Utilization of virtual low-keV monoenergetic images generated using dual-layer spectral detector computed tomography for the assessment of peritoneal seeding from ovarian cancer

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Abstract
This study aimed to compare the quality of virtual low-keV monoenergetic images vs conventional images reconstructed from dual-layer spectral detector computed tomography (SDCT) for the detection of peritoneal implants of ovarian cancer.

Fifty ovarian cancer patients who underwent abdominopelvic SDCT scans were included in this retrospective study. Virtual monoenergetic images at 40 (VMI\textsubscript{40}) and 50 keV (VMI\textsubscript{50}), and two conventional images were reconstructed using filtered back projection (FBP) and iterative model reconstruction (IMR) protocols. The mean attenuation of the peritoneal implant, signal-to-noise ratio (SNR), contrast-to-noise ratio relative to ascites (CNR\textsubscript{A}) and adjacent reference tissues (e.g., bowel wall, hepatic, or splenic parenchyma [CNR\textsubscript{R}]) were calculated and compared using paired t tests. Qualitative image analysis regarding overall image quality, image noise, image blurring, lesion conspicuity, was performed by two radiologists. A subgroup analysis according to the peritoneal implant region was also conducted.

VMI\textsubscript{40} yielded significantly higher mean attenuation (183.35) of SNR and CNR values (SNR 11.69, CNRA 7.39, CNRB 2.68), compared to VMI\textsubscript{50}, IR, and FBP images (P < .001). The mean attenuation (129.65), SNR and CNR values (SNR 9.37, CNRA 5.72, CNRB 2.02) of VMI\textsubscript{50} were also significantly higher than those of IR and FBP images (P < .001). In the subgroup analysis, all values were significantly higher on VMI\textsubscript{40} regardless of the peritoneal implant region (P < .05). In both readers, overall image quality and image blurring showed highest score in VMI\textsubscript{40}, while image noise and lesion conspicuity showed best score in IMR and VMI\textsubscript{40} respectively. Inter-reader agreements are moderate to almost perfect in every parameter.

The low-keV VMIs improved both quantitative assessment and lesion conspicuity of peritoneal implants from ovarian cancer compared to conventional images.

Abbreviations: CNR = contrast-to-noise ratio, DECT = dual-energy computed tomography, SD = standard deviation, SDCT = spectral detector computed tomography, SNR = signal-to-noise ratio, VMI = virtual monoenergetic image.

Keywords: dual-energy CT, dual-layer spectral detector CT, ovarian cancer, peritoneal implant, virtual monoenergetic image.

1. Introduction
Approximately 90% of ovarian cancers are epithelial ovarian cancers. It most frequently disseminates via the transcoelomic route except for direct extension, with about 70% of patients having peritoneal metastases at staging laparotomy.\textsuperscript{[1]} Cyto-reductive surgery is considered for epithelial ovarian cancer at the time of initial treatment and recurrence, and it has been established that improved survival after surgery is associated...
with minimal-volume residual disease.[2] So the accurate imaging-based detection of peritoneal metastases is important to the staging and follow-up of ovarian cancer. Currently, computed tomography (CT) is considered the best imaging modality for the evaluation of patients with known or suspected peritoneal metastases.[3,4] Recent study of peritoneal implants from ovarian tumors have indicated a sensitivity of 83% and a specificity of 86% for the correlation of pathologic and CT diagnoses.[5] The sensitivity decreased to 25% to 50% for detection of implants less than 1 cm in size.[6]

Recent technical developments in the field of clinical radiology have led to a re-emergence of dual-energy CT (DECT).[7] Dual-layer spectral detector CT (SDCT), the most recently developed dual-energy technique, uses a single polychromatic x-ray source and spectral detector CT (SDCT), the most recently developed dual-energy technique, uses a single polychromatic x-ray source and detects the photons of lower energies in the surface and of higher energies in the layer below.[8] This allows dual-energy analysis to be performed on every data set acquired, which enables to generate spectral images such as virtual monoenergetic image (VMI). In several studies, low-energy VMIIs generated via SDCT have yielded high levels of contrast between iodine-enhanced lesions and adjacent tissue.[9,10] Because the peritoneal implants enhance with intravenous contrast material, we presumed low-energy VMIIs in SDCT may be helpful for assessment of peritoneal seeding, even in small lesion. The present study aimed to compare the image quality of low-keV VMIs with conventional images reconstructed using SDCT to address the challenges associated with the assessment of peritoneal implants of ovarian cancer.

