIENTS STUDIED

Age (in years)	Number
<10	0
11-20	2
21-30	4
31-40	5
41-50	8
51-60	8
61-70	9
71-80	3
80-90	1
Total	40
Mean age	50.65 years

Table 7: Age distribution of patients

Most number of patients fall into age group 61-70, nine patients. Second most number of patients equally fall into age groups 41-50 and 51-60, eight patients each. Least number of patients was in age group 80-90, only one patient. There was no patient in the age group <10 and > 90. The mean age is found to be 50.65. 12.5% of patients fall into age group 31-40. Four patients in age group 21-30 which is 10%. Three patients are in age group 71-80. Two patients fall in age group 11-20. Minimum number of cases were found in the both extremes of age group, with peak incidence at age group 61-70.

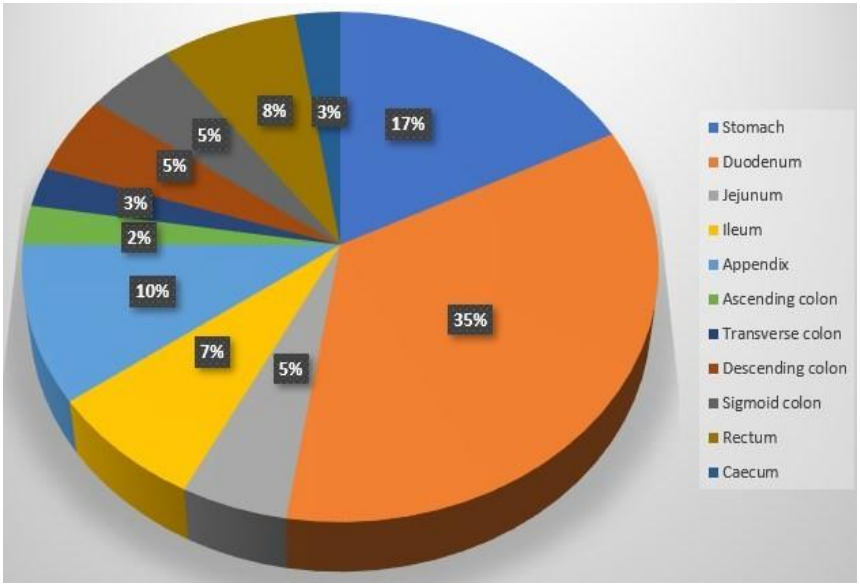
2. GENDER DISTRIBUTION OF PATIENTS



Graph 1: Sex distribution of patients

The patients included in the study were 80% males, which is 32 cases. Females constitute the rest of 20 %, that is 8 out of 40 patients. Hollow viscus perforation was found to be more in male patients compared to female patients.

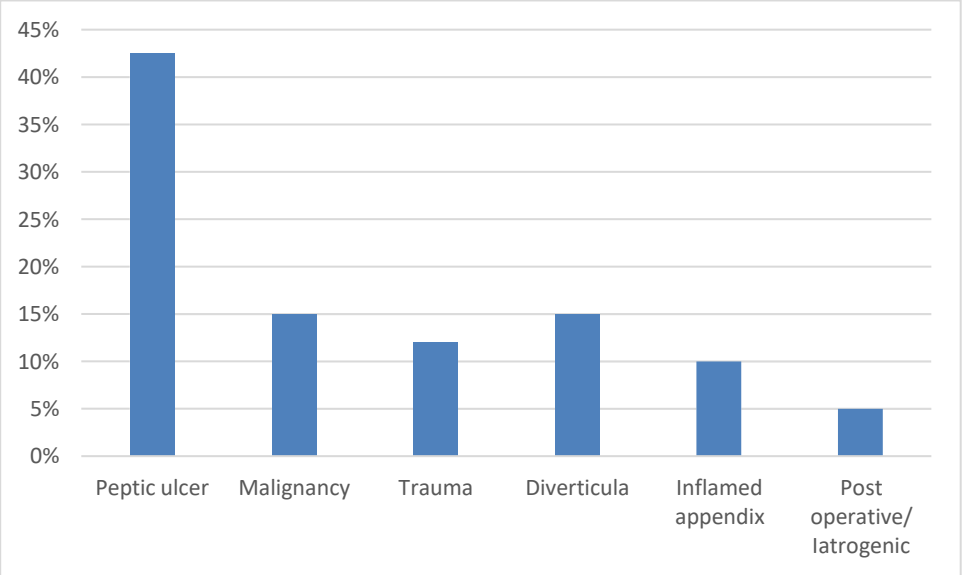
3. SITE OF PERFORATION



Graph 2: Site of perforation

The most common site of perforation was duodenum, 14 out of the 40 patients had duodenal perforation on surgery. The second most common site of perforation was stomach, 7 cases of gastric perforation was identified intra operatively. Appendicular perforation was found to be in 3 patients. The least common sites of bowel perforation were ascending colon, transverse colon and caecum, one each case. Three cases of rectal perforations were identified. Perforation of stomach and duodenum together constitutes the largest number of cases, which is 52% of cases.

4. CAUSE OF PERFORATION

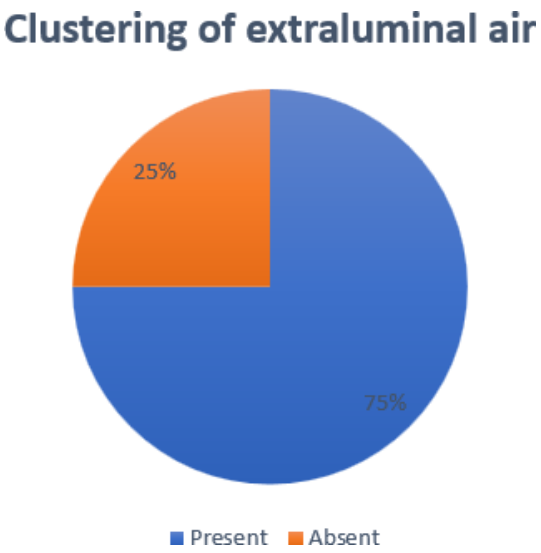


Graph 3: Cause of perforation

The most common cause of perforation among the patients who took part in the study was due to peptic ulcer disease. The most common site of perforation due to peptic ulcer disease was duodenum, second most was stomach. Traumatic perforation constitutes 12.5% of the cases which is five cases, small bowel was the most common site of traumatic perforation than large bowel. No cases of traumatic gastroduodenal perforation were recorded. Six cases of malignant perforation were recorded which included two cases each of gastric and duodenal perforation.

