Diagnosis and assessment of resectability of pancreatic cancer: the role of computed tomography

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Learning objectives

1. To illustrate computed tomography (CT) findings of pancreatic cancer important for the diagnosis.
2. To review pancreatic cancer staging system and CT criteria that determine resectability.
Background

Pancreatic adenocarcinoma accounts for 85-95% of pancreatic neoplasms and for 20% of all cancer deaths in the United States. There is an higher incidence in males (2:1) and at ages 60-80 years. Most are located in the pancreatic head (60-70%).

Surgery is the only cure, with a post operative survival rate of 20%. However, 75-85% of patients have non-resectable disease at presentation, 85% of which present with metastasis. As such, it is important to accurately stage and determine the resectability status to choose the appropriate treatment, while avoiding surgical procedures that will not benefit the patient. On the other hand, since surgery is the only potentially curative treatment, it is important that no patient that could benefit from surgery is refused the procedure. As such, an high positive predictive value method for determining unresectability is favored.

Computed tomography has become established as the primary imaging method for both the diagnosis and staging of suspected pancreatic adenocarcinoma, having high positive predictive value for unresectability and a high sensitivity when a triple-phase technique is used (with acquisitions at arterial, pancreatic and portal phases). However, a dual phase examination, with a late arterial (pancreatic parenchymal) and a portal phase, is also an established technique for evaluating pancreatic adenocarcinoma, with the first phase defended as providing optimal visualization of the tumor and peripancreatic arteries and the later phase being optimal for detecting metastasis and for assessing the peripancreatic veins. If there is a prior monophasic portal venous examination it is considered insufficient and the CT should be repeated. In addition, the smallest available section thickness should be used at image acquisition to enable the production of high fidelity reformated images.
Findings and procedure details

DIAGNOSIS

The typical CT appearance of a pancreatic adenocarcinoma is an ill-defined hypoattenuating mass in the pancreas but small lesions may be isoattenuating (10% of cases). In the latter case, secondary signs of pancreatic adenocarcinoma are particularly important, such as: change in pancreatic contour, mass effect, vascular invasion and ductal obstruction. Ductal obstruction may present differently according to tumor location as main pancreatic duct ectasia Fig. 1 on page 8, main bile duct ectasia Fig. 2 on page 8 or both ("double duct sign" Fig. 3 on page 9). Parenchymal atrophy Fig. 1 on page 8 proximal to the tumor can also be seen due to chronic obstruction. Patients with isoattenuating pancreatic lesions may benefit from magnetic resonance imaging or endoscopic ultrasonography. While uncommon, it should be noted that cystic necrotic degeneration may occur.

STAGING

Computed tomography is an useful tool for local and regional staging, determining resectability, and simultaneously allows the search for distant metastasis.

The staging system indicated for pancreatic cancers is the TNM (tumor-node-metastasis) system. Based on the TNM category, an anatomic stage/prognostic group is determined (stage grouping).

TNM Staging

Primary tumor (T)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tis</td>
<td>carcinoma in situ</td>
</tr>
<tr>
<td>T1</td>
<td>limited to the pancreas ≤ 2 cm in greatest diameter Fig. 4 on page 10</td>
</tr>
<tr>
<td>T2</td>
<td>limited to the pancreas &gt; 2 cm in greatest diameter Fig. 5 on page 11</td>
</tr>
<tr>
<td>T3</td>
<td>extra pancreatic extension without involvement of the celiac axis or the superior mesenteric artery (SMA) - Fig. 6 on page 12</td>
</tr>
</tbody>
</table>
Regional lymph nodes (N)  
Nx - evaluation impossible  
N0 - No nodal involvement  
N1 - nodal involvement (Fig. 7 on page 13)  

Distance metastasis (M)  
M0 - Absent  
M1 - Present (Fig. 8 on page 14 and Fig. 9 on page 15)  

### Stage grouping

<table>
<thead>
<tr>
<th>Clinical stages</th>
<th>TNM stages</th>
<th>Resectability</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Tis</td>
<td>Resectable</td>
</tr>
<tr>
<td>IA</td>
<td>T1,N0,M0</td>
<td>Resectable</td>
</tr>
<tr>
<td>IB</td>
<td>T2,N0,M0</td>
<td>Typically resectable</td>
</tr>
<tr>
<td>IIA</td>
<td>T3,N0,M0</td>
<td>Typically resectable</td>
</tr>
<tr>
<td>IIB</td>
<td>T1-3,N1,M0</td>
<td>Typically resectable</td>
</tr>
<tr>
<td>III</td>
<td>T4,N0-1,M0</td>
<td>Unresectable</td>
</tr>
<tr>
<td>IV</td>
<td>T1-4,N0-1,M1</td>
<td>Unresectable</td>
</tr>
</tbody>
</table>

Only the regional lymph nodes (located along the normal drainage pathways to be included in the surgical field and resected with the primary tumor) should be included in the N staging. Metastasis to lymph nodes outside the normal drainage pathways (i.e., aortocaval or paraaortic) or the ones not routinely included in the surgical resection are classified as M1 (distant metastasis present). However, CT is not accurate in the assessment of nodal involvement in pancreatic ductal adenocarcinoma. As such, in patients with otherwise resectable tumor the detection of enlarged peripancreatic nodes should not preclude resection. Anyway, the detection of these nodes can be used to choose an appropriate surgical technique.

