

Spiral computed tomography for preoperative staging of potentially resectable carcinoma of the pancreatic head

S. S. K. S. Phoa, J. W. A. J. Reeders, E. A. J. Rauws*, L. de Wit†, D. J. Gouma† and J. S. Laméris

Departments of Radiology, *Gastro-enterology and †Surgery, Academic Medical Centre, Meibergdreef 9, 1105 AZ, Amsterdam, The Netherlands
Correspondence to: Dr S. S. K. S. Phoa

Background: Pancreatic cancer is often locally invasive. Preoperative staging attempts to identify patients suitable for resection, in order to minimize unnecessary operations. The aim of this study was to assess the improved imaging provided by spiral computed tomography (CT) in the preoperative staging of potentially resectable pancreatic head carcinoma.

Methods: In 56 consecutive patients with pancreatic head carcinoma spiral CT findings were correlated prospectively with operative and histopathological findings. Criteria for irresectability at CT were infiltration of the peripancreatic fat and vascular ingrowth grade D, on a scale from A to F.

Results: At operation 27 (48 per cent) of 56 tumours were irresectable. Small metastases were found in seven patients (12 per cent). Ingrowth (adherence) to the portal or mesenteric vein was present in 19 patients (34 per cent). The sensitivity and specificity of CT for irresectability were 78 and 76 per cent respectively. Resection rates with a vascular margin free of tumour were 100 per cent for grade A, 63 per cent for grade B, 44 per cent for grade C, 15 per cent for grade D and 0 per cent for grade E, with a predictive value for ingrowth of 88 per cent for grades D or higher. The resectability rate was 11 per cent (one of nine) when infiltration of the anterior peripancreatic fat was present and 67 per cent when infiltration was absent ($P < 0.01$).

Conclusion: Spiral CT with thin slices seems to improve detection of distant metastases and vascular ingrowth in patients with pancreatic head carcinoma.

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Introduction

Patients with a pancreatic head carcinoma have a poor prognosis and the only chance of cure is surgical resection. Preoperative staging focuses on detection of non-resectable disease to prevent unnecessary laparotomy¹⁻³. Before the introduction of spiral computed tomography (CT), dynamic CT was regarded the best technique in staging pancreatic head carcinoma with an accuracy of 90-100 per cent for predicting irresectable tumours^{2,3}. However, the predictive value for resectability was as low as 28 per cent⁴. The predictive value for resectability was reported to be slightly better (56 per cent) for spiral CT, in a series using sections 8 mm thick⁵. Small metastases and vascular ingrowth in portal or mesenteric veins accounted for approximately 40 per cent each in causing a false-negative spiral CT scan⁴. Detection of liver lesions and visualization of anatomical details of the pancreas and peripancreatic vessels can be improved using thinner sections in spiral CT^{6,7}.

The aim of this study was to evaluate the use of spiral CT with thin sections (5 mm) for staging of patients with potentially resectable malignancy in the pancreatic head region. The CT findings were correlated with findings at operation and histopathological examination in 56 patients with pancreatic head carcinoma, who underwent resection with curative intent.

Patients and methods

Between June 1995 and December 1996, 113 consecutive patients suspected to have pancreatic head carcinoma underwent both spiral CT and duplex sonography as preoperative assessment.

In 14 patients benign disease was diagnosed: chronic focal pancreatitis in seven, obstructing bile duct stones in three and no pancreatic abnormality in four. In eight patients percutaneous biopsy proved metastases to the liver or distant lymph nodes. In 16 patients the pancreatic mass was considered irresectable, owing to the local extent of tumour,

vascular occlusion or a perivascular mass, with narrowing of the vessel and an abnormal Doppler shift. Ten patients presumed to have resectable tumours were unfit for surgery ($n=1$), refused operation ($n=1$) or were treated at other institutions ($n=8$).

The remaining 65 patients underwent diagnostic laparoscopy with laparoscopic sonography and subsequent planned laparotomy for attempted resection. In two patients no final diagnosis was obtained (in one extensive pancreatitis prohibited resection and one patient died from cholangitis before operation). In two patients operation was delayed for more than 2 months after CT. Five patients underwent resection but no carcinoma was found (one carcinoid tumour and four cases of chronic focal pancreatitis).

This study included the remaining 56 patients, with proven pancreatic head carcinoma, in whom CT could be correlated with surgical findings. There were 34 men and 22 women, with a mean age of 60 (range 40–76) years.

