Primary and secondary neoplasms of the small bowel: Appearance on MRI and MDCT

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Learning objectives

1. To illustrate small bowel anatomy and to review the available techniques with MRI and MDCT.

2. To describe imaging findings and differential diagnosis for the most frequent neoplasms of the small bowel on MDCT and MRI images in correlation with gross pathology.

I. ANATOMY

From an anatomical point of view the small bowel is divided into duodenum, jejunum and ileum:

The duodenum is compressed between the pyloric antrum and the Treitz ligament and is divided into three or four portions.

1. The first (superior) part begins as a continuation of the duodenal end of the pylorus. It passes laterally (right), superiorly and posteriorly, for approximately 5 cm, before making a sharp curve into the superior duodenal flexure. It is intra-peritoneal

2. The second (descending) part of the duodenum begins at the superior duodenal flexure. It passes inferiorly to the lower border of vertebral body L3, before making a sharp turn medially into the inferior duodenal flexure (the end of the descending part). The pancreatic duct and common bile duct enter the descending duodenum, commonly known together through the major duodenal papilla. This part of the duodenum also contains the minor duodenal papilla, the entrance for the accessory pancreatic duct.

3. The third (inferior/horizontal) part of the duodenum begins at the inferior duodenal flexure and passes transversely to the left.

4. The fourth (ascending) part passes superiorly, either anterior to, or to the right of, the aorta, until it reaches the inferior border of the body of the pancreas. Then, it curves anteriorly and terminates at the duodenojejunal flexure where it joins the jejunum before the ligament of Treitz.

Jejunum and ileum do not present a neat anatomical division and no landmarks are clearly identified. The most simple way to differentiate each other on imaging is to pick out the different mucosal pattern: in healthy individuals multiple mucosal folders are present in the jejunal tract, while the ileum has a smooth surface.

Moreover the jejunum contains very few Brunner's glands (found in the duodenum) or Peyer's patches (found in the ileum). Instead, it has many large circular folds in its submucosa called

plicae circulares which increase the surface area for nutrient absorption.

II. PATHOPHISIOLOGY OF SMALL BOWEL MALIGNANCIES

Although the small bowel contains 90% of the mucosal surface area and 75% of the length of the alimentary tract and is located between 2 organs with high cancer prevalence (ie, stomach, colon), malignant neoplasms of the small bowel are among the rarest types of cancer, accounting for only 2% of all GI cancers. This low prevalence is explained by large volumes of alkaline fluid, enzymes, and immuno-globulins, which dilute and detoxify carcinogens and by the limited numbers of bacteria in that are less capable of transforming procarcinogens.

Approximately 64% of all small-bowel tumors are malignant, and approximately 40% of these tumors are adenocarcinomas with much resemblance to large-bowel adenocarcinomas. They tend to occur toward the gastric end of the small intestine: 50% in the duodenum, 30% in the jejunum, and 20% in the ileum.

Sarcomas and GISTs account for approximately 8% of small-bowel malignancies, while other common neoplasms are represented by carcinoid tumours (20-43%) and lymphomas. Last are found metastases, mainly from melanoma, lymphoma, ovarian cancer and breast cancer.

III. MRI and MDCT IMAGING

Good quality imaging of small bowel neoplasms with advanced cross sectional modalities mainly relies on one single factor apart from technology limitations: PATIENTS' PREPARATION.
When preparing a patient two points must be considered:

- In physiological conditions the small bowel can be totally or in part empty, so the lumen must be distended with oral contrast material. In MRI the biphasic agents are the most diffused, cost effective and appreciated compounds. Biphasic agents make out the most of T1 and T2 weighted sequences and contrast enhanced T1 sequences with fat saturation. Water is the most common and less expensive biphasic agent, but other compounds with moderate osmolar effects are also employed with success to achieve better bowel distension.

In MDCT the contrasts employed are different in correlation to the segment of interest: low density agents (i.e. water or low density barium suspensions) are preferred to imagine the upper tract, such as the duodenum, or to evaluate wall enhancement, while high-density

agents (i.e. iodine-based oral contrasts) are preferred to imagine jejunum and ileum.

-In physiological conditions the small bowel does have peristalsis, so a precise evaluation of contrast medium doses, delay of administration and eventual use of anti-peristaltic agents should be performed. Usually up to a 1-1.5 lt of the oral contrast compound are administered for both MRI and MDCT examinations (the administration of contrasts through naso-gastric tube is performed in some specific clinical situation and will not be considered in this exhibit). The optimal delay between the administration and the examination is in the order of seconds/few (5) minutes for the evaluation of duodenum and the first tract of the jejunum, while it must be longer when dealing with ileum (up to 25-30 minutes). Anti-peristaltic agents should always be administered, but their use is a MUST in MRI where image degradation from peristaltic movements cannot be prevented.

- Imaging protocols for MRI usually include T2 weighted single-shot sequences (HASTE or similar, to image bowel lumen, wall and surrounding anatomical structures), T2 weighted steady-state precession sequences (TRU-Fisp or similar, mainly to image the lumen) and T1 weighted 3D GRE sequences with fat-suppression acquired before and after i.v. Gd administration (for the evaluation of enhancing formations). All sequences should be performed on at least the axial plane, with a couple of coronal acquisitions usually on TRU-Fisp and GRE sequences. MDCT examinations should be performed using thin-slice protocols with low collimations values (1 mm) to empower 3D reconstructions. Scanning delay is usually set on the portal-venous phase (65 s), unless exists the clinical suspect for hyper-vascular formations (i.e. carcinoid tumours) that must be imaged even in the artero-portal phase.

