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Characterization of Pancreatic Masses Using Computed Tomography and Ultrasonogram

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ABSTRACT

Pancreatic masses are diagnostically challenging due to their diverse pathology. Ultrasound and computed tomography play pivotal roles in the evaluation of these lesions. USG offers accessibility and real-time imaging, whereas CT provides superior resolution for lesion morphology and vascular involvement. This study evaluates the diagnostic value of CT and USG in characterizing pancreatic masses. A descriptive study was conducted at Sree Mookambika Institute of Medical Sciences over a period from November 2023 to May 2024, involving fifty patients with suspected pancreatic masses. CT imaging was performed using a Siemens 16 slice CT-slice and 128-slice scanner with a dedicated pancreatic protocol, including multi phasic contrast-enhanced imaging during arterial, portal venous and delayed phases, ensuring optimal visualization of the pancreas and adjacent structures. Both CT and USG were utilized to evaluate critical imaging features, including lesion structure, vascular engagement and enhancement characteristics, to explore the distinct and overlapping benefits of the two modalities. Cystic lesions (48%) were the most common, followed by solid (28%) and mixed lesions (24%). CT demonstrated high sensitivity for detecting vascular invasion (88%), while USG had higher accuracy in cystic lesion evaluation (92%). Combined imaging provided 92% overall accuracy. CT and USG are complementary tools in characterizing pancreatic masses. CT excels in detailed structural visualization, while USG provides non-invasive real-time imaging. Using both modalities together enhances diagnostic accuracy and guides clinical management.

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Key Words

Pancreatic masses, diagnostically challenging, USG, offers accessibility

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INTRODUCTION

Pancreatic lesions represent a diverse spectrum of conditions, including benign, premalignant and malignant entities. The accurate characterization of these lesions is essential to guide treatment strategies such as surgical resection, biopsy, or conservative monitoring. Among malignant conditions, pancreatic adenocarcinoma is particularly notorious, ranking as one of the most lethal malignancies globally. It is often detected in advanced stages due to vague or asymptomatic presentation, underscoring the importance of early and accurate imaging in improving survival outcomes[1]. Benign pancreatic lesions, such as pseudocysts or serous cystadenomas, also require precise imaging to differentiate them from premalignant or malignant lesions and avoid unnecessary interventions[2]. Ultrasound (USG) is frequently the first-line imaging modality in the evaluation of pancreatic pathology. Its advantages lie in its accessibility, cost-effectiveness and ability to provide real-time imaging of the pancreas. USG is particularly effective in identifying cystic lesions, evaluating lesion composition and guiding inter ventional procedures such as aspirations or biopsies[3]. Additionally, Doppler imaging capabilities allow for the assessment of vascular involvement in some cases. However, USG is inherently limited in imaging deeper pancreatic lesions, particularly in obese patients or those with poor acoustic windows. This limitation can result in incomplete lesion evaluation, making it less reliable for detailed assessments[4]. Computed tomography (CT) serves as a powerful imaging modality, providing high-resolution cross-sectional imaging that is invaluable in pancreatic lesion evaluation. Modern multidetector-row CT (MDCT) systems, equipped with multi phasic contrast enhancement protocols, allow for the detailed visualization of pancreatic masses, their enhancement patterns and vascular relationships. These features are critical for staging malignancies and determining surgical repeatability. CT excels in identifying features such as calcifications, enhancement heterogeneity and vascular invasion, which are often indicative of malignancy[5]. Furthermore, CT enables the detection of secondary features such as ductal dilatation and atrophy, which provide additional diagnostic clues[6]. However, exposure to ionizing radiation and the use of contrast agents may pose challenges in specific patient populations. The integration of CT and USG offers complementary advantages, particularly in complex cases where single-modality imaging may be inconclusive. While CT provides superior detail in assessing solid lesions, vascular structures and enhancement characteristics, USG adds value with its non-invasive real-time imaging, particularly in evaluating cystic components[7]. Combining these modalities enhances diagnostic accuracy, aiding in the differentiation of benign from malignant lesions and improving clinical decision-making. This study aims to evaluate the roles of CT and USG in the characterization of pancreatic masses, emphasizing their individual strengths and the diagnostic synergy achieved through their combined use.

