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Comparison of Radiation Dose and Image Quality between the 2nd Generation and 3rd Generation Dual-Source Single-Energy and Dual-Source Dual-Energy CT of the Abdomen

2세대와 3세대 이중 소스 단일 에너지와 이중 소스 이중 에너지를 이용한 복부 컴퓨터단층촬영의 방사선량 및 영상 품질 비교

Chang Gun Kim, MD[1], See Hyung Kim, MD[2]*, Seung Hyun Cho, MD[1], Hun kyu Ryeom, MD[2], Won Hwa Kim, MD[1], Hye Jung Kim, MD[1]

[1]Department of Radiology, School of Medicine, Kyungpook National University, Kyungpook National University Chilgok Hosptial, Daegu, Korea
[2]Department of Radiology, School of Medicine, Kyungpook National University, Kyungpook National University Hospital, Daegu, Korea

ORCID iDs
Chang Gun Kim https://orcid.org/0000-0003-3980-8624
See Hyung Kim https://orcid.org/0000-0002-3268-3091
Seung Hyun Cho https://orcid.org/0000-0001-7617-7302
Hun kyu Ryeom https://orcid.org/0000-0003-4327-8777
Won Hwa Kim https://orcid.org/0000-0001-7137-9968
Hye Jung Kim https://orcid.org/0000-0002-0263-0941

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***Corresponding author**
See Hyung Kim, MD
Department of Radiology, School of Medicine, Kyungpook National University, Kyungpook National University Hospital, 130 Dongdeok-ro, Jung-gu, Daegu 41944, Korea.

Tel 82-53-200-5390
Fax 82-53-422-2677
E-mail kimseehyung72@outlook.kr

Purpose We compared the radiation dose and image quality between the 2nd generation and the 3rd generation dual-source single-energy (DSSE) and dual-source dual-energy (DSDE) CT of the abdomen.

Materials and Methods We included patients undergoing follow-up abdominal CT after partial or radical nephrectomy in the first 10 months of 2019 (2nd generation DS CT) and the first 10 months of 2020 (3rd generation DS CT). We divided the 320 patients into 4 groups (A, 2nd generation DSSE CT; B, 2nd generation DSDE CT; C, 3rd generation DSSE CT; and D, 3rd generation DSDE CT) (n = 80 each) matched by sex and body mass index. Radiation dose and image quality (objective and subjective

qualities) were compared between the groups.
Results The mean size-specific dose estimation of 3rd generation DSDE CT group was significantly lower than that of the 2nd generation DSSE CT (42.5%, p = 0.013) and 2nd generation DSDE CT (46.9%, p = 0.015) groups. Interobserver agreement was excellent for the overall image quality (intraclass correlation coefficient [ICC]: 0.8867) and image artifacts (ICC: 0.9423).
Conclusion Our results showed a considerable reduction in the radiation dose while maintaining high image quality with 3rd generation DSDE CT as compared to the 2nd generation DSDE CT and 2nd generation DSSE CT.

Index terms Radiography, Dual-Energy Scanned Projection; Computed Tomography, X-Ray; Radiation Dosage

INTRODUCTION

Dual-source dual-energy (DSDE) CT in the abdomen is rapidly becoming a commonly used modality in clinical settings (1). However, radiation exposure from the growing number of abdominal CT examinations is of increasing concern to the medical community (1-3).

Recent technological applications in CT have been focusing on dose reduction and faster acquisition for the reduction of artifacts. Because dose and radiation exposure vary approximately with the square of the voltage in the setting of a constant tube current, lowering the voltage is expected to have a greater effect on patient dose than when reducing the tube current (4-7). Therefore, current dose-reduction strategies primarily rely on reducing radiation output from the scanner. However, the inherent trade-off involves greater image noise and diminished image quality. In particular, the DSDE CT system is equipped with two independent X-ray tube detector systems at different voltages. The DSDE technology offers the potential to improve image contrast and increase intravascular iodine signal under suboptimal contrast conditions (3, 5, 6-8).

