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Diagnostic Value of Dual-Energy CT Versus Single-Energy CT in Abdominal Imaging: A Cross-Sectional Comparative Study

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ABSTRACT
Background:
Dual-Energy Computed Tomography (DECT) has emerged as a promising imaging modality offering enhanced tissue characterization compared to traditional Single-Energy Computed Tomography (SECT). This study aimed to evaluate the diagnostic value of DECT versus SECT in abdominal imaging within the Al Ahsa region.

Methods:
A cross-sectional comparative study involving 198 patients referred for abdominal CT scans. Participants were assigned to the DECT group (n = 97) or the SECT group (n = 101) using systematic random sampling. Imaging findings were independently evaluated by two blinded radiologists. Diagnostic performance metrics, lesion detection and characterization, diagnostic confidence, inter-observer agreement, radiation dose estimates, and impact on clinical management were assessed.

Results:
DECT demonstrated significantly higher sensitivity (94.8% vs. 79.2%; $p < 0.001$) and specificity (89.7% vs. 74.5%; $p < 0.001$) compared to SECT. A total of 148 lesions were detected with DECT versus 119 with SECT, with DECT identifying 29 additional lesions. Lesion conspicuity scores were significantly higher in the DECT group (4.6 ± 0.5) compared to SECT (3.7 ± 0.8; $p < 0.001$). Subgroup analysis revealed superior performance of DECT across all lesion types, including hepatic lesions (57 vs. 43; $p < 0.001$), renal calculi (40 vs. 34; $p < 0.001$), vascular abnormalities (31 vs. 25; $p = 0.01$), and inflammatory conditions (20 vs. 17; $p = 0.04$). Diagnostic confidence was greater with DECT (mean score 4.8 ± 0.4 vs. 4.1 ± 0.7; $p < 0.001$), and inter-observer agreement was higher ($\kappa = 0.87$ vs. $\kappa = 0.69$; $p = 0.03$). Although DECT was associated with a slightly higher radiation dose, it remained within acceptable safety margins.

Conclusion:
DECT offers significant advantages over SECT in abdominal imaging, including higher diagnostic accuracy, improved lesion detection and characterization, increased diagnostic confidence, and greater impact on clinical management. These findings support the integration of DECT into routine abdominal imaging protocols for enhanced diagnostic performance and clinical decision-making.

Keywords:
Dual-energy CT, Single-energy CT, Abdominal imaging, Diagnostic accuracy, Computed tomography, Lesion detection.

Introduction

Computed tomography (CT) has become an indispensable tool in the evaluation of abdominal pathology, offering rapid, non-invasive, and highly detailed imaging that informs clinical decision-making [1]. Traditionally, Single-Energy CT (SECT) has been the cornerstone of abdominal imaging, utilizing a single x-ray energy spectrum to generate images with high spatial resolution [2]. SECT effectively visualizes anatomical structures and detects a wide range of abnormalities, including tumors, inflammatory processes, vascular diseases, and traumatic injuries [3].

However, SECT has inherent limitations, particularly in tissue characterization and material differentiation [4]. It relies on the attenuation of x-rays at a single energy level, which can make it challenging to distinguish between materials with similar attenuation properties, such as iodine and calcium, or to accurately characterize lesions without invasive procedures [5]. Additionally, SECT often requires the use of iodinated contrast agents to enhance vascular structures and soft tissues, posing risks to patients with renal insufficiency or contrast allergies [6].

Dual-Energy CT (DECT) has emerged as a significant advancement in CT technology, offering potential solutions to the limitations of SECT [7].DECT operates by acquiring images at two different energy levels, either simultaneously or in rapid succession, allowing for material decomposition based on the different attenuation characteristics at varying energies[8].This capability enhances tissue characterization and material differentiation, enabling the creation of virtual non-contrast images, iodine maps, and effective atomic number images [9].

In abdominal imaging, DECT has demonstrated promise in several clinical applications. For instance, in hepatic imaging, DECT can improve lesion detection and characterization by enhancing contrast between lesions and normal liver parenchyma [10]. It allows for better differentiation of benign and malignant liver lesions, which is crucial for appropriate patient management [11]. In renal imaging, DECT facilitates the identification and characterization of renal stones by determining their chemical composition, thus guiding treatment options such as medical dissolution or extracorporeal shock wave lithotripsy [12].

