CT Enterography: Interpretation of Findings

Poster No.:	C-2053
Congress:	ECR 2015
Type:	Educational Exhibit
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Keywords:	Abdomen, Gastrointestinal tract, Small bowel, CT, Diagnostic procedure, Education and training
DOI:	10.1594/ecr2015/C-2053

Learning objectives

1. Demonstrate the utility of CT enterography in assessing diseases of the small bowel.
2. Review and illustrate the various manifestations of active inflammatory bowel disease.

Background

CT enterography is the main imaging modality in the investigation of confirmed or suspected inflammatory bowel disease and in the detection of small bowel neoplasms. This is due to improved spatial and temporal resolution provided by multidetector CT scanners, combined with adequate luminal distention after administration of negative oral contrast agents. It is a noninvasive, easy performing technique, which allows excellent visualization of the entire thickness of the bowel wall and the extraenteric involvement, adding more detailed information about the extent and severity of the disease process.

CT enterography has some disadvantages, such as the exposure to ionizing radiation, which is of particular concern in young patients, and the need for intravenous contrast material.

Findings and procedure details

CT Enterographic Technique

Patients undergoing CT enterography are requested to abstain from all oral intake for 6 hours before the examination.

An adequate luminal distention of the small bowel is necessary because poorly distended bowel can simulate disease or hide pathologic processes. In order to achieve bowel distention a polyethylene glycol (PEG) electrolyte solution is administered. Typically, 2000mL of PEG are administrated within 60 minutes (min) prior to scanning, with 1500mL ingested over the first 15min, and two 250 mL fractions consumed 25 and 15min prior to examination.

We administer 10mg of metoclopramide intravenous in cases of oral intake intolerance.

After the oral contrast agent is ingested, a bolus (1,5mL/Kg) of intravenous contrast material (Ultravist®, Iopromida 370mg/mL) followed by 50mL of saline solution is administered with a power injector at a rate of 3,5-4mL/sec.

Scanning is performed on a 64-channel multi-detector row CT scanner from the diaphragm to the symphysis pubis, beginning 45 seconds after the injection of contrast material. Images are acquired with a section thickness of 3mm and a reconstruction interval of 1mm. Automatic coronal reformatted images are generated using similar parameters. Postprocessing techniques include multiplanar reformatting of axial image data and maximum intensity projection images, being the later particularly useful for visualizing the mesenteric vasculature.

CT Enterographic Findings

Crohn Disease

Crohn disease predominantly involves the small bowel, particularly the terminal ileum, but is also commonly associated with extraintestinal manifestations.

Conventional abdominopelvic CT has traditionally been used to evaluate extraenteric complications of Crohn disease such as abscesses, fistulas, phlegmon, obstruction and other extraenteric sequels, but has played a minimal role in identifying small bowel inflammatory disease per se. CT enterography has the added advantage of depicting mural and luminal abnormalities, thus differentiating acute from chronic Crohn disease.

Small bowel involvement in Crohn disease is typically transmural, with characteristic skip lesions (Fig. 1 on page 9).

Active Crohn Disease

CT enterographic findings of active Crohn disease include mural hyperenhancement, mural stratification, bowel wall thickening (thickness >3mm) (Fig. 2 on page 9), mesenteric fat stranding and engorged vasa recta ("comb" sign) (Fig. 3 on page 10).

Mural hyperenhaced refers to segmental hyperenhancement of distended small bowel loops relative to nearby normal-appearing loops. The comparison should be made to the loops in the same region since normal jejunal loops enhance to a greater degree

than normal ileal loops. It is also important to compare the bowel loops with similar degree of distention because normal collapsed loops exhibit greater attenuation than distended ones. The degree of bowel wall enhancement correlates with the severity of active inflammation and may be used to monitor anti-inflammatory therapy.

Mural stratification refers to visualization of layers of the bowel wall at contrast-enhanced CT. Oedematous bowel wall usually has a trilaminar appearance on CT enterography: an internal ring of mucosal enhancement; an external ring of serosal and muscular enhancement; an interposed submucosal layer with decreased attenuation. Submucosal layer can have various degrees of attenuation depending on what pathological process is present (Fig. 4 on page 10). The presence of intramural fat indicates past or chronic inflammation, while the presence of intramural oedema (water attenuation) indicates active inflammation. Mural stratification is not specific for Crohn disease and may be seen with other small bowel diseases (ischemia, ulcerative colitis, radiation enteritis).

Mural thickness greater than 3mm is considered abnormal (Fig. 2 on page 9). This bowel wall thickness is asymmetric, affecting predominantly the mesenteric border. Mural thickening correlates highly with disease activity and, when associated with mural hyperenhancement, it is the most sensitive sign of active disease.

Mesenteric fat stranding is due to transmural extension of inflammation across the serosa and to engorgement of the vasa recta surrounding the inflamed bowel segment. The prominence and engorgement of the vasa recta adjacent to the affected bowel loop is known as "comb" sign (Fig. 3 on page 10). This sign, along with increased mesenteric fat attenuation, is the most specific CT feature of active Crohn disease.

Chronic Crohn Disease

Long-standing inflammatory process leads to chronic manifestations of Crohn disease. Findings that might be seen in inactive long-standing disease include submucosal fat deposition (Fig. 4 on page 10), pseudosacculation, surrounding fibrofatty proliferation and fibrotic strictures.

As mentioned earlier, in Crohn disease, the mesenteric border of the bowel is preferentially affected, which eventually results in mural fibrosis and shortening of the wall. Asymmetric fibrosis, combined with the intraluminal pressure during the peristaltic movement, results in sacculations of the antimesenteric wall.

Fibrofatty proliferation in the surrounding mesentery is thought to play a role in sustaining the inflammatory process related to the production of tumor necrosis factor #.

Strictures can occur in patients with active disease, however, they are more frequent with chronic fibrosis. Reversible strictures produced by active disease demonstrate mucosa hyperenhancement, mural stratification, fat stranding and engorgement of the vasa recta. Lack of enhancement and loss of stratification suggests transmural fibrosis. This differentiation is important as irreversible strictures may require surgical intervention.

CT enterography also may depict Crohn disease involving the large bowel, perianal region and surgical anastomosis, less common sites of involvement.

The findings of acute and chronic Crohn disease are summarized in table 1.

Findings of active inflammation	• Mural hyperenhancement, stratification and thickening • Perienteric fat stranding and engorged vasa recta
Findings of chronic inflammation	• Submucosal fat deposition • Mural thickening without enhancement • Perienteric fat hypertrophy • Sacculation of antimesenteric wall

Table 1 - Findings of active and chronic Crohn disease on CT enterography

Extraenteric Complications

As mentioned before, the excellent spatial resolution and multiplanar imaging capability make CT enterography the modality of choice for evaluating extraintestinal complications. Fistulas generally appear as hyperenhancing linear extraluminal tracts, usually connecting bowel loops that exhibit signs of active inflammation, and may or may not contain fluid (Fig. 5 on page 11). Abscesses appear as extraluminal fluid collections either within the leaves of the mesentery or in a retroperitoneal location. Other extraenteric manifestations of Crohn disease include mesenteric lymphadenopathy, cholelithiasis, nephrolithiasis, sacroiliitis and primary sclerosing cholangitis.

Ulcerative Colitis

Ulcerative colitis is characterized by a continuous pattern of bowel wall involvement, starting from the rectum. It predominantly involves the large bowel but may extend to the terminal ileum, a condition called "backwash ileitis" (Fig. 6 on page 11).

Because CT enterography is less sensitive than colonoscopy and principally allows evaluation of the small bowel, it is not used for the diagnosis or staging of ulcerative colitis. However, when specific features are present, CT enterography can be helpful for achieving an accurate diagnosis and excluding small bowel involvement. In addition, severe ulcerative colitis may result in pseudopolyp formations or toxic megacolon, features that may be seen at CT.

Small Bowel Neoplasms

Although small bowel tumors are rare, they are commonly included in the differential diagnosis of small bowel disease because of their nonspecific presenting symptoms. This nonspecific nature of the symptoms and the lack of reliable clinical findings virtually assure significant delay in diagnosis.

CT enterography has demonstrated a fairly high level of accuracy in the evaluation of small bowel tumors, including adenocarcinoma, carcinoid, lymphoma, gastrointestinal stromal tumor (GIST) and metastases.

