Section: Radiodiagnosis

Original Research Article

DIAGNOSTIC UTILITY OF DUAL-ENERGY COMPUTED TOMOGRAPHY IN THE EVALUATION OF PANCREATIC PATHOLOGIES

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ABSTRACT

Background: Pancreatic diseases, such as chronic pancreatitis and pancreatic cancer, pose diagnostic challenges due to their subtle progression and complex pathology. Conventional CT imaging often lacks the precision necessary for early detection. Dual-energy computed tomography (DECT), with its enhanced contrast-to-noise ratio (CNR) and ability to perform iodine mapping, offers potential for improved diagnostic accuracy in pancreatic pathologies.

Materials and Methods: This cross-sectional observational study included 42 patients with known or suspected pancreatic lesions at the Department of Radiodiagnosis, A.J. Institute of Medical Sciences, Mangalore. Patients underwent DECT scans using the Siemens SOMATOM go Top system. Post processing monoenergetic images were acquired at 50 keV and 60 keV and compared with conventional 120 kVp images with respect of image quality and confidence in detecting pancreatic lesion by calculating Contrast to Noise ratio [CNR].

Results: Out of 42 patients, 79% had abnormal pancreatic findings, with chronic calcific pancreatitis being the most prevalent (23.8%). The mean DECT value at 50 and 60 keV in patients with suspected pancreatic lesions in this study found to be 0.54 ± 0.36 and 0.46 ± 0.32 (Mean ± SD) respectively. The mean Conventional CT value at 120 keV in patients with suspected pancreatic lesions in this study found to be 0.31± 0.26(Mean ± SD). DECT at 50 keV showed significantly higher CNR compared to conventional CT at 120 keV ($p < 0.001$). DECT exhibited high sensitivity (90.9%) and specificity (88.8%) for detecting pancreatic lesions.

Conclusion: DECT provides enhanced diagnostic accuracy compared to conventional CT, particularly lower kiloelectron volt monochromatic energy images. This improvement has the potential to reduce morbidity and mortality associated with pancreatic diseases.

Keywords: Chronic pancreatitis, contrast-to-noise ratio, dual-energy CT, iodine mapping, pancreatic lesions, ROC analysis.

INTRODUCTION

The pancreas, a retroperitoneal gland with both endocrine and exocrine functions, is vital in digestion and metabolic regulation. Due to its deep location in the upper abdomen, physical examination of the pancreas is challenging, often allowing disorders such as diabetes, cystic fibrosis, pancreatitis, and pancreatic cancer to progress unnoticed over long periods of time.[1] Pancreatic diseases, particularly acute pancreatitis (AP), chronic pancreatitis (CP), and pancreatic cancer, have a significant global health impact. The incidence rates of AP, CP, and pancreatic cancer are 33.7, 9.6, and 8.1 per 100,000 person-years, respectively.[2] In the United States, the financial burden of AP alone is substantial, with the average

cost of an AP hospital admission around $9,870, and the total annual healthcare cost exceeding $2.2 billion. These diseases also dramatically reduce the quality of life, with AP, CP, and pancreatic cancer contributing to a loss of 11%, 23%, and 98%, respectively.[3] Additionally, many patients with these conditions develop metabolic complications such as diabetes of the exocrine pancreas (DEP) and exocrine pancreatic dysfunction (EPD), further complicating disease management.

Despite advancements in imaging technologies, diagnosing pancreatic pathologies early remains challenging due to their subtle and complex pathophysiological development.[4] Traditional imaging methods, including computed tomography (CT), primarily provide qualitative or semi-quantitative information, making precise diagnosis difficult. Dual-energy computed tomography (DECT), which was first conceptualized in the 1970s, has become clinically viable due to technological advancements that have overcome earlier limitations like scan duration and image resolution.[5,6] DECT employs two distinct energy levels (low: 80-100 kVp, high: 140 kVp) to provide enhanced imaging capabilities, allowing for the quantification of iodine concentration (IC) and other parameters, which helps in better tissue characterization and lesion detection.[4,7] The ability of DECT to generate iodine overlay maps and virtual non-contrast (VNC) images without additional radiation exposure offers advantages over conventional CT.[8]

Numerous studies have shown that DECT offers improved signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) compared to traditional 120 kVp images, especially in detecting pancreatic adenocarcinoma, where it also enhances reader confidence.[7] Despite its promising potential, there is still a need for further research to fully establish DECT's utility in routine clinical practice, particularly for pancreatic diseases. This study aims to assess the diagnostic value of DECT in pancreatic pathologies by comparing its effectiveness with conventional CT in lesion detection and evaluating its role in iodine mapping.

MATERIALS AND METHODS

This study was a cross-sectional observational study conducted in the Department of Radiodiagnosis at A.J. Institute of Medical Sciences, Mangalore. A total of 42 patients with known or suspected pancreatic lesions were included based on a sample size calculation derived from a previous study by Bhosale et al.[9] Assuming a 95% confidence interval and 90% power with a pooled standard deviation of 3, the required sample size was determined to be 42.

