Malignant tumors of the small bowel: CT features with pathologic correlation

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Purpose

1. To describe how to perform a CT when a small bowel tumor is suspected

2. To review the characteristic CT features of the main malignant tumors of the small bowel

3. To understand the CT findings thanks to the pathologic correlation
Contents

1. Epidemiology and clinical considerations

2. Technical management of CT-enteroclysis

3. CT features with gross pathologic and histologic features
Epidemiology and clinical considerations

• Rare:
  ➢ <5% of gastrointestinal (GI) tumors
  ➢ Incidence rate of 1.9/100,000/year

• Clinical features:
  • Asymptomatic
  • Non-specific complaints: abdominal pain, bleeding, anaemia, nausea and vomiting, weight loss, diarrhea and intestinal obstruction (adenocarcinoma and neuroendocrine tumors)
  • Only 10% of patients (mostly if hepatic metastases are present) with neuroendocrine tumors develop a carcinoïd syndrome (secretory diarrhea, flush, cardiac valvular lesions, bronchial constriction)

Significant delay in diagnosis
WHO classification of tumours of the small intestine

<table>
<thead>
<tr>
<th>Epithelial tumours</th>
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<td>Premalignant lesions</td>
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| Adenoma | 8140/0  
| Tubular | 8211/0  
| Villous | 8261/0  
| Tubulovillous | 8263/0  
| Dysplasia (intraepithelial neoplasia), low grade | 8148/0*  
| Dysplasia (intraepithelial neoplasia), high grade | 8148/2  
| Hamartomas |  
| Juvenile polyp |  
| Peutz-Jeghers polyp |  
| Carcinoma |  
| Adenocarcinoma | 8140/3  
| Mucinous adenocarcinoma | 8480/3  
| Signet ring cell carcinoma | 8490/3  
| Adenosquamous carcinoma | 8560/3  
| Medullary carcinoma | 8510/3  
| Squamous cell carcinoma | 8070/3  
| Undifferentiated carcinoma | 8020/3  
| Neuroendocrine neoplasms |  
| Neuroendocrine tumour (NET) |  
| NET G1 (carcinoid) | 8240/3  
| NET G2 | 8249/3  
| Neuroendocrine carcinoma (NEC) |  
| Large cell NEC | 8013/3  
| Small cell NEC | 8041/3  
| Mixed adenoneuroendocrine carcinoma | 8244/3  
| EC cell, serotonin-producing NET | 8241/3  
| Gangliocytic paraganglioma | 8683/0  
| Gastrinoma | 8153/3  
| L cell, Glucagon-like peptide-producing and PP/PYY-producing NETs | 8152/1*  
| Somatostatin-producing NET | 8156/3  
| Mesenchymal tumours |  
| Leiomyoma | 8890/0  
| Lipoma | 8850/0  
| Angiosarcoma | 9120/3  
| Gastrointestinal stromal tumour | 8936/3  
| Kaposi sarcoma | 9140/3  
| Leiomyosarcoma | 8890/3  
| Lymphomas |  
| Secondary tumours |  

*a The morphology codes are from the International Classification of Diseases for Oncology (ICD-O) [904A]. Behaviour is coded /0 for benign tumours, /1 for unspecified, borderline or uncertain behaviour, /2 for carcinoma in situ and grade III intraepithelial neoplasia, and /3 for malignant tumours.

*b The classification is modified from the previous (third) edition of the WHO histological classification of tumours [691] taking into account changes in our understanding of these lesions. In the case of neuroendocrine neoplasms, the classification has been simplified to be of more practical utility in morphological classification.

* These new codes were approved by the IARC/WHO Committee for ICD-O at its meeting in March 2010.
CT-enteroclysis (CTE)

- CTE has emerged to be an effective imaging tool for:
  - the detection of small bowel tumors (Sensitivity=92.8%; Specificity 99.2% *)
  - the characterization of small bowel tumors
  - the exploration of extraluminal manifestations of disease

- CTE is complementary to capsule endoscopy in the investigation of small-bowel tumors.


