AI-Driven Volumetric 17-Segment Myocardial Blood Flow Characterisation Using [^{82}Rb] PET/CT

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Aim/Introduction: Dynamic 82Rb PET/CT enables quantitative assessment of myocardial blood flow (MBF), which has important diagnostic and prognostic value. However, robust segment-level MBF analysis requires reliable left ventricular (LV) segmentation and regional assignment. We developed an AI pipeline for 17-segment MBF characterisation from 82Rb PET.

Materials and Methods: 50 patients (17 women, 33 men) with high ischemia and necrosis (median 4.4% and 14.7%) who underwent rest and stress 82Rb PET/CT were manually delineated to obtain LV ground truth (GT). The cohort was processed with FlowQuant to obtain standard-of-care MBF, arterial input function (AIF) and 17-segment regional mapping. The mapping was adapted to cover the whole heart and applied to the GT to obtain the segmental GT, which is needed due to partial exclusion of basal voxels due to approximate fitting in standard-of-care. We trained nnU-Net models following a stratified 5-fold cross-validation scheme using two early and two late frames to automatically segment the 17 segments and extract their centrelines (LV_{CL}). Volumetric MBF was obtained using AI-enabled 3D mapping [1], further sampled on LV_{CL} using the segmental prediction and averaged per region $MBF_{Reg(i)}$.

Three scans were excluded due to abnormally thick LV walls, resulting in 97 LV_{CL}. $MBF_{Reg(i)}$ were compared with FlowQuant, split by gender, using Pearson's correlation coefficient and Bland-Altman analysis focusing on 11 comparable segments excluding the base.

Average $\mu_{|\Delta Diff|}$, and standard deviation $\sigma_{\Delta Diff}$, of the mean difference per segment is reported. All metrics are given as mean ± standard deviation.

Results: Automatic segmentation achieved a Dice coefficient of 92±4% for the entire LV. Pearson's correlation of the regional MBF for men/women reached 0.91±0.03/0.94±0.02. When comparing mean $\mu_{|\Delta Diff|}$, men's differences were smaller than women's (0.05±0.03 vs 0.20±0.08). This was also visible when comparing mean $\sigma_{\Delta Diff}$ going from 0.30±0.06 for men to 0.42±0.06 for women. The differences are larger in the mid regions due to the potential mismatch between segments $\mu_{|\Delta Diff|}$=0.06±0.02, $\sigma_{\Delta Diff}$=0.35±0.03 for men and $\mu_{|\Delta Diff|}$=0.25±0.05, $\sigma_{\Delta Diff}$=0.44±0.07 for women. The larger MBF difference in women can be explained by smaller hearts, which are under-represented in our cohort and left for further work.

Conclusion: Our fully automatic segmentation and CL extraction pipeline on 82Rb PET, using semi-automatic AIF, allows volumetric segmental MBF characterisation aligned with standard-of-care.

References: 1. Moulton, Eric, et al. "Artificial Intelligence-Derived Arterial Input Functions for Optimizing Pharmacokinetic Modeling of Myocardial Blood Flow with Data-Driven Physics-Informed Neural Networks." (2024)