Atrial Scar Segmentation from 3D Late Gadolinium Enhanced Datasets: Effect of Time After Contrast Injection

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Background: Late gadolinium enhancement (LGE) imaging enables visualization and quantification of native and ablation induced atrial scars. A recent study reported a marked increase in measured atrial scar percentage (AS%) in data acquired at different times after contrast agent injection (median [IQR]: 17.9% [11.7%–28.5%] at 20 mins vs. 24.1% [19.2%–35.2%] at 30 mins [1]) as the blood-scar contrast increased. This reflects issues with the analysis technique, which determined scar as a fixed threshold above blood signal intensity. We have used a newly developed deep learning-based method to analyze AS% at two different time points after gadolinium administration. We hypothesized that this fully automated method would be less dependent on the contrast characteristics and that the measured AS% would be more reproducible.

Methods: Transverse navigator-gated 3D LGE imaging [2][3] was performed in 20 atrial fibrillation (AF) patients (4 pre-ablation and 16 three months post-ablation) using an inversion prepared segmented gradient echo sequence (TE/TR=2.2/5.2ms). Imaging was performed 20 mins after gadolinium administration (Scan 1) and then repeated immediately (~30 mins post-injection, depending on the respiratory efficiency) (Scan 2). A joint multiview two-task (MVTT) segmentation method [4] which had been trained on 184 previously acquired datasets (20 mins after post-injection) was used to simultaneously segment both the left atrium (LA) and the AS tissue in these 40 datasets and AS% (100×scar volume/LA volume) was calculated. Segmentation time was ~0.3 seconds per 3D dataset on a state-of-the-art GPU. Intraclass correlation coefficient of the AS% and apparent contrast-to-noise (aCNR) ratios were also evaluated.

Results: The mean (±SD) acquisition times of Scans 1 and Scans 2 were 17.6±1.3mins and 27.6±3.3mins post injection, respectively. The aCNR was significantly lower in Scan 1 than Scan 2 (median [IQR]: 14.10 [10.36–19.30] vs. 18.42 [12.53–24.42], $P<0.05$). There was a small change in measured AS% with time after contrast administration (median [IQR]: Scan 1–24.11% [21.26%–26.82%] vs. Scan 2–21.34% [18.74%–22.65%]) as shown in Figure 1 but this did not reach statistical significance (paired Wilcoxon rank sum test, $P=0.0531$). Visualization of the delineated scar demonstrated good subjective agreement between scans at the two timepoints (example cases shown in Figure 2). The AS% intraclass correlation coefficient (absolute agreement) was 0.901.

Conclusion: Our fast fully automatic MVTT model results in AS% measurements that are relatively independent of the image contrast changes that occur with time after contrast administration. Further studies using multi-center and multi-scanner datasets with different acquisition protocols are underway.

Reference

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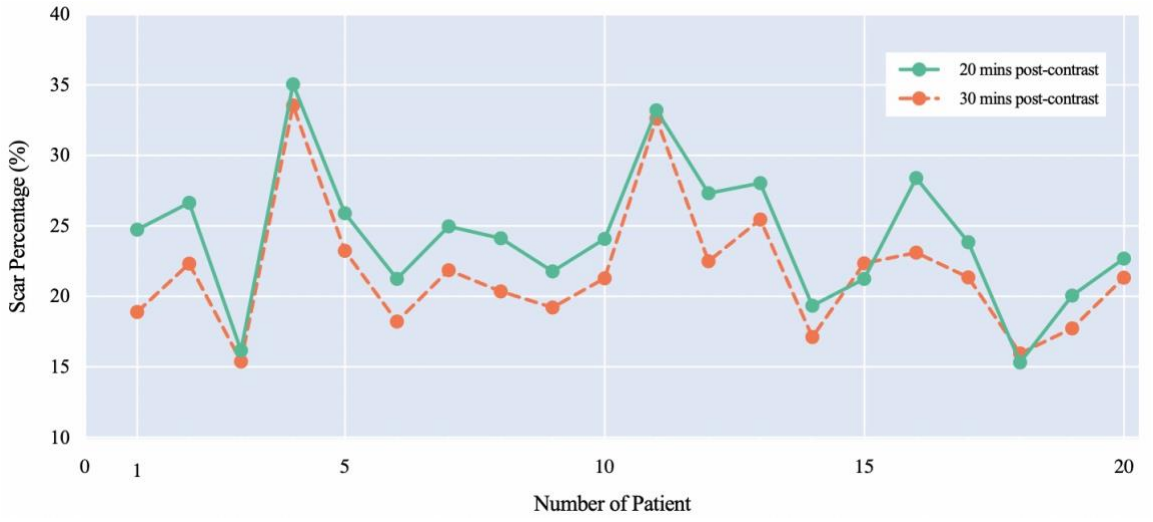

