Staging cancer of the pancreas

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Abstract

Pancreatic carcinoma is the fourth cause of death from cancer in the United States, with a survival rate at 5 years of less than 5%. About 60% of tumors originate at the head of the pancreas, 15% in the body, 5% in the tail; 20% are diffuse within the pancreas. This article discusses the imaging and staging of pancreatic cancer.

Keywords: Staging; pancreatic cancer.

Introduction

Pancreatic carcinoma is the fourth cause of death from cancer in the United States, with a survival rate at 5 years of less than 5%[1,2]. About 60% of tumors originate at the head of the pancreas, 15% in the body, 5% in the tail; 20% are diffuse within the pancreas[3]. At the time of diagnosis tumors located in the head are usually smaller (2.5–3 cm) compared with those in the body and tail (5–7 cm), as a result of earlier clinical manifestation because of the close contiguity with the choledochus. Imaging of pancreatic carcinoma has a leading role in assessing the best options for the treatment of pancreatic carcinoma.

Surgical resection is the only curative treatment of pancreatic carcinoma. Unfortunately, at surgical exploration only 5–30% of tumors are amenable to resection[4,5]. Even in expert hands, Whipple’s procedure has a mortality of up to 4% and exploratory laparatomy has a morbidity up to 25%[6]. Therefore, the principle goal of preoperative staging is identify all resectable disease to avoid surgical exploration in those patients with unresectable disease.

Multislice computed tomography (MSCT) is the most commonly used technique for staging pancreatic cancer. MSCT has high accuracy with highly accurate isotropic voxel values, which permits multiplanar reconstruction and improves the capacity of the imaging technique to evaluate the relationship between the tumor and the surrounding structures and organs.

Magnetic resonance imaging (MRI) has a leading role in the imaging of the pancreas because of the most recent technical innovations with breath-hold T1- and T2-weighted images and respiratory triggered T2-weighted images, as well as dynamic imaging after injection of contrast material and the use of secretin, allowing greater capacity for non-invasive exploration of the pancreatic ducts and pancreatic parenchyma, and imaging of the pancreatic vessels. With state-of-the-art magnetic resonance equipment, a complete study of a pancreatic lesion can be conducted in about 30–40 min.

[18F]Fluorodeoxyglucose (FDG)-positron emission tomography (PET), especially combined with computed tomography (CT), has an established role in differentiating benign from malignant lesions and in the staging and treatment planning of various tumors. The increased glucose metabolism of most malignant lesions results in significant uptake of FDG in primary malignant tumors and metastases that does not occur in healthy tissues and benign lesions after i.v. injection, allowing a higher conspicuity compared with that of the surrounding tissue[7,8].

Imaging of pancreatic carcinoma

The gross pathologic features of pancreatic carcinoma are represented by a mass with irregular ill-defined contours and a significant fibrous component, and less frequently necrotic changes. Lack of capsule is responsible for early spread of the lesion to the surrounding structures, with special regard to vascular and neural infiltration.

On dynamic imaging after injection of contrast agent, either with CT or MR, the presence of an abundant
fibrous stroma within the tumor makes the tumor hypo-
vascular, thus appearing hypodense/hypointense to
the surrounding parenchyma, but it can be responsible for
a delayed enhancement with secondary isointensity of the
lesion[9]. Isointensity of the tumor to the surrounding parenchyma as well as coexisting or secondary chronic pancreatitis upstream can make the identification of the tumor as well as differential diagnosis with chronic pancreatitis difficult[10,11]. Some authors suggest that a time–intensity curve of the lesion is useful for the differential diagnosis between pancreatic carcinoma and mass-
forming pancreatitis[12]. Hata et al.[13] have correlated
the enhancement pattern on CT with the vessel density and
the amount of fibrous stroma; the results of their study suggest a direct correlation between vessel density and fibrous content and the amount of enhancement. The same results were obtained by Johnson and Outwater[14] with MRI.

Because normal pancreas has low glucose utilization,
the foci of abnormal FDG uptake can be easily visualized
as focal areas of increased activity.

