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## FOCUS ON: PANCREATIC NEOPLASMS

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# Pancreatic adenocarcinoma: diagnosis and staging using multidetector-row computed tomography (MDCT) and magnetic resonance imaging (MRI)

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**Abstract**

Pancreatic adenocarcinoma continues to be a leading cause of cancer death in the Western world and is amongst the leading gastrointestinal cancers. The incidence of pancreatic cancer has been stable or slowly rising in the past few decades. Overall the prognosis is poor with 5-year survival rates still under 5%. Therefore early detection and accurate staging of these tumors is crucial for optimal treatment.

**Keywords:** *Pancreatic adenocarcinoma.*

## Introduction

Pancreatic adenocarcinoma continues to be a leading cause of cancer death in the Western world and is amongst the leading gastrointestinal cancers. The incidence of pancreatic cancer has been stable or slowly rising in the past few decades. Overall the prognosis is poor with 5-year survival rates still under 5%. Therefore early detection and accurate staging of these tumors is crucial for optimal treatment.

Pancreatic adenocarcinoma is the most common pancreatic exocrine neoplasm and accounts for 75–85% of all pancreatic malignancies. Common etiologies implicated are cigarette smoking, chronic pancreatitis and hereditary chronic pancreatitis[1–6].

The majority of the tumors are located in the head of the pancreas[7,8]. Tumors located in the pancreatic head can obstruct the common bile duct leading to jaundice and tend therefore to be detected earlier, compared to tumors located in the body and tail which usually present in the late stages of the disease, often with distant metastases or locally advanced disease. However most tumors present late with advanced stages of the disease and so curative resection is possible only in about 10–15% of patients[1–6]. Therefore accurate staging is essential to differentiate the resectable patient from the unresectable and imaging plays a critical role in making this differentiation.

Contraindications to curative resection are the presence of liver or other distant metastases, peritoneal metastases, greater than half circumferential encasement of major mesenteric vascular structures (celiac, hepatic, superior mesenteric artery), and local infiltration into the peripancreatic fat, and mesentery of the jejunum or transverse mesocolon[6]. Mesenteric venous encasement (superior mesenteric vein and portal vein) is a relative contraindication for resection, as at some centers, en-bloc resection of tumor and the involved vein is performed with placement of a graft.

## Imaging

While ultrasonography (US), computed tomography (CT) and magnetic resonance imaging (MRI) can all be used in the detection and staging of pancreatic carcinoma, CT is probably the most common modality used. As CT is the main diagnostic technique used in our

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center for the detection and staging of pancreatic carcinoma, the following discussion focuses on the use of multidetector-row computed tomography (MDCT).

## *MDCT*

MDCT enables evaluation of the pancreas during various phases of parenchymal enhancement during intravenous contrast administration. Several studies have shown that biphasic imaging of the pancreas is helpful in the detection and staging of pancreatic carcinoma and that the tumor-to-parenchymal differences are maximized during the pancreatic parenchymal phase of contrast enhancement[9,10] (Fig. 1a,b). Using a 64-detector MDCT, we perform a biphasic protocol consisting of thin section (0.625 mm collimation) images obtained during the pancreatic parenchymal phase (50 s following commencement of intravenous contrast administration) followed by a hepatic parenchymal or portal venous phase at 65 s. A total of 125 ml of iodinated intravenous contrast (concentration 370 mg/ml of iodine) is injected at 4–5 ml/s followed by a 50 ml saline flush. Negative oral contrast is used to delineate and distend the stomach and duodenum permitting the rendering of 3D images (Fig. 2).

The thin-section images obtained with this technique are sent to the 3D laboratory for image processing and reformatting (curved planar, coronal and sagittal images) (Fig. 3)[11–15]. Some recent studies have shown that these 3D images may be more accurate in staging[13].

