Local radiological staging of the cephalic ductal pancreatic adenocarcinoma: Resectability criteria and evaluation of the retroportal lamina. A pictorial essay

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Learning objectives

This pictorial shows in a schematic way the most important CT, MRI and EUS findings in the local staging of cephalic pancreatic adenocarcinoma. Analyzing resecability criteria, we focused on the involvement of the retroportal lamina (retroportal fat tissue).
Background

Pancreatic ductal adenocarcinoma is the most frequent type of pancreatic cancer. It has a very poor prognosis, which is mainly due to a late clinical presentation and the limited effects of chemotherapy[1]. Surgical resection still remains the only potentially curative treatment. However, 80% of patients present with an advanced, unresectable disease [2]. CT is the gold standard for staging patients with pancreatic adenocarcinoma allowing a correct assessment of the neoplastic mass, the vascular involvement, the margin involvement and therefore the resectability criteria [3].

Retroportal lamina is a very important but complex anatomical area, where the tumor cells could potentially growth and spread remaining "hidden". In this site recidive and recurrence are frequent after chirurgical approach, because tumor cells are often not completely surgically removed during routine resection [1-3].
Findings and procedure details

Because of the poor prognosis, pancreatic adenocarcinoma has been described and studied since years. A detailed imaging schema for the TNM-classification has been modified, adapted and finally proposed in order to achieve better standardization in the therapeutic approach. The diagnostic CT-parameters of resectability are well known and in common use of radiologists, who describe the tumor. [3,4]

Parameters of evaluation of resectability at CT. [4, 5]

1. Tissue obliteration: gross macro infiltration.
2. Alteration of the tissue density (ROI in the region of interest): spread, fine increased density or suspicion of micro infiltration
3. Irregularity of the medial margin of the uncinate process with focal bulge in the pancreatic contur --> micro infiltration soft tissue mass surrounding the area of involvement
4. Collateral vessels, engorgement of collateral circles: secondary sign of vascular involvement
5. Venous thrombosis
6. Contact with the vessels: Superior Mesenteric Artery (SMA), Common Hepatic Artery (CHA), Celiac Axis, Gastroduodenal Artery (GDA), Splenic Artery (SA ), Portal Vein (PV), Inferior Vena Cava (IVC), Superior Mesenteric Vein (SMV): <180° without deformity, > 180° without deformity, >180° with deformity, >180° with tear drop deformity. Attention: arterial variants. (Figure 1)
7. Involvement of the retroportal lamina, retroportal fat tissue, connective tissue, lymphatic and Retropertitoneal nerves: pain (Figure 2)

Non resectability criteria were: Distant metastases (liver, lung, pleura or peritoneum), presence of distant metastastic lymphnodes (medistinal, supraclavicular, interaortocaval or paraaortal), infiltration of extrapancreatic or extraduodenal viscerals and tumorous arterial vessels encircling of over 180° as described in the CT-parameters.[6]

Invasion of the peripancreatic fat tissue, lymphatic network and extrapancreatic neural plexuses (Figure 3) affects the staging and the patients prognosis, because neoplastic tissue may remain in the resection margins, resulting in postoperative recurrence.[7-10]

On CT examination a retroperitoneal fat tissue invasion appears as streaks extending into the soft tissues from tumor margin. Coronal and sagittal multiplanar reformatted images are very useful to perform a correct assessment of these findings, increasing CT
performance in the evaluation of local extension, useful for discriminate preoperatively the best treatment-strategy.[9, 11-13]

Anatomical location of the retroportal fat tissue:

The retroportal lamina is roughly rectangular in shape. It is located behind the portal vein, behind the distal parts of the mesenteric vein and between the left margin and right proximal wall of the uncinate process. It contains adipose tissue, nervous structures, lymphatic vessels and capillaries. Because of the absence of fibrous sheath or fascia, its complete removal in pancreatic head carcinoma is feasible by a subadventitial dissection of the superior mesenteric artery, which can be consideres as the real limit of the mesopancreas.[14, 15].

