

CORRELATION OF MULTIDETECTOR COMPUTED TOMOGRAPHY
IMAGING WITH SURGICAL AND HISTOPATHOLOGICAL FINDINGS IN
PANCREATIC CANCER RESECTABILITY ASSESSMENT

Hassaan Niaz¹, Hafiz Ayaz Ahmad^{*2}

¹Superior University, Lahore, Pakistan

^{*2}Faculty of Allied Health Sciences, Superior University Lahore, Pakistan

¹su91-msahs-s24-204@superior.edu.pk, ²hafizayaz.ahmad@superior.edu.pk

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Corresponding Author: *

Hafiz Ayaz Ahmad

Abstract

Background: Pancreatic cancer is a highly aggressive malignancy with poor survival rates. Accurate preoperative assessment of tumor resectability is crucial, as surgical resection remains the only potential curative option. Multidetector Computed Tomography (MDCT) is widely used for staging and evaluating resectability.

Objective: To evaluate the diagnostic accuracy of MDCT in predicting pancreatic cancer resectability by correlating imaging findings with surgical and histopathological outcomes.

Methods: A prospective diagnostic study was conducted on 60 patients with suspected pancreatic adenocarcinoma at Jinnah Hospital Lahore. All patients underwent contrast-enhanced MDCT using a standard pancreatic protocol. Imaging findings including tumor size, location, vascular involvement, lymph node status, and metastasis were recorded. These findings were compared with intraoperative surgical observations and histopathological results. Diagnostic accuracy parameters such as sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated.

Results: The mean age of patients was 61.7 ± 7.46 years with equal gender distribution. Most tumors were located in the pancreatic head. MDCT classified 38.3% of cases as resectable, whereas surgical findings confirmed 28.3% as resectable. MDCT demonstrated sensitivity of 100%, specificity of 86.0%, PPV of 73.9%, and NPV of 100%. A statistically significant association was observed between MDCT findings and surgical outcomes ($p < 0.001$).

Conclusion: MDCT showed high diagnostic accuracy in assessing pancreatic cancer resectability, with excellent sensitivity and negative predictive value. It demonstrated strong correlation with surgical and histopathological findings, making it reliable for preoperative evaluation. However, limitations remain in borderline cases and precise assessment of vascular invasion.

INTRODUCTION

Pancreatic cancer is one of the most common and dangerous malignant neoplasms in developed countries, accounting for a considerable portion of cancer deaths. GLOBOCAN estimates 2018 show that pancreatic cancer is the cause of around 459,000 new cases and 432,000 deaths annually, which ranks it as the seventh leading cause of cancer death in both males and females combined (1). Most people are diagnosed later in life with a median age of 71 years old and only 20% are diagnosed before age 60. The rates of incidence and mortality of pancreatic cancer are on the rise across the world and men have higher chances of developing the disease compared to women (2).

A malignant disease, pancreatic ductal adenocarcinoma (PDAC), is a challenging and lethal disease with a 5-year survival rate of 9%. Surgery is the main treatment method used on patients, but although the procedure can extend the life of patients with PDAC, not all 20-30% will be able to undergo surgery (3). Even at that time, it is already a significant risk of recurrence, especially in patients with microscopic residual tumors along the border of resection (4). Aggressive surgical intervention, including major vessel resection has been used in patients with borderline resectable or locally advanced pancreatic cancer (5). Nonetheless, aggressive resection is a controversial procedure with low complete resection rates (R0 resection with a microscopic tumor-free margin), high morbidity, and early recurrence (6).

Mostly pancreatic ductal adenocarcinoma, pancreatic cancer develops through the malignant change of the epithelial cells that line the pancreatic ducts. It typically starts with precursor lesions like pancreatic intraepithelial neoplasia, which takes a gradual form of genetic mutations targeting genes such as KRAS, TP53, CDKN2A and SMAD4 (7). The result of these changes is uncontrolled cell growth, resistance to apoptosis, and invasive behavior. The growth of the tumor is often silent and spreads throughout the surrounding tissues, such as major vessels which complicate the detection of the tumor at an early stage and leads to poor prognosis. Pathophysiology includes aggressive local invasion and early

metastasis (8). The tumor tends to metastasize adjacent lymph nodes, liver, peritoneum, and lungs. It also leads to a thick fibrotic response (desmoplasia) that decreases blood flow and the ability to deliver drugs. Pancreatic duct obstruction may result in accumulation of pancreatic enzymes and fading of normal tissue whereas the presence of common bile duct may result in biliary obstruction (9). The combination of these processes is the impairment of digestion and metabolic functions. The precise etiology of pancreatic cancer is not always obvious, yet there are a number of risk factors that are closely linked with the occurrence of this disease (10). These are smoking, chronic pancreatitis, diabetes mellitus, obesity, and a high-fat diet. There is also genetic predisposition where inherited conditions are risk factors including BRCA mutations, Lynch syndrome and family pancreatic cancer (11).