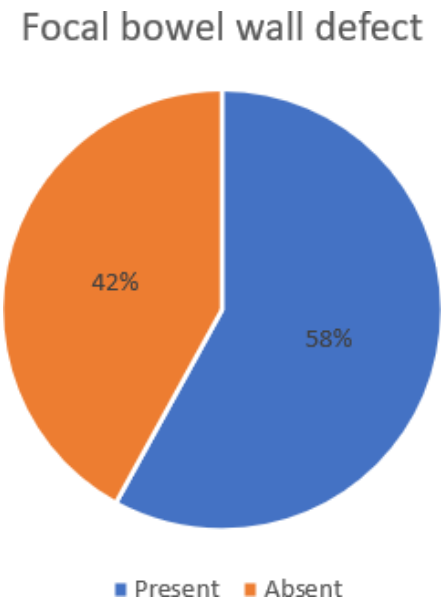
5. CT FINDINGS

a) **Clustering of extraluminal air:** CT images showed clustering of extraluminal air in 30 out of the 40 cases, hence extraluminal air clustering was identified on 75% of the cases. In 10 patients there was no evidence of extraluminal air clustering on CT images. Clustering of air was observed in all cases of gastric perforation and seven cases of duodenal perforations. Five cases of duodenal perforation and one each case of rectum, transverse colon, descending colon, caecum and ileum perforations did not show extraluminal air clustering on CT images. Extraluminal air clustering was observed in three cases of appendicular perforation.

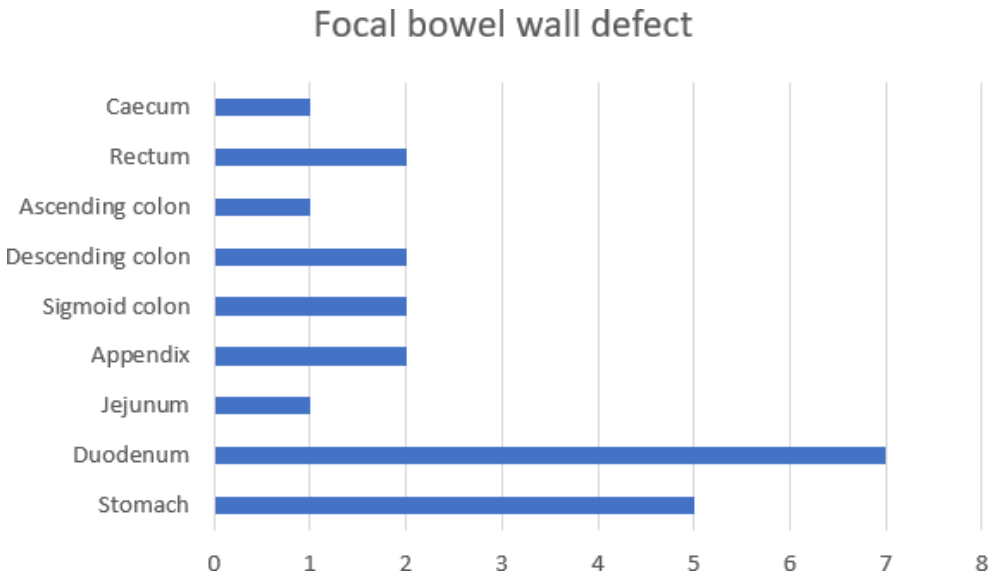


Graph 4: Clustering of extraluminal air

b) **Focal bowel wall defect:** Focal bowel wall defect was identified on CT images in 23 cases out of the 40 cases. In 42% cases, focal bowel wall defect was not identified. In all the cases with focal bowel defect identified on CT images, the site of hollow viscus perforation as described by the CT and the intraoperative site of perforation was the same. All the cases of focal bowel wall defect were associated with fat stranding and focal bowel wall thickening. The most common sites where focal bowel defect was observed on CT images are in gastroduodenal perforation, duodenum with the greatest number of cases.

