CT AND MR STAGING OF PANCREATIC CANCER

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University of Michigan
Ann Arbor, Michigan
PANCREATIC CARCINOMA
WHAT THE SURGEON OR ONCOLOGIST WOULD LIKE TO KNOW

- Local tumor infiltration
- Perivascular infiltration of CA, SMA, HA
- Invasion of SMV, PV
- Distant metastases - lung, liver, peritoneum, distant lymph node metastases (para-aortic nodes)

* Schima W Eur Radiol 2007
PANCREATIC CARCINOMA
CRITERIA FOR UNRESECTABILITY

• Major mesenteric arterial encasement (>½ circumference encasement of hepatic, celiac, & SMA)
• Occlusion of SMV and PV- long segment (>2 cms)
• Metastatic implants- peritoneum
• Distant metastatic lymph nodes
• Distant metastases (liver, lung, bone)
• CAVEAT: Locally advanced tumors can have local peripancreatic invasion - may be resectable but not curative

* Lu DS et al AJR 1997
* O’Malley ME et al AJR 1999
* Lall CG et al. AJR 2007
* Brennan DD et al. Radiographics 2007
## Definitions of TNM

<table>
<thead>
<tr>
<th>TNM Code</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX</td>
<td>Primary tumor cannot be assessed</td>
</tr>
<tr>
<td>T0</td>
<td>No evidence of primary tumor</td>
</tr>
<tr>
<td>Tis</td>
<td>Carcinoma in situ</td>
</tr>
<tr>
<td>T1</td>
<td>Tumor limited to the pancreas, 2 cm or less in greatest diameter</td>
</tr>
<tr>
<td>T2</td>
<td>Tumor limited to the pancreas, greater than 2 cm in greatest diameter</td>
</tr>
<tr>
<td>T3*</td>
<td>Tumor extends beyond pancreas but no involvement of celiac axis or superior mesenteric artery</td>
</tr>
<tr>
<td>T4*</td>
<td>Tumor involves the celiac axis or the superior mesenteric artery (unresectable)</td>
</tr>
<tr>
<td>NX</td>
<td>Regional nodes cannot be assessed</td>
</tr>
<tr>
<td>N0</td>
<td>No regional lymph node metastasis</td>
</tr>
<tr>
<td>N1</td>
<td>Regional lymph node metastasis</td>
</tr>
<tr>
<td>MX</td>
<td>Distant metastasis cannot be assessed</td>
</tr>
<tr>
<td>M0</td>
<td>No distant metastasis</td>
</tr>
<tr>
<td>M1</td>
<td>Distant metastasis</td>
</tr>
</tbody>
</table>

## Stage Grouping

<table>
<thead>
<tr>
<th>Stage Grouping</th>
<th>TNM Code</th>
<th>NX</th>
<th>N0</th>
<th>M0</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 0</td>
<td>Tis</td>
<td>N0</td>
<td>M0</td>
<td>M0</td>
<td>Localized within pancreas</td>
</tr>
<tr>
<td>Stage IA*</td>
<td>T1</td>
<td>N0</td>
<td>M0</td>
<td>M0</td>
<td>Localized within pancreas</td>
</tr>
<tr>
<td>Stage IB*</td>
<td>T2</td>
<td>N0</td>
<td>M0</td>
<td>M0</td>
<td>Localized within pancreas</td>
</tr>
<tr>
<td>Stage IIA</td>
<td>T3</td>
<td>N0</td>
<td>M0</td>
<td>M0</td>
<td>Locally invasive, resectable</td>
</tr>
<tr>
<td>Stage IIB*</td>
<td>T1, 2, or 3</td>
<td>N1</td>
<td>M0</td>
<td>M0</td>
<td>Locally invasive, resectable</td>
</tr>
<tr>
<td>Stage III*</td>
<td>T4</td>
<td>Any</td>
<td>N</td>
<td>M0</td>
<td>Locally advanced, unresectable</td>
</tr>
<tr>
<td>Stage IV</td>
<td>Any T</td>
<td>Any</td>
<td>N</td>
<td>M1</td>
<td>Distant metastasis</td>
</tr>
</tbody>
</table>
PANCREATIC IMAGING
CT SCANNING TECHNIQUES

