The Wheel of the Mesentery:

Imaging Spectrum of Primary and Secondary Mesenteric Neoplasms—How Can Radiologists Help Plan Treatment?

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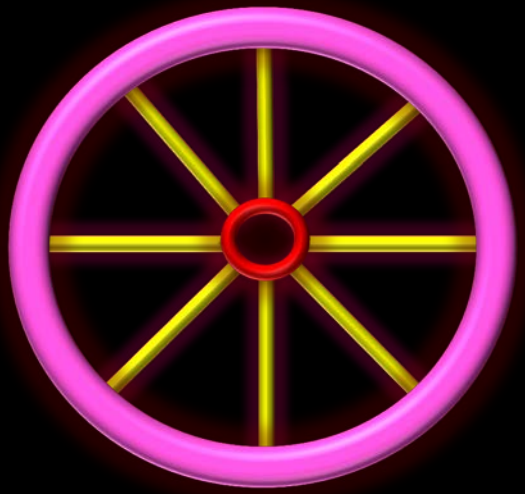

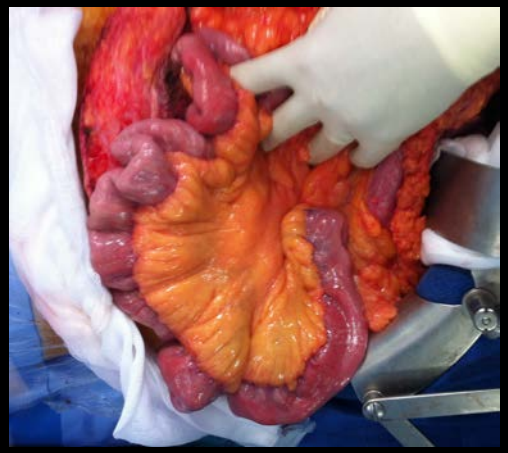

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Learning Objectives

- Explain the anatomy of the small bowel mesentery.
- Describe major computed tomographic (CT) and magnetic resonance (MR) imaging features of primary and secondary mesenteric lesions by using an algorithm illustrated in the presentation.
- Discuss available treatment options and describe how imaging findings may guide management.

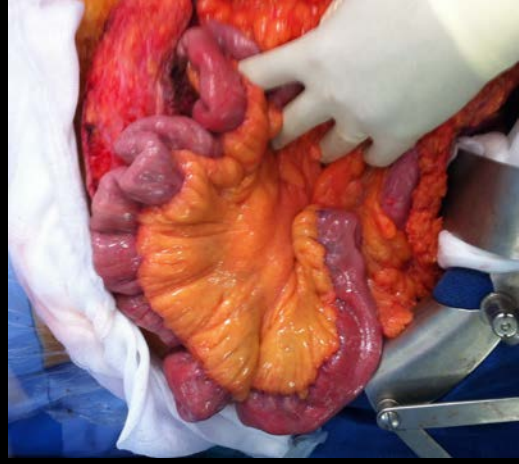
Introduction

- Small bowel mesentery may harbor primary mesenteric lesions and a number of secondary neoplasms.
- CT and MR imaging examinations are frequently performed for the evaluation of abdominal symptoms and may reveal mesenteric pathologic findings.
- It is important for the radiologist to be familiar with the characteristic imaging features of various mesenteric lesions, to recognize them at CT and MR imaging, to provide thoughtful differential diagnoses, and to serve as effective consultants to the referring clinicians.

After viewing this presentation, readers should be able to:

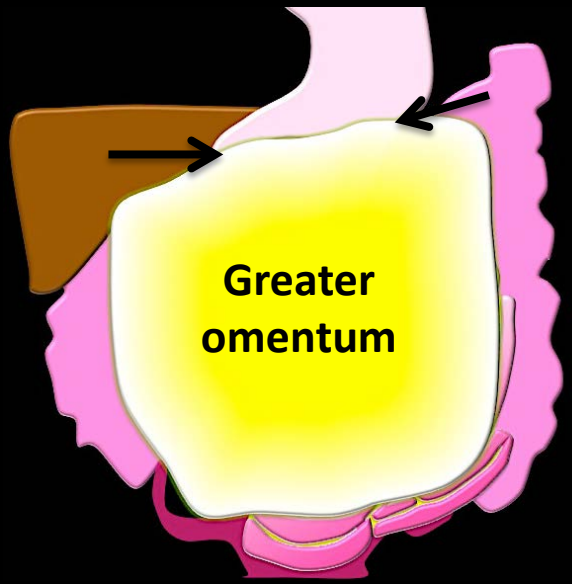
- Describe the normal anatomy of small bowel mesentery.
- Discuss primary mesenteric lesions on the basis of their tissue composition and growth pattern.
- Name secondary mesenteric neoplasms according to their major route of spread.
- List key CT and MR imaging features of mesenteric lesions and describe their possible complications.
- Describe the ways in which an effective imaging report can add value and inform management decisions.

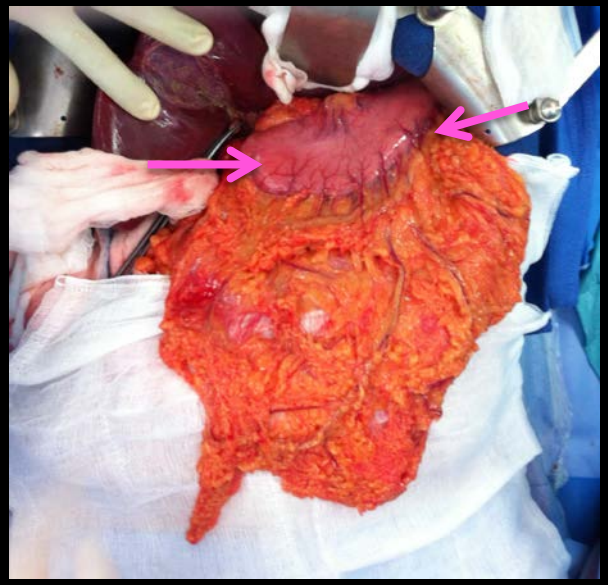
How Can Radiologists Help Plan Treatment?



Know the anatomy of the mesentery (ie, wheel)
Identify primary lesions of the mesentery
Detect secondary neoplastic involvement of the mesentery
Diagnose tumor-related complications
Assess tumor resectability

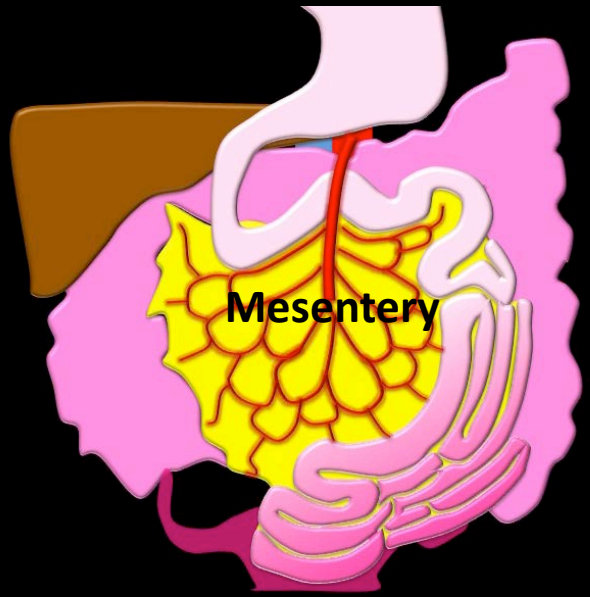
ANATOMY OF THE WHEEL

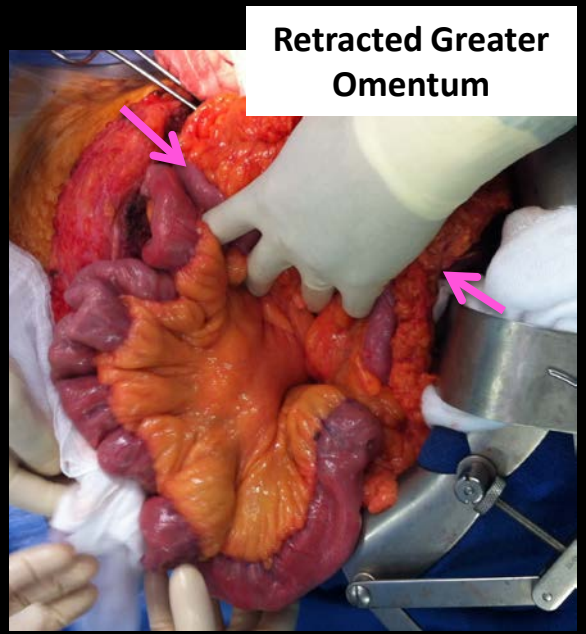




Greater omentum is the largest peritoneal fold in the body. It is suspended from the greater curvature of the stomach (black and pink arrows) and the free border of the transverse colon. Greater omentum extends down into the pelvis, covering the small intestines.

Greater omentum drapes over the small bowel and its mesentery. Small bowel mesentery is a broad fan-shaped fold of the peritoneum suspending the small intestines from the posterior abdominal wall.





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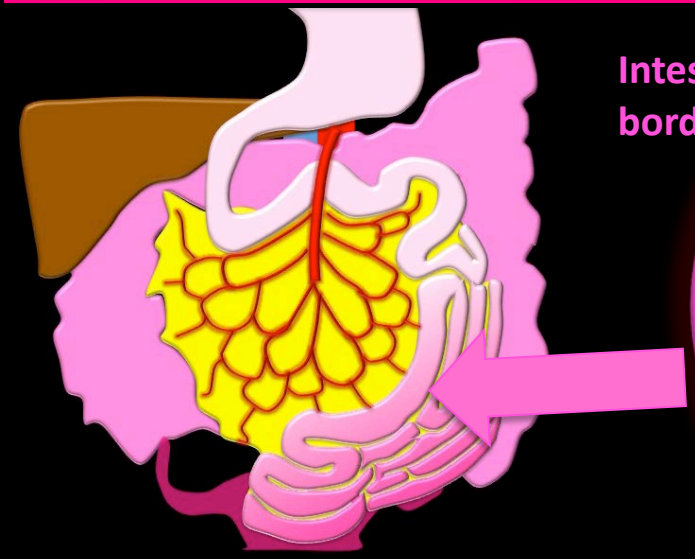
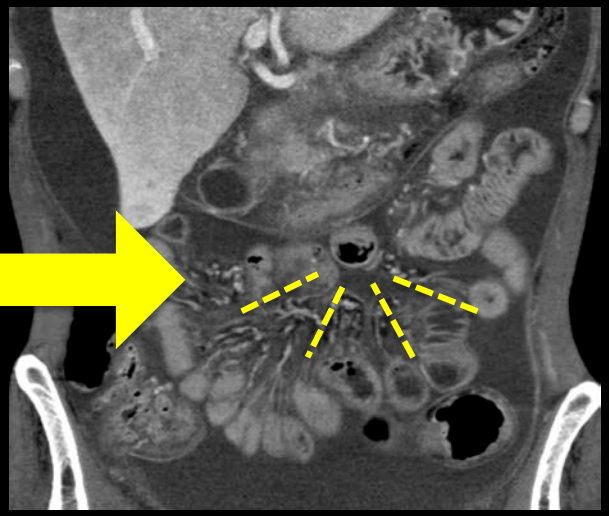
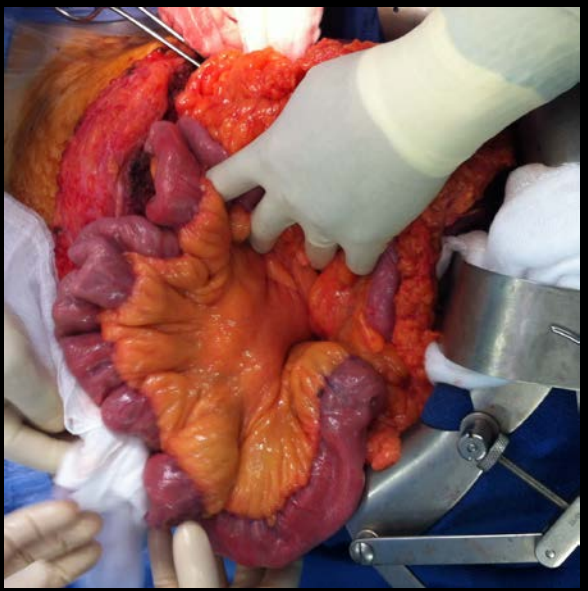
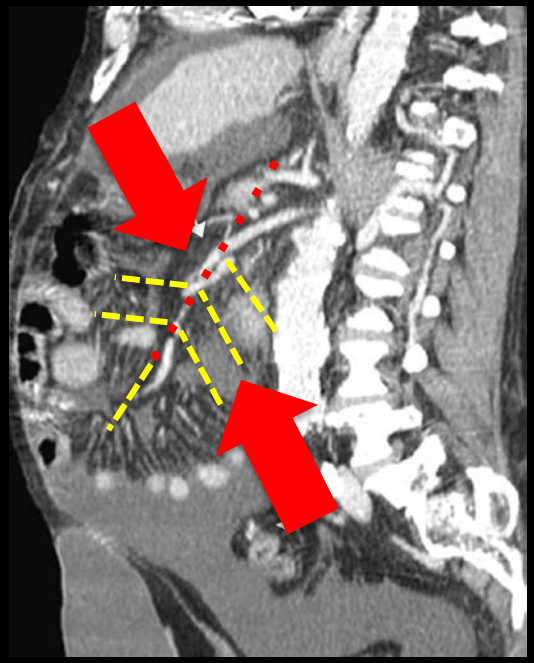




Small bowel mesentery can be represented as a wheel:

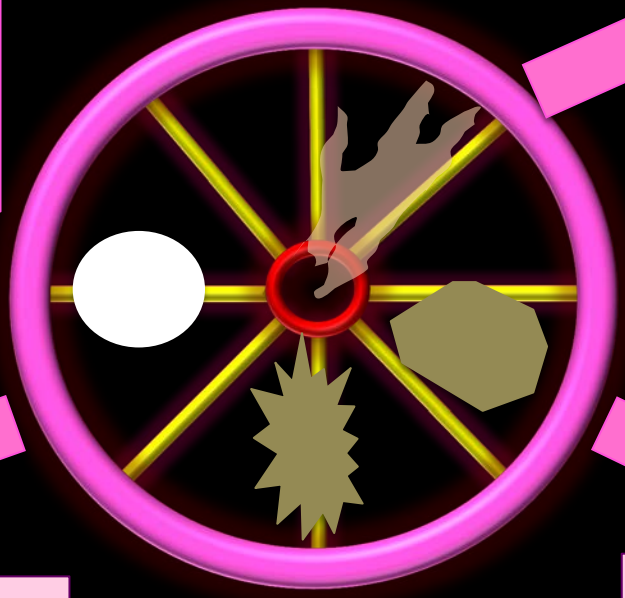


- The rim of the wheel is the small bowel.
- The spokes of the wheel are two peritoneal reflections containing fat, vessels, and lymphatic channels.
- The center of the wheel is the root of the mesentery. It contains major blood vessels and extends diagonally from the ligament of Treitz to the ileocecal valve.



PRIMARY MESENTERIC CONDITIONS

Primary mesenteric conditions are rare. Most are mesenchymal in origin, and the vast majority are benign.