Most often pancreatic adenocarcinomas are seen as hypoattenuating masses. Rarely they can be isodense to the normal pancreatic parenchyma, and difficult to detect. In these situations, indirect signs such as 'upstream' pancreatic duct dilation or the 'double duct'

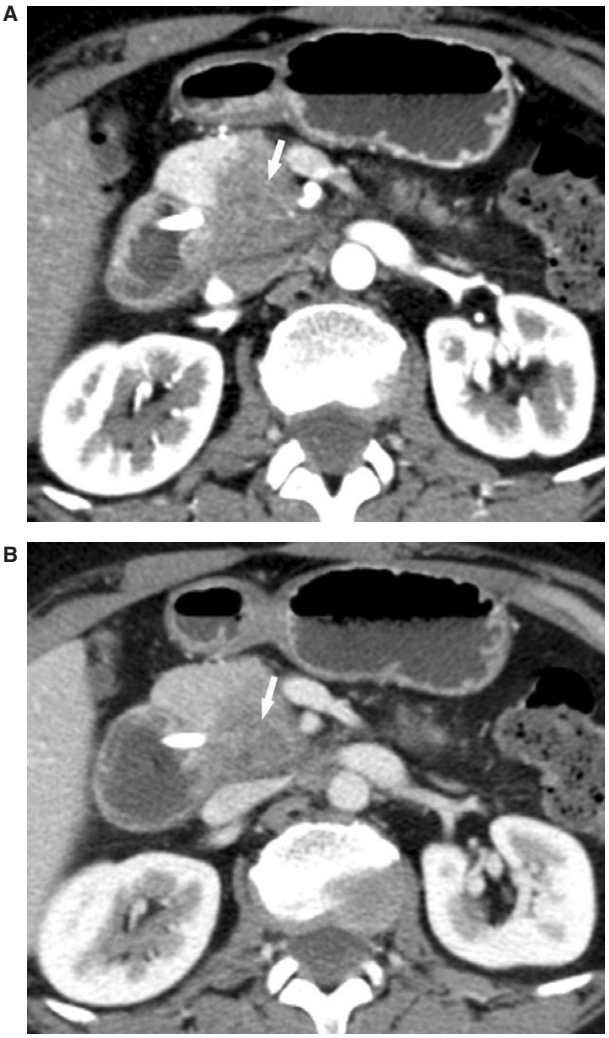


***Figure 1*** **Contrast-enhanced axial CT images in pancreatic parenchymal (a) and portal venous phases of enhancement (b). Note the tumor (arrow) is best seen in the pancreatic parenchymal phase (a).**

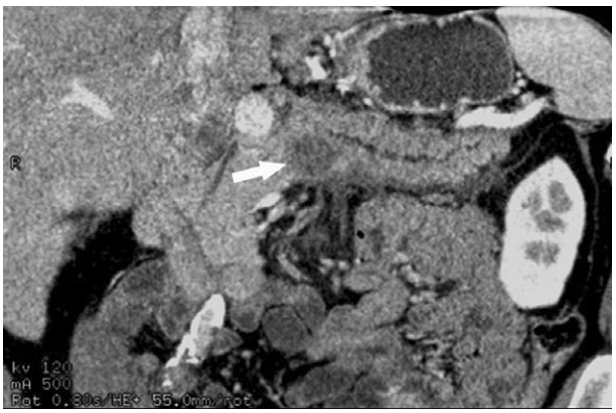


***Figure 2*** **Curved planar reformatted CT image through the pancreatic duct shows the relationship of the tumor (arrow) to the pancreatic duct.**

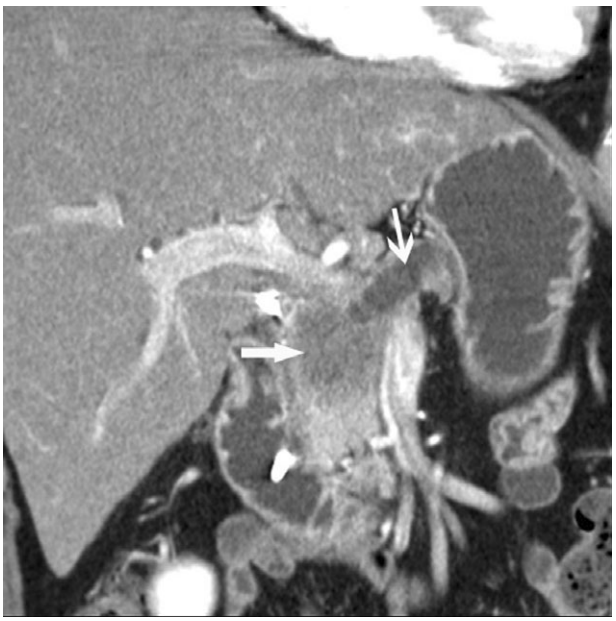

***Figure 3*** **Coronal reformatted CT image depicts dilated pancreatic duct (arrowhead) due to obstructing tumor (arrow) in the pancreatic head.**

sign due to pancreatic and common bile duct obstruction are helpful to diagnose the small isoattenuating tumors.