Ileal NET in a 68-year-old man with abdominal pain. CTE shows a submucosal polypoid mass of the ileum (red arrow). The nasojejunal tube (yellow arrow) is clearly seen in the duodenum.
Technical management of CTE

• CTE combines enteroclysis and helical CT.

• Our procedure:

1. Nasojejunal tube (8F) placed beyond the duodenojejunal flexure using fluoroscopy.
2. 1 - 1.5L of water infused with an electric pump at a rate of 150 mL/min
3. Unenhanced scan
4. Intravenous iodinated contrast: 3-4 mL/s; 2 mL/kg
5. Biphasic scan: arterial phase, 25s; portal phase, 70s
6. Water infusion through the nasojejunal tube is maintained during image acquisition.
Neuro-endocrine tumors (NET)

- Mainly originate from the enterochromaffin cells (EC-cells)
- Produce serotonin and other histamine-like substances
- Predominantly located in the distal ileum, followed by the jejunum
- 5-year survival rate = 54%

Photomicrograph (original magnification, x20; Hematoxylin and eosin (H-E) stain) of a small bowel NET.
NET: Pathologic features

- **Gross pathology**
  - Small (often <3.5cm) mucosal /sub-mucosal nodule
  - Transmural extension to the adjacent mesentery stimulate considerable fibroblastic or desmoplastic reaction (induced by the secretion of serotonin), with consequent angulation, kinking of the bowel

- **Histopathology**
  - Characteristic rounded nests of tumor cells that may be oriented into cords
  - Reactive with chromogranin A antibodies
  - EC-cells can be identified using immunohistochemical staining
  - Proliferative activity (G1-G3)

Pathologic features of small bowel NET. (a) Photograph of a cut section of a resected ileum shows a submucosal nodule (*). (b) Photomicrograph (original magnification, x20; H-E stain) shows the rounded configuration of an ileal NET (*) with focal desmoplastic thickening of the muscularis propria (*). (c) Photomicrograph (original magnification, x200; H-E stain) shows the nests of tumor cells oriented into cords.
**NET: CT features**

- **The primary tumor:**
  - Usually a small submucosal lesion but can vary to a large intraluminal ulcerating lesion
  - With early and marked enhancement
  - Lesions may be multiple (30%)

Multifocal ileal NETs discovered in a 55-year-old man with associated liver metastases. (a) Contrast-enhanced CT scan shows two small hypervascular submucosal masses of the ileum with a calcified adjacent mesenteric mass (*) (b, c) Photographs of the resected ileum show the two NETs. (d, e) Photomicrographs (original magnification, x20, H-E stain) show the two tumors.
• Larger tumors may generate **kinking**, fixation, and distortion of small bowel loop
• **Obstruction is not uncommon** since the tumor is usually associated with desmoplastic reaction

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**Ileal NET in a 71-year-old man with abdominal pain.**

(a) Contrast-enhanced CT scan shows a submucosal mass causing kinking of the small bowel loop (curved red arrow) associated with a mesenteric mass (blue arrow). (b) Photograph of the resected ileum shows the submucosal mass (arrow). (c) Photomicrograph (original magnification, x20, H-E stain) demonstrates the angulation of the ileal wall. The desmoplastic kinking forms a hairpin turn (*) in the ileal wall.
The most characteristic feature is a mesenteric mass resulting from the desmoplastic reaction.

CTE shows an ill-defined soft-tissue mass with stellar spiculations and calcifications in up to 70%, adjacent to a thickened small bowel wall.

Reformatted images help confirm the presence of radiating strandlike densities, that correlate to the degree of fibrosis.

