EDITORIAL POINT OF VIEW

Should Artifacts of the Inferior Wall Be Reduced Using Image Processing?

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^{99m}Tc labelled myocardial perfusion imaging agents, such as ^{99m}Tc-tetrofosmin and ^{99m}Tc-sestamibi, can visualize activities of the myocardium, liver, gallbladder, small bowel, and colon in single-photon emission computed tomography (SPECT) images (1). Intense hepatic and gallbladder activities can obscure myocardial ^{99m}Tc uptake, which can result in heart-liver artifacts. High infra-diaphragmatic activity can also cause artifacts. Clinical studies have attempted to avoid such artifacts overlapping the true left ventricular (LV) myocardium by adjusting the time when SPECT scanning starts, having patients drink soda water before scanning (2), and exercising under pharmacological stress (3). A deep learning approach might help to reduce artifacts due to extracardiac activity (4).

Komuro et al. modified reconstruction and filtering processes to reduce artifacts resulting from high infra-diaphragmatic activity (5). The authors manually masked the LV region and Gaussian filtering was applied for the masked reconstruction images (modified reconstruction process) instead of masking after image filtering, which is currently the routine method of clinical reconstruction. Ordered subset expectation maximization (OSEM) was more efficient than filtered back projection (FBP) and resolution recovery (RR) correction was also more effective during modified reconstruction. High-resolution images were generally preferable from the viewpoint of discriminating LV and infra-diaphragmatic activities. When we see Figure 2 which showed the relationships between inferior counts and the distances from the infra-diaphragmatic activity, the combination of RR correction and image acquisition condition with small pixel sizes maximized the reduction of the artifacts. Figure 3 shows short axial views of phantom images in which artifacts were eliminated from the inferior wall.

The strengths of their study are that the modified reconstruction process can be implemented in any hospital without additional instruments and software. By changing from FBP to OSEM reconstruction with RR, the modified reconstruction process can be applied to myocardial perfusion SPECT images. However, a limitation of the study is that the need for high-resolution images for modified reconstruction increases the duration of image acquisition using current gamma camera systems. Modified reconstruction might be suitable for cadmium zinc telluride camera systems. The authors used attenuation correction using X-ray computed tomography (CT) images in addition to RR and scatter corrections. Such additional radiation exposure is controversial, and low-dose CT would be preferable.

Selecting patients who would derive the most benefit from modified reconstruction should be considered. For example, patients with intense extracardiac activity close to the LV might be indicated. However, complete exclusion of an artifact would be impossible in this situation and some artifacts might persist. A closer look at Figure 3 reveals slight inferior artifacts due to infra-diaphragmatic activities located 5 cm from the LV. Differentiating a true inferior perfusion abnormality from remaining artifacts even on masked myocardial perfusion images would be difficult for interpreters. Therefore, misinterpretation could be avoided using comparative unmasked and masked myocardial perfusion images. When the degree of extracardiac activities is