Pancreatic adenocarcinoma generally grows in a less cohesive fashion. It is characterized by "tumor desmoplasia", a remarkable increase of connective tissue that infiltrates and envelops the neoplasm. More extensive fibroblastic cell proliferation in pancreatic carcinoma correlates with poor outcome.

The tumor cells produce and secrete proteolitic matrix-degrading enzymes, angiogenic growth factors (f.e. VEGF, bFGF, PDGF, IGF, TGF-beta) and lymphangiogenesis factors (VEGF-C).[16]

The resulting stimulation of neovessels formation in the stroma encourages the carcinoma progression by delivering nutrients and oxygen, promoting local growth and cell-scattering around the extrapancreatic tissue, resulting in a fibrotic thickening of adipose tissue and forming peripancreatic strands. This creates an inhomogeneity which can be seen on CT, frequently described and identified as "reticular", "tubular", "soft tissue mass" along the lymphatic system, including microvessels in peri-pancreatic fat tissue.

Talking about the retroportal lamina, there is an imaging-classification of invasion:

**Grade 0:** No retroperitoneal fat infiltration (*Figures 4, 5*)

**Grade 1:** Strands or streaks in peri-pancreatic soft tissues (<0,5mm) radiating from the tumor margins (*Figure 6*)

**Grade 2:** Strands or streaks in peri-pancreatic soft tissues (>0,5 mm) radiating from the tumor margins without abutting the major artery (*Figures 7-8*)
Grade 3: Strands or streaks structures (>0.5) radiating from the tumor abutting the major artery *(Figure 9)*

Surgical procedure:

After excluding intra-abdominal contraindications like peritoneal carcinomatosis and liver metastasis, all patients underwent a pylorus-sparing pancreaticoduodenectomy (PPPD), also known as Traverso-Longmire procedure, with the removal of the duodenum, the gall bladder and its cystic duct, the common bile duct, the proximal jejunum, the head of the pancreas and the regional lymph nodes. Reconstruction of the anastomosis was performed in Blumgart’s technique (transpancreatic U-suture technique). If the tumor does not involve vascular structure, it does not performed any vascular resection.[17, 18]

Histopathological work up:

All histopathological specimens were assessed by size, histological type, differentiation (grading), lymphovascular invasion and resection margins.

On pathological examinations, there may be two ways of peripancreatic invasion by pancreatic cancer:

- tumor emboli, that fill up the dilatated lymphatics and neovessels
- tumor extension along the lymphatic channels and nerve plexuses (f.e. posteriorly to the portal vein along the plexus pancreaticus capitalis, involving the right celiac ganglion; anteriorly along the gastroduodenal artery involving the neural plexus of the common hepatic artery and the plexus of the hepatoduodenal-ligament) appearing as confluent tissue with similar attenuation values of the primary pancreatic cancer, extending along neural plexuses pathways in directed contiguity with the primary intrapancreatic adenocarcinoma. It occurs even in relatively small cancers (<2cm).[8]

The current grading criteria are useful to descriminate the best treatment strategy preoperatively, because the grades were significantly associated with overall survival, as well as the incidence of surgical margin status and recurrence. The posterior margin of the retroportal lamina was found to be the only aspect of a R1 resection margin that significantly influenced the disease free survival. The invasion of the retroportal fat tissue (grade 3) is considered as T3 tumor, and it may be managed as a systemic disease, using for example with neoadjuvant chemo-radiotherapy before surgery.
Prognostically it was seen that intraoperative inability of complete resection of the involved retropancreatic fat tissue had the same prognosis as a non-operation. On the other hand it must be considered that Whipple operation is a complicated and long procedure with a high risk of pre-and postoperative complications. A positive involvement of the retroportal lamina means that the operation was useless and a recurrent of the disease is very likely. [11]
Fig. 1: Arterial phase CT in the axial (A, B) sagittal (C, D) and coronal plane (E). Pancreatic head adenocarcinoma (arrows) that involves all peri-pancreatic structures, enclosing the celiac trunk (black arrowheads in A and D), the superior mesenteric artery (white arrowheads in D), and causing dilatation of the entire biliary tree (curved arrows) and gallbladder (asterisk in E)