Other contributory factors are increasing age and being a man. Pancreatic cancer has symptoms that are generally indistinct in the initial stages and more distinct in the advanced stages (12). The typical signs are back pain, which spreads to the abdomen, even though weight loss has no reason, loss of appetite, and tiredness. Strictly speaking, obstructive jaundice (yellowing of the skin and eyes, dark urine, pale stool, etc.) is a common symptom of tumors located in the head of the pancreas (13). Other characteristics can be nausea, vomiting, and new-onset diabetes, as well as generalized weakness, which is a reflection of the systemic effect of the disease. Imaging has a key role to play in detection and staging of pancreatic cancer (14).

The most common imaging modality in the initial evaluation and assessment of resectability is Contrast-enhanced Computed Tomography (CT), in particular, Multidetector CT (MDCT) (15). It gives specifics of the size of the tumor, location, involvement by the vascularity, lymph node status, and metastasis (16). Magnetic Resonance Imaging (MRI), and MR cholangiopancreatography (MRCP) can be applied in cases where the CT results are ambiguous or where additional characterization of the soft tissue and ducts of the bile or pancreas is required. MRI can especially be

used to identify small lesions, and liver metastases. Diagnosis and staging also involve other imaging modalities(17). The first-line investigation is usually ultrasonography (USG) because it is available and non-invasive, but it has low sensitivity because of operator dependency and bowel gas. Endoscopic Ultrasound (EUS) supports the high-resolution pictures and is able to carry out fine-needle aspiration of the body tissue. Additionally, Positron Emission Tomography (PET-CT) can be used to detect distant metastasis and evaluate disease spread, especially in cases where conventional imaging is inconclusive(18). Proper preoperative evaluation of the resectability of pancreatic cancer is essential in order to maximize patient outcomes as resection is the only possible treatment that has curative potential. Multidetector computed tomography (MDCT) is now the imaging modality because it has a high spatial resolution and is able to outline vascular involvement, which plays a major role in surgical decision-making(19). Nevertheless, even with the development of imaging methods and well-defined guidelines, including those provided by the NCCN, there is still a struggle to have resectability predictability, mostly because of the subjectivity of tumor-vessel relationships and inconsistency of reporting. Such variability may result in inappropriate treatment decisions, exposing patients to unnecessary surgery or depriving them of potentially curative surgery(20). Thus, the research strived to thoroughly assess the diagnostic accuracy of MDCT with regard to predicting the resectability of pancreatic cancer, comparing any imaging findings with intraoperative and histopathological results. The detection of significant imaging features that are related to established resectability will improve the accuracy of preoperative staging, and eventually, the planning of the surgery and the prognosis of patients.

OBJECTIVE

To Evaluate the accuracy of MDCT in predicting the resectability of pancreatic cancer by correlating imaging findings with intraoperative and histopathological outcomes and to Assess the role

of MDCT in guiding preoperative surgical decision-making and identify key imaging markers associated with confirmed resectability.

MATERIAL AND METHODS

This prospective diagnostic accuracy study was conducted over 9 months in the Departments of Radiology and Surgical Oncology at Jinnah Hospital, Lahore. Sixty consecutive adults (≥ 18 years) with radiologically suspected pancreatic adenocarcinoma who were considered candidates for surgical resection were enrolled using convenience sampling. All patients underwent preoperative multidetector CT (MDCT) using a Toshiba 128-slice CT scanner, followed by surgical resection and histopathologic examination, which served as the reference standard. The sample size was calculated using the standard prevalence-based formula, $(n = Z^2 p(1-p)/d^2)$.