Spiral computed tomography

Spiral CT was performed on a Siemens Somatom Plus scanner. Unenhanced contiguous 10-mm slices of liver and pancreas were followed by contrast-enhanced spiral CT of the pancreas (5 mm slice thickness, 24 rotations, pitch 1). Some 130 ml Megluminejoxithalamate 300 mg/ml (Guerbet, Paris, France) was infused at 2 ml/s; the scan delay was 55 s. A second spiral CT with 5-mm slice thickness was made through the liver.

Computed tomography staging

CT examinations were scored prospectively by a radiologist, who was blinded to all clinical and diagnostic information. Obstruction of the bile or pancreatic duct and the presence of a mass in the pancreatic head was noted.

Tumours were graded according to Loyer *et al.*⁸: grade A, fat plane visible between tumour and vessel; grade B, normal pancreatic tissue between tumour and vessel; grade C, tumour adjacent to vessel with a convex contour towards vessel; grade D, tumour adjacent to vessel with a concave contour towards vessel; grade E, circumferential involvement of vessel; and grade F, vascular occlusion. Tumours were scored as irresectable if infiltration of peripancreatic fat planes was present or when involvement of the portal vein or superior mesenteric vein was graded as D or higher. Lesions were also scored as irresectable when arterial encasement was present: complete circumferential involvement (cuff sign), narrowing or occlusion of the artery. All other lesions were scored as resectable, including liver lesions that could not be punctured percutaneously.

At laparoscopy with laparoscopic sonography and at surgical exploration tumour irresectability owing to metastases or local extent was always confirmed with biopsies. CT findings were correlated with findings at laparoscopy, surgical exploration and histopathological findings. Evidence of tumour adherence to the portal or mesenteric vein was regarded as tumour ingrowth; decisions about resectability and vein resection were made on the basis of macroscopic appearances.

Statistical analysis was by χ^2 test with one degree of freedom.

Results

Computed tomography diagnosis

In 54 of the 56 malignant lesions CT demonstrated a mass in the pancreatic head. In two patients CT demonstrated only dilatation of both pancreatic and common bile ducts. Forty-nine (91 per cent) of the 54 lesions detected were qualified by CT as malignant (hypodense lesion, clearly demarcated from normal pancreas, with ductal obstruction). In five cases distinction from pancreatitis was not possible. The mean diameter of the tumours visible at CT was 2.8 (range 1–4.5) cm. On pathological examination the mean size of resectable lesions was 3 cm.

Surgical findings

Twenty-seven (48 per cent) of 56 carcinomas were irresectable; liver metastases were found in six patients (11 per cent) and peritoneal metastases in one. One patient also had distant malignant lymph nodes. In 21 patients without liver metastases, local irresectability was proven with biopsies at trial dissection (19 had venous involvement).

Twenty-nine (52 per cent) of the 56 carcinomas were resectable, and a resection was performed. Three patients underwent a sleeve resection of the vein, owing to tumour ingrowth detected at a late phase of the resection (after transection of the pancreas).

Computed tomography staging

CT data were correlated with overall resectability at surgical exploration, including patients with metastases. In 28 patients CT scored the tumour as resectable, correctly in 22 (79 per cent); six were proven irresectable owing to vascular ingrowth. CT graded 28 tumours as irresectable, correctly in 21 patients. In seven a resection could be performed (three with tumour-positive vascular resection margins). All six patients with liver metastases were in the

group scored as irresectable. Sensitivity, specificity, and positive and negative predictive values of CT for irresectability at surgery were 78 per cent (21 of 27), 76 per cent (22 of 29), 75 per cent (21 of 28) and 79 per cent (22 of 28) respectively. Excluding the patients with metastases (who did not undergo trial dissection of the vein), CT findings are correlated with local surgical resectability in *Table 1*. The sensitivity and positive predictive value for local irresectability were slightly lower than those for overall resectability (71 and 68 per cent respectively).

A radical resection (tumour-negative resection margins at pathology) was obtained in 20 of 29 resected tumours, including one case of sleeve resection (*Fig. 1*). In *Table 2* resectability at CT is correlated with radicality of the resection, excluding the patients with metastases. The positive predictive value of CT for a non-radical resection was 82 per cent, with a sensitivity of 60 per cent. If patients with metastases were included, the overall positive predictive value of CT for a non-radical resection was 86 per cent, with a sensitivity of 67 per cent.

