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DIFFERENTIAL DIAGNOSIS OF SMALL BOWEL WALL THICKENING

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LEARNING OBJECTIVES

- To recognize the several patterns of small bowel wall thickening at CT.
- To become acquainted with their most frequent causes.





BACKGROUND

- Small bowel wall thickening is extremely common in nowadays radiology practice.
- Although clinical data is invaluable in this setting, computed tomography (CT) can be a very helpful adjunct in determining a specific diagnosis.
- Thickening of the small bowel wall is predominantly caused by inflammatory, infectious, ischemic or neoplastic conditions.
- There are several useful features to look for on CT, that help in narrowing the differential diagnosis:
 - Morphology of the diseased segment (length, symmetry, edges, thickness, *valvulae conniventes*);
 - Adjacent mesenteric, vascular or distant organ anomalies;
 - Pattern of mural thickening.



MORPHOLOGY OF THE DISEASED SEGMENT

	EDGES	THICKNESS	VALVULAE CONNIVENTES	LENGHT
 BENIGN	Tapered	Uniform Symmetric Thinner	Present	Segmental* (>6cm) Diffuse (>40cm)
 MALIGNANT	Heaped up	Variable Asymmetric Thicker	Absent	Focal (<5cm)

* exception - lymphoma



ASSOCIATED ANOMALIES

Mesentery

- Mesenteric stranding present – **likely inflammatory**
- Mesenteric stranding absent – **lymphoma, hemorrhage; inflammatory much less likely**
- Abscesses, fistulas, sinus tracts – **Crohn's disease**
- Fibrofatty proliferation, vascular engorgement – **Crohn's disease**
- Mesenteric calcifications – **treated lymphoma, mucinous metastases, carcinoid, tuberculosis**
- Mesenteric desmoplastic reaction – **carcinoid**



ASSOCIATED ANOMALIES

Vascular

- Thrombus at the mesenteric arteries or veins – **mesenteric ischemia**

Adenopathy






- Bulky retroperitoneal adenopathy +/- splenomegaly - **lymphoma**
- Low-attenuation lymph nodes– **tuberculosis**
- High-attenuation lymph nodes in an AIDS patient – **Kaposi sarcoma**

Distant organs

- Liver or peritoneal metastases – **neoplasia**
- Cirrhotic liver, splenomegaly, portal thrombosis – **portal hypertensive enteropathy**



PATTERNS OF THICKENING

WHITE	GRAY	WATER-TARGET	FAT-TARGET	BLACK - GAS
				
<ul style="list-style-type: none"> • Acute IBD • Shock bowel • Ischemia • Infection • Inflammation • Intramural hematoma 	<ul style="list-style-type: none"> • Adenocarcinoma • Lymphoma • Chronic Crohn's • Ischemia • Intramural hematoma • Radiotherapy 	<ul style="list-style-type: none"> • Acute IBD • Infection • Ischemia • Portal hypertension • Angioedema • AIDS 	<ul style="list-style-type: none"> • Chronic Crohn's • Obesity • Chemotherapy • Radiotherapy • Celiac disease 	<ul style="list-style-type: none"> • Ischemia • Infection • Trauma • Benign causes (connective tissue disease, COPD) • Pseudo-pneumatosis

- Some entities may show several patterns of enhancement and attenuation.
- More than one pattern may coexist in the same CT examination.



1- WHITE PATTERN



- Represents avid and uniform contrast enhancement of the bowel wall.
- The mural attenuation is at least the same or greater than that of venous vessels seen in the same scan.
- There may be associated mesenteric vessels' engorgement.
- It is caused either by vasodilation (inflammatory bowel diseases), interstitial leakage ("shock bowel" and ischaemia) or intramural hematoma (blunt trauma, anticoagulation, bleeding diathesis)
- Malignancy almost never manifests as "white pattern".
- With the exception of intramural hematoma, all the other entities require IV contrast administration for their assignment as a "white pattern".



2- GRAY PATTERN



- Represents homogeneous and poor enhancement of the thickened bowel wall.
- The mural enhancement is comparable with that of the enhanced muscle.
- The layers of the bowel wall are not distinguishable.
- It is the least specific pattern, as it can be seen in a variety of both malignant and benign conditions.
- IV contrast administration is necessary for the classification in this type of pattern.



3- WATER HALO PATTERN



- Bowel wall stratification may show two (double-halo) or three layers (target sign).
- The water-target sign represents three concentric layers: an outer enhancing *muscularis propria*, a middle layer of gray attenuation and an internal high-attenuation mucosa.
- The middle layer attenuation is thought to represent edema at the submucosa, although the exact limits of the histological layers may not totally correspond to the enhancement pattern.
- This pattern is mostly seen in acute benign situations such as inflammatory, infectious and ischemic injuries. It may also be found in portal-hypertensive patients.
- Malignancy can confidently be excluded when this pattern is seen.



4- FAT HALO PATTERN



- It represents a three layered thickened bowel wall, in which the middle layer shows fat attenuation.
- Although its differentiation from a water-target sign may be visually difficult, attenuation below -10 Hounsfield units is diagnostic for a fat-target sign.
- It indicates past inflammation, so it is most frequently found in the chronic phase of Crohn's disease.
- Other situations where it can be seen are in obesity, celiac disease and patients that underwent chemotherapy.



5- BLACK PATTERN



- In this kind of pattern, air bubbles are trapped both within the dependent and independent bowel wall (pneumatosis).
- Intravenous gas at the mesenteric veins, portal vein or pneumoportia may concomitantly be seen in this setting.
- Pneumatosis is highly suggestive of acute necrotizing enteritis, while its pathogenesis is still not completely understood.
- Its causes are infection, ischemia or trauma.
- On rare occasions, pneumatosis may not represent a life-threatening event (after intestinal anastomosis, patients with COPD or connective tissue diseases).



HEMORRHAGE

- Intramural hematoma manifests as thickening of the bowel wall with variable attenuation, depending on the timing of the examination. In the first hours the hematoma shows spontaneously hyperdense attenuation (**white pattern**). As the time passes, the attenuation values lower to approximately the same density as water (**water-halo pattern**).
- The bowel segments that are most commonly affected by trauma are the portion of the jejunum near the ligament of Treitz and the portion of the ileum near the ileocecal valve.
- If the cause was trauma, fluid or hematoma in the mesentery, adjacent fat stranding and other organ injuries are expected.
- If the hematoma was spontaneous because of anticoagulation or vasculitis, there are usually no associated findings at the mesentery or other organs.



HEMORRHAGE

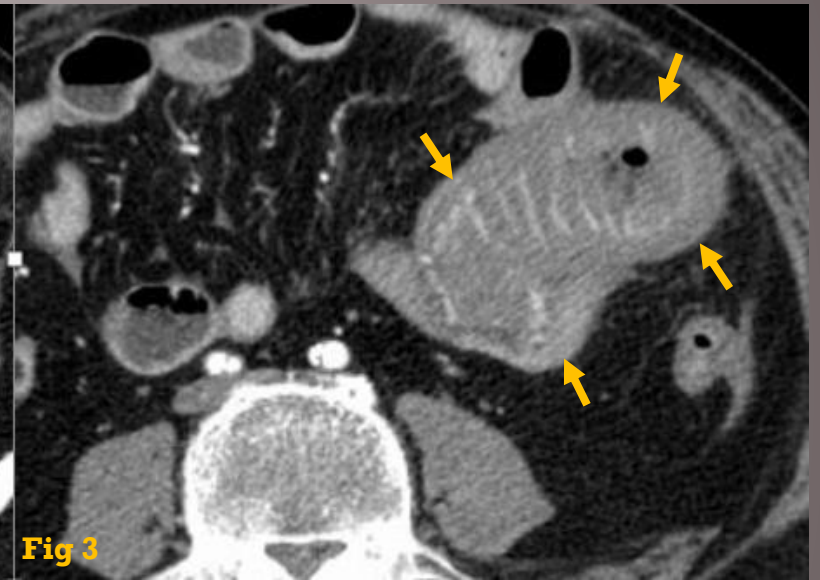
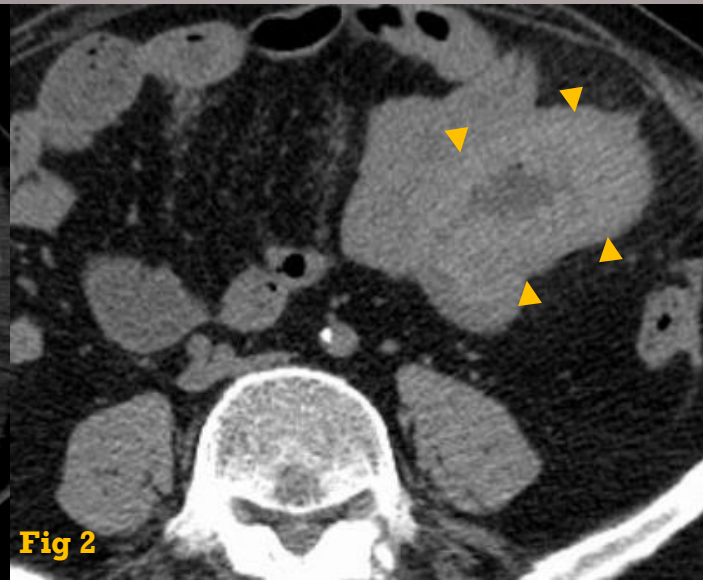
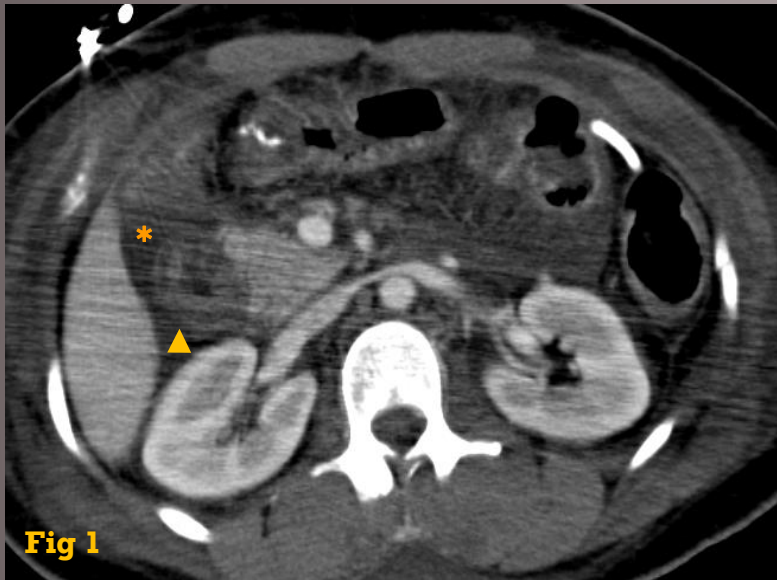


Fig 1 – Abdominal CT of a patient who had had a car accident a week before shows duodenum contusion. The 2nd portion of the duodenum is surrounded by fluid (asterisk) and its wall presents the water-target sign (arrowhead).