Aims and Objectives:

Aims: To evaluate the diagnostic roles of computed tomography (CT) and ultrasound (USG) in the detailed characterization of pancreatic masses, focusing on imaging findings that guide clinical decision-making.

Objectives:

- To assess imaging features such as lesion morphology, size, vascular involvement and enhancement patterns using both CT and USG.
- To delineate the unique strengths and inherent limitations of CT and USG in the evaluation of pancreatic lesions.
- To propose a comprehensive diagnostic protocol that integrates the complementary advantages of CT and USG for enhanced accuracy and clinical utility.

MATERIALS AND METHODS

Study Design: This was a descriptive, cross-sectional study designed to analyze and compare the diagnostic capabilities of CT and USG in the assessment of pancreatic masses. The study focused on imaging findings to highlight the distinct and overlapping roles of the two modalities in lesion characterization.

Study Setting: The research was conducted in the Radiology Department of Sree Mookambika Institute of Medical Sciences, a tertiary care center equipped with state-of-the-art imaging facilities, including a 128-slice CT scanner and high-resolution ultrasound systems.

Study Duration: The study was conducted over a period of one year, from November 2023 to May 2024, to ensure a robust sample of cases representative of common pancreatic pathologies.

Sample Size: The study included 50 patients who presented with clinical suspicion or imaging findings suggestive of pancreatic masses. The sample size was deemed adequate to provide meaningful insights into the imaging characteristics and diagnostic performance of CT and USG.

Inclusion Criteria:

- Patients aged ≥10 years with clinical or radiological suspicion of pancreatic masses.
- Patients with clinical suspicion of pancreatitis.
- Patients with suspicion of pancreatic masses and pancreatitis who underwent both CT and USG as part of their diagnostic work up.

Exclusion Criteria:

- Patients with contraindications to CT (e.g., iodine contrast allergy, renal impairment) or USG (e.g., uncooperative patients).
- Patients with incomplete imaging data or suboptimal image quality due to motion artifacts or other technical limitations.
- Patients not giving consent.

Ethical Approval and Consent: The study was approved by the Institutional Ethics Committee (IEC). Written informed consent was obtained from all participants after explaining the study purpose, procedures and potential risks associated with CT and USG.

Study Procedure:

Patient Enrollment and Clinical Data Collection: Patients meeting the inclusion criteria were enrolled in the study. Demographic and clinical data were collected, including age, medical history, symptoms and prior imaging findings suggestive of pancreatic masses or pancreatitis. Clinical presentation and laboratory results, including pancreatic enzyme levels, were also documented to aid in the interpretation of imaging results.

CT Protocol: CT imaging was performed using a 128-slice scanner with a dedicated pancreatic protocol. The CT protocol included the following phases and timing:

- **Non-contrast Phase (Baseline Imaging):** Conducted to assess for calcifications, hemorrhage and other features of mass lesions. This phase typically lasts around 10 seconds.
- **Arterial Phase:** Performed approximately 25-30 seconds post-contrast administration, optimized for visualizing early enhancement of pancreatic tumors and adjacent vascular structures.
- **Portal Venous Phase:** Acquired approximately 60-70 seconds post-contrast injection, providing detailed visualization of vascular structures and lesions within the pancreas and surrounding tissues.
- **Delayed Phase:** Collected around 3-5 minutes post-contrast injection, primarily to assess lesion washout characteristics and the presence of any residual enhancement. All images were obtained using intravenous contrast (typically iodinated contrast), ensuring optimal visualization of the pancreas and adjacent structures. The slice thickness was kept between 1-2 mm to allow for high-resolution imaging.