INFILTRATIVE PATTERN

Sclerosing mesenteritis

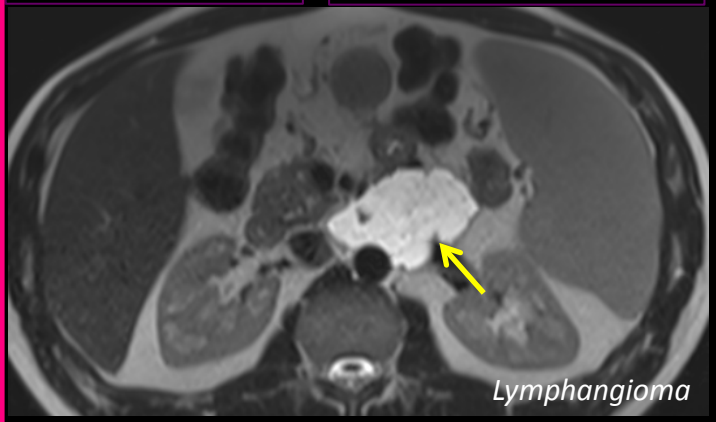
CYSTIC PATTERN

Unilocular:

Mesothelial cyst
Enteric cyst

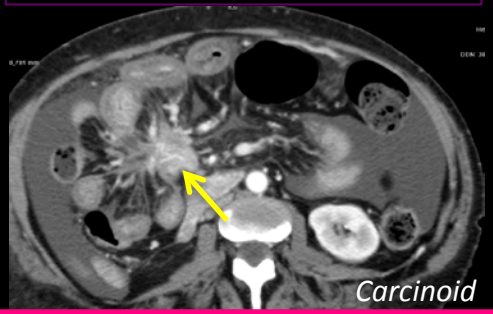
Multilocular:

Lymphangioma
Cystic mesothelioma



STELLATE PATTERN

Sclerosing mesenteritis
Carcinoid



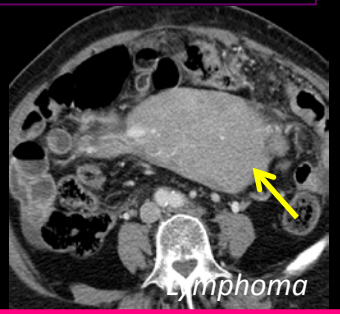
SOLID PATTERN

Fatty content:

Lipoma
Liposarcoma
Lipoblastoma

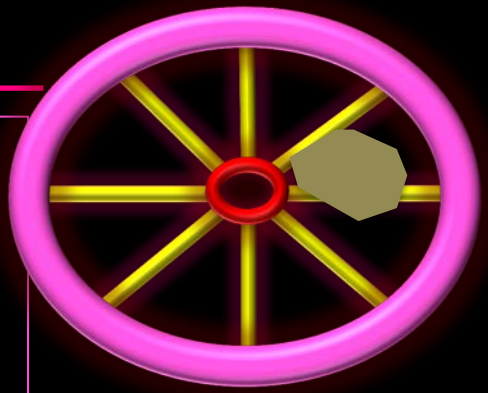
Nonfatty content:

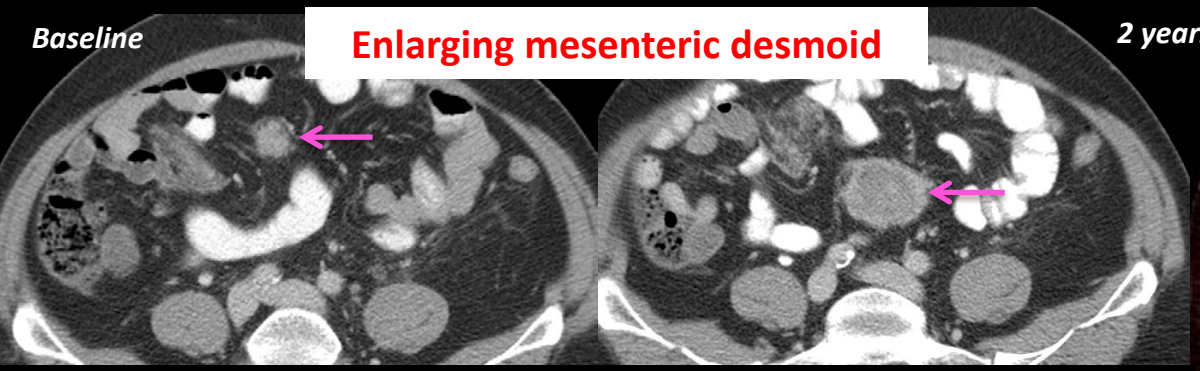
Desmoid tumor
Lymphoma
Gastrointestinal stromal tumor (GIST)
Solitary fibrous tumor
Mesothelioma

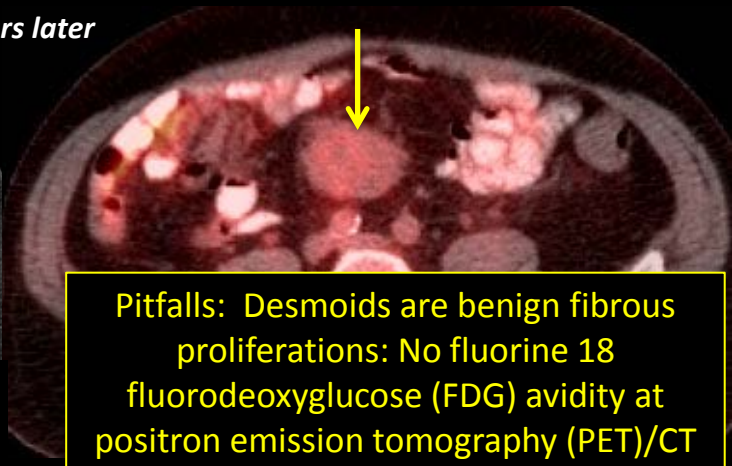


Solid Pattern: Desmoid Tumor

Desmoid tumors are rare. They arise from benign but locally aggressive fibroblastic proliferations. Although desmoid tumors can develop anywhere in the abdomen, common locations include surgical scars and small bowel mesentery. In fact, 75% of desmoid tumors develop in patients with prior abdominal surgeries. Patients with familial adenomatous polyposis (ie, Gardner syndrome) are also at increased risk for the development of these tumors.

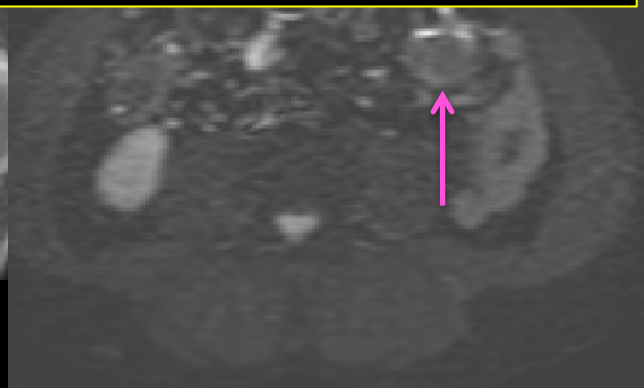






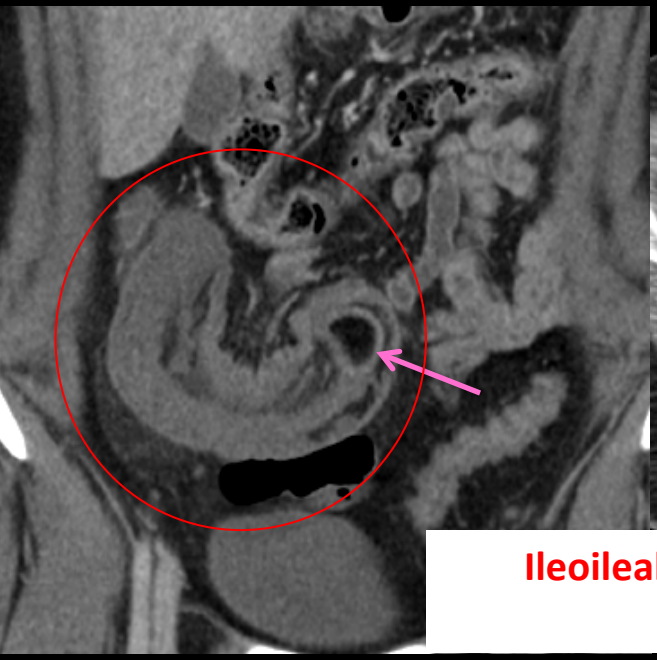
At CT, mesenteric desmoids appear as soft-tissue masses with either well-demarcated or poorly defined borders.

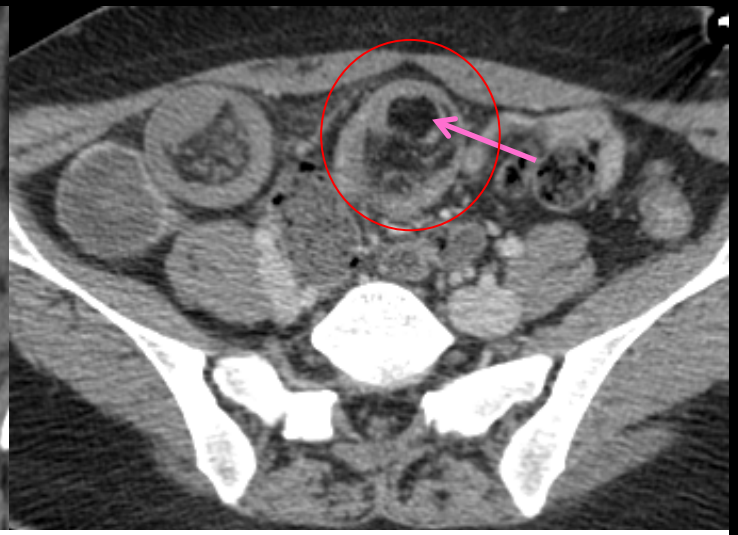
Pitfalls: Desmoids are benign fibrous proliferations: No fluorine 18 fluorodeoxyglucose (FDG) avidity at positron emission tomography (PET)/CT and no restriction at diffusion-weighted (DW) imaging.



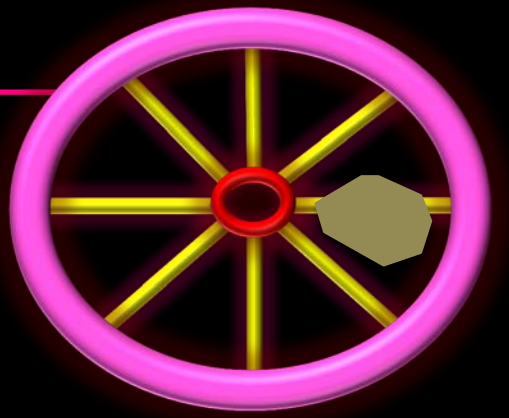
At MR imaging, desmoid tumors have variable signal intensity (SI) on T2-weighted images that depends on their cellularity (typically low T2 SI).

Solid Pattern: Lipoma





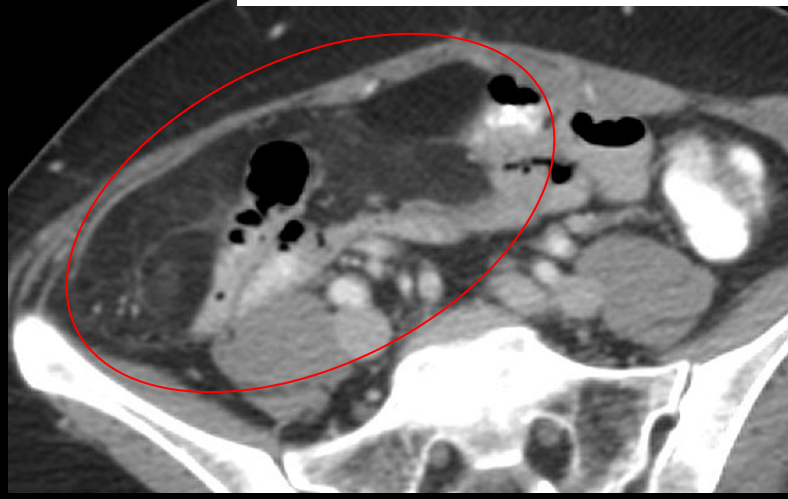
Ileoileal intussusception caused by a small mesenteric lipoma



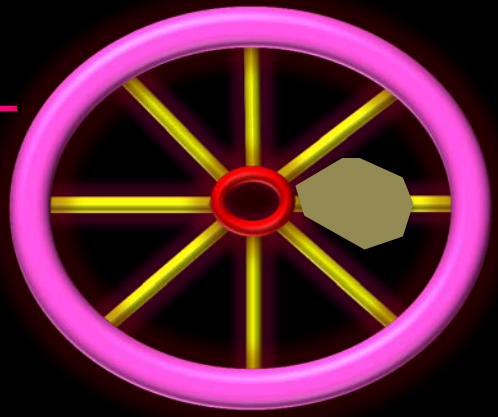
Rare
Mean age: 40–60 years
Typical location: Ileal mesentery

- Most mesenteric lipomas are asymptomatic. Occasionally, symptoms may develop in the setting of enteric intussusception or volvulus.
- At CT, mesenteric lipoma appears as a homogeneous fat-attenuation mass with no contrast enhancement. A surrounding capsule may be seen.
- Differential diagnosis includes lipoblastoma (if patient is a young child) or well-differentiated liposarcoma (if patient is an adult). Lipoma and well-differentiated liposarcoma cannot be distinguished at imaging. Tissue diagnosis may be required.

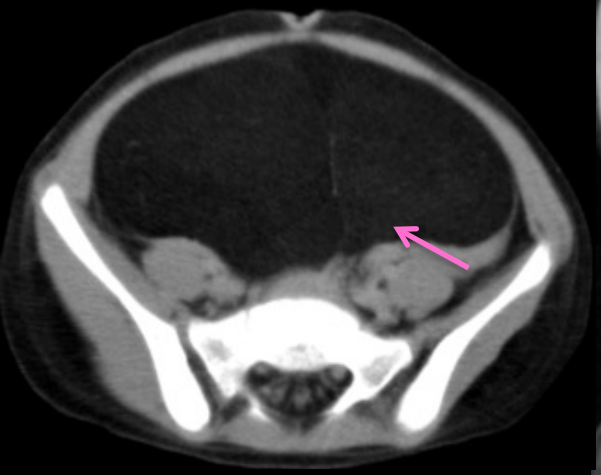
Large mesenteric lipoma



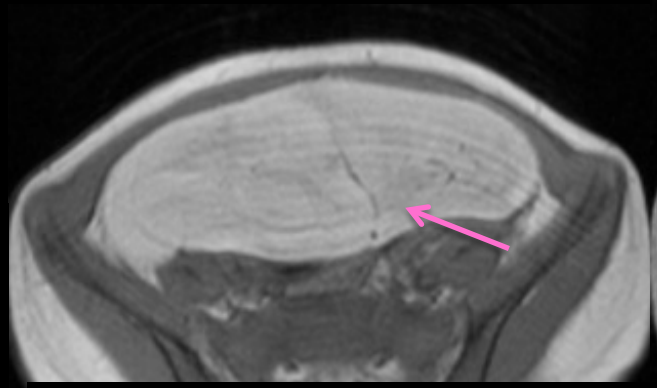
Solid Pattern: Lipoblastoma



Lipoblastoma is a rare benign childhood tumor (age <3 years) composed of embryonic fat. Fewer than 10% of lipoblastomas occur in the abdomen, with most tumors affecting the limbs or trunk. Abdominal lipoblastomas are most commonly found in the retroperitoneum, with fewer than 15% of reported cases observed in small bowel mesentery.

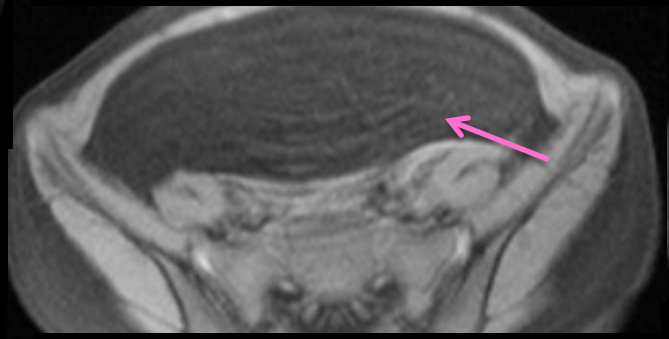


At CT, the tumor is purely fat in attenuation and has subtle lobulations.