Figs 2 and 3 – Unenhanced abdominal CT of a patient with a spontaneous mural hematoma because of poor warfarin management. There is a thickened jejunal loop with high attenuation (arrowheads). After IV contrast administration, there is only mucosal enhancement, while the blood thickened submucosa does not enhance (arrows).

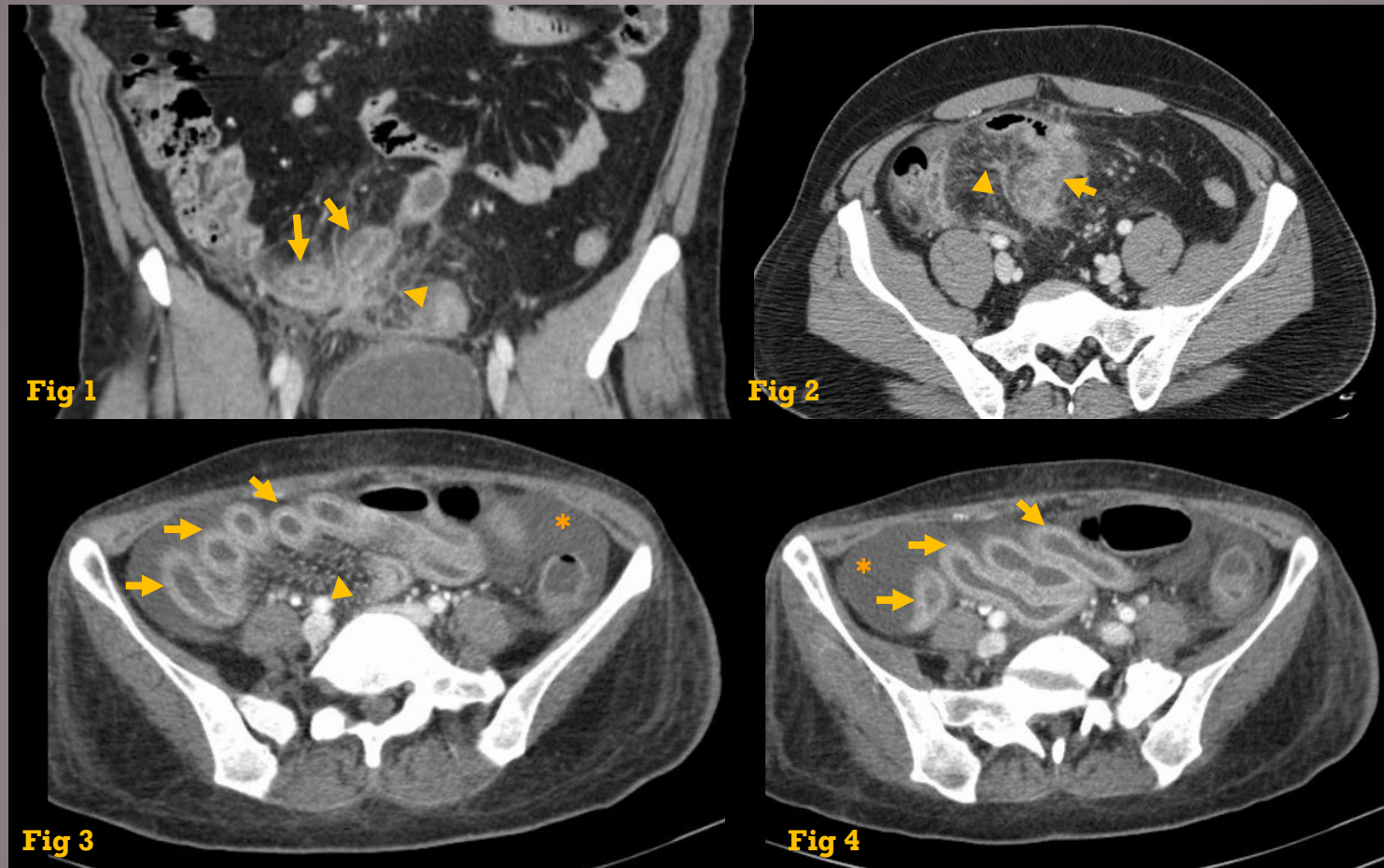


INFECTION

- Small bowel enteritis appears as normal or mildly thickened bowel wall, in contrast with infectious colitis, namely pseudomembranous colitis, which presents as marked colon thickening.
- The affection is usually segmental or diffuse, symmetric and uniform.
- The small bowel wall may show submucosal edema (**water-halo pattern**) or mucosal hyperenhancement (**white pattern**).
- Stranding of the peri-enteric fat and ascites may be seen.



INFECTION



Figs 1 and 2 – Abdominal CT of a patient with unspecific infectious enteritis at the terminal ileum. There is segmental bowel wall thickening with a water-halo sign (arrows). Note also adjacent mesenteric fat stranding (arrowheads).

Figs 3 and 4 – Abdominal CT of an AIDS patient with cytomegalovirus enteritis. CT shows a long continuous segment of bowel wall thickening, with hyperenhancing mucosa (arrows); there is also mesenteric vascular engorgement (arrowhead) and ascites (asterisks).

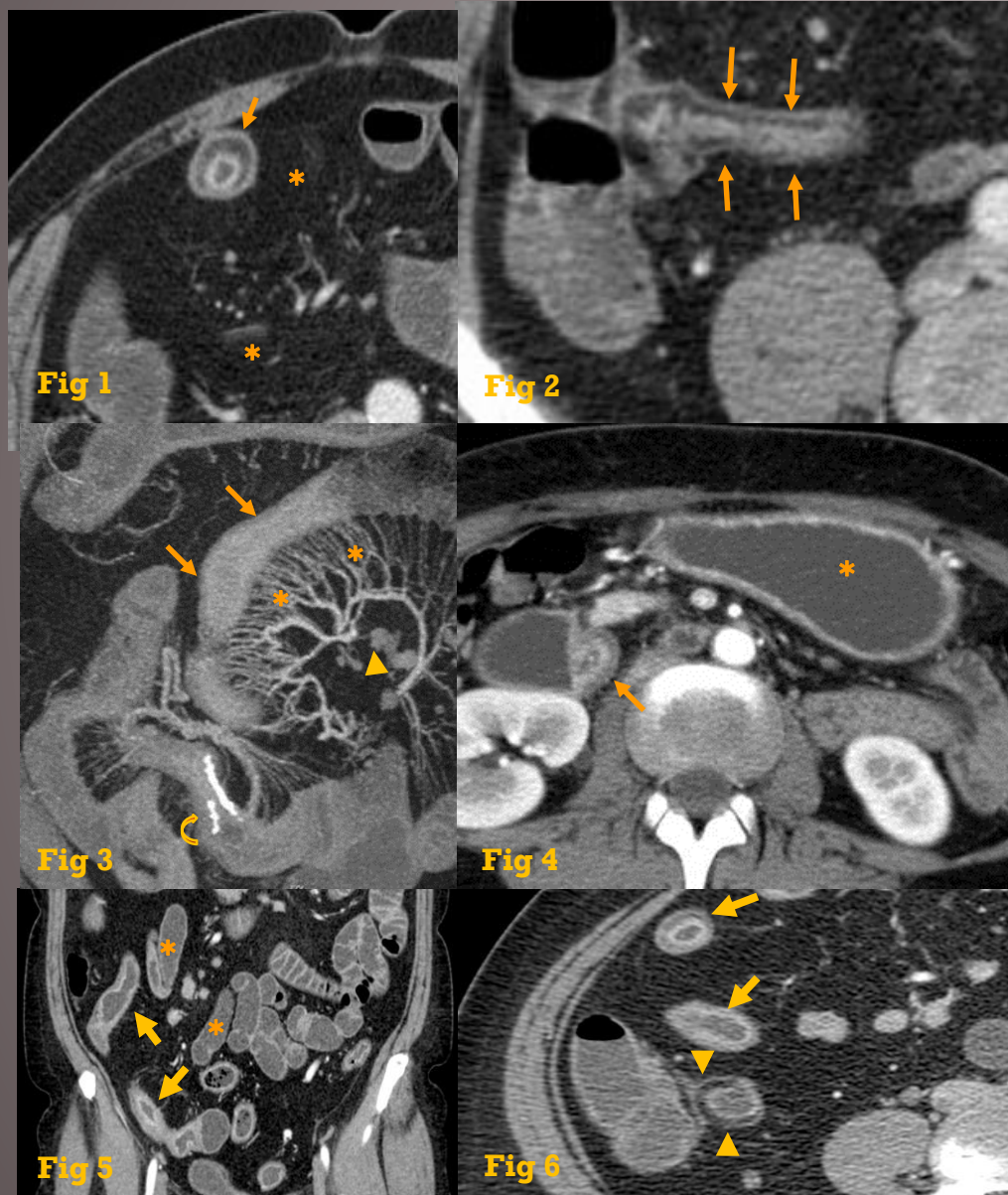


CROHN'S DISEASE

- Crohn's disease is an inflammatory bowel disease that can affect any segment of the intestine, but is most frequent at the terminal ileum.
- The disease features asymmetric and transmural thickening, with discontinuous involvement (skip lesions).
- In the active phase the two most frequent patterns are the **white** (hyperenhanced mucosa) and the **water-halo** (submucosal edema).
- Accompanying changes along the mesentery can be found, such as: ascites, vascular engorgement, fat stranding, fistulous tracts and abscesses.
- In the chronic phase the bowel wall may show a **gray pattern** (fibrosis) or a **fat-halo sign** (fat in the submucosa).
- Creeping fat along the mesenteric border of the bowel can be seen, as well as associated diseases elsewhere in the CT scan (sclerosing cholangitis, gallstones, ankylosing spondylitis...).



