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**ORIGINAL ARTICLE**

Resectability of pancreatic tumors: Correlation of multidetector CT with surgical and pathologic results

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KEYWORDS

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Abstract *Purpose:* The purpose of this study is to evaluate the ability of multidetector CT (MDCT) in predicting resectability of pancreatic tumors.

Patients and methods: Thirty-nine patients were included in this study, there were 29 males and 10 females, and their age range was 44–73 years with a mean age of 58.3 years. All the patients were subjected to contrast enhanced biphasic examinations on 64-slice CT machine.

Results: Twenty-one patients (53.8%) were considered inoperable with unresected tumor, the remaining 18 patients (46.2%) were considered suitable for tumor resection according to MDCT criteria. 15 out of the 18 patients (83.3%) had a successful tumor resection while the remaining 3 (16.7%) showed unresectable tumor during operation. On the basis of pathology results 12 patients out of the 18 (66.7%) had successful surgery with negative tumor margin, and a positive predictive value of 66.7% and accuracy of 66.7%.

Conclusions: There is better prediction of resectability of pancreatic tumors with the development of MDCT technology. As compared to Helical computed tomography (HCT) studies, there is a rise in

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the rate of successful surgical resection. The positive predictive value of multidetector computed tomography for resectable pancreatic tumors is decreased when pathologic results are used as a reference standard.

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1. Introduction

Pancreatic cancer is one of the most aggressive human malignancies. It represents the fourth most frequent cause of cancer-related death and the second most frequent cause, after colorectal cancer, when considering digestive tract cancers alone (1). Because of its silent course, late clinical symptoms, and rapid growth patterns, it has been named the “silent killer” (2,3). About 15–20% of the patients have resectable disease at the time of presentation (4). Surgical resection offers the only chance for cure with reported 5-year survival rates of 8–21% (3). Tumors are considered unresectable when metastatic disease or local vascular invasion is present. The vessels most often involved are the celiac trunk, the hepatic artery, the superior mesenteric artery, as well as, the superior mesenteric vein and the portal vein (4). Because of the recent improvements in radiologic techniques, a wide range of imaging tools is now available, such as helical CT, MR imaging, endoscopic sonography, endoscopic retrograde cholangiopancreatography, and angiography (5). Contrast enhanced, helical computed tomography (HCT) and more recently multi-detector computed tomography (MDCT) have been widely accepted as the imaging technique of choice for the staging of pancreatic adenocarcinoma (4). The main role of preoperative staging procedures is to distinguish between potentially resectable and non-resectable patients so that unnecessary surgical procedures may be avoided; survival benefits can be achieved only in patients in whom the tumor can be completely resected (5). A significant number of patients are still incorrectly diagnosed as having resectable tumor on CT only to be unresectable at surgery. The proportion of patients undergoing unnecessary laparotomy may vary between 21% and 44% (4).

The purpose of this study is to evaluate accuracy of 64-slice multidetector CT (MDCT) in preoperative assessment of resectability of pancreatic cancer using the surgical outcome and pathologic results as a reference standard.

2. Patients and methods

Between December 2009 and August 2011, 39 patients with clinical and sonographic findings that raised suspicions of pancreatic cancer were included in our study. They were 29 males and 10 females. Their age ranged from 44 to 73 years with a mean age of 58.3 years. All the patients underwent MDCT examination with 64-slice CT scan after obtaining a prior consent.

2.1. CT examination technique

All examinations were performed with the same 64-slice CT scan (Light speed volume VCT, GE medical system, Milwaukee, WI, USA). Prior to examinations patients drank 1000 mL of mixed water and contrast to demarcate the duodenum and delineate the pancreatic head region. All patients

received an intra-venous injection of 100 ml of Omnipaque® 350 (Amersham, GE Healthcare, Canada) at a rate of 4 ml/s. The protocol of 64-slice MDCT was biphasic, performed with a detector width of 0.625 mm, a section width of 1.5 mm and an interval reconstruction of 0.5 mm. The scan done by bolus tracking at (110 H.U.) threshold at the aorta at corresponding level of superior mesenteric artery. The scan delay after contrast injection 20 s for pancreatic arterial phase and 50 s for delayed venous phase. All images were interpreted on a picture archiving and communication system (PACS) workstation. Curved and multiplanar reformations were obtained at a dedicated post-processing workstation (Advantage® Windows Volume share 4.5, GE Medical System, Milwaukee, WI, USA). Multidetector CT (MDCT) scans were analyzed prior to surgery to determine resectability.