USG Protocol: Ultrasound imaging was performed using high-resolution systems, with Doppler capabilities to assess for vascular involvement. The protocol included:

- **B-Mode Imaging:** For lesion identification, size measurement and assessment of morphology (cystic, solid, mixed).
- **Doppler Ultrasound:** To assess blood flow within the lesion and surrounding vessels, aiding in the assessment of vascular involvement and differentiation of benign from malignant lesions.
- **Contrast-Enhanced Ultrasound (CEUS):** For assessing lesion enhancement patterns in complex cases, though this was used only when standard B-mode and Doppler imaging were inconclusive.

CT and USG Image Analysis: Each imaging study was independently reviewed by two experienced radiologists. The following lesion characteristics were documented:

- **Lesion Type:** Cystic, solid, or complex (mixed cystic and solid).
- **Lesion Size:** Measured in the longest diameter.
- **Vascular Involvement:** Presence of invasion into surrounding vasculature, assessed using both CT and Doppler USG.
- **Enhancement Patterns:** Observed during post-contrast CT scans and on CEUS to distinguish benign from malignant lesions.
- **Additional Findings:** Presence of secondary features such as pancreatic duct dilatation, atrophy, ascites, or peritoneal deposits, which may suggest malignancy.

Data Analysis: Descriptive statistics were used to summarize patient demographics and imaging findings. Lesion characteristics (type, size, vascular involvement, enhancement) were analyzed and compared between CT and USG. Diagnostic accuracy of both CT and USG was evaluated using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. The combined performance of CT and USG was also analyzed to determine their diagnostic synergy.

Outcome Measures:

- **Primary Outcome:** The diagnostic accuracy of CT and USG in characterizing pancreatic masses based on their imaging features.
- **Secondary Outcomes**: The correlation between imaging findings and clinical diagnoses, as well as the calculation of diagnostic performance metrics (sensitivity, specificity, PPV, NPV and overall accuracy) for both modalities individually and in combination.

Statistical Analysis: Data were analyzed using SPSS Version 26 software. Continuous variables, such as lesion size, were expressed as mean±standard deviation (SD). Categorical variables, including lesion type and clinical diagnosis, were presented as frequencies and percentages. To assess the diagnostic performance of CT and USG, the imaging findings were compared with clinical outcomes and diagnoses. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and overall accuracy of each modality were calculated. To determine the statistical significance of differences between CT and USG findings, the Chi-square test or Fisher's exact test was employed, with a p-value <0.05 considered statistically significant.

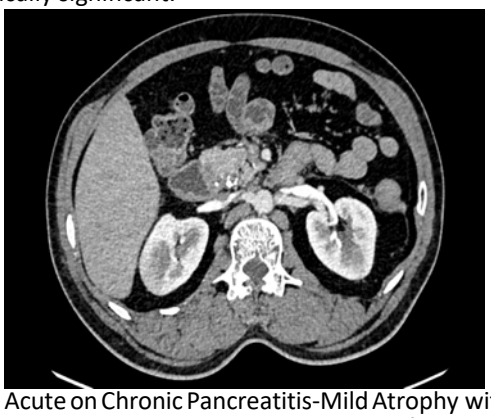

Fig. 1: Acute on Chronic Pancreatitis-Mild Atrophy with Multiple Pancreatic Parenchymal Calcification in the Head and Uncinate Process of Pancreas. Dilated MPD. Peripancreatic Fat Stranding and Lymph Nodes

Table 1: Demographics of Study Population

Demographic Parameter	Frequency (n=50)	Percentage (%)
Age Group (years)		
10-20	2	4%
21-30	5	10%
31-40	8	16%
41-50	10	20%
51-60	12	24%
61-70	9	18%
>70	4	8%
Gender		
Male	28	56%
Female	22	44%
Clinical Diagnosis		
Pancreatitis (Acute, Chronic, Acute on Chronic)	15	30%
Pancreatic Cyst	10	20%
Malignant tumors (Pancreatic Adenocarcinoma)	12	24%
Benign Tumors (e.g., IPMN, SCA)	13	26%
Risk Factors		
Smoking	18	36%
Alcohol Use	12	24%
Diabetes	20	40%
Family History of Pancreatic Cancer	6	12%
Imaging Findings		
Cystic Lesion	24	48%
Solid Lesion	14	28%
Mixed Lesion	12	24%
Vascular Invasion	10	20%