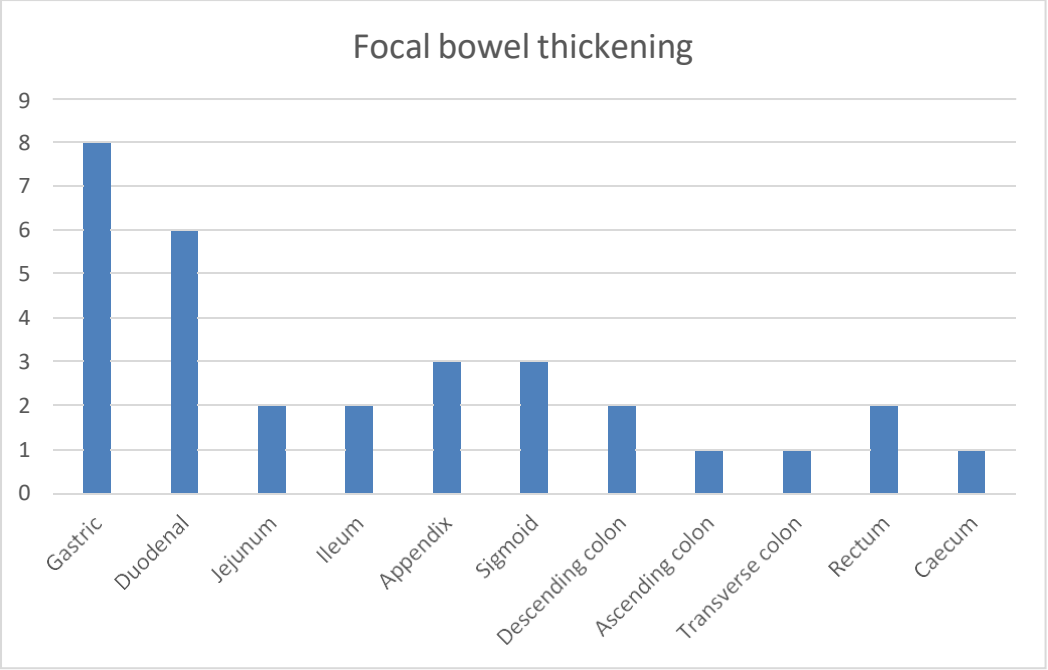


Graph 5: Focal bowel wall defect



Graph 6: Distribution of cases with focal bowel wall defect

c) **Focal bowel thickening**: Focal bowel thickening was identified in 31 cases and was absent in 9 cases. Six cases of duodenal perforation, one case each of rectal, sigmoid colon and ileal perforation showed no evidence of bowel thickening on CT images. Focal bowel thickening was identified in all the cases with focal wall defect.



Graph 7: Focal bowel thickening distribution of cases

d) **Fat stranding:** Fat stranding was one of the findings that was consistently observed in 39 cases with bowel perforation. In one of the cases of duodenal perforation, fat stranding was not observed, however there was large amount of extraluminal fluid in that patient which may have masked the fat stranding. Early stages of perforation showed focal fat stranding localized to the site of perforation and helped in identifying the site of perforation along with other findings. In patients with delayed presentation there was diffuse intraabdominal fat stranding due to diffuse peritoneal inflammation.

e) **Extraluminal fluid:** Extraluminal free fluid is another consistently observed finding in patients with hollow viscus perforation. It was found in 39 out of the 40 cases. The amount of extraluminal free fluid ranges from mild to large ascites. One of the cases of rectal perforation did not show any extraluminal free fluid likely due to the early stage of perforation. Large amount of fluid are found in cases with gastric perforation and also in traumatic perforations.

f) **Abscess:** Intraabdominal abscess was identified in 37.5% of cases with hollow viscus perforation. Gastroduodenal perforations together constitute the greatest number of cases. Amount of abscess varied from mild to large.

Distribution of cases with intraabdominal abscess	
Gastric	2
Duodenal	3
Appendix	3
Transverse colon	1
Descending colon	2
Sigmoid colon	4
Total	15

Table 8: Distribution of cases with intraabdominal abscess

STATISTICAL ANALYSIS

Number of cases CT correctly predicted the site of perforation	35/40
Number of cases CT incorrectly predicted the site of perforation	5/40

Table 9: Specificity of CT

MDCT was able to correctly predict the site of hollow viscus perforation in 87% of patients with the 7 criteria used. CT was able to correctly identify the site of perforation in 35 out of the 40 patients studied. Incorrect diagnosis was made in five cases. Three cases surgically diagnosed as duodenal perforation were mistaken as gastric perforation in two and appendix perforation in one on imaging. One case of surgically confirmed sigmoid perforation was mistaken as jejunal perforation on CT images. One case of rectal perforation which was confirmed on surgery was incorrectly interpreted as sigmoid perforation on CT images.

Clustering of air bubbles adjacent to bowel wall and segmental bowel wall thickening were the strong predictors of the site of perforation. Focal defect in bowel wall was found to have the highest positive predictive value. The sensitivity, specificity, positive predictive value and negative predictive value of individual CT findings are given below.

CT finding	Patients with positive finding among 35 with identified perforation Location (Sensitivity, %)	Patients Without CT Finding Among 5 With Unidentified Perforation Location (Specificity, %)	Correct Diagnoses in Patients With CT Finding (%)	Correct Diagnoses in Patients Without CT Finding (%)
Concentrated extraluminal air bubbles	85 (30/35)	80 (4/5)	92 (24/26)	78.0 (11/14)
Free air in supra or inframesocolic compartment	82 (29/35)	25 (1/5)	88 (30/34)	83 (5/6)
Focal bowel-wall defect	65 (23/35)	100 (5/5)	100 (18/18)	54 (12/22)
Segmental bowel-wall thickening	77 (27/35)	80 (4/5)	96 (31/32)	37 (3/8)
Perivisceral fat stranding	92 (32/35)	25 (1/5)	85 (30/35)	40 (2/5)
Abscess	37 (13/35)	40 (2/5)	86 (13/15)	88 (22/25)
Extraluminal fluid	94 (33/35)	25 (1/5)	83 (30/36)	25 (1/4)

Table 10: Diagnostic values of seven CT Findings in predicting site of gastrointestinal perforation

REPRESENTATIVE IMAGES

Figure 23: Extraluminal air pocket in a patient with gastric perforation

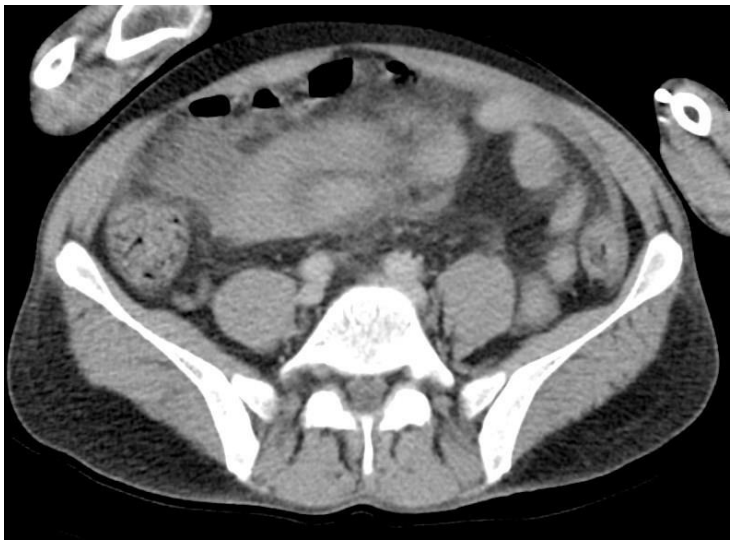


Figure 24: Extraluminal air pocket and mesenteric hematoma in a patient with traumatic ileal perforation.

Figure 25: Edematous wall thickening of ascending colon with peri colic fat stranding in a case of ascending colon perforation.

