Author’s response to reviews

Title: Value of Virtual Monochromatic Spectral Image of Dual-Layer Spectral Detector CT with Noise Reduction Algorithm for Image Quality Improvement in Obese Simulated Body Phantom

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Dirk Krüger,
Editor-in-Chief
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Dear Editor,


First of all, thank you very much for providing us an opportunity to revise our manuscript for consideration of publication. We truly appreciate the thoughtful comments made by you and the reviewers and we believe that we have responded to as many recommendations made by the reviewers as possible. Your comments and recommendations have clearly improved the quality of our manuscript and we hope that you will agree. The following are our responses and changes.
Response to Reviewer reports

Jeong Hee Yoon (Reviewer 1): This is a phantom study which investigated image quality and lesion conspicuity of liver CT using different dose, different size phantom, and spectral CT. Authors created two size of phantoms including eight focal liver lesions with different attenuation. Authors found that virtual monoE images showed superior CNR, less image noise, and better lesion conspicuity, subjective image quality (diagnostically acceptable) than conventional images at the same radiation dose. This is an interesting study which investigated relationship between image quality, patients' (simulated) size, radiation dose, and reconstruction (conventional vs. monoE). Spectral CT has been released recently, and there have not been many reports for body imaging. With that regard, this study has a scientific merit. However, there are some issues which need to be addressed before publication. I would recommend authors add the information of keV value range for qualitative analysis- which keV reviewers scored the best image quality or lesion conspicuity. It is because low monoE and high monoE have different values in clinical practice. In addition, availability of low monoE (better than 70keV) is clinically more relevant. Image noise, SNR or CNR at monoE of 120-200keV are rarely clinically relevant and I am sure that reviewers did not evaluate lesion conspicuity or image quality on monoE images higher than 70keV. In addition, authors need to clarify how analyze lesion conspicuity using an appropriate statistical method. Otherwise, there are only minor issues.

Abstract

R1-1) Background is too long.

⇒ Thank you for your comment. As per your suggestion, we edited Background section shorter.

R1-2) Method is not clear. Please mention the range of monoE values. Please add that phantom has high and low contrast FLL.

⇒ Thank you for your comment. According to your recommendation, we added the information of monoE ranges and FLL in Method.

R1-3) Key word: please change dual energy scan to dual energy.

⇒ Thank you for your comment. As per your suggestion, we change dual energy scan to dual energy.

Introduction

R1-4) p.5, line 10-12: because some are disadvantages of one type (for example, lack of dose modulation is only for rapid kV switching), and some of them are addressed in newly released scanner. So please tone it down.
Thank you for your comment. As per your suggestion, we toned it down and revised the sentence.

R1-5) p.5, line 12-p.6, line 2: this part can be reduced. Please address the anticipated main advantage related with this study design (probably not increased radiation dose in obese patients). Please consider removing the last sentence (however~to reduce noise) because it sounds a bit against to your hypothesis in following sentence. In addition, it is also against to recent papers reporting low image noise which allows low monoE images at spectral CT (Kalisz et al, EJR 2018).

Thank you for your comment. We edited and reduced that paragraph more properly.

R1-6) p.6, line 3-9: the purpose is not clear enough- comparison of VMI and conventional images is too vague because VMI with different energy level has different imaging characteristics. Based on the sentence (…the higher contrast resolution of VMI…), I assume that authors intended to compare low monoE images with conventional images. However, in study method (p.10, line 1-2), readers were allowed to change energy level, so it is not clear which energy level was chosen by reviewers and what score they gave to.

Thank you for your comment. As you expected, quality analysis were done in low monoE level, though the quantitative analysis were performed in all monoE ranges. Thus, we edited this paragraph more clearly.

Methods

R1-7) p.7, line 19-20: please remove the sentence (the top~ higher energies (1)).

Thank you for your comment. As per your suggestion, we removed that sentence.

R1-8) p.8, line 8-14: To improve readability, please consider simply showing reconstructed images (iDose and VMI using spectral level 4) in addition to monoE levels.

Thank you for your comment. As per your suggestion, we edited the Figure 2. In addition to presenting eight FLLs in liver phantom (which are reconstructed by iDose level 4), we added the VMS images (which are reconstructed by spectral level 4).