IV. IMAGING FINDINGS AND DIFFERENTIAL DIAGNOSIS OF SMALL BOWEL MALIGNANCIES

- Adenocarcinoma: may manifest as an annular narrowing with irregular edges, discrete tumor mass, or an ulcerative lesion. Narrowing of the lumen leads to partial or complete obstruction. Imaging shows a soft-tissue mass with heterogeneous enhancement, usually. Although distal adenocarcinomas tend to be annular, duodenal adenocarcinomas are more likely papillary or polypoid.

- GISTs: may be submucosal, subserosal, or intraluminal. Submucosal GISTs appear as smooth oval filling defects. Subserosal GISTs are extrinsic or exocentric masses that displace adjacent bowel loops. Hypervascular intraluminal GISTs are associated with hemorrhage and ulceration. Both benign malignant GISTs may take any of these forms. Findings associated include irregular mass with central necrosis, ulceration, calcification or direct extension and vascular encasement (10).

- Carcinoid: may vary in appearance from a small submucosal lesion to a large intraluminal ulcerating lesion. Are usually small (<2- cm). Single or multiple filling defects may be detected. Carcinoid tumor may appear as an [Jejunal carcinoid tumour] ill-defined, homogeneous mass with displaced bowel loops. A stellate pattern of [Ileal carcinoid tumour] soft tissue stranding (desmoplastic reaction) and calcification of the mesentery can be demonstrated easily at CT.

- Lymphoma: may appear as a nodular filling defect, a discrete polyp that may be the lead point of an intussusception, a long, infiltrating lesion with ill-defined, thick walls with or a large exocentric mass extending into adjacent tissues. In most cases, small bowel lymphoma appears as a large, segmental nodular wall thickening. A gradual junction of tumor with normal mucosa can be present. The asymmetry of the bowel wall that occurs with lymphoma may be mistaken as a sign of adenocarcinoma. However, lymphoma is usually accompanied by bulky retroperitonea! lymphadenopathy.

-Metastases:

From intraperitoneal seeding: the most frequently encountered intraperitoneal metastases to the small bowel are primary mucinous tumors of the ovary, appendix, or colon. Metastases may increase bowel wall thickness or may infiltrate the mesenteric or intraperitoneal fat and cause stranding.

Hematogenous metastases: bronchogenic carcinoma, breast carcinoma, malignant melanoma, and renal cell carcinoma often metastasize to the small bowel via the bloodstream. Malignant melanoma produces smooth, round to polypoid metastases that can cause transient intussusception rather than complete obstruction. The mass often is a 'target' lesion with central ulceration. Metastatic renal cell carcinoma may lead not only to local invasion but also to small bowel intussusception.

V. CONCLUSIONS

Small bowel neoplasms are uncommon. MRI and MDCT are useful for evaluating small bowel masses, especially in patients with obstruction. They may determine location and features of the mass and ancillary findings to document the extent of disease or concomitant disease. CT may distinguish between primary and metastatic tumors. Differentials diagnoses can be focused when there are typical features of tumors in specific locations, such as a polypoid mass in a duodenal adenocarcinoma, marked wall thickening with bowel dilatation in lymphoma, a mesenteric mass with calcification and desmoplasti reaction in a distal ileal carcinoid tumor or a large inhomogenous and necrotic tumour in a GIST. However, the overlapping appearances of many of these lesions constitute imaging pitfalls.

References

Sailer J, Zacherl J, Schima W. MDCT of small bowel tumours. Cancer ImagingCancer Imaging. 2007 Dec 17;7:224-33. PMID: 18083648 [PubMed - in process]

Fidler J. MR imaging of the small bowel. Radiol Clin North AmRadiol Clin North Am. 2007 Mar;45(2):317-31. Review. PMID: 17502220 [PubMed - indexed for MEDLINE]

Gore RM, Mehta UK, Berlin JW, Rao V, Newmark GM. Diagnosis and staging of small bowel tumours. Cancer ImagingCancer Imaging. 2006 Dec 29;6:209-12. Review. PMID: 17208678 [PubMed - indexed for MEDLINE]

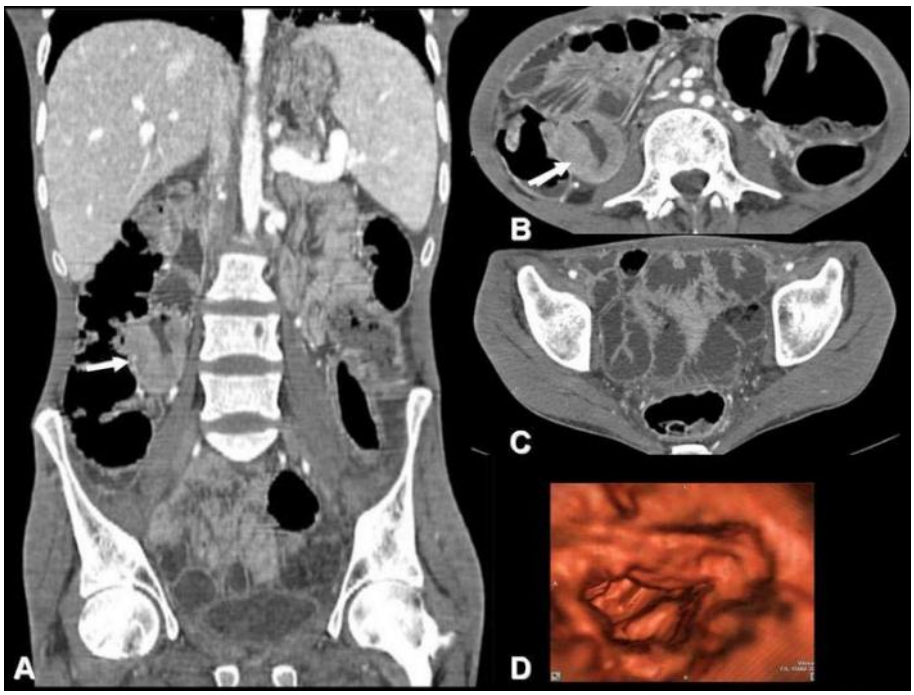
Darnell A, Dalmau E, Pericay C, Musulén E, Martín J, Puig J, Malet A, Saigí E, Rey M. Gastrointestinal stromal tumors. Abdom ImagingAbdom Imaging. 2006 Jul-Aug;31(4):387-99. Epub 2006 Feb 7. PMID: 6465584 [PubMed - indexed for MEDLINE]