NET in a 65-year-old women with chronic digestive disorder. Contrast-enhanced CT scan sagittal MIP (a) and axial (b) reformation reveal a spiculated mesenteric mass (*) that contains a small calcification in association with radiating strand-like densities (blue arrows). Vascular encasement of the mesenteric vessels (red arrow) and thickening of the bowel loops (*) are seen.
NET in a 65-year-old women with chronic digestive disorder (same patient as previous slide). (a) Contrast-enhanced CT scan reveals a spiculated mesenteric mass that contains a small calcification (curved arrow) in association with radiating strand-like densities. (b, c, d) Photographs show the mesenteric mass (*) resected with cut section, the mesenteric fibrosis (red arrow) and the vascular encasement (black arrow). (e) Photomicrograph (original magnification, x20, H-E stain) of the mesenteric mass shows the vascular encasement by the tumor (black arrow).
NET: CT features

- **Mesenteric vessel** can be involved:
  - Directly by tumour encasement and narrowing
  - Indirectly by the secretion of neuroendocrine chemicals that causes **elastic sclerosis**

- As a result, **thickening and ischemia** of the involved small-bowel loops may be seen

Small bowel NET in a 60-year-old man who complained of a history of diarrhea and flushing. (a, b) Contrast-enhanced CT scans show vascular encasement (red arrow) of the superior mesenteric artery and small bowell wall thickening (blue arrow). (c) Photomicrograph (original magnification, x20; H-E staining) shows elastic sclerosis (*) of the superior mesenteric artery. (d) Photomicrograph (original magnification, x20; H-E staining) of a resected ileal loop shows a submucosal edema (*).
Adenocarcinoma (ADK)

- Second most common primary malignant tumor in the small intestine

- Mostly located in the *proximal jejunum* with the incidence decreasing distally, except in Crohn disease (ileum) (duodenum was not included in the definition of small bowel)

- **Risk factors:**

- Poor prognosis (5 year survival rate = 26-39%)
ADK: Pathologic features

- **Gross pathology:**
  - annular, constricting tumors with circumferential involvement of the intestine wall
  - at the time of diagnosis most show a fully parietal penetration and involvement of the serosal surface.

- **Histopathology:**
  - composed of villous or tubular structures
  - resemble their counterparts in the colon, but with a higher proportion of poorly differentiated tumors with glandular, squamous and undifferentiated neuroendocrine components

Pathologic features of an ADK of the small bowel. (a) Photograph of a cut section of a resected ileum shows an annular tumor of the intestine wall. (b) Photomicrograph (original magnification, x40, H-E stain) shows infiltration of the submucosa by the tumor cells (*)
ADK: CT features

• May appear as an **annular narrowing** with abrupt concentric or irregular edges, a discrete tumor mass or an ulcerative lesion

• Luminal narrowing may result in partial or complete small bowel obstruction

• **Moderate heterogeneous enhancement**

• Secondary lymphadenopathies may be present and must be differentiated from the bulkier nodes of lymphomatous involvement.

Jejunal adenocarcinoma in a 74 year-old man with anemia. CTE reveals an irregular, circumferential and short thickening of the jejunum wall (arrow) with moderate enhancement.
Ileal adenocarcinoma in a 61 year-old man with abdominal pain. (a) Contrast-enhanced CT scan shows an abrupt constricting mass (curved arrow) resulting in a partial small bowel obstruction with an intussusception (*). (b) Photograph of the resected ileum shows an annular constricting lesion (white arrows). (c) Photograph of a cut section of the resected ileum demonstrates the circumferential mass (black arrows).
Ileal mucinous ADK in a 84 year-old woman with a Crohn disease, who presented with abdominal pain and fever. (a, b) Contrast-enhanced CT scans show an irregular circumferential thickening of an ileal loop (red arrow) associated with an enterocutaneous fistula (blue arrow). (c) Photograph shows on the left side, the circumferential tumor of the bowel wall(*), compared to a normal small bowel loop on the right side. (d) Photomicrograph (original magnification x20; H-E stain) shows the infiltration of the bowel wall by the tumor cells (e) Photomicrograph (original magnification x200; Alcian-blue and H-E stain) shows the lines of tumor cells (yellow arrow) and the mucus (blue arrow).
Lymphoma

- Primary lymphomas are most often non-Hodgkin B cells lymphomas.
- Small bowel lymphoma = 20-30% of all gastro-intestinal tract lymphomas.
- Risk factors:
  - HIV infection, coeliac disease (T-cell lymphoma), immunosuppression after solid organ transplantation, inflammatory bowel disease
- The distal ileum is the most common site of tumor (greater amount of lymphoid tissue)
- Unlike B-cells lymphomas, T cells lymphomas are often seen in the jejunum
- Multiple sites are involved in 10-25% of cases
- 5 year survival rate = 8-25%
Lymphoma: Pathologic features

