Peritoneal Carcinomatosis Index: What Radiologist Should Know

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LEARNING OBJECTIVES

The purpose of this review is to illustrate the imaging findings of peritoneal carcinomatosis, discuss Peritoneal Carcinomatosis Index (**PCI**) concept and its clinical usefulness, and explore the role of the radiologist in the multidisciplinary team of peritoneal disease.

BACKGROUND – Peritoneal Carcinomatosis

Peritoneal carcinomatosis (**PC**) is defined as intraperitoneal dissemination of any form of cancer that does not originate from the peritoneum itself and traditionally it is associated with a poor outcome.

Most commonly, it arises from gastrointestinal tract carcinomas, such as colorectal, gastric, appendix, pancreatic or ovarian cancer.

Less frequently, hepatocellular carcinoma, melanoma, breast and lung tumors can be causes of **PC**.

Manifestation of **PC** has a very wide spectrum and includes ascites, diffuse enhancement of the peritoneum, irregular or nodular peritoneal thickening and omental nodularity, masses or caking. Mesenteric effacement, bowel wall thickening, hyperenhancement and luminal narrowing may indicate small bowel disease.

BACKGROUND – Peritoneal Carcinomatosis

Computerized Tomography (**CT**) is the most frequently used modality to investigate patients with suspected peritoneal metastasis. However, diffuse peritoneal invasion may also remain unapparent on CT, especially when it consists of scattered micronodules covering the peritoneum.

CT also permits assessment of metastatic extraperitoneal disease.

Accurate preoperative assessment of disease burden is important as it changes the staging of disease, treatment plan and prognosis, avoiding nontherapeutic laparotomies in many patients.

Cytoreductive surgery (**CRS**) with or without hyperthermic intraoperative chemotherapy (**HIPEC**) can be used as a therapeutic option for **PC** and has been shown to improve the long-term survival in selected patients.

BACKGROUND – CRS and HIPEC

CSR is a procedure that includes a number of organ resections and peritonectomy. The aim is complete removal of tumor tissue, organ and/or the peritoneal surfaces without leaving any visible tumor in the abdominal cavity

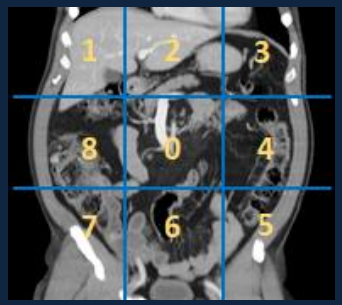
The principle of **HIPEC** is to provide a high locoregional concentration of chemotherapy to penetrate the remaining microscopic disease. Hyperthermia is used as it has direct cytotoxic effects as well as synergistically increases the effect of the chemotherapy.

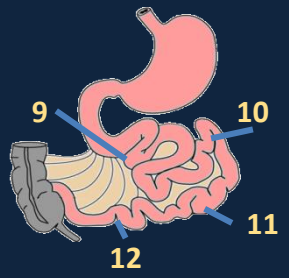
Appropriate patient selection, namely through Peritoneal Carcinomatosis Index (**PCI**), is one of the most important factors to achieve successful results for the treatment of **PC**.

BACKGROUND – Peritoneal Carcinomatosis Index

The Peritoneal Carcinomatosis Index (**PCI**), described by Jacquet and Sugarbaker, is a preoperative radiologic assessment used to evaluate the extent and volume of peritoneal disease.

The abdomen is divided into **nine** regions and the small bowel into **four** parts.





The tumor deposits in each site are classified using a size based score ranging from **0** to **3**.

Score	Lesion Size
0	No visible tumour
1	< 0,5 cm
2	0,5 cm – 5 cm
3	> 5 cm or caking

	Region	Score
0	Central	
1	Right Upper	
2	Epigastrum	
3	Left Upper	
4	Left Flank	
5	Left Lower	
6	Pelvis	
7	Right Lower	
8	Right Flank	
9	Upper Jejunum	
10	Lower Jejunum	
11	Upper Ileum	
12	Lower Ileum	
	Total	

PCI is the result obtained by adding all the scores and may range from **0** to **39**.

The greater the extent of peritoneal disease, the smaller the chances of a successful cytoreduction.