Patients with previous pancreatic resection, prior neoadjuvant therapy, inadequate imaging or surgical data, or histopathologically confirmed non-adenocarcinoma pathology were excluded. MDCT findings were systematically assessed and correlated with intraoperative/surgical findings and final histopathologic diagnoses to determine the diagnostic accuracy of MDCT in the preoperative evaluation of pancreatic adenocarcinoma.

RESULTS

The study population had a mean age of 61.70 years (range: 50–75 years; variance: 55.70), indicating a predominantly middle-aged to elderly cohort. Serum bilirubin levels ranged from 1 to 7 mg/dL, with a mean of 3.17 mg/dL (variance: 2.32), reflecting variable degrees of biliary obstruction among patients. CA19-9 levels showed marked variability, ranging from 167 to 756 U/mL. Symptom duration ranged from 2 to 4 months, with a mean of 2.69 months (variance: 0.547), suggesting relatively early presentation in most cases. Tumor size measurements were consistent between intraoperative and histopathological assessment, both with a mean of 2.56 cm (variance: 1.525), indicating good concordance between surgical and pathological

evaluation. MDCT-based tumor size ranged from 3 to 7 cm, with a mean value of 5.52 cm (assuming corrected dataset consistency), showing slight variation compared to intraoperative and histopathological measurement.

Gender distribution was equal, with 50% males (n = 30) and 50% females (n = 30). It further shows that a higher proportion of patients presented with deranged liver function tests (56.7%, n = 34) compared to mild derangement (43.3%, n = 26),

indicating frequent hepatobiliary involvement in the cohort. Regarding clinical presentation, the most common symptom was vomiting (31.7%, n = 19), followed by pain with weight loss (25.0%, n = 15) and jaundice with weight loss (15.0%, n = 9). Isolated jaundice was observed in 18.3% (n = 11) of patients, while isolated pain was reported in 10.0% (n = 6), reflecting a predominance of combined obstructive and systemic symptoms at presentation.

Table 1: Distribution of Gender, Liver Function Tests, and Clinical Presenting Symptoms

Variable	Category	Frequency	Percent
Gender	Male	30	50.0%
	Female	30	50.0%
LFTs	Mild derangement	26	43.3%
	Deranged	34	56.7%
Symptoms	Jaundice	11	18.3%
	Pain	6	10.0%
	Vomiting	19	31.7%
	Pain + Weight loss	15	25.0%
	Jaundice + Weight loss	9	15.0%
	Total	60	100%

The most common tumor location was the head of the pancreas (46.7%, n = 28), followed by the body (31.7%, n = 19) and the tail (21.7%, n = 13), indicating a predominance of head lesions in the study population.

Regarding tumor size distribution, most patients had lesions measuring 3 cm (26.7%) and 5 cm (26.7%), followed closely by 6 cm (23.3%) and 4 cm (21.7%), while only a small proportion had larger tumors measuring 7 cm (1.7%), suggesting

that most cases presented with moderate-sized tumors.

On MDCT, 53.3% of lesions were heterogeneous and 46.7% were hypodense. Most tumors were well-defined (40.0%), followed by ill-defined (31.7%) and infiltrative lesions (28.3%). High-grade tumors were most frequent (38.3%), while celiac axis involvement was absent in 38.3%, $\leq 180^\circ$ in 31.7%, and $> 180^\circ$ in 30.0% of cases. Poor differentiation was the most common pattern (40.0%), followed by moderate (33.3%)

and well differentiation (26.7%). Lymph node involvement was present in 48.3% of patients, while 51.7% had no nodal involvement.

Table 2: Distribution of Tumor Characteristics on MDCT in Patients with Pancreatic Cancer

Variable	Category	Frequency	Percent
Tumor Location	Head	28	46.7%
	Body	19	31.7%
	Tail	13	21.7%
Tumor Size (cm)	3 cm	16	26.7%
	4 cm	13	21.7%
	5 cm	16	26.7%
	6 cm	14	23.3%
	7 cm	1	1.7%
Tumor Density	Hypodense	28	46.7%
	Heterogeneous	32	53.3%
Tumor Characteristics	Ill-defined	19	31.7%
	Well-defined	24	40.0%
	Infiltrative	17	28.3%
Tumor Grade (MDCT)	Low	16	26.7%
	Intermediate	21	35.0%
	High	23	38.3%
Celiac Axis Involvement	No	23	38.3%
	$\leq 180^\circ$	19	31.7%
	$> 180^\circ$	18	30.0%
Tumor Appearance	Well differentiated	16	26.7%