Adenocarcinoma

Adenocarcinoma of the small bowel is far less common than colonic carcinoma. Almost half of small bowel adenocarcinomas are found in the duodenum. At CT enterography, adenocarcinoma may manifest as an annular narrowing (Fig. 7 on page 12a), as a discrete heterogeneous tumor mass, with moderate enhancement or as an ulcerative lesion (Fig. 7 on page 12b). Small bowel adenocarcinomas are more likely to be annular, however duodenal adenocarcinomas tend to be papillary or polypoid (Fig. 8 on page 12).

Small bowel adenocarcinomas may lead to progressive small bowel obstruction, intussusception or, rarely, perforation.

Lymphoma

The finding of primary small bowel lymphoma include a primary tumor mass centered in the small bowel, with the appropriate draining lymph node involvement, absence of palpable lymph nodes or mediastino-hilar adenopathy and a normal white blood cell count.

Small bowel lymphomas are more likely to be located in the ileum. At CT enterography, lymphoma may appear as: a nodular filling defect; a discrete polyp that may be the lead point of an intussusception; a long, distensible, infiltrating lesion with or without aneurysmal dilatation of the lumen; or a large exocentric mass extending into adjacent tissues (Fig. 9 on page 13b). In most cases, it appears as a large, segmental nodular wall thickening (Fig. 9 on page 13a, Fig. 10 on page 13). Lymphoma is usual accompanied by bulky retroperitoneal lymphadenopathy.

Carcinoid Tumor

Nearly one third of all small bowel neoplasms are neuroendocrine in origin. Carcinoid tumors are a group of generally low-grade malignancies arising from the endocrine system outside the pancreas or thyroid.

About 90% of carcinoid tumors arise in the ileum. A carcinoid tumor often appears as an intensely enhancing mucosal polyp (Fig. 11 on page 14) or an enhancing carpet lesion with apparent wall thickening. Mesenteric carcinoid tumors lead to a desmoplastic reaction that produces a spiculated masslike appearance (Fig. 12 on page 14).

GIST

GISTs (Fig. 13 on page 15, Fig. 14 on page 15) are usually solitary benign tumors that are categorized by their differentiation into smooth muscle or neural tissue. They are classified as benign or malignant. Benign GISTs can occur anywhere in the small bowel while malignant ones arise mainly in the distal bowel.

GISTs may be submucosal, subserosal or intraluminal and both benign and malignant may take any of these three forms.

CT findings of a lesion larger than 5cm, gastric location, associated metastases and a cystic-necrotic component were significantly more common among malignant GISTs.

Metastases

The most common malignancy involving the small bowel is metastatic. Small bowel metastases are categorized by means of spread: hematogenous spread, intraperitoneal seeding, or local extension.

Small bowel hematogenous metastases are common and frequently originated from bronchogenic carcinoma, breast carcinoma, malignant melanoma and renal cell carcinoma. Malignant melanoma (Fig. 15 on page 16) produces smooth, round to polypoid metastases that can cause transient intussusception rather than complete obstruction.

The most common intraperitoneal metastases are from primary mucinous tumors of the colon (Fig. 16 on page 16), appendix or ovary. The malignant cells are implanted on the mesenteric border of the small bowel wall. CT shows the extent of metastatic involvement and often helps to identify the primary tumor.

Local extension to the small bowel from primary pancreatic (Fig. 17 on page 17), biliary or colonic (Fig. 18 on page 17) tumors is not rare. CT depicts extension of the disease into local tissues and adjacent organs.

Other neoplasms

At CT, lipomas (Fig. 19 on page 18) appears as a well-circumscribed, intraluminal homogeneous masses with attenuating values consisting with fat. Malignant liposarcoma of the small bowel is extremely rare.

Celiac Disease

Celiac disease is a chronic autoimmune disorder induced in genetically susceptible individuals after ingestion of gluten proteins.

Celiac disease is recognized as a common condition with significant long-term morbidity and increased risk of mortality. However, due to relatively low and nonspecific morbidity during the early disease course, with chronic mild pain and anemia, most cases remain undiagnosed. Increased physician and radiologist awareness of the clinical range of this disorder and continued high degree of suspicion are therefore needed. It is important for radiologists to be familiar with imaging findings of celiac disease.

Serological analyses and endoscopy remain the pillar in the initial work-up for celiac disease, and histologic analysis remain the reference standard. Imaging can be helpful in evaluating patients with nonspecific symptoms.

The CT findings in celiac disease include: parietal thickening (Fig. 20 on page 18); small bowel loops dilatation and fluid-filled, leading to progressive dilution of enteric contrast material; jejunization of the ileum, reflected by a decrease in jejunal folds in contrast with the increasing fold pattern seen in the ileum; transient small bowel intussusception; increased splanchnic circulation; retroperitoneal lymphadenopathy; and hyposplenism.

Images for this section:

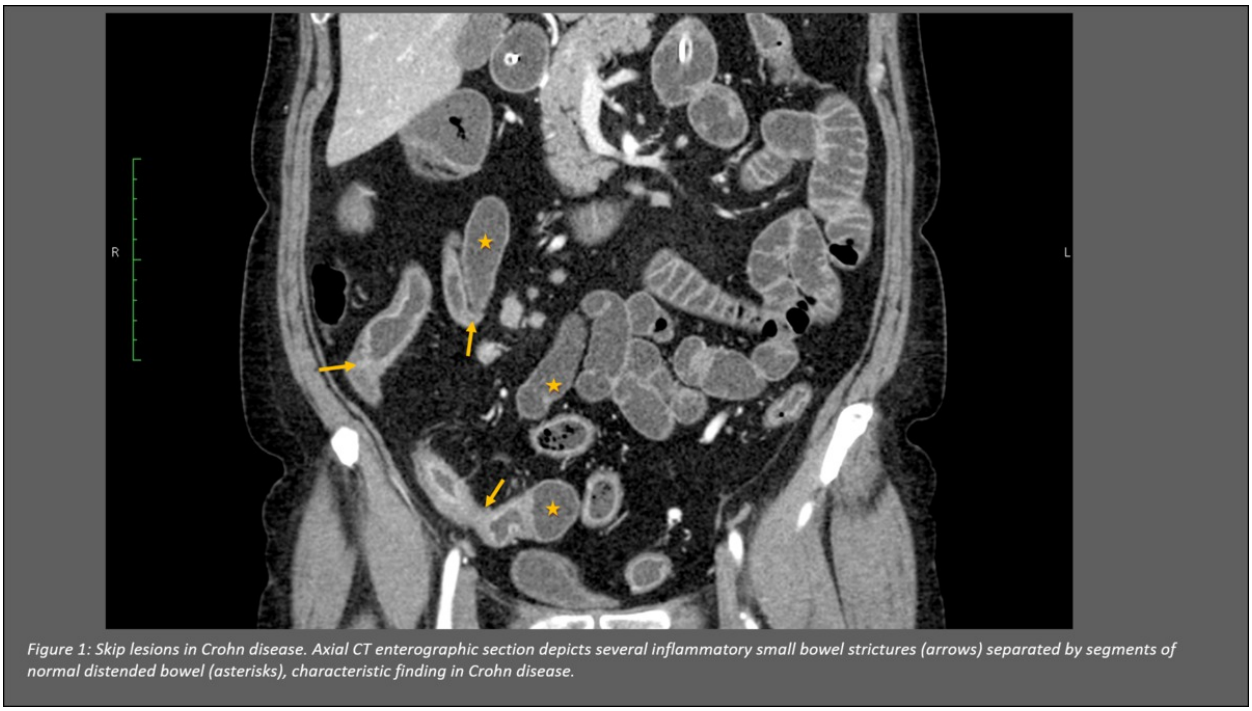

Figure 1: Skip lesions in Crohn disease. Axial CT enterographic section depicts several inflammatory small bowel strictures (arrows) separated by segments of normal distended bowel (asterisks), characteristic finding in Crohn disease.