2. Materials and methods

2.1. Patient selection

This retrospective, single-center study was approved by Institutional Review Board of Seoul National University Hospital (IRB No: 1805-066-946). The requirement for written informed consent was waived due to the mandatory nature of abdominopelvic CT examination during routine clinical practice. We retrospectively evaluated a total of 50 abdominopelvic CT scans from ovarian cancer patients that were obtained at our institution using a standard DECT protocol during follow-ups for ovarian cancer between February and July 2017. The 50 images were obtained from 50 female patients with a mean age of 58.02 ± 12.19 years. All patients met the following eligibility criteria:

1. Pathological diagnosis of ovarian cancer,
2. Receipt of abdominopelvic SDCT scans with available virtual monoenergetic reconstructions,
3. Previous abdominopelvic CT scans available for comparison, and
4. Available clinical data, including laboratory findings such as the serum carbohydrate antigen (CA)-125 level.

For all patients, the electronic medical records regarding pathologic findings, laboratory findings, operative history, body mass index and clinical course were reviewed. The demographics of the study population are summarized in Table 1.

2.2. Image acquisition

Imaging data were acquired on a 128-channel SDCT (IQON spectral CT; Philips Healthcare, Cleveland, OH) with a tube voltage of 120-kVp under automated tube current modulation. The acquisition parameters were as follows: rotation time: 0.33 s; detector collimation: 64 × 0.625 mm; pitch: 0.891; matrix: 512 × 512. All axial images were reconstructed with a slice thickness of 3 mm and a slice increment with 3 mm. The scan range was from the top of the liver to the pubic symphysis. Iodinated contrast media at a concentration of 350 mgI/mL (iohexol; Bonorex 350, Central Medical Service, Seoul, South Korea) was administered into a peripheral vein in the upper extremity via an automatic power injector at a total dosage of 1.6 ml/kg over 30 s. Biphasic post-contrast imaging was performed to include the arterial (30-s delay after the aortic signal reached 100 HU using the bolus tracking method) and delayed (fixed 3-min delay) phases, as indicated clinically. Because arterial phase did not cover upper abdomen in this protocol, only delayed phase images were subjected to analysis.

For delayed phase images, conventional 120-kVp images were reconstructed using filtered back projection (FBP) and iterative reconstruction algorithms, iterative model reconstruction (IMR). VMIs were reconstructed at 40 (VMI40) and 50 keV (VMI50) retrospectively. IMR was also used. Previous CT examinations for comparison were taken with same protocol, CT parameters, type and quantity of contrast agent as above, and reconstructed to the same conventional FBP and IMR images.

2.3. Quantitative image analysis

The VMI40, VMI50, FBP, and IMR images were retrospectively subjected to an objective image analysis using a commercially available PACS workstation (Infinitt, Infinitt Healthcare, Seoul, Korea). Upon achieving consensus, two radiologists obtained mean and standard deviation (SD) CT attenuations (in Hounsfield units; HU) for the peritoneal implant, adjacent tissue parenchyma (bowel wall, liver or splenic parenchyma), and ascites by manually placing circular ROIs at the same image level for every image set. Peritoneal implants were defined as nodular, plaque-like or infiltrative soft tissue lesions in peritoneal fat or on the serosal surface with parietal peritoneal thickening or enhancement and, most importantly, an unequivocal size increase or new appearance.

| Characteristic | Value |
|---------------|-------|
| Mean age (years)* | 58.02 (36–89) |
| Mean weight (kg) | 52.5 (32.2–76.8) |
| Mean BMI (kg/m²)* | 21.6 (14.2–33.7) |
| Median CA-125 level at the time of previous CT exam (UI/mL)* | 81.52 ± 32.33 |
| Median CA-125 level at the time of DECT exam before (UI/mL)* | 167.95 (20–1316) |
| Median CA-125 level at the time of last CT exam before DECT exam (UI/mL)* | 114 (6.2–935) |

*Numbers in parentheses are ranges.
†Values are expressed as mean ± standard deviation.
since previous exam that exhibited the same trend as the increase of serum CA-125 level. The size change of peritoneal implants were assessed in IMR images at delayed phase side by side.