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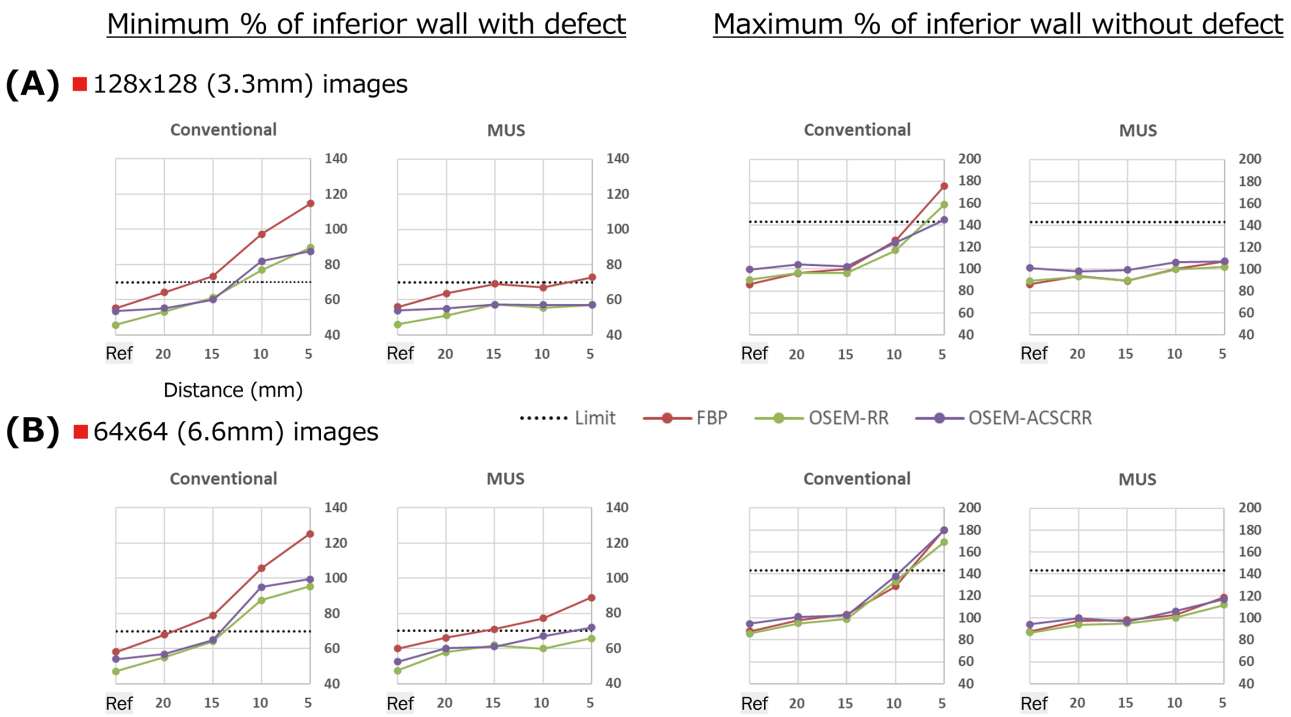

Figure 2

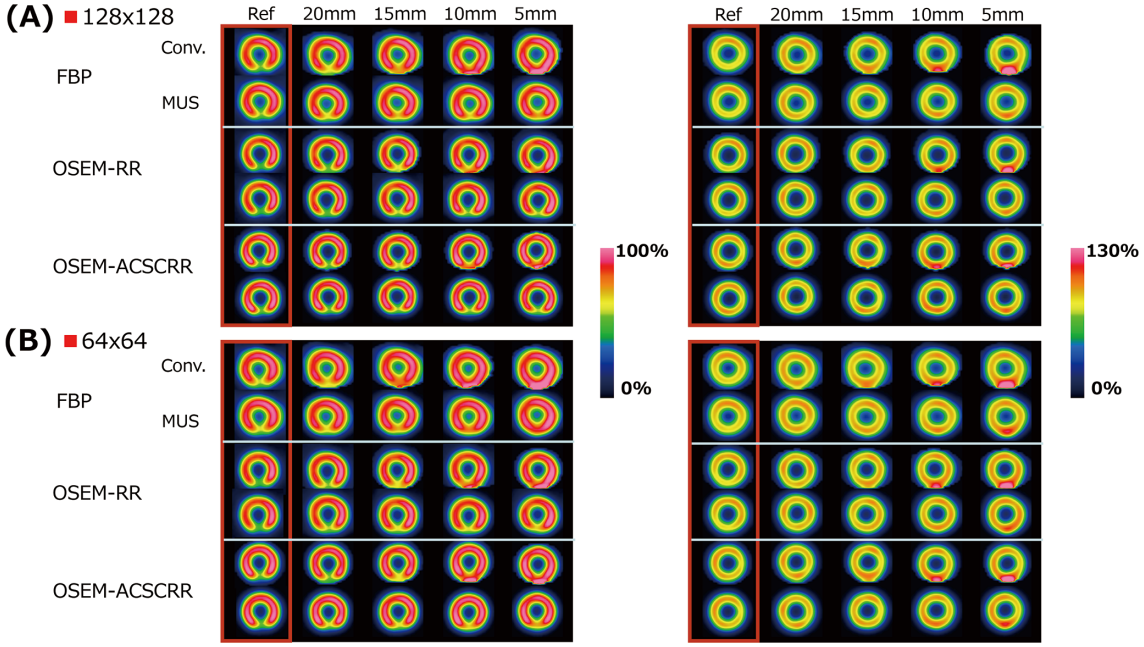

Figure 3

moderate, modified reconstruction can be applied, but conventional quantitation with careful adjustment of regions of interest to separate the LV and extracardiac activities might also be appropriate. Further investigation is needed to select the most appropriate patients for modified reconstruction.