Minordi LM, Vecchioli A, Mirk P, Filigrana E, Poloni G, Bonomo L. Multidetector CT in small-bowel neoplasms. Radiol Med (Torino)Radiol Med (Torino). 2007 Oct;112(7):1013-25. Epub 2007 Oct 21. English, Italian. PMID: 17952678 [PubMed- indexed for MEDLINE]

Kaltsas G, Rockall A, Papadogias D, Reznek R, Grossman AB. Recent advances in radiological and radionuclide imaging and therapy of neuroendocrine tumours. Eur J EndocrinolEur J Endocrinol. 2004 Jul;151(1):15-27. Review. PMID: 15248818 [PubMed - indexed for MEDLINE]

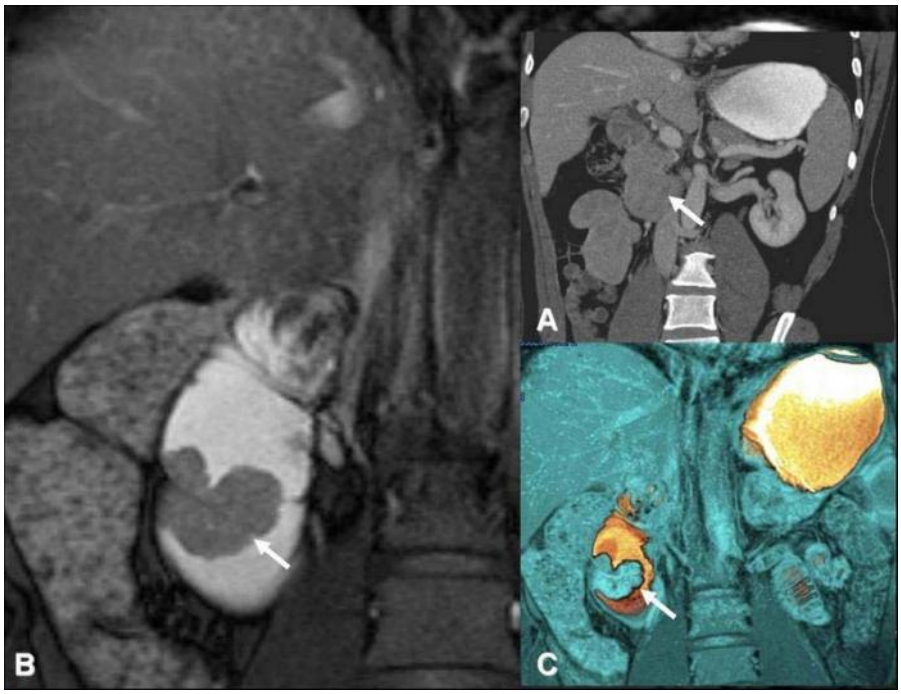
Horton KM, Fishman EK. Multidetector-row computed tomography and 3-dimensional computed tomography imaging of small bowel neoplasms: current concept in diagnosis. J Comput Assist Tomogr. 2004 Jan- Feb;28(1):106-16. Review. PMID: 14716243 [PubMed - indexed for MEDLINE]

Carcinoid tumour of the last ileal loop



A large concentric stenosis of the last ileal loop (arrow) is identified on coronal (A) and axial (B) CT images. On caudal slices is also seen fluid distension of the small bowel, a finding that is coherent with hypersecretion induced by hormonal discharge from the carcinoid tumour. The lesions were identified by chance in a patient referred for positive blood stools whom underwent virtual colonoscopy. Volume rendering image (C) shows the irregular mucosal surface of the last ileal loop seen from the ciecum.