The single ROI was drawn in the most enhancing solid portion of the peritoneal implant (mean size: 34.5 mm²). The lesions which were under 0.3 cm in size were excluded for evaluation for the accuracy of measurement. If the peritoneal implant was located near the bowel, another ROI was drawn in the most homogeneous area of adjacent small or large bowel wall (mean size: 36.2 mm²) (Fig. 1A). In case of the peritoneal implant was located in the surface of liver or spleen, ROI was drawn in the adjacent liver or splenic parenchyma (mean size: 85.5 mm²) (Fig. 1B). Large vessels, bile duct, areas of necrosis or calcification, and focal lesions were carefully avoided. Additionally, the ROI was also drawn in the most nearby ascites for each peritoneal implant (mean size: 87.2 mm²).

Image sets from the same examination, including the sizes, shapes, and positions of the ROIs, were kept constant at the workstation by using the copy and paste function. The peritoneal cavity was classified into seven regions: perihepatic space, perisplenic space, right paracolic gutter, left paracolic gutter, small bowel mesentery, sigmoid mesocolon, and posterior-cul-de-sac (PCDS). Each peritoneal implant was evaluated according to these regions.

For each image set, the signal-to-noise ratio (SNR) of the peritoneal implant and contrast-to-noise ratio relative to the ascites (CNRA) and adjacent reference tissue such as bowel wall, liver or splenic parenchyma (CNRB) were calculated respectively using the following equations:

\[
\text{SNR} = \frac{\text{ROI_{peritoneal implant}}}{\text{SD}_{\text{peritoneal implant}}}
\]

\[
\text{CNRA} = \frac{\text{ROI_{peritoneal implant}} - \text{ROI_{ascites}}}{\sqrt{\text{SD}_{\text{peritoneal implant}}^2 + \text{SD}_{\text{ascites}}^2}}
\]

\[
\text{CNRB} = \frac{\text{ROI_{peritoneal implant}} - \text{ROI_{reference tissue}}}{\sqrt{\text{SD}_{\text{peritoneal implant}}^2 + \text{SD}_{\text{reference tissue}}^2}}
\]

2.4. Qualitative image analysis

The subjective image analysis was performed by two experienced radiologists (S.Y.K. and T.M.K. with 15 and 5 years of genitourinary imaging experience, respectively). The reviewers were asked to evaluate four qualitative features in each image set using 5-point Likert scale. The features include overall image quality ranging from 1, nondiagnostic to 5, excellent, subjective image noise ranging from 1, extensive image noise to 5, absence of noise, imaging blurring ranging from 1, severe blurring, edge definition very poor to 5, no blurring, edges well defined, and conspicuity of peritoneal seeding lesion as follows:

1. poor lesion delineation with insufficient contrast to adjacent tissue
2. difficult lesion delineation with subtle contrast to adjacent tissue
3. intermediate lesion delineation with moderate contrast to adjacent tissue
4. sufficient lesion delineation with clear contrast enhancement
5. excellent lesion delineation with strong contrast enhancement

All image series were assessed in random order to avoid potential bias. The reviewers were blinded to the applied reconstruction technique and VMI energy level.

2.5. Radiation dose evaluation

The volume CT dose index (CTDItvol) and dose–length product (DLP) were obtained by reviewing the dose reports from each examination. The CTDIvol was determined with reference to a 32-cm phantom.
2.6. Statistical analysis
A one-way analysis of variance (ANOVA) with Dunnett post hoc analysis was used to compare CT attenuation in the peritoneal implant, SNR, CNRA, CNRB, and qualitative image parameters among VMI40, VMI50, IMR, and FBP images. Subgroup analysis was performed according to the region in which the peritoneal implant was located. A P value <.05 was considered to indicate statistical significance. Ratios of improvement in SNR and CNR values were compared between VMI40 and conventional FBP and IMR images according to the region. Interreader variability was calculated by using weighted κ statistics and interpreted as follows: 0.21–0.40, fair; 0.41–0.60, moderate; 0.61–0.80, substantial; and 0.81–1.00, almost perfect. A commercially available software package (SPSS 21.0 for Windows; IBM, Inc, Armonk, NY) was employed for the statistical analysis.

3. Results

3.1. Quantitative image analysis
The quantitative measurements of image quality in VMI40, VMI50, FBP, and IMR images are summarized in Table 2. The average CT attenuation, SNR, CNRA, and CNRB of the peritoneal implant was significantly higher in VMI40 (mean ± SD, 183.35 ± 48.51, 11.69 ± 4.87, 7.39 ± 2.98, 2.68 ± 1.96, respectively) than in VMI50 (129.65 ± 33.25, 9.37 ± 3.56, 5.72 ± 2.23, 2.02 ± 1.50), IMR (83.04 ± 19.83, 8.62 ± 3.85, 5.10 ± 2.12, 1.72 ± 1.33) and FBP images (83.33 ± 19.81, 3.50 ± 2.12, 3.16 ± 1.20, 1.10 ± 0.86) (all, P < .05). Notably, VMI40 also yielded significantly higher average CT attenuation, SNR, CNRA and CNRB values compared to IMR and FBP images (all, P < .05).