CROHN'S DISEASE



Figs 1 and 2 – Abdominal CT shows the fat halo sign (arrows) in the wall of the terminal ileum, in a patient with quiescent Crohn's disease. Note also mesenteric creeping fat (asterisks).

Fig 3 - MIP coronal reformation on a CT enterography of a Crohn's disease patient with active disease who had previously had a segmental enterectomy - note the surgical clips at the ileal-ileal anastomosis (curved arrow) - shows mesenteric engorgement (asterisks) and adenopathies (arrowhead) near a thickened bowel wall segment (arrows).

Fig 4 - Abdominal CT of another patient with active disease, shows gastric outlet obstruction (asterisk) and a stricture in the 2nd portion of the duodenum that shows a water-halo pattern (arrow).

Fig 5 – CT enteroclysis depicts several small bowel inflammatory strictures (arrows) separated by segments of normal distended bowel (asterisks) – skip lesions.

Fig 6 - Axial CT enterography section demonstrates mural stratification, with mucosal hyperenhancement and submucosal edema indicative of active disease (arrows). Submucosal fat deposition due to chronic disease is also present in an adjacent bowel loop (arrowheads).



ULCERATIVE COLITIS

- Ulcerative colitis is an inflammatory bowel disease that affects the colonic mucosa but may later extend to other layers.
- Because it is primarily a mucosal disease, the changes are beneath the spatial resolution of CT.
- When the thickening is more severe, it can usually be seen as a continuous ascending thickening of the rectum, that may ultimately involve the entire colon and the terminal ileum (backwash ileitis).
- The patterns of thickening most frequently seen are the **water-halo** in the acute phase and the **fat-halo** in the chronic stages.
- Unlike Crohn's disease, fistula and abscess formation is not common.



ULCERATIVE COLITIS

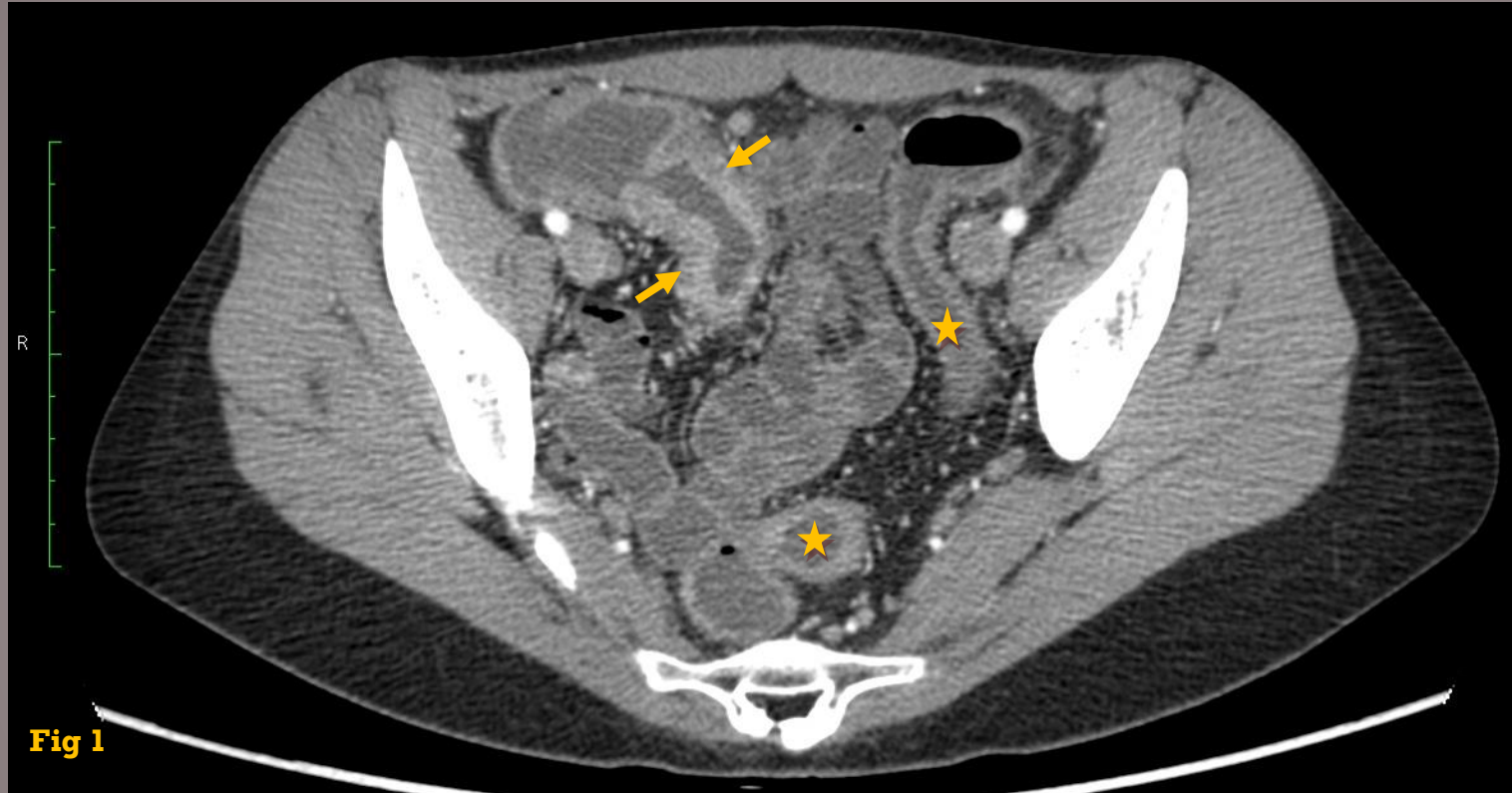


Fig 1 - Axial CT enterographic section shows continuous involvement of the large bowel (stars) and backwash ileitis, with a gray pattern of attenuation (arrows).

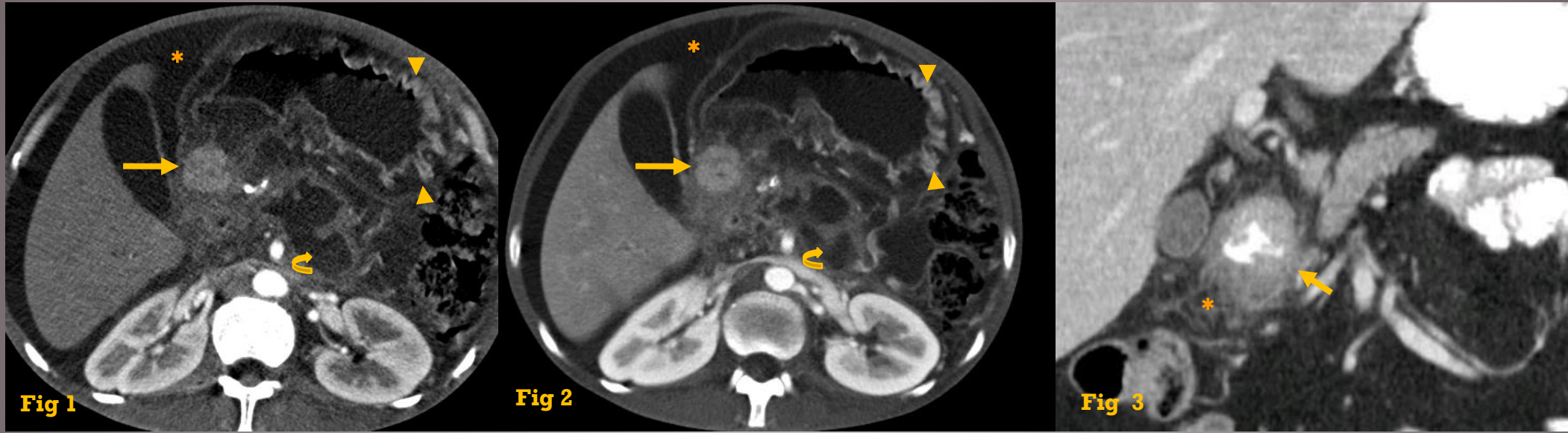


INFLAMMATION

- Inflammation, other than inflammatory bowel diseases such as Crohn's disease and ulcerative colitis, can happen anywhere in the small bowel, namely at the duodenum.
- Duodenitis refers to inflammation of the duodenum without discrete ulcer formation.
- It may manifest at CT as duodenal wall thickening, nodules (enlarged Brunner glands) and deformity of the duodenal bulb.
- **Mucosal hyperenhancement** or a **water-halo sign** can be seen.
- Complications include bleeding, perforation and stricture, in which cases CT is a great diagnostic tool.



INFLAMMATION



Figs 1 and 2– Abdominal CT of an alcoholic patient shows marked thickening and intense enhancement of the duodenal bulb wall (duodenitis) observed in both the arterial (Fig 1) and portal venous phase (Fig 2), displaying a pseudo-tumoral appearance (arrows). Note also ascites (asterisks) and severe gastritis (arrowheads). There is also a pancreatic pseudocyst (curved arrows).

Fig 3 – Abdominal CT of another case of duodenitis – the lumen of the duodenum is irregular, the wall is irregularly thickened with a gray pattern (arrow) and there is adjacent fat stranding (asterisk).