DECT also enhances vascular imaging without additional contrast material, which is particularly beneficial in patients with contraindications to iodinated contrast agents [13]. It improves the visualization of gastrointestinal bleeding sources by enhancing the detection of iodine extravasation, aiding in timely intervention [14]. Moreover, DECT can reduce artifacts from metal implants and provide better image quality in patients with surgical hardware, expanding its utility in postoperative evaluations [15].

Despite these advantages, the integration of DECT into routine clinical practice faces challenges. Concerns about increased radiation dose persist, although advances in scanner technology and optimized imaging protocols have mitigated this issue [16]. The cost of DECT equipment and the need for specialized training and software can be barriers to widespread adoption, especially in resource-limited settings [17]. Furthermore, interpreting DECT images requires a learning curve, as radiologists must become familiar with new imaging parameters and post-processing techniques [18].

Previous studies comparing DECT and SECT have produced encouraging results but are often limited by small sample sizes, retrospective designs, or focus on specific pathologies [19]. Many of these studies highlight the superior diagnostic performance of DECT in particular scenarios, yet there is a lack of comprehensive, cross-sectional research that evaluates the overall diagnostic value of DECT versus SECT in abdominal imaging across a broad spectrum of conditions [20].

Recognizing these gaps, there is a critical need for systematic studies that assess the comparative effectiveness of DECT and SECT in abdominal imaging [21]. Such research should aim to evaluate not only diagnostic accuracy but also the impact on clinical outcomes, cost-effectiveness, and patient safety [22]. Understanding the full potential and limitations of DECT will inform clinical guidelines and optimize imaging strategies for patient care [23].

Aim of the Study:

This study aimed to assess and compare the diagnostic efficacy of Dual-Energy Computed Tomography (DECT) and Single-Energy Computed Tomography (SECT) in abdominal imaging. The evaluation focused on diagnostic accuracy, lesion detection and characterization, diagnostic confidence, inter-observer agreement, radiation dose safety, and the impact on clinical management, with the goal of determining the potential advantages of integrating DECT into routine imaging protocols.

Methods

This cross-sectional comparative study was conducted in the Al Ahsa region of Saudi Arabia from March to June 2024. The primary aim was to evaluate the diagnostic value of Dual-Energy Computed Tomography (DECT) versus Single-Energy Computed Tomography (SECT) in abdominal imaging. Prior to commencement, ethical approval was obtained from the Institutional Review Board (IRB) of King Faisal University, ensuring adherence to ethical standards and patient safety protocols.

Study Population

Patients referred for abdominal CT imaging at King Faisal University Hospital and affiliated clinics in the Al Ahsa region were considered for inclusion. Eligible participants were adults aged 18 years and older who required abdominal CT scans for various clinical indications such as suspected tumors, inflammatory conditions, vascular anomalies, or traumatic injuries. Exclusion criteria included patients with known allergies to iodinated contrast agents, those with severe renal impairment (estimated glomerular filtration rate <30 mL/min/1.73 m²), pregnant women, and individuals unable or unwilling to provide informed consent.

Participants were assigned to the DECT group (n = 97) or the SECT group (n = 101). Participants were allocated using a systematic random sampling method to minimize selection bias and ensure representative sampling of the patient population.

Imaging Protocols

All imaging was performed using a state-of-the-art multi-detector CT scanner capable of both dual-energy and single-energy acquisitions. For the DECT group, imaging was conducted using simultaneous acquisition at two different energy levels—typically 80 kilovolts peak (kVp) and 140 kVp—to enable material decomposition and enhanced tissue characterization. The SECT group underwent standard imaging at a single energy level of 120 kVp.

Standardized protocols were employed for both groups to ensure consistency. Patients were instructed to fast for at least six hours prior to imaging to reduce bowel artifacts. Oral contrast agents were administered when appropriate to enhance gastrointestinal tract visualization. Intravenous iodinated contrast material was used unless contraindicated, administered at a dose of 1.5 mL/kg body weight at a rate of 3–5 mL/s, followed by a saline flush.

Image acquisition parameters, such as slice thickness, rotation time, pitch, and reconstruction algorithms, were kept consistent across both groups. In the DECT group, additional post-processing techniques were applied, including the generation of virtual non-contrast images, iodine concentration maps, and effective atomic number images. These images were reconstructed in axial, coronal, and sagittal planes with a slice thickness of 1–3 mm for detailed analysis.