Table 1 Resectability at computed tomography correlated with local surgical resectability

	Surgery		Total
	Resectable	Irresectable	
CT			
Resectable	22	6	28
Irresectable	7	15	22
Total	29	21	50

The sensitivity, specificity, and positive and negative predictive values of computed tomography (CT) for local irresectability at operation were 71 per cent (15 of 21), 76 per cent (22 of 29), 68 per cent (15 of 22) and 79 per cent (22 of 28) respectively

Table 2 Resectability at computed tomography correlated with radicality on pathological examination

	Radical resection	Non-radical resection	Total
	CT		
Resectable	16	12	28
Irresectable	4	18	22
Total	20	30	50

The sensitivity, specificity, and positive and negative predictive values of computed tomography (CT) for a non-radical resection at pathological examination were 60 per cent (18 of 30), 80 per cent (16 of 20), 82 per cent (18 of 22) and 57 per cent (16 of 28) respectively

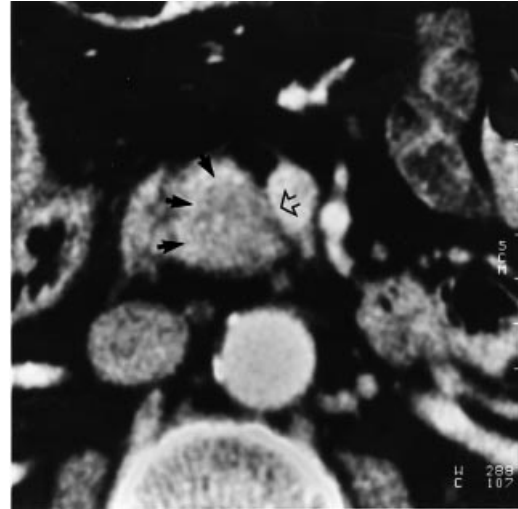


Fig. 1 Small pancreatic head carcinoma (black arrows). Computed tomography grade C contact with superior mesenteric vein with flattening of the vein (open arrow). The lesion was radically resected; sleeve resection was necessary

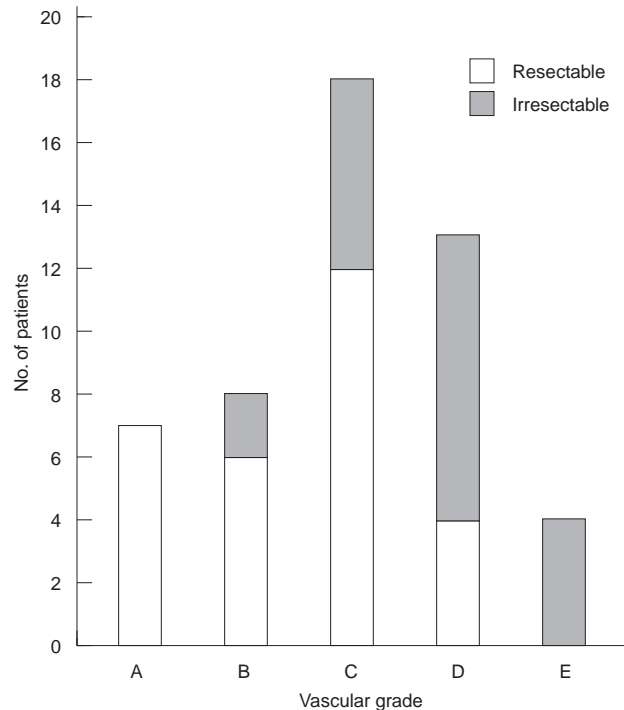


Fig. 2 Computed tomography (CT) grade of venous involvement correlated with local surgical resectability. The sensitivity, specificity, and positive and negative predictive values of CT for local irresectability at surgery (CT grade D and E) were 62, 86, 76 and 76 per cent respectively ($n = 50$)

Vascular grading by computed tomography

In 19 patients local irresectability at operation was due to venous ingrowth. Arterial ingrowth was found in eight patients, but never without coexisting venous ingrowth. Excluding patients with metastases and using the highest CT grade for portal vein and superior mesenteric vein as a single parameter, surgical resection rates for grades A–E were 100, 75, 67, 31 and 0 per cent respectively (Fig. 2). The resection rate was 76 per cent (25 of 33) in grades A–C and 24 per cent (four of 17) at grades D and E ($P < 0.001$).

