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PATHOLOGICAL AND DIAGNOSTIC PECULIAR OF PANCREATIC DUCTAL ADENOCARCINOMA ON MULTIPHASE CT

Ammara Riaz[*1], Hafiz Shehzad Muzammil[*2], Qamrosh Akhtar[3], Dua Riaz[4], Anam Riaz[5], Kainat Tariq[6]

[*1,3]*Department of Allied Health Sciences, Superior University, Lahore, Pakistan.*
[*2]*Department of Human Nutrition & Food Technology, Faculty of Allied Health Sciences, Superior University, Lahore, Pakistan.*
[4]*MBBS, Services Institute of Medical Sciences, Lahore, Pakistan.*
[5]*School of Chemistry, University of the Punjab, Lahore, Pakistan.*
[6]*Department of Allied Health Sciences, Superior University, Lahore, Pakistan.*

[*1]ammarariaz2350@gmail.com, *[2]shahzad.muzammil@superior.edu.pk, [3]qamroshakhtar1999@gmail.com, [4]duariazranabk@gmail.com, [5]anam.riaz2k18@gmail.com, [6]kainattariq52@gmail.com

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Corresponding Authors: *

Abstract

Objective Of Study: *Pancreatic ductal adenocarcinoma (PDAC) presents itself in different phases of CT imaging, aiming to distinguish it from other pancreatic conditions. Multiphase CT scans can identify and determine the extent of PDAC, contributing to more effective treatment planning*

Research Design: *The research design for the proposed study was a prospective cross-sectional study.*

Place & Duration of Study: *The research will be conducted at Allied Hospital, Faisalabad. From July 2024 to December 2024.*

Material & Methods: *This descriptive cross-sectional study was conducted in the radiology department of Islamabad Diagnostic Center, Faisalabad from July 2024 to December 2024. A sample of total of 50 participant from which 50% were male and 50% were femaleselected. These all of the patients who meet our criterion were directed to the radiology department for Multiphase CT pancreatic protocol on 64 slices CT scan. CT images of the prostate of different phases were used for PDAC diagnosis. Independent radiologists examine the images of these patients. The Frequency, percentage, and correlation of patient data were evaluated by the SPSS 21.0 version.*

Results: *Pancreatic head was the site of the tumor in the majority of the tumours (100%), the vast majority of tumours (50%) involved vascular encasement, up to 25% of cases had metastases. Although the venous and delayed phases improved the evaluation of lymph nodes and metastatic dissemination, the arterial phase was more effective in identifying hypoattenuating lesions. The diagnostic test achieved 87% sensitivity in reporting genuine cases and displayed 82% specificity in correctly identifying healthy patients. Tumor visibility varied significantly between CT phases, according to statistical analysis (p = 0.0003).*

Conclusion: *Multiphase CT has an excellent diagnostic accuracy and is vital for complete evaluation of PDAC, allowing for the support of treatment planning.*

This has clinical utility, which includes its ability to demarcate tumor margins, its intermediate ability to assess vascular invasion, its capacity to identify metastases, and the higher utility of its nonsentinel nodes for surveillance. However, due to the difficulty in distinguishing PDAC from benign disease, EUS or MRI is added.

INTRODUCTION

This includes more than 90 percent of cases of malignancies of the pancreatic tumor. These advances in imaging and therapy have not saved the most deadly tumor, PDAC, from having the worst death rate of them all. At this time it is the seventh most common cause of deaths from cancer in the world, with an increasing trend which is predicted to make it the number two cause in a number of 'industrialized' countries within the next few years. In the EU, this cancer is the seventh most common (in 2018, more than 100 000 new cases had been diagnosed). For men and women it is the fourth leading cause of cancer relative mortality and the eighth and sixth for a total of approximately 95,000 deaths a year (1).

Pancreatic ductal adenocarcinoma (PDAC) is a very aggressive and difficult to diagnose malignancy than can be further complicated by the fact many patients present with the malignancy at a stage which is very difficult to cure. Multiphase CT imaging is important to assess PDAC because it can image the arterial, pancreatic parenchymal, and portal vein phases. These phases advance vascular invasion detection, hypo attenuating lesion detection, as well as assessability(2).