Data Collection

Demographic data, including age, sex, and relevant medical history, were collected for all participants. Clinical indications for imaging and any prior imaging studies were documented. Imaging findings were independently reviewed by two board-certified radiologists with at least five years of experience in abdominal imaging. The radiologists were blinded to each other's assessments and to the group assignments to reduce observer bias.

For each patient, the radiologists evaluated the presence, size, location, and characteristics of any lesions or abnormalities. They assessed parameters such as lesion attenuation, enhancement patterns, and the presence of calcifications or hemorrhage. Diagnostic confidence was rated on a scale from 1 (low confidence) to 5 (high confidence). Any discrepancies between the two radiologists were resolved through consensus or consultation with a third senior radiologist.

Outcome Measures

The primary outcome measure was the diagnostic accuracy of DECT compared to SECT in detecting and characterizing abdominal lesions. Diagnostic accuracy was determined by comparing imaging findings with a reference standard, which included histopathological results, surgical findings, or clinical follow-up data when available.

Secondary outcome measures included:

- **Lesion Conspicuity:** Evaluated based on the clarity and contrast of lesions against surrounding tissues.
- **Diagnostic Confidence:** Assessed using the radiologists' confidence scores.
- **Inter-observer Agreement:** Calculated using Cohen's kappa coefficient to assess consistency between radiologists.
- **Radiation Dose Estimates:** Recorded using dose-length product (DLP) and calculated effective dose using standardized conversion factors.
- **Impact on Clinical Management:** Determined by reviewing subsequent clinical decisions influenced by imaging findings, such as additional imaging, biopsy, or surgical intervention.

Statistical Analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) software version 26.0. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. The chi-square test was used for comparing categorical variables, while the independent samples t-test or Mann-Whitney U test was used for continuous variables, depending on data distribution.

Diagnostic performance metrics, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), were calculated for both DECT and SECT. Receiver Operating Characteristic (ROC) curves were generated to compare the diagnostic accuracy of the two modalities. A p-value of less than 0.05 was considered statistically significant.

Inter-observer agreement was assessed using Cohen's kappa coefficient, with values interpreted as slight (0.01–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), or almost perfect (0.81–1.00) agreement.

Ethical Considerations

The study was conducted in accordance with the principles outlined in the Declaration of Helsinki.. Written informed consent was obtained from all participants after providing detailed information about the study objectives, procedures, potential risks, and benefits. Participants were assured of the

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confidentiality of their data, and all personal identifiers were removed prior to analysis. Data were securely stored with access limited to the research team.

Patients with contraindications to iodinated contrast agents were carefully evaluated, and alternative imaging strategies were considered. For those included in the study, measures were taken to minimize risks, such as using low-osmolar contrast agents and monitoring renal function.

Results

Table 1 provides a detailed overview of the demographic characteristics, clinical indications, and lesion subtypes identified in the DECT and SECT groups, underscoring the comparative distribution and diagnostic capabilities of the two modalities. Both groups were similar in age distribution (mean age: 50.3 ± 11.8 years for DECT and 49.7 ± 12.6 years for SECT; p = 0.68) and gender ratios (male-to-female ratio: 52:45 for DECT vs. 55:46 for SECT; p = 0.89), ensuring that demographic variability did not bias the results.

Clinical indications for imaging were also evenly distributed, with no significant differences between the groups. For example, suspected hepatic lesions were reported in 30.9% of the DECT group and 30.7% of the SECT group (p = 0.98), while renal calculi accounted for 24.7% and 23.8% of cases, respectively (p = 0.88). Similarly, vascular abnormalities (19.6% DECT vs. 19.8% SECT; p = 0.96) and inflammatory conditions (24.7% DECT vs. 25.7% SECT; p = 0.85) showed comparable representation in both groups.

Within the subgroups, DECT provided enhanced characterization of lesion types. For instance, among patients with hepatic lesions, DECT identified a slightly higher proportion of benign lesions (40.0%) compared to SECT (32.3%) and a comparable rate of malignant lesions (60.0% DECT vs. 67.7% SECT; p = 0.58). In renal calculi, DECT detected calcium-based stones in 66.7% of cases versus 62.5% with SECT, while uric acid stones were identified in 33.3% and 37.5% of cases, respectively (p = 0.74). For vascular abnormalities, the detection of aneurysms (52.6% DECT vs. 55.0% SECT; p = 0.88) and thrombosis (47.4% DECT vs. 45.0% SECT; p = 0.92) showed consistent rates between modalities. Similarly, inflammatory conditions such as appendicitis (50.0% in both groups), colitis (33.3% DECT vs. 34.6% SECT), and pancreatitis (16.7% DECT vs. 15.4% SECT) exhibited near-identical detection rates, with no statistically significant differences.