2.2. Image analysis

Axial images and multiplanar reconstructions with coronal and sagittal reformations were obtained for all patients. Our patients were classified into two groups: group A included patients who had lesions which are resectable or probably resectable according to CT criteria, and group B included patients who had lesions definitely unresectable according to CT criteria. Criteria of unresectability included: 1- Tumors which were larger than 2 cm in size (tumors less than 2 cm may be associated with favorable outcome (6)), 2- Presence of local metastasis (such as enlarged lymph nodes outside peripancreatic draining chains) or direct invasion of the surrounding organs with exclusion of the duodenum, or more, 3- Distant metastases (liver or pulmonary metastasis), 4- Infiltration of the walls of major vessels including (celiac trunk, hepatic artery, splenic artery, superior mesenteric artery and portal vein or the superior mesenteric vein). Arterial Vascular involvement was estimated using the criteria by Lu et al. (7) grade 0, no contiguity of tumor to vessel; grade 1, tumor contiguous less than one quarter of circumference; grade 2, between one quarter and one half; grade 3, between one half and three quarters; grade 4, greater than three quarters. Grade 0–2 was considered operable, whereas grades 3 and 4 were considered radiologically inoperable. Venous invasion was defined as tumor-to-vessel circumferential contiguity of 50% or more. Tumor-to-vein circumferential contiguity of less than 50% was not considered venous invasion (5).

So our patients were assessed for tumor resectability according to (1) tumor size, (2) local spread, and/or (3) distant spread and (4) vascular involvement.

All the examinations were reviewed by at least two radiologists followed by discussing the results with the surgeon. In cases with discrepancy between the dual MDCT reports an open discussion was done until reach to final diagnosis.

According to our data collection and interpretation, patients were divided into two groups on the basis of preoperative MDCT criteria: Group A included patients who had

Table 1 Classifications of patients according to preoperative MDCT criteria.

	Resectable Group A	Unresectable Group B	Total no of patients
MDCT findings	18	21	39

Table 2 Resectability of MDCT correlated with surgical outcome.

	Resectable tumors by surgery	Unresectable Tumors by surgery	Total No. of patients
MDCT resectable <i>N</i> = 18	15	3	18

Table 3 Resectability of MDCT correlated with pathological results.

	Free margin	Positive tumor margin	Total No. of patients
MDCT resectable <i>N</i> = 15	12	3	15

Table 4 Accuracy and positive predictive values of resectability of MDCT in correlation with surgical outcome and pathological results.

	Surgical outcome No = 18	Pathological results No = 15
MDCT PPV of resectability	83.3%	66.7%
MDCT accuracy	83.3%	66.7%

resectable or probably resectable lesions according to MDCT criteria (18 patients) and those were included in the data analysis, while group B included patients with definitely unresectable disease (21 patients) were excluded from our statistical

data analysis. On the basis of surgical outcomes and pathological results the MDCT findings were retrospectively reviewed to assess positive predictive value and accuracy in detecting tumor resectability.

2.3. Statistical analysis

Accuracy and positive predictive values for resectability of MDCT were calculated by using surgical results and pathological findings (regarding the presence or absence of tumor infiltration at the surgical margins) as a reference standard.