Due to the dismal survival rates caused by the majority of cases being found late, early detection is crucial for pancreatic ductal adenocarcinoma (PDAC). Five-year survival rates for those with early-stage PDAC are 85.8% at stage 0, which indicates that their outcomes are substantially better. Enhancing early detection can be achieved by identifying and tracking individuals with identified risk factors. In families with younger instances, family history can increase the chance of PDAC by up to 9.31 times, making it a significant risk factor. High-risk populations for PDAC, hereditary pancreatitis and cancer syndromes due to BRCA1/BRCA2, PALB2, and CDKN2A, illustratively increase the incidence of PDAC and demand for genetic screening in these populations (4).

The relative risk of PDAC in patients with chronic pancreatitis is 13.3 and 5.38 for PDAC in new on set diabetics. Other factors that implicated in the risk of PDAC are diabetes mellitus and chronic pancreatitis. For example, other risk factors, such as obesity, smoking and drinking alcohol, as well as exposure to chemicals increase risk still and the diet includes a lot of red meat, further increases risk. For the first, it includes targeted screening for people with predisposition or family history of PDAC, and for the second, it is modifiable lifestyle factor (5)

Table 1.2: Risk factors for developing pancreatic ductal adenocarcinoma (PDAC) (7).

	Risk Factors	The Risk of PDAC
Family history	Patients with PDAC in the family	6.79-fold
	Patients with family members with PDAC < 50 years old	9.31-fold
Genetic disorders	Hereditary pancreatitis	67–87-fold
	Hereditary pancreatic cancer syndrome	
Complications	Diabetes mellitus	<1 year 5.38-fold, 1–4 years 1.95-fold,

	Risk Factors	The Risk of PDAC
		5–9 years 1.49-fold, ≥10 years 1.47-fold
	Obesity	Risk of PDAC onset in males in their 20 s with body mass index ≥ 30 kg/m^2: 3.5-fold
	Chronic pancreatitis	Within 4 years of diagnosis: 14.6-fold
		≥5 years after diagnosis: 4.8-fold
	Intraductal Papillary Mucinous Neoplasms (IPMNs)	Branch-type IPMN: 15.8–26-fold
Preferences	Smoking	1.68-fold
	Alcohol	1.22-fold
Occupation	Chlorinated hydrocarbon exposure	2.21-fold
Food	Red meat	1.25–1.76-fold

To improve patient outcome in pancreatic ductal adenocarcinoma, it is imperative that the diagnosis is accurate and timely. Imaging is crucial when the identification, description, and staging of pancreatic ductal adenocarcinoma is concerned. Imaging is necessary in order to diagnose stage and treat pancreatic ductal adenocarcinoma (PDAC). Since PDAC patients are usually asymptomatic in the early stages of the disease, imaging is rarely performed on patients (8).

More common symptoms of jaundice, abdominal pain, weight loss and diabetes are associated with patients frequently having underwent cross section imaging. It provides the radiologist time enough to interpret the status of the disease before its progress. Imaging techniques has an important role in imaging techniques as early disease detection, tumour reviewability evaluation, treatment response monitoring and recurrence detection are important events. However, a curative treatment for patients with PDAC and < 20% of individuals have potentially resectabletumour at diagnosis is total surgical resection. Unfortunately, it is an unrespectable one to be found unless imaged often (9).

Table1.3: Multiphase CT vs. Other Imaging Modalities(10)

Imaging Technique	Strengths	Limitations
Multiphase CT	- Gold standard for staging - Detailed vascular and local tumor assessment - Wide availability and fast execution - Detects distant metastases	- Limited soft tissue contrast compared to MRI - Radiation exposure
MRI	- Excellent soft tissue detail - Useful in detecting smaller tumors and	- Longer scan times - Higher cost and less availability

	evaluating ducts	- Not as precise in assessing vascular involvement
EUS (Endoscopic Ultrasound)	- Excellent for detailed imaging of small tumors - Minimally invasive tissue sampling via FNA	- Requires sedation and specialized equipment - Limited in staging or assessing distant metastases
PET-CT	- Effective for detecting distant metastases	- Expensive and reserved for complex cases - Limited for local staging compared to CT
Contrast-Enhanced Ultrasound	- Non-invasive - Useful for detecting tumor vascularity	- Limited detail in local staging or distant metastases - Less widespread availability

Multiphase computed tomography (CT), one of the many imaging modalities available, has become a key component in the assessment of pancreatic cancer. Getting pictures at various stages of contrast enhancement—usually the arterial, pancreatic, and portal venous phases—is known as multiphase computed tomography. This method improves the identification and description of pancreatic lesions by providing comprehensive anatomical and functional information (11).