Figure 1: Measured scar percentage calculated in 20 patients scanned 20 mins (Scan 1, green) and 30 mins (Scan 2, orange) after gadolinium administration.

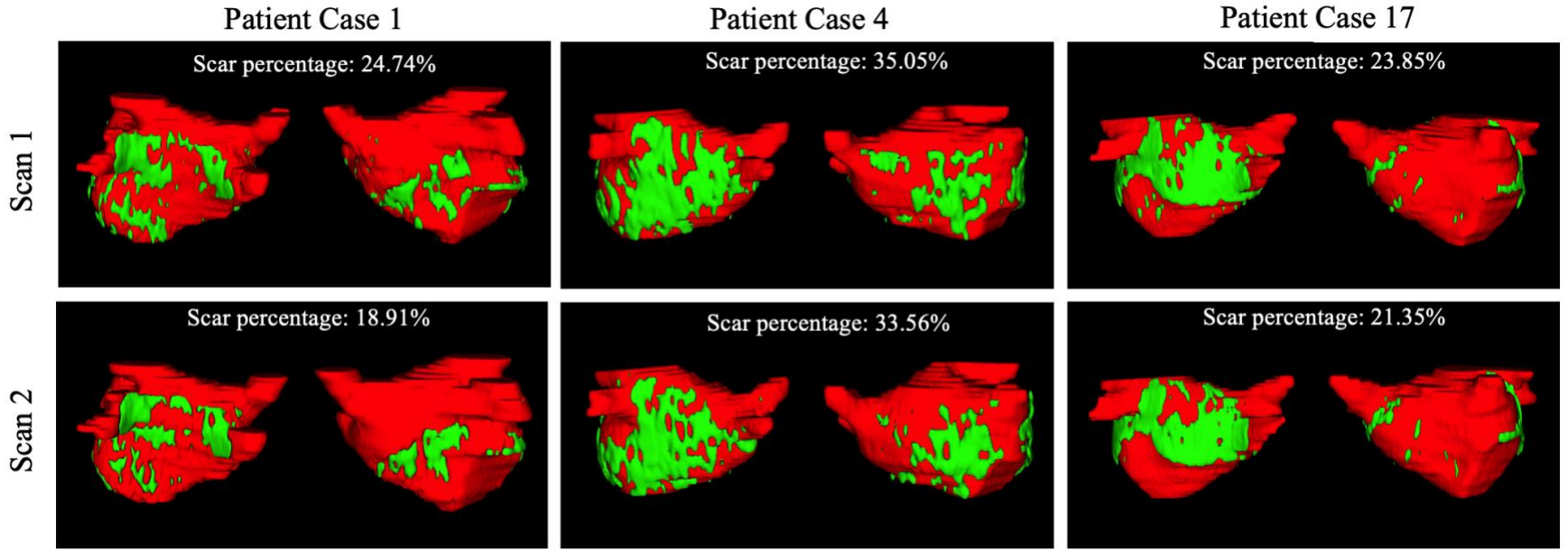

Figure 2: Visualization of the delineated LA and AS for two AF patients scanned 20 mins (Scan 1) and 30 mins (Scan 2) after the gadolinium administration.