3.2. Region-based quantitative analysis of monoenergetic image quality
Table 2 summarizes the results of a subgroup analysis according to peritoneal implant location. In all locations, VMI40 had higher SNR, CNRA, and CNRB values relative to the other image sets (all, P < .05). Furthermore, VMI40 had significantly higher SNR, CNRA, and CNRB values relative to FBP images, regardless of location (all, P < .05). By contrast, although the overall quantitative image quality was significantly higher with VMI40 than with IMR, these image sets did not differ significantly with respect to the SNR and CNRB in the perihepatic (P = .724 and P = .212, respectively), the right paracolic gutter (P = .071 and P = .081), the sigmoid mesocolon (P = .375 and P = .051), the SNR and CNRA in the small bowel mesentry (P = .234 and P = .157) or the SNR in left paracolic gutter (P = .51).

Table 2
Comparison of CT number, SNR, CNRA, and CNRB between virtual monoenergetic images at 40-keV, 50-keV, and conventional 120-kVp images with IMR and FBP reconstruction techniques with subgroup analysis according to the location of peritoneal implants.

| Image sets | VMI40 | VMI50 | IMR | FBP | P |
|------------|-------|-------|-----|-----|---|
| VMI40 vs  |       |       |     |     | <.001* |
| VMI50      |       |       |     |     | <.001* |
| IMR        |       |       |     |     | <.001* |
| FBP        |       |       |     |     | <.001* |

Values are expressed as mean ± standard deviation (Hounsfield unit). CNR, contrast-to-noise ratio; SNR = signal-to-noise ratio; VMI40 = virtual monoenergetic images reconstructed at 40 keV; VMI50 = virtual monoenergetic images reconstructed at 50 keV; IMR = iterative model reconstruction; FBP = filtered back projection; *P values refer to the comparison between each image set ( indicates statistical significance).
The ratios of improvement of quantitative image quality between VMI40 and conventional images using FBP and IMR techniques are summarized in Table 3 (Figs. 2–4).

### 3.3. Qualitative image analysis

In both readers, the score of overall image quality and image blurring were highest in VMI50, followed by IMR images. VMI40 obtained significantly lower score than VMI50 or IMR images (all, \( P < .05 \)). In case of image noise, IMR obtained the highest score, followed by VMI50 in both readers. The score of subjective image noise in VMI40 was significantly lower than that of IMR or VMI50 images (all, \( P < .05 \)). However, the conspicuity of the peritoneal seeding showed highest score in VMI50, followed by VMI50, IMR, and FBP (all, \( P < .05 \)) in both readers. Interreader agreements are moderate to almost perfect in all parameters (0.472–0.931). The scores of qualitative image analysis were summarized in Table 4.

### 3.4. Radiation dose evaluation

The average CTDIvol and DLP for abdominopelvic SDCT in delayed phase were 5.71 mGy (range, 4.5–10.9 mGy) and 315.45 mGy·cm (range, 200.3–625.1 mGy·cm).

### 4. Discussion

This study aimed to evaluate the quantitative and qualitative image parameters of VMIs generated using abdominopelvic CT data obtained from a SDCT. When detecting peritoneal implants, it is especially important to maximize the CNR and SNR during the 3-minute delayed phase because the difference in contrast between these implants and the adjacent tissues will be less obvious than in earlier contrast-enhanced phases. We found that VMI at low-energy levels yielded significantly higher CNR, SNR values and superior lesion conspicuity of peritoneal implants, and furthermore, VMI50 achieved higher score in overall image quality, image blurring than IMR and FBP images obtained using same SDCT.