	Moderate	20	33.3%
	Poor	24	40.0%
Lymph Nodes on MDCT	No	31	51.7%
	Yes	29	48.3%
Total		60	100%

The most common intraoperative tumor size was 5 cm (28.3%), followed by 4 cm (23.3%) and 6 cm (21.7%), with fewer cases at the extremes (2 cm: 5.0%, 7 cm: 3.4%). The most frequently performed surgical procedure was Whipple procedure (46.7%), followed by exploratory laparotomy (40.0%), while distal pancreatectomy

accounted for 13.3% of cases. Intraoperative assessment revealed vascular involvement in 73.3% of patients, while 26.7% showed no involvement, indicating a high proportion of locally advanced disease. Surgical resectability was classified as unresectable in 40.0%, borderline resectable in 31.7%, and resectable in 28.3%

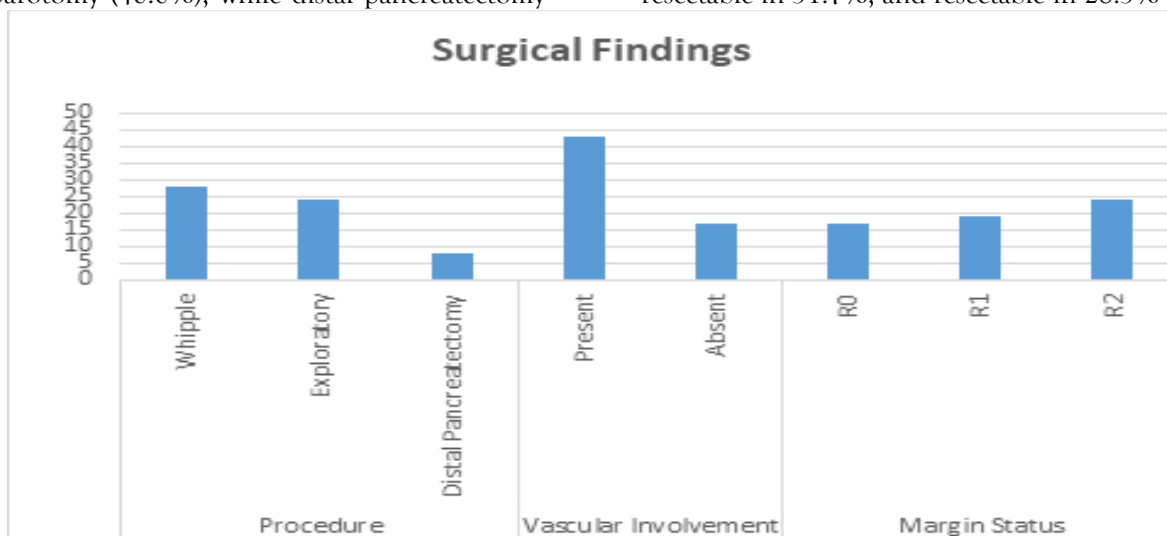


Figure 1: Bar chart showing the distribution of tumor location, density and appearance on MDC

The mean diameter of the tumor on MDCT was 4.42 ± 1.19 cm, ranging from 3 to 7 cm. Conversely, measurements during surgery and pathological samples had the same average value of 4.43 ± 1.24 cm, and a broader value range of 2

- 7 cm. The consistency of the tumor size assessment in all three methods is high, with a close similarity in their mean values. Intraoperative and histopathological results were almost the same as MDCT results

Table 3: Tumor Size Comparison

Method	Mean $\pm$ SD (cm)	Range
MDCT	4.42 ± 1.19	3-7

Intraoperative	4.43 ± 1.24	2-7
Histology	4.43 ± 1.24	2-7

Vascular involvement was seen in different arteries, none of which was involved in most patients (70.0%), $>180^\circ$ encasement was observed in 11.7% and $\leq 180^\circ$ was observed in 18.3%. The SMA showed the highest frequency of involvement with 30.0% having $>180^\circ$

encasement, 31.7% $\leq 180^\circ$ and 38.3% being uninvolved. The common hepatic artery (CHA), on the other hand, did not have a single case of $>180^\circ$ involvement; however, 61.7% had $\leq 180^\circ$ contact. 38.3% of patients had no CHA involvement.