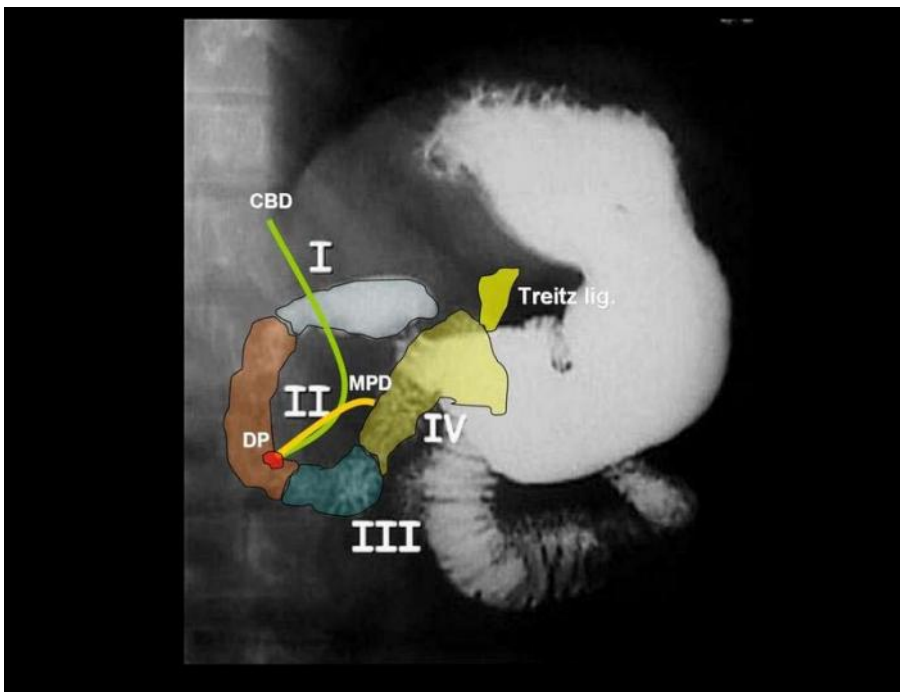
Duodenal adenocarcinoma



Well differentiated duodenal adenocarcinoma (arrow) is nicely seen on coronal FS TRU-fisp T2-w images with (C) and without (A) color- coding. CT

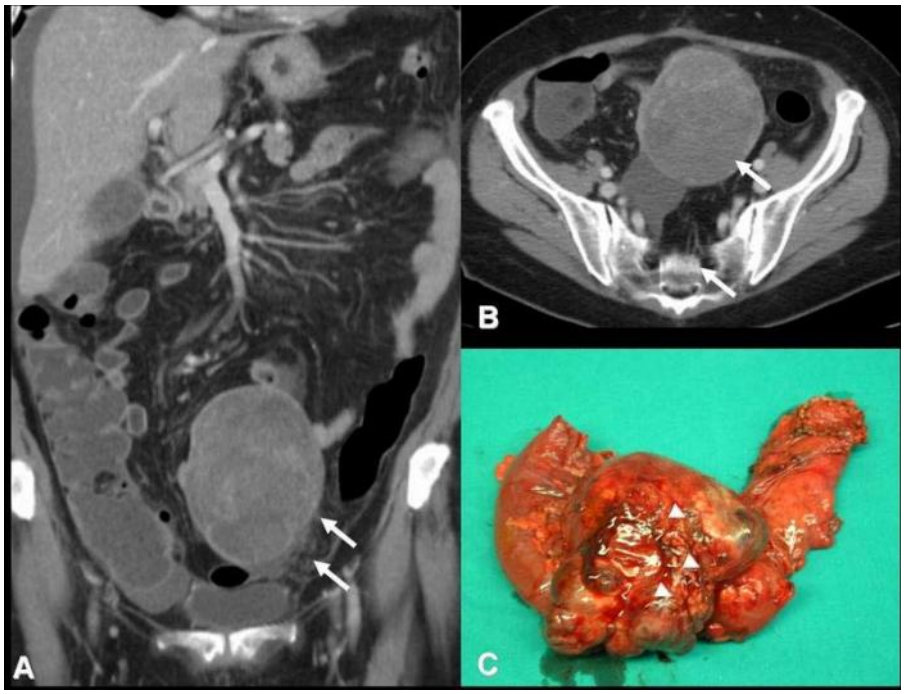
Image (B) only showed a specific irregular thickening of the duodenum without clear differentiation between the lesions and the surrounding wall.

Duodenum: anatomy



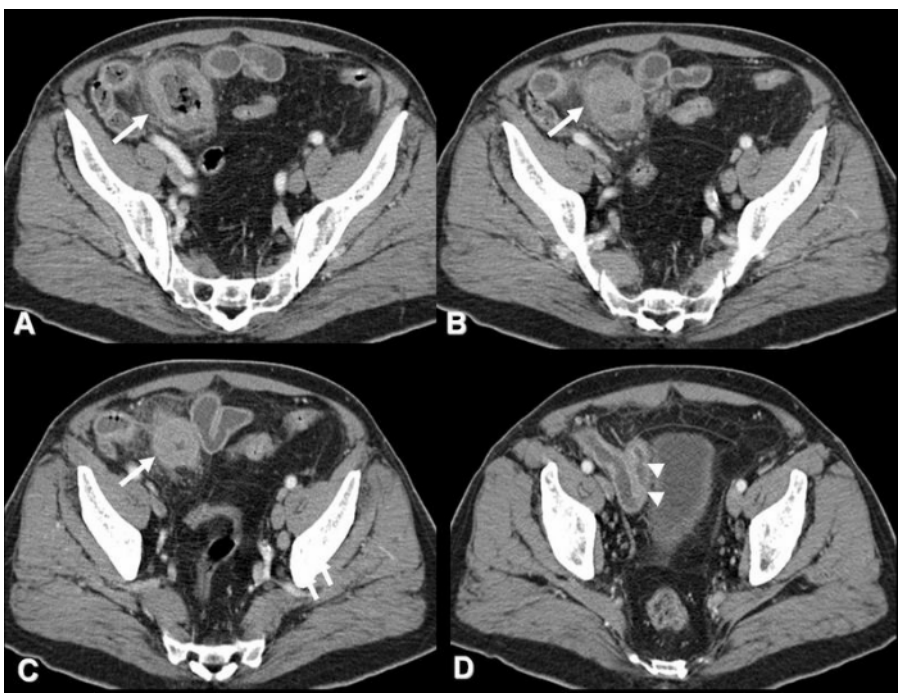
Cyan: I portion, Pale Red: II portion, Dark Green: III portion, Yellow: IV portion. Green: Common Bile Duct, Orange: Main Pancreatic Duct, Red: Duodenal Papilla, Sand: Treitz ligament.