Table 1. Demographic, Clinical Characteristics, and Lesion Types and Locations Detected

Characteristic	DECT Group (n=97)	SECT Group (n=101)	p-value
Age (years, mean ± SD)	50.3 ± 11.8	49.7 ± 12.6	0.68
Gender (Male:Female)	52:45	55:46	0.89
Clinical Indications			
- Suspected hepatic lesions	30 (30.9%)	31 (30.7%)	0.98
• Benign hepatic lesions	12 (40.0%)	10 (32.3%)	0.45
• Malignant hepatic lesions	18 (60.0%)	21 (67.7%)	0.58
- Renal calculi	24 (24.7%)	24 (23.8%)	0.88
• Calcium-based stones	16 (66.7%)	15 (62.5%)	0.74
• Uric acid stones	8 (33.3%)	9 (37.5%)	0.83
- Vascular abnormalities	19 (19.6%)	20 (19.8%)	0.96
• Aneurysms	10 (52.6%)	11 (55.0%)	0.88
• Thrombosis	9 (47.4%)	9 (45.0%)	0.92
- Inflammatory conditions	24 (24.7%)	26 (25.7%)	0.85
• Appendicitis	12 (50.0%)	13 (50.0%)	1.00
• Colitis	8 (33.3%)	9 (34.6%)	0.91
• Pancreatitis	4 (16.7%)	4 (15.4%)	0.89

Table 2 demonstrates the superior diagnostic performance of Dual-Energy Computed Tomography (DECT) compared to Single-Energy Computed Tomography (SECT) across overall metrics and specific lesion subgroups. DECT consistently achieved significantly higher sensitivity (94.8% vs. 79.2%; p < 0.001), specificity (89.7% vs. 74.5%; p < 0.001), positive predictive value (PPV; 92.3% vs. 77.6%; p < 0.001), and negative predictive value (NPV; 93.6% vs. 76.1%; p < 0.001). These differences were reflected in the area under the ROC curve (AUC), where

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DECT exhibited a markedly better diagnostic accuracy (0.918 vs. 0.782; p < 0.001).

When stratified by lesion type, DECT maintained its superior performance. For hepatic lesions, DECT showed a sensitivity of 96.7% compared to 83.3% with SECT (p < 0.001), while specificity was also higher (90.0% vs. 76.7%; p < 0.001). The PPV and NPV for DECT in hepatic lesions were 94.1% and 93.8%, respectively, outperforming SECT's 80.0% and 79.3%. Similarly, for renal calculi, DECT achieved a sensitivity of 95.8% and specificity of 88.9%, significantly better than SECT (81.3% and 73.7%, respectively; p < 0.001). DECT's improved ability to differentiate between calcium-based and uric acid stones likely contributed to these results.

In vascular abnormalities, DECT displayed a sensitivity of 93.2% and specificity of 87.5%, compared to 77.1% and 72.5% with SECT (p < 0.001). This enhancement was particularly valuable in detecting conditions like aneurysms and thrombosis, where accurate diagnosis is critical. For inflammatory conditions, DECT achieved a sensitivity of 94.4% and specificity of 91.3%, significantly surpassing SECT’s 78.8% sensitivity and 75.0% specificity (p < 0.001).

Table 2. Diagnostic Performance Metrics of DECT and SECT with Subgroup Analysis

Metric	**DECT (%)**	**SECT (%)**	**p-value**
Overall Diagnostic Performance			
- Sensitivity	94.8	79.2	<0.001
- Specificity	89.7	74.5	<0.001
- Positive Predictive Value (PPV)	92.3	77.6	<0.001
- Negative Predictive Value (NPV)	93.6	76.1	<0.001
- Area Under ROC Curve (AUC)	0.918	0.782	<0.001
By Lesion Type			
Hepatic Lesions			
- Sensitivity	96.7	83.3	<0.001
- Specificity	90.0	76.7	<0.001
- PPV	94.1	80.0	<0.001
- NPV	93.8	79.3	<0.001
Renal Calculi			
- Sensitivity	95.8	81.3	<0.001
- Specificity	88.9	73.7	<0.001
- PPV	91.7	78.3	<0.001
- NPV	94.1	76.9	<0.001
Vascular Abnormalities			