CELIAC DISEASE

- Celiac disease is a chronic autoimmune condition of gastrointestinal malabsorption that occurs in genetically susceptible individuals to gluten.
- The bowel mucosa becomes flattened and villi disappear, while the submucosa, muscularis and serosa remain normal. This destruction begins in the duodenum and progresses distally to the ileum over time.
- CT may show **unspecific bowel wall thickening**, dilated small bowel, dilution of intraluminal contrast by fluid excess secretion, reversed jejunoileal fold pattern and non-obstructing and transient intussusceptions.
- **Submucosal fat** is frequently seen in patients with celiac disease. Especially if there is isolated fat in the walls of the duodenum or in the proximal jejunum, celiac disease should be investigated.
- Lymphadenopathy and vascular engorgement may be associated.



CELIAC DISEASE

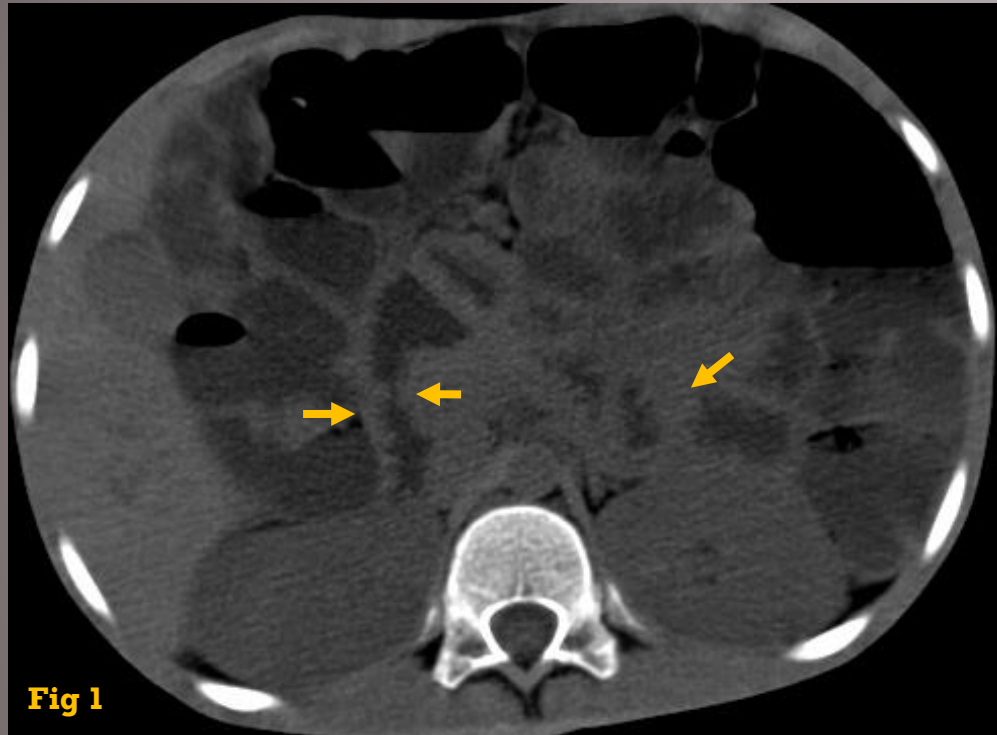


Fig 1



Fig 2

Figs 1 and 2 – Abdominal CT before (Fig 1) and after i.v. contrast administration (Fig 2), of a 14-year-old boy, shows thickening and irregularity of the duodenal mucosa (arrows), with intense enhancement – white pattern of attenuation. Duodenal mucosa biopsy showed findings consistent with celiac disease.



ADENOCARCINOMA

- Small bowel adenocarcinoma is uncommon (only 0,4% of all GI tract tumors) and is most frequent at the duodenum.
- It is most often sporadic, although associations with Familial Adenomatous Polyposis, Peutz-Jeghers syndrome and Crohn's disease have been reported.
- While it may manifest as a polypoid or ulcerative mass, it usually manifests as a soft tissue attenuation thickening of the small bowel wall (**gray pattern**), with or without enhancement, depending on the absence or existence of necrosis.
- Differently than lymphoma, adenocarcinoma typically causes obstruction.
- Perilesional adenopathy is frequent at the time of diagnosis and 5-40% of the patients have distant metastases or peritoneal seeding at presentation.



ADENOCARCINOMA

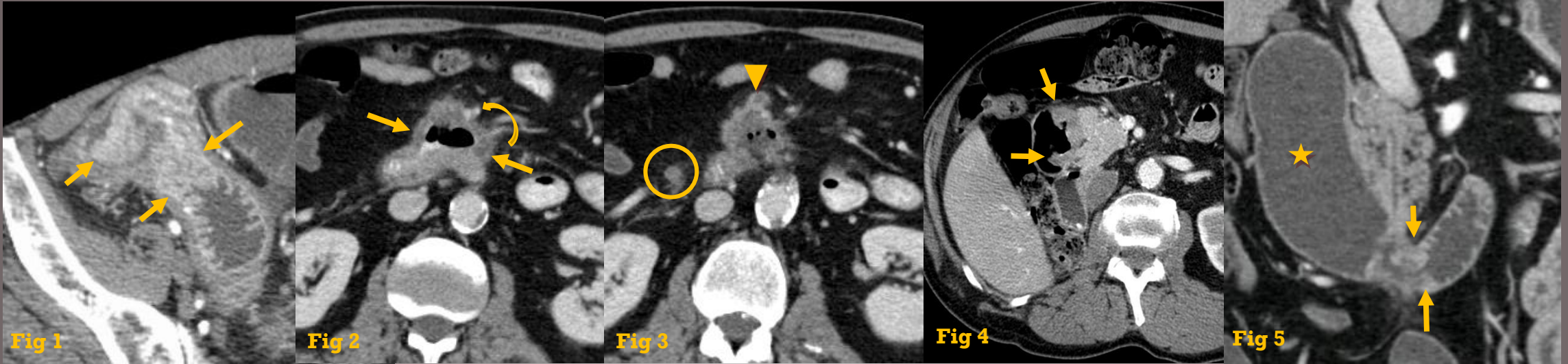


Fig 1 – Abdominal CT of a patient with an adenocarcinoma of the ileum that extended to the ileocecal valve shows focal irregular thickening with enhancement of the terminal ileum (arrows). Note absence of mesenteric inflammatory signs.

Fig 2 and 3 - Abdominal CT shows an irregular, circumferential, asymmetric thickening of the 3rd portion of duodenum, causing deformity of the lumen (arrows). There is encasement of the superior mesenteric artery (curved arrow) and tumour thrombosis of the superior mesenteric vein (arrowhead). There is also periduodenal fat stranding and adenopathy (circle).

Fig 4 – Abdominal CT of another case of duodenal carcinoma; there is an excentric thickening of the medial wall of the 2nd portion of the duodenum with gray attenuation (arrows).

Fig 5 – Abdominal CT of yet another case of duodenal carcinoma; there is an asymmetric circumferential duodenal thickening (arrows) which caused luminal stenosis with proximal dilatation (star).



LYMPHOMA

- Lymphoma of the gastrointestinal tract is most common at the distal ileum.
- Muscular wall replacement by tumor and destruction of the autonomic plexus causes typical aneurismal dilatation of the lumen, so obstruction is less likely (in contradiction with adenocarcinoma).
- CT may show a long segment of circumferential and asymmetric wall thickening that is of relatively homogenous soft-tissue density (**gray pattern**) and has little enhancement.
- It may also manifest as aneurysmal dilatation, an exophytic mass or as a polypoid mass.
- Bulky paralesional and retroperitoneal adenopathies are frequently associated.



LYMPHOMA

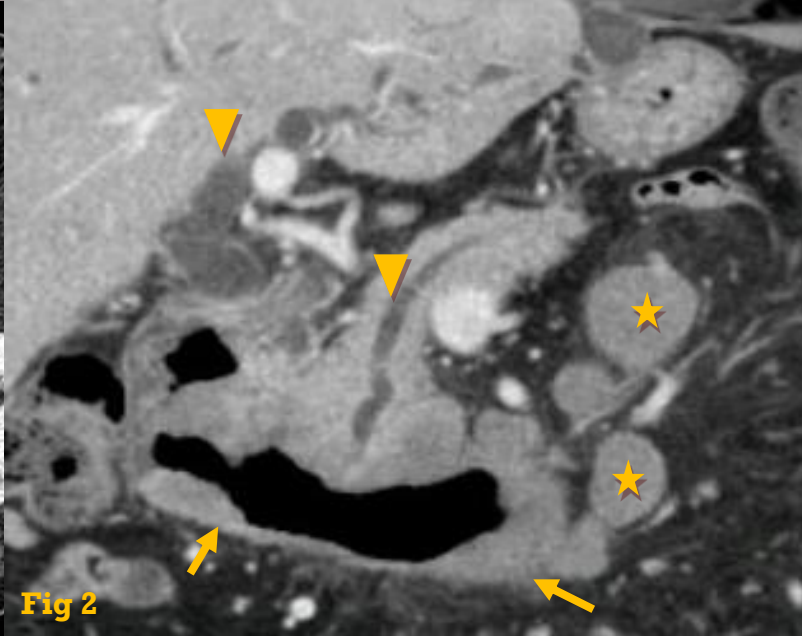
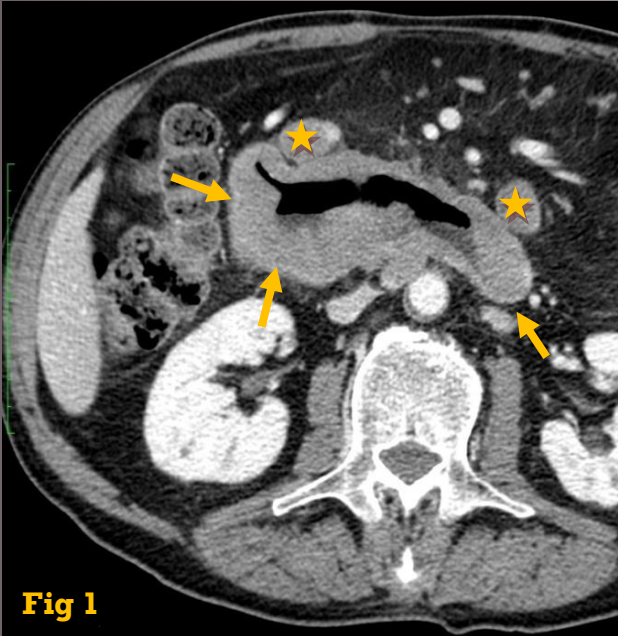


Fig 1 and 2 – Contrast-enhanced CT shows homogeneous (with gray attenuation) and asymmetric thickening of the duodenal wall with mild dilatation of the lumen (arrows); there is biliary and Wirsung duct dilatation (arrowheads); perilesional adenopathies are also evident (stars).