IMAGING FINDINGS – Peritoneal carcinomatosis

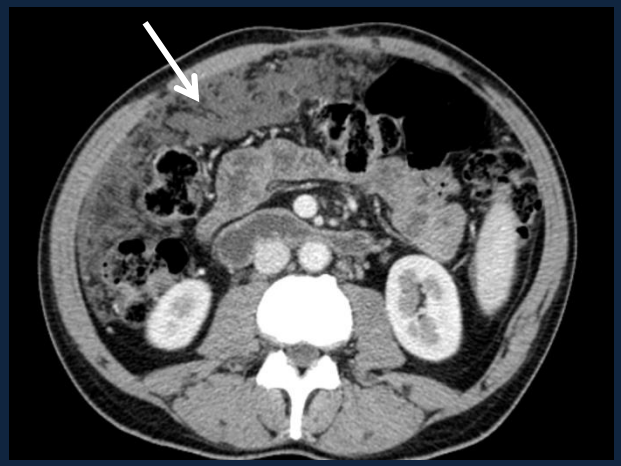


Figure 1 — 55-year-old man who presented peritoneal disease in the setting of gastric adenocarcinoma. Axial contrast-enhanced CT image on soft-tissue windows shows densification of epiploic fat described as omental cake (*arrow*).

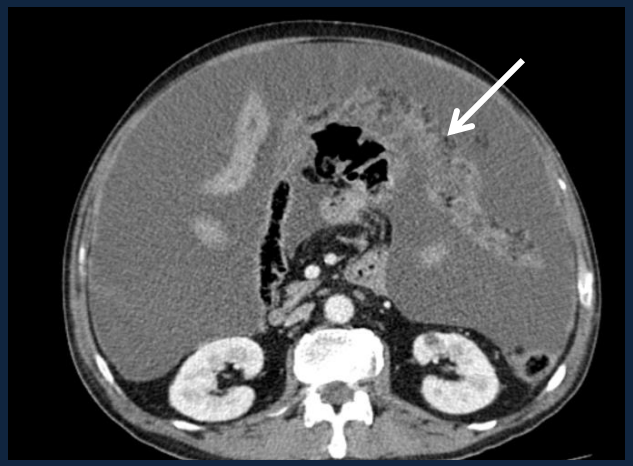


Figure 2 — 57-year-old man who presented with advanced gastric adenocarcinoma.
Axial contrast-enhanced CT image on soft-tissue windows shows omental cake (*arrow*) associated with high volume ascitis.

IMAGING FINDINGS – Peritoneal carcinomatosis

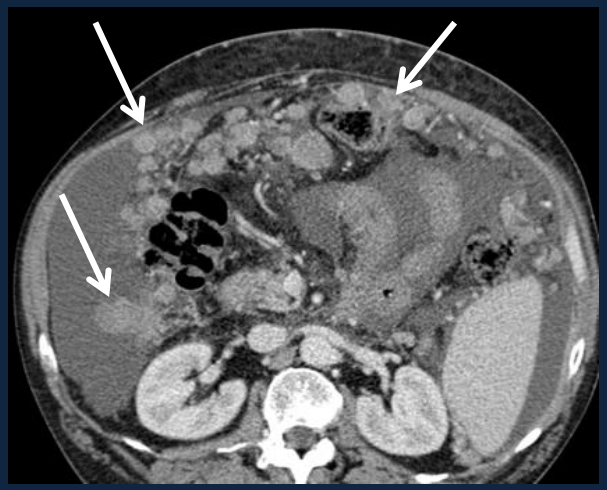


Figure 3 — 59-year-old man who presented with multifocal hepatocarcinoma.
Axial contrast-enhanced CT images on soft-tissue windows shows multiple nodular peritoneal implants (*arrows*) with ascitis.

Figure 4 — Axial contrast-enhanced CT image on soft-tissue window demonstrate peritoneal irregular and nodular thickening (*arrow*) in a 45-year-old woman with advanced ascending colon adenocarcinoma.