3. Results

Thirty-nine patients were included in our study; all the patients underwent 64-slice MDCT examination. Out of the 39 patients 21 (53.8) were diagnosed as unresectable tumors, 16 out of 21 patients (76.2%) showed associated liver metastasis, one patient out of 21 (4.8%) showed both liver and lung metastasis with ascitis, 3 patients (14.3%) showed vascular involvement of superior mesenteric artery (grade 3 and 4 according to Lu et al (7)), and last patient (4.8%) showed tumor encasement of superior mesenteric vein with possible venous thrombosis.

18 patients out of 39 (46.2%) were diagnosed according to our criteria as resectable pancreatic masses. All the 18 patients underwent surgical operations within 7–25 days (with mean 14.5 days) post MDCT examination, 15 out of the 18 (83.3%) had successful tumor resection with positive predictive value for resectability 83.3% and accuracy of 83.3%, while 3 (16.7%) patients had unresectable pancreatic masses (one patient showed invasion of the superior mesenteric vein with infiltration of the root of mesentery, one patient showed small liver metastasis with unexpected metastatic lymph node the last one showed superior mesenteric artery involvement). All the three patients underwent palliative procedures. On the basis of pathological results (considering the positive surgical margin), 3 out of the 15 (20%) patients, who underwent a Whipple procedure and were believed to be resectable on the basis of MDCT, were found to have positive surgical margins. So our positive predictive value of MDCT for overall resectability fell to

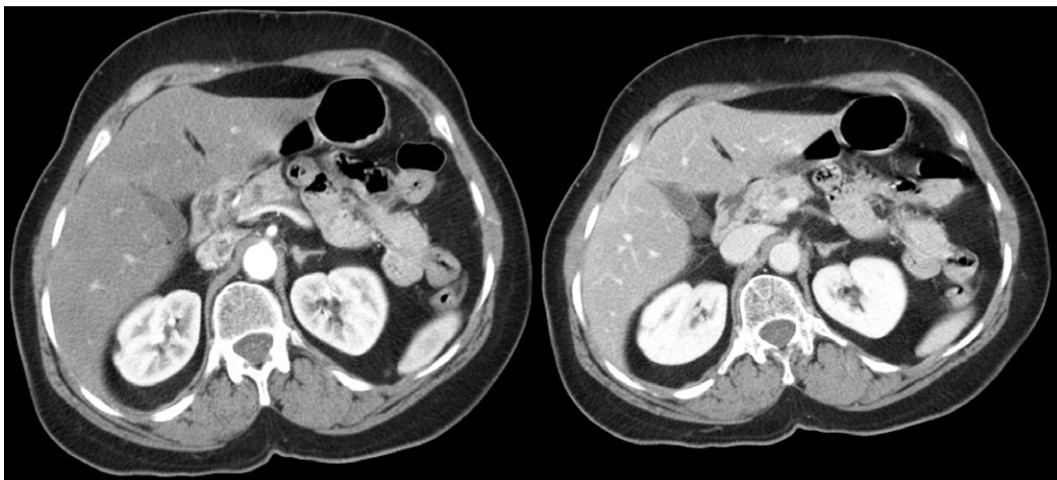


Fig. 1 Axial MDCT of 54 years old man (venous phase) shows small pancreatic head non enhanced hypodense focal mass in contiguity of less than 50% with the superior mesenteric vein (SMV) reported as resectable tumor mass (true positive).