The recently introduced 3rd generation DSDE CT system provides substantially higher X-ray tube current reserves, additional dual-energy tube voltage combinations, and a thicker tin filter for the high-kV tube that increases spectral separation for improved material decomposition (7-10). Consequently, our study hypothesis was that the use of 3rd generation DSDE CT would result in decreased radiation dose to patients without a significant decrease in image quality.

Thus, the purpose of this study was to compare dual-source single-energy (DSSE) CT and DSDE abdominal CT examinations in matched patient groups to assess the potential differences in radiation dose and image quality performed with 2nd and 3rd generation DSDE CT systems.

MATERIALS AND METHODS

PATIENT POPULATION

This retrospective, single-centered study was approved by our Institutional Review Board, and informed consent was waived (IRB No. B-2019/231).

We included adult patients (> 20 years old) who underwent CT examinations at the Division of Genitourinary Radiology of Kyungpook National University Hospital. Patients were scanned in the first 10 months of 2019 with 2nd generation DS CT system and in the first 10 months of 2020 with a 3rd generation DS CT system.

Examination protocols included abdominal studies in oncologic patients undergoing follow-up after partial or radical nephrectomy for renal cell carcinoma; a total of 320 patients were divided into 4 groups of 80 each. The groups were then matched by sex (50 males and 30 females in each group) and body mass index (BMI, target group value of 27.5 kg/m^2) to allow for direct comparison of study groups. Our hospital has been using the 2nd generation DSDE CT system with the 3rd generation DSDE CT since November 2018.

We included matched cohorts of the last subsequent patients who underwent abdominal 2nd generation DSSE CT scanning (group A) or DSDE CT (group B) prior to 3rd generation DS CT scanning. After a time interval of 1 month, to allow CT technicians to become familiar with new scanners and examination protocols, we compiled two matching control groups of patients who were examined using a 3rd generation abdominal DSSE CT (group C) or DSDE CT (group D) protocol. Repeated examinations of the same patients from the same groups were excluded. Indications for imaging were also recorded.

IMAGE ACQUISITION

Groups A and B were examined using a 2nd generation DS CT system (Somatom Definition Flash, Siemens Healthineer, Forchheim, Germany), whereas scans of groups C and D were performed using a 3rd generation DS CT system (Somatom Definition Force, Siemens Healthineer). Automated tube current modulation (average setting, CARE Dose4D) was activated in all examinations. Automated tube voltage selection was not used. Standard soft-tissue kernels were used. A single-image series was created for each DSDE CT case using standard linear blending from the spectral data sets. The injection protocols were the same for all examinations, and they consisted of 100 mL of contrast material (Xenetics 300 mgI/mL, Iobitridol, Guerbet, France) at a flow rate of 2 mL/s followed by a 20-mL saline flush using a dual-headed pump injector. CT image acquisition during the late portal venous phase (70–80 seconds) was initiated using the bolus-tracking technique (CARE Bolus, Siemens Healthineer) after a trigger threshold of 150 Hounsfield units (HU) was reached within a region of interest (ROI) placed in the abdominal aorta just below the diaphragmatic dome. After completion of image acquisition, images were transferred to a dedicated workstation (Syngo.via, Siemens Healthineer) for further analysis. The image acquisition and postprocessing parameters are listed in Table 1.