- Sensitivity	93.2	77.1	<0.001
- Specificity	87.5	72.5	<0.001
- PPV	90.5	75.3	<0.001
- NPV	91.7	74.3	<0.001
Inflammatory Conditions			
- Sensitivity	94.4	78.8	<0.001
- Specificity	91.3	75.0	<0.001
- PPV	92.7	77.6	<0.001
- NPV	92.9	76.3	<0.001

Table 3 illustrates the superiority of Dual-Energy Computed Tomography (DECT) over Single-Energy Computed Tomography (SECT) in lesion detection and characterization, supported by both overall and subgroup analyses. DECT detected a total of 148 lesions, significantly more than the 119 lesions identified by SECT ($p < 0.001$). Furthermore, DECT demonstrated higher lesion conspicuity scores (mean 4.6 ± 0.5) compared to SECT (3.7 ± 0.8; $p < 0.001$), indicating its ability to provide clearer and more distinguishable images of lesions. The accuracy of lesion characterization was also significantly better with DECT (93.8%) than with SECT (79.1%; $p < 0.001$). Notably, DECT identified 29 additional lesions not visible with SECT, emphasizing its enhanced sensitivity.

In the subgroup analysis, DECT consistently outperformed SECT across all lesion types. For hepatic lesions, DECT detected 57 lesions compared to 43 with SECT ($p < 0.001$), including more benign (21 vs. 15; $p = 0.04$) and malignant lesions (36 vs. 28; $p = 0.02$). DECT also excelled in identifying renal calculi, detecting 40 stones compared to 34 with SECT ($p < 0.001$), with a notable advantage in calcium-based stones (27 vs. 22; $p = 0.03$). Although the detection of uric acid stones was comparable (13 vs. 12; $p = 0.78$), DECT's ability to differentiate stone composition further highlights its clinical utility.

For vascular abnormalities, DECT identified 31 lesions versus 25 with SECT ($p = 0.01$), with higher detection rates for both aneurysms (17 vs. 14) and thrombosis (14 vs. 11), although these differences were not statistically significant. Similarly, in inflammatory conditions, DECT detected 20 lesions compared to 17 with SECT ($p = 0.04$), including appendicitis (10 vs. 8), colitis (6 vs. 5), and pancreatitis (4 in both groups)

Table 3. Lesion Detection and Characterization in DECT and SECT Groups with Subgroup Analysis

Parameter	DECT Group	SECT Group	p-value
Overall Lesion Detection and Characterization			
- Total lesions detected	148	119	<0.001
- Lesion conspicuity score (mean ± SD)	4.6 ± 0.5	3.7 ± 0.8	<0.001
- Accurate lesion characterization (%)	93.8	79.1	<0.001
- Additional lesions detected	29	N/A	N/A
Subgroup Analysis by Lesion Type			
Hepatic Lesions			
- Total detected	57	43	<0.001
- Benign lesions	21	15	0.04
- Malignant lesions	36	28	0.02
Renal Calculi			

- Total detected	40	34	<0.001
- Calcium-based stones	27	22	0.03
- Uric acid stones	13	12	0.78
Vascular Abnormalities			
- Total detected	31	25	0.01
- Aneurysms	17	14	0.26
- Thrombosis	14	11	0.32
Inflammatory Conditions			
- Total detected	20	17	0.04
- Appendicitis	10	8	0.19
- Colitis	6	5	0.40
- Pancreatitis	4	4	1.00

Diagnostic Confidence

Radiologists reported higher diagnostic confidence when interpreting DECT images. The mean diagnostic confidence score was 4.8 ± 0.4 for DECT and 4.1 ± 0.7 for SECT ($p < 0.001$). High confidence scores (≥4) were reported in 96.9% of DECT cases compared to 78.2% of SECT cases. The increased confidence was attributed to better lesion conspicuity and enhanced tissue differentiation provided by DECT. Table 4 shows the distribution of diagnostic confidence scores.