IMAGING FINDINGS – Peritoneal carcinomatosis

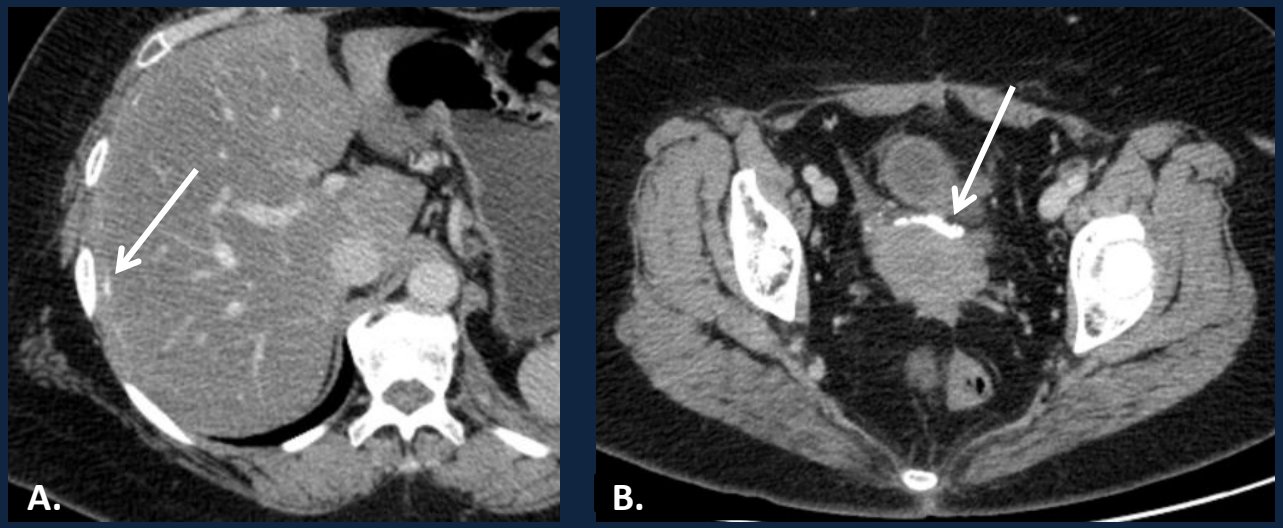


Figure 5 - 52-year-old woman who presented with advanced ovarian cancer. **A.** and **B.** Axial contrast-enhanced CT images on soft-tissue windows show perihepatic (**A**) and vesicouterine (**B**) scattered calcifications of peritoneal reflections, a manifestation of peritoneal carcinomatosis.

IMAGING FINDINGS – Peritoneal carcinomatosis

Figure 6 – Same patient as in fig. 5. Coronal contrast-enhanced CT image on soft tissue window demonstrates diffuse small bowel involvement with bowel wall thickening and hyperenhancement (*arrow*).

Figure 7 – 63-year-old man who presented with advanced gastric adenocarcinoma.
Axial contrast-enhancement CT images on soft tissue window demonstrate distal jejunum involvement with bowel wall thickening and hyperenhancement (*arrow*), which suggests small bowel disease.

IMAGING FINDINGS – Peritoneal carcinomatosis

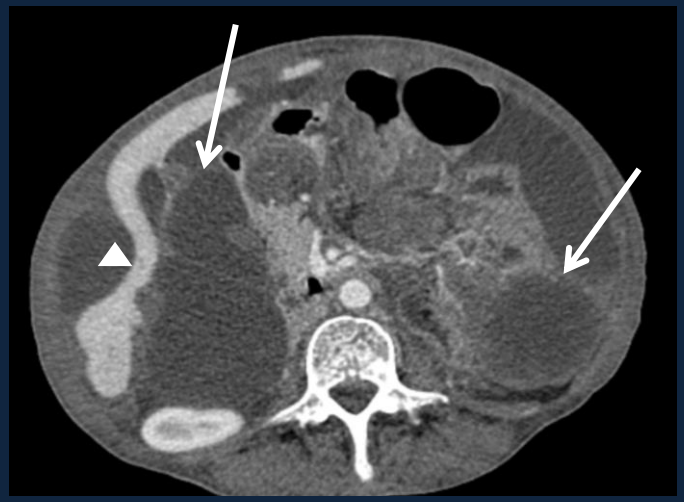


Figure 8 — 58-year-old woman with peritoneal disease in the setting of appendiceal mucinous adenocarcinoma. Axial contrast-enhanced CT image on soft-tissue windows shows low density implants (*arrows*), indicating its probable mucinous nature. The mucin collection produce notches on the hepatic parenchyma (**scalloping**, *arrow head*).