Fig. 1

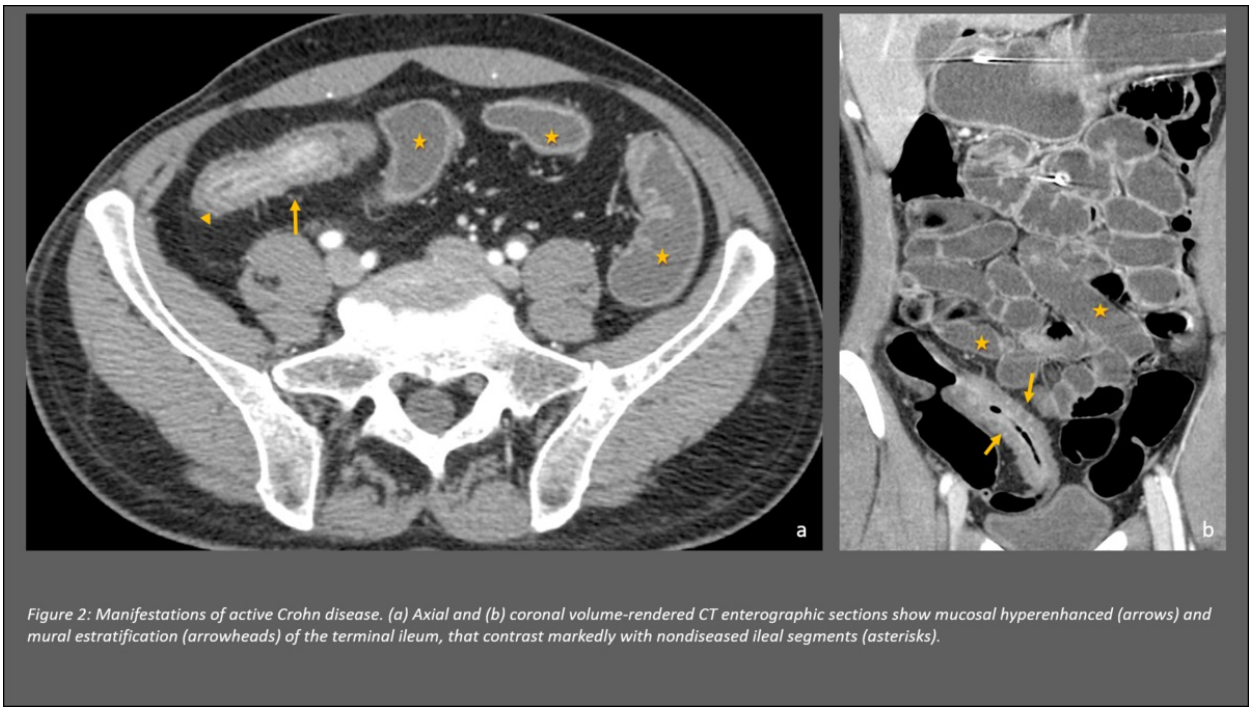

Figure 2: Manifestations of active Crohn disease. (a) Axial and (b) coronal volume-rendered CT enterographic sections show mucosal hyperenhanced (arrows) and mural estratification (arrowheads) of the terminal ileum, that contrast markedly with nondiseased ileal segments (asterisks).

Fig. 2

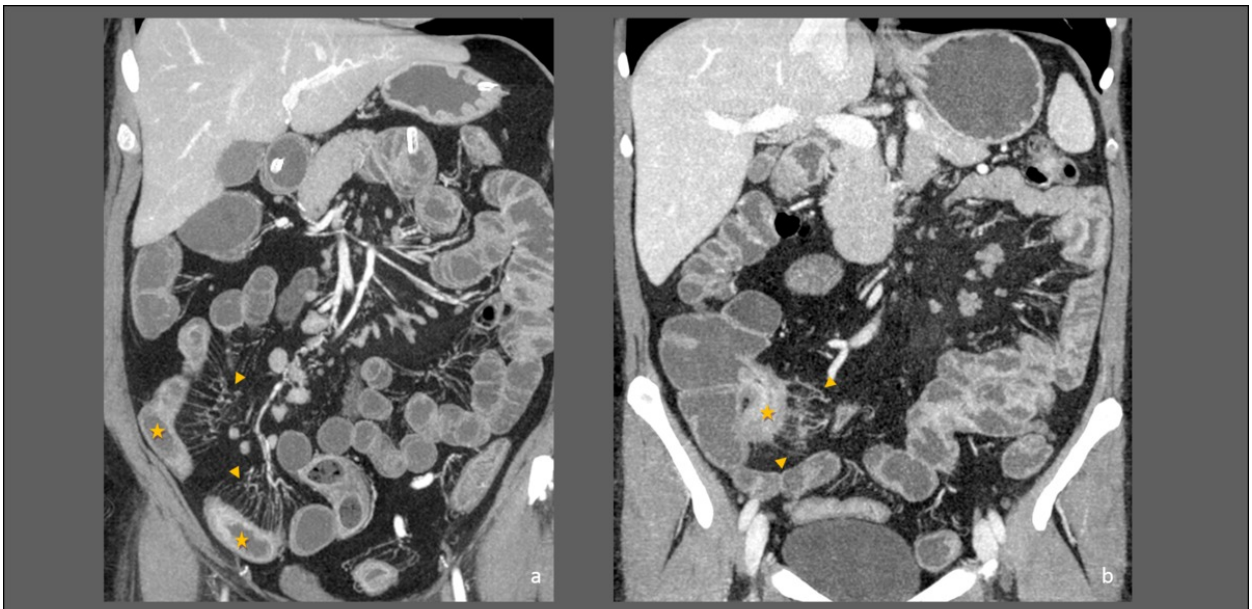

Figure 3: Manifestations of active Crohn disease. Coronal volume-rendered (a and b) CT enterographic sections show mesenteric hypervascularity and proeminence of the vasa recta or "comb sign"(arrowheads), adjacent to the involved bowel segments (asterisks).

Fig. 3

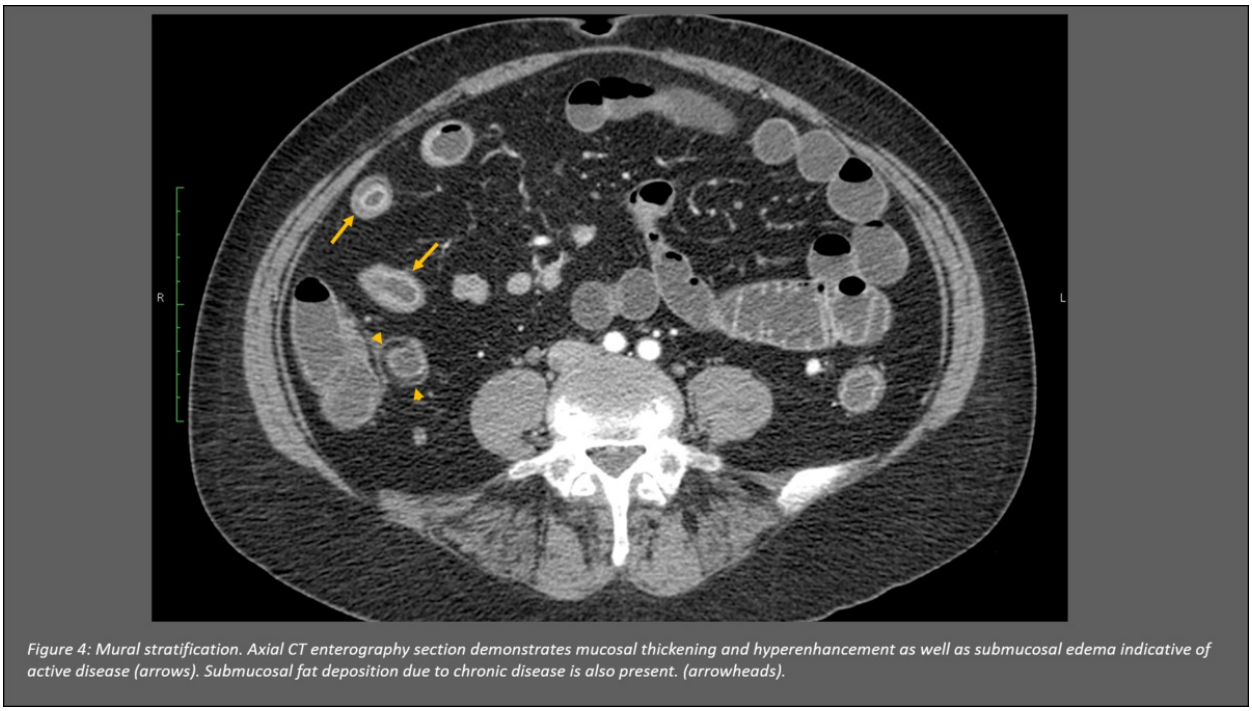

Figure 4: Mural stratification. Axial CT enterography section demonstrates mucosal thickening and hyperenhancement as well as submucosal edema indicative of active disease (arrows). Submucosal fat deposition due to chronic disease is also present. (arrowheads).

