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Reduction of Molecular Breast Imaging Scan Time by Half with a Denoising Diffusion Probabilistic Model-based Algorithm

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Introduction/Background

Molecular Breast Imaging (MBI) uses a dedicated gamma camera to image functional uptake of a radiopharmaceutical (Tc-99m sestamibi) in breast cancer. Following an MBI patient satisfaction study (Hruska, JNMT 2024), reducing scan time and/or radiation dose while maintaining image quality is desirable. We designed an automated denoising tool and evaluated its application to “reduced-count” MBI in maintaining lesion contrast and diagnostic accuracy.

Methods/Intervention

MBI scans comprise four ten-minute images: two projections for each breast. We generated “reduced-count” MBI scans by using only data from the first five minutes of each image. We trained a denoising diffusion probabilistic machine learning model (DDPM) (Khosravi, CMPB 2023) to “denoise” reduced-count images without reducing clarity of features such as suspicious lesions. We used a random sample of patients undergoing MBI at Mayo Clinic from January to April, 2021. The model was trained repeatedly on the training set (343 patients, 4962 images) and validation set (114 patients, 1614 images) until it had seen 40 million images. For model evaluation, we selected 81 additional MBI exams (15 negative, 66 positive). Quantitative evaluation was performed through region of interest analysis on both reduced-count denoised and ground truth images. We calculated contrast-to-noise ratios as CNR = (mean of lesion - mean of breast tissue) / (standard deviation of breast tissue). A retrospective reader study of this dataset is underway; breast radiologists are presented the reduced-count denoised and ground truth exams in a random order while blinded to image status and provide an assessment of cancer likelihood (ACR BI-RADS 1-5 scale) and image quality (1-5 scale).

Results/Outcome

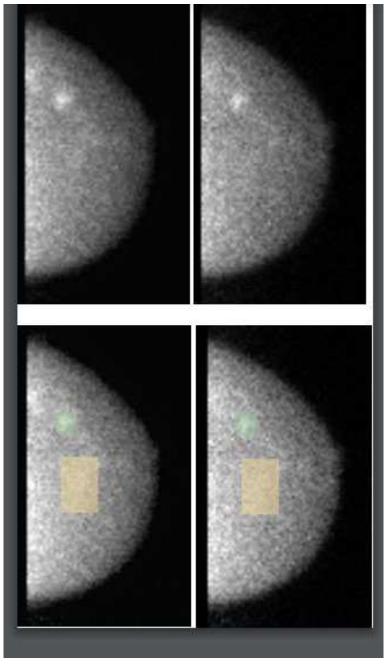
In a random sample of 18 images containing a lesion, CNR of the DDPM-denoised image was equal to or higher than CNR of the ground truth, due to reducing standard deviation of intensities in breast tissue. Pending results from the reader study will be presented.

Conclusion

DDPM-denoised images acquired for half the acquisition time of ground truth data provided similar image quality without producing artifacts. DDPM-denoised images maintained or improved lesion contrast, and had less noise (ie, reduced standard deviation of breast tissue intensities).

Statement of Impact

DDPM-denoised MBI exams could improve patient satisfaction and/or reduce radiation dose.



Example of regions of interest used for contrast-to-noise ratios. Left: DDPM-denoised image acquired for 5 min, right: ground truth image acquired for 10 min. Top: raw image, Bottom: Regions of interest.

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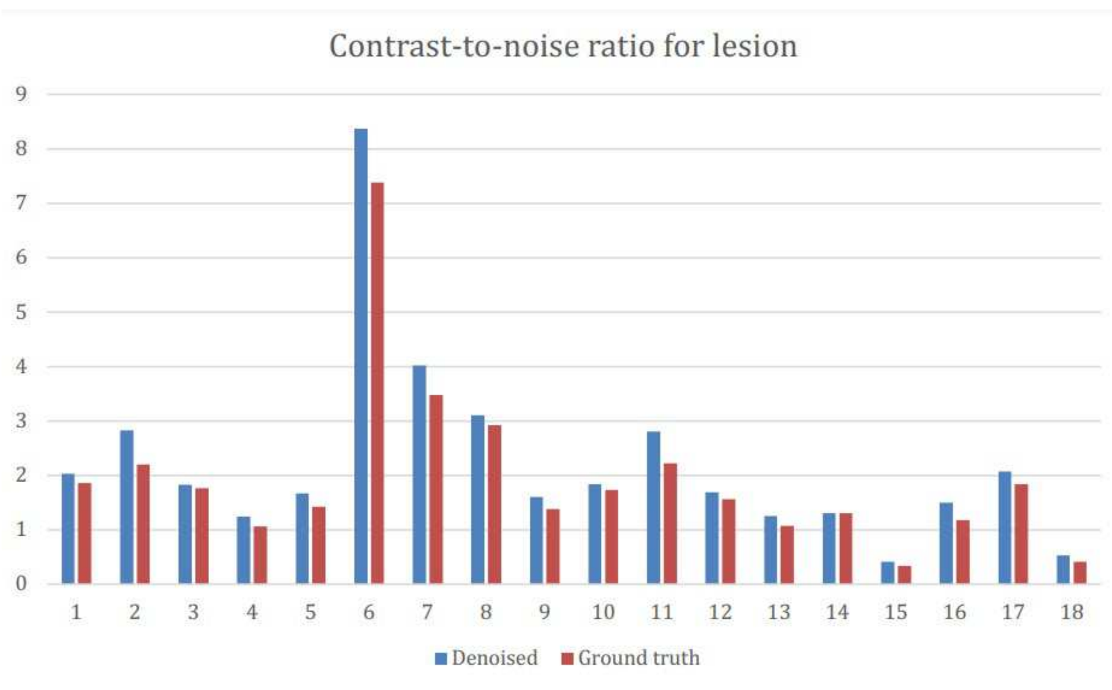

Contrast-to-noise ratios for a random selection of 18 views displaying a lesion. CNR for 5-min denoised images was equal to or higher than the ground truth 10-min images in all 10 cases, with a mean difference of 0.28 and standard deviation of 0.25.

Keywords

Molecular Breast Imaging; Denoising; Generative AI; Diffusion models