Left Ventricle Segmentation in Dynamic ^{82}Rb PET/CT Using Deep Convolutional Neural Networks

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Aim/Introduction

Precise delineation of the left ventricle (LV) enables advanced analyses of endo-to-epicardium blood perfusion patterns and their gradients in PET, which can support various clinical applications, including coronary microvascular dysfunction. Approaches like simple thresholding or semi-automatic curve fitting often fall short in accurately capturing the LV boundaries in dynamic ^{82}Rb PET/CT. They also require expert manual input. This study presents a reliable manual, multi-modal LV delineation strategy, and a fully automatic segmentation algorithm using deep convolutional neural networks (CNNs).

Materials and Methods

We manually segmented 40 non-gated dynamic PET/CT volumes from 20 patients, acquired under both rest and stress examinations. The cohort consists of patients who underwent ^{82}Rb PET/CT examinations for revascularization and includes several cases with evident apex thinning and hypoperfused septal and lateral walls. To support accurate delineation, multiple time frames—including early and late uptake phases—were used to segment the LV while excluding the blood pool. Additionally, computed tomography (CT) scans were used as a sanity check to ensure that the contours remained within the LV muscle tissue. This dataset was then used to train and evaluate an nnU-Net architecture [1] using a 5-fold cross-validation. The results are compared to a simple semi-automatic baseline thresholding method.

Results

Best segmentation performance using semi-automatic baseline thresholding was achieved with a threshold equal to 35% of the highest photon count inside the LV, which achieved a mean Dice of 0.7452 and a balanced accuracy of 0.9101. The fully automatic nnU-Net outperformed this baseline by a large margin, achieving a mean Dice of 0.8701 and a balanced accuracy of 0.9392. Thresholding especially fails to contour the LV in ischaemic patients in the presence of hypoperfused septal and lateral walls or apex thinning. In such cases, the performance gap between the best nnU-Net and thresholding is even more pronounced, with nnU-Net achieving a Dice of 0.8525 compared to 0.7026 for thresholding. This performance gap is also more evident in stress examinations compared to rest, where nnU-Net boosts the Dice from 0.7387 (using thresholding) to 0.8696 for stress.

Conclusion

Deep CNNs enable fully automated segmentation of ^{82}Rb dynamic PET sequence. It eliminates the need for human expert intervention in segmentation and achieves a relative improvement of 21% for patients with hypo-perfused tissues compared with the baseline thresholding algorithm.

References

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