• **Gross pathology:**
  – Early lesions may appear as plaque-like mucosal expansion while advanced lesions produce **full mural thickening** and mucosal ulceration.
  – Infiltration of the muscularis propria and myenteric plexus causes motility failure and **aneurysmal dilatation**
  – The lack of stromal support may determine necrosis and wall **perforation**

• **Histology:**
  – Primary lymphomas mostly originate from the mucosa-associated lymphoid tissue

**Distribution of histological sub-types of small bowel lymphoma**


Pathologic features of a lymphoma of the small bowel. (a) Photograph of a cut section of the resected ileum shows the full mural infiltrating tumor. (b) Photomicrograph (original magnification, x400; H-E stain) shows small lymphoid cells.
Lymphoma: CT features

- The most common pattern is a **circumferential bulky mass** in the intestinal wall with extension into the mesentery.

- **Other patterns:**
  1. multifocal nodules (requiring differentiation from carcinoid tumour)
  2. single mass-forming lesion
  3. exophytic sarcoma-like form

- **Satellite lymphadenopathies** are usually bulky, larger than in other neoplasms.

- Obstruction is uncommon, since the tumor does not elicit a desmoplastic response.

- **Homogeneous, mild enhancement**
• Aneurysmal dilatation of the lumen may be seen due to replacement of the muscularis propria and destruction of the autonomic nerve plexus.
It may ulcerate and **perforate** into the adjacent mesentery.

Ileal non-Hodgkin lymphoma in a 69-year-old man with acute abdominal pain. (a,b) Contrast-enhanced CT scans show a circumferential bulky mass (*) developed in the bowel wall, with perforation (red arrow) and free air (orange arrow). (c) Contrast-enhanced CT-scan shows the infiltration of the mesenteric fat: peritoneal lymphomatosis (blue arrows). (d) Photograph of a cut section of the resected ileal loop shows the infiltrating lesion with full mural thickening and perforation of the bowel wall (orange arrow).
Gastro-intestinal stromal tumor (GIST)

- GISTs are mesenchymal tumors and 25% of them are located in the small bowel.
- Most GISTs (70%–80%) are benign. There is, however, a continuum from benign to malignant.

- Risk factors:
  - Neurofibromatosis type 1: multiple small intestinal GISTs
  - Carney triad: GIST in association with epithelioid leiomyosarcoma with paraganglioma and pulmonary chondroma

- GISTs are usually located more often in the jejenum than in the ileum.

- 5 year survival rate = 45-55%

*Other includes appendix, gallblader, pancreas, mesentery, omentum and retroperitoneum
GIST: Pathologic features

- **Gross pathology:**
  - Involve the muscularis propria
  - Rounded, well-defined mass (from several millimeters to greater than 30 cm) often developing exophytically or intraluminally
  - Focal areas of hemorrhage, cystic degeneration, and necrosis may occur, particularly in large lesions

- **Histology:**
  - By definition, GISTs are positive for KIT (CD117)
  - Differential diagnosis with true leiomyomas
  - The number of mitotic figures per high powerfield (HPF) is an empirical cut-off to predict the behaviour of the lesion: >5 per 10 HPFs indicate malignancy.

**Histo-pronostic factors: size and mitotic index**

Pathologic features of a GIST of the small bowel arising in a Meckel diverticulum. (a) Photograph of a cut section of the resected Meckel diverticulum shows the tumor developed exophytically (*). (b) Photomicrograph (original magnification, x20; H-E stain) shows infiltration of tumor cells involving the muscularis propria (*).
GIST: CT features

- Most commonly have an exophytic growth pattern and manifest as dominant masses outside the organ of origin.
- Intramural masses (often hypervascular with haemorrhage) are less common radiologic manifestations.
- Patients with malignant GISTs may present with metastases to the liver, omentum, and peritoneum.
- Lymph node metastasis is very uncommon.

