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Diagnostic Accuracy of Contrast-Enhanced CT in Predicting Resectability and Vascular Involvement in Pancreatic Carcinoma Correlation with Intraoperative and Histopathological Findings.

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Abstract

Background: Pancreatic carcinoma is an aggressive malignancy with a poor prognosis, and surgical resection remains the main potentially curative treatment. Accurate preoperative assessment of tumour resectability and vascular involvement is essential for appropriate surgical planning. Contrast-enhanced computed tomography (CECT) plays a crucial role in evaluating tumour extent and its relationship with major vascular structures. ***Objective:*** To evaluate the diagnostic accuracy of contrast-enhanced computed tomography (CECT) in predicting tumour resectability and vascular involvement in patients with pancreatic carcinoma. ***Methods:*** A prospective observational study was conducted at a tertiary care centre from January to December 2024. A total of 200 patients underwent preoperative CECT followed by surgical exploration. Radiological findings were compared with intraoperative observations and available histopathological findings. ***Results:*** CECT demonstrated 90% diagnostic accuracy for detecting vascular involvement compared with intraoperative findings. Agreement between CECT-based and intraoperative resectability classification was 80%. ***Conclusion:*** CECT is an important imaging modality for preoperative assessment of pancreatic carcinoma and evaluation of tumour resectability.

Keywords: Pancreatic carcinoma, contrast-enhanced computed tomography, vascular involvement, resectability, intraoperative findings, histopathology.

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INTRODUCTION

Pancreatic carcinoma is an aggressive malignancy associated with substantial morbidity and mortality. Surgical resection remains the principal potentially curative treatment; however, only a proportion of patients are suitable for surgery at the time of diagnosis. Accurate preoperative assessment is therefore essential for selecting appropriate treatment and avoiding unnecessary surgical exploration [1]. Contrast-enhanced computed tomography (CECT), particularly when performed using a dedicated pancreatic protocol, is widely used for the detection and staging of pancreatic malignancies. It provides information regarding tumour location, size, local extension, lymph node involvement, distant metastasis and relationships with adjacent vascular structures [1,2]. Assessment of the superior mesenteric artery, celiac artery, common hepatic artery, superior mesenteric vein and portal vein is particularly important when determining tumour resectability [3].

Based on vascular involvement and the extent of local disease, pancreatic tumours are generally classified as resectable, borderline resectable or unresectable. This classification assists in treatment planning and helps identify patients who may require neoadjuvant therapy or vascular reconstruction [3,4]. Despite advances in imaging, radiological findings may not always correspond with operative observations or microscopic vascular invasion. Peritumoural inflammation, fibrosis and desmoplastic reactions can complicate the interpretation of vascular involvement [5].

The present study was undertaken to evaluate the diagnostic accuracy of CECT in predicting tumour resectability and vascular involvement in patients with pancreatic carcinoma, with correlation to intraoperative and histopathological findings.

MATERIALS AND METHODS

Study design, setting, duration and sample size

A prospective observational study was conducted at a tertiary care centre from January 2024 to December 2024. A total of 200 patients with pancreatic carcinoma who underwent preoperative CECT followed by surgical exploration were included.

Inclusion criteria

- Patients aged 18 years or older.
- Patients with suspected or confirmed pancreatic carcinoma.
- Patients who underwent preoperative pancreatic protocol CECT.
- Patients who underwent surgical exploration with documented operative findings.

Exclusion criteria

- Contraindication to intravenous contrast.
- Technically inadequate CECT images.
- Previous pancreatic surgery.
- Neoadjuvant treatment before the evaluated CECT.
- Incomplete clinical or operative records.

Imaging and operative assessment

CECT images were assessed for tumour location, size, local extension, lymphadenopathy, distant metastasis and involvement of major vessels, including the SMA, SMV, portal vein, celiac artery and common hepatic artery. Vascular involvement was evaluated using tumour-vessel contact, circumferential involvement, narrowing, contour irregularity and occlusion. Tumours were classified as resectable, borderline resectable or unresectable according to established anatomical criteria [2,3].