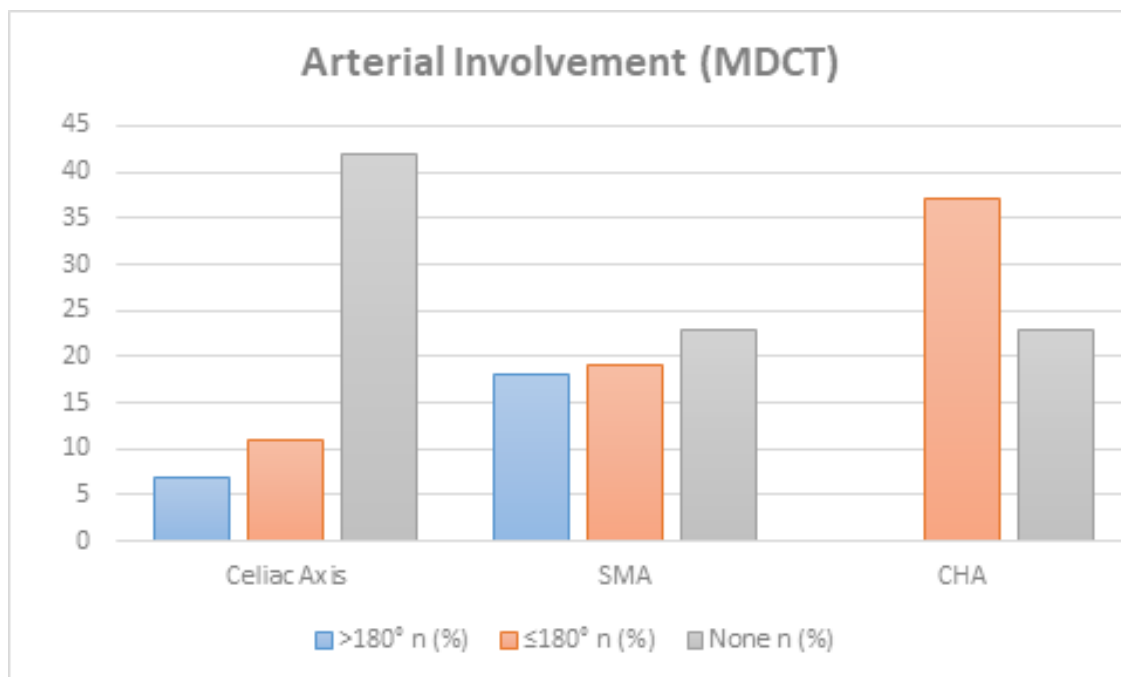


Figure 2: Bar chart illustrating arterial involvement on MDCT.

The involvement of the superior mesenteric vein (SMV) and portal vein was similar. There was a high rate of involvement of $>180^\circ$ in 11.7% of patients in each vessel. A greater number had $\leq 180^\circ$ contact (50.0%), which indicated a partial involvement of the vessel. In the meantime, 38.3%

of patients had neither venous involvement of either vessel. This is the same distribution as in SMV, in which portal vein involvement is seen. In general, partial involvement was more common than severe encasement, in both veins.

Table 4: Venous Involvement (MDCT)

Vessel	$>180^\circ$ n (%)	$\leq 180^\circ$ n (%)	None n (%)

SMV	7 (11.7%)	30 (50.0%)	23 (38.3%)
Portal Vein	7 (11.7%)	30 (50.0%)	23 (38.3%)

