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RESEARCH

Analysis of radiation dose reduction in oncological followup cases by using dual energy CT

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Abstract

Background Concern about radiation effects is particularly significant for cancer patients who require frequent imaging for follow-up assessments. Computed tomography (CT) is a key tool in the diagnosis and monitoring of cancer.

Purpose To demonstrate radiation dose reduction using dual-energy CT (DECT) compared with single-energy CT (SECT) in the follow-up of cancer patients.

Patients and methods This retrospective cohort study, conducted at the Fondazione INT IRCCS G. Pascale in Naples, Italy, evaluated the effectiveness of spectral dual-energy CT in reducing radiation doses during follow-up compared with conventional CT. 80 patients undergoing oncology follow-up for different cancers underwent both DESCT and conventional CT scans. A quantitative approach focused on the analysis of radiation dose measurements (CTDI and DLP), while qualitative assessments evaluated improvements in image quality. Statistical analysis was performed using SPSS version 27.0, with paired t-tests comparing radiation doses between the two methods to determine significant differences.

Results DECT showed statistically significant reductions in radiation exposure: mean CTDI (SECT: 9.3 ± 1.1 mGy vs DECT: 5.7 ± 1.0 mGy, $p < 0.001$), DLP (SECT: 875.3 ± 112.5 mGy·cm vs DECT: 621.0 ± 95.7 mGy·cm, $p < 0.001$), ED (SECT: 12.3 ± 2.0 mSv vs DECT: 8.0 ± 1.5 mSv, $p < 0.001$). SNR and CNR were also improved. No statistically significant gender-based differences were found.

Conclusion Dual-energy spectral CT significantly reduces radiation dose compared to conventional CT, with substantial decreases in CT dose index (CTDI), dose-length product (DLP), and effective dose.

Keywords Radioprotection · CT scan · Radiation dose · Dual energy · Cancer therapy

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Introduction

Radiation effects are of major concern for patients with cancer [1, 2], and more so while as sessing follow up imaging, where normally more imaging is done to assess the evolution or the regression of the disease. Computed Tomography (CT) has been used intensively in cancer diagnosis, as well as in staging and follow up because of its capability to generate detailed cross-sectional images of the targeted areas. However, there are disadvantages of this modal- ity especially with the use of single energy computed tomography (SECT) such as radiation dose and contrast media. Dual-source computed tomography (DSCT), another late generation of CT technology which was presented earlier, can help to address these concerns owing to the explicit advantages of DECT both in dose saving

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and diagnostic accuracy especially in oncology follow-up protocols [3–6].

Dual-energy CT works through the scanning with two energy levels (low and high kVp) during the examination, which improves the comparison of tissues by their attenuation is distinguished by. This feature allows DECT to eliminate some of the shortcomings of traditional SECT depending on the material differentiation and enhancement of tissue contrast. Specifically, keeping radiation dose and the volume of contrast agents, a patient is exposed to in oncology follow-ups, in which frequent imaging is inevitable, is critical in terms of overall life observations' impact on patients' health. DECT enables combination of contrast enhanced im- ages to produce virtually non-contrast (VNC) image as opposed to taking more than one scan leading to less radiation dose. Furthermore, the virtual monochromatic imaging (VMI) to detect hypervascular and/or hypovascular lesion is beneficial in distinguishing between malignant and benign lesions even without a large amount of iodinated contrast material to that helps in avoiding the complication of acute nephrotoxic in patients with renal disease or those patients who are undergoing nephrotoxic chemotherapy treatment regimens [7–10].

Another advantage of DECT in oncology is that it affords the facility to obtain good images with less radiation as compared to SECT. Namely, the SECT technique originally calls for the pre-contrast and post-contrast imaging, which results in higher radiation dose. DECT has the ability to obtain VNC images which means that there is no longer a need for a pre contrast scan and this shows that the radiation dose given to a patient is less. Also, in this imaging method, radiologists can get the optimal diagnostic information from a single post contrast phase, thus reducing the amount of ionizing radiation exposure [3, 11–13].