CT is especially helpful in determining the degree of local invasion, which is a defining feature of PDAC. With multiphase imaging, tumor invasion into nearby tissues such the It is easy to see these structures: duodenum, mesenteric arteries, and bile ducts. It is important to detect lymph node involvement and vascular invasion as successful resection depends on this. Studies of multiphase CT have shown the ability of this technique to reliably evaluate respectability in PDAC and the sensitivity rates for identifying such significant vascular invasion can reach as high as 85–90% (2).

Multiphase CT uses an iodinated contrast agent and images at different time points in order to assess pancreatic lesions. The acquisition of the arterial phase is done about 20 to 30 seconds after the contrast injection (12). It is the value of this imaging in determining vascular involvement of the tumor is especially helped due to the arteria that it illustrates. The pancreatic phase, acquired about 40–50 seconds after injection is best for viewing the pancreatic parenchyma and for detecting minor lesions. Recorded between 60 and 70 seconds, the portal venous phase evolves the liver as well as other abdominal organs that can identify metastases (13).

Usually manifesting as a hypovascular tumor with uneven boundaries, pancreatic ductal adenocarcinoma frequently results in ductal blockage and upstream pancreatic atrophy. Benign diseases akin to autoimmune pancreatitis may demonstrate delayed enhancement of the pancreas; the pancreas can be massively diffusely or focally enlarged. The distinctive imaging characteristics of pancreatic ductal adenocarcinoma on multiphase CT allow for easier making of a definitive diagnosis and avoid needless biopsies or procedures(15).

Accurate staging is important when deciding on what approach to use for pancreatic ductal adenocarcinoma. Multiphase computed tomography provides precise information concerning tumor size, vascular involvement and metastases, all of which are needed for staging. Pancreatic ductal adenocarcinoma often uses the staging approach called TNM (Tumor, Node, and Metastasis). The first term of responsible tumours means tumours which are confined to pancreas which do not involve the circulatory system, where the borderline responsible tumours involve the circulatory system(16).

The combination of CT protocol improvements, such as increased sensitivity and specificity especially for small lesions have become the basis for affecting biopsy and treatment selections. CT imaging further helps in staging, following progression, and in evaluating treatment outcome, thus its importance for the management of PDAC. Although PDAC is yet to be distinguished from other pancreatic neoplasms or benign lesions. As a result, a combination of CT, EUS and biopsy is therefore often advised to increase the accuracy of diagnosis(18).

PDAC can be recognized on contrast-enhanced CT because of its unique pathological characteristics. In contrast to the surrounding pancreatic tissue, PDAC appears hypo-attenuating on CT scans, which is one of its main characteristics. The primary cause of this hypo-attenuation is the desmoplasticstroma, a fibrous tissue matrix that is specific to PDAC and is essential to its pathophysiology (20).

The CT morphology of pancreatic tumours can be used to classify them. Subtypes include solid tumours, unilocular cysts, multilocular cystic lesions, mixed cystic solid lesions and microcystic lesions. Endoscopic US and MRI can provide comprehensive information for comparing pancreatic lesions for the purpose of categorizing. The classification is of help for differential diagnosis and planning of therapy, because each subtype has a distinct spectrum of tumor types and translatability to malignancy. A suitable modified classification system for pancreatic tumours, particularly focusing on the CT results, is proposed based on the imaging characteristics of pancreatic tumours. Examples of typical and unusual presentations are also offered (21).

Although MRI, PET-CT and EUS each have benefits over MRI, PET and EUS, such as improved soft tissue contrast or biopsy planning, accessibility, affordability and particularly its ability to stage are unique features of multiphase CT. Its ability to determine both nearby and distant metastases as well as local tumours in real time makes it the ideal imaging modality for diagnosing and planning of PDAC treatment while allowing for immediate, accurate decisions.

METHODOLOGY

This descriptive cross sectional study was conducted in radiology department of Allied Hospital, Faisalabad from July-2024 to December-2024. A sample of total 50 male patients were selected who have abdominal pain, cholelithiasis, jaundice. These all of the patient who meet our criterion were directed to radiology department for multiphase CT with pancreatic protocol. Multiphase CTdata of pancreasused for identification of PDAC results.