MULTI SLICE CT

• Oral contrast-Negative/ neutral
  \textit{Volume}^R - 1000 ml

• Volume of IV contrast 150 cc of high concn. nonionic contrast

• Rate of injection - at 4-5 cc/ sec
PANCREATIC CARCINOMA
MULTIPHASE IMAGING WITH MDCT

- Arterial phase - 25-30 sec (peak aortic enhancement + 10-12 sec) - usually not performed
- Pancreatic parenchymal phase - 45 sec
- Portal venous (hepatic venous) phase - 65-70 sec

* Lu DS et al Radiology 1996
* McNulty N et al Radiology 2001
* Fletcher JG et al Radiology 2003
PANCREATIC CARCINOMA
MULTIPHASE IMAGING WITH MDCT

- Mean tumor-to-pancreas density difference greatest in pancreatic parenchymal phase
- Tumor detection and vascular invasion best assessed on pancreatic parenchymal and portal venous phases
- Routine early arterial phase images are not needed for detecting or staging pancreatic adenocarcinoma

* McNulty N et al Radiology 2001
* Fletcher JG et al Radiology 2003
PANCREATIC IMAGING:
IMAGE DISPLAYS

- Multiplanar Reformations
- Curved planar reformations
- Volume Rendered
PANCREATIC CARCINOMA
ARTERIAL INVOLVEMENT

- Soft tissue “cuff” replacement of perivascular fat - NOT hazy, ill-defined stranding = tumor
- Thickened vasculature
- Commonly involved vessels - celiac axis, splenic, SMA, GDA
PANCREATIC CARCINOMA VENOUS INVOLVEMENT

“Tear-drop” sign - SMV

- Commonly involved veins: SMV, PV, splenic vein
- Tethering of SMV
- Useful sign of unresectability
- PPV 95%
- Fairly sensitive- In 76% of pts. this was only sign of unresectability

* Hough et al. AJR ‘99
## Circumferential contiguity of tumor to vessel

<table>
<thead>
<tr>
<th>Grade</th>
<th>Contiguity of tumor w/ vessel</th>
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<tbody>
<tr>
<td>0</td>
<td>No tumor contact</td>
</tr>
<tr>
<td>I</td>
<td>0-90° (&lt; ¼ circumference)</td>
</tr>
<tr>
<td>II</td>
<td>90-180° (¼ - ½ circumference)</td>
</tr>
<tr>
<td>III</td>
<td>180-270° (&gt; ½ &amp; up to ¾)</td>
</tr>
<tr>
<td>IV</td>
<td>270-360° (&gt; ¾ circumference)</td>
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* O’ Malley ME et al AJR 1999  
* Phoa SS et al Br J Radiol 20000  

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Absence of invasion
**Circumferential contiguity of tumor to vessel**

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*Absence of invasion*
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Unresectable

![Image showing contiguity of tumor to vessel](image-url)
Pancreatic adenocarcinoma staging: Vascular involvement

Vascular criteria for unresectability

- High likelihood for resectability
  - Tumor surrounding $< 180^\circ (< \frac{1}{2})$
    - Grade 0-II
- Unresectable
  - Tumor surrounding $>180^\circ (> \frac{1}{2})$
    - Grade III-IV

Sensitivity 84%
Specificity 98%

* Lu DS et al AJR 1997
* O’ Malley ME et al AJR 1999
* Phoa SS et al Br J Radiol 2000
<table>
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<tr>
<th>Study</th>
<th>Veins Sensitivity</th>
<th>Arteries Sensitivity</th>
<th>Veins Specificity</th>
<th>Arteries Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lu (1997)</td>
<td>84%</td>
<td>98%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O’Malley (1999)</td>
<td>46%</td>
<td>99%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nakayama (2001) Veins</td>
<td>71%</td>
<td>86%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arteries 78%</td>
<td>79%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li (2005) Veins</td>
<td>49%</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arteries 97%</td>
<td>91%</td>
<td></td>
<td></td>
</tr>
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PANCREATIC CARCINOMA
VARIANT VASCULAR ANATOMY