The overall sensitivity for tumor detection by MDCT has been reported to be between 76 and 92%, but drops to between 63% and 77% when small tumors <2 cm in size are included in the analysis[5–7,10,15–17]. The use of multiplanar reconstructions has improved the detection especially of small tumors[12–14].

### *MRI*

Breath-hold sequences such as axial two dimensional (2D) spoiled gradient-recalled (SPGR), axial T1 spin echo (SE) with fat saturation, and axial three-dimensional (3D) gadolinium-enhanced SPGR images are combined with coronal single shot fast spin echo (SSFSE), and axial T2 fat saturated FSE images to provide excellent visualization of the pancreas and the adjacent structures thereby providing images that can detect, characterize and stage pancreatic carcinoma. Magnetic resonance cholangiopancreatography (MRCP) can be used in conjunction with pancreatic MRI for depiction of the pancreatico-biliary system[18–25].

Most pancreatic carcinomas are seen as hypointense tumors compared to the normal pancreas on T1-weighted fat suppressed images, and as hypointense lesions on arterial phase gadolinium-enhanced images (Fig. 4), but can show progressive enhancement on delayed scans.

Most studies comparing MDCT and MRI for the detection and staging of pancreatic carcinoma have shown that both studies have similar accuracy, although recent studies have shown sight superiority for MDCT, in part due to the recent technical improvements in MDCT[18,19,21,23].

### *Endoscopic ultrasound*

MDCT is inferior to endoscopic ultrasound (EUS) especially in the detection of small tumors. A recent study by DeWitt has shown that EUS had a sensitivity of 98% compared to 86% for MDCT[26]. EUS has also been shown to have a high negative predictive value for excluding pancreatic cancer, and may therefore play a role in screening for pancreatic malignancies[27,28].

## Staging

Although TNM staging is not widely used by radiologists, oncologists do use this staging system[29] (Table 1). T stage is defined by tumor size, and local spread of the tumor, with T1 tumors being <2 cm in size and confined to the pancreas, with T2 tumors being >2 cm in size but still confined to the pancreas (Fig. 5). Tumor infiltration into the common bile duct, duodenum or peripancreatic tissues without associated major peripancreatic

***Table 1 TNM staging of pancreatic carcinoma***

| Stage | Definition |
|---|---|
| *Primary tumor* | |
| Tis | Carcinoma in situ |
| T1 | Tumor limited to pancreas, ≤2 cm in any direction |
| T2 | Tumor limited to pancreas, ≥2 cm in any direction |
| T3 | Infiltration into peripancreatic tissue, duodenum and/or common bile duct |
| T4 | Infiltration into peripancreatic vessels, stomach, spleen, large bowel |
| *Regional lymph nodes* | |
| N0 | No lymph node metastases |
| N1 | Metastasis in peripancreatic lymph nodes |
| Nx | Unknown |
| *Distant metastases* | |
| M0 | No distant metastases |
| M1 | Distant metastases present |
| Mx | Unknown |

Adapted from ref. [29].