R1-9) p.10, line 1-2: so any monoE levels were not determined? Please specify it.

In addition, please explain the number of FLLs in table 4 (eight FLLs, five reviewers, one conventional images, and how many VMIs??)
Thank you for your comment. All reviewers were allowed change keV level up to 110 keV and recorded the used keV range in each image stack. In addition, we edited the number of FLLs in table 4. Five reviewers evaluated eight FLLs in four DRIs, as well as poly or monochromatic images, so, total number of FLLs were 320.

R1-10) p.10, line 15: Is the McNemar test appropriate for lesion conspicuity analysis?

Thank you for your comment. There was a mistake for describing statistic method. We used the paired T-test for evaluating lesion conspicuity and have edited it properly.

R1-11) p.10, line 15: Meaning of pooling the data is not clear to me. Does this mean that authors pooled all data from low monoE to high monoE? And then compared it with conventional images? If so, I have concerns about it may not reflect advantage of low monoE images with higher CNR appropriately (because low monoE would perform better than conventional images whereas high monoE would perform poorly than conventional images). Please specify it.

Thank you for your comment. As we mentioned on R1-10, there was a mistake for describing statistic methods, thus data pooling methods was not used. Also, refer to R1-6, the quality analysis was done in using low monoE range (up to 110 keV), though changing its levels were allowed.

Results

R1-12) As authors mentioned in introduction, the primary purpose is comparison of VMI and conventional polychromatic images. Then it should be shown first, followed by changes of image quality and noise in accordance of monoE change. Then show the changes of image noise, SNR or CNR according to monoE level, which would be easy to follow the study flow.

Thank you for your comment. As per your suggestion, we rearranged the paragraphs.

R1-13) p. 14, line 7-10: please consider revise the sentence to improve readability. Authors can compare conventional image of DRI 19 and low monoE (50keV…) of DRI 16 regarding to CNR or image noise.

Thank you for your comment. Following your suggestion, we reviewed this paragraph more readable.

R1-14) Table 1. Please add phantom size (25cm, 35cm). Please revise 'percentage of increase' to clarify the meaning. Does it refer radiation dose?

Thank you for your comment. We added the phantom size on Table 1 and removed ‘percentage of increase’ column to avoid confusing.
Tables 2-4: please specify monoe level, if there is.

Thank you for your comment. The VMIs in range of 40-110 keV were used for qualitative analysis, so, this information were added in bottom of Table 3 and 4. For quantitative analysis, every level of keV were analyzed and the values of all keV were shown in Table 2.

Table 4: there is a discrepancy between total number of FLLs (180) and subgroups (n=60 x4). Please explain how 60 FLLs were included in each DRI group.

Thank you for your comment. There was a mistake in counting the number of FLLs. We edited it properly.

Minor comment

In abstract (and some part of main body), SDCT is not corresponding to dual-layer spectral CT. Do authors mean spectral detector CT as it is in Introduction? please avoid uncommon abbreviations (VMSI). VMI is more commonly used term.

Thank you for your comment. We edited ‘dual-layer spectral CT’ to ‘dual-layer spectral detector CT’ and VMSI to VMI.

p.7, line 17-18: IQon (Philips Healthcare, Cleveland, OH, USA)

Thank you for your comment. We edited it following your suggestion.

p.9, line 1: please correct typo (detail data)

Thank you for your comment. We corrected it following your suggestion.

p.11, line 5: please correct typos in the sentence (When the same radiation dose level…)

Thank you for your comment. We’re corrected the typos and rephrased this sentence.

I would suggest replacing 'hypervascula' or 'hypovascular' with 'hyperattenuating or hypoattenuating'.

Thank you for your comment. We’re replacing ‘hypervascular’ to ‘hyper-attenuating’ and ‘hypovascular’ to ‘hypo- attenuating’.
R1-22) p.9, line 13: please consider replacing 'attending radiologist' with 'fellowship trained body radiologist'.

➔ Thank you for your comment. We’re replacing it following your suggestion.

R1-23) p.14, line 10: do not refer figure or table in Discussion.