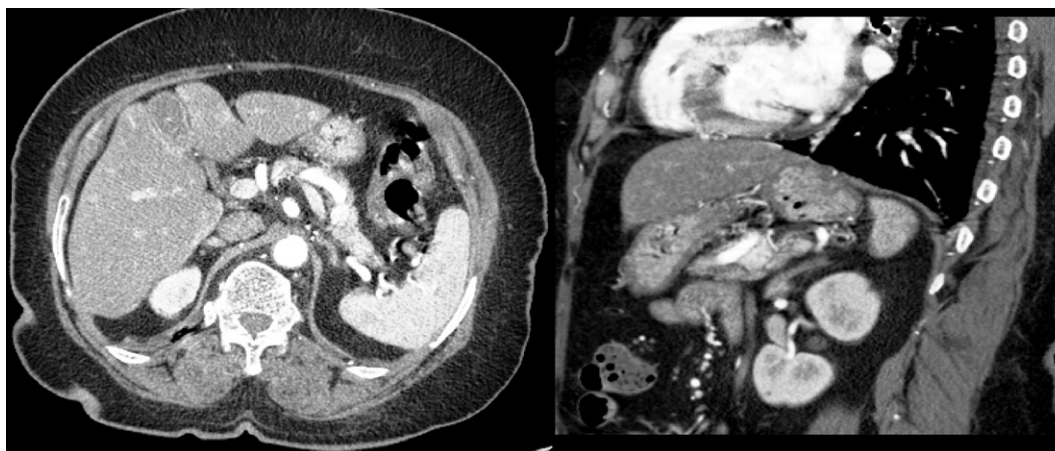


Fig. 2 Axial MDCT with sagittal reformation (arterial phase) in 48 years old man shows uniform enhanced pancreatic body mass in contiguity with the splenic artery less than 50% reported as resectable case (true positive).



Fig. 3 Axial MDCT (arterial phase) in 64 years old male with pancreatic body mass abutting both SMA and SMV reported as probably resectable mass, while during laparotomy unexpected SMV invasion was detected with failed surgical resection (false positive).

66.7% (12 out of the 18) and overall accuracy of 66.7% (Tables 1–4 and Figs. 1–7).

4. Discussion

The indications for radical pancreaticoduodenectomy for pancreatic cancer have expanded over recent years as a result of a dramatic decline in surgical mortality rates (8). However, according to the findings of a recent surgical series, less than 20% of pancreatic cancers are amenable to surgical resection (9). Moreover, prognosis is not improved for patients whose tumors are resected with positive margins or vascular invasion (10,11). The reasons for unresectability include unsuspected liver metastasis, vascular invasion, lymph node metastasis, and peritoneal carcinomatosis (5).

The accurate determination of resectability in patients with pancreatic cancer is the most important contribution of pre-operative staging; the goal being to reduce needless surgery to a minimum (4). On the other hand, for patients with unresectable lesions, laparotomy for palliative procedures has

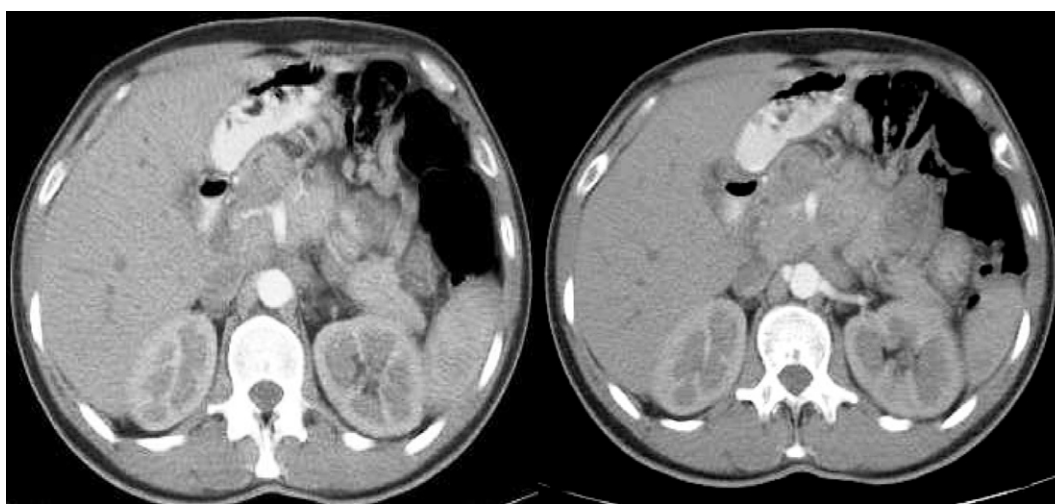


Fig. 4 Axial MDCT (arterial phase) in 44 years old male patient with large pancreatic body mass encasing the celiac trunk and its main branches (Lu grade 4), picture of definite unresectability.