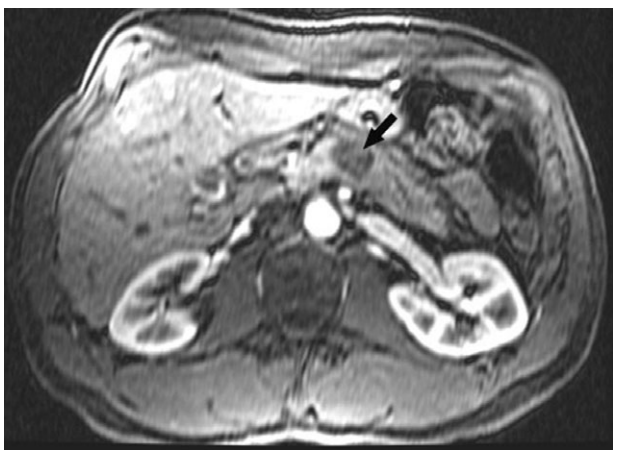

***Figure 4*** **Axial contrast-enhanced spoiled gradient-echo 3D MR image depicts a tumor in the pancreatic body as a hypointense mass (arrow) relative to the enhancing normal pancreatic parenchyma.**

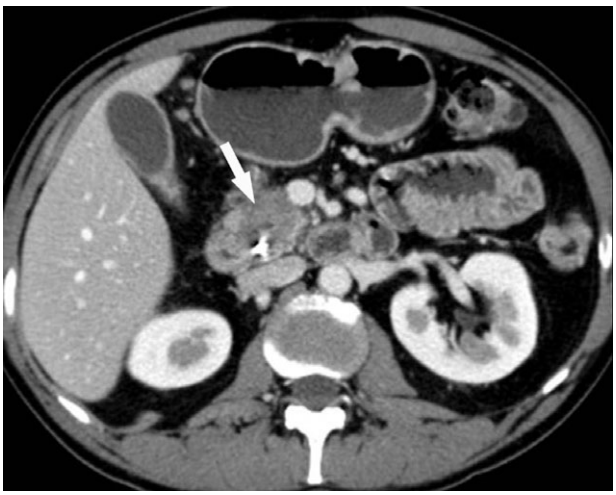

***Figure 5*** **Axial contrast-enhanced CT image shows a pancreatic head tumor measuring >2 cm (arrow) but still confined to the pancreatic parenchyma, representing a T2 tumor.**

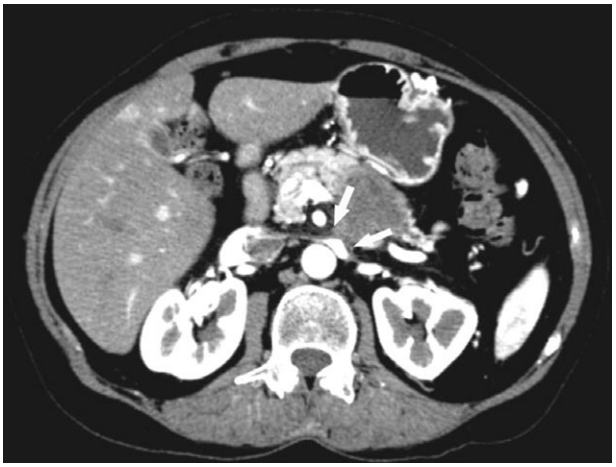

*Figure 6* **Contrast-enhanced axial CT image shows a mass in the body of the pancreas with peripancreatic invasion (arrows).**

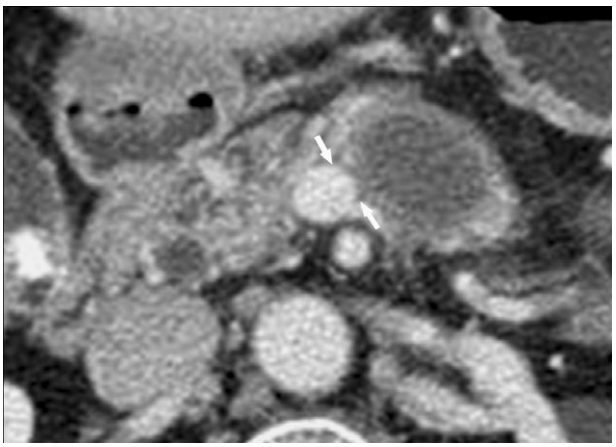

*Figure 7* **Contrast-enhanced axial CT image shows a tumor in the body of the pancreas with less than 180 degrees of circumferential involvement (arrows) of the superior mesenteric vein. The tumor was resectable at surgery.**

vascular infiltration is defined as T3 (Fig. 6); infiltration into the major peripancreatic vessels and contiguous organs such as the spleen, stomach or transverse colon is defined as T4. N stage is dependent on the presence of nodal metastasis, with N1 representing peripancreatic nodal metastases. Metastasis to more distant nodes such as para-aortic nodes is defined as M1 disease. Other sites of distant metastases are the liver and peritoneum.