As with radiation dose reduction, DECT supports major advantages for the use of contrast agents. Enhancers are also often used in oncological practice with the help of which the contrast of tumors and other lesions is intensified, especially iodine-containing compounds. However, most of the oncology patients have compromised renal function because of their treatments, use of contrast agents is therefore risky. By means VMI DECT which brings improved iodine.

Attenuation and the capability of applying lesser amount of contrast while achieving optimal image quality is possible. By reducing the volume of contrast, one is able to minimize the incidence of contrast induced nephropathy which is a major issue amongst patients who have beforehand experienced renal complications from chemotherapy [13–16].

DECT also enhances diagnostic reliability of follow-ups in oncological patients. Thus, the possibility to produce VMI at various energy levels helps to distinguish between lesions and adjacent tissues clearer. For example, at lower energies of around 40–55 keV, hypervascular lesions such as those of HCC or hypervascular metastases may be conspicuous on SPECT as compared to SECT. On the other hand, artifact reduction, and increasing the visibility of hypo- vascular lesions can be evidential when energy levels are high and can prove difficult to be seen in CT scanning. The fact that DECT can improve the identification of both hypervascular and hypovascular lesions represents a major advantage of the technique in oncology, particularly in staging and follow-up, since it permits the diagnosis of earlier relapse or metastasis [17–20].

Moreover, it also provides greater effectiveness in the minimization of beam hardening artefacts which is typical in SECT mainly in locations where there are metallic implant and also thereby bone mass. Such artefacts may obscure vital anatomic structures and thus complicate accurate diagnosis. High monoenergetic images enables DECT to decrease these artifacts, and allows radiologists and oncologists to have better and clearer picture of the treatment progress and make the necessary decisions regarding the patient's care [7, 21–23].

There are several studies that refer to the dose reduction of DECT compared to SECT, but none of them addressed the issue of comparing patients in oncology follow-up, i.e. patients undergoing recurrent CT examinations, where the importance of exposure to ionizing radiation should be greater. Cancer patients are more susceptible than any other patients to the harmful effects of ionizing radiation, especially in the case of repeated follow-ups. For this reason, a careful analysis of these data can increase knowledge and provide useful information on the reduction of radiation dose in categories of fragile patients, such as to prefer the use of DECT to SECT.

Patients and methods

Research design

This is a retrospective observational cohort study, conducted in INT IRCCS G. Pascale Foundation in Naples, Italy, a tertiary level oncology facility, from January 2023 to July 2024. 80 patients undergoing oncology follow-up for different tumors underwent both DESCT and conventional CT scans. The study is aimed to analyze the efficacy of Dual Energy Spectral CT (DESCT) in decreasing radiation doses for cancer patients during follow-up scans compared to conventional CT scans. All the patients underwent for both DESCT and conventional CT. The patient's eligibility in this study have been discussed in the relevant section. The quantitative approach was adopted for this research with a focus on numerical and statistical analyses of radiation dose measurements such as Computed Tomography Dose Index (CTDI) and Dose length product (DLP) as well as qualitative

assessments regarding improvements in image quality. This design was selected in order to make an accurate comparison between efficacy of DESCT versus conventional CT technology in practical medical settings. The primary aim of this study was to assess reduction in radiation doses when using DESCT and its effects on imaging quality for the diagnosis of different oncological conditions. All patients who were part of this study had at least one examination done with DESCT and one prior conventional CT indicating that there was direct comparison between the radiation doses and imaging qualities.

Patients eligible for inclusion in the study were adults aged 18 years or older, with a confirmed diagnosis of an oncological pathology requiring routine follow-up with CT imaging. All included patients had undergone at least one conventional single-energy CT (SECT) and one dual-energy spectral CT (DESCT) examination at the INT IRCCS G. Pascale Foundation between January 2023 and July 2024. Only examinations performed under a standardized acquisition protocol—specifically limited to portal or venous phase were considered. Furthermore, inclusion required the availability of complete clinical records, including detailed radiation dose metrics and imaging parameters.