RADIATION DOSE RETRIEVAL

Data were acquired by radiation dose index monitoring (Radimetrics, Bayer Healthcare, Whippany, NJ, USA), collecting all the information present on the DICOM header and on the DICOM radiation dose structured report to obtain information on the single scans. Patient age, BMI, kVp, X-ray tube current per rotation (mAs), total exposure time (ms), slice thickness (ST), and spacing (SP) were retrieved. When DE CT was performed, a low kVp was reported; the high kVp was always 150 Sn kV. Regarding the dose parameters, the mean volume CT dose

Table 1. Image Acquisition and Post-Processing Parameters for the Different Abdominal CT Protocols

Parameter	Group A	Group B	Group C	Group D
Scanner generation	Second	Second	Third	Third
Acquisition mode	DSSE	DSDE	DSSE	DSDE
Detector configuration	128 × 0.6	2 × 64 × 0.6	192 × 0.6	2 × 64 × 0.6
Tube voltage, kVp	120	80/140	100	90/150
Reference, mAs	230	230/178	214	180/90
Pitch	0.6	0.6	0.6	0.6
Iterative reconstruction	SAFIRE (level 3)	SAFIRE (level 3)	ADMIRE (level 3)	ADMIRE (level 3)
Kernel	I30f	Q30f	Br36	Br36
Section thickness, mm	3	3	3	3
Section increment, mm	1	1	1	1
Tin filter	-	Selective Photon Shield	-	Selective Photon Shield II
Dual-source image blending	-	60% 80 kVp/ 40% 140 kVp	-	70% 90 kVp/ 30% 150 kVp

ADMIRE = advanced modeled iterative reconstruction, DSDE = dual-source dual-energy, DSSE = dual-source single-energy, SAFIRE = sinogram affirmed iterative reconstruction

index ($CTDI_{vol}$ [mGy]), the total dose length product (DLP [mGy·cm]) and the calculated size-specific dose estimation (SSDE [mGy; Radimetrics, Bayer Healthcare]) were extracted.

IMAGE QUALITY ANALYSIS

Objective and subjective image quality was assessed for all patients in a blinded and randomized fashion at an offline workstation. All technical and personal identifiers were removed from the images. The CT attenuation of tissues (HU), image noise (standard deviation of CT attenuation values), signal-to-noise ratio (SNR), and contrast-to-noise ratio (CNR) were assessed within the same four areas (liver [left medial, right anterior, and right posterior segments of the liver at the level of the main portal vein], pancreas [head and body], kidneys, abdominal aorta, and main portal vein) using an ROI of at least 10 mm^2 (aorta, 40 mm^2) by one experienced radiologist (Y.H.K., with 18 years of experience in abdominal CT imaging). To calculate the CNR, ROIs were additionally measured in the bilateral psoas muscles. In addition, the image noise was measured in the adjacent mesenteric fat.

Subjective image quality was initially assessed independently by two radiologists (K.S.H. and C.S.H., with 15 and 13 years of experience in abdominal CT imaging, respectively) and subsequently in a consensus reading to reconcile discrepant scales. Both radiologists rated the image quality and image artifacts on a five-point scale. The overall image quality was scored as follows: score 1, severe distortion; score 2, poor quality; score 3, fair but compromised quality; score 4, good quality; and score 5, excellent quality. For image artifacts, the scale used was as follows: score 1, unacceptable; score 2, deemed acceptable for limited clinical condition; 3, acceptable; 4, good; and 5, excellent.

STATISTICAL ANALYSIS

Continuous variables were expressed as the mean ± standard deviation, and categorical variables were expressed as percentages. Comparisons among the groups were analyzed using two-way analysis of variance if data were normally distributed according to the Shapiro–Wilk test. In contrast, the Kruskal–Wallis two-way analysis of variance was used if the data were not normally distributed. Spearman correlation analysis was performed to assess the effect of patient BMI on SSDE. Subsequent Bonferroni correction was performed to account for multiple testing influences, and Tamhane T2 post-hoc testing was performed when variances in Levene statistics were not equal.

The radiologist agreement on subjective image quality score was quantified using the intraclass correlation coefficient (ICC; using a two-way mixed model for consistencies with the average measures coefficient as the outcome). ICC values of 0.5–0.75, 0.75–0.90, and > 0.90 were considered moderate, good, and excellent, respectively. To compare differences in diagnostic image quality among the four groups, a single dichotomous variable was derived by using the overall image quality, image artifacts, and radiologist confidence scores as acceptable versus unacceptable given by each radiologist. This dichotomous variable reflected image acceptability of any case if all scores by all observers were 3 or higher, or, conversely, if at least one score was 1 or 2. X^2 or Fisher's exact test was used to compare the proportions of acceptable images.