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**Table 3**

| Location                  | SNR \( VMI_{40}/\text{FBP} \) | SNR \( VMI_{40}/\text{IR} \) | SNR \( VMI_{50}/\text{FBP} \) | SNR \( VMI_{50}/\text{IR} \) | CNR \( A, VMI_{40}/\text{FBP} \) | CNR \( A, VMI_{40}/\text{IR} \) | CNR \( B, VMI_{40}/\text{FBP} \) | CNR \( B, VMI_{40}/\text{IR} \) |
|--------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Perihepatic              | 1.32                        | 1.27                        | 2.26                        | 1.43                        | 1.84                        | 1.16                        | 1.16                        | 1.59                        |
| Perisplenic              | 2.08                        | 1.41                        | 2.46                        | 1.59                        | 2.42                        | 1.59                        | 2.42                        | 1.67                        |
| Rt. paracolic gutter     | 2.16                        | 1.37                        | 2.28                        | 1.44                        | 2.42                        | 1.47                        | 2.42                        | 1.76                        |
| Lt. paracolic gutter     | 2.10                        | 1.41                        | 2.30                        | 1.47                        | 2.72                        | 1.76                        | 2.72                        | 1.64                        |
| Small bowel mesentery    | 2.25                        | 1.37                        | 2.37                        | 1.40                        | 2.60                        | 1.64                        | 2.60                        | 1.57                        |
| Sigmoid mesocolon        | 2.24                        | 1.28                        | 2.50                        | 1.43                        | 2.72                        | 1.57                        | 2.72                        | 1.57                        |
| Posterior cul-de-sac     | 2.05                        | 1.38                        | 2.28                        | 1.49                        | 2.79                        | 1.88                        | 2.79                        | 1.88                        |

Values are expressed as mean (Hounsfield unit).

CNR = contrast-to-noise ratio, FBP = filtered back projection, IR = iterative reconstruction, SNR = signal-to-noise ratio, VMI40 = virtual monoenergetic images reconstructed at 40 keV.

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**Figure 2.** Fifty-seven years old female patient with peritoneal enhancement and thickening in the pelvic peritoneum and sigmoid serosa (arrows). More prominent enhancement is observed in a virtual monoenergetic image at 40 keV (VMI40), compared to VMI50 and conventional images reconstructed using iterative model reconstruction (IMR) and filtered back projection (FBP).
In this study, we used a SDCT, which is a third mechanism for acquiring DECT projection data after dual-source technique and rapid kVp switching technique. It uses a single high tube potential beam and layered scintillation detectors, in which the top layer selectively absorbs low-energy photons and the bottom layer absorbs high-energy photons. An advantage to this approach is that the low- and high-energy data sets are acquired simultaneously, and the data from the inner and outer detector layers are recorded at all times. It facilitates the use of anti-correlated noise suppression, particularly available for detector-based

Figure 3. Sixty-two years old female patient with a seeding lesion in the small bowel wall (arrow). The seeding lesion is most strongly enhanced in the virtual monoenergetic image at 40keV (VMI40), compared to VMI50 and conventional images reconstructed using iterative model reconstruction (IMR) and filtered back projection (FBP).

Figure 4. Sixty-nine years old female patient with perihepatic and perisplenic seeding lesions (arrows). A greater contrast difference was observed in the virtual monoenergetic image at 40keV (VMI40), compared to VMI50 and conventional images reconstructed using iterative model reconstruction (IMR) and filtered back projection (FBP).
dual-energy CT systems.\textsuperscript{11} Importantly, this capability allows the use of monoenergetic images at the lowest possible keV level (40 keV) for diagnostic imaging and could potentially enhance vascular contrast or improve lesion conspicuity. In a recent study, low noise levels were observed in VMI obtained in both phantom and patient experiments via a detector-based spectral CT scan, across energy levels ranging from 40 to 200 keV.\textsuperscript{12} Furthermore, combination of the projection data from upper and lower detector layer from a SDCT acquisition always offers a true combination of the projection data from upper and lower energies abdominal CT (9.2 mGy and 310.3 mGy) values for abdominopelvic SDCT in the delayed phase (5.71 mGy vs FBP were relatively lower in the perihelaric and perisplenic space, compared to other regions. Accordingly, it may be difficult to detect peritoneal implants in those spaces when using conventional images, whereas the use of low-keV monoenergetic images could improve the diagnostic performance of imaging for the detection of peritoneal seeding lesions. We further note that the ratios of improvement for SNR, CNRA, and CNRB with VMI\textsubscript{40} vs FBP were relatively higher in the small bowel mesentery, sigmoid mesocolon and PCDS, respectively. In case of VMI\textsubscript{40} vs IMR, the highest ratios of improvement for SNR and CNRA were showed in the perisplenic space, and CNRB in PCDS. Therefore, we would expect improvements in diagnostic performance when using low-keV VMIs to detect peritoneal implants, especially in these spaces.