Fig 3 – CT enterography shows homogeneous enhancing and greatly thickened wall of an ileal loop (arrows). Pathologic examination revealed small cell B lymphoma.

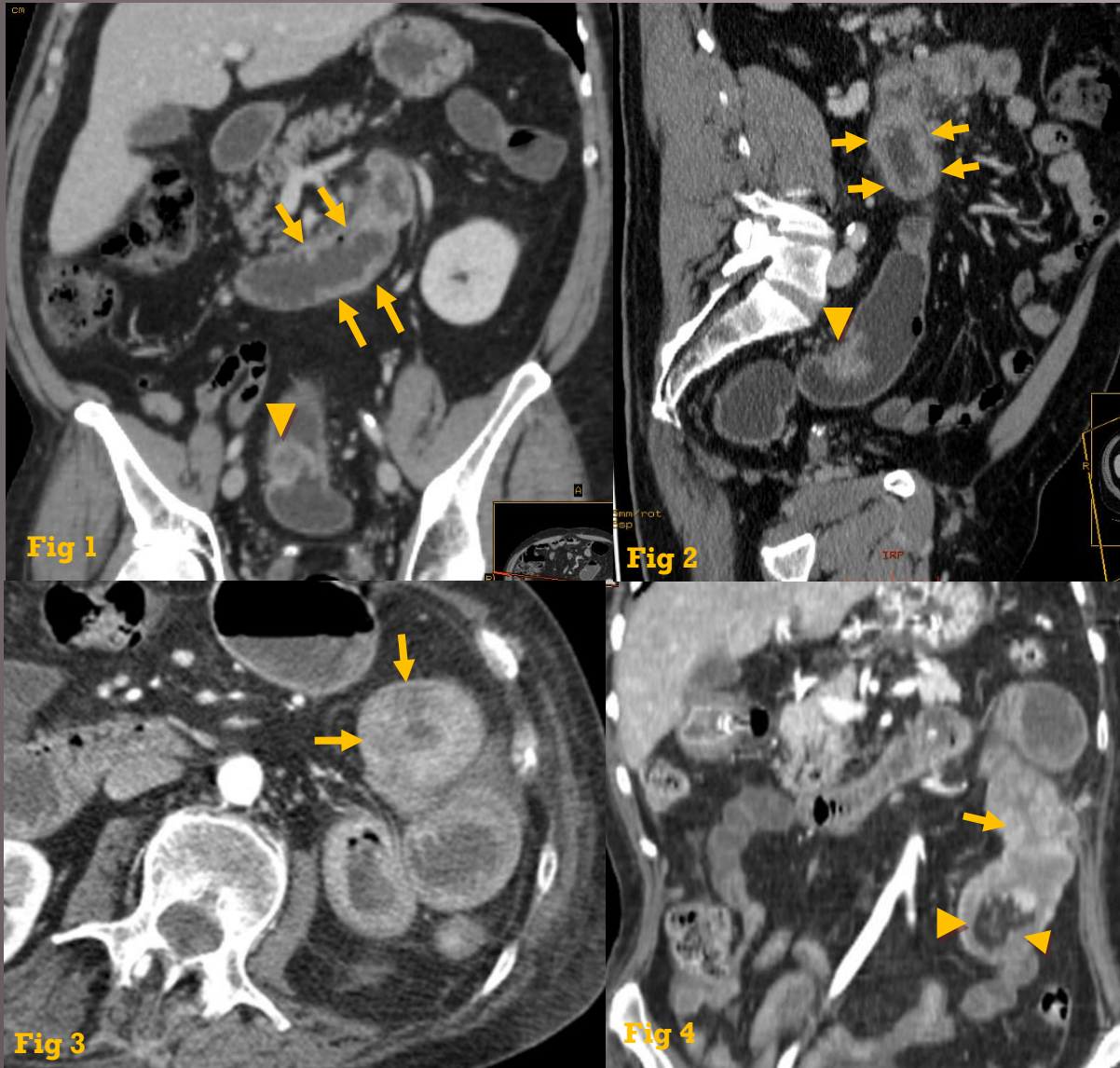


METASTASES

- Metastatic lesions of the small intestine are more frequent than primary tumors.
- The most common primaries are breast, lung, malignant melanoma and other GI tumors.
- Metastases to the small bowel may originate in the subserosa, but as they grow, they can extend into the lumen and present as intraluminal masses, that may ulcerate or act as a lead point for an intussusception.
- Although there are **no specific imaging features** of metastasis at CT, thickening of the bowel wall or folds in a patient with known malignancy is highly suspicious for bowel metastasis.



METASTASES



Figs 1 and 2 – Abdominal and pelvic CT of a patient with sigmoid colon cancer, performed to stage the disease, clearly demonstrated the sigmoid tumour (arrowheads) but failed to show distant metastases. However, MPR and retrospective analysis revealed a discrete circumferential thickening on the 3rd and 4th portions of the duodenum (arrows) which was not recognised initially.

Figs 3 and 4 – Patient with previous history of malignant melanoma. Axial (fig 3) and coronal volume-rendered (fig 4) CT enterographic sections demonstrate an intussusception (arrowheads). The invaginated small bowel shows heterogeneous wall thickening (arrows). Histopathological study of the resected specimen revealed malignant melanoma metastases.

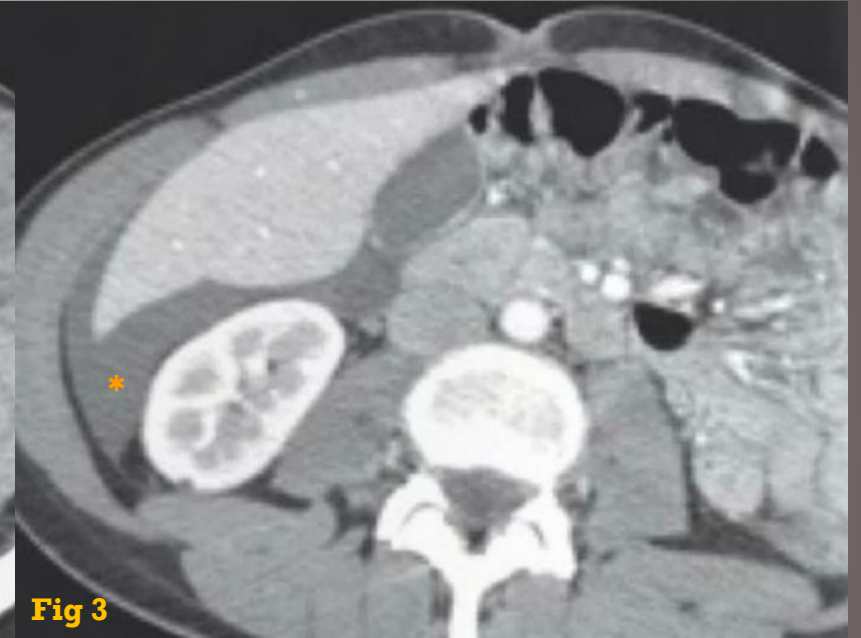
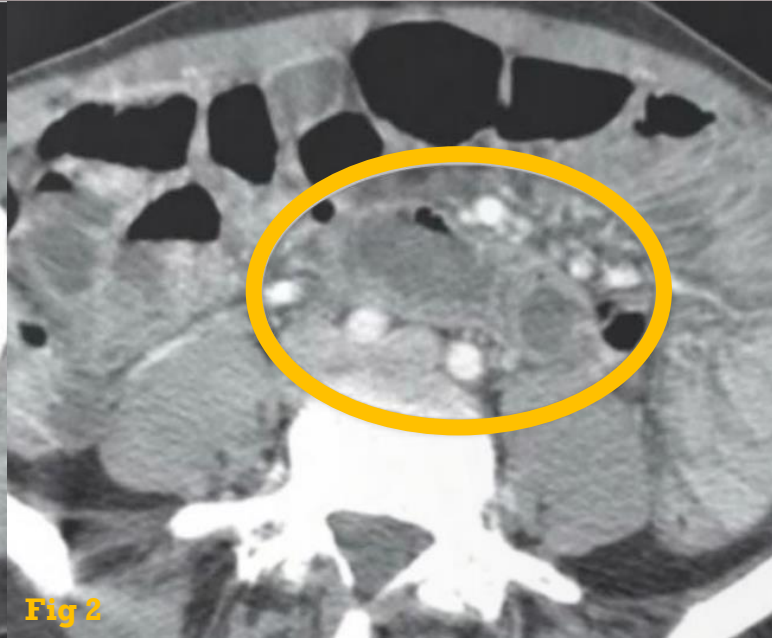
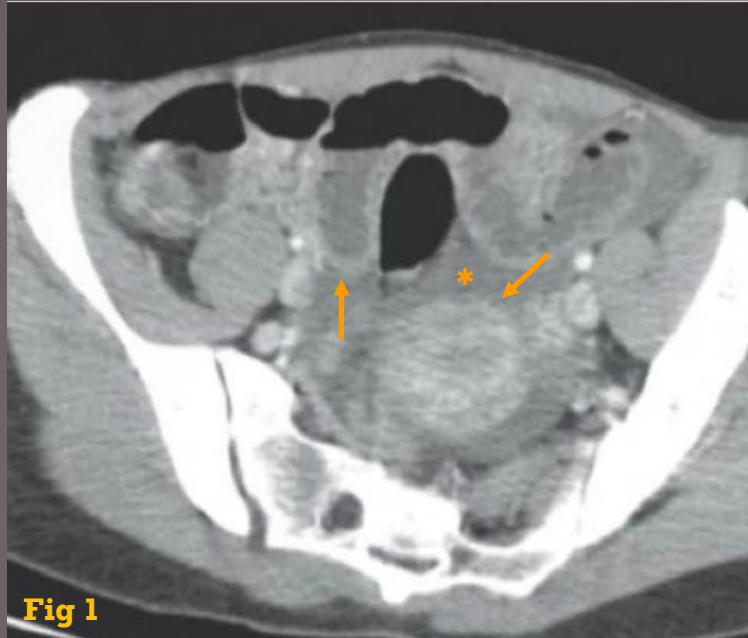