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Fig. 2: Portal phase CT in the axial (A, B) and sagittal plane (C). Pancreatic head adenocarcinoma with involvement of the retroportal fat tissue (arrows in A and C) causing initial dilatation of the main pancreatic duct (arrowheads in B). The ecoendoscopy shows even an initial dilatation of the choledochus (curved arrows in E), which is restricted in its distal portion (curved arrow in D)

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Fig. 3: Arterial phase CT in the axial (A) and Sagittal plane (B). Pancreatic head adenocarcinoma that causes fine streaks in the anterior structures (arrows) with involvement of the pancreatic nerve plexus

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Fig. 4: Portal phase CT in the axial (A) and sagittal plane (B). Pancreatic head adenocarcinoma. Grade 0: no evidence of retroperitoneal fat infiltration (arrows)

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**Fig. 5:** Arterial phase CT in the axial plane (A) and portal phase CT in the sagittal plane (B). Pancreatic head adenocarcinoma. Grade 0: no evidence of retroperitoneal fat infiltration (arrows). MRI T2 weighted image in the axial plane (C) confirms the non-involvement of the retroperitoneal adipose tissue (arrow). The portal phase CT curved reconstruction (D) shows main pancreatic duct dilatation (arrows). Magnetic resonance cholangiopancreatography (3D MRCP) (E) confirms the dilatation of main pancreatic duct (arrows), of the common bile duct (curved arrow) and of the intrahepatic bile ducts (arrowheads)

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Fig. 6: CT without contrast media in the sagittal (A), axial (B) and coronal (C) plane. Pancreatic head adenocarcinoma. Grade 1: streaks in peri-pancreatic soft tissues (< 0, 5 mm) radiating posteriorly from the tumour margin (arrow)

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Fig. 7: Portal phase CT in the axial (A) and sagittal plane (B). Pancreatic head adenocarcinoma. Grade 2: strands in peri-pancreatic soft tissues (> 0.5 mm) radiating posteriorly from the tumour margin (arrows) without vascular involvement. The gallbladder is hydropic (asterisk in A). It has thickened walls due to the involvement of the biliary tract.

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Fig. 8: Arterial phase CT in the axial (A) and sagittal plane (B). Pancreatic head adenocarcinoma. Grade 2: strands in peri-pancreatic soft tissues (> 0.5 mm) radiating posteriorly from the tumour margin (arrow). MRI FIESTA sequence in the axial plane with contrast media (C) confirms the involvement of the retroperitoneal adipose
tissue <0.5 mm (arrows). MRI diffusion weighted sequences (DWI, b=1000) shows the focal restricted diffusion of the pancreatic tumor (arrow). Magnetic resonance cholangiopancreatography (3D MRCP) (E) confirms the dilatation of main pancreatic duct (arrows), of the common bile duct (curved arrows) and of the intrahepatic bile ducts (arrowheads).

Fig. 9: Portal phase CT in the axial (A) and sagittal plane (B) with curved reconstruction (C). Pancreatic head and uncinate process adenocarcinoma. Grade 3: strands in peri-pancreatic soft tissues (> 0.5 mm) radiating from the tumor margin. The tumoral tissue surrounds the celiac trunk (arrows)
Conclusion

In this pictorial we did not focus on the different therapy options like neoadjuvant chemotherapy regimes or new surgery possibilities. The focus lied on the diagnostic imaging criteria of the cephalic ductal pancreatic adenocarcinoma, especially the evaluation of the retroportal fat tissue. Our purpose is to familiarize radiologists with other potential pathways of perineural, extrapancreatic and peripancreatic fat tissue invasion, which is an important criteria for resectability but also a prognostic factor for recurrence of the disease.
References