The OSEM reconstruction with RR is required for the modified reconstruction process. However, FBP reconstruction remains popular in Japan. Shibutani et al. described the current status of myocardial perfusion SPECT image reconstruction in Japan when myocardial perfusion agents were labelled with ^{99m}Tc (6). Among 173 hospitals that used ^{99m}Tc labelled myocardial perfusion agents, images were reconstructed using FBP in 49.1% of them (OSEM in 29.5%, and either FBP or OSEM in 21. 4% depending on the situation). Reconstructed images were not corrected in 44.9% of all hospitals in Japan, possibly because attenuation, scatter, and RR corrections could impact the distribution of myocardial perfusion (7, 8). Furthermore, the apical thinning

phenomenon appears after attenuation correction (9, 10). Although the impact of attenuation, scatter, and RR corrections could lead to confusion, we believe that OSEM reconstruction and other corrections should be applied in clinical practice.

The modified reconstruction processing for myocardial perfusion SPECT images contributed significantly to reducing extreme artifacts from extracardiac activities. Although this is one way to reduce artifacts, OSEM processing and attenuation, scatter, and RR corrections should be applied before modified reconstruction processing in clinical practice.

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Conflicts of interest

KN has collaborative research with Siemens Healthcare, Tokyo, Japan. The others have no conflicts of interest to disclose.

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References

1. Shih WJ, McFarland KA, Kiefer V, Wierzbinski B. Illustrations of abdominal abnormalities on ^{99m}Tc tetrofosmin gated cardiac SPECT. Nucl Med Commun 2005; 26: 119–27.
2. Hara M, Monzen H, Futai R, Inagaki K, Shimoyama H, Morikawa M, et al. Reduction of infracardiac intestinal activity by a small amount of soda water in technetium-99m tetrofosmin myocardial perfusion scintigraphy with adenosine stress. J Nucl Cardiol 2008; 15: 241–5.
3. Thomas GS, Prill NV, Majmundar H, Fabrizi RR, Thomas JJ, Hayashida C, et al. Treadmill exercise during adenosine infusion is safe, results in fewer adverse reactions, and improves myocardial perfusion image quality. J Nucl Cardiol 2000; 7: 439–6.
4. Kikuchi A, Wada N, Kawakami T, Nakajima K, Yoneyama H. A myocardial extraction method using deep learning for ^{99m}Tc myocardial perfusion SPECT images: A basic study to reduce the effects of extra-myocardial activity. Comput Biol Med 2022; 141: 105164.
5. Komuro A, Teraoka S, Yasushi I, Tsuboko M, Tanno M, Ishimori K, et al. A novel method to suppress the effect of subdiaphragmatic activity in ^{99m}Tc myocardial perfusion SPECT and evaluation of its usefulness using a myocardial phantom. Ann Nucl Cardiol 2022; 8: 30–35.
6. Shibutani T, Okuda K, Ichikawa H, Kato T, Miwa K, Tsushima H, et al. Imaging technology for myocardial perfusion single-photon emission computed tomography 2018 in Japan. Jpn J Radiol 2020; 38: 274–82.
7. Okuda K, Nakajima K, Yamada M, Wakabayashi H, Ichikawa H, Arai H, et al. Optimization of iterative reconstruction parameters with attenuation correction, scatter correction and resolution recovery in myocardial perfusion SPECT/CT. Ann Nucl Med 2014; 28: 60–8.
8. Okuda K, Nakajima K, Yoneyama H, Shibutani T, Onoguchi M, Matsuo S, et al. Impact of iterative reconstruction with resolution recovery in myocardial perfusion SPECT: phantom and clinical studies. Sci Rep 2019; 9: 19618.
9. Okuda K, Nakajima K, Matsuo S, Wakabayashi H, Taki J, Kinuya S. Cause of apical thinning on attenuation-corrected myocardial perfusion SPECT. Nucl Med Commun 2011; 32: 1033–9.
10. Julien HM, Bravo PE. Thick and thin: Bridging the gap to a better understanding of apical thinning. J Nucl Cardiol 2020; 27: 461–4.