Fig. 4

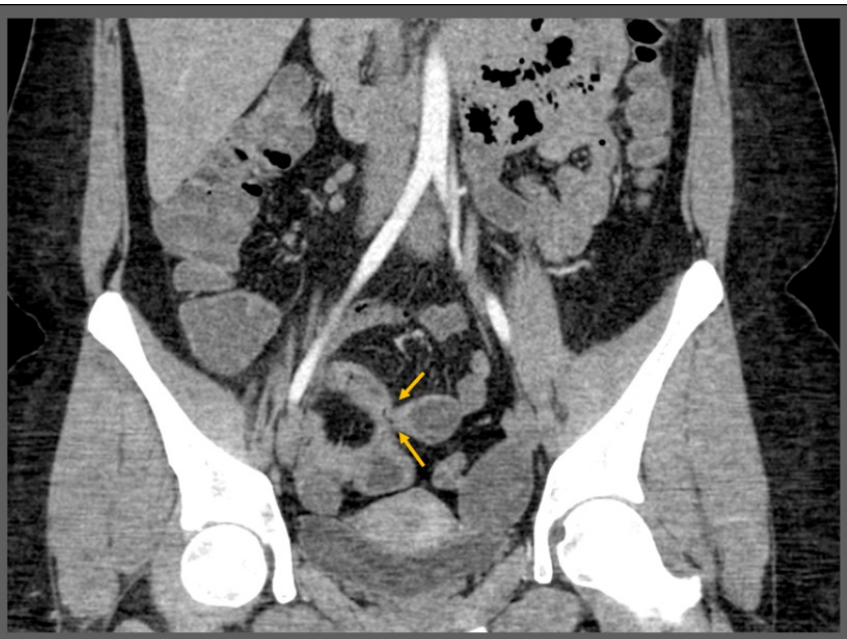

Figure 5: Fistula formation in Crohn disease. Coronal volume-rendered CT enterographic section depict ilio-ileal fistula (arrows).

Fig. 5

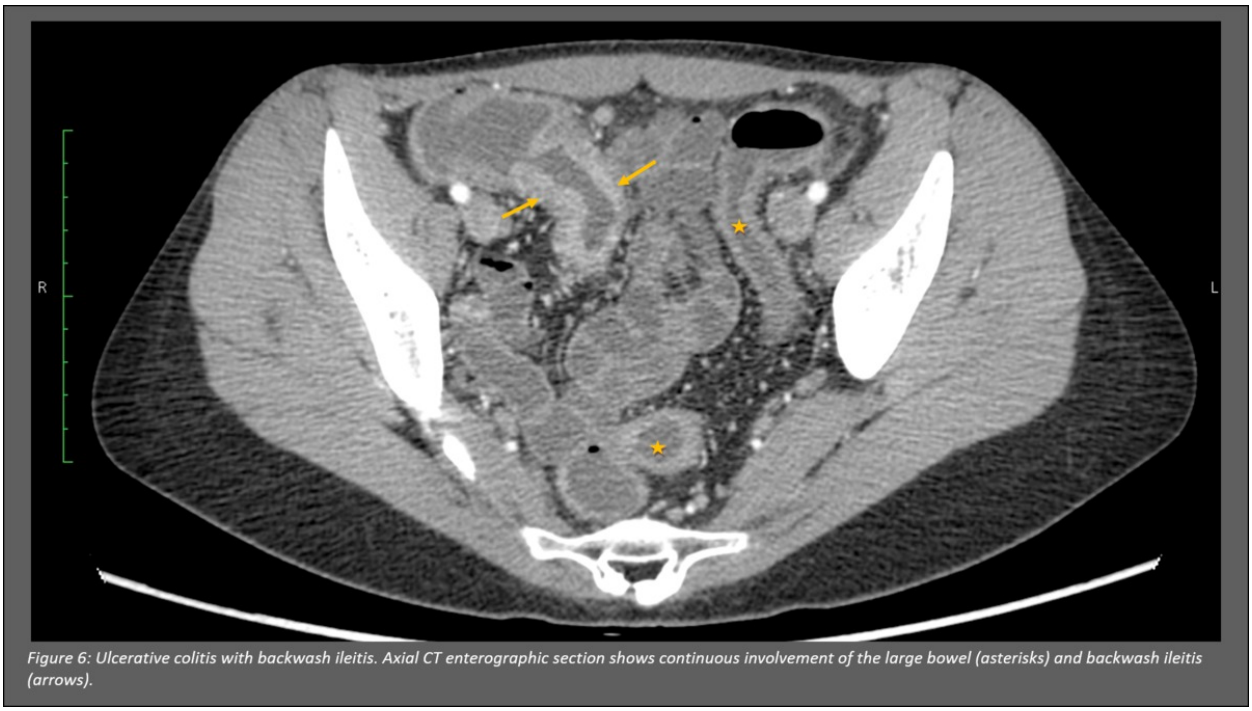

Figure 6: Ulcerative colitis with backwash ileitis. Axial CT enterographic section shows continuous involvement of the large bowel (asterisks) and backwash ileitis (arrows).

Fig. 6

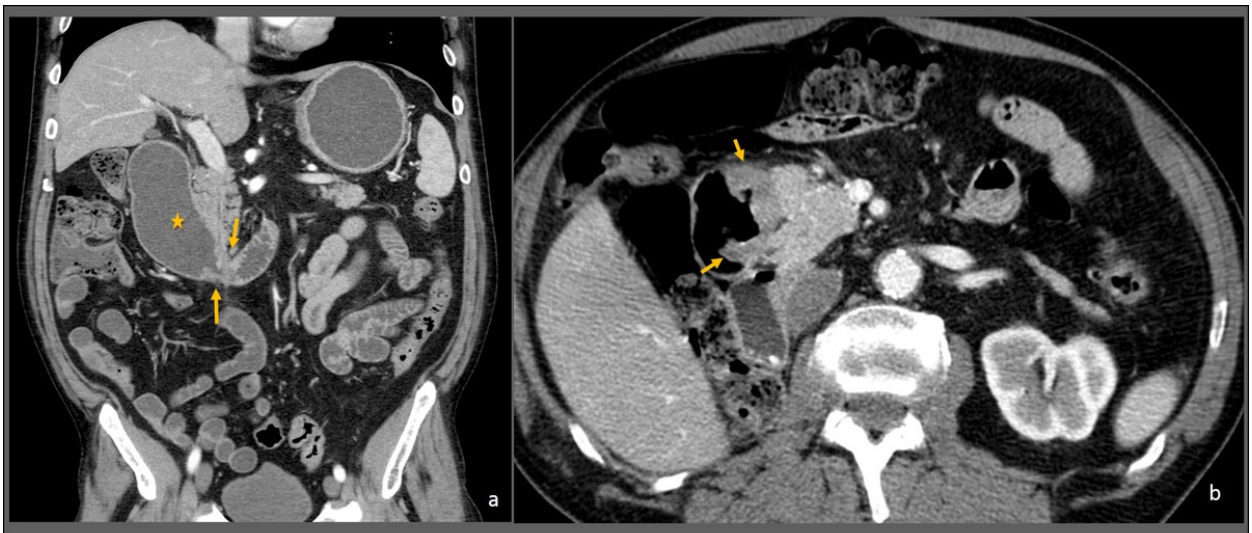

Figure 7: Adenocarcinoma. (a) Coronal volume-rendered CT enterographic section demonstrates an irregular anular narrowing arising in the third portion of the duodenum (arrows), which caused luminal stenosis with proximal dilatation (asterisk). Axial CT (b) enterographic sections of another patient, show an ulcerated mass at the 2nd portion of the duodenum (arrows).