Venous ingrowth on histopathological examination could be assessed in 50 patients, after resection or if biopsies of the vascular plane were taken during trial dissection. A sleeve resection was considered as ingrowth, regardless of resection margins. Venous ingrowth was thus found in 15 of 17 tumours with CT grades D or E, yielding a predictive value of 88 per cent (Figs 3 and 4). Resection rates with a vascular margin free of tumour were 100 per cent for grade A, 63 per cent for grade B, 44 per cent for grade C, 15 per cent for grade D and 0 per cent for grade E. Infiltration of peripancreatic fat planes was one of the CT parameters for

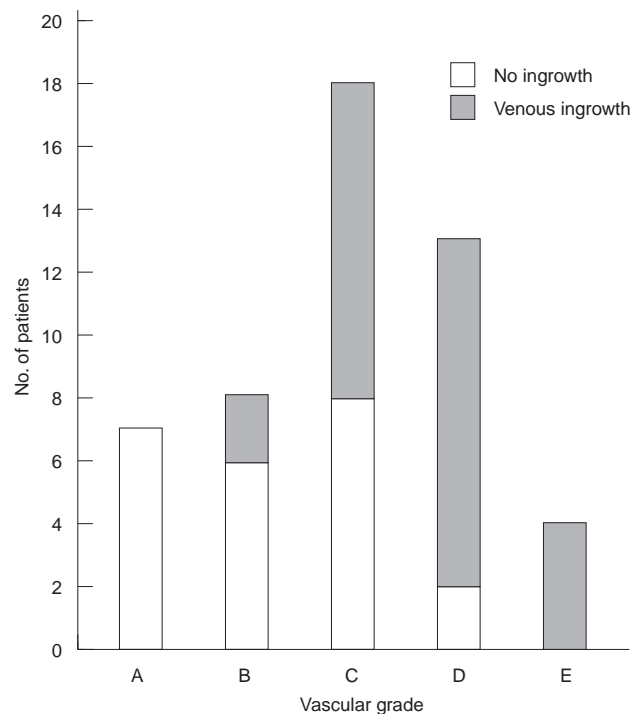


Fig. 3 Computed tomography (CT) grade of venous ingrowth correlated with vascular ingrowth at pathological examination. The sensitivity, specificity, and positive and negative predictive values of CT (grades D and higher) for venous ingrowth at pathological examination were 56, 91, 88 and 64 per cent respectively

local irresectability. Correlation with local surgical resectability was examined for patients without metastases. Infiltration of the anterior peripancreatic fat plane was seen in nine patients and a resection could be performed in only one. If anterior fat plane infiltration was absent the resectability rate was 67 per cent ($P < 0.01$). Posterior fat infiltration was present in 16 patients and seven of these underwent resection (resection margins were free of tumour in five).

There were seven patients with indeterminate liver lesions at CT which could not be biopsied percutaneously. The lesions were smaller than 15 mm in two, less than 10 mm in two and less than 5 mm in three. Two lesions were proven malignant at laparoscopic sonography and four were shown to be benign; one lesion had negative biopsies at laparoscopic sonography, but proved malignant after a short follow-up.

Discussion

CT has been regarded as the most accurate diagnostic modality in preoperative staging of pancreatic head carcinoma. The sensitivity and specificity for irresectability have been reported to be as high as 100 per cent (Table 3)^{5,9–12}. The findings from the present study seem comparable to those of McCarthy *et al.*⁹, but are less accurate than those in studies using a 3-mm helical technique¹⁰. Results should be interpreted cautiously as variation in resectability rates could indicate differences

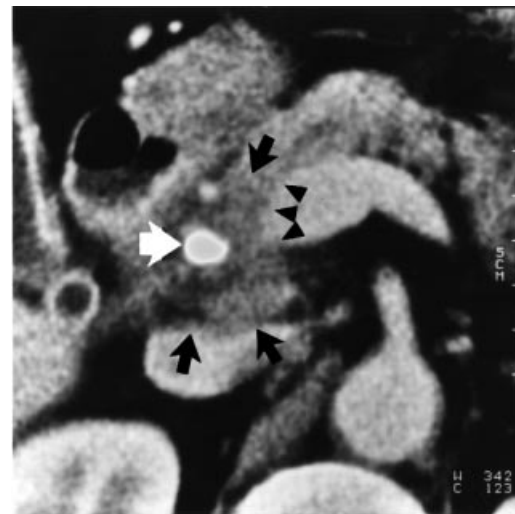


Fig. 4 Pancreatic head carcinoma (black arrows). Computed tomography grade D vascular ingrowth with concave contour of the tumour towards the venous confluence (arrowheads). Stent in common bile duct (white arrow). At operation the lesion was irresectable owing to vascular ingrowth