Jejunal GIST in an 89-year-old man discovered incidentally. Contrast-enhanced CT scans in coronal (a) and axial (b) planes, demonstrate a well-defined mass arising from the proximal jejunum with exophytic growth.
GIST: CT features

- GISTs are typically enhancing **masses with areas of low attenuation** from hemorrhage, necrosis, or cyst formation
- Extension into the adjacent small bowel mesentery and encasement of noncontiguous segments of small intestine, colon, ureter, and abdominal wall may occur

Jejunal GIST in a 81-year-old man with a history of melena. Contrast-enhanced CT scans in axial (a) and sagittal (b) planes, demonstrate an heterogeneous exophytic mass with low attenuation arising from the proximal jejunum.
GIST arising in a Meckel diverticulum in a 79-year-old man with abdominal pain. (a) Contrast-enhanced CT scan shows an intramural mass with exophytic growth (arrows). (b) Photograph of a cut section of the resected Meckel diverticulum shows a tumor developed exophytically (*). (c) Photomicrograph (original magnification, x20; H-E stain) shows infiltration of the tumor cells (*) from the muscularis propria.
Metastases

- The small bowel remains the main site of metastatic disease in the GI tract

- A small bowel tumor in a patient with a known malignancy is likely to be a metastasis

- Small bowel metastases are categorized by their mean of spread:
  - Hematogenous spread
  - Intraperitoneal seeding
  - Local extension

Ileal metastases of a cutaneous melanoma in a 76-year-old woman who presented with persistent abdominal pain. Contrast-enhanced CT scan reveals multiple heterogeneous lesions of the ileum (red arrows) with ascites.
Hematogenous metastases

- Primary tumors: melanoma, lung and breast
- Typically submucosal or subserosal
- Round to polypoid nodules that can ulcerate, cause intussusception rather than complete obstruction
- Usually multiple

Small bowel metastases in a 78-year-old man with a lung adenocarcinoma. Contrast-enhanced CT scan shows the multiple subserosal necrotic masses of the intestine and the primary lung tumor (*).

Small bowel metastases in a 30-year-old woman with melanoma. (a) Contrast-enhanced CT scan reveals multiple submucosal nodules (red arrows) with intussusception (*). (b, c) Photographs of a cut section of the resected small bowel show a submucosal tumor. (d) Photomicrograph (original magnification, x200, HMB 45 immunostain) shows strong reaction to HMB 45 (*), a marker of melanocytic cells.
Liposarcoma of the ileum in a 61-year-old man with small bowel obstruction. (a) Contrast-enhanced CT scan shows an intraluminal heterogeneous mass of the ileum, predominantly composed of fat attenuation (arrow). Small bowel feces sign (*) upstream dilated small bowel loop is present. (b) Photographs of the sectioned gross specimen shows the yellow lipomatous tissue (L) and a septa (arrow). (d) Photomicrograph (original magnification, x200; H-E stain) shows the infiltration of lipocytes (black star).

High grade sarcoma of the ileum, mimicking a lymphoma in a 80 year-old woman presented with anemia. (a) Contrast-enhanced CT scan shows a well-circumscribed lesion with a markedly thickened wall and an aneurysmal pattern. (b) Photograph of surgical specimen shows a bulky tumor with a thickened wall (arrows). (c) Photograph of a cut section of the resected tumor demonstrates the thickened wall (arrow). (d) Photomicrograph (original magnification, x100; H-E stain) shows tumor cells infiltrating all the layers of the small bowel.
The CTE is the first imaging modality to perform if a small bowel neoplasm is suspected.

Although the differential diagnosis for a small bowel tumor is extensive, some small bowel neoplasms have characteristic features at CTE:

- Small, avidly enhancing nodule + Stellate pattern mesenteric mass
- Annular and constricting lesion
- Pronounced circumferential mural thickening with aneurysmal luminal dilatation
- Exophytic, well-circumscribed, heterogeneous tumor
- History of cancer + multiple lesions

NET, ADK, Lymphoma, GIST, Metastases