Fig. 7

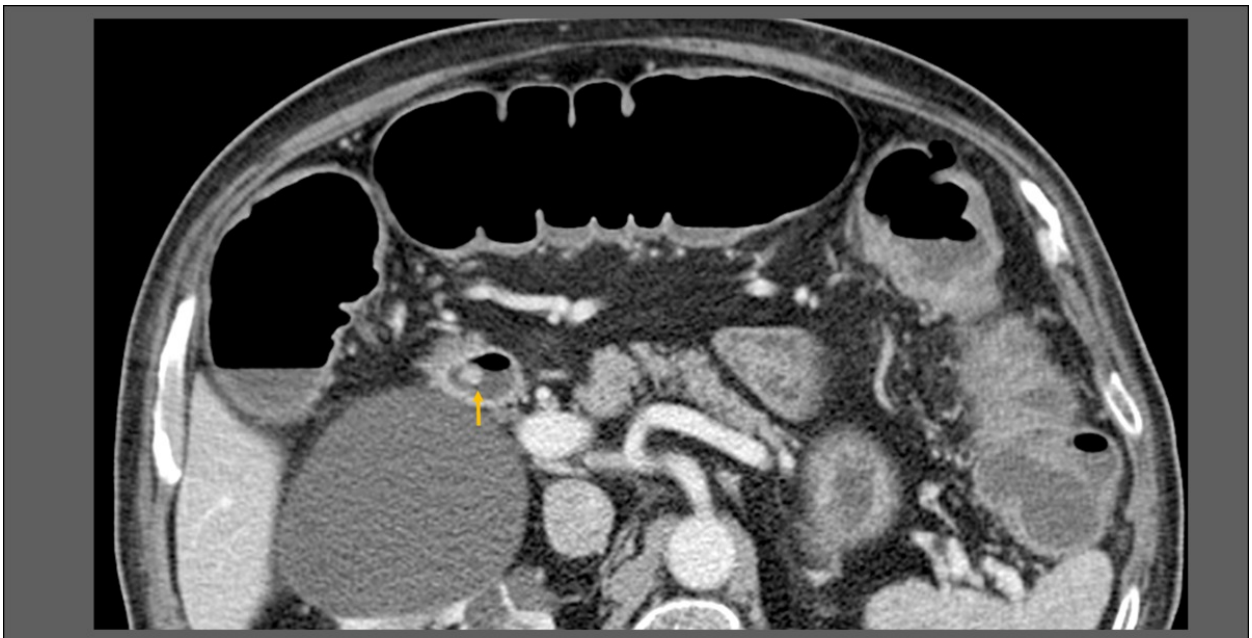

Figure 8: Adenocarcinoma. Axial CT enterographic section depicts a small polypoid lesion in the second portion of the duodenum. Pathologic examination revealed adenocarcinoma.

Fig. 8

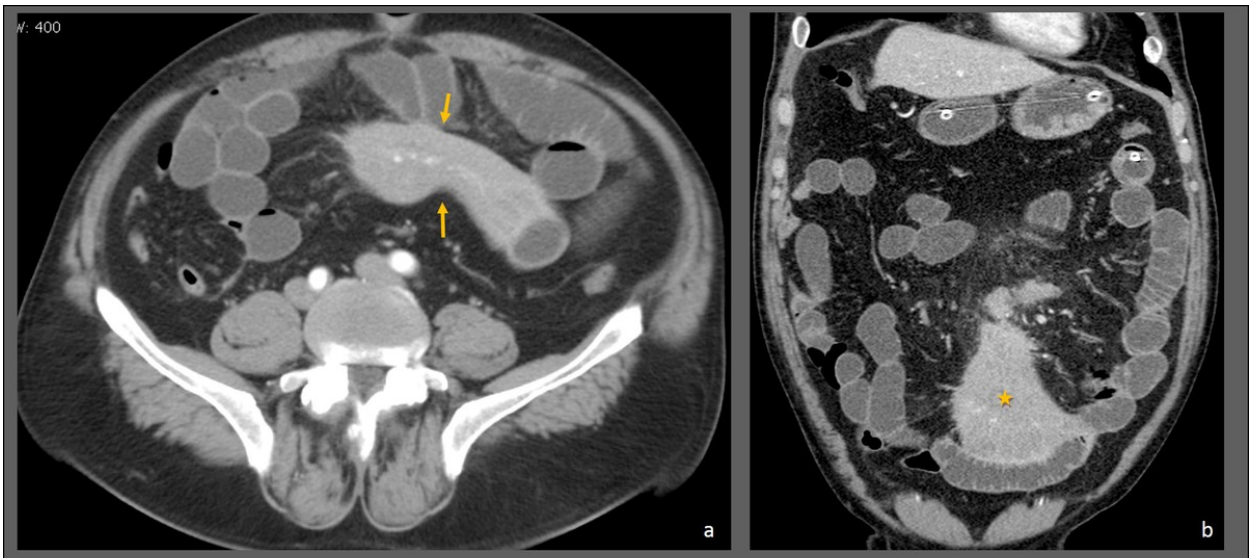

Figure 9: Small bowel lymphoma.
(a) Axial CT enterographic section demonstrates a difuse wall thickening of an ileal loop (arrows). Pathologic examination reavealed small cell B lymphoma.
(b) Biopsy-proved non-hodgking lymphoma. Coronal volume-rendered CT enterography section of another patient show a large mesenteric mass (asterisk) involving a small bowel loop.

Fig. 9

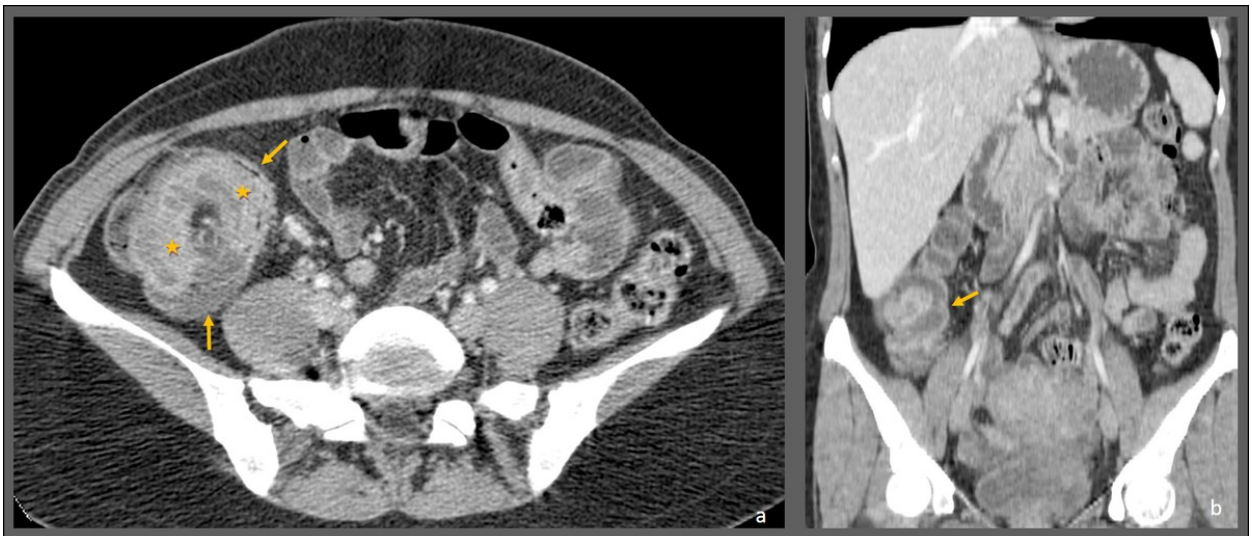

Figure 10: Lymphoma in a 70-year-old woman. Axial (a) and Coronal volume-rendered (b) CT enterographic sections demonstrate an ileo-colic invagination (arrows). Note that the invaginated small bowel segment has areas of irregular wall thickening (asterisks). Pathologic examination after surgery reavealed a large cell B lymphoma.

Fig. 10

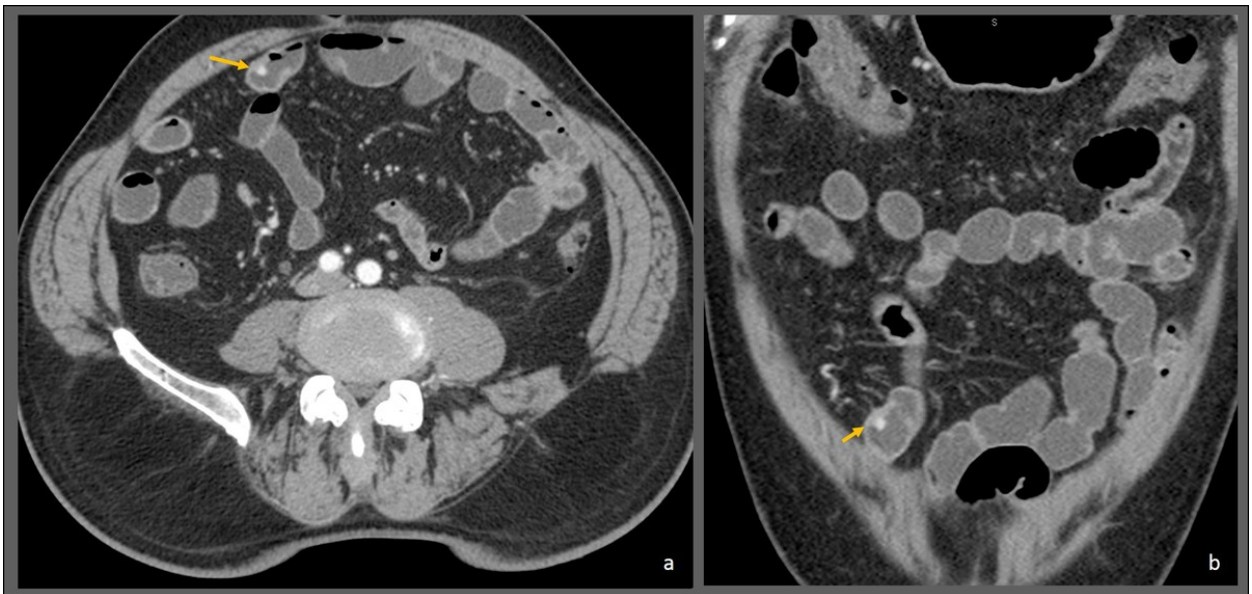

Figure 11: Carcinoid tumor in a 69-year-old man. Axial (a) and Coronal volume-rendered (b) CT enterographic sections show a small, enhancing lesion in a small bowel loop (arrows), that was proved, at pathologic analysis, to be a carcinoid