Sampling Technique and Study Population

The study adopted a purposive sampling technique, selecting individuals referred to the department for computed tomography (CT) scans due to suspected or confirmed pancreatic lesions. Patients who met the inclusion criteria of undergoing CT scans for pancreatic pathology were enrolled. However, patients with known pregnancy, contraindications to contrast agents, or those who did not provide consent were excluded from the study.

Data Collection and Imaging Protocol

Detailed informed consent was obtained from all participants. Clinical characteristics such as age, gender, symptoms, and relevant blood test results, including serum amylase and lipase, were collected and analysed. Pancreatic pathologies were confirmed using ultrasound and histopathological evaluation in cases of malignancy. Subjects underwent dual-energy computed tomography (DECT) scans of the abdomen, utilizing the Siemens SOMATOM go Top twin beam dual-energy system. This system allows simultaneous acquisition of high and low kilovolt (kV) datasets in a single scan by splitting the X-ray beam with two filters. The imaging protocol followed was a triphasic abdominal scan with dual-energy images acquired during the late arterial phase.

Post-processing of the images was conducted using Syngo. via workstation software. A region of interest (ROI) measuring 1 cm^2 was placed in the affected pancreatic area and in the normal pancreatic parenchyma. Monoenergetic images at 50 keV and 60 keV were acquired and compared to conventional 120 kVp images to assess image quality and diagnostic confidence. The contrast-to-noise ratio (CNR) was calculated to evaluate the detection of pancreatic lesions.

Imaging Parameters

The DECT scans were performed with the following parameters:

- kV: AuSn 120
- mAs: 117
- Acquisition: 640 x 0.6 mm
- Pitch: 0.3
- Rotation time: 0.33 seconds
- Scan duration: 10-11 seconds
- Slice width: 5 mm
- Reconstruction: 1.5 mm
- Scan direction: Cranial-Caudal

Statistical Analysis

Data were entered into Excel and analysed using SPSS version 24.0. Quantitative data were presented as mean and standard deviation, while qualitative data were presented as numbers and percentages. To determine the significance of differences between two groups, unpaired t-tests or Mann-Whitney U tests were applied. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The average age of patients with suspected pancreatic lesions in this study found to be 44.5 ± 17.59 (Mean ± SD) years. Majority of patients with

suspected pancreatic lesions belonged to age group of 35-54 years (47.6%) followed by 19-34years (21.4%). Majority of the study participants were males (90.5%) when compared to females (9.5%). Out of 42 study participants, 79% patients had any pancreatic lesion (abnormal pancreas) when compared to normal pancreas (21%)

The mean DECT [Contrast to Noise ratio CNR] value at 50 keV in patients with suspected pancreatic lesions in this study found to be 0.54± 0.36(Mean ± SD).The mean DECT value at 60 keV in patients with suspected pancreatic lesions in this study found to be 0.46±0.32(Mean ± SD).The mean Conventional CT value at 120 keV in patients with suspected pancreatic lesions in this study found to be 0.31± 0.26(Mean ± SD).There is extremely significant difference observed between CNR 50keVand CNR 120keV(which is conventional CT) with a p value <0.001. There is significant difference observed between CNR 60keVand CNR 120keV (which is conventional CT) with a p value <0.05. There is no significant difference observed between CNR 50keVand CNR 60keV with a p value >0.5.

As shown in the Figure 1 & Table 1, there is significant AUC for DECT prediction of pancreatic lesions with a AUC value of 0.943 ± 0.037 (Standard Error) with a p value <0.001 & with a 95% confidence interval (0.871-1.00). DECT has sensitivity and specificity rates of 90.9% and 88.8% respectively for the prediction of pancreatic pathological lesions.

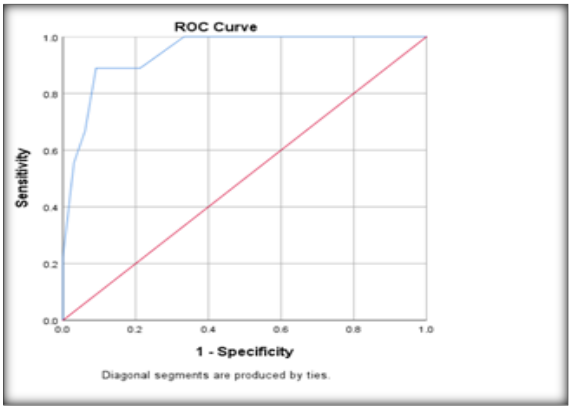

Figure 1: ROC curve for DECT prediction of pancreatic lesions

Table 2 presents the sensitivity and specificity of DECT (Dual-Energy Computed Tomography) in predicting pancreatic pathology. The DECT model demonstrated a high sensitivity of 90.9%, indicating its ability to correctly identify patients with pancreatic lesions. Additionally, it showed a specificity of 88.8%, reflecting its accuracy in ruling out those without the pathology. The positive predictive value (PPV) was 96.77%, meaning that 96.77% of patients who tested positive using DECT indeed had pancreatic pathology. The negative predictive value (NPV) was 72.72%, indicating that 72.72% of patients who tested negative were truly free of pancreatic pathology. Overall, these metrics highlight the strong diagnostic capability of DECT in detecting pancreatic lesions. [Table 2]