Several authors have reported values for the sensitivity
and specificity of FDG-PET in identification of pan-
creatic malignant lesions that vary in the different
studies from 71% to 100% and from 64% to 99%, respec-
tively[15,16]. A tabulated review of published data by
Gambhir et al.[17] demonstrated that in the 387 patients
studied, the weighted average sensitivity and specificity
of FDG-PET was 94% and 90% compared with 82%
and 75% for CT, respectively. Furthermore, false-negative
cases were described because of well-differentiated
tumors, small periampullary cancers or in cases of hyper-
glycemia. In normoglycemic subjects, PET has a sensitiv-
ity for tumor identification of 93–98%, although this
value decreases to 63% or lower in hyperglycemic
patients; a similar trend is found for the negative predic-
tive value, which can decrease from 96% to 38%[17].

**Staging of pancreatic carcinoma**

Staging of pancreatic carcinoma is based on the TNM
classification, that is, on the dimensions and extension of
the primary tumor (T), presence or absence of metastatic
lymph nodes (N), presence or absence of distant metas-
tases (M)[18,19].

Based on TNM, the most commonly used classification
for extension of pancreatic cancer is that of the Union
Internationale Contre le Cancer[20], the American Joint
Committee Classification[21] and the Japan Pancreas
Society (Pancreatic Cancer Registration Committee of
the Japan Pancreas Society 2003)[22,23]. According to
the different T, N and M stages, pancreatic cancer is
classified as locally resectable, locally unresectable and
unresectable for distant metastases.

For the T parameter, recent changes in the TNM clas-
sification have extended the number of patients amenable
to surgical resection, as T4 is now considered the only
tumor that infiltrates either the celiac axis or the superior
mesenteric artery; limited superior mesenteric vein
infiltration is now considered resectable as a result of
venous interposition grafts, thus downstaging the tumor
to T3[24].

Contrast-enhanced techniques for both CT and MRI,
combined with multiplanar reconstruction and maximal
intensity projection post-processing, have improved the
capability to identify and stage the extent of the tumor
and extra-pancreatic involvement[25], especially vascular
arterial and venous involvement, with an accuracy for
resectability of about 90% for both CT and MRI in a
direct comparison[26,27].

The degree of circumferential vessel involvement by
tumor as shown by CT and MRI is useful in predicting
which patients will have surgically unresectable tumors.
Involvement of vessel in a tumor that exceeds one-half
the circumference of the vessel is highly specific for unre-
sectable tumor[28,29], both for arteries and veins. CT and
MRI with vascular reconstruction allow a higher degree
of recognition than axial alone[30]. However, in a direct
comparison of CT and MRI for detection and resectabil-
ity of pancreatic carcinoma with two independent read-
ers, kappa analysis of interobserver agreement showed a
good correlation for CT (0.71) and a moderate correla-
tion of both groups for MRI (0.49)[27].

A specific sign of venous involvement is a reduction in
the diameter of the superior mesenteric vein (SMV), the
teardrop shape of the SMV[30,31], and dilatation of SMV
tributaries[32,33], especially enlargement of the posterosu-
perior pancreaticoduodenal vein (PDV)[34], and visual-
ization of the inferior PDV[33]; enlargement of the
gastro-colic trunk is not conclusive[35].

The location of the tumor in the pancreas determines
its route of spread and the nodal groups involved. Lymph
node involvement has a significant effect on the survival
of patients with pancreatic cancer[36]. However, lymph
node involvement in the peripancreatic area does not
affect surgical planning, because lymph nodes are
removed with the surgical specimen; it is more important
to recognize nodal metastases in the celiac node, common
hepatic artery node and paraaortic node, because metas-
tases to these nodes preclude patients from surgery,
especially for tumors at the head of the pancreas[37].
Nodal involvement in the paraaortic region does not indi-
cate regional invasion but is a statistically independent
predictor of early recurrence, and affects survival
considerably[38].

The size threshold for suspicion of nodal involvement
is 1 cm in the short axis; however, although with a 1-cm
threshold specificity is quite good (85%), its sensitivity
is very low (14%), because up to 36% of lymph nodes
of 5–10 mm in the short axis have been found to
have tumoral involvement, even in lymph nodes less
than 5 mm[39], and lymph nodes >10 mm can also be
inflammatory[40].
The presence of distant metastases precludes surgical resection and correct identification and characterization are therefore fundamental. Sixty percent of patients who present with pancreatic ductal adenocarcinoma have advanced disease[41]. The liver and peritoneum are the most common sites of distant metastases. To date, no definite decision on the best technique for the staging of abdominal metastases can be given; MRI and laparoscopy are the most commonly used techniques and give similar results[42].