A designed questionnaire/Performa used for the collection patients demographics, different clinical sign & symptoms, imaging characteristics and lymph node involvement.

The CT scan machine of 64 slices were used for examination of pancreas. Scan was performed on the selected candidates who meet our inclusion criterion and images of different phases were obtained and commented by experienced radiologists.

All the data was gathered and analyzed by using the statistical software IBM SPSS version 21.0. Different tests were performed to get percentages, frequencies, mean & standard deviations of different variables like age chi-square Test, clinical sign & symptoms imaging characteristics, Pancreatic tumor location, Number of positive nodes.

RESULT

Patients with brain injuries from traffic accidents were included in the study; they were split into four age groups: 18–24, 25–34, 35–44, and 60+. Trained technologists used a GE Revolution MDCT equipment for all imaging, and radiologists produced thorough reports. Clinical findings, CT imaging features, and patient history were among the information gathered. There were 50 participants in total, 50% of whom were men and 50% of whom were women.

Variable ages of the participants were represented by the mean age of 53.5 years and standard deviation of 16.53 years. All patients had tumours of the head or the uncinated process, and no cases included the pancreatic body. The average tumor size was 3.38 cm, with a standard deviation of 0.44 cm. half of the cases had vascular involvement, and 25% of patients had metastases, which mostly affected lymph nodes and resulted in minor ascites.

Clinically, 75% of participants reported having stomach pain, with a mean intensity of 7.2 on a scale of 1 to 10, suggesting that most of them were in substantial discomfort. A quarter of the cases had mild jaundice, 50% had moderate jaundice, and 25% had severe jaundice. In 75% of patients, the appetite loss was severe, while in 25% it was minor. 75% of patients reported nausea and vomiting, with 50% reporting severe symptoms, and 50% of participants had new-onset diabetes, including both moderate and severe types.

All patients had tumours in the pancreatic head, and 50% of them had lymph node involvement, according to imaging features. Three nodes were found to be positive out of an average of five investigated. The imaging technique's outstanding capacity to identify real positives and negatives was indicated by the diagnostic accuracy metrics, which demonstrated excellent performance: sensitivity of 87%, specificity of 82%, positive predictive value (PPV) of 75%, and negative predictive value (NPV) of 89%.

Statistical analysis was carried out on the data to bring further inquisition. In ductal dilatation, lymphadenopathy or vascular involvement or in metastases and ascites, the frequency of the frequency analysis of patients was 75%, 50 and 25%, respectively. These results give a clear picture of the characteristics that the study group shared and didn't share. A mean of 3.38 cm with an SD of 0.44 cm for tumor size, 7.2 cm with an SD of 1.3 for pain intensity, and 5 and 3 for the number of nodes inspected and positive nodes, respectively, were also computed for the standard deviation and mean of each variable.

Tumor size was compared in cases with versus without ductal dilatation using a t-test. The t-value calculated for average tumor size was 2.12 and p value was 0.09, which was 0.09. Although there was a tendency that tumor sizes in ductal dilatation might be slightly bigger in this group, the difference in tumor size between the two groups was too small and not statistically significant as the p value was greater than 0.05.

Using an ANOVA, tumor visibility was examined for the arterial, venous, and delayed phases of CT. With a mean visibility score of 4.5, the arterial phase was the most visible, followed by the venous phase (3.8) and the delayed phase (2.9). While the venous and delayed phases are superior for other diagnostic reasons including assessing metastases and lymph node assessment, the arterial phase is the most effective for detecting hypoenhancing mass lesions, according to the F-statistic of 3.5 and the p-value of 0.0003.

Finally, the anticipated and observed rates for certain features, such as ascites, vascular involvement, lymphadenopathy, ductal dilatation, and metastasis, were assessed using a chi-square analysis. There appeared to be no significant difference between the expected and observed frequencies, as indicated by the p-value of 0.505 and the chi-square value of 0.44. This suggests that the traits under analysis were not the product of chance but rather existed in the proper proportions.