Ileal GIST



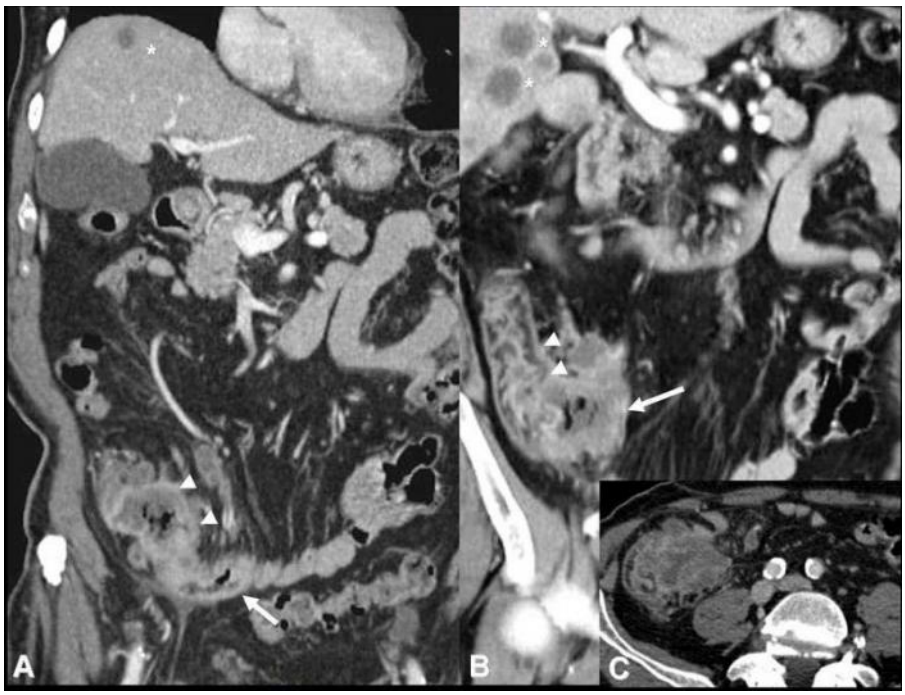
Reformatted (A) and conventional (B) CT images demonstrate a large, extrinsic mass originating from the ileal wall. The lesion (arrows) is round with smooth margins; however the large size and the concurrent necrotic manifestations (arrowheads in C) are highly suspicious for a malignant GIST. Findings were confirmed at gross pathology (C).

Ileal Lymphoma



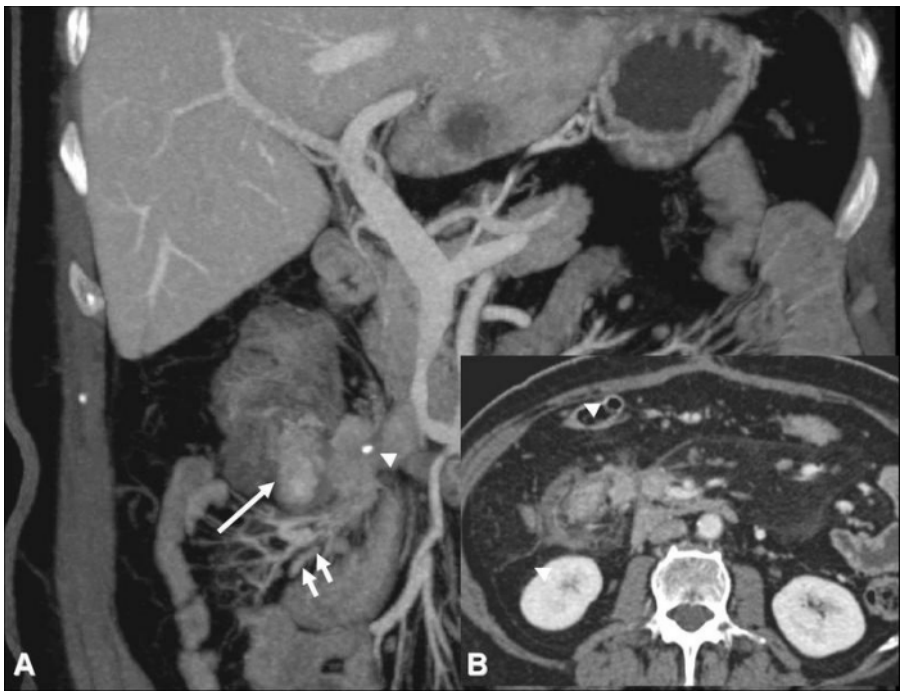
A large globular intraparietal mass is depicted on one of the the last ileal loops (A-B-C-arrows). Gradual passage between the affected loop and the following bowel tract can be seen (D-arrowheads).