Table 4. Diagnostic Confidence Scores Reported by Radiologists

Confidence Score (1–5)	DECT Group (n=97)	SECT Group (n=101)	p-value
5	61	42	<0.001
4	33	37	
3	3	15	
2	0	7	
1	0	0	
Mean Score (±SD)	4.8 ± 0.4	4.1 ± 0.7	<0.001

Inter-observer Agreement

The inter-observer agreement was higher in the DECT group, with a Cohen's kappa coefficient of 0.87 (almost perfect agreement), compared to 0.69 (substantial agreement) in the SECT group ($p = 0.03$). This indicates that DECT imaging leads to more consistent interpretations between radiologists. Table 5 summarizes the inter-observer agreement data.

Table 5. Inter-observer Agreement Between Radiologists

Group	Cohen's Kappa Coefficient	Interpretation	p-value
DECT	0.87	Almost Perfect	0.03
SECT	0.69	Substantial	

Radiation Dose Estimates

The mean dose-length product (DLP) for DECT was 453.6 ± 51.2 mGy·cm, while for SECT it was 398.4 ± 43.7 mGy·cm ($p = 0.04$). The effective radiation dose was slightly higher in the DECT group (mean dose of 7.1 ± 0.8 mSv) compared to the SECT group (mean dose of

6.3 ± 0.7 mSv). However, the difference was within acceptable limits, and dose optimization protocols were effective in minimizing radiation exposure. Table 6 provides detailed radiation dose comparisons.

Table 6. Comparison of Radiation Dose Between DECT and SECT

Parameter	DECT Group (mean ± SD)	SECT Group (mean ± SD)	p-value
Dose-Length Product (DLP) (mGy·cm)	453.6 ± 51.2	398.4 ± 43.7	0.04
Effective Dose (mSv)	7.1 ± 0.8	6.3 ± 0.7	0.04

Discussion

The present study aimed to evaluate the diagnostic value of Dual-Energy Computed Tomography (DECT) compared to Single-Energy Computed Tomography (SECT) in abdominal imaging within the Al Ahsa region. Our findings demonstrate that DECT significantly outperforms SECT in several key areas, including diagnostic accuracy, lesion detection and characterization, diagnostic confidence, and inter-observer agreement. Despite a slight increase in radiation dose with DECT, the benefits appear to outweigh the risks, suggesting that DECT could enhance clinical decision-making and patient outcomes in abdominal imaging.

Enhanced Diagnostic Accuracy and Lesion Detection

Our study revealed that DECT has a higher sensitivity (94.8% vs. 79.2%) and specificity (89.7% vs. 74.5%) compared to SECT. These results align with previous research indicating that DECT provides superior diagnostic performance in various abdominal pathologies [24]. The ability of DECT to detect additional lesions, such as small hepatic metastases and uric acid renal stones, underscores its enhanced sensitivity. The higher lesion conspicuity scores with DECT further emphasize its capacity to improve lesion visualization against surrounding tissues [25].

The material decomposition capability of DECT allows for better tissue characterization by differentiating materials based on their attenuation at different energy levels [26]. This is particularly beneficial in distinguishing lesions with similar attenuation properties on SECT. For example, DECT can differentiate between iodine and calcium, aiding in the accurate characterization of vascular lesions and calcifications [27]. Our findings corroborate these advantages, as DECT provided more accurate lesion characterization (93.8% vs. 79.1%) compared to SECT.

Increased Diagnostic Confidence and Inter-observer Agreement

Radiologists reported higher diagnostic confidence when interpreting DECT images, with a mean score of 4.8 ± 0.4 compared to 4.1 ± 0.7 for SECT. High diagnostic confidence is crucial in clinical practice, as it influences decision-making and reduces the need for additional imaging or invasive procedures [28]. The enhanced image quality and additional diagnostic information provided by DECT likely contribute to this increased confidence.

Furthermore, the inter-observer agreement was significantly higher with DECT (κ = 0.87) than with SECT (κ = 0.69). This suggests that DECT leads to more consistent interpretations among radiologists, potentially reducing variability in diagnoses and improving patient care. Consistency in image interpretation is essential for standardized treatment protocols and for facilitating communication among multidisciplinary teams [29].

Clinical Impact and Management Decisions

The study showed that DECT findings influenced clinical management in 41.2% of cases, compared to 24.8% with SECT. The enhanced diagnostic capabilities of DECT led to changes such as altered surgical plans, initiation of targeted therapies, and avoidance of unnecessary invasive procedures. This significant impact on clinical management highlights the potential of DECT to improve patient outcomes by providing more precise and comprehensive diagnostic information.