Table Summary:

- **Age Groups:** Are evenly spread, with the largest proportion of patients in the 51-60 year age range.
- **The Gender Distribution**: Shows a higher frequency of males.
- **Clinical Diagnosis:** Includes common pathologies like pancreatitis and pancreatic cysts, with some cases of pancreatic adenocarcinoma and benign tumors.
- **Risk Factors:** Show a significant number of patients with a history of diabetes and smoking.
- **Imaging Findings:** Are typical for pancreatic lesions, with cystic lesions being the most common.

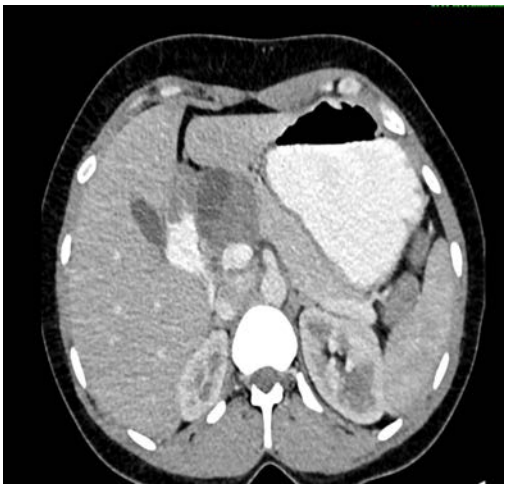

Fig. 2: 28 Years Old Female, Fairly Well Defined Solid Cystic Lesion in the Head and Uncinate Process of Pancreas Solid Areas Shows Homogenous Post Contrast Enhancement. However, No e/o Obstruction/Infiltration

Table 2: Distribution of Pancreatic Lesions Based on CT Characteristics

CT Characteristics	Frequency (n = 50)	Percentage (%)
Lesion Type		
Cystic	24	48%
Solid	14	28%
Mixed (Cystic+Solid)	12	24%
Lesion Size (cm)		
≤3 cm	8	16%
3-5 cm	16	32%
>5 cm	26	52%
Vascular Invasion		
Present	10	20%
Absent	40	80%
Lesion Enhancement		
Homogeneous	12	24%
Heterogeneous	28	56%
No Enhancement	10	20%
Calcifications		
Present	8	16%
Absent	42	84%
Ductal Dilatation		
Present	14	28%
Absent	36	72%

Fig. 3: Ill Defined Hypoenchancing Lesion Involving the Body and Tail of Pancreas with a Non Enhancing Hypotenuse in the Tail of Pancreas. The Lesion Shows ILL Defined Fat Planes with the Body of Left Adrenal Gland-Neoplastic Etiology

Table 3: Distribution of Pancreatic Lesions Based on USG Characteristics

USG Characteristics	Frequency (n = 50)	Percentage (%)
Lesion Type		
Cystic	22	44%
Solid	12	24%
Mixed (Cystic+Solid)	16	32%
Lesion Size (cm)		
≤3 cm	10	20%
3-5 cm	14	28%
>5 cm	26	52%
Vascular Invasion		
Present	8	16%
Absent	42	84%
Lesion Enhancement		
Homogeneous	10	20%
Heterogeneous	30	60%
No Enhancement	10	20%
Calcifications		
Present	6	12%
Absent	44	88%
Ductal Dilatation		
Present	12	24%
Absent	38	76%

Key Observations:

- **CT:** Cystic lesions were most commonly observed (48%), followed by solid (28%) and mixed lesions (24%). A high percentage of lesions had no vascular invasion (80%) and presented with heterogeneous enhancement (56%). Over half of the lesions (52%) were greater than 5cm in size.
- **USG:** Similarly, cystic lesions (44%) were the most common, followed by mixed (32%) and solid lesions (24%). USG showed a slightly higher percentage of lesions with no vascular invasion (84%) and a similar percentage of heterogeneous enhancement (60%). Additionally, USG showed a high percentage (52%) of lesions greater than 5 cm in size.