Figure 26: Extraluminal leakage of rectal contrast material in case of rectal perforation.

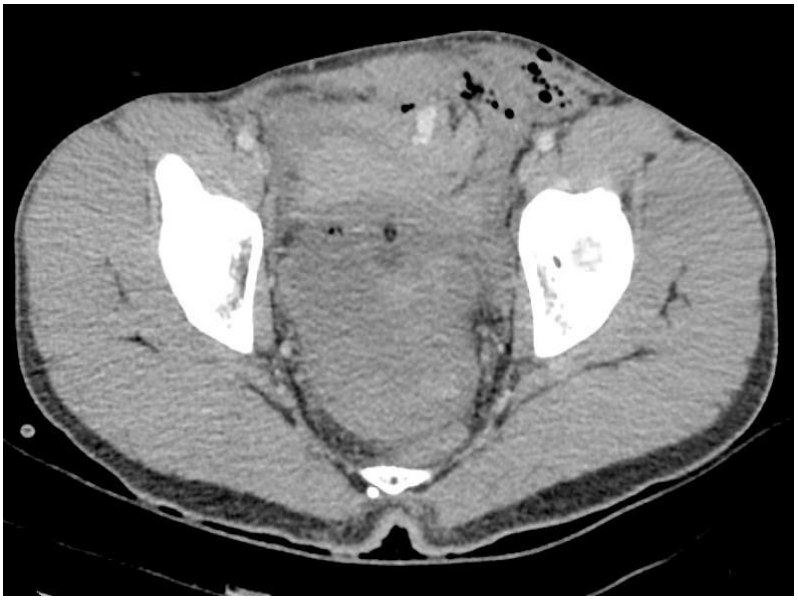


Figure 27: Crowding of extraluminal air pockets in a case of traumatic small bowel perforation, identified as ileal perforation intraoperatively.

Figure 28: Intra operative image of a patient with perforated gastric peptic ulcer.

Figure 29: Wall thickening, adjacent fat stranding and extraluminal air pocket in a case of cecal perforation.

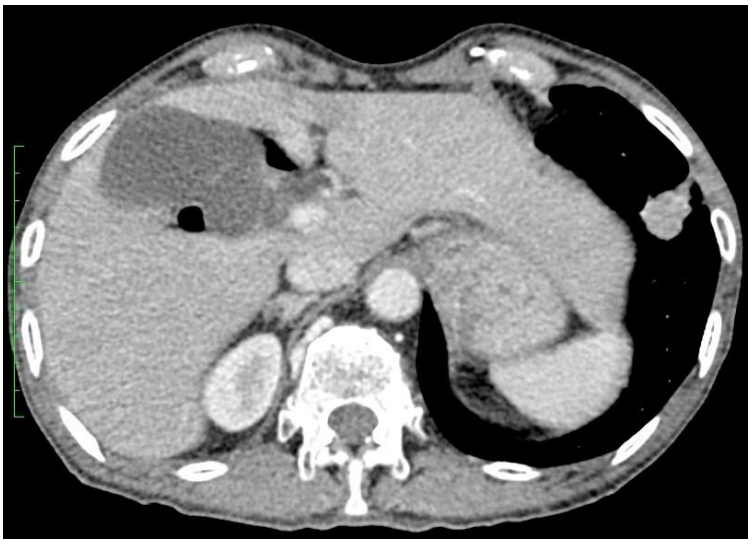


Figure 30: Extraluminal air locules in supramesocolic compartment in a case of duodenal perforation.

Figure 31: Colonic wall thickening with fat stranding in a case of diverticulitis with perforation.

Figure 32: Pneumoperitoneum in the supramesocolic compartment in a patient presented with acute abdomen.

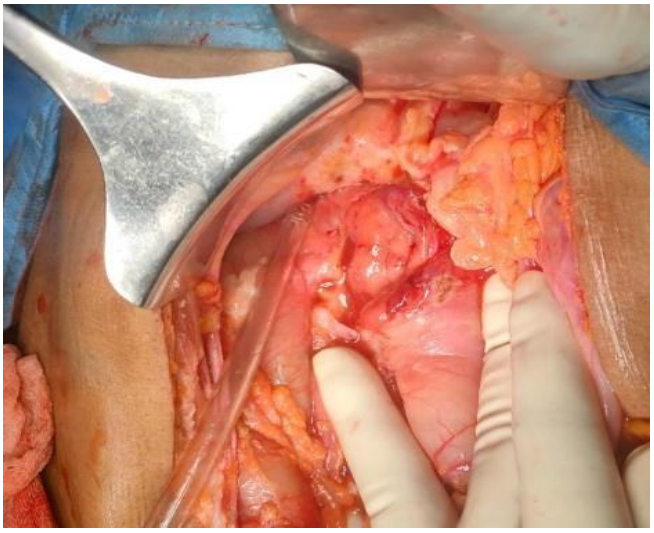


Figure 33: Intraoperative image of a case of duodenal perforation.

Figure 34: Inflamed appendix with a tiny extraluminal air locule in a case of appendicular perforation.

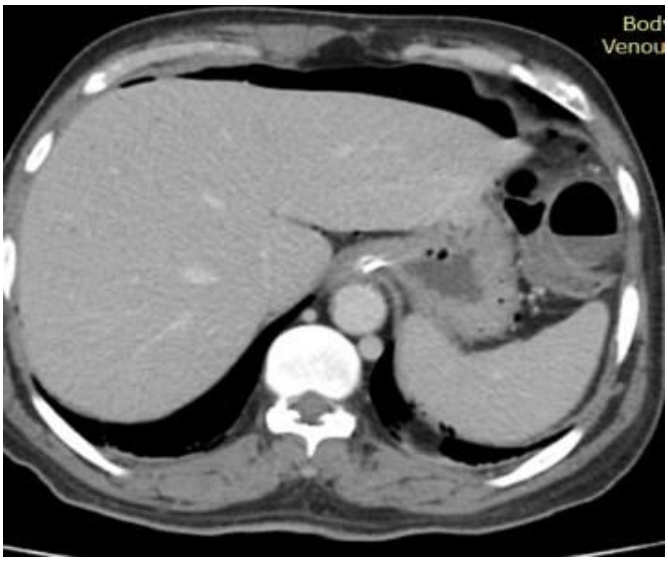


Figure 35: Axial section of CECT Abdomen shows extraluminal air with a collection adjacent to the splenic flexure of colon.