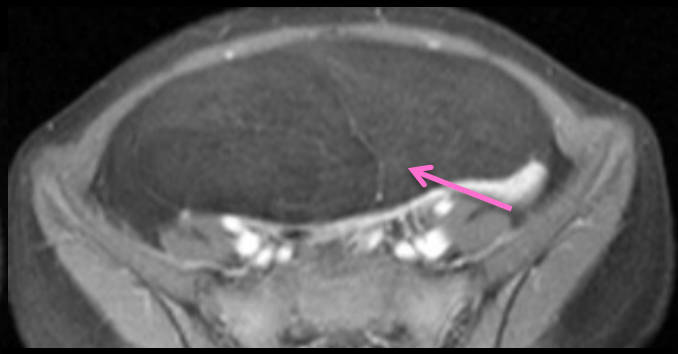


T1-weighted: Hyperintense and has the same SI as the nearby subcutaneous fat

T2-weighted: Hyperintense and has the same SI as the nearby subcutaneous fat



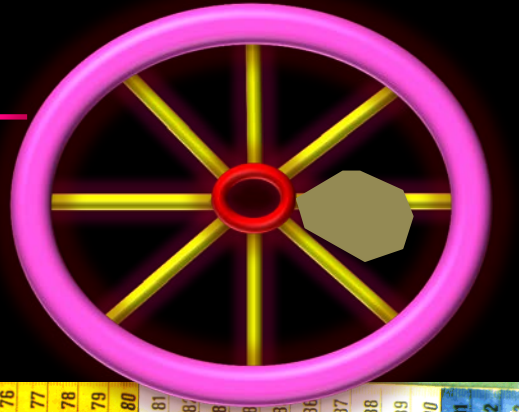
T-1 weighted fat-saturated: Diffuse signal drop with fat saturation



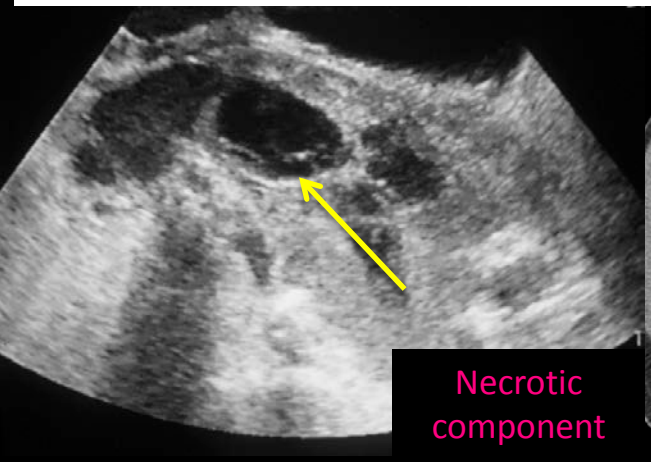
T1-weighted + gadolinium-based agent: No enhancement after intravenous administration of contrast material

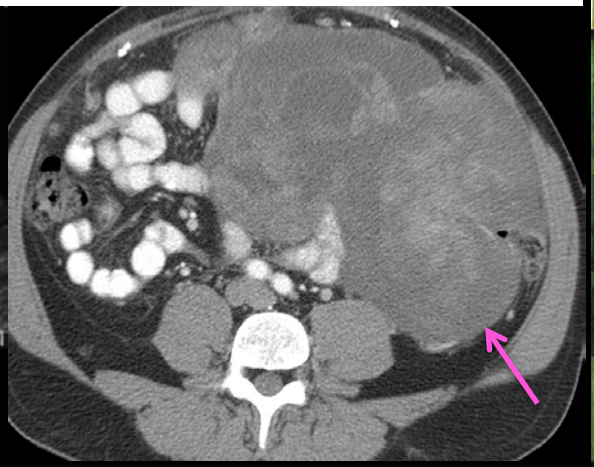
Solid Pattern: Sarcoma

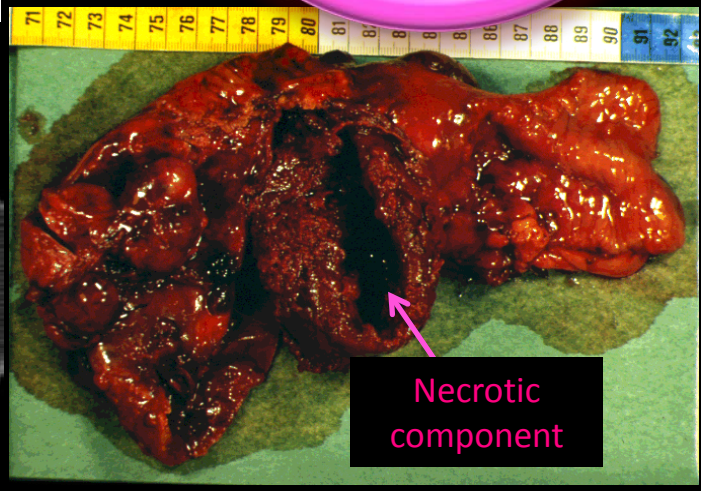
Mesenteric sarcomas are rare, and liposarcoma is the most common subtype of mesenteric sarcoma. The mesenteric origin can be hard to assess in large sarcomas.



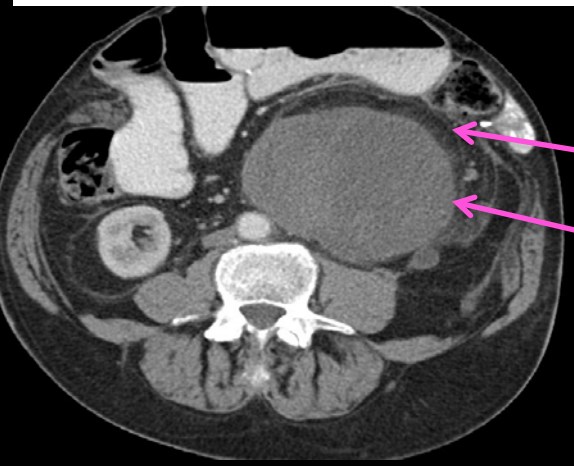
Myxoid liposarcoma





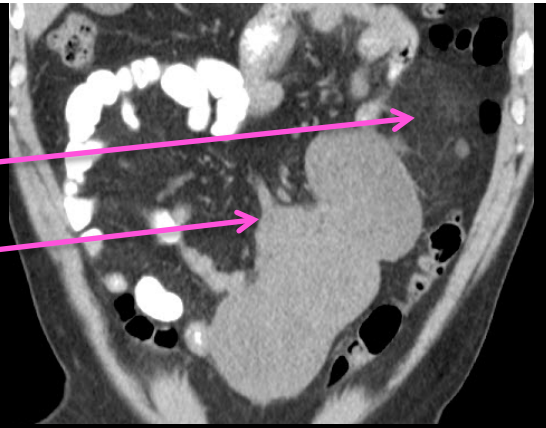


Dedifferentiated Liposarcoma



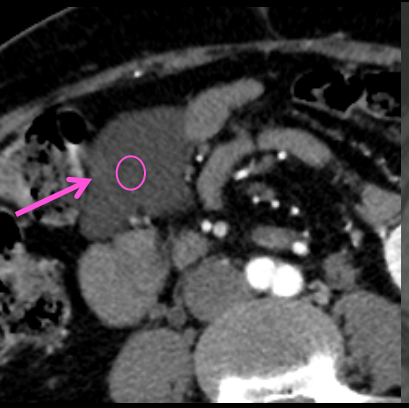
Large mesenteric tumor with two distinct components:

- Fatty component consistent with well-differentiated portion
- Soft-tissue component consistent with dedifferentiated portion

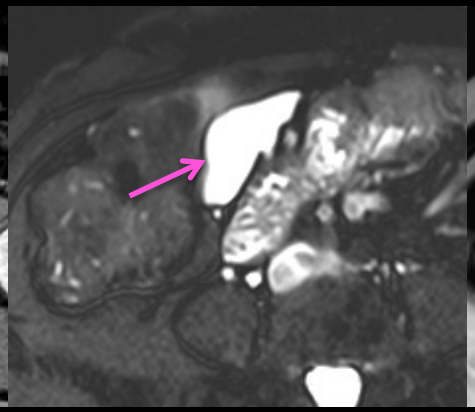


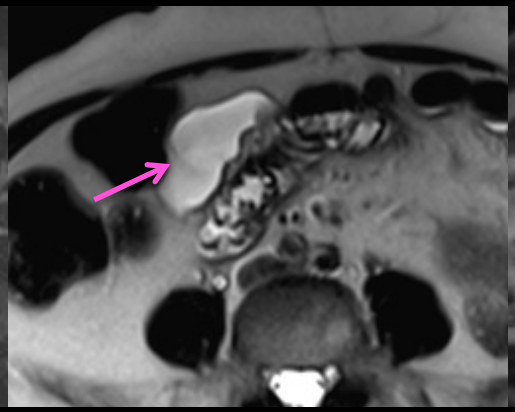
Cystic Pattern: Lymphangioma

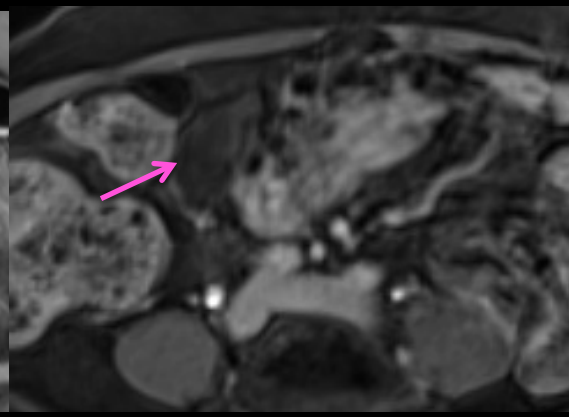
Lymphangiomas are uncommon benign lymphatic proliferations that manifest as thin-walled cystic masses. Lymphangiomas typically present during childhood. Although they can occur anywhere in the body, these lesions are often found in the neck. The most common site of abdominal lymphangiomas is the mesentery. Mesenteric lymphangiomas are usually asymptomatic but may cause intestinal obstruction or volvulus.



At CT, lymphangioma appears as a lobulated fluid-attenuation mass.

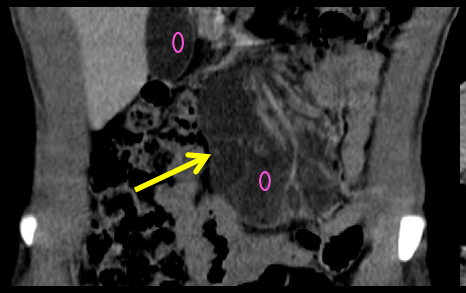


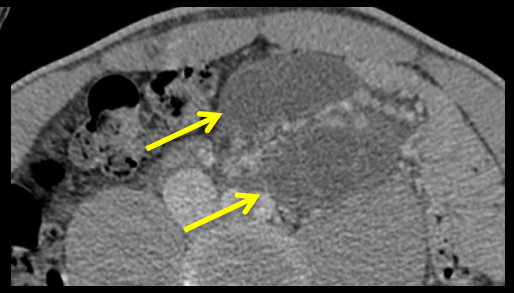




At MR imaging, lymphangioma is a lobulated fluid-SI nonenhancing mass (hypointense on T1-weighted and hyperintense on T2-weighted images, with a thin enhancing wall on postcontrast images).

Pitfalls: When found in the root of the mesentery, lymphangiomas may be mistaken for enlarged lymph nodes. This mistake can be avoided by measuring the attenuation value of the mass.

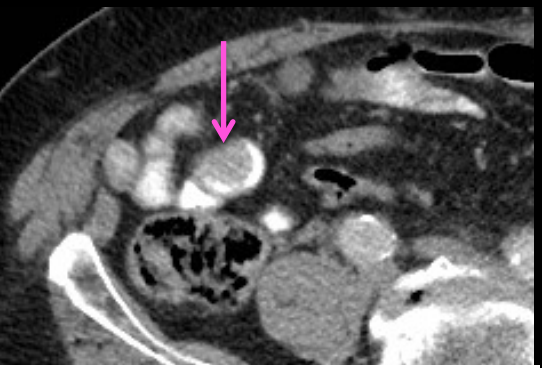




Fluid-attenuation mesenteric mass with attenuation similar to that of the gallbladder.

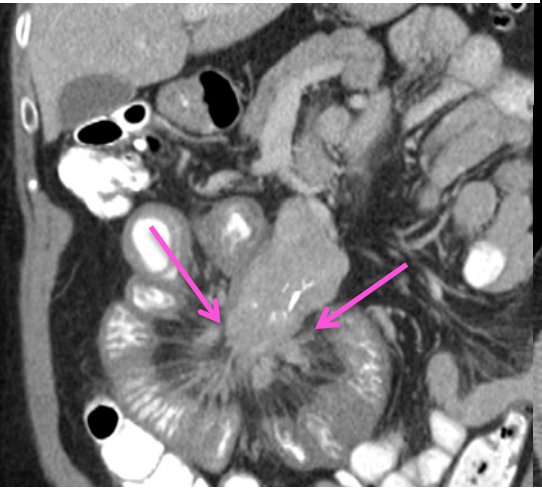
Stellate Pattern: Carcinoid

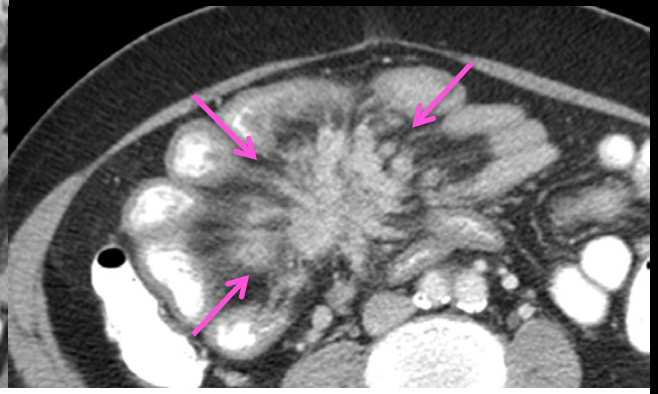
Primary mesenteric carcinoid is rare, but secondary mesenteric involvement is common. Carcinoid tumors usually originate in the small intestine and spread to the adjacent mesentery. The primary intestinal tumor is often not identified because of its small size. Because mesenteric tumor spread is the dominant imaging finding of carcinoid tumors, they are included in the present discussion.



Small primary tumor

Mesenteric masses caused by carcinoid tumors often have a spoke-wheel or sunburst appearance due to mesenteric fibrosis and desmoplastic reaction. In addition, up to 70% of lesions contain calcifications.

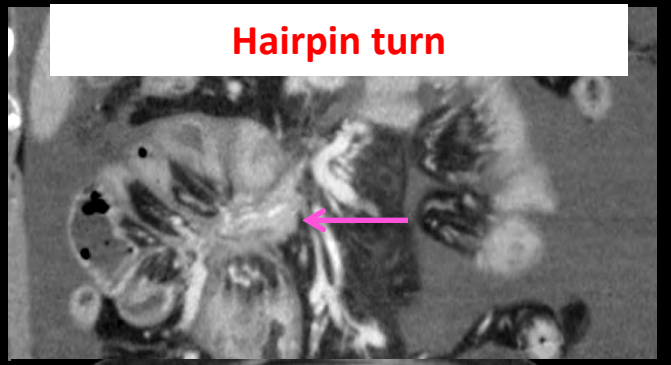


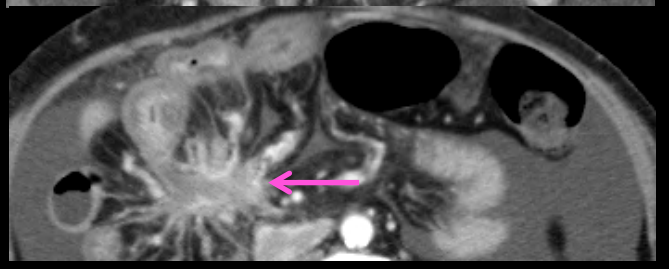


Spoke-wheel or sunburst pattern

Carcinoids may produce a kink of the intestinal wall known as a hairpin turn. The kinking is the result of tumor infiltration and fibrosis.

Hairpin turn





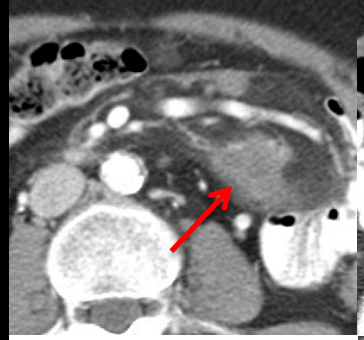
Infiltrative Pattern: Sclerosing Mesenteritis

Sclerosing mesenteritis is a rare condition of unknown cause characterized by chronic mesenteric inflammation and fibrosis. It typically involves small bowel mesentery, especially its root. The CT appearance is variable, ranging from a subtle increase in attenuation of the mesentery to a soft-tissue mass. Mesenteric panniculitis is a subgroup of sclerosing mesenteritis in which chronic mesenteric inflammation is a predominant feature. At CT, mesentery may have increased attenuation, with small lymph nodes and surrounding pseudocapsule.

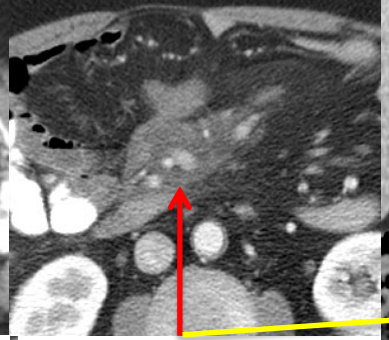
At MR imaging, pseudocapsule and small lymph nodes are easily detected on T2-weighted images.

Pitfall: On DW images, lymph nodes demonstrate restricted diffusion. DW imaging is not useful to distinguish benign from pathologic lymph nodes. However, it does help with lymph node detection.

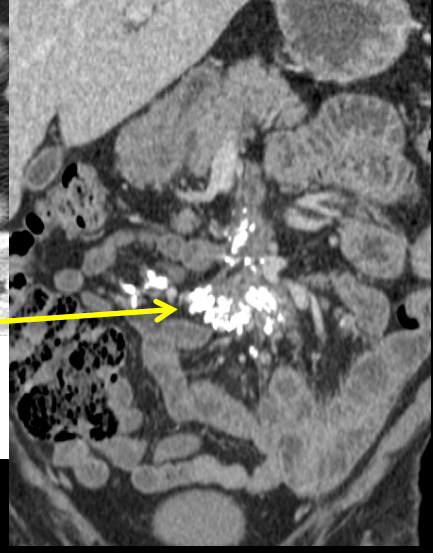
The chronic form of sclerosing mesenteritis in which fibrosis predominates is known as retractile mesenteritis. CT typically demonstrates a soft-tissue mass that may contain central calcifications due to fat necrosis. At imaging, retractile mesenteritis may be indistinguishable from lymphoma or desmoid and may require excisional biopsy to establish definitive diagnosis.