Fig. 11

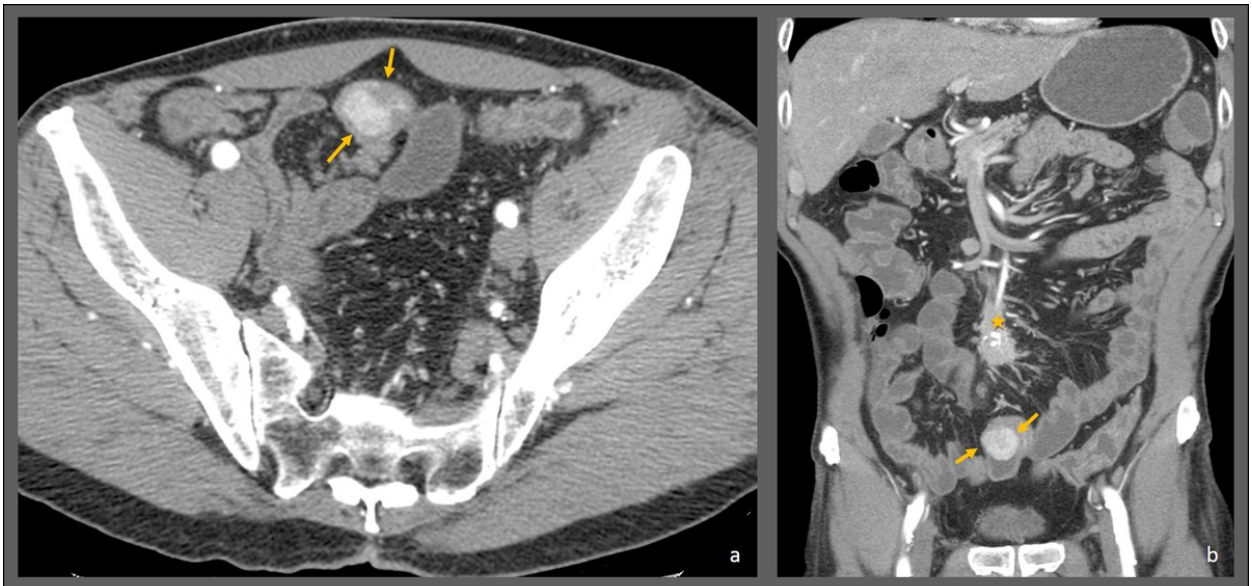

Figure 12: Pathologically-proved carcinoid tumor in a 65-year-old man. Axial (a) and Coronal volume-rendered (b) CT enterographic sections show an enhancing mass in a small bowel loop (arrows). It is also seen a calcified mesenteric mass (asterisk) with spiculated margins (desmoplastic reaction) sugestive of mesenteric carcinoid.

Fig. 12

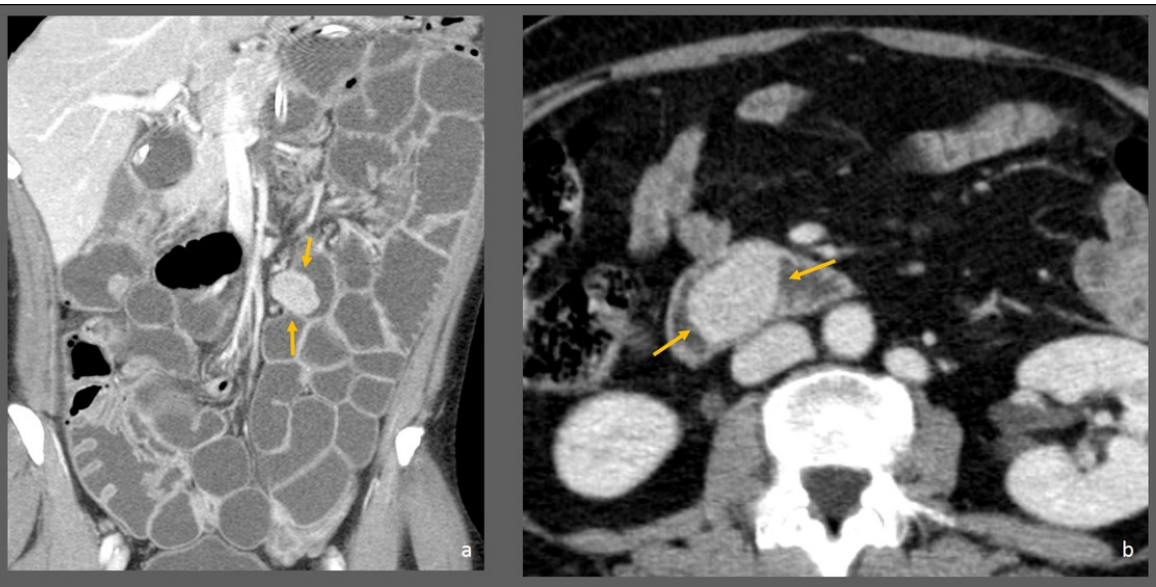

Figure 13: GIST.
(a) Coronal volume-rendered CT enterographic section demonstrates an homogeneous enhancing endoluminal mass in a small bowell loop.
(b) Axial CT enterographic sections of another patient, show a mass with same characteristics of the former. Both were proved to be GISTs by histology.

Fig. 13

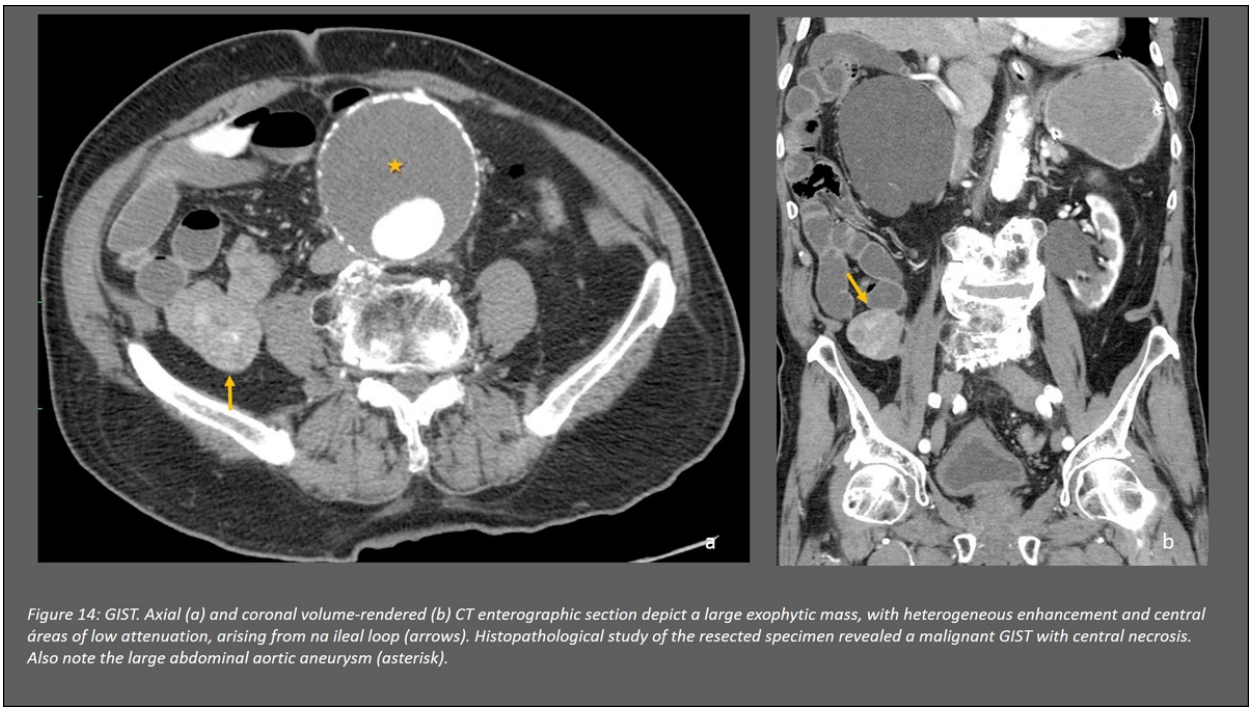

Figure 14: GIST. Axial (a) and coronal volume-rendered (b) CT enterographic section depict a large exophytic mass, with heterogeneous enhancement and central áreas of low attenuation, arising from na ileal loop (arrows). Histopathological study of the resected specimen revealed a malignant GIST with central necrosis. Also note the large abdominal aortic aneurysm (asterisk).