Patients were excluded from the study if their clinical data were incomplete or if radiation dose measurements, specifically CTDI or DLP, were unavailable due to missing DICOM metadata or PACS documentation, which prevented valid dose analysis. Additional exclusion criteria included patients who had undergone only one type of CT examination (either SECT or DESCT), individuals with contraindications to CT imaging (e.g., severe renal impairment or known allergy to iodinated contrast media), and those whose scans were performed under non-standardized conditions. The latter included multiphasic protocols not aligned with institutional follow-up standards, non-contrast-only scans, examinations affected by severe motion artifacts, or deviations in contrast administration. Pregnant or lactating women were also excluded due to the potential risks associated with radiation exposure.

CT scan protocol

The method used in this research was the usage of Dual Energy Spectral CT (Somatom Drive Dual Source CT System 256 slice) compared to conventional CT (GE Healthcare Lightspeed VCT 64). All participants underwent at least two follow-up CT examinations; one through the conventional CT while the other utilized DESCT following standard acquisition protocol (Table 1) only including either portal or venous phase.

Using Dual Energy Spectral CT Somatom Drive dual source system, which has two X-ray sources operating at different energy levels, dual-energy CT scans were obtained simultaneously from multiple energy spectra. Hence, characterizing tissues better and limiting radiation dose by optimizing imaging parameters are facilitated.

For DECT acquisitions, scans were performed using a Somatom Drive Dual Source CT system (Siemens Healthineers) operating in spectral dual-energy mode with two simultaneously active tubes set at 80 kVp and 140 kVp, controlled by an automatic exposure control system (CARE Dose 4D). Tube current modulation was actively used in all DECT examinations. The reported values of 150 mA (standard) and 80 mA (low dose) refer to reference settings, while actual effective mAs were automatically modulated based on patient size and anatomy. Iterative reconstruction was applied to all DECT scans to enhance image quality and reduce noise. DECT protocols included multiple acquisition phases, specifically both pre-contrast and post-contrast (venous or portal) phases.

On the other hand, the normal CT was done given by GE Healthcare Lightspeed VCT 64, a single-source 64-slice scanner where general protocols for oncological follow-ups were maintained.

In conventional SECT examinations, scans were acquired at a tube voltage of 120 kVp with a fixed tube current of 120 mA in order to maintain protocol consistency across patients and ensure comparability of results. Iterative reconstruction (IR) techniques were used with SECT,

Table 1 Acquisition protocols

Parameter	SECT (GE Lightspeed VCT 64)	DECT (Somatom Drive DS 256)
Tube voltage (kVp)	120	80/140
Tube current (mA)	120 (fixed)	150/80 (auto modulation)
Rotation time (s)	0.5	0.5
Pitch	1.0	1.0
Beam collimation	40 mm	38.4 mm
Slice thickness (mm)	0.5	0.5
Iterative reconstruction	Yes	Yes
Typical scan length (cm)	65 ± 8	64 ± 7

employing the system's standard IR algorithm to improve image quality and reduce noise.

Iterative reconstruction techniques were applied in both SECT and DECT acquisitions to reduce image noise and improve diagnostic quality. For SECT, Adaptive Statistical Iterative Reconstruction was employed with a strength of 40%. For DECT scans, the SAFIRE (algorithm provided by the Siemens system was used at strength level 3. These reconstruction settings were kept constant across all scans to ensure consistency in image quality and quantitative assessments.

Differences in CTDI and DLP between DESCT and conventional CT were included for comparison purposes.

For all DECT examinations, image reconstruction was performed using virtual monochromatic images (VMI) at 70 keV. This energy level was selected because it provides an optimal trade-off between image contrast and noise, and closely resembles the appearance of conventional 120 kVp single-energy images, facilitating a consistent comparison with SECT data.

Outcome assessment

The primary outcomes of interest were the radiation doses measured by CTDI and DLP, and the secondary outcomes included the improvement in image quality between the DESCT and conventional CT.