➔ Thank you for your comment. We edited the sentence so that it does not refer figure of table in Discussion.

R1-24) Overall, too many decimals throughout the manuscript. Please reduce it.

➔ Thank you for your comment. We edited the decimals in throughout the manuscript.

jin liu (Reviewer 2): The manuscript compared image quality of virtual monochromatic spectral images and polychromatic images reconstructed from SDCT with different body size and radiation dose using anthropomorphic liver phantom. Studies are run with both small and one large size of body phantoms, and each containing 8 simulated focal liver lesions (FLLs). The authors conclude that the VMSI is viable for subjective image noise and diagnostic acceptabilities indexes improve in both phantom sizes. The paper could be considered for publication after careful revisions. The main points are as follows:

R2-1. VMSI is not described in detail in the paper. This is an important topic and should be discussed in the main body, especially considering the reconstruction procedures.

➔ Thank you for your important comment. We added more information of reconstruction procedure of VMSI in M&M section.

R2-2. Parameter selection of hybrid iterative reconstruction algorithm is not discussed in detail in the paper. This is an important topic and should be discussed in the main body. In the paper, the VMSI were reconstructed at level 4, but the reconstructed images seem over-smooth in figure 2.

➔ Thank you for your thoughtful comment. We added the reason of parameter selection of hybrid iterative reconstruction. The reconstruction level of 4 (iDose) were selected by vendor’s recommendation and had been used for patients in our institute more than 5 years (other Philips CT machine). Thus, we think the level of 4 are reliable values for generalization.

Also, the figure 2 are just showing the character of eight FLLs which are hyper-, hypo-attenuating and high-, low-contrast. This figure was conventional polychromatic images, reconstructed adopting iDose level 4. We further edited the Figure 2 to show the VMI (which are
reconstructed by spectral level 4) in addition to polychromatic images (which are reconstructed by iDose level 4).

R2-3. In Section of Quantitative Analysis, there is a mistake in the definition of the CNR.

➢ Thank you for your comment. We edited our mistake in the definition of the CNR.

R2-4. In Section of Quantitative Analysis, both the ROI and background region are selected manually. What is the criteria of selecting the target regions? The authors would be show it in the figures.

➢ Thank you for your comment. As following your suggestion, we selected ROIs in T9 vertebral body level except FLLs. Detailed information were added on M&M section and it presented it new Figure 3.

R2-5. For quantitative analysis, the authors only consider the CNR metric, more quantitative comparative on some state of art metric should be provided. The authors would be focus on noise and resolution or MTF for reconstruction were influence for different parameter settings.

➢ Thank you for your important comment. We totally agree with your opinion. However, our scope is image quality comparison between poly- and mono-chromatic images in obese simulated phantom. Thus, to minimize the influence of variable CT parameters (e.g. pitch, kVp, etc.), we fixed that values. We added this limitation in Discussion. Further study regarding different parameter would be interesting and strongly warranted.

R2-6. Suggest adding the more phantom sizes CT scan in main body. And suggest supplementing the coronal views and sagittal views results.

➢ Thank you for your comment. As following your suggestion, we added the information of phantom size in axial, coronal and sagittal direction (3-dimension).

R2-7. Figure3-figure5, please increase the resolution to remove the blurred impression

➢ Thank you for your comment. We further increased the resolution of figures and please check it by downloading the original figure files (This figures are a bit blur in PDF file, though the resolution is already high. When we checked original files, the blur is no more appeared. We don’t know why this phenomenon happens in PDF.)

R2-8. In this manuscript, the authors only consider the VMSI for noise reduction in CT imaging. Also, some recent works provide some new strategy for noise reduction, such as [1]-[3]. I would encourage the authors to make a comprehensive comparison.
Reference


➔ Thank you for your comment. We added these valuable references in Discussion and these post-processing technique would be promising tools for decreasing radiation dose.

We hope that we have satisfactorily addressed all of the questions and comments made by the reviewers and that our manuscript now meets the high standards for publication in “BMC Medical Imaging”. We thank you in advance for your consideration and look forward to hearing positive news from you soon.

Respectfully,

Jeong Min Lee, M.D.