Fig. 14

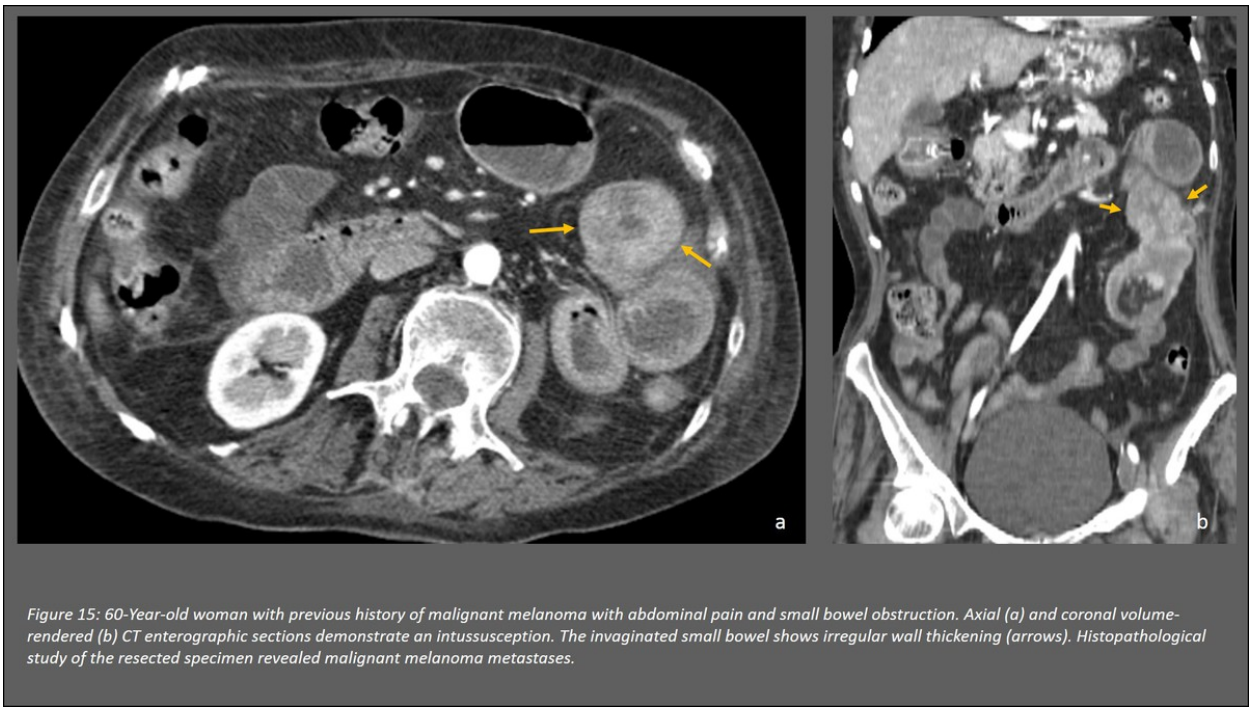

Figure 15: 60-Year-old woman with previous history of malignant melanoma with abdominal pain and small bowel obstruction. Axial (a) and coronal volume-rendered (b) CT enterographic sections demonstrate an intussusception. The invaginated small bowel shows irregular wall thickening (arrows). Histopathological study of the resected specimen revealed malignant melanoma metastases.

Fig. 15

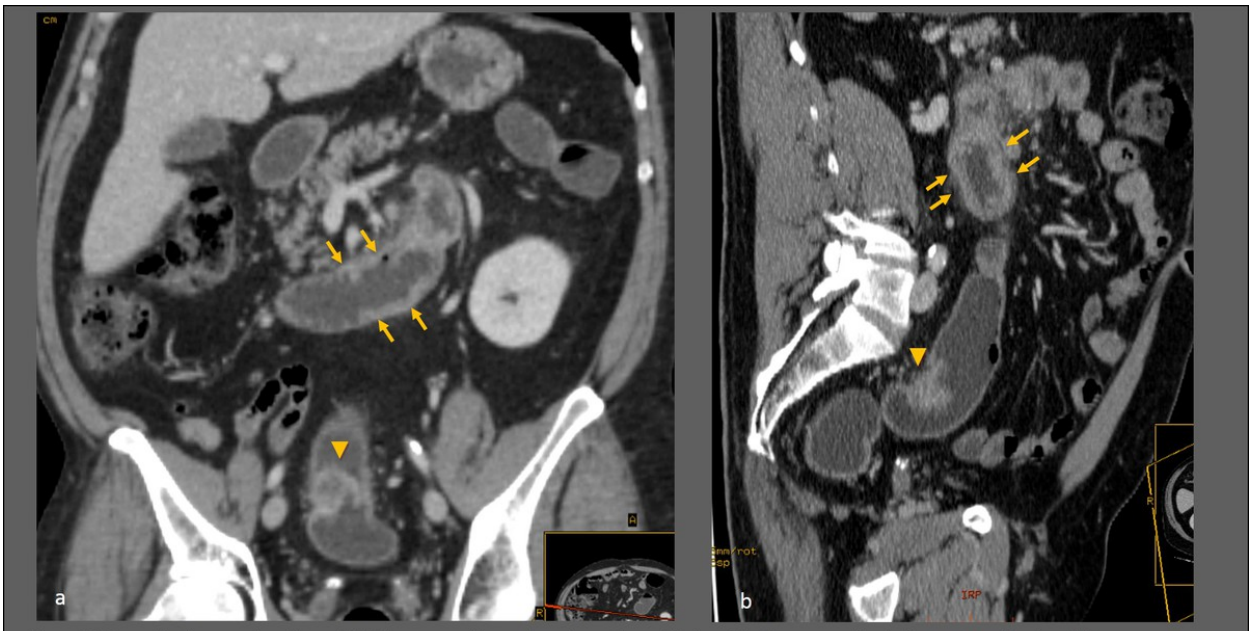

Figure 16: Coronal volume-rendered (a and b) CT enterographic sections of a patient with sigmoid colon cancer, clearly demonstrate the sigmoid tumor (arrowheads). Closed analysis reveal a discrete circumferential thickening on the 3rd and 4th portions of the duodenum (arrows) which was biopsy-proven to be metastases from colonic adenocarcinoma.

Fig. 16

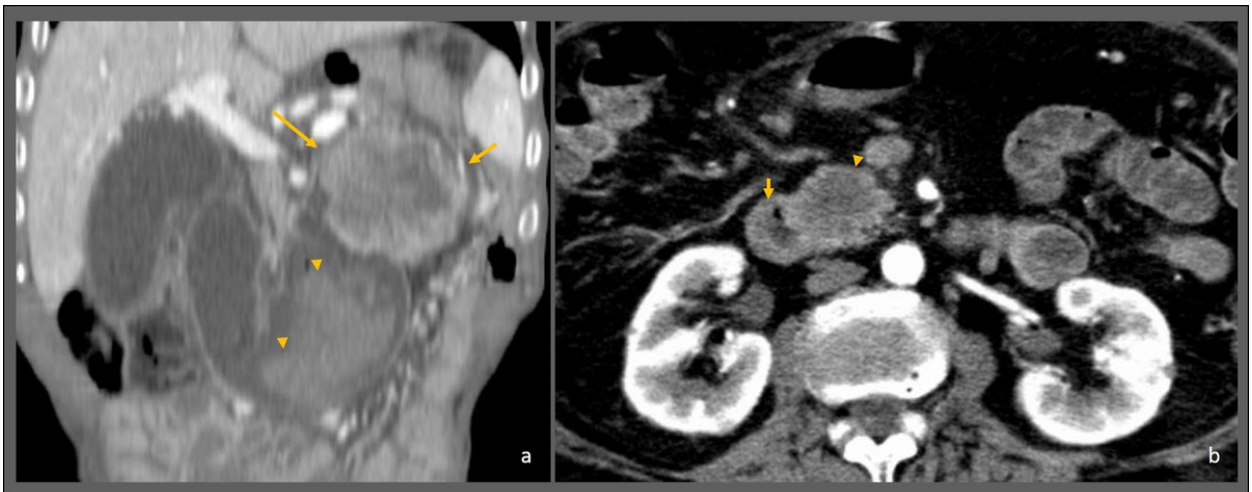

Figure 17: Coronal volume-rendered (a) CT shows evidence of gastric adenocarcinoma (arrows) with duodenal invasion and haemorrhage (arrowheads) inside the duodenal lumen. (b) Abdominal CT of other patient shows an hypodense soft tissue density mass (arrowhead) which was a pancreatic adenocarcinoma with invasion of the medial wall of the 2nd portion of the duodenum (arrow).