MRI has the best sensitivity for liver metastases, as a result of its high contrast; both T2-weighted (especially fat saturated) and gradient recalled echo T1-weighted images (especially three-dimensional with thin slices after administration of paramagnetic contrast agent) and the use of liver-specific contrast agents have greatly improved the sensitivity of the technique.

Hepatic metastases from pancreatic carcinoma are usually multiple[43] and their size range from a few millimeters to some centimeters[44]. They appear hypointense on T1 images and moderately hyperintense on T2 images and diffusion-weighted imaging (DWI), frequently with a capsular based distribution.

DWI is a promising technique for the identification of small hepatic metastases; respiratory triggering and a b value of 50 give a high quality image, with a high signal-to-noise ratio and suppression of signal from vessels, thus allowing easy detection of the lesion from the nearby intrahepatic vessels. According to many authors, lesion detection with DWI is significantly higher than for T2-weighted images, with more significant results for small metastases (<10 mm)[45].

During dynamic imaging after injection of paramagnetic contrast agent, tumors usually appear hypointense with peri-lesional enhancement in more than 50% of patients[44], with either ring peri-lesional enhancement or wedge-shaped peri-lesional enhancement. Occasionally pancreatic liver metastases have been misdiagnosed as pseudolesions because they initially emerged as arterioportal shunts on dynamic CT and MR imaging. The cause of this transient enhancement related to liver metastases from pancreatic cancer is unknown. Gabata et al.[43] suggested that the cause of transient hepatic enhancement of liver metastases from pancreatic carcinomas may be correlated with tumor invasion of the portal tract and tumor thrombi of portal venules, which causes decreased portal flow and increased hepatic arterial flow. Delayed contrast enhancement of the central portion of the lesion can be observed, as a result of a desmoplastic reaction secondary to the stimulation of hepatic stellate cells[46].

Dynamic imaging after injection of paramagnetic liver-specific contrast agent (MultiHance, Bracco SpA, Milano, Italy; Primovist, Bayer Schering, Berlin, Germany) is superimposable on that obtained with conventional extravascular, extracellular gadolinium-based contrast agents; in the hepatobiliary phase the lesions do not show significant enhancement, as they are not able to uptake the contrast medium[47,48]. After administration of mangafodipir trisodium (Teslascan, GE Health) there is an increase in the liver-to-lesion contrast-to-noise ratio because of the lack of contrast uptake[49]. Metastases do not contain RES cells, thus after super paramagnetic iron oxide injection, the liver metastasis contrast-to-noise ratio is improved with increased lesion conspicuity and detection compared with non-enhanced T2-weighted images[50–52].

Poor spatial resolution of FDG-PET limits the local (T) staging of pancreatic cancer. In nodal staging (N) of disease, both FDG-PET and CT perform poorly. Report sensitivity and specificity for FDG-PET have varied between 46% and 71% and 63% and 100%, respectively[15,53–56]. One possible reason for the apparent low sensitivity of FDG-PET is the close proximity of the peripancreatic lymph node basin to the primary tumor, which can obscure their detection. The major effect of FDG-PET on staging has been its ability to identify distant metastases (M). The liver is the commonest organ to be affected, followed by the lung and bone marrow. Direct spread into the peritoneum is also not uncommon and is often missed on conventional anatomical imaging. Diederichs et al.[15] in a series of 89 patients with pancreatic malignancy, showed the sensitivity and specificity of 70% and 95% for FDG-PET in detecting hepatic metastases, missing just one subcentimeter liver lesion. FDG-PET also detected occult peritoneal metastases in 25% of cases, once again missing poorly localized and microscopic spread. Frohlich et al.[57] who looked at the detection of liver metastases with FDG-PET in 168 preoperative patients found FDG-PET to have an overall sensitivity of 68%.

**Conclusion**

In daily practice MSCT is the most useful imaging technique for staging of pancreatic cancer. More sophisticated techniques, such as MRI or PET/CT can be used in cases of unequivocal findings at MSCT that suggest the lesion is border-line for resection. In particular, MRI is the best imaging technique to evaluate equivocal focal liver lesions. PET/CT is indicated in cases of suspicious distant spread of the disease.

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