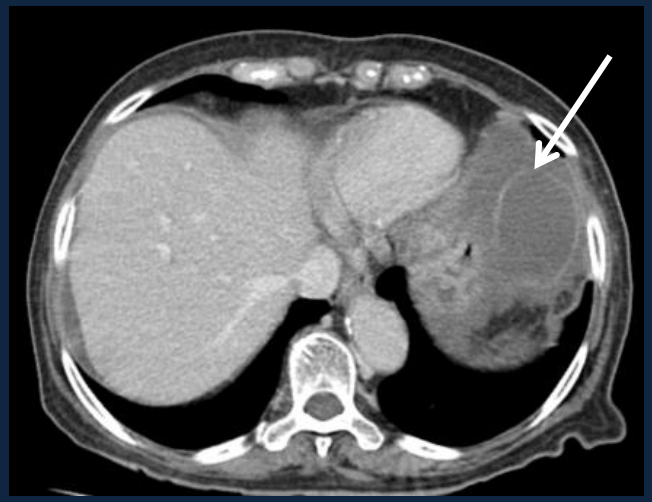


Figure 9 — 72-year-old woman who presented with appendiceal mucinous adenocarcinoma.
Axial contrast-enhanced CT image on soft-tissue windows shows a left subdiaphragmatic mucinous deposit (*arrow*) and ascitis.

IMAGING FINDINGS – Peritoneal Carcinomatosis

Tumor nodules > 5cm
Segmental small bowel obstruction
Extensive disease in the right upper quadrant

⇨ most strongly associated with a **POOR OUTCOME**

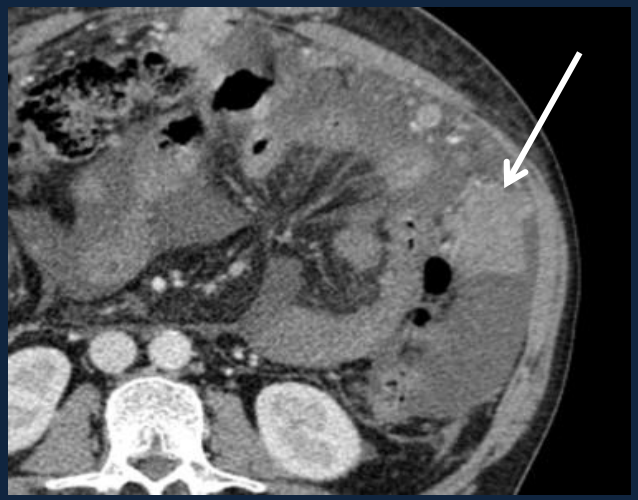


Figure 10 – Same patient as in figure 4. Axial contrast-enhanced CT image on soft-tissue windows shows macronodular peritoneal implants, the largest one (*arrow*) with 5,4cm.

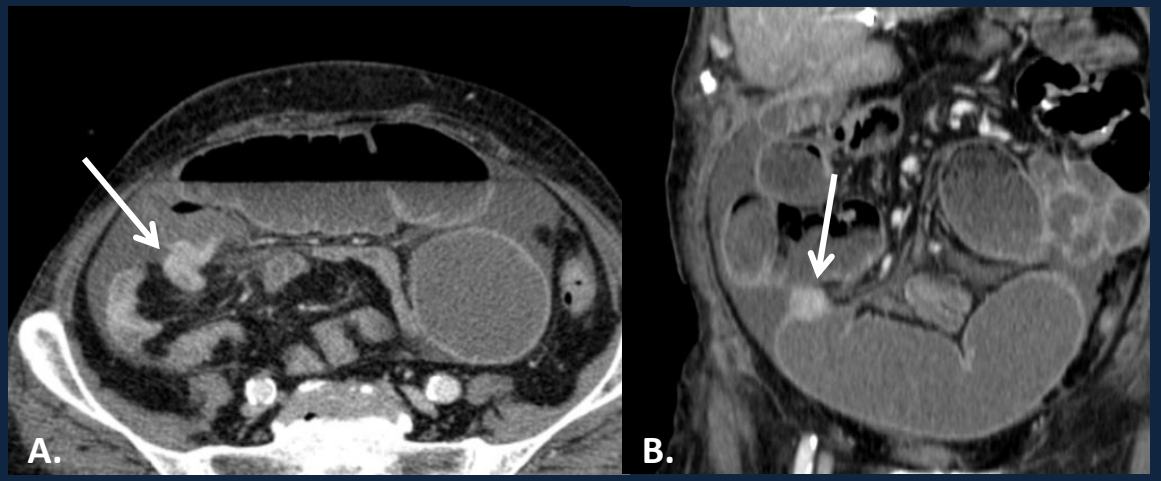


Figure 11 – 75-year-old woman who presented with gastric adenocarcinoma.
A. and **B.** Axial and coronal contrast-enhanced CT images on soft-tissue windows show a significant dilatation of small bowel loops conditioned by ileal parietal thickening (*arrows*) caused by peritoneal carcinomatosis.

