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Patient-Level SPECT Myocardial Perfusion Classification Using Tracer-Aware Deep Learning

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Single-photon emission computed tomography myocardial perfusion imaging is widely used for the non-invasive assessment of coronary artery disease. Although deep learning has shown promise for automated SPECT myocardial perfusion interpretation, most previous approaches have focused on single-tracer datasets and have not explicitly considered tracer-dependent variability. This study aimed to evaluate a tracer-aware deep learning framework for patient-level classification using SPECT myocardial perfusion polar maps.

A retrospective cohort of 640 patients was included, comprising 274 technetium-99m and 366 thallium-201 studies. For technetium-99m imaging, the task was normal versus abnormal perfusion classification, whereas for thallium-201 imaging, the task was low-risk versus intermediate/high-risk classification. Polar maps were processed as RGB images and resized to 224×224 pixels. A ResNet-18 model pretrained on ImageNet was used as a shared feature encoder with tracer-specific classification heads. Stress-only, rest-only, and dual-input stress-rest configurations were evaluated using repeated patient-stratified cross-validation and an independent held-out test set. Performance was assessed using AUC and balanced accuracy.

For technetium-99m studies, the stress-only model achieved a cross-validation AUC of 0.88±0.067 and test AUC of 0.88 [0.67-0.99], with balanced accuracy values of 0.75±0.061 and 0.87 [0.70-0.98], respectively. Although the dual-input model achieved a slightly higher test AUC of 0.91 [0.79-0.99], it did not consistently outperform the stress-only configuration. For thallium-201 studies, the stress-only model achieved a cross-validation AUC of 0.88 ± 0.051 and test AUC of 0.80 [0.71-0.89], with balanced accuracy values of 0.78 ± 0.083 and 0.80 [0.68-0.89]. Rest-only models showed lower and less consistent performance across both tracers.

These findings suggest that stress-phase polar maps contain the dominant discriminative information for patient-level SPECT myocardial perfusion classification. The proposed tracer-aware framework demonstrated stable performance across clinically distinct tracers, while rest information did not consistently improve classification. Stress-focused, tracer-aware deep learning may provide an efficient approach for automated SPECT myocardial perfusion analysis, although further external validation is required.