Statistical significance was set at $p < 0.05$. Statistical analyses were performed using SPSS version 18.0 (SPSS Inc., Chicago, IL, USA).

Table 2. Patient Demographic Data and Dosimetric Parameters for the Different Abdominal CT Protocols

Parameter	Group A	Group B	Group C	Group D	*p*-Value
Age, years	48.5 ± 12.2	50.5 ± 15.7	44.5 ± 14.9	46.5 ± 16.5	All ≥ 0.981
Body mass index, kg/m^2	27.2 ± 2.6	27.8 ± 2.1	27.4 ± 3.1	27.9 ± 2.3	All ≥ 0.928
Effective tube current-time product per tube, mAs	97 ± 26	74 ± 12	90 ± 24	71 ± 8	A vs. B, 0.873 All other < 0.051
Reference tube current-time product per tube, mAs	80	80	80	80	All ≥ 0.953
CT dose index, mGy	7.9 ± 3.1	8.3 ± 2.9	5.2 ± 2.5	4.8 ± 2.1	A vs. B, 0.921 C vs. D, 0.893 All other < 0.032
Dose length product, mGy · cm	417.7 ± 62.4	452.9 ± 61.5	320.8 ± 42.6	297.3 ± 50.9	A vs. B, 0.755 C vs. D, 0.641 All other < 0.037
Size-specific dose estimation	7.3 ± 2.9	7.9 ± 2.7	4.9 ± 2.6	4.2 ± 2.3	A vs. B, 0.982 C vs. D, 0.957 All other < 0.024

Group A = 2nd generation DSSE CT scanning, Group B = 2nd generation DSDE CT scanning, Group C = 3rd generation DSSE CT scanning, Group D = 3rd generation DSDE CT scanning.
DSDE = dual-source dual-energy, DSSE = dual-source single-energy

RESULTS

PATIENT POPULATION

The demographic characteristics of each group are summarized in Table 2. Since patient cohorts were matched by age, sex, and BMI, no significant differences in these parameters were found among the four matched groups, although the standard deviations varied. Average patient age varied between groups ranging from 45.5 ± 18.5 years to 62.5 ± 12.8 years.

RADIATION DOSE

The dosimetric parameters for portal phase abdominal CT are summarized in Table 2. A significant positive correlation between patient BMI and SSDE was found in each group (2nd generation DSSE CT, $r^2 = 0.607$; 2nd generation DSDE CT, $r^2 = 0.798$; 3rd generation DSSE CT, $r^2 = 0.516$; 3rd generation DSDE CT, $r^2 = 0.507$; all p values < 0.005). The mean SSDE dose based on the DLP values was the lowest in 3rd generation DSDE CT and without significant differences compared to 3rd generation DSSE CT ($p = 0.957$), but it was significantly lower than the mean SSDE in 2nd generation DSSE CT ($p = 0.013$) and in 2nd generation DSDE CT ($p = 0.015$). The highest radiation dose was found in 2nd generation DSDE CT. Overall, all differences among the patients examined with 2nd and 3rd generation CT were significant (all $p < 0.05$). However, differences between DSSE CT and DSDE CT were not significant, regardless of the type of scanner generation used (all $p \geq 0.957$). Consequently, the mean SSDE was 42.5%, 46.9%, and 14.2% lower with the 3rd generation DSDE CT system.

OBJECTIVE IMAGE QUALITY

All examinations were completed without any complications, and contrast enhancement was rated as sufficient in all patients. The results of the objective image analyses are presented in Table 3. For comparison of SNR, the mean attenuation values were significantly higher with 3rd generation DSSE or DSDE CT system than with 2nd generation DSSE CT system ($p = 0.032$ and $p = 0.027$, respectively) in the liver, abdominal aorta, and portal vein. In addition, the mean attenuation values were significantly higher with 3rd generation CT than with 2nd generation CT in the kidney, with a significantly higher value for the 3rd generation DSDE CT ($p = 0.042$). No other comparisons regarding mean attenuation values were found to be statistically significant.