IMAGING FINDINGS – PC: the role of MRI and PET-CT

Figure 12 - 71-year-old woman with sigmoid colon adenocarcinoma.

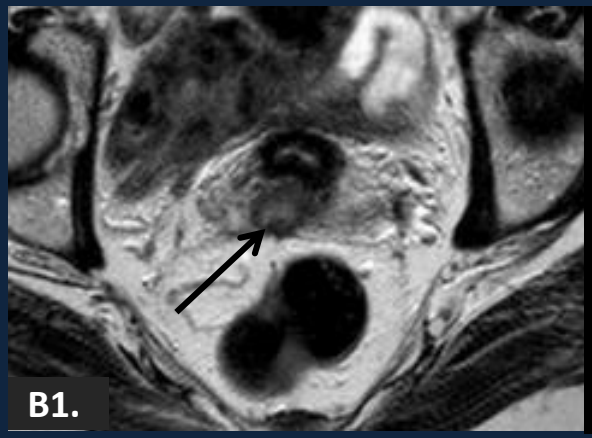
A. Axial contrast-enhanced CT image obtained after patient had previously undergone left hemicolectomy for pT3N1M0 sigmoid tumor shows a discrete hyperenhancing nodular lesion (*arrow*), that may correspond to a tumor deposit.

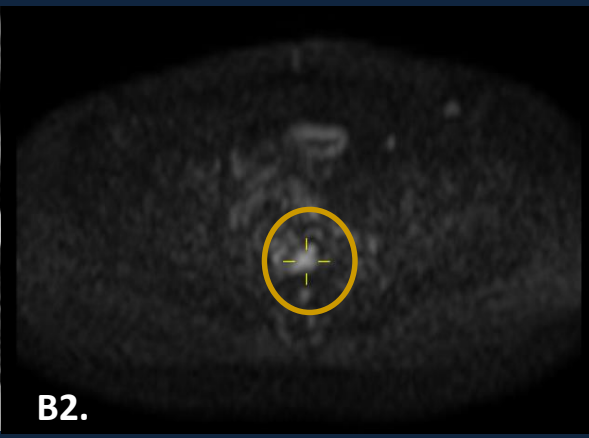
B. To clarify the focal lesion, patient was referred for further evaluation with MRI.

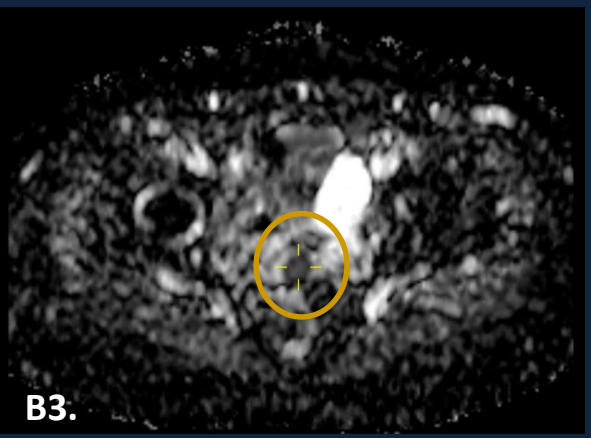
B1. T2-weighted axial MRI image shows a nodular lesion posterior to the uterine cervix (*black arrow*).

B2. Axial DWI (b value = 1000 s/mm2) shows high signal intensity, which suggests restricted diffusion

B3. Axial MRI apparent diffusion coefficient map at same level shows low signal intensity, which confirms restricted diffusion