Figure 36: Crowding of extraluminal air pockets with fat stranding in case of perforated ileal diverticulitis

DISCUSSION

The study was conducted over a period of one year and a total of 40 patients with surgically confirmed cases of hollow viscus perforation who underwent preoperative MDCT abdomen evaluation were studied. Preoperative CT findings were used to predict the site of hollow viscus perforation and were correlated with the intra- operative finding.

Majority of the patients who form the part of study were males and constitute 80% which is in accordance with the literature. Eight of the study subjects were females. In our study hollow viscus perforation was found to be more common in males than females with a ratio of 4:1. This is in agreement with the study done by Anjaneya T et al(54).

Most number of patients fall into age group 61-70, nine patients. Second most number of patients equally fall into age groups 41-50 and 51-60. The age group 80-90 had the least number of patients. No patient in the age group <10 and > 90 were included in the study. The mean age is found to be 50.65 years. Minimum number of cases were found in the both extremes of age group, with peak incidence at age group 61-70. Thus in our study hollow viscus perforation is most commonly found in middle and old age groups compared to the younger age group. In a study done by Nicolau et al the mean age was found to be 41.5 years +/- 17.9 years(55). A study done by Arikanoglu et al reported a mean age of 37.5 ± 17 years and a significant male (80.3%) predominance in cases with hollow viscus perforation(56).

The most common cause of perforation in our study was peptic ulcer disease which constitute 40% of the cases. This is in agreement with the literature, most of the published studies reported peptic ulcer as the most common cause of perforation. The most common location of perforated peptic ulcer disease was duodenal. Perforation is the second most common complication of peptic ulcer disease(57). The previously known trend of male predominance in peptic ulcer disease has changed, male to female ratio is now 1.0 and 1.3 for hospitalization and mortality, complicated peptic ulcer disease are more commonly found in males(58).

The second most common cause of perforation in our study was found to be inflammatory causes which constitutes 27.5%. This includes eight cases of diverticulitis and three cases of appendicitis. Cases of diverticulitis with perforation

are more commonly seen involving sigmoid colon. Traumatic perforation constitutes 12.5% of the cases and are more commonly found in small bowel than large bowel.

No cases of gastric, duodenal or appendicular perforations due to trauma was reported. Six cases of malignant perforation were reported, which included two duodenal, sigmoid, and one rectal, cecal perforations. Two cases of post operative bowel injury were reported involving the sigmoid colon and descending colon.

The most common site of perforation was found to be gastroduodenal, which together constitutes 50% of the cases and includes twelve cases of duodenal and eight cases of gastric perforation. 83% of duodenal perforation and 75% of gastric perforation are found to be due to peptic ulcer disease. In our study large bowel perforations are most commonly due to diverticulitis or due to surgery related bowel injury. The most common site of large bowel perforation in cases of diverticulitis is sigmoid colon, three cases. We report two cases of surgery related complications causing bowel injury causing perforation of sigmoid colon and descending colon. Two cases of ileal, and one each case of jejunal, ascending colon and rectal perforations are reported due to trauma. Traumatic perforation resulted in large irregular defect in bowel wall and was associated with other intraabdominal injuries.

Hainaux B et.al. in his study on "Accuracy of MDCT in predicting site of gastrointestinal tract perforations" had evaluated 8 criteria's for predicting the site of perforation and found out that MDCT was predictive of the site in 86%; and concentration of extraluminal air bubbles, segmental bowel wall thickening and focal defect in bowel wall being the strong predictors(6).

Similar studies by Maniatis et.al reported a sensitivity of MDCT as 85.5% in predicting the site of pneumoperitoneum(59). Rodrigues CL et.al in his retrospective study on 98 patients for locating the site of perforation found MDCT was sensitive in 80% of cases, and concentration of extraluminal air bubbles as the most sensitive sign and segmental bowel wall thickening with the highest PPV(60).

In our study on 40 patients, MDCT correctly identified the site of perforation in 35 cases. We report a sensitivity of 87% which is in agreement with similar published studies. We observed that focal defect in bowel wall have the highest PPV. Clustering of air bubbles adjacent to bowel wall and segmental bowel wall thickening were strong predictors of the site of perforation. As with other studies, the location of free air was also linked with the site of perforation. We observed that more air in the

supramesocolic compartment is found in gastroduodenal perforation. Infra mesocolic

compartment pneumoperitoneum was commonly associated with large bowel perforation. However, these pattern of extraluminal gas is lost in some cases of large bowel perforation with massive pneumoperitoneum involving both supra and inframesocolic compartment, especially in cases with delayed presentation. Incorrect diagnosis was made in five cases which include three cases surgically diagnosed as duodenal perforation mistaken for gastric perforation in two and appendix in one, one case of sigmoid perforation mistaken as jejunal and one case of rectal perforation incorrectly interpreted as sigmoid perforation.

Extraluminal fluid and perivisceral fat stranding are consistently observed in cases with hollow viscus perforation and have the highest sensitivity, 94% and 92% respectively, however have a low specificity of 25%. Clustering of extraluminal air, free air in supra/inframesocolic compartment and segmental bowel wall thickening are also strongest predictors of perforation and have a sensitivity of 85%, 82% and 77% respectively. The most specific finding was focal bowel wall defect have 100% specificity. Clustering of extraluminal air and segmental bowel wall thickening have a specificity of 80%. Extraluminal free fluid, fat stranding and free air in supra/inframesocolic compartment observed to have a low specificity of 25% in predicting the site of bowel perforation, however was consistently observed in most of the cases. Focal bowel wall defect has the highest positive predictive value of 100%. Clustering of extraluminal air and segmental bowel wall thickening were observed to have a PPV of 92 and 96% repectively. Negative predictive value was highest for abscess and free air in supra/inframesocolic compartment, 88% and 83% respectively.