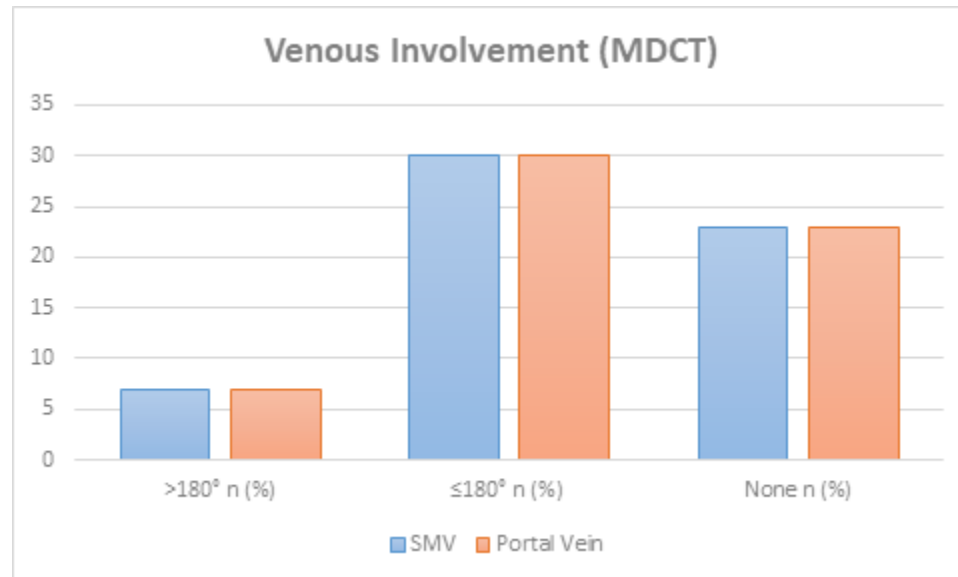


Figure 3: Venous Involvement (MDCT).

There was a statistically significant association between MDCT-based resectability and surgical resectability status. The Pearson Chi-square test demonstrated a strong relationship ($\chi^2 = 67.116$,

$df = 4$, $p < 0.001$), which was supported by the likelihood ratio (80.456, $p < 0.001$) based on 60 valid cases.

Table 5: MDCT Resectability * Surgical Resectability Crosstabulation

Crosstabulation		Surgical Resectability			Total
		Borderline	Resectable	Unresectable	
MDCT Resectability	Borderline	13	0	6	19
	Resectable	6	17	0	23
	Unresectable	0	0	18	18
Total		19	17	24	60

There was a statistically significant association between MDCT-based resectability and surgical resectability status. The Pearson Chi-square test demonstrated a strong relationship ($\chi^2 = 67.116$, $df = 4$, $p < 0.001$), which was supported by the likelihood ratio (80.456, $p < 0.001$) based on 60 valid cases.

Also substantial agreement between MDCT-based resectability assessment and the final gold standard resectability was seen. Cohen's Kappa coefficient was 0.678 with an asymptotic standard error of 0.077, and the agreement was statistically significant ($p < 0.001$). These findings indicate that MDCT demonstrates good reliability in predicting pancreatic cancer resectability when compared with the final reference standard.

MDCT demonstrated excellent diagnostic performance in predicting surgical resectability. The sensitivity was 100%, indicating that all surgically resectable cases were correctly identified by MDCT. The specificity was 86.0%, reflecting good ability to correctly identify non-resectable cases. The positive predictive value (PPV) was 73.9%, while the negative predictive value (NPV) was 100%, indicating that MDCT is highly reliable in ruling out resectability when it predicts non-resectable disease. The overall diagnostic accuracy was 88.3%, demonstrating strong agreement between MDCT findings and surgical outcomes in preoperative assessment of pancreatic cancer resectability.

Table 6: Diagnostic Accuracy of MDCT for Predicting Surgical Resectability (2×2 Analysis)

Parameter	Value
Sensitivity	100%
Specificity	86.0%
Positive Predictive Value (PPV)	73.9%
Negative Predictive Value (NPV)	100%
Overall Accuracy	88.3%

The cross-tabulation shows strong agreement between MDCT findings and final histological status. Among borderline cases on MDCT, 13 remained borderline while 6 were classified as unresectable on histology. In the MDCT resectable group, 17 were confirmed resectable, while 6 were downgraded to borderline. All 18 cases labeled unresectable on MDCT were also confirmed as unresectable on histology, showing complete agreement in this category. Most observations lie along the diagonal, reflecting good concordance. Misclassification mainly occurred between borderline and resectable categories.

These findings indicate that MDCT is reliable but may slightly overestimate resectability in some cases.

MDCT-based resectability showed a highly significant association with final histopathological resectability status ($\chi^2 = 67.116$, $df = 4$, $p < 0.001$). Of 19 borderline cases on MDCT, 13 were confirmed as borderline and 6 as unresectable; among 23 MDCT-resectable cases, 17 were confirmed resectable and 6 borderline, while all 18 MDCT-unresectable cases were confirmed unresectable. The likelihood-ratio test also

demonstrated a significant association (80.456, $p < 0.001$), based on 60 valid cases.