Ileal adenocarcinoma



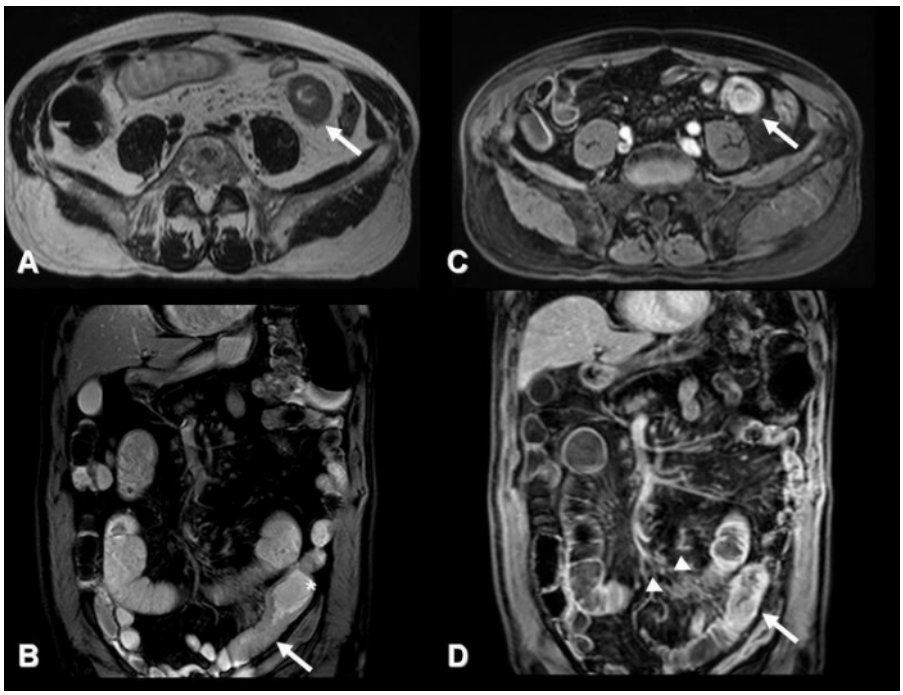
Reformatted (A-B) and conventional axial (C) CT images demonstrate an ill-defined, infiltrating lesions with ulcerated borders (arrows) that originates from the last ileal loop and infiltrates the ciecum (arrowheads). Scanting of the surrounding fat tissue is also depicted, as for neoplastic infiltration.

Ileal carcinoid tumour



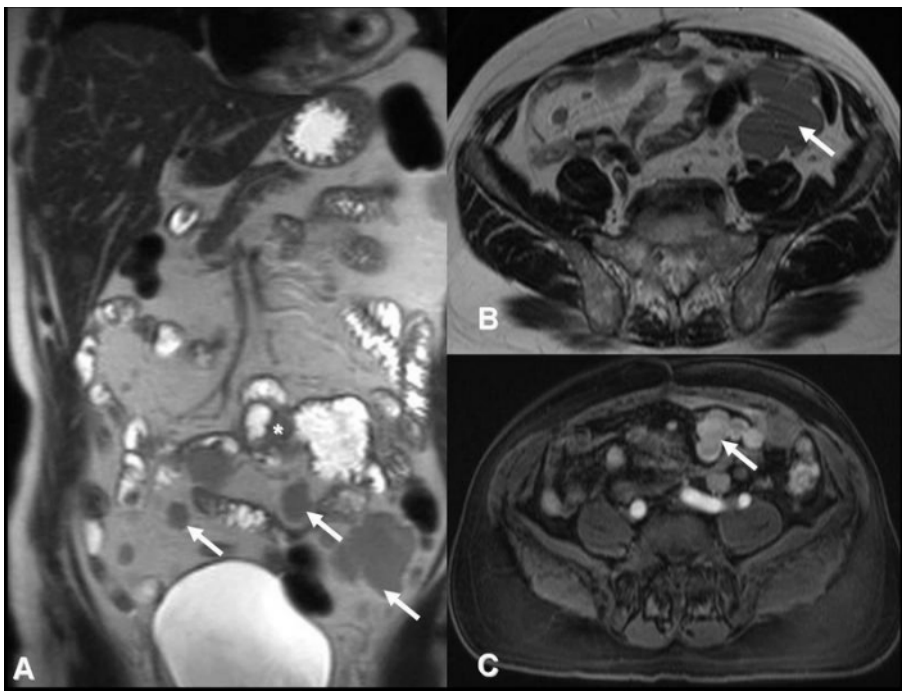
Again a hypervascular lesion (A-arrow) can be identified inside one of the ileal loops. Calcifications as well as diffuse and infiltrative stranding of the mesentery can be seen (B).

Jejunal Adenocarcinoma



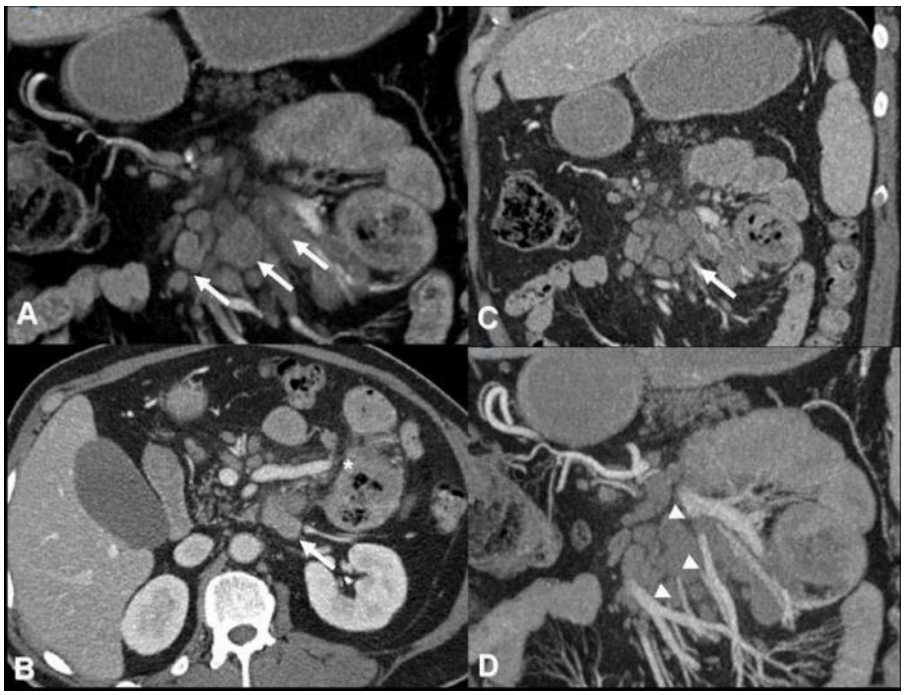
Concentric narrowing of a jejunal loop (arrows) is clearly identified on TSE axial T2-w images (A) and coronal T2-w FS TRU-fisp images. After i.v. Gd administration the lesion shows marked enhancement on GRE 3D T1-w images and concurrent congestion of mesenteric feeding vessels (arrowheads).