Table 3 shows that DECT, particularly at 50 keV, has a higher mean contrast-to-noise ratio (CNR) compared to conventional CT, indicating better lesion detection. DECT at 50 keV had the highest mean CNR (0.54), followed by 60 keV (0.46), and conventional CT (0.31). The P-values confirm that DECT, especially at 50 keV ($P < 0.001$), offers significantly better detection and reader confidence than conventional CT. [Table 3]

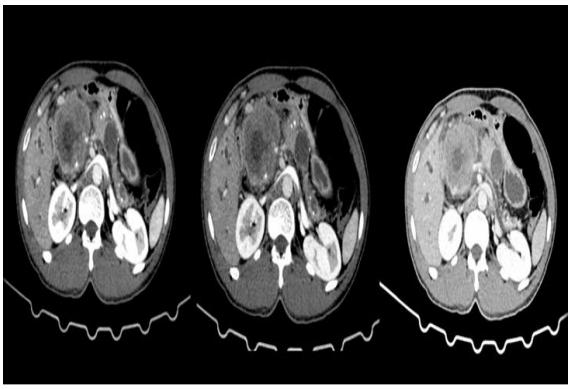

Figure 2: [From Left to Right]: Monochromatic images at 50 keV, 60 keV and conventional 120 kvP images of the pancreatic adenocarcinoma. The lower kiloelectron volt images were better when compared to conventional images for the identification and assessment of pancreatic diseases due to their greater contrast to noise ratio.

Table 1: Area under the curve for DECT prediction of pancreatic lesions

AUC	Std. Error	P value	95% Confidence Interval	
			(Lower Bound)	(Upper Bound)
0.943	0.037	<0.001	0.871	1

Table 2: Sensitivity & Specificity of DECT Prediction for pancreatic pathology

DECT Prediction for Pancreatic Pathology	Percentage (%)
Sensitivity	90.9
Specificity	88.8
Positive Predictive Value (PPV)	96.77
Negative Predictive Value (NPV)	72.72

Table 3: Comparison of detection and reader confidence of pancreatic lesions using Conventional CT and DECT

	DECT - 50 keV [CNR]	DECT - 60 keV [CNR]	CONVENTIONAL CT - 120 keV
Mean	0.54	0.46	0.31
SD	0.36	0.32	0.26
P value	< 0.001***	< 0.05*	> 0.05 ns

*Significant at 95% CI

DISCUSSION

The principle of dual energy CT (DECT), though conceived in the 1970s, was limited by technical issues such as scan time and slice thickness, requiring separate acquisitions which led to motion artifacts and increased dose. Advances in CT technology have made DECT clinically viable. Increasing literature, especially in abdominopelvic imaging, highlights DECT's advantages, such as improved lesion visibility, better tissue characterization, reduced metallic artifacts, fewer acquisition phases, less contrast volume, and reduced need for follow-up imaging.[10-16] Pancreatic pathologies are particularly challenging to detect with conventional CT, often requiring additional imaging for full characterization, making DECT a promising tool in this area.[17,18]

Despite DECT's excellent detection of benign and malignant lesions, limitations exist that prevent its routine clinical application. More studies are needed, especially focused on pancreatic pathologies, as there is limited data available in this area. This study aims to compare the detection and reader confidence of pancreatic lesions using DECT versus conventional CT, as well as to assess the role of iodine mapping.

The study included 42 patients with a mean age of 44.5 ± 17.59 years, predominantly males (90.5%). The majority of patients had abnormal pancreatic findings (79%), with chronic calcific pancreatitis (23.8%) being the most common, followed by acute-on-chronic pancreatitis (16.7%) and pancreatic adenocarcinoma (9.5%).

The area under the curve (AUC) for DECT prediction of pancreatic lesions was 0.943 ± 0.037 ($p < 0.001$), with a 95% confidence interval of 0.871-1.00.

The mean DECT CNR at 50 keV was 0.54 ± 0.36 (Mean ± SD), at 60 keV was 0.46 ± 0.32 (Mean ± SD), and at 120 keV (conventional CT) was 0.31 ± 0.26 (Mean ± SD). A significant difference was observed between CNR at 50 keV and 120 keV ($p < 0.001$), as well as between 60 keV and 120 keV ($p < 0.05$), but not between 50 keV and 60 keV ($p > 0.05$).

CONCLUSION

According to the current research, there was a very noticeable difference between conventional CT values of CNR 120keV and CNR 50keV and between CNR 120keV (standard CT) and CNR 60keV. This highlighted that in comparison to traditional CT images, monochromatic energy images offer advantages for the identification and assessment of pancreatic diseases due to their greater contrast to noise ratio. DECT showed high sensitivity (90.9%) and specificity (88.8%) for detecting pancreatic lesions, highlighting its utility in improving diagnostic accuracy and reducing morbidity and mortality in pancreatic diseases.

Conflict of Interest: None

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