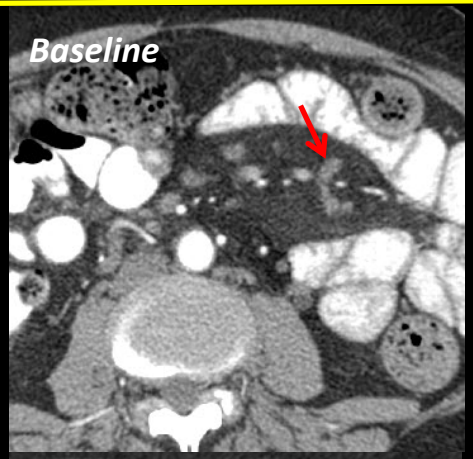


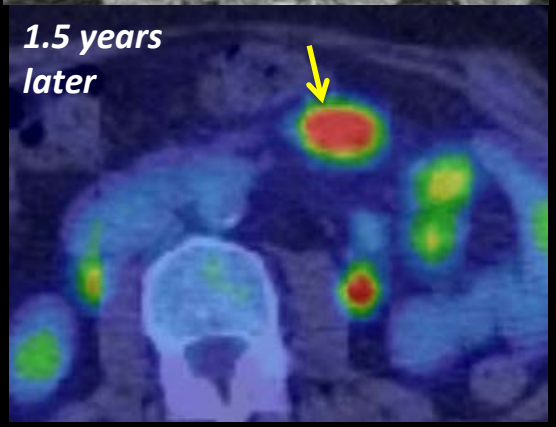
Masslike appearance



Retractile infiltration



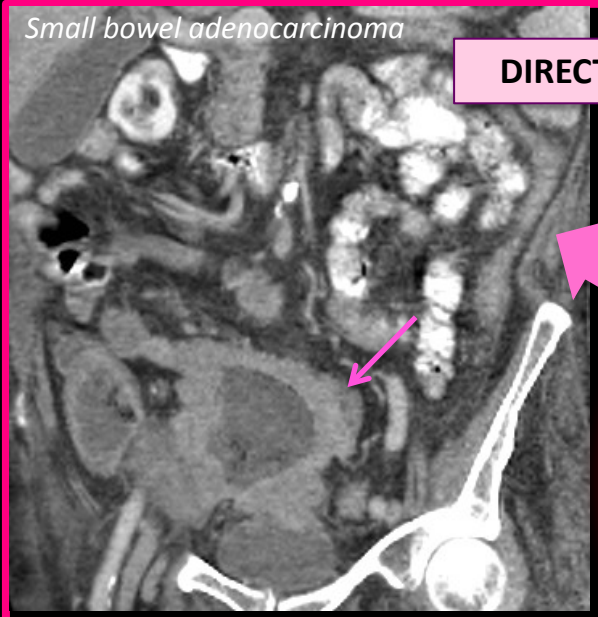




Sclerosing mesenteritis may be observed in association with an immunoglobulin G4–related sclerosing disease. In addition to the mesentery, affected organs may include the pancreas, bile ducts, gallbladder, kidneys, retroperitoneum, thyroid, lacrimal glands and orbits, salivary glands, lymph nodes, lungs, gastrointestinal tract, and blood vessels. Sclerosing mesenteritis may also coexist with several malignancies, including lymphoma.

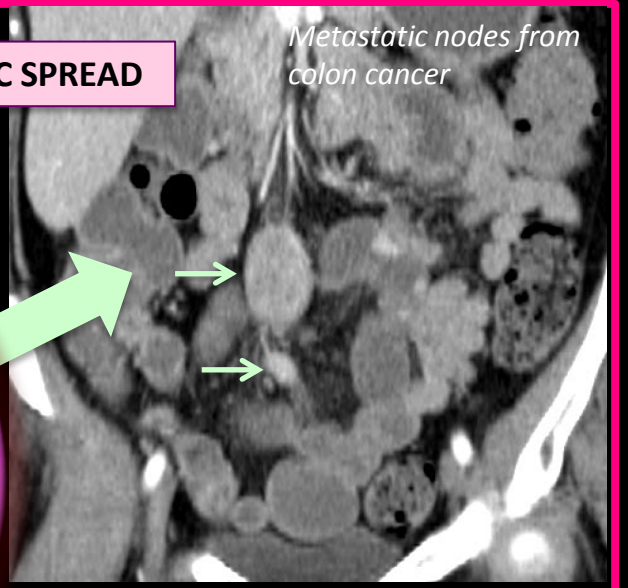
Images in a 63-year-old man with sclerosing mesenteritis demonstrate progressive enlargement of the mesenteric lymph nodes and marked FDG avidity at PET/CT. Subsequent biopsy finding was consistent with lymphoma.

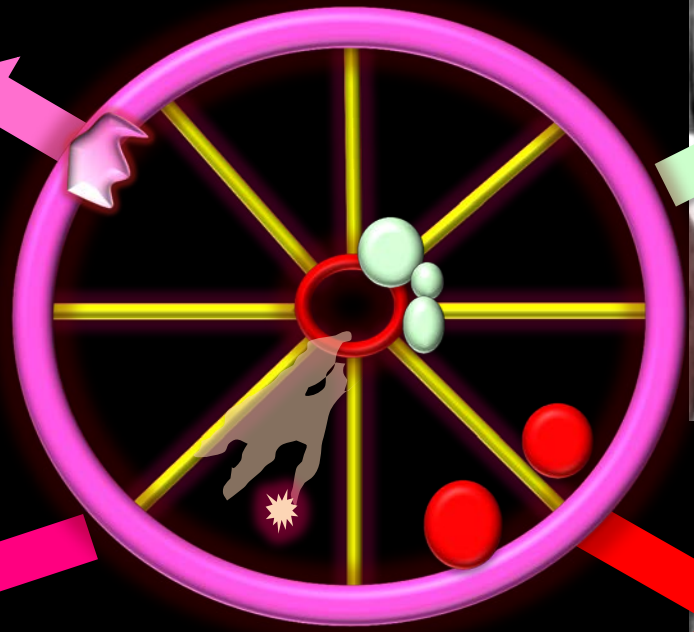
PATTERNS OF SECONDARY NEOPLASMS



DIRECT EXTENSION

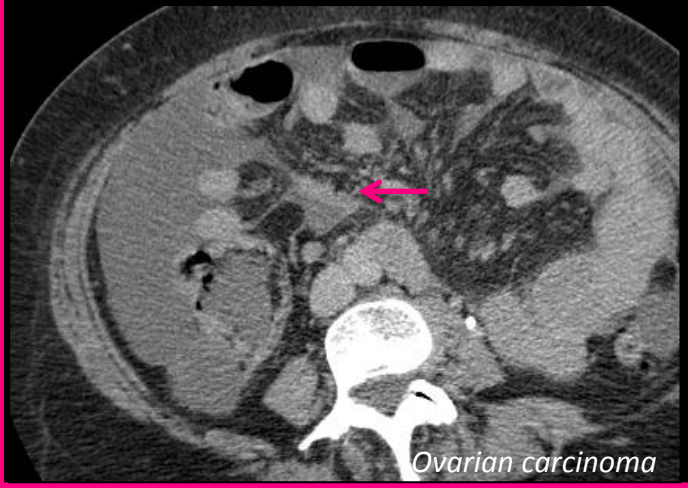
LYMPHATIC SPREAD

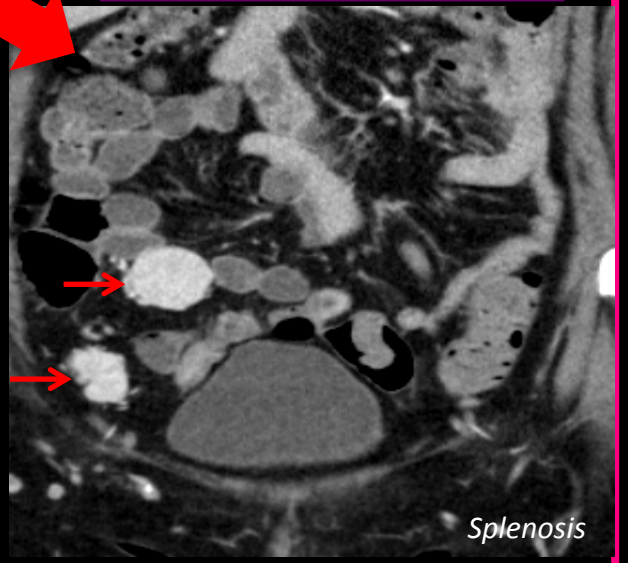




PERITONEAL SEEDING

HEMATOGENOUS SPREAD

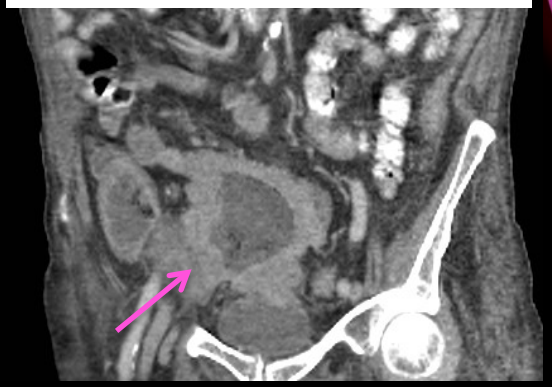




Direct Tumor Spread

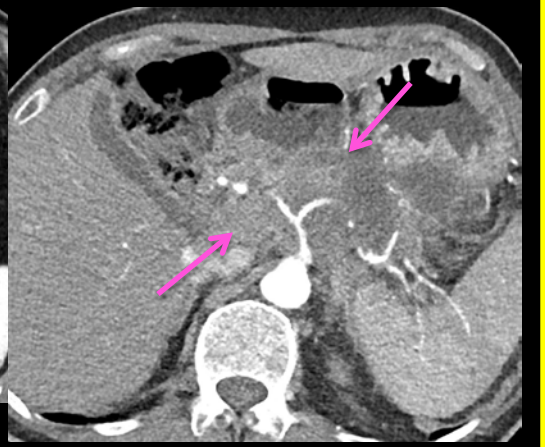
Several abdominal malignancies, such as biliary, pancreatic, gastric, and colon cancers, may invade directly into the mesentery or spread along the mesenteric vessels.

Small bowel adenocarcinoma



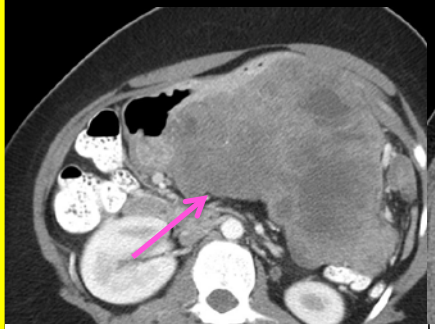
About 40% of pancreatic adenocarcinomas are unresectable at the time of initial presentation due to tumor extension along the root of the mesentery and vascular encasement.

Subtle encasement of superior mesenteric artery (SMA)



Extensive encasement of the root of the mesentery

GISTs are mesenchymal tumors that occur in the stomach (60%–70%), small bowel (20%–30%), colon and rectum (10%), and esophagus (<5%) and may also extend into the mesentery. Several cases of primary mesenteric GIST have been described. GISTs are typically well-circumscribed masses with central necrosis.

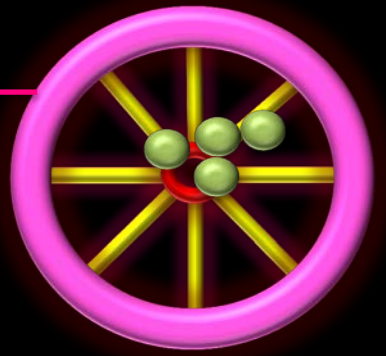


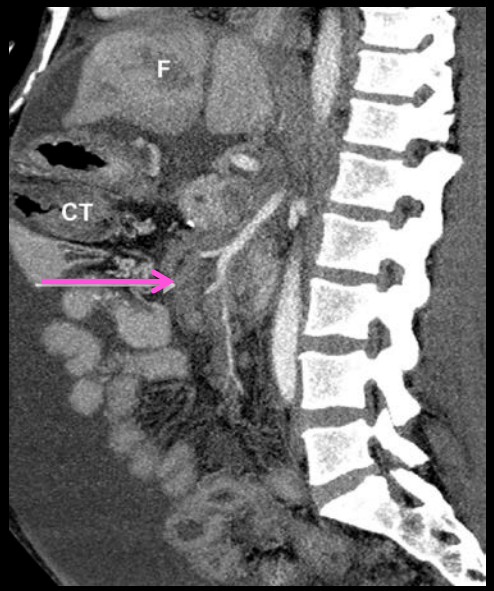
Gastric GIST

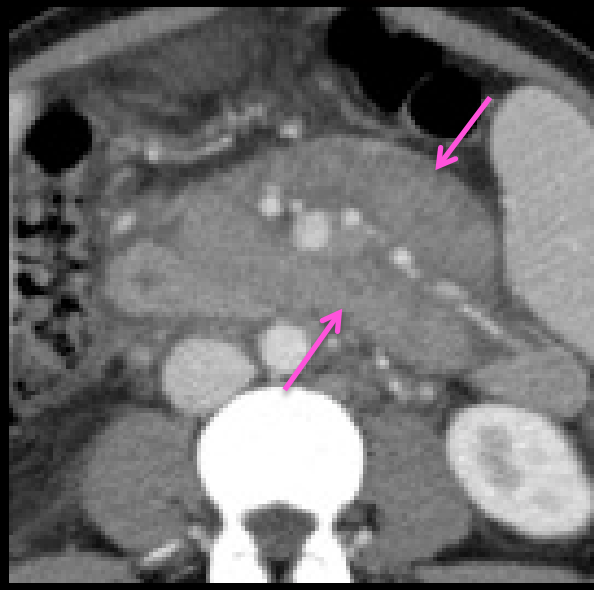
Jejunal GIST

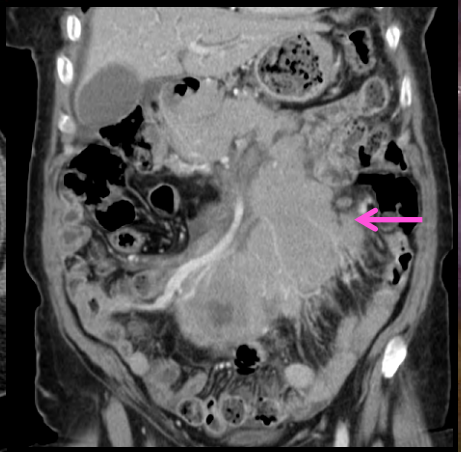
Lymphatic Spread

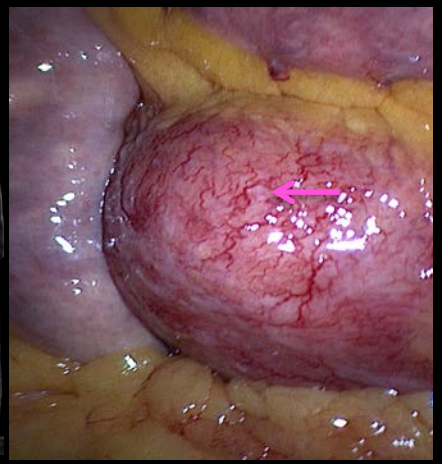
Lymphoma is the most common malignant neoplasm that affects the mesentery. Approximately 30%–50% of patients with non-Hodgkin lymphoma have mesenteric nodal involvement. Mesenteric lymphadenopathy may also be observed in the setting of chronic lymphocytic leukemia.







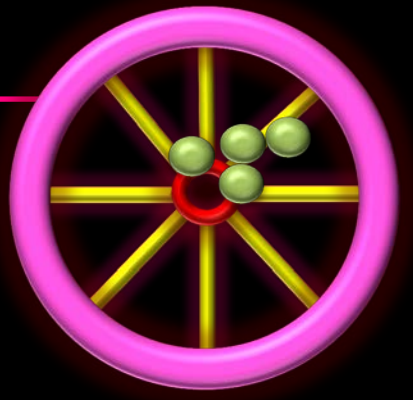




CT often demonstrates multiple rounded mildly homogeneously enhancing masses that frequently encase mesenteric vessels, known as the sandwich sign.

Lymphatic Spread

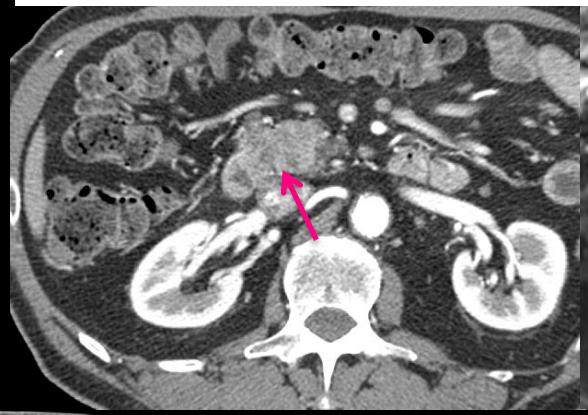
Many tumors, including lung cancer, breast cancer, colon cancer, ovarian cancer, melanoma, and carcinoid tumors, can spread to the mesenteric lymph nodes via lymphatics.