Fig. 17

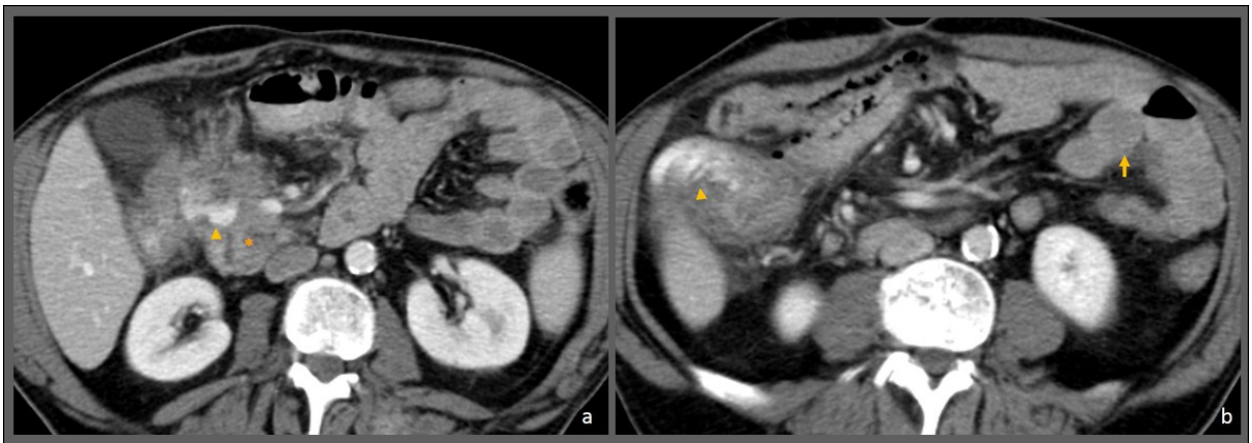

Figure 18: (a) and (b) - Abdominal CT of a patient with a neoplasm of the hepatic flexure of the colon. An undefined mass apparently involves the duodenum (asterisk) and the colon. A small amount of positive oral contrast agent (arrowhead) is present within the mass. An image obtained caudally (Fig 2) shows oral contrast agent in the colon (arrowhead) without evidence of contrast in the jejunum (arrow), a feature related to a colo-duodenal fistula.

Fig. 18

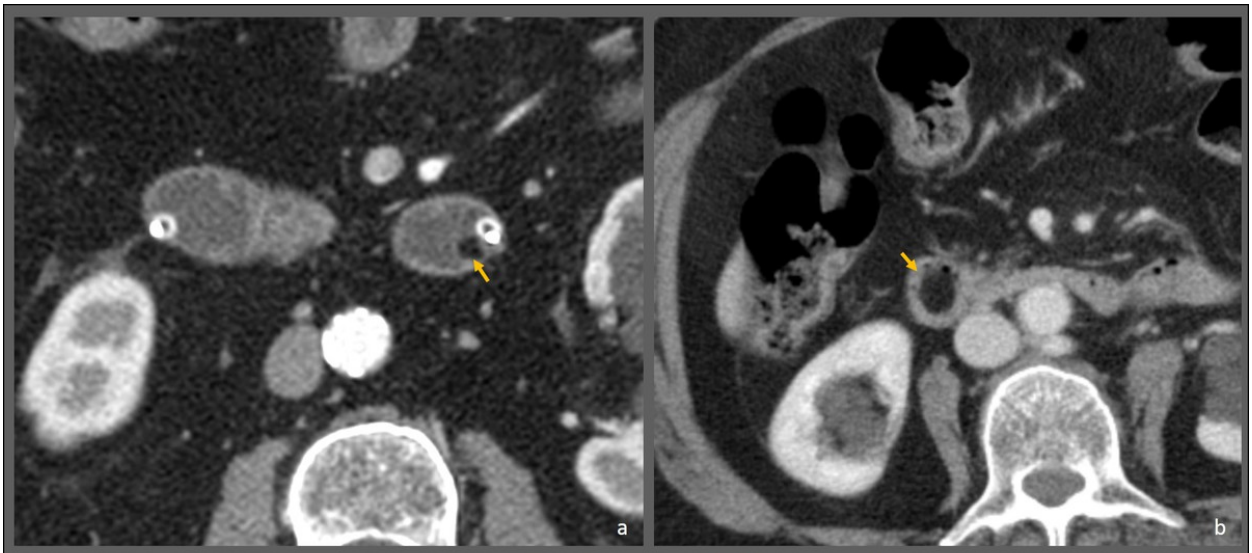

Figure 19: Both *Axial CT enterographic sections (a) and (b) show* endoluminal nodules, with fat density, sugestive of lipomas

Fig. 19

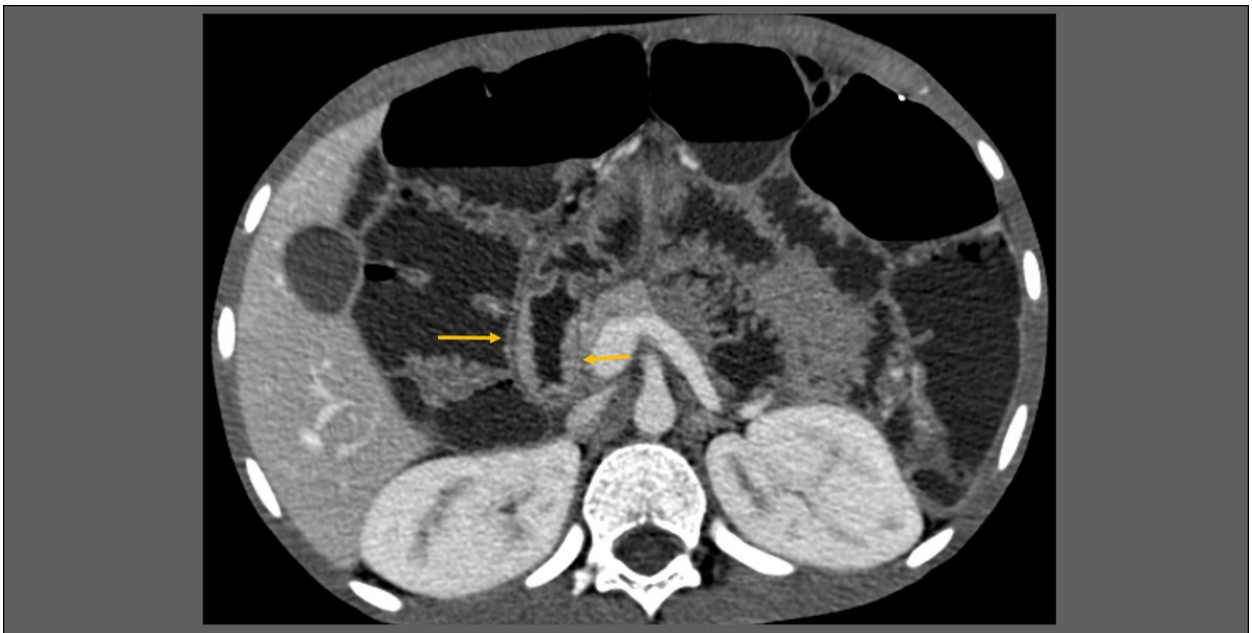

Figure 20: Axial CT enterographic sections of a 14-year-old boy, shows thickening and irregularity of the duodenal mucosa (arrows), with intense enhancement. Duodenal biopsy revealed disappearance of the "villi" associated with crypt hyperplasia, consistent with celiac disease.

Fig. 20

Conclusion

CT enterography is a valuable technique in the assessment of inflammatory bowel disease and small bowel neoplasms. It is noninvasive and allows mapping of disease activity before endoscopy and in cases where the endoscope cannot reach a bowel segment. It is rapid, readily available, operator independent, and allows evaluation of extraenteric complications of small bowel disease. However, an optimal technique with adequate bowel distention is required for accurate diagnostic results.

Personal information

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