In the assessment of CNR, 3rd generation DSDE CT was significantly higher than 2nd generation CT and 3rd generation DSSE CT (all $p < 0.05$), with the exception of the pancreas and abdominal aorta. For the pancreas and abdominal aorta, 3rd generation DSDE CT was not significantly higher than 3rd generation DSSE CT but was significantly higher than 2nd generation CT. 3rd generation DSSE CT was significantly higher than 2nd generation DSSE and DSDE CT for the kidney and abdominal aorta. No significant differences were found in the CNR between 2nd generation DSSE CT and DSDE CT.

SUBJECTIVE IMAGE QUALITY

Overall interobserver agreement was excellent for both parameters (ICC: 0.9279), agreement on overall image quality (ICC: 0.8867), and agreement on image artifacts (ICC: 0.9423). No significant differences were found in all pairwise comparisons. Overall image quality was

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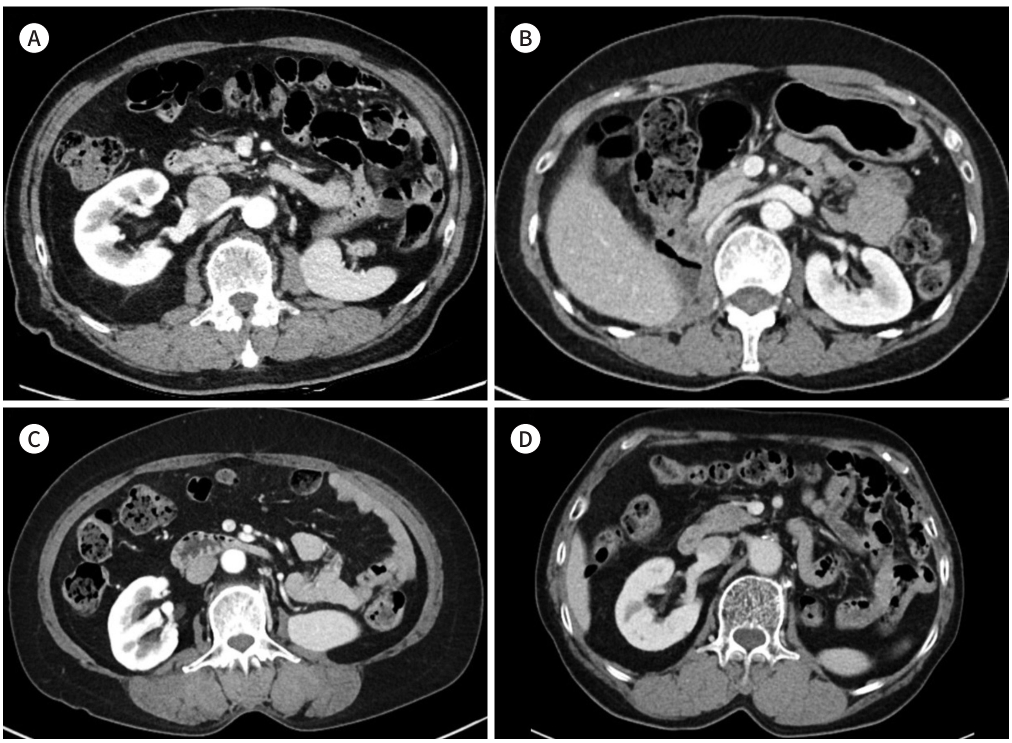
Table 3. Objective and Subjective Image Assessments for the Four Abdominal CT Protocols