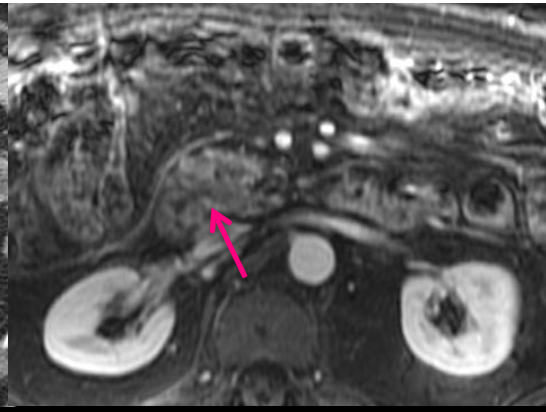


Pearls: Lymphoma versus nodal metastases from other primary malignancies

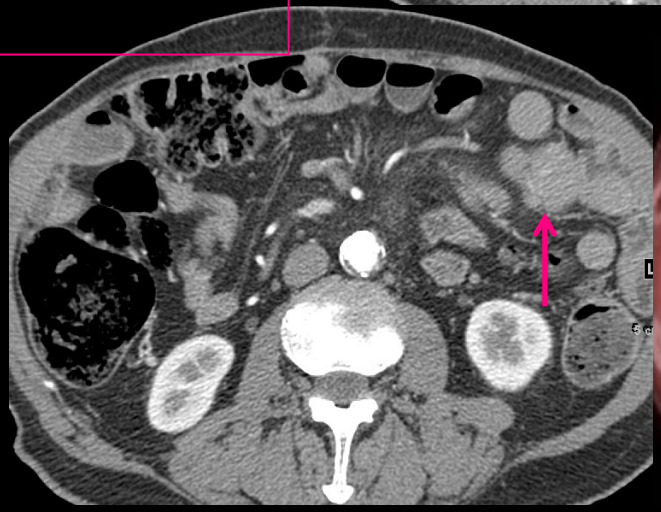
- In general, the degree of nodal enlargement is more pronounced and diffuse in lymphoma than in other primary malignancies, which usually present with smaller and more localized mesenteric lymph nodes.

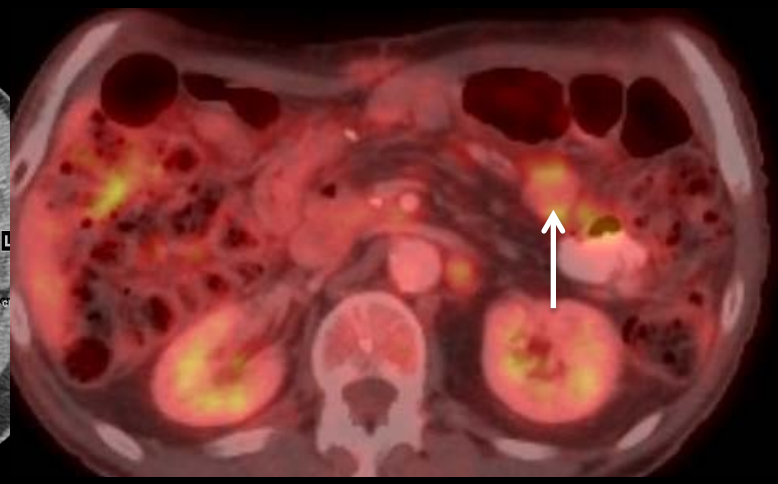
Newly diagnosed adenocarcinoma of the pancreas





Biopsy-proven lymphoma

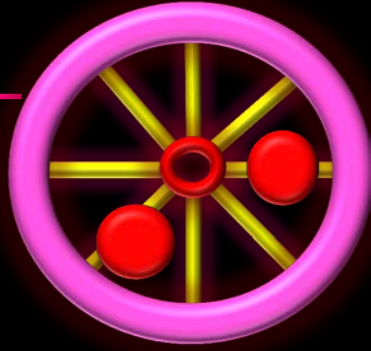


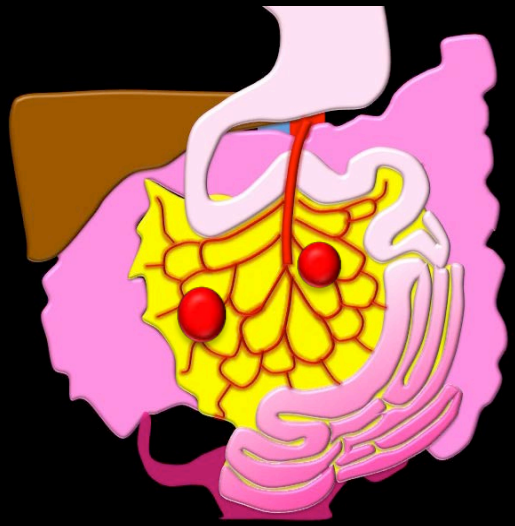


Large mesentery lymphadenopathy with FDG avidity

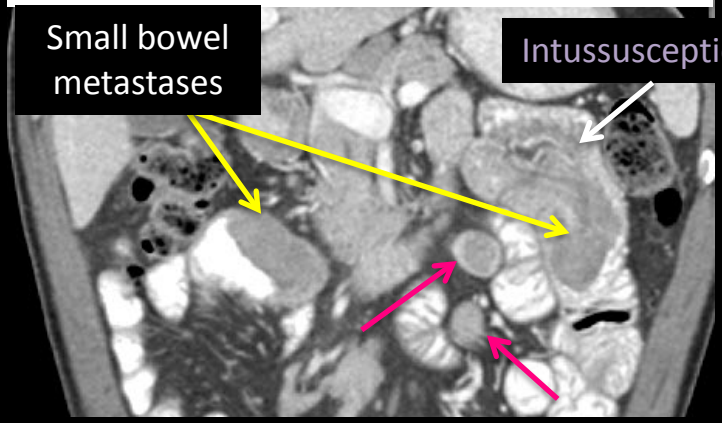
Hematogenous Spread

The small intestine and its mesentery are the most common sites of gastrointestinal metastases from melanoma. Breast cancer and lung cancer may also undergo hematogenous dissemination via mesenteric arterial branches.





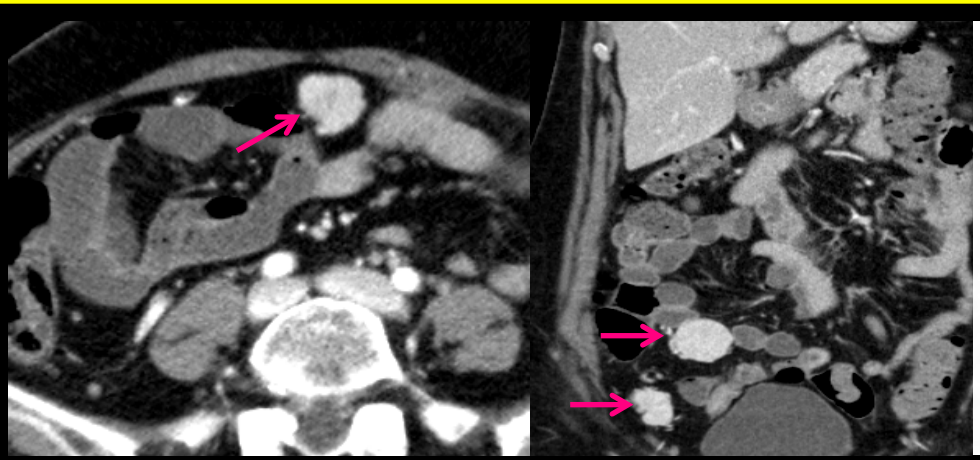
Melanoma metastasis



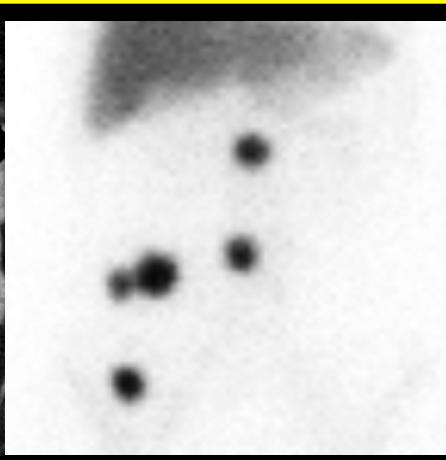
Multiple metastatic nodules in the mesentery

Metastasis from the pancreatic carcinoid

Pitfalls: Splenosis in a patient with prior posttraumatic splenectomy



Multiple hypervascular nodules in the omentum and mesentery

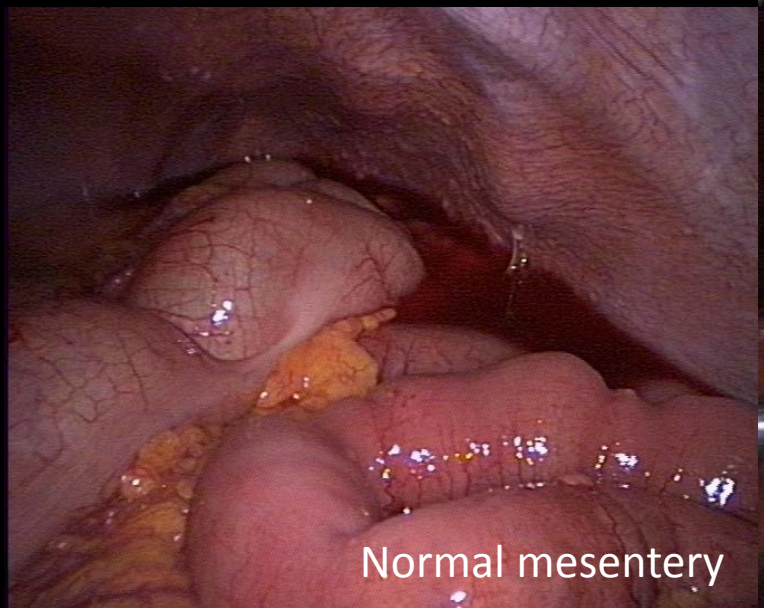


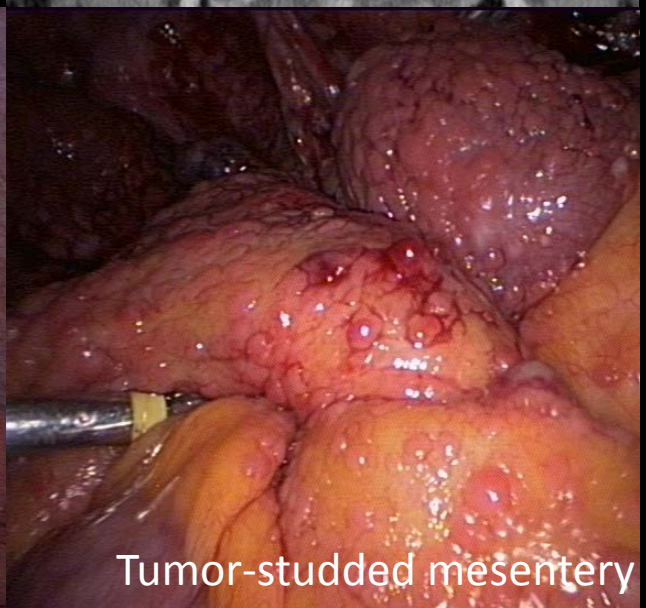
Heat-damaged red blood cell scan

Peritoneal Seeding: Ovarian Cancer Example

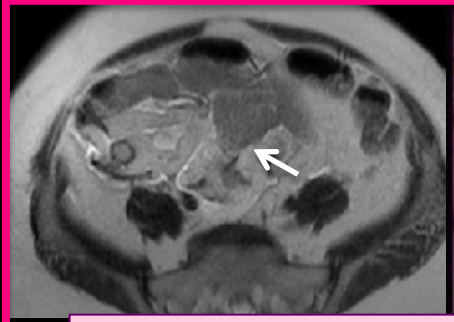
Following a clockwise route, the ascitic fluid flows from the right paracolic gutter to the Morison pouch, followed by the omental foramen and subdiaphragmatic spaces.

The route is completed when ascitic fluid travels caudally via the inframesocolic compartment into the mesentery and the pouch of Douglas.





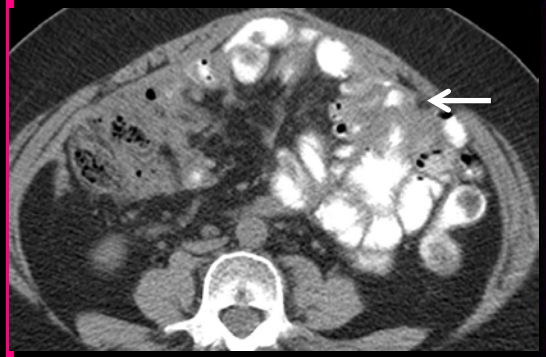
Pattern of Peritoneal Seeding



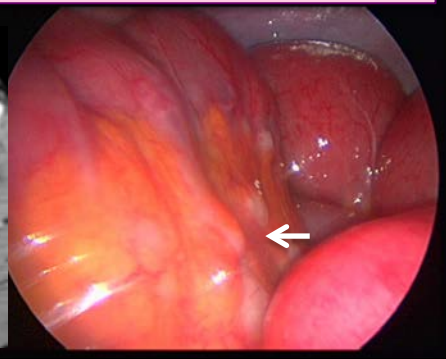
SMALL BOWEL INVOLVEMENT PATTERN

INFILTRATIVE PATTERN LEADING TO A "MISTY MESENTERY"

RETRACTILE PATTERN

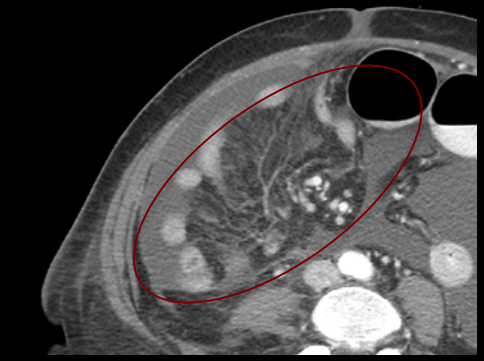


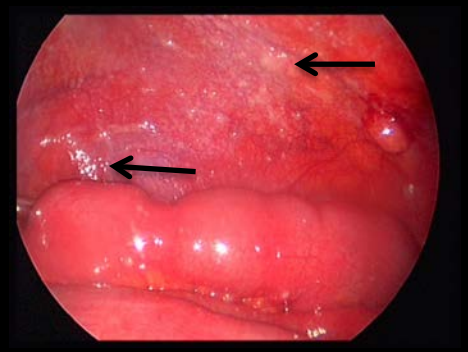
NODULAR PATTERN



Infiltrative Pattern: Misty Mesentery

Misty mesentery is a subtle imaging sign of mesentery involvement. When it is observed in a patient with ovarian cancer, it may signify diffuse mesenteric involvement that would preclude optimal cytoreduction.

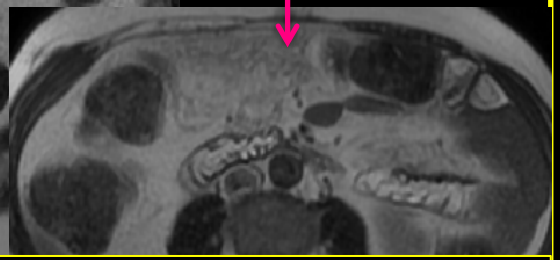




Subtle linear fat infiltration at CT

Pearl: loculated ascites

Mesenteric fat infiltration at MR

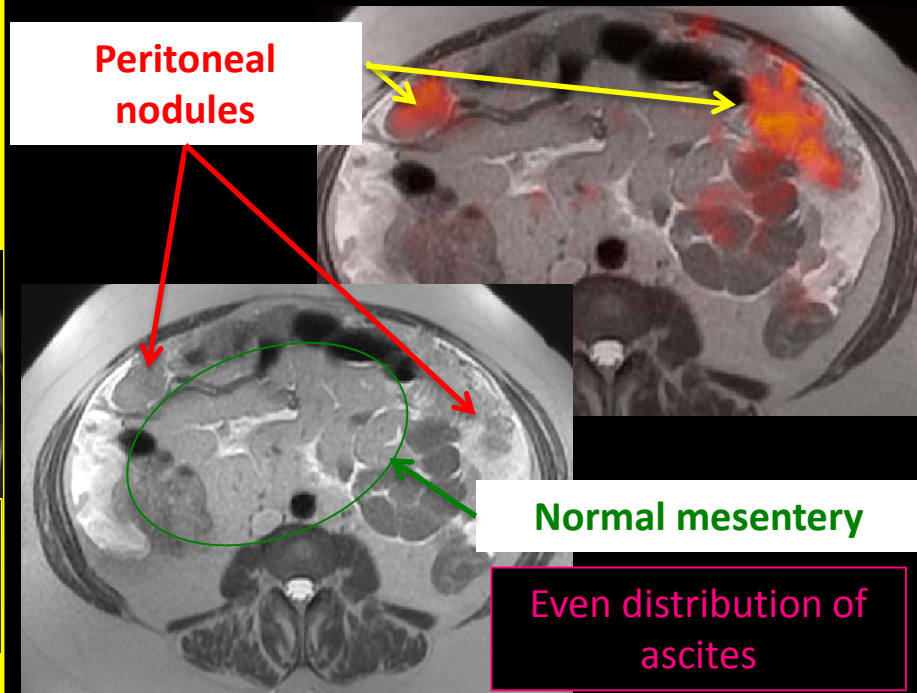


Pitfalls: Misty mesentery is a relatively nonspecific imaging finding. Differential considerations include mesenteric edema, lymphedema, inflammation, hemorrhage, and neoplasms.