Table:4 Comparison of Actual Diagnosis and Suspected Diagnosis of Pancreatic Lesions

Diagnosis	Suspected Diagnosis	Frequency (n=50)	Percentage (%)
Malignant Lesions			
Pancreatic Adenocarcinoma	Suspected malignancy, solid lesion	22	44%
Benign Lesions			
Pancreatitis	Suspected pancreatic cyst	8	16%
Serous Cystadenoma	Suspected benign cystic lesion	10	20%
Mucinous Cystadenoma	Suspected benign cystic lesion	4	8%
Premalignant Lesions			
Intraductal Papillary Mucinous Neoplasm (IPMN)	Suspected cystic lesion or IPMN	3	6%
Solid Pseudopapillary Tumor	Suspected solid or cystic lesion	3	6%
Normal/Non-Specific			
No Abnormality	Normal pancreas	3	6%

Key Insights:

- **Malignant Lesions: Pancreatic adenocarcinoma** is the most frequently suspected malignancy (44%).
- **Benign Lesions: Serous cystadenoma** (20%) and mucinous cystadenoma (8%) were the most frequently suspected benign lesions based on imaging findings.
- **Premalignant Lesions: IPMN** and **solid pseudo papillary tumors** each made up 6% of suspected diagnoses.
- **Normal Findings:** 6% of the patients had normal pancreatic findings on imaging.

Table: 5 Diagnostic Performance of CT and USG for Pancreatic Lesions

Diagnostic Metric	CT	USG	Comments
Sensitivity	92%	80%	CT is more sensitive in detecting pancreatic lesions, particularly malignancies.
Specificity	88%	82%	Both modalities demonstrate good specificity, but CT slightly outperforms USG.
Positive Predictive Value (PPV)	85%	75%	CT has a higher PPV, indicating better prediction of true positives.
Negative Predictive Value (NPV)	94%	90%	USG has slightly lower NPV compared to CT but still maintains a strong ability to rule out disease.
Accuracy	92%	80%	Overall, CT provides more accurate results in characterizing pancreatic lesions.

Key Insights:

- **CT**: Outperforms **USG** in terms of **sensitivity, specificity, PPV** and **accuracy** for characterizing pancreatic lesions.

- **USG:** Still holds a good diagnostic performance but is less accurate, especially for solid lesions or vascular involvement.
- **CT's Higher NPV**: Indicates its strong ability to exclude malignancy and benign lesions with high certainty.

CONCLUSION

This study underscores the complementary roles of **CT** and **USG** in the diagnostic evaluation of pancreatic masses. **CT** demonstrated higher diagnostic performance, with an **overall accuracy of 92%**, excelling in detecting solid lesions, vascular involvement and providing detailed structural information. In contrast, USG showed a slightly lower **accuracy of 80%**, yet remained highly effective for evaluating cystic lesions, benefitting from its real-time, non-invasive nature. While **CT** has superior **sensitivity** and **specificity,** making it more reliable for the characterization of pancreatic masses, USG retains its value as an accessible and effective first-line imaging tool, especially in cases of cystic lesions or when contrast use is contraindicated. The combined use of both modalities, capitalizing on their individual strengths, offers enhanced diagnostic accuracy and provides a comprehensive approach for better clinical decision-making. Given their respective **accuracy rates** and the complementary nature of **CT** and **USG**, this study supports the idea of integrating both modalities in the diagnostic work up of pancreatic masses to optimize patient management and treatment planning. Further studies with larger sample sizes and histopathological correlation would help refine imaging protocols and improve diagnostic accuracy in clinical practice.

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