Fig. 5 Axial MDCT with coronal reformation (arterial phase) in a 68 years old male with cystic mass of the uncinate process away from the vascular structures, reported as resectable mass despite of associated ascitis (true positive case).

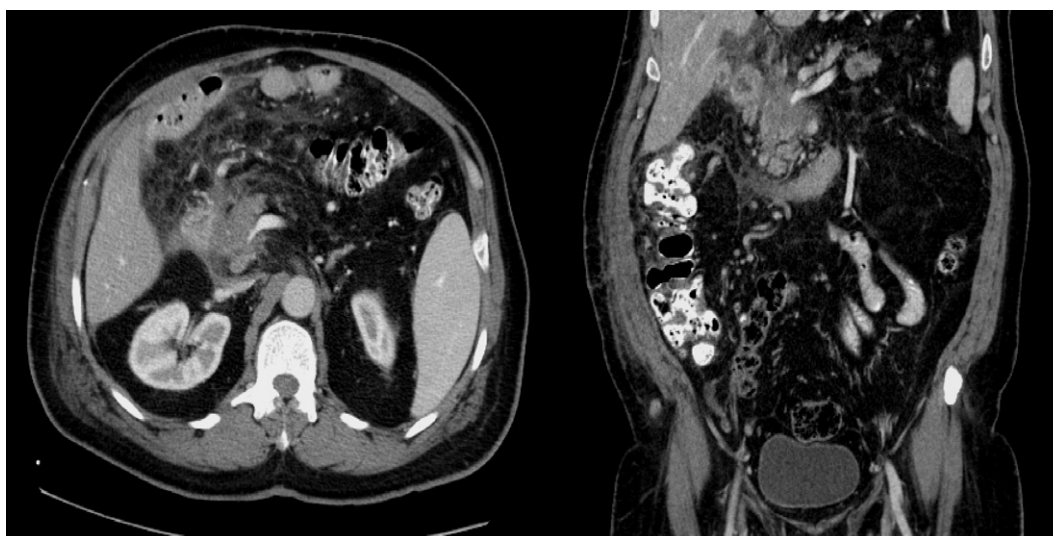


Fig. 6 Axial MDCT with sagittal and coronal reformation (venous phase) in a 66 years old man shows a pancreatic head mass encasing the SMV with possible thrombosis, which are a CT sign of definite unresectability.

become unnecessary because of recent advances in endoscopic and percutaneous methods of biliary and duodenal decompression (4). The improvement in CT technology has been paralleled by an improvement in the ability of CT to predict resectability. In our study based on surgical outcome, the proportion of patients submitted to surgery whose pancreatic tumors were successfully resected was 83.3% (15 out of 18). In the study reported by Vargas et al., the resection rate was 80% (12). In previously published series using helical CT (HCT), the resection rate varied between 28% and 73.5% (13–15). In the study published by Phoa et al., using a dual detector HCT, the resection rate was 57% (16). Vargas et al. reported a predictive value for the ability of MDCT to detect

resectability of 87% (12). Our results show a predictive value of 83.3% for resectability when compared to surgical outcome. Comparing CT results to pathologic findings modified our results. Our prediction of resectability reduced to 66.7% with three patients showed positive tumor margin (negative tumor margins are requirement for successful resection). Similarly, Phoa et al. (16) also showed a decrease in the predictive value for resectability (from 72% to 50%), when pathologic, rather than surgical, correlation was considered.