- **VARIANTS THAT PRECLUDE RESECTION**
- **Venous:**
  - High insertion of jejunal veins near SMV/ PV confluence
- **Arterial variants:**
  - Low origin of the common hepatic artery with aberrant course
  - Replaced hepatic artery from SMA

- **VARIANTS THAT AID RESECTION**
- Separate origin of hepatic artery from aorta
- Accessory right and left hepatic artery arising from SMA and LGA

* Lall et al AJ R 2007
PANCREATIC CARCINOMA
VASCULAR RECONSTRUCTION

• Not amenable to vascular reconstruction:
  - Longer than 2 cm of venous involvement
  - Thrombus in major veins
  - Transverse mesocolon invasion
  * Lall et al AJR 2007
PANCREATIC CARCINOMA
MR IMAGING

• T1 fat sat & Arterial phase imaging with Gd are most useful sequences
  – Normal pancreas - higher SI on unenhanced images and enhances in PP
  – Adenocarcinoma- typically does not enhance and is of low SI
PANCREATIC CARCINOMA

CT/ MR STAGING ACCURACY

- Detection has improved for small tumors - >80%
- Positive predictive value for determining unresectability >90%
- Positive predictive value for determining resectability - > 80%
- Multislice CT has slightly improved resectability PPV
- Limitations for both techniques: small surface hepatic, peritoneal metastases, nodal metastases and subtle local invasion

* Lopez-Hanninen E et al Radiology 2002
* Laghi A et al Dig and Liver Dis 2002
* Vargas R et al AJR 2004
ENDOSCOPIC ULTRASOUND- EUS
Advantages and Disadvantages

**Advantages**
Superior for detecting small tumors
- Lymph nodes easily identified separate from primary tumor
- Biopsy for diagnosis

**Disadvantages**
- Detection of distant metastases (liver, peritoneal, distant nodes)
PANCREATIC CARCINOMA

ROLE OF LAPAROSCOPY

- Survey in Oregon State for patients managed surgically between 1999-2003
- 298 pts. from 24 hospitals studied
- Staged with CT (98%), laparoscopy (29%) and EUS (32%)
- Laparoscopy used in patients at high-risk for metastases- back pain, weight loss, large tumor size, tumors located in body and tail, elevated CA-19-9

PANCREATIC CARCINOMA
ROLE OF LAPAROSCOPY

• In group undergoing laparoscopy, vascular invasion was most common reason for unresectability
• Evolving role of laparoscopy in pancreatic cancer
• Early reports showed that laparoscopy prevented unnecessary laparotomy in up to 25%
• More recent reports suggest ranges of 10-15%
• Laparoscopy used in subset of patients at high risk for mets. - not used routinely

Current Imaging Limitations

- Isodense tumor (about 10%)
- Small tumors (<2 cm) not as well seen - detection rate improved with MDCT-MPR images
- Distinguishing between pancreatitis and pancreatic carcinoma still a problem
- Less than 180 degree of vascular contact not always reliable for predicting absence of invasion and resectability
- Poor sensitivity for:
  - Local tumor extension
  - Small < 1 cm. surface and sub-surface liver metastases
  - Small peritoneal implants
  - Nodal metastases-size criteria
  - Role for MR lymph node imaging- USPIO
Early diagnosis of pancreatic cancer

- 62 CT scans in 28 pts. obtained prior to a diagnosis of pancreatic cancer compared with 89 control CT scans
- CT findings suspicious for pancreatic cancer seen in 50% of scans at 2-6 and 6-18 mths. prior to diagnosis
- Pancreatic duct dilatation and cut-off seen as early findings

* Gangi S AJR 2004
PANCREATIC CARCINOMA
EARLY DETECTION
BIOLOGICAL MARKERS

• **K-ras** mutations in DNA-
• Serum CA 19-9 levels- newer more accurate tumor markers needed
• Limitation : Overlap with pancreatitis
• Novel molecular imaging- cell surface proteins that act as antigens could be used to develop new targeted molecular imaging methods

Biomarkers with high specificity+ imaging = Diagnosis