Radiation Dose Metrics calculated:

CTDI (Computed Tomography Dose Index): The CTDI, which represents the dose per slice of CT scanning, was recorded for each examination with both conventional CT and DESCT. CTDI was measured in milligrays (mGy).
DLP (Dose Length Product): The DLP, representing the total radiation dose accumulated during the scan, was also recorded for both types of CT scans. DLP was measured in milligrays per centimeter (mGy·cm).
The effective dose (ED) was estimated by applying a region-specific conversion coefficient (k-factor) to the DLP values. For abdominal and pelvic CT scans, a factor of $k = 0.014$ mSv/mGy·cm was used, in accordance with ICRP Publication 103 guidelines. Therefore, effective dose was calculated using the formula:

$$ED\ (mSv) = DLP\ (mGy \cdot cm) \times 0.014.$$

Image Quality metrics calculated:

Assessment of image quality was performed by two independent radiologists who were blinded to the type of CT used. Signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) were calculated objectively by placing standardized regions of interest (ROI) in homogeneous tissues and lesion areas, respectively, using the imaging console.

The percentage of cases where DESCT provided superior image quality compared to conventional CT was also calculated.

Statistical analysis

Data analysis was conducted using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). The statistical significance level was set at a p-value < 0.05 for all tests. Baseline characteristics of the patients, including age, gender, and oncological pathology, were summarized using means, medians, and standard deviations for continuous variables, and frequencies and percentages for categorical variables. The mean and standard deviation of the CTDI and DLP values for both conventional CT and DESCT were calculated. A paired t-test was performed to compare the mean radiation doses (CTDI and DLP) between conventional CT and DESCT. This test allowed the comparison of two related samples (i.e., the same patients undergoing two different types of scans). The percentage reduction in radiation dose between the two methods was calculated for each patient, and the overall mean reduction was analyzed.

Results

The majority of patients in the study were in older age groups: 38 patients (42%) were aged 66–80 years, followed by 33 patients (37%) in the 51–65 range. Only 8 patients (9%) were between 36 and 50 years, and a single patient (1%) was over 80. This distribution reflects the well-established higher prevalence of oncological diseases in older adults, particularly those between 51 and 80 years (Table 2).

Regarding cancer types, the most frequent diagnoses were liver (11 patients), colorectal (13), breast (10), and pancreatic cancer (10). Notably, breast cancer was observed in 6 male patients and 4 female patients—an unexpected finding considering its usual predominance in women. Ovarian cancer, as expected, was exclusive to female patients ($n = 5$), while prostate cancer was exclusive to males ($n = 9$). Other cancer types, such as esophageal and lung, showed a slight male predominance (Table 2).

As for cancer staging, Stage I and II cases accounted for 23 and 19 patients, respectively, suggesting that most patients were diagnosed in early or intermediate stages. Stage III included 14 patients, while Stage IV was observed in 24 cases. Interestingly, the proportion of female patients in Stage IV was higher ($n = 15$) compared to males ($n = 9$), which may reflect delayed diagnosis or more aggressive disease progression in some female patients (Table 2).

The results of the paired t-test (Table 3) reveal statistically significant differences between conventional CT (SECT) and dual-energy spectral CT (DECT) across all measured

Table 2 Summary of Patient Demographics, Cancer Types, and Staging by Gender

Category	Subcategory	Female (n)	Male (n)	Total (n)
Age group	36–50	4	4	8
	51–65	20	13	33
	66–80	18	20	38
	> 80	0	1	1
Cancer type	Breast	4	6	10
	Colorectal	6	7	13
	Esophageal	3	9	12
	Liver	5	6	11
	Lung	3	7	10
	Ovarian	5	0	5
	Pancreatic	6	4	10
	Prostate	0	9	9
Cancer stage	I	9	14	23
	II	7	12	19
	III	5	9	14
	IV	15	9	24

parameters, with p-values consistently below 0.001. Specifically, the mean reduction in CTDI was 3.60 mGy (t = 34.408), while DLP showed a substantial decrease of 254.29 mGy·cm (t = 40.488), both indicating a meaningful reduction in radiation exposure with DECT.

A similar trend was observed for the effective dose, which was reduced by an average of 4.32 mSv (t = 40.476).