Peritoneal nodules

Normal mesentery

Peritoneal nodules

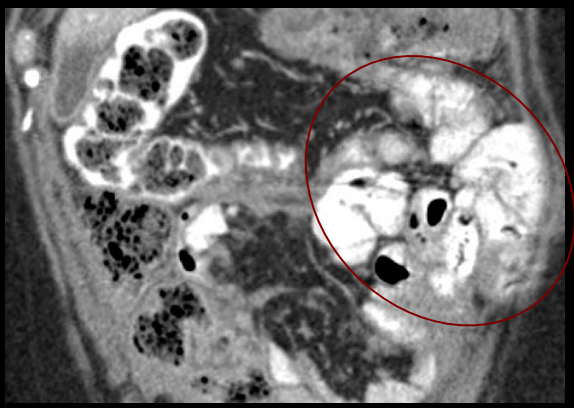


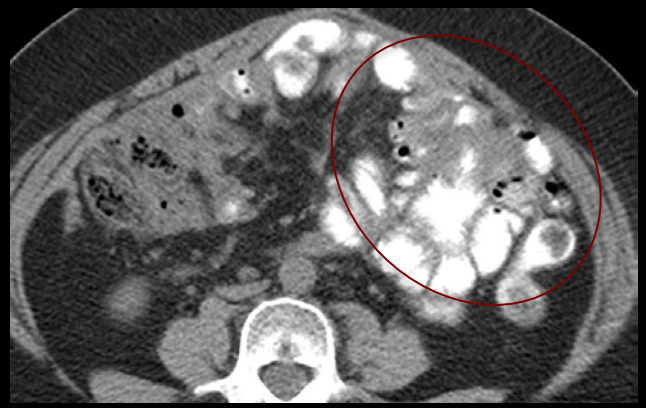
Normal mesentery

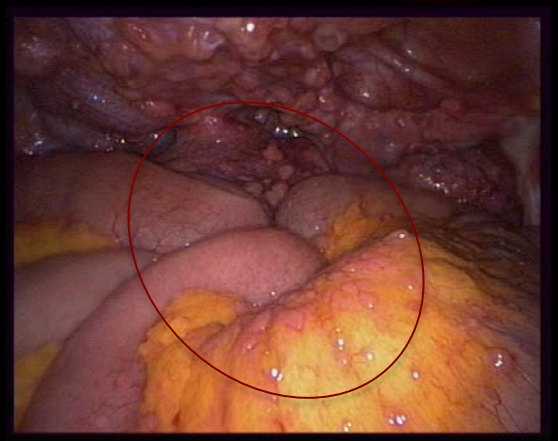
Even distribution of ascites

Retractile Pattern

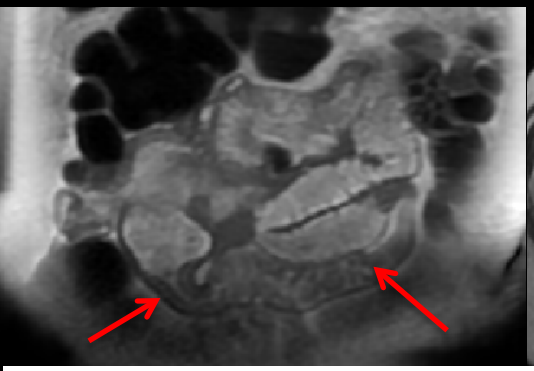
Retractile pattern is evident as small bowel retraction, angulation, and kinking. Small bowel edema and/or thickening may be present secondary to the ischemia and/or vascular congestion, or invasion of the serosa. Mesenteric tumor nodules may not be apparent, and retraction may be the only sign of severe mesenteric involvement.

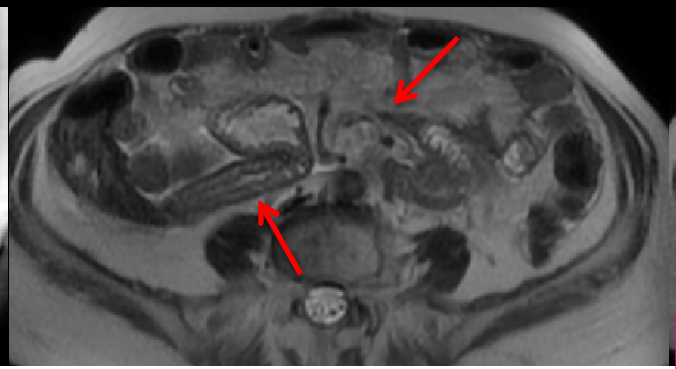






Clumping and retraction of small bowel loops

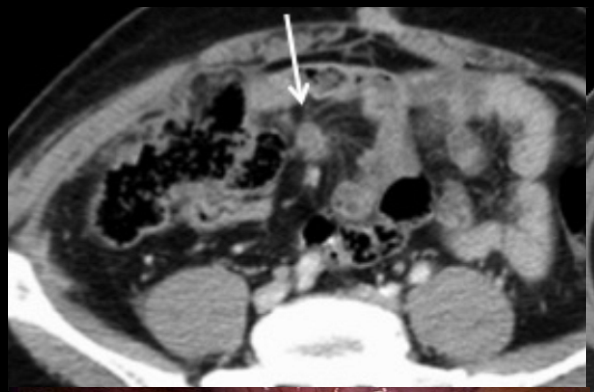


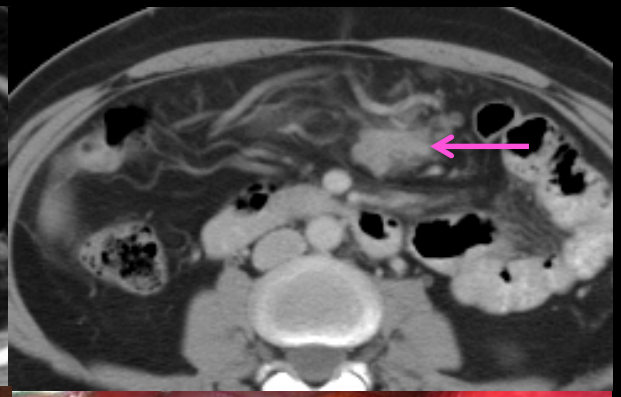


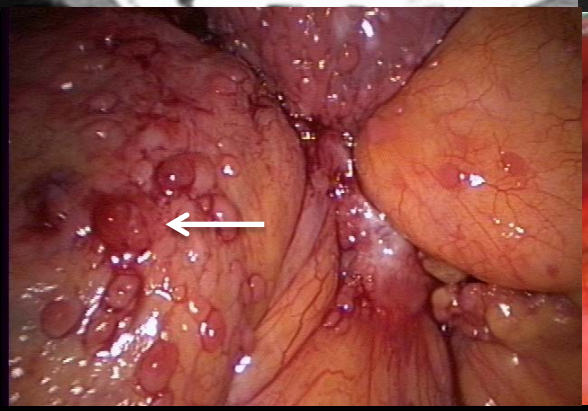
Small bowel wall thickening, angulation, and kinking consistent with mesenteric infiltration. No discrete tumor nodules are seen.

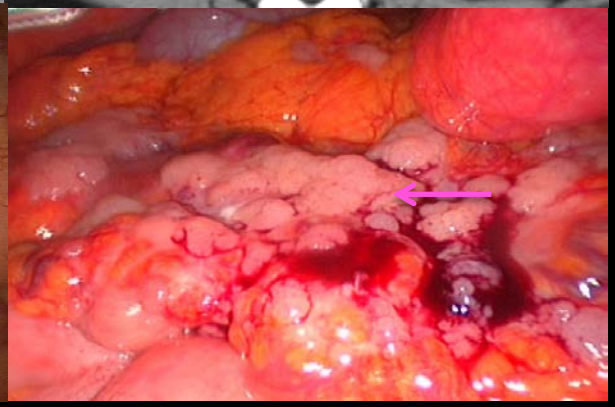
DW imaging may show restricted diffusion in the bowel serosa consistent with diffuse neoplastic involvement.

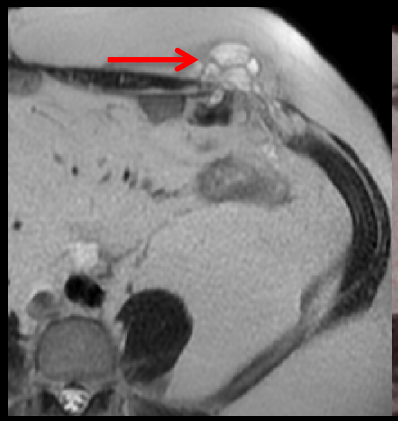
Nodular Pattern

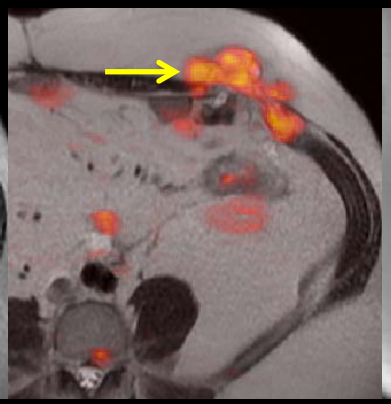


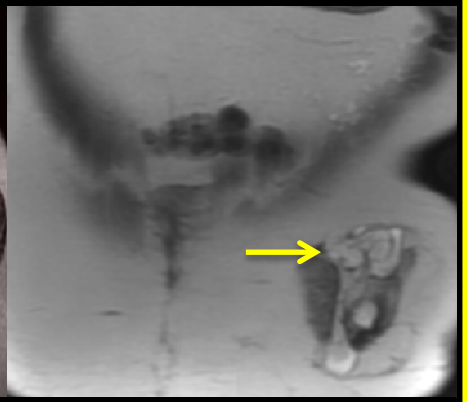






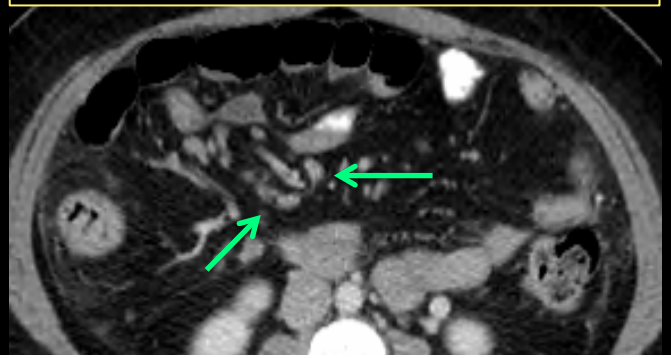






Mesentery implant in the incisional hernia

Pitfalls: Normal lymph nodes

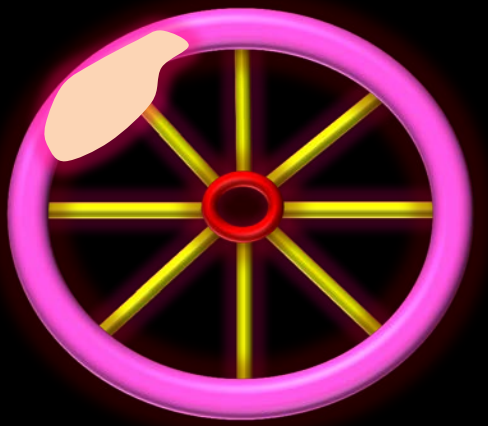


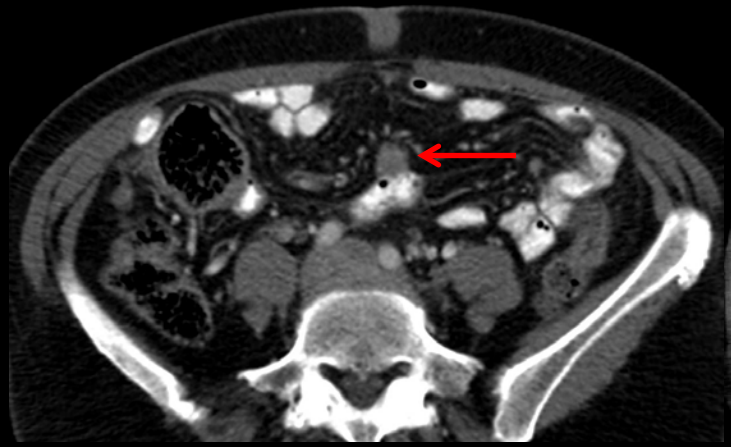
Normal lymph nodes (oblong shape)
Nodular implants have more rounded shape or spiculated borders

DW imaging is not helpful because all lymph nodes demonstrated restricted diffusion.

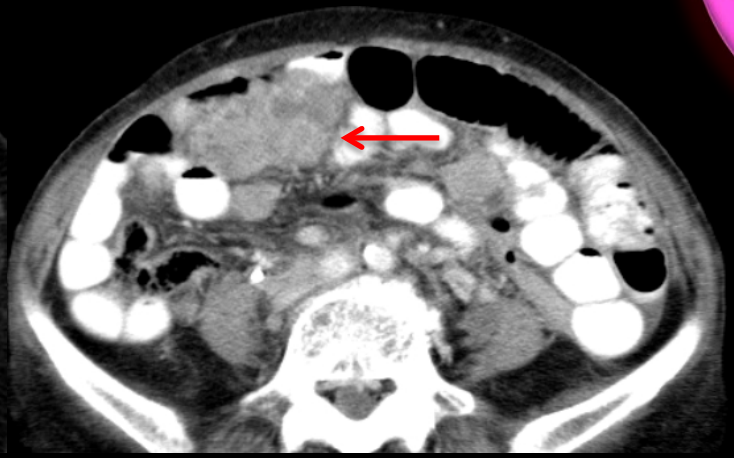
Small Bowel Involvement Pattern

This pattern is usually present in advanced disease. Nodules may involve just the serosa or the entire thickness of the intestinal wall.