IMAGING FINDINGS – PC: the role of MRI and PET-CT

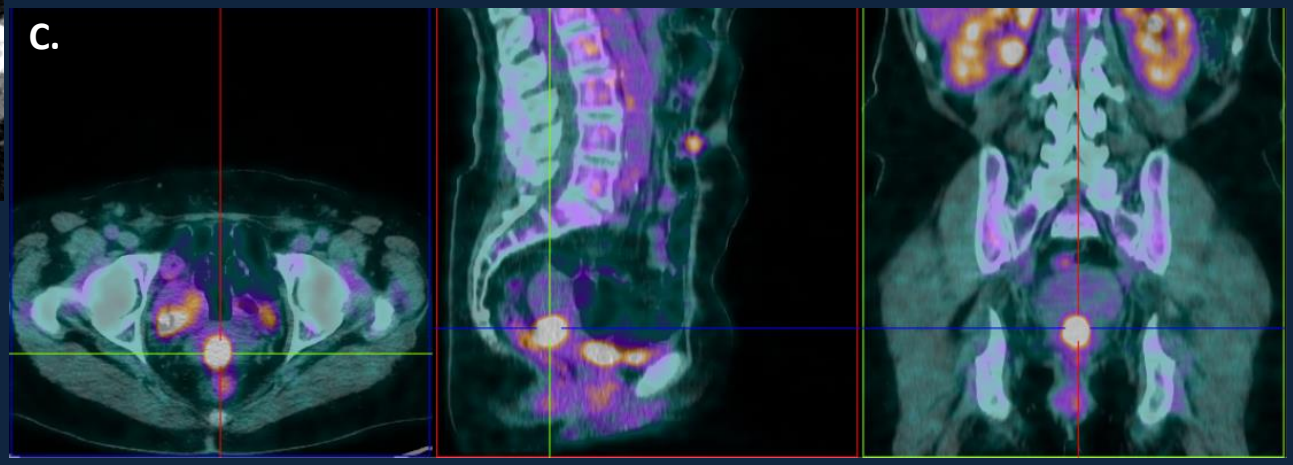


Figure 12 – 71-year-old woman who presented with sigmoid colon adenocarcinoma.

C. Patient was referred for further evaluation with PET-CT to help evaluate disease's extension.
Axial, sagittal and coronal fused PET-CT images show peritoneal implant with 18F-FDG-avid deposit in Douglas pouch, suggesting the metastatic nature of this deposit.

IMAGING FINDINGS – PC: the role of PET-CT

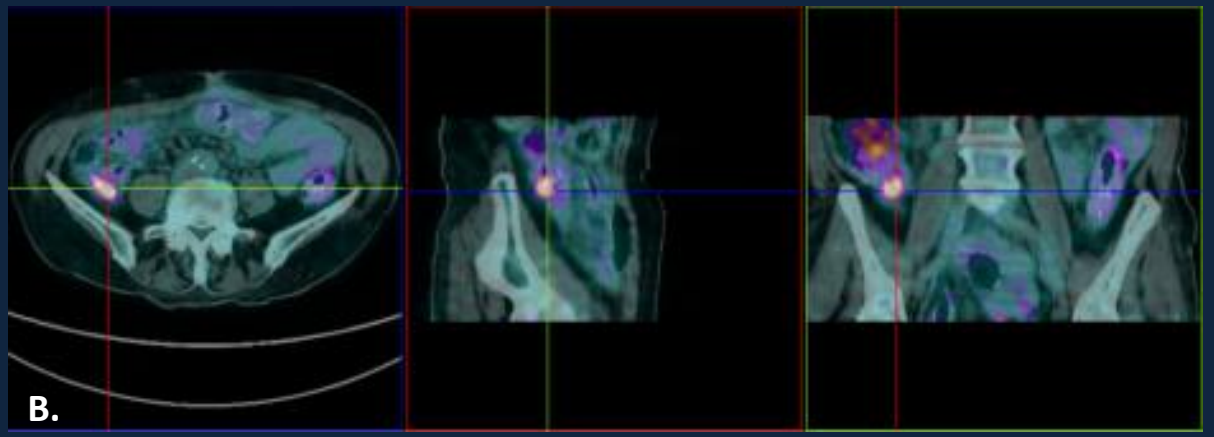


Figure 13 – 72-year-old woman who presented with mucinous adenocarcinoma of the appendix with peritoneal and ovarian metastasis (same patient as in fig. 10)

A. Surveillance CT image obtained after patient had previously undergone right hemicolectomy for pT4N0M1 mucinous appendix tumor, hysterectomy and bilateral salpingo-oophorectomy shows a perianastomotic hyperenhancing nodule (*arrow*), that may correspond to a peritoneal implant.

B. Patient was referred for further evaluation with PET-CT to help evaluate disease's extension.
Axial, sagittal and coronal fused PET-CT images show perianastomotic implant with avid 18F-FDG uptake, confirming it to be a peritoneal deposit.