CONCLUSION

MDCT due to its faster rates of image acquisition and the multiplanar reconstruction capability is an excellent imaging tool to evaluate cases of acute abdomen. MDCT is highly sensitive and is able to detect even small amounts of pneumoperitoneum that Xray or ultrasound fails to demonstrate, making it the investigation of choice in patients with suspecting hollow viscus perforation. With the improved resolution, thin section imaging and multiplanar imaging capabilities MDCT is not only able to diagnose a case of hollow viscus perforation, but also capable of preoperatively identifying the site of perforation which helps the surgeon to plan the procedure accordingly.

Our study concluded that MDCT is highly accurate in predicting the site of hollow viscus perforation. Focal defect in bowel wall, clustering of extraluminal air bubbles adjacent to bowel and segmental bowel wall thickening have a high predictive value for determining the site of perforation.

STUDY LIMITATIONS

- The COVID-19 pandemic situation prevailed during the time of study and resultant lockdowns resulted in reduced number of patients attending the hospital, thus decreasing the sample size.
- Only the patients who were managed with surgery were included in the study, patients with perforation who were managed conservatively were not included in the study (For example appendicular perforation treated conservatively).
- CT scan may miss identifying sealed off perforations or at an early stage of perforation resulting in patient being managed conservatively.
- Patients with hollow viscus perforation but with only mild clinical symptoms (diabetics, old age) or improving clinical status may have been evaluated with xray and ultrasound alone, without performing CT scan.

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ANNEXURE I

PROFORMA

DEPARTMENT OF RADIODIAGNOSIS, GMC KANNUR

1	NAME			
2	AGE			
3	SEX			
4	I.P. NUMBER			
5	DATE			
6	HISTORY			
7	PNEUMOPERITONEUM DEMONSTRATED ON PLAIN RADIOGRAPH	YES	NO	
8	CT FINDINGS	YES	NO	SITE
A	Focal defect in bowel wall			
B	Segmental bowel wall thickening			
C	Clustering of extraluminal air bubbles near bowel wall			
D	Free air in supra/infra mesocolic compartment			
E	Perivisceral fat stranding			
F	Abscess			
G	Extraluminal fluid			
10	CT SITE OF PERFORATION			

11	INTRAOPERATIVE SITE OF PERFORATION	

ANNEXURE II

KEY TO MASTER CHART

A. GENDER

MALE	1
FEMALE	2

B. HISTORY/ CAUSE

PEPTIC ULCER	1
MALIGNANCY	2
TRAUMA	3
DIVERTICULITIS	4
APPENDIX	5
POSTOPERATIVE	6

C. SITE OF PERFORATION

STOMACH	1
DUODENUM	2
JEJUNUM	3
ILEUM	4
APPENDIX	5
ASCENDING COLON	6
TRANSVERSE COLON	7
DESCENDING COLON	8
SIGMOID COLON	9
RECTUM	10
CAECUM	11

D. PNEUMOPERITONEUM ON XRAY

NO	1
YES	2

E. EXTRALUMINAL AIR, FOCAL DEFECT, WALL THICKENING, FAT STRANDING, EXTRALUMINAL FLUID

NO	1
YES	2

F. SUPRAMESOCOLIC OR INFRAMESOCOLIC

INFRAMESOCOLIC	1
SUPRAMESOCOLIC	2

ANNEXURE- 3:

MASTERCHART

S. NO	AGE	SEX	HISTORY/ CAUSE	PNEUMOPERITONEUM ON X-RAY	EXTRALUMINAL AIR	SUPRA/INFRA MESOCOLIC	FOCAL DEFECT	WALL THICK	FAT STRANDING	ABSCESS	EXTRALUMINAL FLUID	CT SITE OF PERFORATION	INTRAOPERATIVE SITE OF PERFORATION
1	54	1	1	2	2	2	1	1	2	1	2	1	2
2	25	1	1	2	2	2	1	1	2	1	2	1	2
3	66	1	1	2	2	2	1	2	2	1	2	1	1
4	48	1	1	2	2	2	1	2	2	1	2	1	1
5	44	1	1	2	2	2	2	2	2	1	2	1	1
6	35	1	1	1	2	2	2	2	2	1	2	1	1
7	62	1	1	2	2	2	2	2	2	1	2	1	1
8	16	1	1	2	2	2	2	2	2	1	2	1	1
9	74	2	2	2	2	2	1	2	2	2	2	1	1
10	54	1	2	2	2	2	2	2	2	2	2	1	1
11	64	1	2	1	1	2	1	1	2	1	2	2	10
12	61	1	1	1	1	2	1	1	2	1	2	2	2
13	89	2	1	2	2	2	2	1	1	1	2	2	2
14	67	1	1	1	2	2	2	2	2	1	2	2	2
15	55	1	2	2	2	2	2	2	2	1	2	2	2
16	37	1	1	2	1	2	2	2	2	1	2	2	2
17	76	1	1	2	2	2	2	2	2	1	2	2	2
18	77	1	2	2	1	2	2	2	2	1	2	2	2
19	42	1	1	2	1	2	1	2	2	2	2	2	2
20	33	1	3	2	2	1	1	2	2	1	2	3	3
21	52	2	4	1	2	1	2	2	2	1	2	3	3
22	54	2	6	1	2	1	1	1	2	2	2	3	9
23	29	1	3	2	2	1	1	1	2	1	2	4	4
24	53	1	4	1	1	1	1	2	2	1	2	4	4
25	46	1	3	2	2	1	1	2	2	1	2	4	4
26	15	1	1	1	1	2	1	1	2	2	2	5	2
27	24	1	5	1	2	1	1	2	2	2	2	5	5
28	42	2	5	1	2	1	2	2	2	2	2	5	5
29	74	1	5	1	2	1	2	2	2	2	2	5	5
30	43	2	1	2	2	1	2	1	2	2	2	2	2
31	37	1	4	1	2	1	2	2	2	2	2	9	9
32	22	2	4	1	2	1	2	2	2	2	2	8	8
33	46	1	3	1	2	1	2	2	2	1	2	6	6
34	56	1	4	1	1	2	1	2	2	2	2	7	7
35	67	1	6	1	1	2	2	2	2	2	2	8	8
36	64	1	4	1	2	1	1	2	2	2	2	9	9
37	47	2	4	1	2	1	2	2	2	2	2	9	9
38	77	1	4	1	2	1	2	2	2	1	1	10	10
39	43	1	3	1	2	2	2	2	2	1	2	10	10
40	63	1	2	1	1	1	2	2	2	1	2	11	11