All patients underwent surgical exploration. Operative findings regarding tumour extent, vascular involvement and feasibility of resection were documented and compared with CECT findings. Histopathological assessment of vascular invasion and resection margins was performed in patients who underwent tumour resection.

Statistical analysis

Data were analysed using IBM SPSS Statistics version 26. Categorical variables were expressed as frequencies and percentages. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy were calculated using intraoperative findings as the reference standard for vascular involvement and resectability. Histopathological findings were used as the reference standard for vascular invasion in patients who underwent tumour resection. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 200 patients with pancreatic carcinoma who underwent preoperative contrast-enhanced computed tomography (CECT) followed by surgical exploration were included in the study. The demographic, clinical, radiological, operative and histopathological findings are presented in the following tables.

Table 1: Demographic and clinical characteristics of the study population (n = 200)

Characteristics		Number	Percentage
Age group (years)	18-40	18	9%
	41-60	112	56%
	>60	70	35%
Sex	Male	126	63%
	Female	74	37%
Presenting Symptoms	Abdominal pain	174	87%
	Jaundice	118	59%
	Weight loss	142	71%
	Anorexia	106	53%
	Vomiting	42	21%

The majority of patients belonged to the 41–60-year age group (56%). Males constituted 63% of the study population. Abdominal pain was the most frequent presenting symptom (87%), followed by weight loss (71%) and jaundice (59%).

Table 2: Tumour characteristics and associated findings on CECT (n = 200)

CECT findings		Number	Percentage
Tumour location	Head of pancreas	120	60%
	Body of pancreas	45	22.5%
	Tail of pancreas	25	12.5%
	Uncinate process	10	5%
Maximum tumour diameter	<2 cm	24	12%
	2-4 cm	116	58%
	>4 cm	60	30%
Associated imaging findings	Pancreatic duct dilatation	132	66%
	Biliary duct dilatation	110	55%
	Peripancreatic fat infiltration	104	52%
	Regional lymphadenopathy	88	44%
	Distant metastasis	38	19%

The pancreatic head was the most common tumour location (60%). Most tumours measured between 2 and 4 cm (58%). Pancreatic duct dilatation and biliary duct dilatation were observed in 66% and 55% of patients, respectively.

Table 3: Distribution of vascular involvement identified on CECT (n = 200)

Vascular structure	Contact/ abutment ≤180°	Encasement >180°	Narrowing/ occlusion
Superior mesenteric artery	22 (11%)	8 (4%)	2 (1%)
Superior mesenteric vein	24 (12%)	14 (7%)	10 (5%)
Portal vein	22 (11%)	12 (6%)	10 (5%)
Celiac artery	12 (6%)	5 (2.5%)	1 (0.5%)
Common hepatic artery	14 (7%)	5 (2.5%)	1 (0.5%)

Note: More than one vessel could be involved in an individual patient; therefore, the percentages are not mutually exclusive.

Venous involvement was more frequently identified than arterial involvement. The superior mesenteric vein and portal vein showed the highest frequencies of narrowing or occlusion in this study population.

Table 4: Correlation between CECT and intraoperative assessment of vascular involvement (n = 200)

CECT assessment	Intraoperative involvement present	Intraoperative involvement absent	Total
Vascular involvement present	82 (TP)	12 (FP)	94
Vascular involvement absent	8 (FN)	98 (TN)	106
Total	**90**	**110**	**200**

Diagnostic performance

Parameter	Value (%)
Sensitivity	91.1%
Specificity	89.1%
Positive predictive value	87.2%
Negative predictive value	92.5%
Diagnostic accuracy	90%

CECT demonstrated a sensitivity of 91.1% and specificity of 89.1% for detecting vascular involvement compared with intraoperative findings. The overall diagnostic accuracy was 90%.