Box-and-whisker plots comparing CTDI, DLP, and Effective Dose (ED) values between SECT and DECT (Fig. 1). Each metric shows a clear reduction in radiation exposure with DECT. The distributions confirm lower median values and narrower interquartile ranges for DECT compared to SECT, supporting the statistical significance of the dose reduction observed across all parameters.

The comparison of dose reduction across genders shows a slight trend toward greater reductions in male patients (Table 4). Mean values for both absolute and percentage reductions in CTDI and DLP were marginally higher in males. However, ANOVA results revealed no statistically significant differences, with p-values of 0.580 for CTDI reduction, 0.953 for DLP reduction, and similarly

Table 3 Absolute Dose and Image Quality Parameters (SECT vs DECT)

Parameter	SECT (Mean ± SD)	DECT (Mean ± SD)	Mean difference	p-value
CTDI (mGy)	9.30 ± 1.10	5.70 ± 1.00	3.60	< 0.001
DLP (mGy·cm)	875.3 ± 112.5	621.0 ± 95.7	254.3	< 0.001
Effective Dose (mSv)	12.3 ± 2.0	8.0 ± 1.5	4.3	< 0.001
SNR	21.4 ± 3.2	30.1 ± 3.6	–8.7	< 0.001
CNR	12.8 ± 2.1	16.6 ± 2.4	–3.9	< 0.001

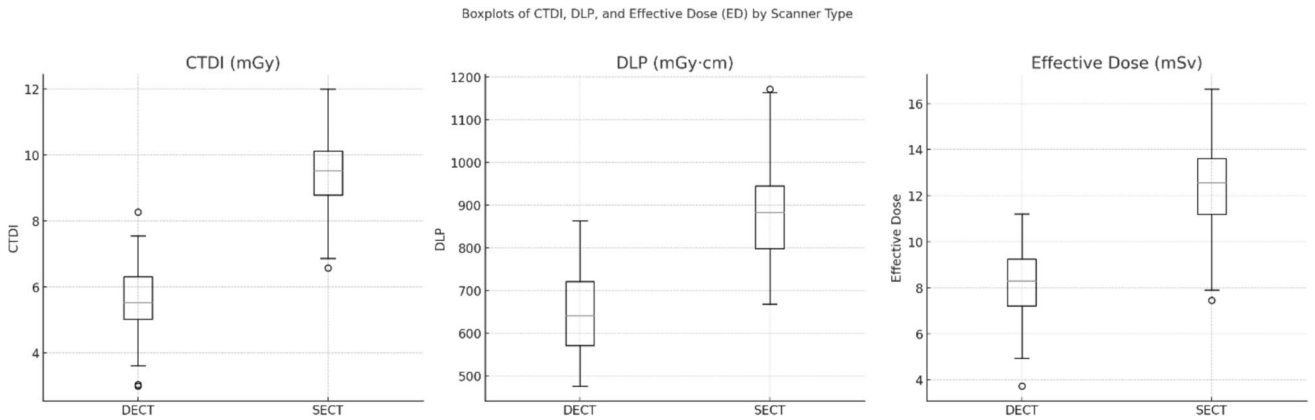

Fig. 1 Box-and-whisker plots comparing CTDI, DLP, and Effective Dose (ED) values

Table 4 Gender-Based Comparison of Dose Reduction Parameters

Parameter	Female (Mean ± SD)	Male (Mean ± SD)	p-value
Percentage reduction in CTDI (%)	38.4 ± 5.2	40.1 ± 4.9	0.580
Percentage reduction in DLP (%)	29.8 ± 6.1	30.2 ± 6.4	0.953
Absolute CTDI reduction (mGy)	3.48 ± 1.02	3.65 ± 0.89	0.481
Absolute DLP reduction (mGy·cm)	243.7 ± 58.6	258.9 ± 54.3	0.580

non-significant values for absolute dose metrics (p = 0.481 and 0.580).

These findings indicate that although minor gender-based differences are observable in the raw data, they do not reach statistical significance, suggesting that radiation dose reduction with DECT is consistent across male and female patients.