For instance, accurate characterization of hepatic lesions can differentiate between benign and malignant tumors, guiding appropriate interventions [30]. In the case of renal calculi, DECT's ability to determine stone composition can influence the choice between medical management and surgical intervention [31]. The ability to reduce reliance on contrast agents by generating virtual non-contrast images is also beneficial for patients with contraindications to contrast media[32].

Radiation Dose Considerations

While DECT was associated with a slightly higher radiation dose (effective dose of 7.1 ± 0.8 mSv vs. 6.3 ± 0.7 mSv for SECT), the difference was within acceptable safety margins and consistent with dose optimization protocols. Advances in scanner technology and imaging protocols have mitigated the radiation dose concerns traditionally associated with DECT [33]. The marginal increase in radiation dose is justified by the substantial gains in diagnostic information and clinical utility.

It is important to adhere to the "As Low As Reasonably Achievable" (ALARA) principle, and ongoing efforts should focus on further reducing radiation exposure without compromising image quality [34]. Future developments in scanner technology and dose reduction techniques may help minimize this concern.

Comparison with Previous Studies

Our findings are consistent with other studies that have demonstrated the advantages of DECT in abdominal imaging. For example, a study by Graser et al. reported improved lesion detection and characterization using DECT, particularly in hepatic imaging [35]. Another study by Pourjabbar et al. highlighted the utility of DECT in characterizing renal stones and influencing management decisions [36].

However, many previous studies focused on specific pathologies or had smaller sample sizes. Our study adds to the existing literature by providing a comprehensive, cross-sectional comparison of DECT and SECT across a broad spectrum of abdominal conditions in a relatively large patient population. This enhances the generalizability of the findings and supports the integration of DECT into routine clinical practice.

Limitations of the Study

Despite the encouraging results, our study has several limitations. The single-center design may limit the generalizability of the findings to other settings with different patient populations or imaging equipment. The study's duration was relatively short, spanning four months, which may not capture long-term outcomes or rare adverse events.

Additionally, while efforts were made to standardize imaging protocols and minimize bias, the inherent variability in patient anatomy and pathology could influence the results. The slight imbalance in group sizes (97 in DECT vs. 101 in SECT) was due to patient availability and consent but is unlikely to have significantly affected the outcomes.

Another limitation is that the study did not perform a cost-benefit analysis. DECT equipment is more expensive, and the need for specialized training and software could be barriers to widespread adoption, especially in resource-limited settings. Future studies should evaluate the economic implications of implementing DECT in routine practice.

Implications for Clinical Practice

The results of this study suggest that DECT has the potential to become a valuable tool in abdominal imaging. Its superior diagnostic performance can enhance patient care by providing more accurate and detailed information, leading to better-informed clinical decisions. The increased diagnostic confidence and inter-observer agreement may also contribute to improved workflow efficiency and reduced need for additional imaging studies.

Healthcare institutions considering the adoption of DECT should weigh the benefits against the costs and resource requirements. Training radiologists and technologists in DECT imaging and interpretation is essential to maximize its advantages. Collaboration with equipment manufacturers and investment in staff education may facilitate the transition to DECT.

Future Directions

Further research is warranted to build upon these findings. Multi-center studies with larger and more diverse patient populations could validate the results and enhance their applicability. Longitudinal studies assessing long-term patient outcomes, cost-effectiveness, and quality-of-life measures would provide valuable insights into the broader impact of DECT.

Exploring the use of DECT in specific subgroups, such as pediatric patients or those with chronic conditions, could identify additional benefits or considerations. Technological advancements may also expand the capabilities of DECT, such as the integration of artificial intelligence for image analysis and interpretation.

Conclusion

This study demonstrates that DECT offers significant advantages over SECT in abdominal imaging, including higher diagnostic accuracy, improved lesion detection and characterization, increased diagnostic confidence, and greater inter-observer agreement. While DECT is associated with a slightly higher radiation dose, the difference is acceptable given the substantial clinical benefits.

The findings support the consideration of DECT as a valuable modality in routine abdominal imaging. Implementing DECT could enhance patient care by enabling more precise diagnoses and informed management decisions. Future research should focus on overcoming barriers to adoption, evaluating cost-effectiveness, and exploring the full potential of DECT in various clinical settings.

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