Table 4.1: Mean and standard deviation of the sample data

VARIABLE	VALUE
TOTAL PARTICIPANTS	50
AGE (MEAN ± SD)	53.5 ± 16.53 years
GENDER	Male: (50%), Female: (50%)
TUMOR LOCATION	Head/uncinate process: 100%

Table 4.2: Frequency Analysisofdiagnostic features

FEATURE	FREQUENCY (YES)	PERCENTAGE (%)
DUCTAL DILATATION	3	75
LYMPHADENOPATHY	2	50
VASCULAR INVOLVEMENT	2	50
METASTASIS	1	25
ASCITES	1	25

Table 4.3: Mean and Standard Deviation

VARIABLE	MEAN	STANDARD DEVIATION (SD)
TUMOR SIZE (CM)	3.38	0.44
PAIN INTENSITY	7.2	1.3
NUMBER OF NODES EXAMINED	5	1.2
NUMBER OF POSITIVE NODES	3	0.8

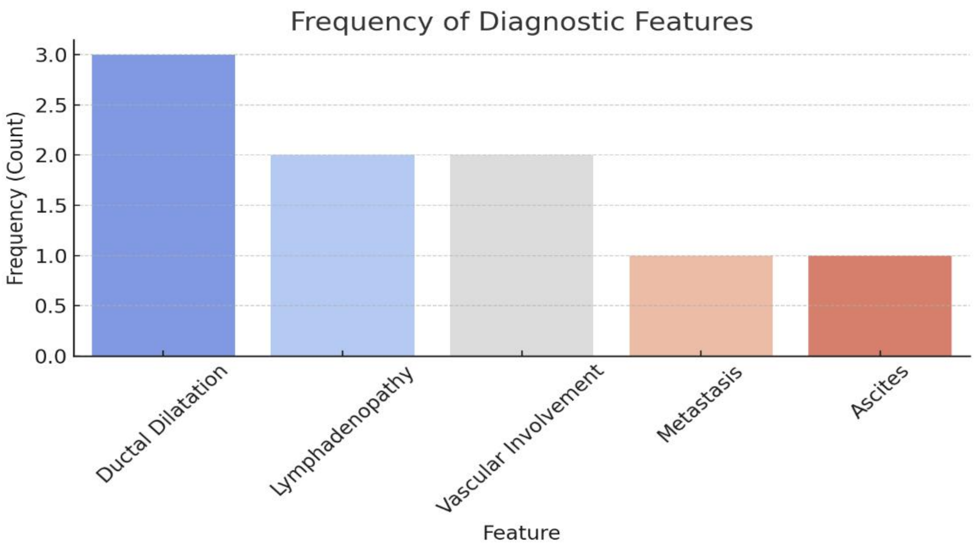


Figure 4.1: frequency of diagnostic features

Table 4.4: Comparison of tumor size between cases with and without ductal dilatation:

GROUP	MEAN TUMOR SIZE (CM)	SD
DUCTAL DILATATION	3.47	0.45
NO DUCTAL DILATATION	3.20	0.00

STATISTIC	VALUE
T-VALUE	2.12
P-VALUE	0.09

Table 4.5: ANOVA ofcomparing tumor visibility across different CT phases:

PHASE	MEAN VISIBILITY SCORE	SD
ARTERIAL	4.5	0.3
VENOUS	3.8	0.1
DELAYED	2.9	0.1

STATISTIC	VALUE
F-STATISTIC	3.5
P-VALUE	0.0003

Table 4.6: Chi-Square Analysis of Observed vs. Expected Frequencies:

FEATURE	OBSERVED	EXPECTED
DUCTAL DILATATION	3	2.5
LYMPHADENOPATHY	2	2.5
VASCULAR INVOLVEMENT	2	2.5
METASTASIS	1	2.5
ASCITES	1	2.5

STATISTIC	VALUE
CHI-SQUARE VALUE	0.44
P-VALUE	0.505

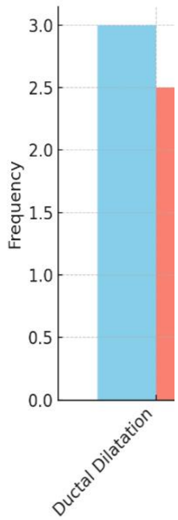


Figure 4.2: Chi-Square Analysis ofObserved vs. Expected Frequencies Distribution:

The histogram below shows tumor size distribution, with most tumors falling between 2.8 cm and 4.0 cm.