ANGIOEDEMA

- Angioedema is characterized by episodes of increased capillary permeability and consequent edema of the skin and mucosal tracts.
- The mechanism for bowel angioedema caused by ACE inhibitors is not yet understood.
- It is most common in females with onset after only a few days to almost a decade.
- Any segment may be involved, but it is most frequent in the jejunum.
- The typical appearance of angioedema on CT images includes the **target sign** (submucosal edema and hyperemia of the mucosa and serosa), straightening/ elongation of the small bowel loops, some amount of ascites and vascular engorgement.
- As it is a self-limited disease (with or without ACE inhibitors discontinuation) with resolution in 24 to 36 hours, different patterns and degrees of bowel wall thickening may be found at the same time.
- It is a diagnosis of exclusion, in an adequate clinical, laboratory and imaging setting.



ANGIOEDEMA



Case courtesy of Maria Luísa Ortiz Coelho, Porto

Figs 1 to 3 - Abdominal CT of a 36-year-old female that was admitted to the emergency department with vomiting and acute abdominal pain. She had been taking angiotensin converting enzyme (ACE) inhibitors for two years.

Fig 1 – Straightening and wall thickening of jejunal loops (arrows), surrounded by ascites (asterisk).

Fig 2 – Segmental jejunal wall thickening and stratification (circle) showing the target sign.

Fig 3 – Moderate volume of ascites in the Morrison space (asterisk).

Ultrasound performed 6 days after the discontinuation of the medication showed resolution of the small bowel wall thickening.

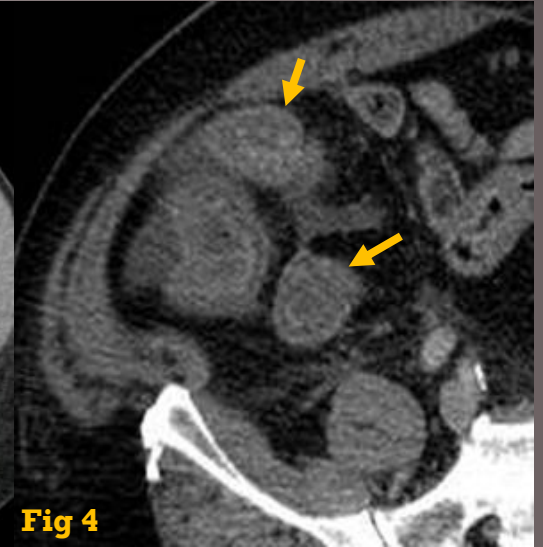
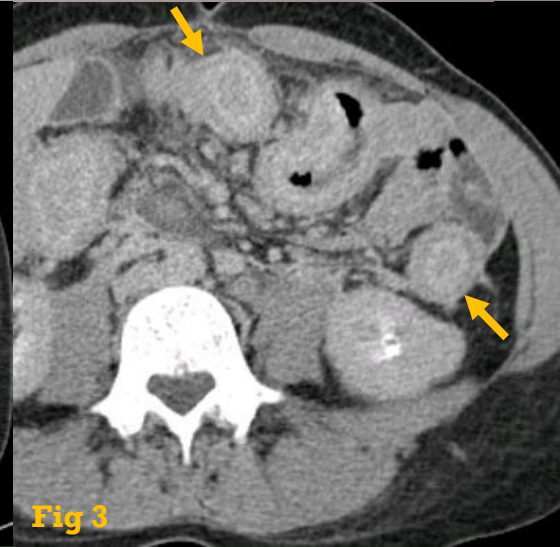
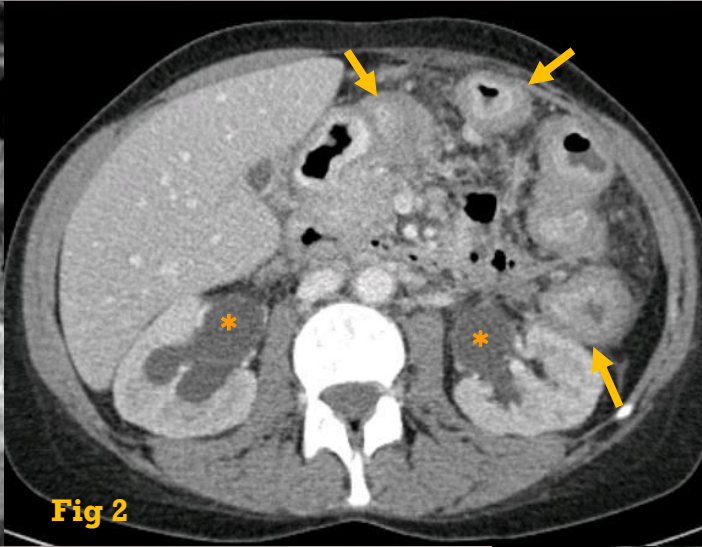
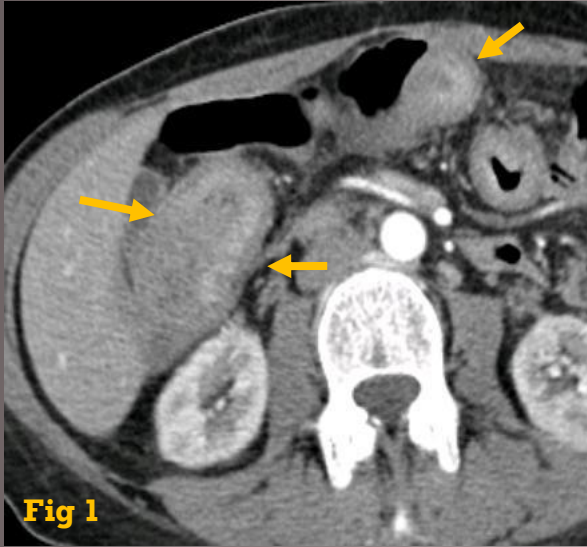


VASCULITIS

- Inflammation of the small caliber blood vessels of the GI tract produces a variety of complications, such as **intestinal ischemia/infarction**, **hemorrhage**, ileus, ulceration and perforation, with according CT findings.
- Vasculitis at the gut usually manifests as bowel wall thickening in a multifocal, transient and migratory fashion.
- It can occur throughout the GI tract, but is most commonly found in the small bowel.
- Whenever mesenteric ischemia occurs in young patients, at unusual sites, with a tendency to affect both the small and large intestine, and is associated with genitourinary disease, the hypothesis of a vasculitis must be raised.
- Because vasculitis may affect several vessels simultaneously, skip lesions are found, and are a discriminating factor for thromboembolic mesenteric ischemia, which shows a continuous pattern of disease.
- Genitourinary tract involvement (lupus nephritis, cystitis, hydronephrosis) is concurrently seen in many cases.
- Radiologic findings in the various types of vasculitis often overlap. Knowledge of the associated clinical manifestations can suggest a specific diagnosis.



VASCULITIS



Figs 1 and 2 – Abdominal CT of a patient with systemic lupus erythematosus and antiphospholipid syndrome – There is evidence of multifocal thickening of several bowel loops with a water-target appearance (arrows), including the stomach, colon and 2nd portion of the duodenum. Note also bilateral hydronephrosis (asterisks), which is an hint for a vasculitis as the cause of the diffuse bowel thickening.

Fig 3 – Abdominal CT of the same patient following 3 weeks of steroid treatment with no clinical improvement. CT revealed resolution of some of the previous affected segments, while other bowel segments showed wall thickening for the first time, with the water-halo sign (arrows).

Fig 4 – Abdominal CT of a patient with Henoch-Shönlein purpura shows a long segment of bowel wall thickening with the target sign (arrows).