IMAGING FINDINGS – contraindications to CSR with HIPEC

Extra-abdominal disease (including pleural extension of disease)

Extraperitoneal disease:
- more than 3 liver metastases
- Retroperitoneal lymph nodes

Unknown primary tumor

Involvement of the liver hilum or ureters

CONTRAINDICATIONS to CRS defined by the preoperative work-up

IMAGING FINDINGS – contraindications to CSR with HIPEC

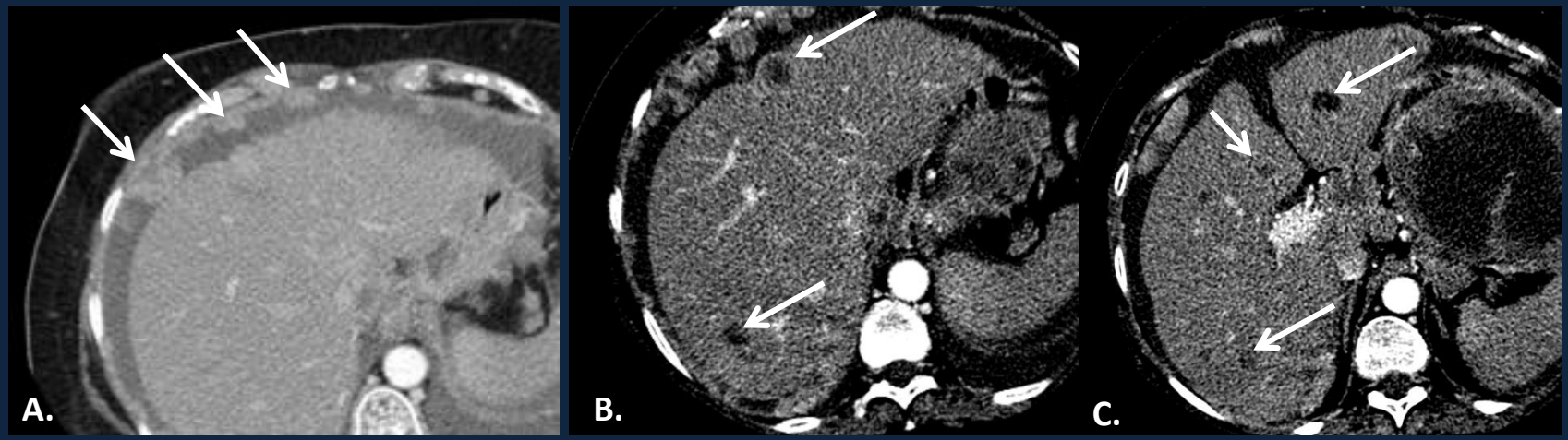


Figure 14 – 62-year-old woman who presented with pancreatic neuroendocrine tumor

A. Axial contrast-enhanced CT image on soft-tissue window shows multinodular involvement of peritoneum (*arrows*).

B. and **C.** Axial contrast-enhanced CT image on liver window illustrate multiple metastatic lesions on hepatic parenchyma (*arrows*), considered a contraindication to CRS.

IMAGING FINDINGS – contraindications to CSR with HIPEC

Figure 15 — 58-year-old man who presented with metastatic gastric adenocarcinoma.
Axial contrast-enhanced CT image on soft-tissue windows shows retroperitoneal lymphadenopathy, considered a contraindication to CRS.