ANNEXURE IV

INFORMED CONSENT

DEPARTMENT OF RADIODIAGNOSIS, GOVT. MEDICAL COLLEGE, KANNUR

I (guardian/ self)_____hereby give consent on my free will for the clinical examination and prescribed investigation (CECT abdomen) that may be necessary. I understand that this examination and investigation will be used as a part of this above-mentioned study

I permit the investigator to use the information for the purpose of the study. The complete procedure of the study and underlying risks had been explained to me very clearly. I understand that there will not be any additional expenses or cost for the above-mentioned study. The details collected will be kept confidential and the identity will not be published in any public or private journals or other media. I understand that I do have full freedom to withdraw from the study as and when I wish

Name of the participant:

Signature of the participant:

Investigator's name and signature:

Witness name and signature:

Place:

Date:

CONSENT (MALAYALAM)

സമ്മതപത്രം

ഗവ: മെഡിക്കൽ കോളജ്, ണ്ണൂരിമെ കേഡിികയേ ഡയഗകwോസിസ് വിഭോഗത്തിമെ കഡോക്ടർ അഖിൽ എം wടത്തുന്ന "ആരോഗ്യം മെരോഗ്യു ുടൽ വൻ ുടെിമെ സുഷിരം wിർണയിക്കുന്നതിൽ സിടി സ് wിംഗിൻ്മേ ഉപകയോഗം" എന്ന പഠwത്തിൽ പമെടുപ്പിക്കുന്നതിൽ എwിക്ക് പരിപൂർണ സമ്മതം ആണ്. ഈ പഠwത്തിൽ പമെടുക്കുന്നത് മ ോണ്ട് എwിക്ക് യോകതോരുവിധ പോർശവഫെങ്ങള§ം ഉണ്ടോവു യിമെന്നും െി ിത്സയ്ക്ക് ആവശയെുള്ളതിന് പുരോമെ ഗകവഷണത്തിൻ്മേ ഭോഗെോയി അധി െിെവു ശ ഉണ്ടോവു യിമെന്നും കഡോക്ടർ പരേഞ്ഞുെwസ്സിെോക്കി തന്നിട്ട§ണ്ട്. എകപ്പോൾ കവണമെെിെുും ഈ പഠwത്തിൽ wിന്നും പിന്മോരോമെന്നും എന്നിരുന്നോെുും ആയത് എൻ്മേ

െി ിത്സമയ യോമതോരു വിധത്തിെുും ബോധിക്കു യിെ എന്നും ഞോൻ െwസ്സിെോക്കുന്നു. എൻ്മേ കപകരോ െറ്റ§ വിവരങ്ങകളോ എൻ്മേ അwുവോദം ൂടോമത ്പസിദ്ധമപ്പടുത്തു യിമെന്നും കഡോക്ടർ ഉരേപ്പ് തന്നിട്ട§ണ്ട്. കെൽ പരേഞ്ഞ രോയങ്ങൾ വോയിച്ച§ െwസ്സിെോക്കി കബോധിച്ച§ ഒപ്പിടുന്നു.

കപര്:

ഒപ്പ്:

സ്ഥലം:

തീയതി:

ഗവേഷകൻ:
ഒപ്പ്:

ANNEXURE V

ASSENT (ENGLISH)

DEPARTMENT OF RADIODIAGNOSIS, GOVT MEDICAL COLLEGE KANNUR

I,_____have been informed about the nature of the study being conducted and hereby give permission for the clinical examination and prescribed investigations (CT scan for evaluating gastrointestinal perforation) that may be necessary. Consent shall also be obtained in written from my parents. I understand that this examination and investigation will be used as a part of this above-mentioned study.

I permit the investigator to use the information for the purpose of this study. The complete procedure of the study and underlying risks had been explained to me very clearly. I understand that there will not be any additional expenses or cost for the above-mentioned study that my parents will have to bear. I have been assured that the data collected during this study will be kept confidential and the name, address or identity etc. will not be published anywhere. I will have full freedom to withdraw from the study as and whenever I wish, regardless of my parents' decision.

Name of the participant:

Signature of the participant:

Place:

Date:

Investigator's signature:

ASSENT (MALAYALAM)

ഗവ: മെഡിക്കൽ കോളജ്, ണ്ണൂരിമെ കേഡികയേ ഡയഗക്wോസിസ് വിഭോഗത്തിമെ കഡോക്ടർ അഖിൽ എം wടത്തുന്ന "ആെേശയം മെേു ുടൽ വൻ ുടെിമെ സുഷിരം wിർണയിക്കുന്നതിൽ സിടി സ് ോwിംഗിൻ്മേ ഉപകയഗം" എന്ന പഠwത്തിൽ പമെടുപ്പിക്കുന്നതിൽ എwിക്ക് പരിപൂർണ സമ്മതം ആണ്. ഇതു ൂടോമത എൻ്മേ ോതോപിതോക്കളുമട സമ്മതവും വോങ്ങിയ കശഷം ോ്തകെ എമന്ന ഈ പഠwത്തിൽ ഉൾമപ്പടുത്തു യുള്ളൂ എന്നും കഡോക്ടർ പേഞ്ഞു ോwസ്സിോോക്കിയിട്ടുണ്ട്.