Despite the strengths of our study, we must discuss several limitations. First, this was a retrospective study performed at a single-center with a relatively small population, which may have introduced significant selection bias. Second, the evaluated peritoneal implants were not pathologically confirmed. But, we minimized this limitation by defining the peritoneal implants as peritoneal lesions that showed unequivocal increase in size or newly appear in correlation with increase of serum level of CA-125, which is a very sensitive indicator of the tumor burden. Third, the diagnostic accuracy of the peritoneal implant in low-keV VMI was not evaluated in this study. Additionally, because most of the patients showed disease progression due to the definition of peritoneal implants in our study, evaluation of the peritoneal implants as peritoneal seeding should be revealed in further studies.

The CT sensitivity and specificity according to region of peritoneal metastases were variable in recent meta-analysis.\textsuperscript{5} In our region-based subgroup analysis, absolute values of SNR and CNR were highest in VMI\textsubscript{40} regardless of the location. The absolute values of SNR and CNR in IMR and FBP images were relatively lower in the perihelaric and perisplenic space, compared to other regions. Accordingly, it may be difficult to detect peritoneal implants in those spaces when using conventional images, whereas the use of low-keV monoenergetic images could improve the diagnostic performance of imaging for the detection of peritoneal seeding lesions. We further note that the ratios of improvement for SNR, CNRA, and CNRB with VMI\textsubscript{40} vs FBP were relatively higher in the small bowel mesentery, sigmoid mesocolon and PCDS, respectively. In case of VMI\textsubscript{40} vs IMR, the highest ratios of improvement for SNR and CNRA were showed in the perisplenic space, and CNRB in PCDS. Therefore, we would expect improvements in diagnostic performance when using low-keV VMIs to detect peritoneal implants, especially in these spaces.

Although the CNR and SNR are often used as quantitative parameters of image quality, the absolute noise level must also be considered. While in our study we achieved the highest CNR and SNR with VMI\textsubscript{40}, the scores of overall image quality and subjective image noise were relatively low. A recent study demonstrated VMI\textsubscript{40} images improved the detection of peritoneal metastatic deposits in dual-source dual-energy CT, and recommended not to solely interpret VMI\textsubscript{40} images because of significant increase in image noise.\textsuperscript{13} However, VMI\textsubscript{10} image in our study showed significantly superior quantitative image parameters and also achieved higher qualitative image qualities compared to those of IMR and FBP images. In other words, reading VMI\textsubscript{40} for maximize lesion contrast in addition to conventional images or using VMI\textsubscript{40} images instead of conventional images could both improve the assessment of peritoneal seeding from ovarian cancer.

### Table 4

| Overall image quality | Image noise | Image blurring | Lesion conspicuity |
|-----------------------|-------------|---------------|-------------------|
| **R1** | **R2** | **Kappa (P)** | **R1** | **R2** | **Kappa (P)** | **R1** | **R2** | **Kappa (P)** |
| VM\textsubscript{40} | 3.04 | 3.16 | .630 (<.001) | 2.16 | 2.24 | .849 (<.001) | 3.28 | 3.36 | .512 (<.001) | 4.52 | 4.64 | .757 (<.001) |
| VM\textsubscript{50} | 4.44 | 4.36 | .846 (<.001) | 3.76 | 3.64 | .690 (.003) | 4.2 | 4.32 | .476 (.002) | 3.92 | 4 | .500 (.001) |
| IMR | 4.04 | 3.96 | .931 (<.001) | 4.08 | 4.2 | .875 (<.001) | 3.6 | 3.76 | .490 (.001) | 3.48 | 3.36 | .472 (.002) |
| FBP | 2.88 | 2.92 | .752 (0.001) | 2.24 | 2.04 | .908 (<.001) | 2.68 | 2.52 | .779 (<.001) | 2.08 | 2.2 | .676 (<.001) |

Values are expressed as mean. Interreader agreements are moderate to almost perfect in all parameters.

FBP = filtered back projection, IMR = iterative model reconstruction, R1 = reader 1, R2 = reader 2, VM\textsubscript{40} = virtual monoenergetic images reconstructed at 40 keV.
neal implants of ovarian cancer. Therefore, low-keV VMIs from abdominopelvic SDCT will provide additional value for the assessment of peritoneal seeding in ovarian cancer patients.

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All the authors contributed to the work described in the paper and all take responsibility for it.

Author contributions

Conceptualization: Taek Min Kim, Sang Youn Kim, Jeong Yeon Cho, Seung Hyup Kim, Min Hoan Moon.
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