Parameter	Group A	Group B	Group C	Group D	*p*-Value
Mean signal-to-noise ratio					
Liver	8.2 ± 2.3	8.7 ± 1.9	9.7 ± 2.2	9.7 ± 2.3	A vs. C, 0.032 A vs. D, 0.027 All other > 0.05
Pancreas	7.4 ± 1.3	7.5 ± 1.6	7.5 ± 2.2	7.7 ± 2.4	All ≥ 0.389
Kidneys	13.5 ± 6.8	13.3 ± 6.9	17.4 ± 7.7	19.2 ± 6.2	A vs. B, 0.872 All other ≤ 0.042
Abdominal aorta	16.4 ± 7.7	17.2 ± 6.2	19.1 ± 5.9	20.2 ± 5.2	A vs. B, 0.792 C vs. D, 0.059 All other ≤ 0.034
Portal vein	15.3 ± 5.5	16.4 ± 4.7	16.9 ± 5.3	19.8 ± 5.1	A vs. B, 0.875 A vs. C, 0.067 All other ≤ 0.043
Mean contrast-to-noise ratio					
Liver	3.4 ± 1.5	3.8 ± 1.3	4.2 ± 2.1	5.9 ± 1.9	A vs. C, 0.032 B vs. D, 0.015 C vs. D, 0.035 All other > 0.059
Pancreas	2.2 ± 1.1	2.4 ± 1.5	2.5 ± 2.4	2.8 ± 2.3	C vs. D, 0.089 All other ≤ 0.041
Kidneys	7.2 ± 7.1	7.8 ± 4.9	9.2 ± 3.9	12.8 ± 4.4	A vs. B, 0.026 A vs. C, 0.025 A vs. D, 0.021 B vs. D, 0.027 C vs. D, 0.032 B vs. C, 0.035 All other > 0.05
Abdominal aorta	7.4 ± 3.7	8.2 ± 4.2	9.8 ± 4.0	9.9 ± 3.9	A vs. B, 0.023 A vs. C, 0.038 C vs. D, 0.121 B vs. C, 0.028 All other > 0.784
Portal vein	8.3 ± 3.9	9.5 ± 4.5	10.2 ± 4.1	14.5 ± 4.5	A vs. B, 0.031 A vs. C, 0.025 A vs. D, 0.013 All other > 0.252
Overall image quality	4.53 ± 0.05	4.52 ± 0.04	4.47 ± 0.04	4.35 ± 0.04	All ≥ 0.899
Image artifacts	4.31 ± 0.06	4.28 ± 0.05	4.25 ± 0.04	4.20 ± 0.03	All ≥ 0.889

Group A = 2nd generation DSSE CT scanning, Group B = 2nd generation DSDE CT scanning, Group C = 3rd generation DSSE CT scanning, Group D = 3rd generation DSDE CT scanning.
DSDE = dual-source dual-energy, DSSE = dual-source single-energy

consistently rated as good or excellent in all groups, with mean values ranging from 4.52 ± 0.04 to 4.47 ± 0.04. Subjective assessment of the presence of image artifacts was similarly consistent and received good or excellent scores with mean values ranging from 4.20 ± 0.03 to 4.31 ± 0.06. After dichotomization into acceptable and unacceptable image quality, all examinations in 2nd generation DSDE CT and 3rd generation CT were considered acceptable.

Fig. 1. Images of patients undergoing the four CT protocols.
A. Group A (2nd generation DSSE CT) of a 52-year-old male with a BMI of 29.1 kg/m^2 and calculated SSDE of 7.6.
B. Group B (2nd generation DSDE CT) of a 42-year-old male with a BMI of 28.8 kg/m^2 and calculated SSDE of 7.5.
C. Group C (3rd generation DSSE CT) of a 48-year-old female with a BMI of 26.1 kg/m^2 and calculated SSDE of 5.2.
D. Group D (3rd generation DSDE CT) of a 54-year-old female with a BMI of 27.4 kg/m^2 and calculated SSDE of 4.8.
All patients had a history of partial or radical nephrectomy. All images are shown with identical standard abdominal window settings (level, 70 HU; width, 280 HU).
BMI = body mass index, DSDE = dual-source dual-energy, DSSE = dual-source single-energy, HU = Hounsfield units, SSDE = size-specific dose estimation



A total of 79 of 80 (98.7%) examinations in 2nd generation SE CT were considered acceptable. The examination was considered unacceptable only due to image artifacts. Fig. 1 shows a representative example.

