Deep Learning Models for Automatic Segmentation of Left Ventricular Fibrosis on Late Gadolinium Enhancement Cardiac Magnetic Resonance Imaging

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Introduction: Many patients at high risk of life-threatening ventricular arrhythmias (VA) and sudden cardiac death who are implanted with an implantable cardioverter defibrillator (ICD), never receive appropriate device therapy (ADT). Prior studies demonstrated the presence of myocardial fibrosis on late gadolinium enhanced (LGE) cardiac magnetic resonance (CMR) imaging to be associated with high risk of VA. Detailed fibrosis evaluation currently remains a (partially) manual annotation process, which is error-prone and time-consuming, and is therefore not part of routine CMR evaluations. This study aims to employ Deep Learning (DL) models for fully automatic segmentation of fibrosis regions on LGE-CMR images, and can enable feature extraction of the ventricular texture that can be utilized to improve VA risk prediction. **Methods**: For the fibrosis segmentation task, short-axis LGE-CMR images of 75 ICD patients (59±16 years, 12 females) were used to train the DL model with their manual expert annotations of the left ventricular (LV) myocardium and the enhanced fibrosis region (70/10/20 train/validation/test-split). We trained and tested a two-stage U-net based model. The first U-net model was trained to segment the LV myocardium. The second U-net model used both the raw LGE images and the output of the myocardium U-net for the segmentation of the enhanced fibrosis regions (see Figure 1). **Results**: We applied different implementations of the U-net based segmentation model, including 2D, 3D and 2.5D U-net implementations. The 2D-model performed best on both the segmentation of the LV myocardium and the fibrosis regions, achieving a Dice score of 0.821 for LV myocardium and 0.732 for fibrosis on the test set.

Conclusion: A two-stage DL model based upon U-net enabled fully automatic segmentation of LV fibrosis on LGE-CMR images. This may enable fully-automatic image-based prediction models for ADT, mortality and other clinical outcomes.

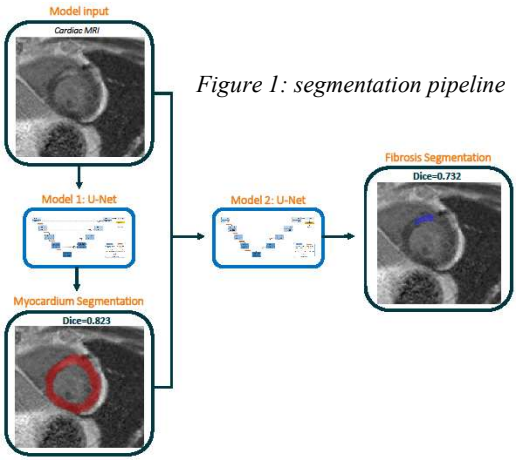

Figure 1: segmentation pipeline