Table 3 Sensitivity and specificity of computed tomography for irresectability correlated with surgery

Reference	Year	Sensitivity (%)	Specificity (%)	No. of patients	Resection rate (%)	Lesion	Technique
McCarthy <i>et al.</i> ^{9*}	1998	72	80	67	48	Pancreatic carcinoma	
Diehl <i>et al.</i> ¹⁰	1998	91	90	76	28	Pancreatic carcinoma	Dual slice 3 mm
Bluemke <i>et al.</i> ⁵	1995	53	100	64	34	Pancreatic carcinoma	Spiral 8 mm
Megibow <i>et al.</i> ⁴	1995	77	50	143	18	Pancreatic neoplasms	Dynamic 5 mm
Warshaw <i>et al.</i> ¹¹	1990	56	87	55	29	Pancreatic head carcinoma	Dynamic
Freeny <i>et al.</i> ¹²	1988	95	100	51	3	Pancreatic carcinoma	Dynamic 10 mm
Present series	1999	78	76	56	52	Pancreatic head carcinoma	Spiral 5 mm

*Retrospective study

in patient selection or surgical strategy. In the present series with 5-mm slice thickness, small metastases were undetected or unproven after CT in 12 per cent of patients. As only patients with biopsy-proven metastases were excluded from further investigation, this seems an improvement in preoperative detection of metastases compared with that in series using dynamic CT¹¹ or helical CT with 8-mm slice thickness. Metastases were found at operation in 40 per cent of patients considered resectable at CT in one series⁵. This improved detection of metastases may partly result from improved fine-needle biopsies often performed under CT or ultrasonographic guidance, but may also be due to patient selection.

Laparoscopy and laparoscopic sonography has been advocated in preoperative staging¹³⁻¹⁵. This technique has recently been shown to demonstrate metastases that were undetected before operation in 35 per cent of patients with pancreatic head carcinoma¹⁶. Laparoscopy with sonography and diagnostic puncture may be useful in patients with indeterminate liver lesions at CT, which cannot be punctured percutaneously. In this study such patients were regarded as potentially resectable and received further investigation by laparoscopy. CT has been reported to detect a large number of small benign lesions¹⁷; the present data agree with this finding (four of seven indeterminate lesions proved to be benign).

Vascular encasement is the major cause of local irresectability and is found in approximately 50 per cent of patients thought resectable after CT⁵. Data are hard to compare as different CT criteria have been used. When correlating findings with surgical resectability, results are also dependent on varying attitudes towards venous resection¹⁸. Complete encirclement of the vessels and total occlusion are considered 100 per cent specific for irresectability, but these criteria are not found in many patients. In a study that used thin-

section helical CT, vascular involvement was found in 88 per cent of patients with more than 180° of vessel encirclement¹⁹. In the present series this criterion represented 100 per cent surgical irresectability, although it was present only in grade E tumours (with complete circumferential involvement of the vessel). In grade D tumours (concave contour of tumour towards vessel) the resectability rate was also low (31 per cent) and all lesions had less than 180° of venous involvement. If radicality is also taken into account, a resection with tumour-free vascular margins could be obtained in only 15 per cent of grade D tumours. It is questionable whether this criterion should be used to exclude patients from resection.

The sensitivity of 56 per cent for vascular ingrowth seems low when correlating CT with pathological examination. This may partly be due to exclusion of patients who have evident vascular encasement at preoperative ultrasonography and CT, and exclusion of patients with encasement on CT without histological confirmation because metastases were found at surgery. In nearly one-third of patients who underwent resection, vascular ingrowth was found at pathological examination. Microscopic ingrowth therefore seems hard to predict at surgery as well. The predictive value of CT for vascular ingrowth at surgery was 76 per cent. A recent study, using 3-mm spiral CT, found a predictive value for ingrowth of 70 per cent for axial CT compared with surgery. In the same study three-dimensional rendering of vessels showed a predictive value for ingrowth of 90 per cent²⁰.

In conclusion, spiral CT with thin slices seems to improve detection of liver metastases and vascular ingrowth in patients with carcinoma of the pancreatic head. Further studies should be performed to find definitive criteria that can exclude patients from laparotomy, because of a high predictive value for ingrowth.

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