DISCUSSION

In this study, DSDE CT demonstrated excellent image quality and provided a significantly lower radiation dose exposure compared to SE CT with both DS CT scanner generations. In recent years, DSDE CT has been proposed for portal venous phase abdominal CT examinations in oncologic patients with concerns about potential risks in terms of induced cancers after radiation exposure (11, 12).

The application of a 3rd generation DSDE CT examination could reduce radiation exposure without image quality impairment compared with 2nd generation DSSE CT (42.5%, $p = 0.013$) and 2nd generation DSDE CT (46.9%, $p = 0.015$). In addition, 3rd generation DSDE CT provided the highest dose-independent CNR value as an indicator of objective image quality (11-13). To maintain adequate image quality, a balance between the optimal tube voltage and tube current must be determined. However, in this study, both noise and attenuation increased significantly when the tube voltage setting was lowered from 120 to 100 kVp, resulting in adequate SNRs and CNRs in abdominal organs for diagnostic decisions. We were able to show a further increase in both SNR and CNR with 3rd generation DSDE CT compared with the 2nd generation DSSE and DSDE CT (13). A higher SNR and CNR may be linked to numerous factors. First, this effect is based on the fact that the mean photon energy of polychromatic X-ray beams generated by low-tube voltage protocols is closer to the k-absorption edge of iodine (14). Thus, the photoelectric effect is enhanced, resulting in an improved vessel-to-tissue contrast. In addition, 3rd generation DSDE CT is equipped with stellar detectors, which are supposed to be more sensitive to electron influx and, thus, dose-efficient. Second, in this study, 3rd generation DSDE CT data with advanced modeled iterative reconstruction (ADMIRE) were used. Previous studies have shown that the use of ADMIRE instead of standard filtered back-projection enables a noise reduction of up to 40% (12). A recent phantom study (15) in which the 3rd generation iterative reconstruction (IR) algorithm was compared with a 2nd generation algorithm with an equivalent dose, but different scanning parameters for a chest study, demonstrated the advantages of the 3rd generation IR algorithm over the 2nd generation. However, the additional extent to which the 3rd generation IR technique led to noise reduction compared with the 2nd generation, using the same scanning parameters, was not assessed in this study. Interestingly, subjective image quality assessment did not reveal any differences in image quality among the three abdominal CT protocols.

Another advantage of low-tube voltage imaging is the resulting reduction in the radiation dose requirements (16-18). As expected, with low-dose abdominal CT examinations, we achieved lower CTDI values in all patient groups. The higher median tube current with DS CT in these groups of patients has to be related to the frequent use of spectral shaping with a tin filter, which is compensated by the tube current (19, 20). Even though the evidence in terms of dose reduction with spectral shaping is less robust for the patient population, we recorded a lower dose in terms of total DLP in smaller patients, whereas it was comparable in older patients. Moreover, in the abdominal scan obtained using DSDE CT, sequential acquisitions planned on single-source CT were avoided with not only volumetric acquisitions with more images but also more information and better anatomical coverage.

In our study, we evaluated a routinely applied 120-kV protocol for 2nd generation DSSE CT and compared it with a standard 100-kV 3rd generation DSSE CT protocol used at our institution. In most current CT scanner generations, automated attenuation-based tube voltage selection (ATVS) and tube current modulation techniques are available (21, 22). A previous study showed that a lower tube voltage was selected in the majority of patients with 3rd generation DS CT ATVS compared to previous examinations for the same patients with 2nd generation DS CT ATVS (23). Thus, the application of dedicated ATVS may result in lower radiation exposure with SE CT. However, DE CT may allow for additional dose reduction compared to SE CT by calculating virtual unenhanced images from contrast-enhanced imaging as a substitute for conventional unenhanced images (22-24). In addition, patient-specific optimized spectral separation based on patient size and body habitus may improve the dose efficiency of DE CT (24).