In our study the overall patients with failed surgery and were believed to had resectable lesions on the basis of preoperative MDCT were 6 out of 18 (33.3%) with overall accuracy of 66.7%. The limitations of our study including failure to

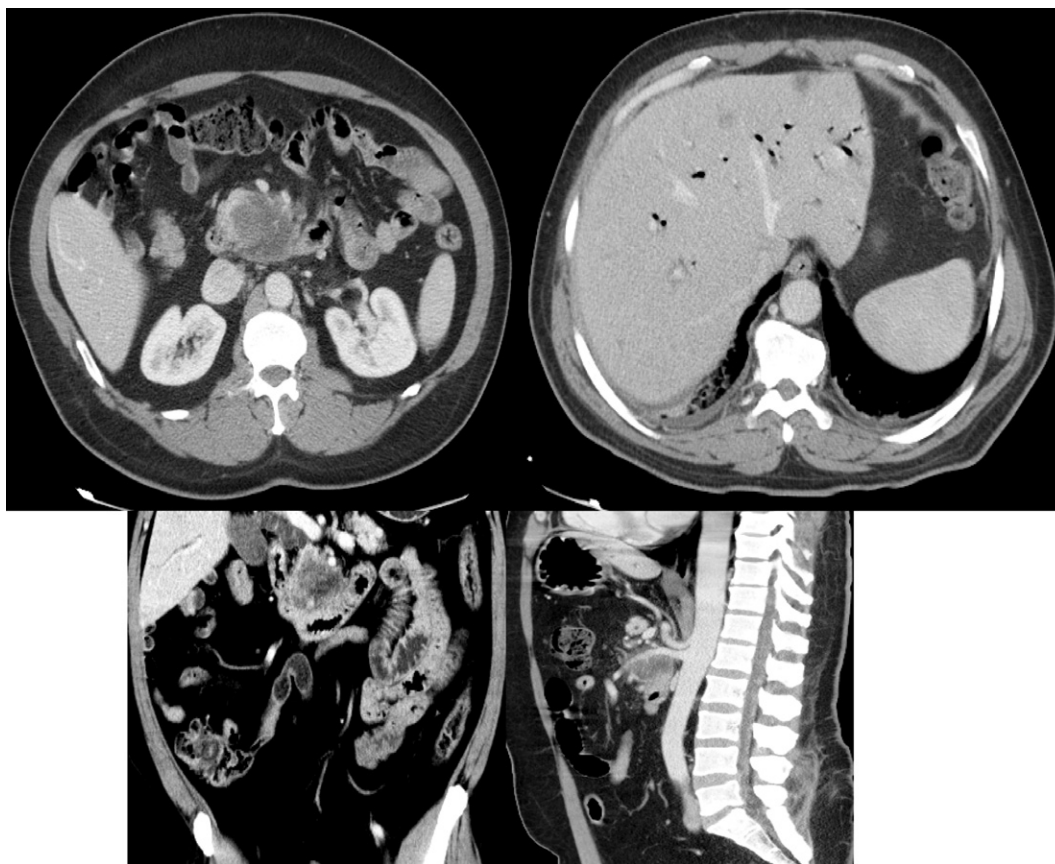


Fig. 7 Axial MDCT with coronal and sagittal reformations in 55 years old male patient shows a pancreatic head mass abutting and displacing the SMA and SMV. This lesion diagnosed as unresectable pancreatic mass because of two small hepatic metastasis.

evaluate the predictive value for unresectability all the 21 patients (53.8%) with unresectable tumor showed aggressive disease with local or distant metastasis as well as vascular invasions, no patients submitted to surgery, with no way to correlate the CT findings with accurate staging. In the current study, 12 patients had their tumors successfully resected, representing 30.7% of all patients (39) initially evaluated. This percentage is higher than the literature reports, as only 15–20% of patients have resectable disease at the time of presentation (4).

5. Conclusion

With the advance of MDCT technology there is improvement in prediction of resectability of pancreatic tumors when compared to HCT studies, there is a rise in the rate of successful surgical resection with the decrease in the rate of palliative surgery. Despite technology advances, a group of patients remains with early but locally invasive pancreatic tumors, where anatomical imaging is unable to predict inoperability. Another limitation is difficulty in measuring the predictive value of unresectability since no patients in our study with unresectable disease undergo laparotomy.

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