Regarding image quality metrics, DECT demonstrated significantly higher values, with a mean increase of 8.73 in SNR (t = –20.814) and 3.86 in CNR (t = –19.396).

These findings provide robust statistical evidence that DECT not only significantly reduces radiation dose compared to SECT but also results in improved image quality in terms of signal-to-noise and contrast-to-noise ratios.

ANOVA results for CTDI and DLP percentage reductions yielded p-values of 0.580 and 0.953, respectively, suggesting that gender does not significantly influence the extent of dose reduction achieved with DECT.

Discussion

DECT has become an important diagnostic modality in follow-up cancer patients. [6, 7, 9, 14].It has a lower radiation exposure but requires shorter scan times and has a high diagnostic yield. Follow-up imaging is needed in cancer patients and, although conventional single-energy CT (SECT) is valuable, it exposes patients to high cumulative radiation doses. DECT solves this problem by allowing the radiologist to obtain better images at two different power levels, thereby reducing the patient's total radiation exposure without compromising the image. DECT is also capable of generating virtual non-contrast (VNC) images; an improvement that eliminates the need for multiple scanning phases. Compared to conventional SECT, where patients received both pre- and post-contrast scans, DECT's ability to construct VNC images from a few contrast-enhanced images eliminated the need for non-contrast acquisition. This results in a reduction in the total radiation dose, which is especially beneficial for cancer patients who require frequent imaging. Cancer patients typically undergo multiple follow-up scans over the years; therefore, it is important to minimize the effects of radiation on their health [10–12, 14].

In addition to reducing radiation exposure, DECT therefore requires small volumes of contrast medium. The use of iodinated contrast media is usually discouraged in cancer patients, as many of them, especially those undergoing chemotherapy, may have impaired kidney function.

DECT offers better results than virtual monochrome imaging (VMI), which aims to improve tissue contrast at different energy levels. This improvement allows less contrast medium to be used during image development, while obtaining better images. Minimizing the volume of contrast medium is important to avoid the development of contrast nephropathy, which can worsen renal failure in predisposed patients [15, 18, 20, 21, 23].

Although taking into account the possibility and advantage of reducing the volume of iodinated contrast medium administered (as reported in several articles in the literature), in our case the same amount was used in all examinations, in relation to the weight of the patient; this allowed an absolutely equal comparison between the examinations performed with the two different equipment.

DECT also improves the detectability of lesions in cancer surveillance follow-up and helps to improve their characterization, which can be useful in early cancer diagnosis and in the development of the therapeutic plan. Pathological conditions involving hypervascular lesions, including liver tumors and some metastatic diseases, are well highlighted by DECT, since lower energy levels improve the contrast of the lesion compared to the surrounding tissues.Several studies have shown that SECT is less effective in identifying hypovascular lesions; therefore, hypovascular lesions, highlighted with the help of DECT, will be considered valuable by a significant number of users. This has improved visualization, allowing radiologists to easily identify small lesions and other related problems at an early stage, thus helping to improve the intervention rate and, consequently, patient outcome [1, 13, 16].

Image quality is an important parameter for reliable DECT imaging, since dual-energy data processing is sensitive to small variations in the Hounsfield unit. Key criteria include spectral separation, temporal uniformity of low- and high-energy data, temporal and spatial resolution of CT images, and dose efficiency, enabling efficient DECT imaging in clinical practice. Image quality can be improved with dual-energy CT (DECT) compared to conventional single-energy CT, especially in some clinical applications, by reducing artefacts such as beam hardening or improving the visualization of iodinated contrast; however, its performance may vary depending on the technique and the specific application. Possible beam hardening artefacts are minimized in DECT, which is an additional advantage of the method. These artefacts, which are frequently observed in SECT, occur in the presence of metal or dense bone around the region of interest, which hinders imaging and diagnosis. An additional advantage of DECT is that these artefacts are minimized by using high-energy monoenergetic images, providing better representation of tumor margins. This is particularly useful for cancer patients who may have received metal implants after surgery, as it allows for better and more accurate treatment planning and follow-ups; However, this aspect is more useful in the staging phase than in the follow-up and for this reason, in our study, mainly focused on the evaluation of dose reduction in oncological follow-up, it does not represent a fundamental aspect [8, 13, 19, 21, 22].