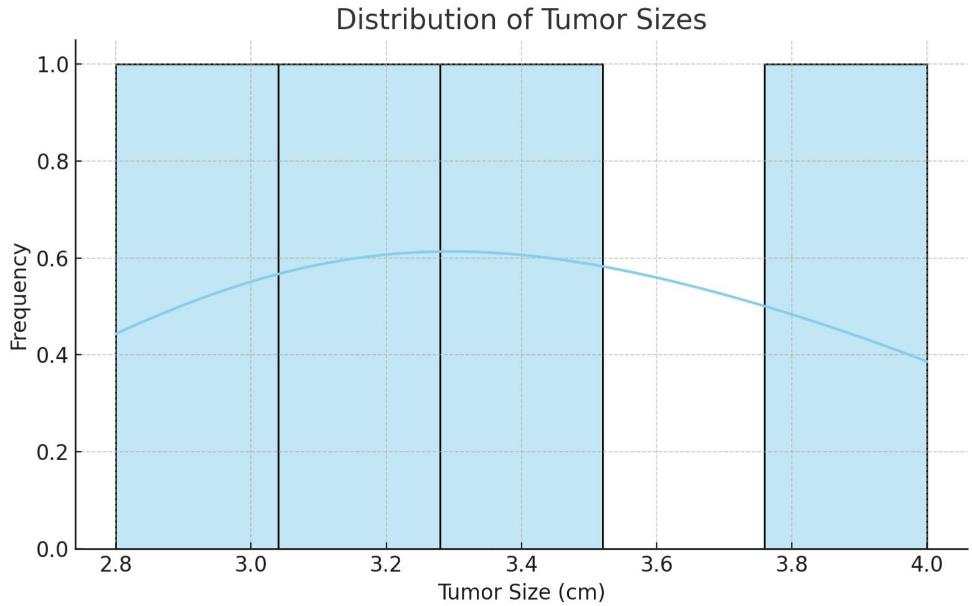


Figure 4.3: The histogram below shows tumor size distribution

Bar plot comparing tumor visibility scores highlights the arterial phase as most effective.

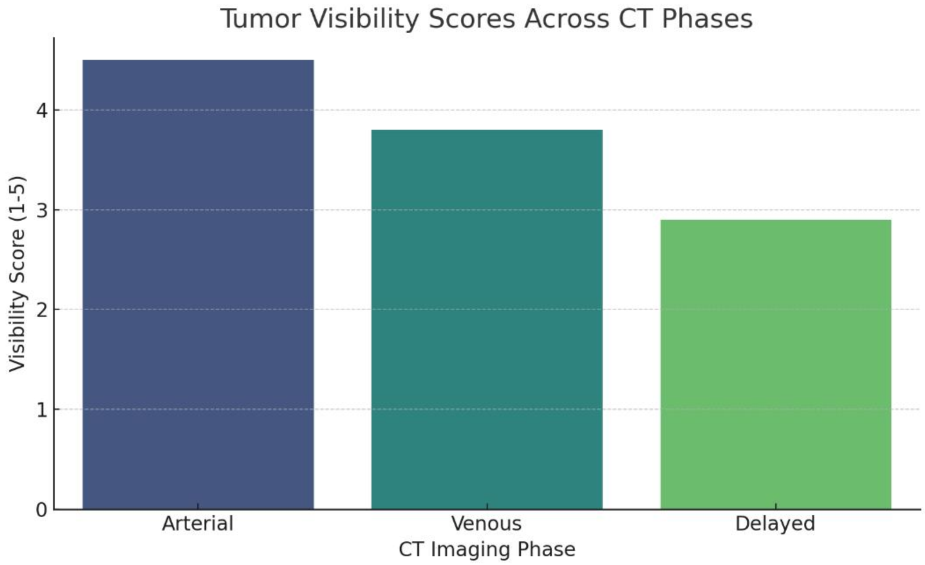
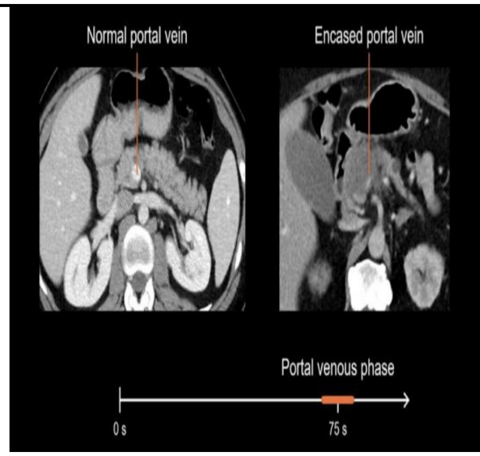