ഈ പഠwത്തിൽ പമെടുക്കുന്നത് മ ോണ്ട് എwിക്ക് യോകതോരുവിധ പോർശവഫോങ്ങളും ഉണ്ടോവു യിമെോെന്നും
ോി ിത്സയ്ക്ക് ആവശയോുള്ളതിന് പുേമെ ഗകവഷ ണത്തിൻ്മേ ഭോഗോോയി അധി ോിെവു ശ ഉണ്ടോവു യിമെോെന്നും കഡോക്ടർ പേഞ്ഞുോwസ്സിോോക്കി തന്നിട്ടുണ്ട്. എകപ്പോൾ കവണമെോി ോുും ഈ പഠwത്തിൽ wിന്നും എൻ്മേ രക്ഷിതോക്കളുമട സമ്മതം ൂടോമതയും പിന്മോോമെന്നും എന്നിരുന്നോുും ആയത് എൻ്മേ ോി ിത്സമയ യോമതോരു വിധത്തിോുും ബോധിക്കു യിെ എന്നും ഞോൻ ോwസ്സിോോക്കുന്നു. എൻ്മേ കപകരോ ോറ്റ വിവരങ്ങകളോ എൻ്മേ അwുവോദം ൂടോമത ്പസിദ്ധമപ്പടുത്തു യിമെ്നും കഡോക്ടർ ഉോപ്പ് തന്നിട്ടുണ്ട്. കോൽ പേഞ്ഞ ോരയങ്ങൾ വോയിച്ച ോwസ്സിോോക്കി കബോധിച്ച ഒപ്പിടുന്നു.

ുട്ടിയുമട
കപര് ഒപ്പ്:
ഗകവഷ ൻ:
ഒപ്പ്:
സ്ഥം:
തീയത
ി:

ANNEXURE VI

PARENTAL CONSENT FORM:

DEPARTMENT OF RADIODIAGNOSIS, GOVT. MEDICAL COLLEGE, KANNUR

I,_____parent/guardian of_____have been informed about the nature of the study being conducted and hereby give permission for the clinical examination and prescribed investigation (CT scan for evaluation of gastrointestinal perforation) that may be necessary on my ward. I understand that this examination and investigation will be used as a part of this above-mentioned study.

I permit the investigator to use the information for the purpose of this study. The complete procedure of the study and underlying risks had been explained to me and my child very clearly. I understand that there will not be any additional expenses or cost for the above-mentioned study that will have to be borne by me.

I have been assured that the data collected during this study will be kept confidential and the name, address or identity etc. will not be published anywhere. I will have full freedom to withdraw from the study as and whenever my child or self wishes to.

Name of the parent/guardian:
Signature of the parent/guardian:
Place:
Date:

Name of the witness:
Signature of the witness:

Investigator's signature:

PARENTAL CONSENT (MALAYALAM)

ഗവ: മെഡിക്കൽ കോളജ്, ണ്ണൂരിമെ കേഡികയേ ഡയഗക്wോസിസ് വിഭോഗത്തിമെ കഡോക്ടർ അഖിൽ എം wടത്തുന്ന "ആെേശയം മെേേു ുടൽ വൻ ുടെിമെ സുഷിരം wിർണയിക്കുന്നതിൽ സിടി സ് ോwിംഗിൻ്മേ ഉപകയോഗം" എന്ന പഠwത്തിൽ എൻ്മേ െ മw/െ മള പമെടുപ്പിക്കുന്നതിൽ എwിക്ക് പരിപൂർണ സമ്മതം ആണ്.

ഈ പഠwത്തിൻ്മേ വിവരങ്ങൾ കഡോക്ടർ ുട്ടിമയയും പേഞ്ഞു െwസ്സിെേക്കിയിട്ടു§ണ്ടു്.ഈ പഠwത്തിൽ പമെടുക്കുന്നതുമ ോണ്ടു് എൻ്മേ ുട്ടിക്കു് യകേതോരുവിധ പോർശവഫെങ്ങള§ും ഉണ്ടോവു യിമെെന്നും െി ിത്സയ്ക്കു് ആവശയെുള്ളതിനു് പുേമെ ഗകവഷ ണത്തിൻ്മേ ഭോഗെോയി അധി െിെവു ശ ഉണ്ടോവു യിമെെന്നും കഡോക്ടർ പേഞ്ഞുെwസ്സിെോക്കി തന്നിട്ടു§ണ്ടു്.

എകപ്പോൾ കവണെിെും എൻ്മേ ുട്ടിക്കു് ഈ പഠwത്തിൽ wിന്നും പിന്മോേോമെന്നും എന്നിരുന്നോെും ആയതു് എൻ്മേ
െി ിത്സമയ യോമതോരു വിധത്തിെും ബോധിക്കു യിെെ എന്നും ഞോൻ െwസ്സിെോക്കുന്നു. എൻ്മേ ുട്ടിയുമട കപകരോ െറ്റ§ വിവരങ്ങകളോ എൻ്മേ അwുവോദം
ൂടോമത ്പസിദ്ധമപ്പടുത്തു യിമെെന്നും കഡോക്ടർ ഉേപ്പു തന്നിട്ടു§ണ്ടു്. കെൽ പേഞ്ഞ ോരയങ്ങൾ വോയിച്ച§ െwസ്സിെോക്കി കബോധിച്ച§ ഒപ്പിടുന്നു.

ഗകവഷ ൻ:
ഒപ്പു്:
ുട്ടിയുമട കപര്:
രക്ഷിതോവിൻ്മേ കപര്:

സോക്ഷ്യമുടമ
കപരു്: ഒപ്പ്:
സ്ഥലം:

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Date:

Place: **Dr. Akhil M**

LIST OF ABBREVIATIONS

CECT	CONTRAST ENHANCED COMPUTERISED TOMOGRAPHY
GIT	GATSROINTESTINAL TRACT
LDCT	LOW DOSE COMPUTERISED TOMOGRAPHY
MDCT	MULTIDETECTOR COMPUTERISED TOMOGRAPHY
MHz	MEGA HERTZ
MIP	MAXIMU INTENSITY PROJECTION
MRI	MAGNETIC RESONANCE IMAGING
NPV	NEGATIVE PREDICTIVE VALUE
NSAID	NONSTEROID ANTI INFLAMMATORY DRUG
PPV	POSITIVE PREDICTIVE VALUE
PUD	PEPTIC ULCER DISEASE
SSD	SHADED SURFACE DISPLAY
UGI	UPPER GASTROINTESTINAL
USG	ULTRASONOGRAPHY