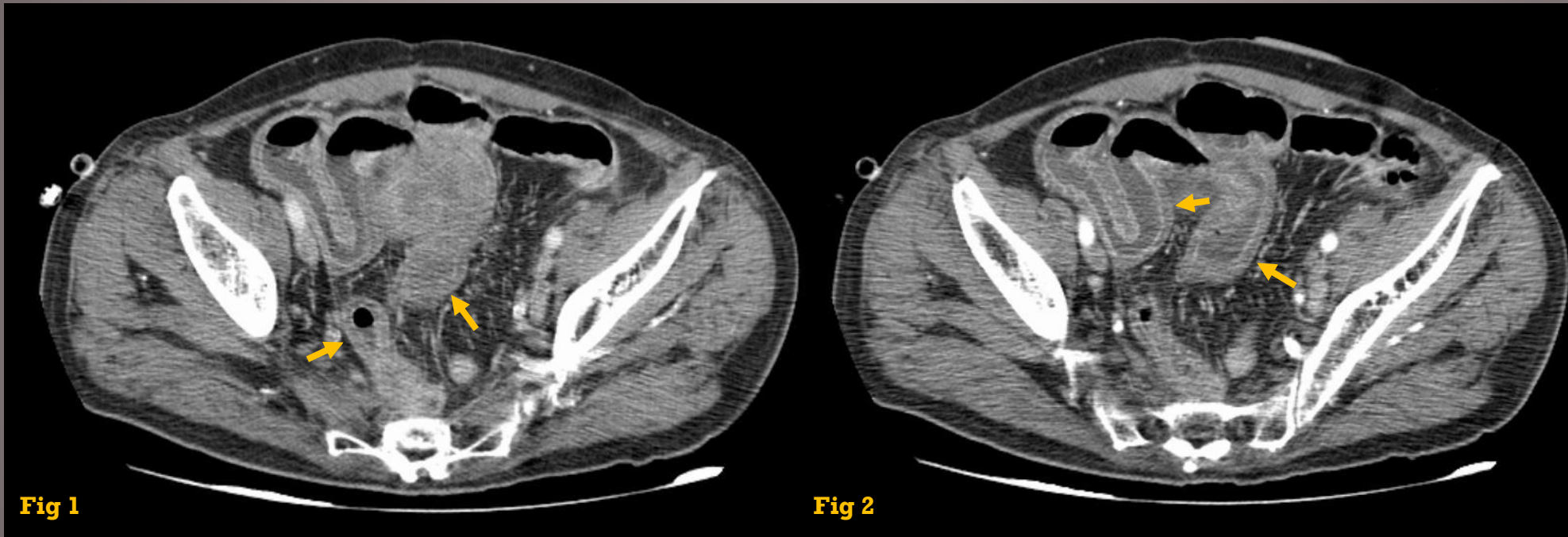


CHEMOTHERAPY

- Chemotherapy-induced enteritis is one of the most common toxicities associated with cytotoxic agents, and it is due to nonspecific targeting of the rapidly dividing cells in the gastrointestinal mucosa.
- It manifests as diffuse thick-walled bowel or predominantly involving the distal ileum.
- The typical appearance of enteritis on CT images includes the **target sign** (submucosal edema and hyperemia of the mucosa and serosa), although it can also present as **homogeneous thickening**.
- Neutropenic enterocolitis is due to chemotherapy-induced mucosal injury and secondary superinfection, and it typically affects the cecum and right colon (typhlitis).
- Rapid **submucosal fat** accumulation can also be seen in patients that are treated with chemotherapy.



CHEMOTHERAPY



Figs 1 and 2 – Abdominal CT of a patient undergoing chemotherapy for chronic lymphocytic leukemia shows a long segment of bowel wall thickening with a target sign (arrows). Note absence of inflammatory signs at the mesentery.

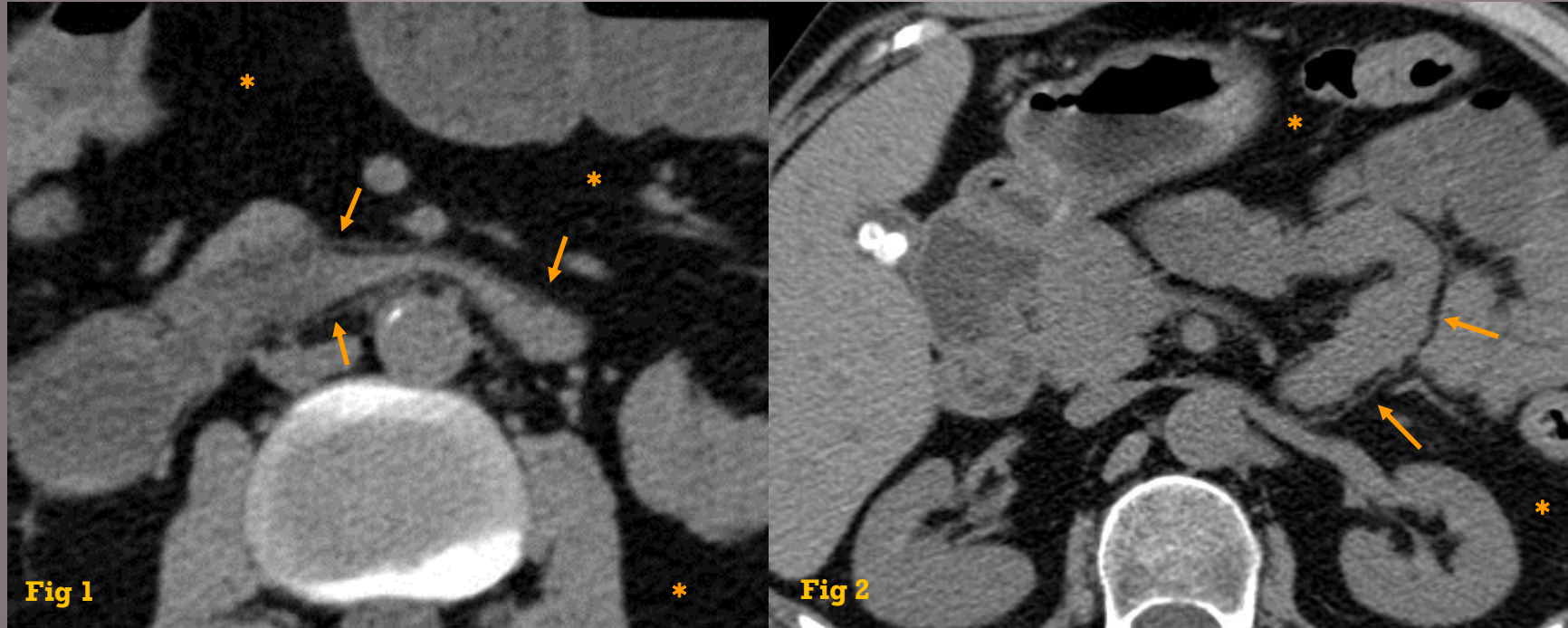


OBESITY

- **Intramural fat** in asymptomatic patients may occur in the bowel as a normal variant, most commonly in the distal ileum and colon.
- Because its incidence is most frequent at the sites where Crohn's disease is also typical (terminal ileum), it can be difficult to distinguish this normal variant from diseased bowel.
- The fat layer is usually very thin, thinner than what is seen in Crohn's disease, and there are no associated mesenteric or vascular anomalies.
- Ultimately, the differential diagnosis is made through clinical history and laboratory evaluations.



OBESITY



Figs 1 and 2 – Plain abdominal CT of a patient with a fat-halo sign at the duodenum wall (arrows) in an obese patient. Note abundance of intraperitoneal and retroperitoneal fat (asterisks). Crohn's disease and celiac disease were excluded and the patient had no history of chemotherapy.



MESENTERIC ISCHEMIA

- Acute mesenteric ischemia can affect any segment of the bowel, in a segmental / diffuse or mural / transmural fashion.
- Occlusion of the superior mesenteric artery is the most frequent cause (thromboembolic disease or atherosclerotic disease). In this setting, bowel wall thinning or thickening in watershed areas may occur.
- Venous thrombosis occurs in the context of vasculitis, portal hypertension or in paraneoplastic syndromes. This aetiology is more likely to present as bowel wall thickening than thinning, and may be more diffuse.
- Several patterns of wall thickening, reflecting different anatomopathological changes (**submucosal edema, submucosal hemorrhage, hypervascular mucosa, pneumatosis intestinalis**) and different stages of the same disease (reversible ischemia, infarction) can be seen.
- Additional findings such as diminished or increased bowel wall enhancement, bowel distension, mesenteric fat stranding and ascites can also be appreciated.
- Intestinal pneumatosis, mesenteric venous gas, pneumoportia, pneumoperitoneum are indicative of bowel gangrene, and carry an extremely bad prognosis.