Jejunal GIST



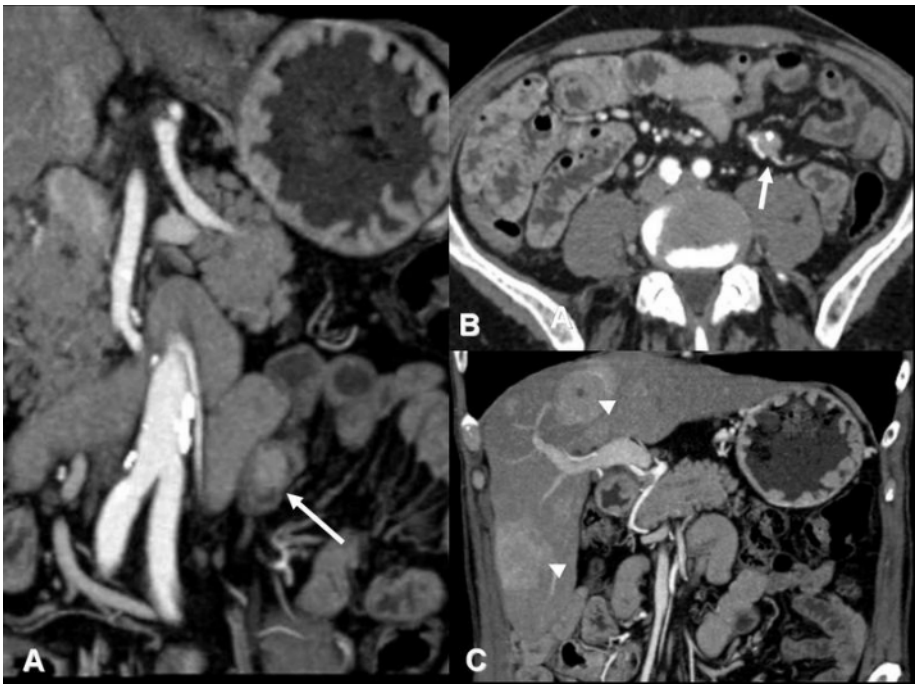
On coronal (A) and axial (B) TSE T2-w images are demonstrated multiple nodularities that infiltrate the mesenteric fat tissue and the bowel loops (arrows). Primitive lesion is also seen on the coronal plane (asterisk). At pathology the lesion was confirmed as a highly malignant, undifferentiated GIST.

Jejunal Lymphoma



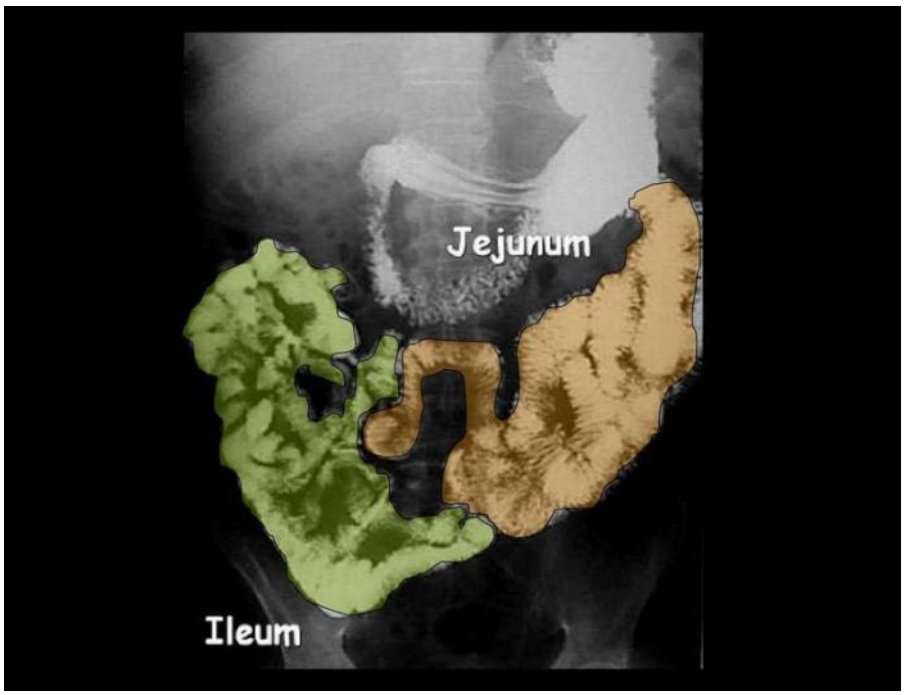
A large ulcerated mass is seen on axial CT images (B-asterisk) originating from one of the first jejunal loops. The lesions has ill-defined margins and determines vascular engorgement (D-arrowheads). Multiple mesenteric adenopathies (A-B-C-arrows) are present. Pathologic findings confrimed a high-grade B-cell lymphoma.