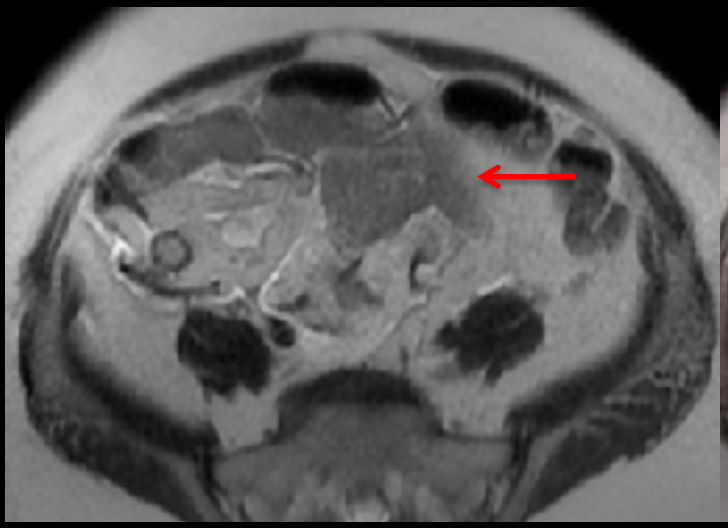


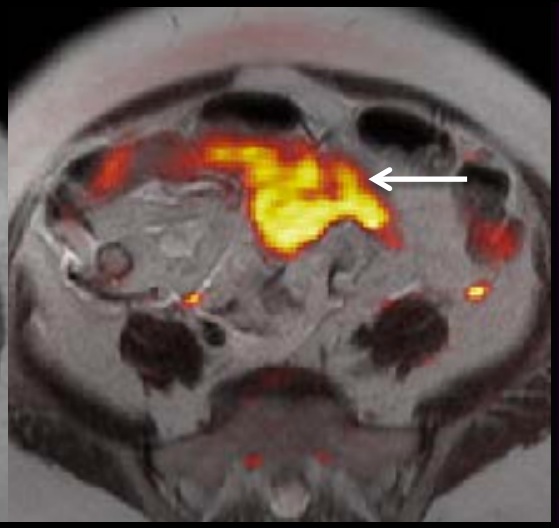


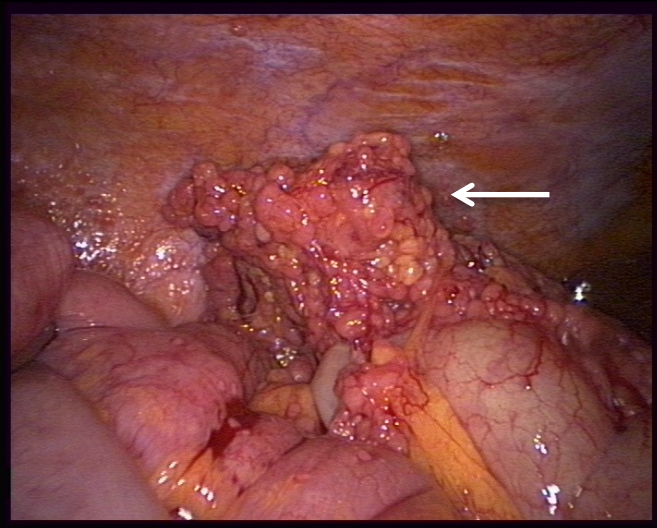
Serosal tumor deposit



Tumor implant with full-thickness bowel wall involvement



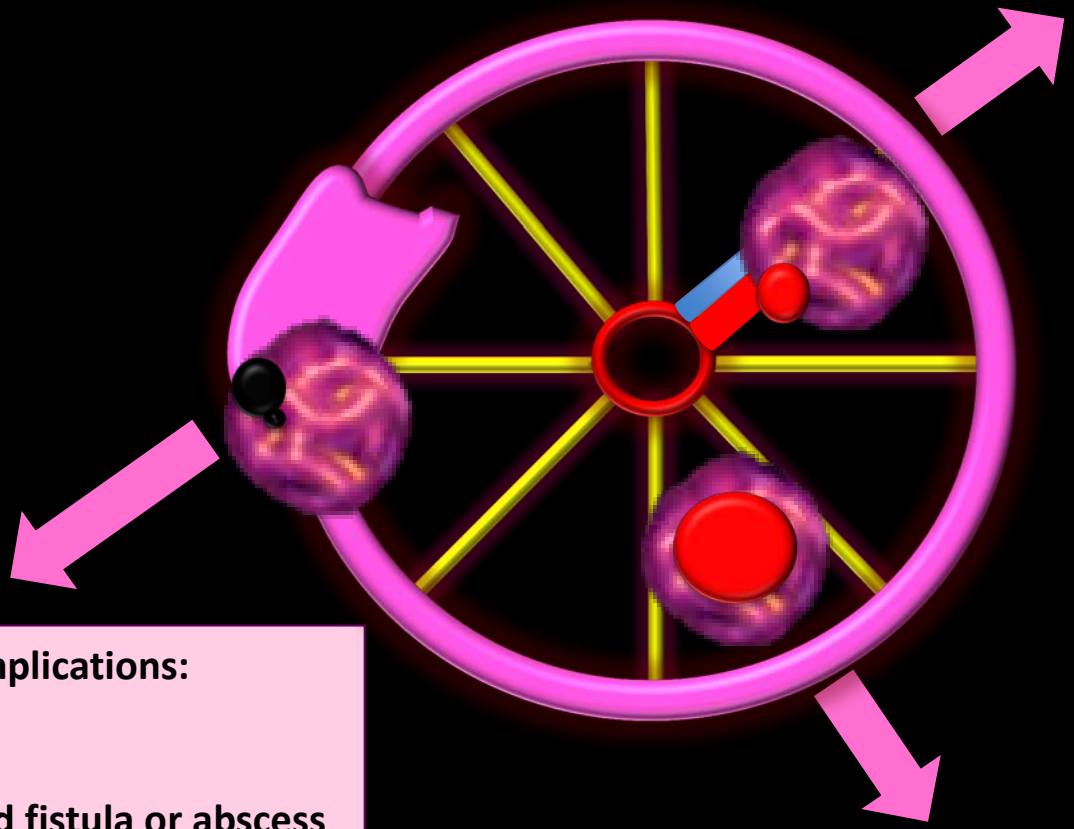




Large mesenteric implant with small bowel invasion

DIAGNOSE TUMOR-RELATED COMPLICATIONS

Complications caused by the mesenteric tumor extension into the adjacent structures:

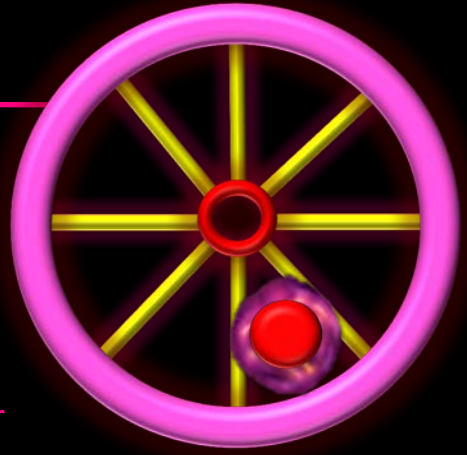


Adjacent Vessels
- **Compression**
- **Erosion**
- **Invasion**
- **Thrombus**

Small Bowel Complications:
- **Obstruction**
- **Perforation**
- **Tumor-related fistula or abscess formation**
- **Ischemia**

Intratumoral hemorrhage

Intratumoral Bleeding

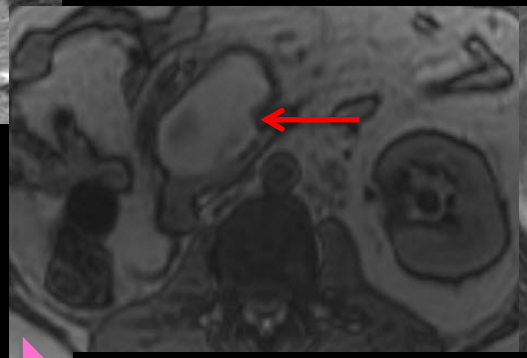


Some tumors may spontaneously rupture and manifest with intratumoral hemorrhage.

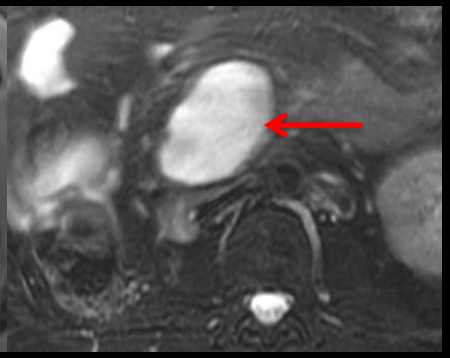
Lymphoma

Interval resolution of prior lymphadenopathy

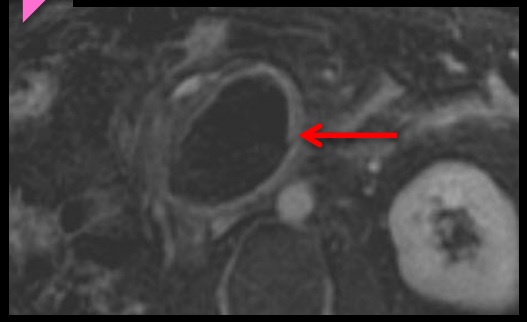
New onset of abdominal pain and a clinical concern for tumor recurrence



T1-hyperintense



T2-hyperintense

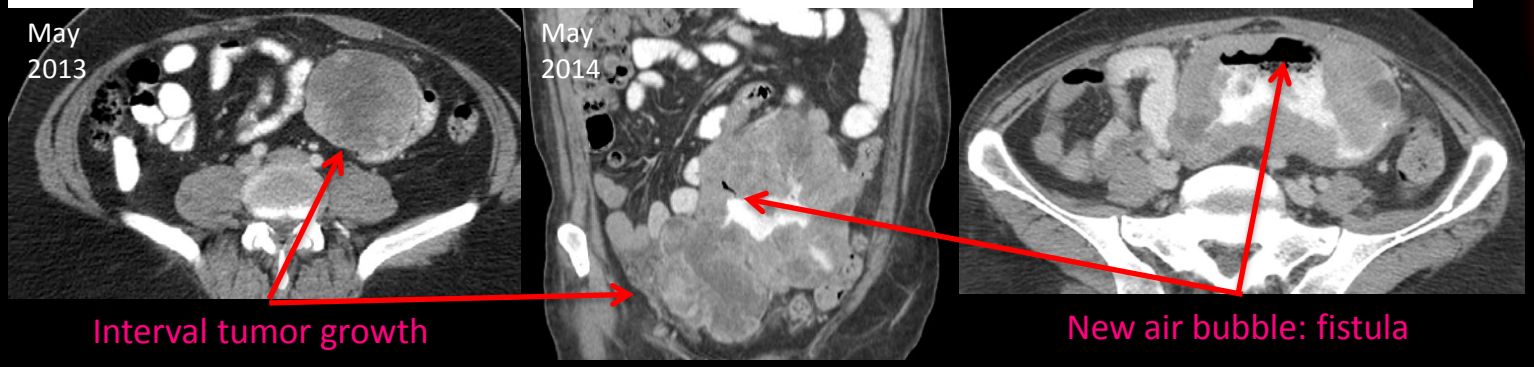


No enhancement

Hematoma

Small Bowel Complications

Mesenteric metastasis from hemangiopericytoma

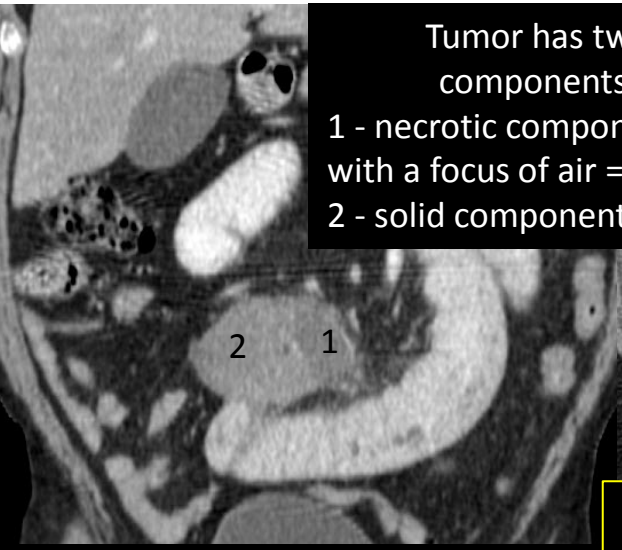


Interval tumor growth

New air bubble: fistula

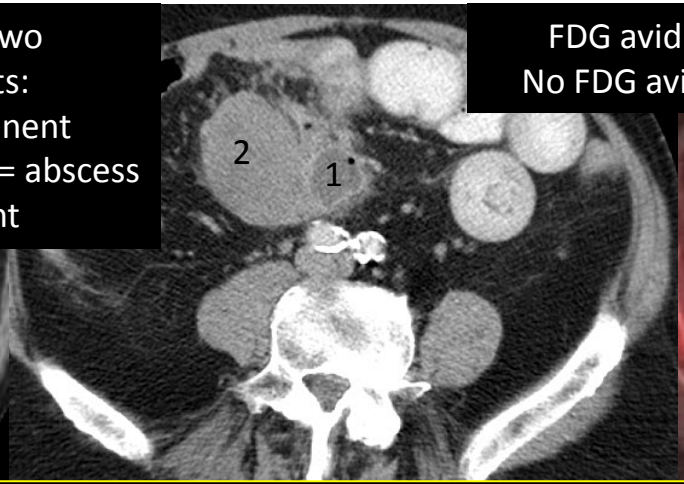
Pearl: New air bubble in the tumor should raise suspicion for a tumor-related fistula. However, a fistulous tract may not always be visible.

Desmoid Tumor

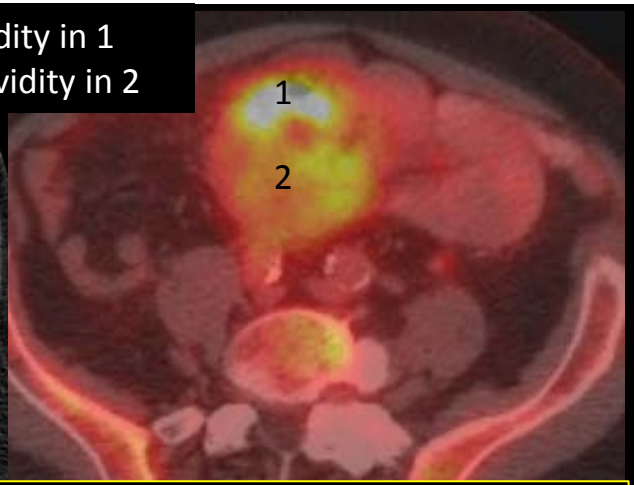


Small bowel obstruction

Tumor has two components:
1 - necrotic component with a focus of air = abscess
2 - solid component



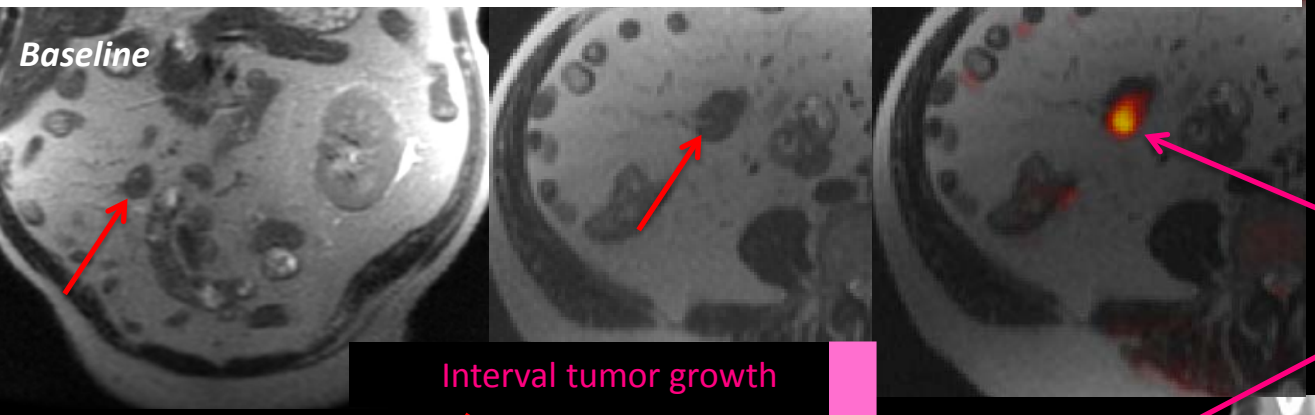
FDG avidity in 1
No FDG avidity in 2



Desmoid tumor with a fistula to the small bowel and abscess formation. Prominent FDG avidity in the abscess, not in the tumor.

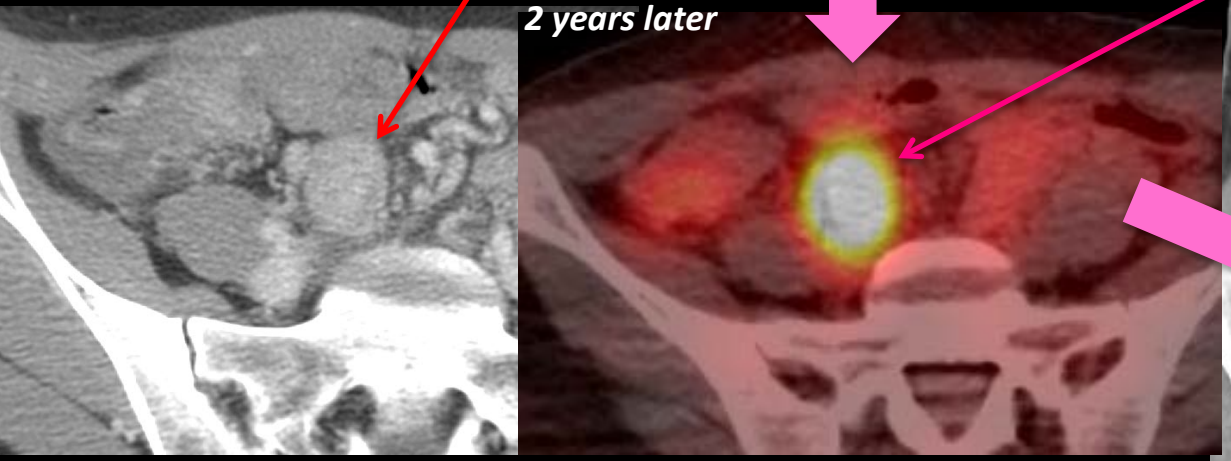
Small Bowel Complications

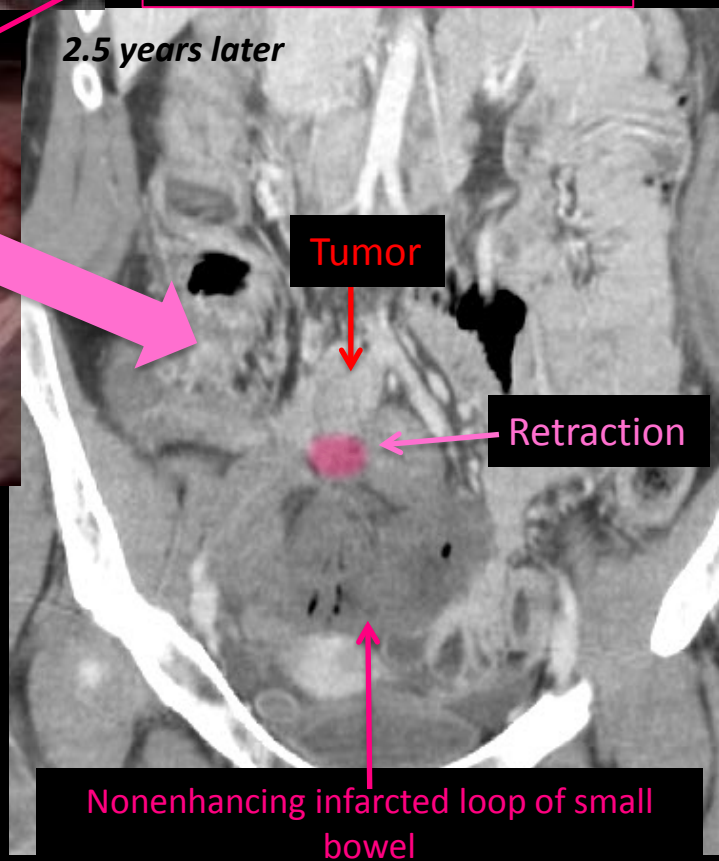
Carcinoid tumor



Pearl: Carcinoid tumors demonstrate restricted diffusion and FDG avidity.