While both MDCT and MRI are reasonably accurate in detecting local spread and distant visceral metastases[1,2,6,7,11,15,17,19,22,23] from pancreatic cancer, both modalities are poor in detecting nodal metastases[30].

## Perivascular tumor infiltration

The probability of tumor invasion of the major peripancreatic vasculature was studied by Lu *et al.*[31] and

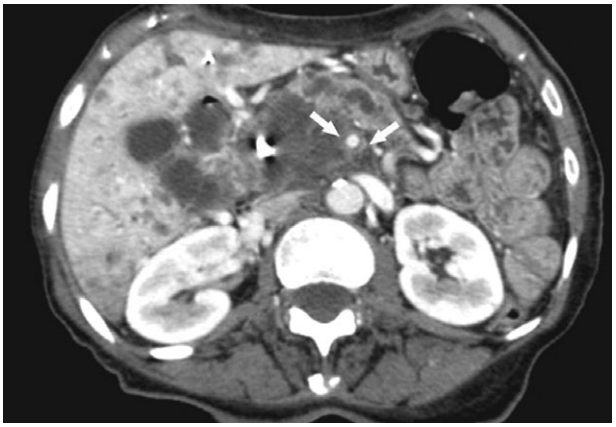

*Figure 8* **Contrast-enhanced axial CT image shows a tumor in the head of the pancreas with more than 180 degrees of circumferential involvement (arrows) of the superior mesenteric vein, indicating unresectability.**

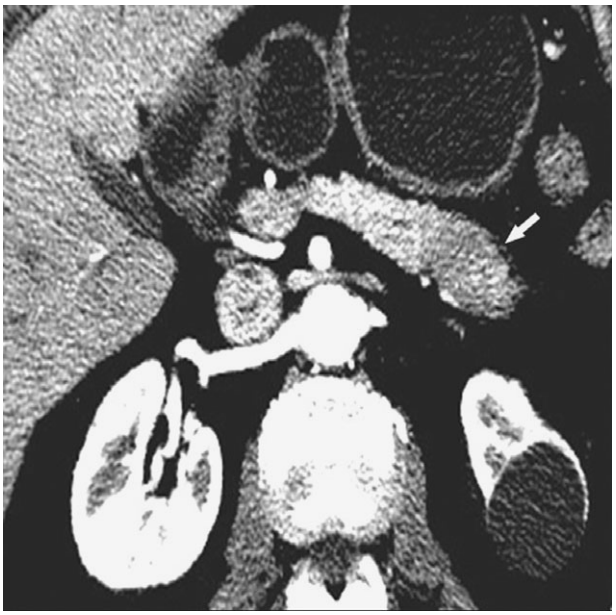

*Figure 9* **Contrast-enhanced axial CT image shows a mass in the tail of the pancreas (arrow), which at surgery proved to represent acute focal pancreatitis.**

O'Malley *et al.*[32] with helical CT by measuring the degree and extent of tumor–vessel contact. Both these studies showed that when tumor–vessel contact was less than half the circumference of the vessel, the likelihood of tumor resectability was high (Fig. 7), whereas if it exceeded half the circumference, there was a high probability (80%) of unresectability (Fig. 8). These guidelines for vascular invasion are still in use today although no recent larger studies have been performed to further validate these criteria[33–35].

## Pitfalls

As already mentioned previously, rarely pancreatic adenocarcinomas can be isoattenuating and difficult to detect, and one must rely on the ancillary findings such as bile duct or pancreatic duct obstruction to suspect the presence of a neoplasm. The most common condition that mimics pancreatic carcinoma is pancreatitis either in the form of focal acute or 'mass-forming' pancreatitis[36–38] (Fig. 9) or chronic pancreatitis. Focal fatty infiltration of the head of the pancreas or focal sparing of fatty infiltration can mimic pancreatic carcinoma. In these situations, MRI is very helpful in excluding pancreatic carcinoma.

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