Table 5: Correlation between CECT and histopathological findings of vascular invasion among resected patients (n = 105)

CECT assessment	Histopathological invasion present	Histopathological invasion absent	Total
Vascular involvement present	28 (TP)	7 (FP)	35
Vascular involvement absent	4 (FN)	66 (TN)	70
Total	**32**	**73**	**105**

Diagnostic performance

Parameter	Value (%)
Sensitivity	87.5%
Specificity	90.4%
Positive predictive value	80%
Negative predictive value	94.3%
Diagnostic accuracy	89.5%

Among the 105 patients who underwent tumour resection, CECT demonstrated a sensitivity of 87.5% and specificity of 90.4% for predicting histopathological vascular invasion. The negative predictive value was 94.3%.

Table 6: Comparison of CECT-based resectability classification with intraoperative findings (n = 200)

CECT classification	Intraoperatively resectable	Intraoperatively borderline resectable	Intraoperatively unresectable	Total
Resectable	82	8	2	92
Borderline resectable	17	18	3	38
Unresectable	6	4	60	70
Total	**105**	**30**	**65**	**200**

Intraoperative assessment classified 105 patients as resectable, 30 as borderline resectable and 65 as unresectable. Of the 200 patients, exact agreement between CECT-based and intraoperative resectability classification was observed in 160 patients (80%). Agreement was highest in the unresectable category, with 60 of 70 patients correctly classified by CECT.

Operative and Histopathological Findings

Of the 200 patients who underwent surgical exploration, tumour resection was performed in 105 patients (52.5%), whereas resection was not performed in the remaining 95 patients (47.5%). Among the resected patients, R0 resection was achieved in 78 patients (74.3%), while R1 resection was observed in 27 patients (25.7%). Histopathological examination revealed vascular invasion in 32 patients (30.5%).

DISCUSSION

Preoperative assessment of pancreatic carcinoma is essential for determining the feasibility of surgical resection and selecting an appropriate treatment strategy. CECT plays a central role in this assessment by providing detailed information regarding tumour extent, vascular relationships and distant disease.

In the study population, CECT demonstrated 91.1% sensitivity and 89.1% specificity for detecting vascular involvement compared with intraoperative findings. Jajodia et al. reported high specificity of CT for detecting vascular invasion, although sensitivity was comparatively lower in their systematic review and meta-analysis [6]. These findings support the importance of pancreatic protocol CT in preoperative vascular assessment. The present study also demonstrated 80% agreement between CECT-based and intraoperative resectability classification. Noda et al. evaluated vascular involvement and resectability using contrast-enhanced MRI in comparison with pancreatic protocol CT, highlighting the importance of detailed cross-sectional imaging in preoperative assessment [7]. Ahmed et al. further demonstrated the role of CT in evaluating vascular invasion and resectability in patients with borderline pancreatic cancer following neoadjuvant treatment [8].

Histopathological correlation was available in the 105 patients who underwent tumour resection. In this subgroup, the diagnostic accuracy of CECT for predicting microscopic vascular invasion was 89.5%. However, radiological vascular contact and microscopic vascular invasion are not identical findings. Fibrosis, inflammatory changes and desmoplastic reactions may produce imaging appearances that resemble tumour infiltration.

Recent studies have explored advanced imaging techniques to improve the assessment of vascular involvement. Bereska et al. investigated artificial intelligence-based assessment of vascular involvement and tumour resectability on CT images [9]. Si et al. evaluated dark-blood dual-energy CT images for predicting vascular involvement and R0 resection in pancreatic cancer [10]. A recent study by Mora et al. also examined the correlation between CT-based vascular invasion and intraoperative and histological findings, further emphasising the clinical importance of imaging-operative correlation [11]. Overall, CECT remains an important modality for preoperative assessment of pancreatic carcinoma. Its systematic interpretation, particularly regarding major vascular structures, can assist in predicting resectability and planning surgical management.

CONCLUSION

Contrast-enhanced computed tomography is an important imaging modality for the preoperative evaluation of pancreatic carcinoma. Systematic assessment of tumour extent and its relationship with major vascular structures helps predict resectability and supports surgical planning. Correlation with intraoperative and histopathological findings provides an important means of evaluating its diagnostic performance.

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