One notable methodological limitation of this study concerns the use of a fixed tube current of 120 mA for SECT acquisitions. This choice was made to maintain consistency across patient scans; however, it does not align with standard CT best practices, which typically recommend the use of automatic tube current modulation to ensure consistent image quality across patients of varying body sizes. This fixed current setting may have introduced some variability in image quality depending on patient habitus. Nevertheless, it is important to highlight that the average CTDI value observed in our SECT scans (9.3 ± 1.1 mGy) is consistent with values reported in the literature for protocols using current modulation, and remains well below commonly accepted diagnostic reference levels (DRLs) for chest and abdominal CT examinations. Therefore, the potential impact of this technical choice on the dose comparison between SECT and DECT is considered limited.

Another aspect to consider is the tube voltage configuration used in DECT acquisitions. The standard dual-energy protocol in our study employed two simultaneously active X-ray tubes set at 80 kVp and 140 kVp. This configuration was applied uniformly to all patients, including those with larger body habitus. It is important to note that modern DECT systems, such as the one used in this study incorporate automated kV selection algorithms (CARE kV) and tube current modulation that adapt scan parameters to patient size and anatomy in real time, optimizing both spectral separation and image quality without requiring manual adjustment.

Although 80/140 kVp provides greater spectral separation than 80/120 kVp, this setting is not necessarily inferior for standard-sized patients. However, for larger patients, the use of 80/140 kVp is generally preferred, as it enhances spectral separation and improves penetration while maintaining sufficient image quality. In our protocol, the 80/140 kVp setting was chosen as a standard to ensure consistent spectral performance across the entire study population. While this may not represent a fully individualized approach, the automated adaptation of tube output and reconstruction algorithms helped ensure diagnostic image quality in all cases.

The study demonstrates that dual-energy spectral CT reduces radiation dose compared to conventional CT, with statistically significant decreases in CT dose ratio (CTDI), dose-length product (DLP), and effective dose. This reduction is consistent across all patients, indicating that dual-energy spectral CT is an effective method to reduce radiation exposure without compromising diagnostic quality. The clinical contribution of this study is that dual-energy spectral CT reduces radiation exposure compared to conventional CT while maintaining diagnostic quality. This reduction in radiation dose, as demonstrated by a lower CT dose ratio (CTDI), dose-length product (DLP), and effective dose, may help mitigate risks associated with radiation exposure, particularly in populations requiring frequent imaging, such as cancer patients. The study found that the mean differences in CTDI and DLP, 3.60 and 254.29, respectively, showed substantial decreases, with p-values well below 0.001, demonstrating a statistically significant difference in favor of dual-energy spectral CT. Furthermore, the mean difference in effective dose (4.32 mSv) further supports the reduction in radiation exposure associated with dual-energy spectral CT. Furthermore, the absence of significant gender differences in dose reduction underscores its broad applicability to different patient groups, further strengthening its value as a fundamental tool in modern diagnostic radiology. This study supports healthcare professionals in making informed decisions and optimizing imaging techniques, while reassuring patients and other providers in terms of reduced risk from therapies.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Carmine Picone and Andrea Magistrelli. The first draft of the manuscript was written by Roberta Fusco, Vincenza Granata, Annamaria Porto,Maria Chiara Brunese, Marcello Zappia, Biagio Pecori, Eugenio Sorgente, Raffaella Mormile, and Claudio Granata. Antonella Santone, Vincenzo Cerciello, Alessandro Ottaiano and Antonella Petrillo commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval It was not required to obtain ethical authorization as this is a retrospective assessment. This study was performed in line with the principles of the Declaration of Helsinki.

Consent to publish Written informed consent was obtained from all partecipants for using anonymized medical images obteined from the facility where the tests were performed.

Consent for publication Informed consent for publication was provided by the participants or a legally authorized representative.