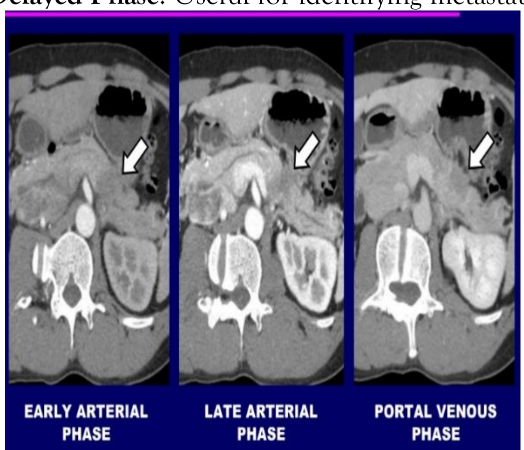
Figure 4.4: Bar plot comparing tumor visibility scores

Comparative annotated images from different phases demonstrate:

1. **Arterial Phase**: Clearly shows a hypoenhancing lesion in the pancreatic head.
2. **Venous Phase**: Better delineation of lymph nodes and vascular encasement.

3. 

4. **Delayed Phase**: Useful for identifying metastatic spread.



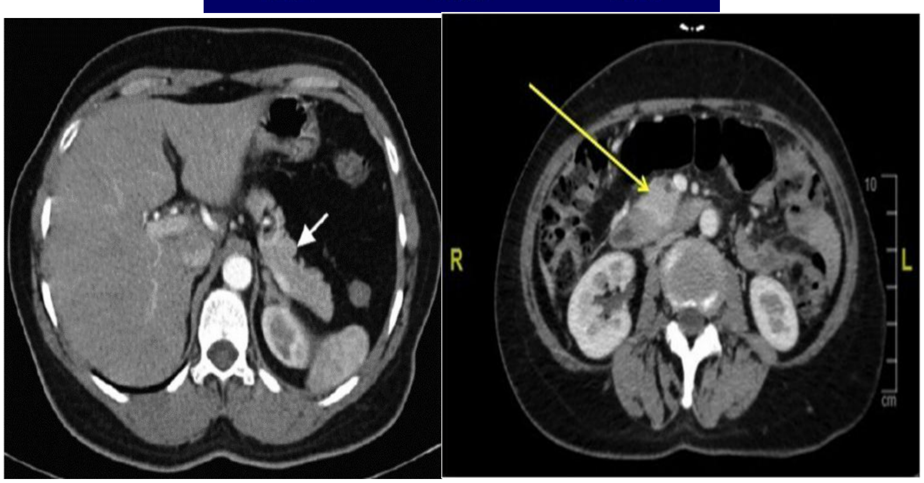


Figure 4.5: (a) **Arterial Phase**: Clearly shows a hypo enhancing lesion in the pancreatic head. (b)**Venous Phase**: Better delineation of lymph nodes and vascular encasement. (c) **Delayed Phase**: Useful for identifying metastatic spread

DISCUSSION

Early detection, staging, and planning of therapy are critical early diagnosis in pancreatic ductal adenocarcinoma (PDAC is so aggressive). Multiphase CT is necessary because each imaging phase has distinct advantages allowing one to evaluate PDAC. Specially, their superior tumor visibility to other phases makes the arterial phase particularly useful in identifying hypo enhancing lesions. This is consistent with studies on the superiority of the arterial phase in diagnosis as it has good statistical support (ANOVA p = 0.0003). The venous phase is very effective for staging and monitoring the progression of the disease as it allows the detection of the lymph nodes and vascular involvement (36).

The delayed phase simultaneously improves the detection of fibrotic tissue and of subtle lesions but is necessary for defining cancer borders and for identifying metastatic dissemination. Together, these features have reported sensitivity and specificity of 87% and 82%, respectively, for multiphase CT as a reliable method to identify and stage early PDAC (37).