Jejunal carcinoid tumour



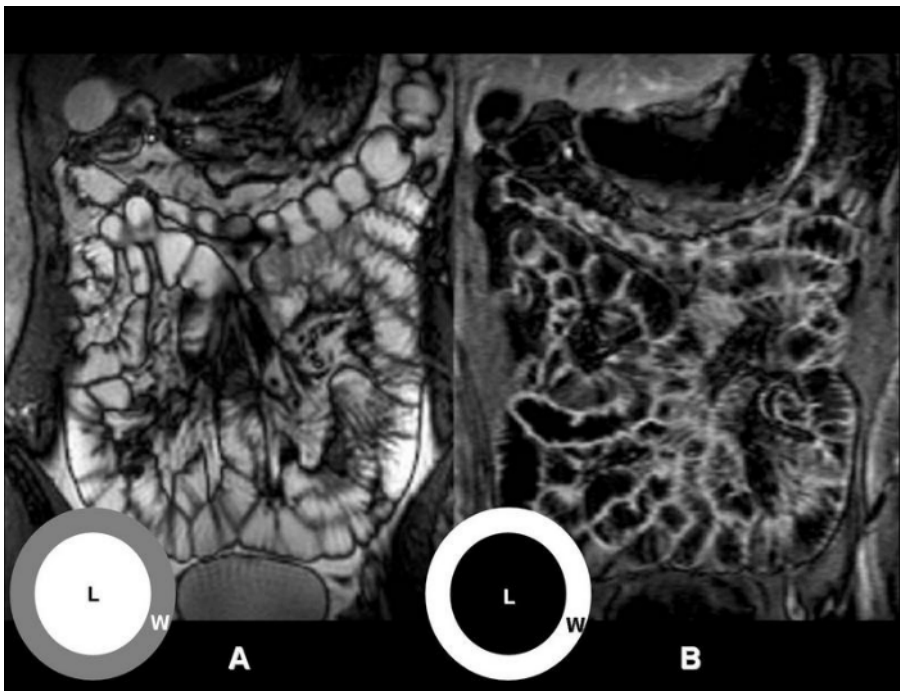
Hypervascular intraluminal mass can be clearly identified in one of the first jejunal loops (A-arrow). The typical desmoplastic reaction with punctate calcifications is also seen (B-arrow). In this patients were also depicted hypervascular liver metastases (C-arrowheads).

Jejunum and Ileum: anatomy



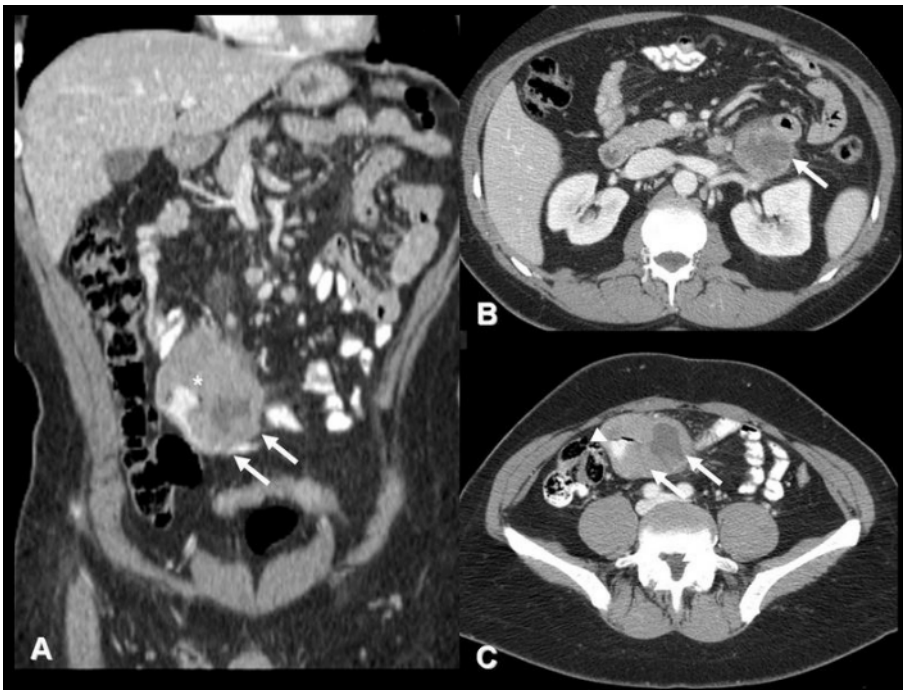
Pale orange: jejunum, on the left side of the peritoneal cavity with evidence of marked mucosal fold pattern. Pale green: ileum, on the right side of the peritoneal cavity, with smooth mucosal appearance.

MRI appearence of biphasic oral contrast agents.



In T2-w sequences (A) biphasic agents allow "bright-lumen" visualization with good contrast with bowel walls. In T1-w sequences (B) they can be coupled with iv. Gd administration to evaluate wall enhancement end eventual engorgement of vascular structures.

Metastases from cutaneous melanoma



Multiple, large, doughnut shaped metastases from cutaneous melanoma to the jejunum (B-arrow) and ileum (A-C-arrows). Necrosis (A- asterisk) and progressive narrowing of the lumen (C-arrowheads) by extrinsic compression are seen.