References

1. Shah DJ, Sachs RK, Wilson DJ (2012) Radiation-induced cancer: a modern view. Br J Radiol 85(1020):e1166–e1173
2. Wang J-S, Wang H-J, Qian H-L (2018) Biological effects of radiation on cancer cells. Mil Med Res 5:1–10
3. Ghasemi Shayan R, Oladghaffari M, Sajjadian F, Fazel Ghaziyani M (2020) Image quality and dose comparison of single-energy ct (sect) and dual-energy ct dect. Radiol Res Pract. 202(1):1403957
4. Furlow B (2015) Dual-energy computed tomography. Radiol Technol 86(3):30
5. Noid G et al (2018) Enhancing soft tissue contrast and radiation-induced image changes with dual-energy ct for radiation therapy. Med Phys 45(9):4238–4245
6. Simons D, Kachelrieß M, Schlemmer H-P (2014) Recent developments of dual-energy ct in oncology. Eur Radiol 24:930–939
7. Kupeli A, Bulut E, Cansu A, Guner A, Soyturk M, Danisan G (2019) Contribution of dect in detecting serosal invasion of gastric cancer. Turk J Med Sci 49(3):782–788
8. Hellbach K et al (2017) Dual energy ct allows for improved characterization of response to antiangiogenic treatment in patients with metastatic renal cell cancer. Eur Radiol 27:2532–2537
9. Forghani R (2019) An update on advanced dual-energy ct for head and neck cancer imaging. Expert Rev Anticancer Ther 19(7):633–644
10. Ozdeniz I et al (2017) "Dual-energy ct characteristics of colon and rectal cancer allows differentiation from stool by dual-source ct. Diagnos Intervention Radiol 23(4):251
11. Guerrini S, Bagnacci G, Perrella A, Di Meglio N, Sica C, Mazzei MA (2023) "Dual energy ct in oncology: Benefits for both patients and radiologists from an emerging quan- titative and functional diagnostic technique", in *Seminars in Ultrasound*. CT and MRI, Elsevier 44:205–213
12. Aran S, Shaqdan KW, Abujudeh HH (2014) Dual-energy computed tomography (dect) in emergency radiology: basic principles, techniques, and limitations. Emerg Radiol 21:391–405
13. Johnson TR (2012) Dual-energy ct: general principles. Am J Roentgenol 199(5 supplement):S3–S8
14. Forghani R (2015) Advanced dual-energy ct for head and neck cancer imaging. Expert Rev Anticancer Ther 15(12):1489–1501
15. McLaughlin PD, Mallinson P, Lourenco P, Nicolaou S (2015) Dual-energy computed tomography: advantages in the acute setting. Radiol Clin 53(4):619–638
16. Silva AC, Morse BG, Hara AK, Paden RG, Hongo N, Pavlicek W (2011) Dual- energy (spectral) ct: Applications in abdominal imaging. Radiographics 31(4):1031–1046
17. Borges AP, Antunes C, Curvo-Semedo L (2023) Pros and cons of dual-energy ct systems:"one does not fit all." Tomography 9(1):195–216
18. De Cecco CN et al (2012) Dual-energy ct: oncologic applications. Am J Roentgenol 199(5 supplement):S98–S105
19. Grajo JR, Patino M, Prochowski A, Sahani DV (2016) Dual energy ct in practice: Basic principles and applications. Appl Radiol 45(7):6
20. Alavandar E et al (2022) Principles and available hardware in dect. J Gastrointest Abdom Radiol 5(02):076–084
21. Chau MS (2019) Diagnostic accuracy and radiation dose of dect protocol for follow-up imaging of evar compared to the standard triphasic protocol: a literature review. J Med Radiat Sci 66(S1):117–117
22. Patel BN et al (2020) Cost-effectiveness of dual-energy ct versus multiphasic single-energy ct and mri for characterization of incidental indeterminate renal lesions. Abdom Radiol 45:1896–1906
23. Itani M et al (2019) Clinical and payer-based analysis of value of dual-energy computed tomography for workup of incidental abdominal findings. J Comput Assist Tomogr 43(4):605–611