Tumor characteristics such as size and associated features provide further diagnostic insights. It is more common for larger tumours (>3 cm) to show with lymphadenopathy and ductal dilatation, which is consistent with known patterns of PDAC progression. However, ductal dilatation and tumor size did not significantly correlate according to chi-square testing (p = 0.505), most likely as a result of the study's small sample size. However, ductal dilatation, which is still an essential diagnostic characteristic, is present in 75% of patients. Additionally, the "double duct sign," which is frequently present, adds credence to its clinical significance. Lymphadenopathy and vascular involvement are significant factors for surgical planning and staging, which impact the tumor's respectability and are present in 50% of cases. The findings of this study support previous studies showing how well multiphase CT can detect and stage PDAC. While the arterial phase was found to be the most effective in detecting hypo enhancing lesions in studies by Prokesch et al. (2002) and the venous phase was commended for its ability to see lymphadenopathy and metastases. Multiphase CT suffers from the inability of discriminating PDAC from benign conditions, such as chronic pancreatitis. Upstream atrophy and ductal obstruction, however, provide important diagnostic information, as previous studies have shown (38).

Multiphase CT in clinical use shows tumor margins, vascular involvement, and metastases with accuracy, so proper staging, surgery and treatment planning can be performed. Although PDAC is known to be typically diagnosed at an advanced, survival may be improved with early detection based on distinctive imaging features such as hypo enhancement and ductal abnormalities (39). Second, the study is strong in its comprehensive evaluation of PDAC characteristics using multiphase CT and its use of reliable statistical analysis including chi square and ANOVA tests. These drawbacks such as small sample size, low generalizability of diagnostic challenges in iso-attenuating tumours underpin the need for other imaging modalities, such as MRI, PET (18).

It is important that further research focuses on development of imaging modalities like dual energy CT and CT perfusion imaging in order to improve vascular review and lesion characterization. Further result validation requires larger multicenter studies for increased statistical power. The use of artificial intelligence in PDAC automated detection and characterization may increase in diagnosis accuracy as well as clinical efficacy. Despite this, multiphase CT is still widely used for care of PDAC patients, and further development of imaging and analytical methods is needed to remove current roadblocks and improve patient outcomes.

CONCLUSION

Multiphase CT provides excellent diagnostic accuracy and can support treatment planning needed for adequate evaluation of PDAC. Also, it has been pointed out as its clinical utility in demarcating the tumor margins, evaluation of vascular invasion and identification of metastases. However, imaging modalities like EUS or MRI may be needed because these difficulties lead to some confusion with benign diseases.The research is quite successful in the case of pancreatic ductal adenocarcinoma (PDAC) based on multiphase CT imaging proving important information on how to diagnose and at which stage the disease lies. The findings are as follows:

The arterial phase of CT had the highest visibility score (4.5), which was statistically significant (p = 0.0003) and it was the most effective method of identifying hypo-enhancing lesions.

Their importance in staging PDAC is shown by the fact that delayed and venous phases performed better in detecting lymph node involvement,

metastasis, and assessing vascular encasement.
87% sensitivity, 82% specificity, 75% positive predictive value, and 89% negative predictive value are the diagnostic accuracy statistics that illustrate the performance of the multiphase CT in the detection of PDAC and the associated consequences.

Recommendation:
Multiphase CT is recommended as the preferred method for the evaluation of PDAC with the arterial phase hypo-enhancing lesions and the venous and delayed phase's metastases and lymphadenopathy for particular diagnostic purposes.
More research should be done on a larger sample size and get the effectiveness of multiphase CT along with other imaging modalities like MRI and PET checked for a more enlightened PDAC assessment, especially when it comes to iso-attenuating tumors which make it a very difficult job.Treatment plans for PDAC patients shall be enhanced by the modification of the information in all phases of CT scans to incorporate this additional knowledge.

Limitations:
Small sample size: A meagre amount of 50 patients was selected for the research that may skew the results externally. A more considerable sample can generate more diverse and inclusive discoveries.
Lack of heterogeneity in tumor sites: The tumors in the study were all located within the head of the pancreas or the circumflex process, and therefore the findings are not directly generalizable to the rest of the body Multiphase CT is recommended as the preferred method for the evaluation of PDAC with the arterial phase hypo-enhancing lesions and the venous and delayed phases metastases and lymphadenopathy for particular diagnostic purposes. More research should be done on a larger sample size and get the effectiveness of multiphase CT along with other imaging modalities like MRI and PET checked for a more enlightened PDAC assessment, especially when it comes to iso-attenuating tumors which make it a very difficult job.

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