This study has some limitations. First, the retrospective design limited the inclusion criteria, homogeneity of the population, and CT examination protocol. Furthermore, we chose an equivalent number of patients per group to minimize the influence of different population sizes, which might have resulted in selection bias. Second, the diagnostic accuracy was not assessed for each image dataset despite the homogenous indications for imaging. Finally, the results of our study apply only to the DS CT system. Other technical DE approaches may yield different results.

In conclusion, this study compared objective and subjective image quality, as well as the radiation dose, between the two latest generations of DS CT systems with the abdominal portal venous phase. Our results showed a considerable reduction in radiation dose with maintained image quality with the use of a 3rd generation DSDE CT compared with the use of 2nd generation DSDE and DSSE CT. The more robust capabilities for SE or DE CT using the DS CT system may bode well for the routine implementation of such protocols in clinical practice.

Author Contributions

Conceptualization, K.C.G., K.S.H., C.S.H., R.H.K.; investigation, K.C.G., K.S.H., K.W.H., K.H.J.; project administration, K.C.G., K.S.H.; resources, K.C.G., K.S.H., K.W.H., K.H.J.; supervision, K.S.H.; visualization, K.C.G., K.S.H., K.W.H., K.H.J.; writing—original draft, K.C.G., K.S.H.; and writing—review & editing, K.C.G., K.S.H.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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2세대와 3세대 이중 소스 단일 에너지와 이중 소스 이중 에너지를 이용한 복부 컴퓨터단층촬영의 방사선량 및 영상 품질 비교

김창건[1] · 김시형[2]* · 조승현[1] · 염현규[2] · 김원화[1] · 김혜정[1]

목적 2세대 및 3세대 이중 소스 단일 에너지와 이중 소스 이중 에너지를 이용한 복부 CT의 방사선량과 영상 품질을 비교하였다.

대상과 방법 부분 또는 근치적 신절제술 후 2019년 첫 10개월(2세대 이중 소스 CT)과 2020년 첫 10개월(3세대 이중 소스 CT)에 추적관찰 복부 CT를 시행한 환자들을 대상으로 하였다. 총 320명의 환자를 성별과 체질량지수에 따라 각각 80명씩 4개 그룹으로 나누었다(A, 2세대 이중 소스 단일 에너지 CT; B, 2세대 이중 소스 이중 에너지 CT; C, 3세대 이중 소스 단일 에너지 CT 및 D, 3세대 이중 소스 이중 에너지 CT). 각 그룹 간 방사선량과 영상 품질(객관적, 주관적 품질)을 비교하였다.

결과 3세대 이중 소스 이중 에너지 CT의 평균 신체 크기 특이적 선량 추정값은 2세대 이중 소스 단일 에너지 CT (42.5%, $p = 0.013$)와 2세대 이중 소스 이중 에너지 CT (46.9%, $p = 0.015$)보다 의미 있게 낮았다. 관찰자 간 일치는 전반적인 영상 품질(intraclass correlation coefficient [이하 ICC]: 0.8867) 및 인공물(ICC: 0.9423)에서 높은 일치도를 보였다.

결론 3세대 이중 소스 이중 에너지 CT는 2세대 이중 소스 이중 에너지 CT 및 이중 소스 단일 에너지 CT와 비교하여 높은 영상 품질을 유지하면서 방사선량을 상당히 감소시킨 결과를 보여주었다.

[1]경북대학교 의과대학 칠곡경북대학교병원 영상의학과,
[2]경북대학교 의과대학 경북대학교병원 영상의학과