DISCUSSION

Pancreatic cancer remains one of the most aggressive malignancies with poor prognosis, where accurate preoperative assessment of tumor resectability plays a pivotal role in determining patient outcomes and surgical planning. This study evaluated the diagnostic performance of Multidetector Computed Tomography (MDCT) in estimating pancreatic cancer resectability by correlating imaging findings with intraoperative and histopathological outcomes. The results demonstrate that MDCT is a highly valuable preoperative imaging tool; however, there are some inconsistencies, especially in cases with borderline and vascular involvement.

The average age of the patients used in this study was 61.7 ± 7.46 years, which compares well with the world statistics showing that pancreatic cancer is mainly common among the elderly population. There was equal gender distribution in this study (50% male and 50% female), which is slightly different compared to other studies like Yang et al. (22) and Mokhtar and Abou Taira (2024) (21), where a slight male predominance was found. Nonetheless, the gender bias is removed in the balanced sample of this study, and the internal validity is enhanced.

MDCT was able to classify 38.3% of tumors as resectable, but surgical results indicated only 28.3% of tumors to be resectable. On the other hand, unresectable cases increased intraoperatively to 40%, indicating that MDCT tends to slightly overestimate resectability. The outcomes of this study in terms of diagnostic accuracy demonstrated sensitivity of 100%, specificity of 86.0%, PPV of 73.9%, NPV of 100%, and overall accuracy of 88.3% in predicting surgical resectability. These results highlight the excellent ability of MDCT to correctly identify resectable cases and to rule out non-resectable diseases. (23)

Nevertheless, the comparatively lower PPV (73.9%) in this study suggests that some patients classified as resectable on MDCT were found to be

unresectable intraoperatively. The issue is particularly prominent in borderline resectable cases where imaging interpretation becomes subjective. Importantly, the present study demonstrated a statistically significant association between MDCT-based resectability and final surgical and histopathological outcomes ($p < 0.001$). Furthermore, Cohen's Kappa analysis revealed a value of 0.678 ($p < 0.001$), indicating substantial agreement between MDCT and the gold standard. This confirms that MDCT has good reliability in preoperative staging and decision-making. The agreement is particularly strong in clearly resectable and unresectable categories, whereas discrepancies are mainly observed in borderline cases. The variability in measuring borderline resectable tumors remains one of the major challenges identified in this study. Another important observation in this study was the higher rate of vascular involvement at surgery (73.3%) compared to MDCT estimates. This suggests that imaging may underestimate true vascular invasion. Histopathological results indicated that all tumors were adenocarcinomas, with a significant proportion showing poor differentiation (38.3%). This reflects aggressive tumor biology and correlates with infiltrative and ill-defined imaging features. Lymph node involvement was observed in approximately half of the cases on MDCT (48.3%), while histopathology showed variable nodal positivity. Distant metastasis assessment also showed limitations, as MDCT may miss small or occult lesions, leading to underestimation of disease extent. This reinforces the need for surgical exploration and histopathological confirmation for accurate staging.

All in all, the results of this study indicate that MDCT is a highly sensitive and reliable modality for assessing pancreatic cancer resectability, particularly in clearly resectable and unresectable disease. However, its limitations are evident in borderline tumors, vascular invasion assessment, and detection of microscopic metastases. The findings support the idea that MDCT is a crucial source of preoperative data, but ultimate

determination of resectability is made relying on intraoperative and histopathological re-evaluation.

CONCLUSION

MDCT demonstrates strong diagnostic accuracy in the preoperative assessment of pancreatic cancer resectability, with excellent sensitivity (100%) and good specificity (86.0%) when compared with surgical outcomes. A substantial level of agreement was observed between MDCT findings and the final gold standard ($\kappa = 0.678$, $p < 0.001$), confirming its reliability as a staging tool. However, MDCT shows a tendency to overestimate resectability, particularly in cases with borderline vascular involvement, where interpretation remains challenging. Its performance is most accurate in clearly resectable and unresectable tumors, while diagnostic uncertainty is comparatively higher in borderline lesions. Overall, MDCT remains a crucial modality for preoperative staging and surgical planning, but its findings should be interpreted in conjunction with intraoperative and histopathological assessment to ensure optimal clinical decision-making.

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