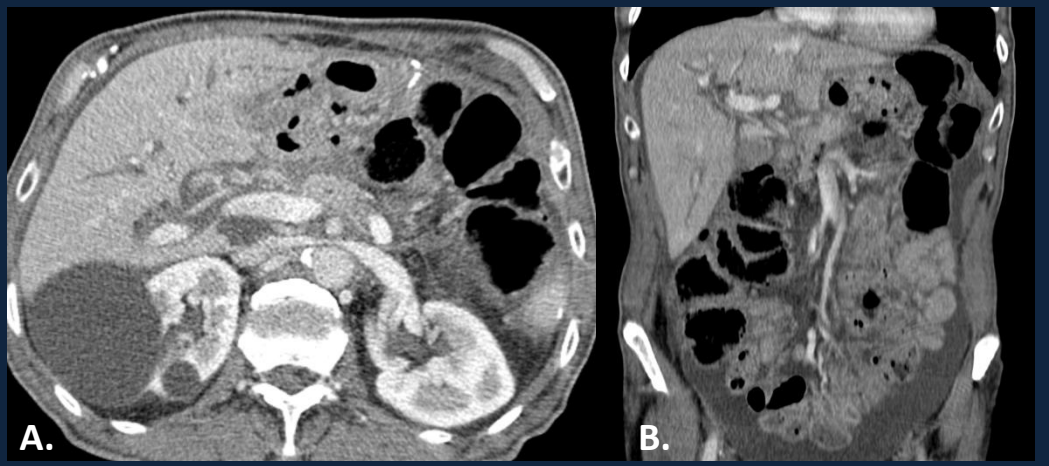


Figure 16 — 77-year-old man with advanced gastric adenocarcinoma.

A. and **B.** Axial and coronal contrast-enhanced CT image on soft-tissue windows shows ascitis and intrahepatic biliary dilatation conditioned by involvement of the hepatic hilum by infiltrative peritoneal carcinomatosis, considered a contraindication to CRS.

IMAGING FINDINGS – contraindications to CSR with HIPEC

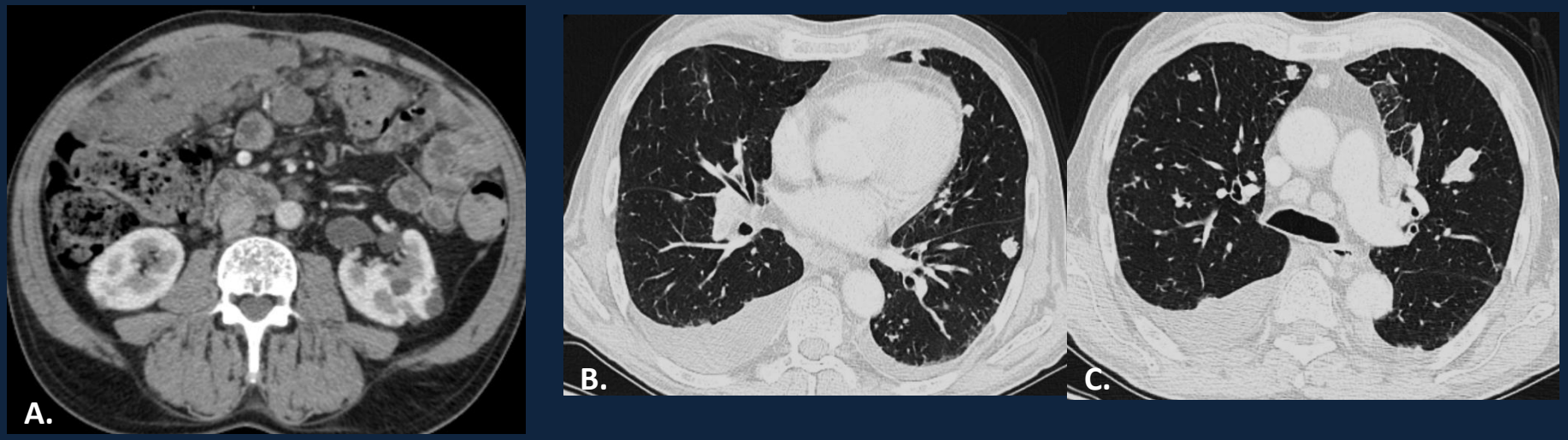


Figure 17 — 75-year-old man who presented with metastatic right colon adenocarcinoma.

A. Axial contrast-enhanced CT image on soft-tissue windows shows densification of epiploic fat (omental cake);

B. and **C.** Axial contrast-enhanced CT image on lung window shows bilateral pulmonary metastatic lesions associated with right pleural effusion.
Extra-abdominal metastasis is considered a **contraindication** to CSR with HIPEC.

CONCLUSIONS

The radiologist plays a key role in diagnosing PC at an early stage.

The cases illustrated in this review are the most common findings that radiologists should be aware when asked to evaluated pre-operatively patients with indication to CSR with HIPEC.

MRI and PET-CT may be useful to clarify some findings that may be not well characterized on CT images.

CSR and HIPEC are aggressive procedures associated with high morbidity, although they improve the long-term survival in selected patients.

Therefore, it is crucial to assess the **PCI** in order to select the candidates who are likely to benefit from this intervention and to prevent unwarranted laparotomy in patients with unresectable disease.

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