Interval tumor growth

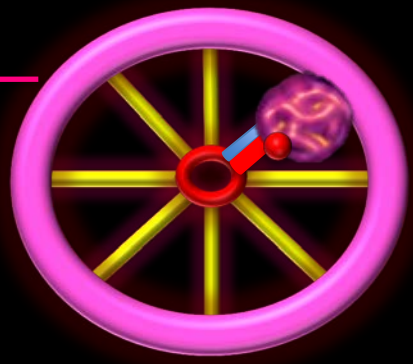




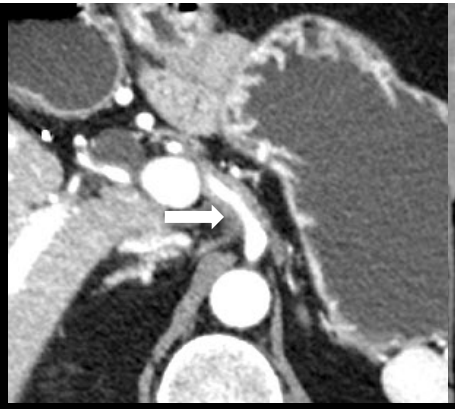
Mesenteric infiltration and adjacent mesenteric fibrosis may result in intestinal ischemia or infraction.
Images should be scrutinized for any signs of bowel ischemia.

Vascular Complications

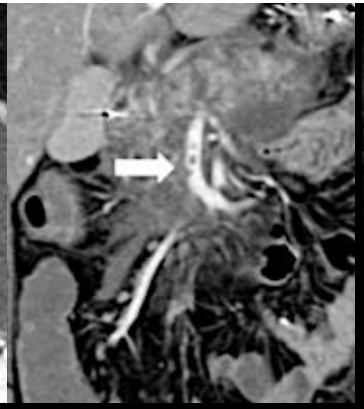
Blood vessels may be compressed, thrombosed, or eroded by the adjacent tumor.



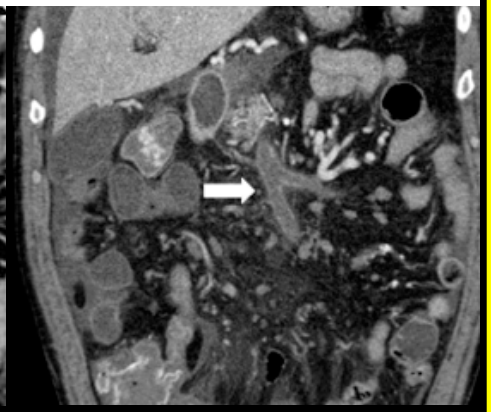
Pancreatic cancer with extension into the root of the mesentery



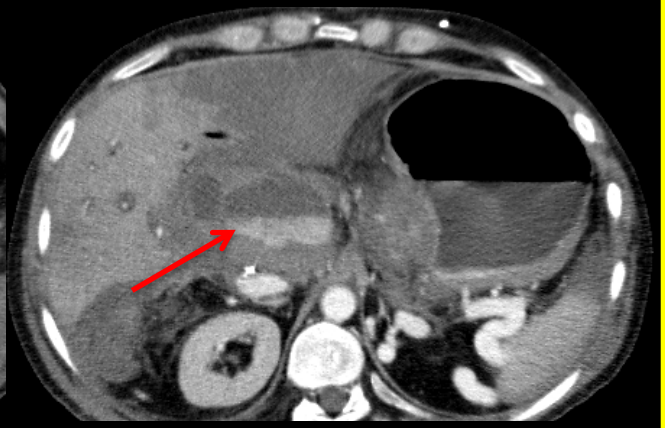
Encasement



SMA thrombus

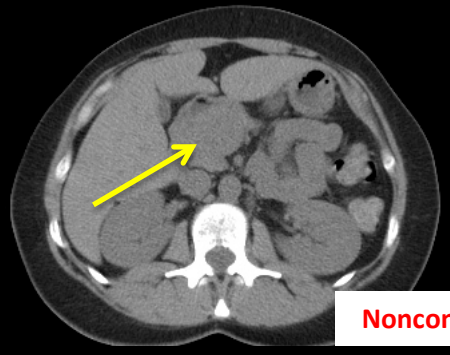


Superior mesenteric vein (SMV) thrombus



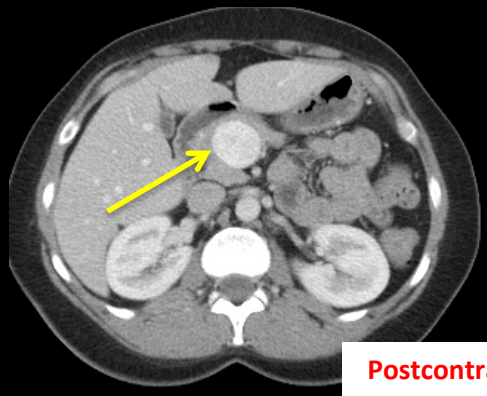
Common hepatic artery encasement by tumor and active contrast extravasation consistent with hemorrhage after a Whipple procedure

Pitfalls: Not every enhancing lesion in the root of the mesentery is a tumor.



Noncontrast

SMV aneurysm



Postcontrast

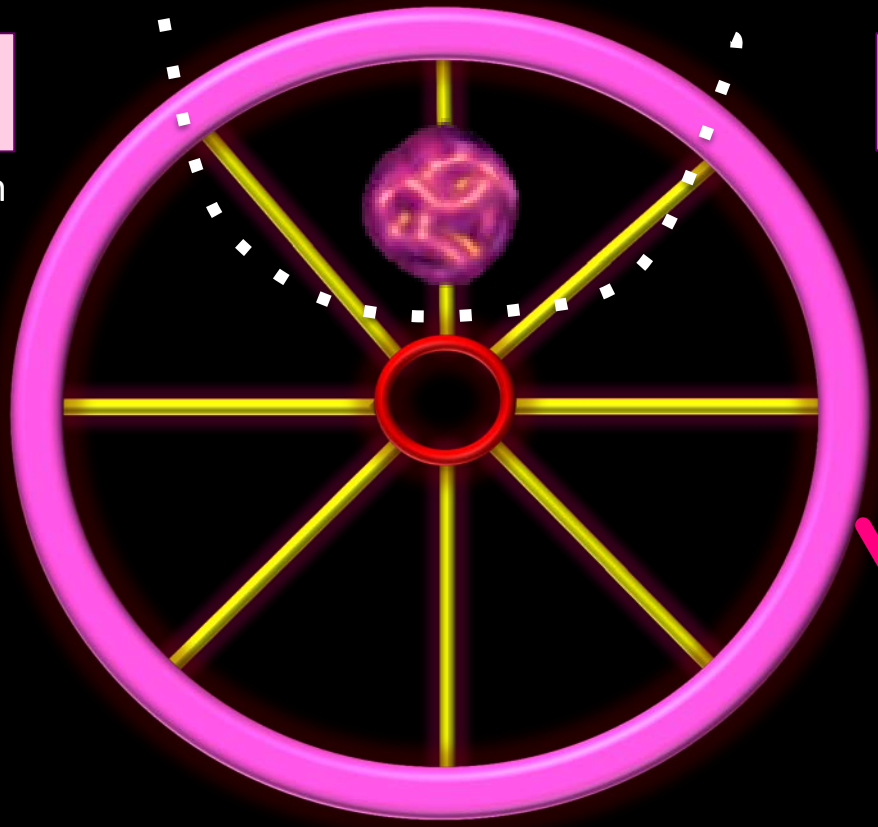
TREATMENT AND MANAGEMENT

IMAGING ASSESSMENT OF TUMOR RESECTABILITY

"The Three Wheel Rules"

1 R0 rules

Complete resection



2 Tumor location

- Peripheral location: higher rate of successful surgical resection because less extensive small bowel resection is required.
- Central location: Lower chance of successful excision because more extensive intestinal resection is needed.

3 Mesenteric vessels

Central tumors impose a greater surgical challenge as they may involve large centrally located vessels that supply large vascular territories and cannot be sacrificed.

TREATMENT AND MANAGEMENT

	SURGICAL	DEBATABLE SURGERY	NONSURGICAL
BENIGN	Cystic lymphangioma Solidary fibrous tumor Desmoid tumors (high risk of recurrence) Lipoma or lipoblastoma		Lymphoma
BENIGN	Complicated Sclerosing Mesenteritis	⟷	Sclerosing mesenteritis
MALIGNANT	R0 PRIMARY GOAL Liposarcoma GIST Ovarian carcinomatosis Carcinoid	⟷	R1 (cytoreductive surgery) Ovarian carcinomatosis Carcinoid ⟷ Secondary neoplasms Ovarian carcinomatosis

Management of Ovarian Carcinomatosis

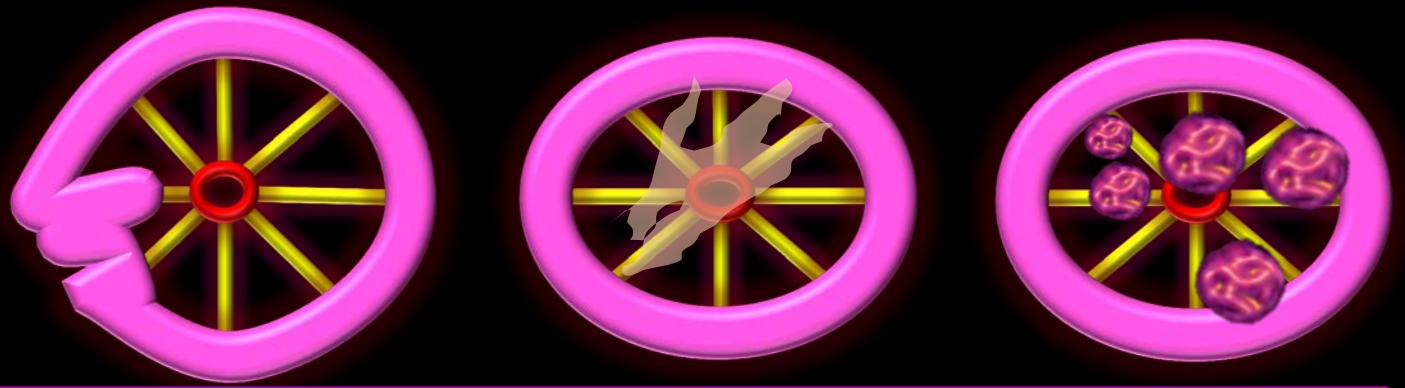
SURGICAL

Limited number of small bowel serosal implants located on the antimesenteric border can be resected.

Limited number of implants with small bowel invasion can be resected, but this entails larger intestinal resection.

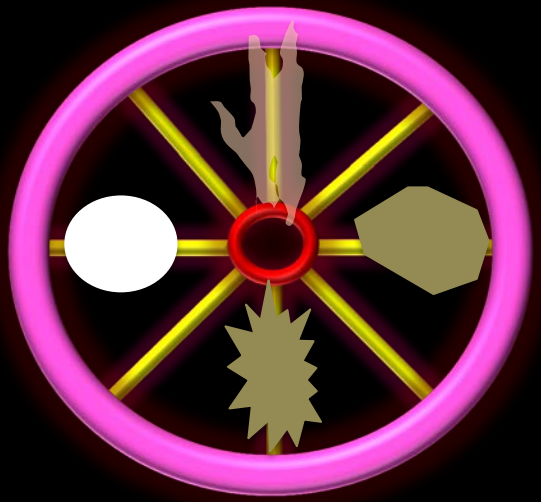
NONSURGICAL

Centrally situated tumors require more extensive intestinal resection.



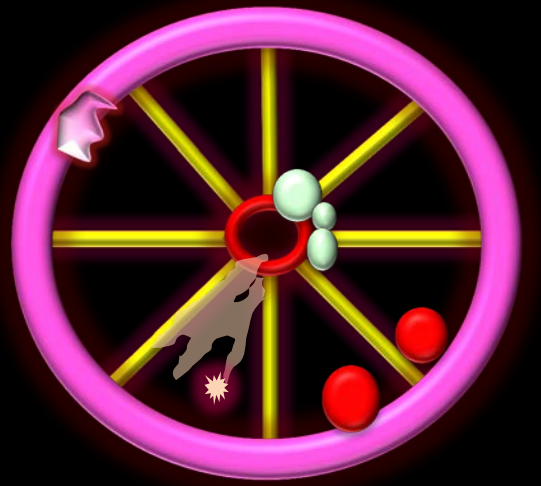
Misty mesentery, retractile mesentery, and multiple mesenteric nodules are all signs of diffuse mesenteric involvement, ruling out surgical management.

CONCLUSIONS



PRIMARY MESENTERIC LESIONS:
Rare
Four patterns
Goal: R0 resection

MORE COMMON:
Desmoid
Sarcoma
Lymphangioma
Carcinoid (Primary)



SECONDARY MESENTERIC LESIONS:
Common
Four patterns
Detection is essential

LYMPHOMA:
Chemotherapy

SECONDARY NEOPLASM:
Usually nonsurgical management

Suggested Reading

1. Coakley FV, Hricak H. *Imaging of peritoneal and mesenteric disease: key concept for the clinical radiologist*. Clin Radiol. 1999 Sep;54(9):563-574.
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3. Fujii S, Matsusue E, Kanasaki Y, Kanamori Y, Nakanishi J, Sugihara S, Kigawa J, Terakawa N, Ogawa T. *Detection of peritoneal dissemination in gynecological malignancy: evaluation by diffusion-weighted MR imaging*. Eur Radiol. 2008 Jan;18(1):18-23.
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9. Sheth S, Horton KM, Garland MR, Fishman EK. *Mesenteric neoplasms: CT appearances of primary and secondary tumors and differential diagnosis.* RadioGraphics. 2003 Mar-Apr;23(2):457-473.
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11. Takagi Y, Yasuda K, Nakada T, Abe T, Saji S. *Small bowel volvulus caused by a lipoma of the mesentery showing a distinct pattern on preoperative computed tomography*. Dis Colon Rectum. 1998 Jan;41(1):122-123.
12. Tomita H, Yamaguchi K, Matsuo M, Ohno T, Nishimoto Y, Hirose Y. *Metastatic myxoid liposarcoma in the mesentery: what is debated? Case report and a review of the literature.* Am Surg. 2006 Jan;72(1):68-70.
13. Tomizawa Y, Garner K, Sohnen A. *Lymphangioma of the small bowel mesentery: a rare intra-abdominal tumor causing anemia*. Clin Gastroenterol Hepatol. 2013 Aug;11(8):e57.
14. McLaughlin PD, Filippone A, Maher MM. *The misty mesentery: mesenteric panniculitis and its mimics*. AJR Am J Roentgenol. 2013 Feb;200(2):W116-W123.
15. Taffel MT, Khati NJ, Hai N, Yaghmai V, Nikolaidis P. *De-misty-fying the mesentery: an algorithmic approach to neoplastic and non-neoplastic mesenteric abnormalities.* Abdom Imaging. 2014 Aug;39(4):892-907.