Since the staging of the primary tumor is based mostly in tumor size and vascular invasion, it is essential to recognize CT features suggesting vascular invasion. A circumferential soft-tissue cuff around peripancreatic vessels with loss of perivascular fat plane denotes vascular invasion. Additionally, if the tumor is contiguous with more than 50% (or 180°) of a vessel there is a very high specificity for invasion. Less than or
equal to $180^\circ$ contact with the vessel circumference is considered "abutment" and more than $180^\circ$ tumor contact is referred to as "encasement". Vessel deformity, thrombosis and development of collateral vessels all suggest vascular invasion. When the superior mesenteric vein assumes a tear drop appearance on axial images ("the tear drop sign" Fig. 10 on page 19) tumoral invasion or peritumoral fibrosis are assumed to be the cause of this finding (high specificity sign). Perivascular haziness may be difficult to differentiate from solid tumor, especially following neoadjuvant chemotherapy and radiation therapy and, occasionally, as a result of pancreatitis secondary to ductal obstruction or recent procedures.

Pancreatic cancer can also be staged according to resectability, based on the National Comprehensive Cancer Network (NCCN) guidelines for pancreatic cancer. With this method, unresectability criteria are sought. If present, pancreatic cancer is classified as locally advanced/unresectable disease, and if absent it is evaluated for borderline resectability. The remaining cases are considered resectable.

**Unresectability criteria (AT LEAST 1):**

- Extensive peri pancreatic nodal involvement (Fig. 7 on page 13)
- Nodal involvement beyond peri pancreatic lymph nodes
- Distant metastasis (Fig. 8 on page 14)
- Direct involvement of SMA (Fig. 9 on page 15), inferior vena cava, aorta (Fig. 9 on page 15), celiac axis (Fig. 8 on page 14) or hepatic artery (Fig. 8 on page 14)
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- Nodal involvement beyond peri pancreatic lymph nodes
- Distant metastasis (Fig. 8 on page 14)
- Direct involvement of SMA (Fig. 9 on page 15), inferior vena cava, aorta (Fig. 9 on page 15), celiac axis (Fig. 8 on page 14) or hepatic artery (Fig. 8 on page 14)

**Borderline resectability criteria (AT LEAST 1):**

Tumors of the pancreatic head:
- Extensive involvement of the superior mesenteric vein (SMV) or portal vein (Fig. 11 on page 16)
- Involvement $<180^\circ$ of SMA (Fig. 12 on page 17)
- Involvement of the hepatic artery if reconstructable

- Short segment occlusion of SMV if non involved extension of SMV is enough for reconstruction

Tumors of the pancreatic tail: - Involvement <180 of SMA or celiac axis (Fig. 13 on page 18)

Other additional imaging findings not clearly referred to in the NCCN guidelines but pertinent to surgical planning include:

- Presence of tumor or bland venous thrombosis
- Extension of tumor contact with the common hepatic artery to the level of the origins of right and left hepatic arteries
- Extension of tumor contact to first SMA branch and to most proximal draining vein into SMV
- Presence of increased hazy attenuation, stranding contact with the vessel, particularly in patients who received prior radiation therapy
- Arterial variants, such as origin of the right hepatic artery from the SMA
Main pancreatic duct ectasia is a secondary sign for pancreatic adenocarcinoma that is especially useful in isoattenuating lesions. Chronic obstruction might lead to pancreatic atrophy which is also a secondary sign for pancreatic adenocarcinoma.

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Fig. 2: Main bile duct ectasia is a secondary sign for pancreatic adenocarcinoma that is especially useful in isoattenuating lesions.

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Fig. 3: "Double duct sign": secondary sign for pancreatic adenocarcinoma. Main bile duct ectasia and main pancreatic duct ectasia may be present ("double duct sign")

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Fig. 4: T1 lesion: small (<2 cm lesion) with no extrapancreatic extension

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Fig. 5: T2 lesion: Lesion with more than 2 cm with no extrapancreatic extension

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Fig. 6: T3 lesion: extrapancreatic extension with no invasion of the celiac axis or superior mesenteric artery

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**Fig. 7:** N1: extensive peripancreatic nodal involvement.

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Fig. 8: Invasion of the celiac axis and pancreatic artery (T4 tumor) means the tumor is unresectable. Note the presence of hepatic lesions suggesting metastasis (M1) which by itself would render the tumor unresectable.

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Fig. 9: Invasion of the superior mesenteric artery (T4 tumor) means the tumor is unresectable. There is also invasion of the aorta which is an unresectability criteria. Note the presence of hepatic lesions suggesting metastasis (M1) which by itself would render the tumor unresectable.

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Fig. 11: Extensive involvement of the portal vein is a borderline resectability criteria

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Fig. 12: Involvement inferior to 180° ("abutment") of the superior mesenteric artery is a borderline resectability criteria

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Fig. 13: Involvement inferior to 180º ("abutment") of the celiac axis is a borderline resectability criteria in pancreatic tail tumors.

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Fig. 10: "Tear drop sign": the superior mesenteric vein assumes a tear drop appearance on axial images. This is an high specificity sign for vascular invasion

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Conclusion

Being complete resection the only potentially curative treatment for pancreatic cancer, it is imperative to know the CT criteria for potential resection.
References