MESENTERIC ISCHEMIA

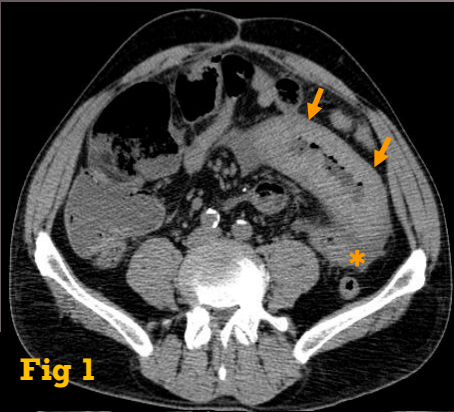


Fig 1



Fig 2

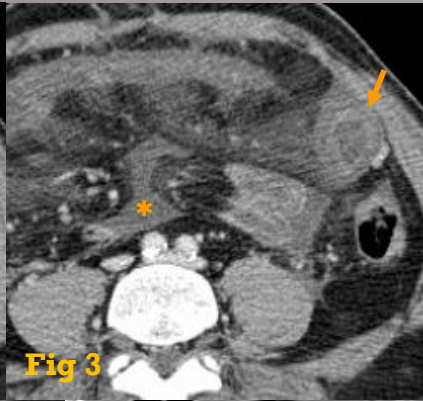


Fig 3



Fig 4

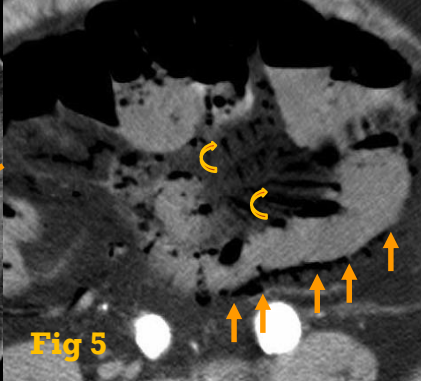


Fig 5

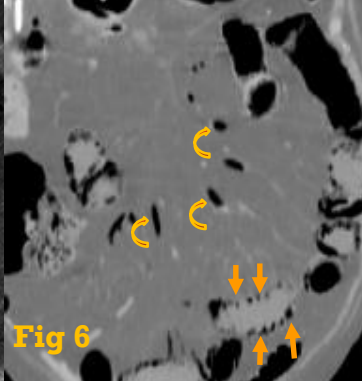


Fig 6

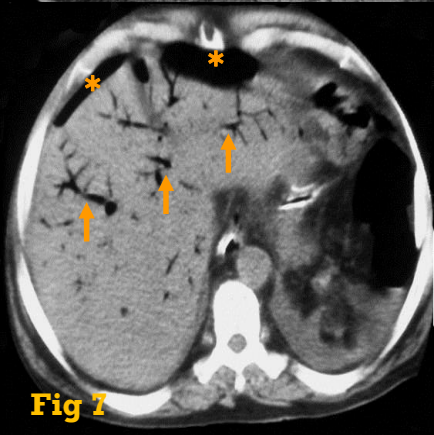


Fig 7



Fig 8

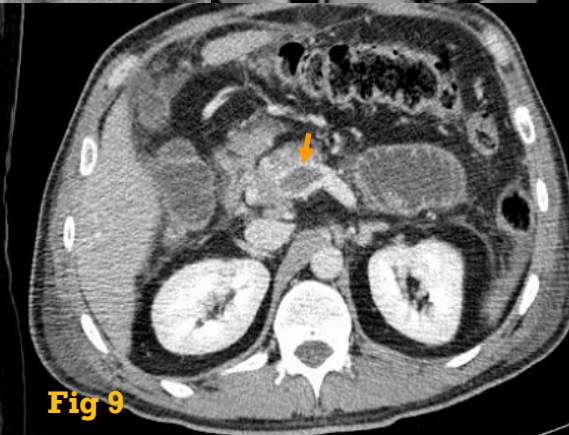


Fig 9

Fig 1 – Submucosal haemorrhage manifests as spontaneously hyperdense thickening of the bowel wall (arrows). Note also ascites (asterisk).

Fig 2 – In an early phase of the disease there might be mucosal hyperenhancement (arrows).

Fig 3 – A water-halo sign may be seen when there is edema at the submucosa (arrows).

Fig 4 – When infarction has already occurred there is bowel wall thinning, rather than thickening, with diminished enhancement (arrows).

Fig 5 and 6 – Bowel wall pneumatosis (arrows) indicates bowel infarction. Note also gas inside the small mesenteric veins (curved arrows).

Fig 7- Portal venous gas (arrows) and pneumoperitoneum (asterisk) indicate bowel wall infarction.

Fig 8 – Occlusion at the superior mesenteric artery (arrow).

Fig 9 – Superior mesenteric venous thrombosis (arrow).



PSEUDO-PNEUMATOSIS AND BENIGN CAUSES OF PNEUMATOSIS

- Gas adjacent to the bowel wall can mimic pneumatosis - this is called pseudopneumatosis.
- Some examples of these conditions are the string of pearls sign in the setting of small bowel obstruction and gas bubbles trapped between fecal debris and the bowel wall.
- Any process that causes discontinuity of the mucosa can cause intramural gas (be it bowel ischemia, trauma or infection).
- In pneumatosis intestinalis the gas bubbles are within both the dependent and antidependent bowel wall and may have a geometric rather than round morphology. Gas in the mesenteric veins and pneumoportia supports this diagnosis.
- In primary pneumatosis cystoides intestinalis, cystic lucencies are seen in the bowel wall of the proximal descending colon.
- The secondary form of pneumatosis cystoides intestinalis can be seen in patients with asthma and COPD. Ruptured lung blebs allows air to dissect down through the retroperitoneum or the mesentery to the serosa or submucosa of the bowel wall. It is more common at the small bowel and manifests as linear and streak-like, rather than cystic, air paralleling the bowel wall.



PSEUDO-PNEUMATOSIS AND BENIGN CAUSES OF PNEUMATOSIS

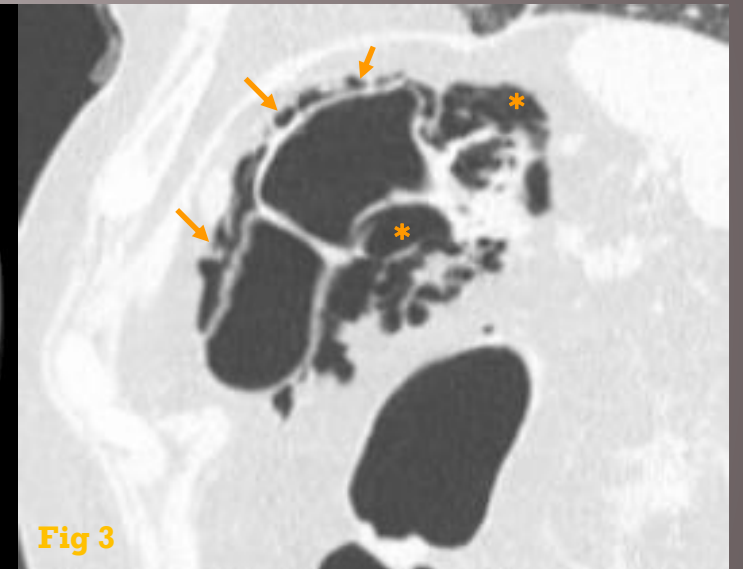
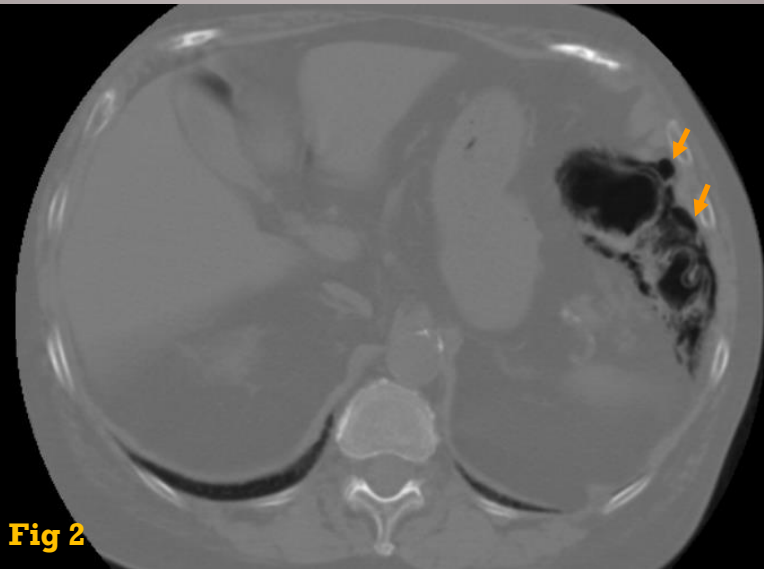
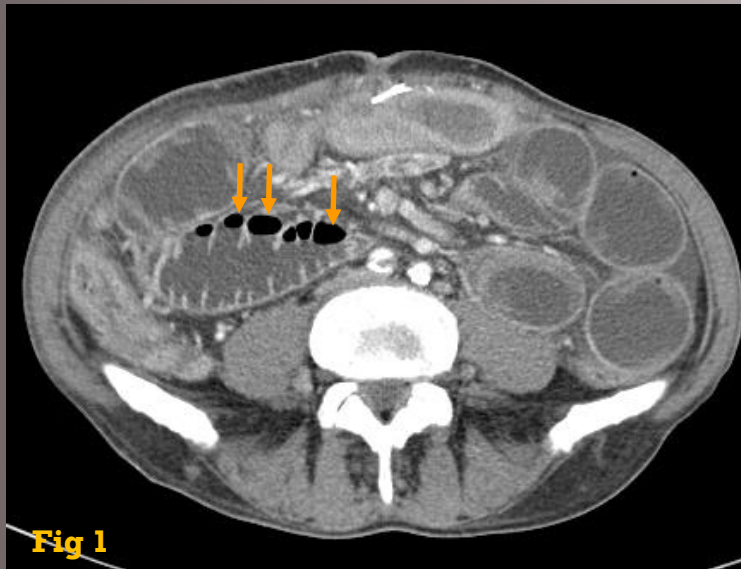


Fig 1 – Abdominal CT of a patient in which the folds of the small bowel are widened and air bubbles become trapped in a stepladder configuration on the ventral side, mimicking pneumatosis (arrows). This is the string of pearls sign in a patient with small bowel obstruction.

Figs 2 and 3 – Routine chest CT of a patient with chronic obstructive pulmonary disease (COPD) shows air bubbles and linear streaks of air within the bowel wall of the hepatic flexure of the colon (arrows) and pneumoperitoneum (asterisks). This was an incidental finding in an outpatient with no abdominal symptoms.



KEY POINTS

- The **white** pattern indicates a benign cause, either inflammatory, infectious or ischemic.
- The **gray** pattern is the most unspecific of all, with benign and malignant causes.
- Malignancy almost always presents with a **gray** pattern and never presents with a stratified appearance (water-halo or fat-halo).
- The double-halo and target signs (**water-halo** pattern) usually indicate an acute inflammatory or ischemic condition.
- A **fat-halo** sign in the small bowel is all but indicative of Crohn's disease.
- Pneumatosis intestinalis (**black pattern**) almost always means bowel gangrene.
- Adjacent mesenteric changes (fat stranding, ascites, vascular engorgement) point to an inflammatory cause, while their absence should raise the hypothesis for malignancy.
- Diffuse or segmental, uniform, symmetric small bowel wall thickening, with tapered edges is indicative of a benign cause (pitfall – lymphoma).
- Focal, asymmetric, broad thickening, with mucosal fold destruction and heaped-up edges is suspicious for malignancy.



CONCLUSION

- In the presence of small bowel wall thickening at CT, a pattern-based approach is highly recommended.
- Knowledge of the different types of bowel wall thickening and most common causes for each pattern is of paramount importance for every diagnostic radiologist, so that a presumptive diagnosis can be formulated at CT.
- Other clues such as the morphology of the diseased segment (length, symmetry, edges, thickness, *valvulae conniventes*) and adjacent mesenteric, vascular or distant organ anomalies, may help in further narrowing the differential diagnosis.



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