Editorial for: "Improved Quantification of Myocardium Scar in Late Gadolinium Enhancement Images: Deep Learning Based Image Fusion Approach"

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Hypertrophic cardiomyopathy (HCM) is characterized by a significantly hypertrophic left ventricle (LV) with fibrotic scarring. Late gadolinium enhancement (LGE) imaging in cardiovascular magnetic resonance (CMR) is a potential diagnostic tool; furthermore, the assessment of scar quantification using LGE is crucial for risk stratification. To date, the associations of LGE with ventricular arrhythmia, cardiac arrest, and mortality have been reported (1). However, the quantification of LGE relies mainly on manual segmentation because of the multiplex structure of the myocardium, including an unclear endocardial boundary with hypertrophic papillary muscles and trabeculations. Furthermore, the contrast between LGE and surrounding tissues is ambiguous. Therefore, a technique that is less laborious with high reproducibility is warranted in LGE data segmentation.

To overcome the aforementioned issues, computer assistance was introduced to facilitate the manual segmentation of LGE data, wherein the intensities are typically thresholded to a fixed number of standard deviations from the mean intensity of the remote myocardium (2) or half of the maximum intensity within a user-selected hyper-enhanced region is selected as the fixed-intensity threshold (3). These methods have become widely used in clinical practice and have helped scar segmentation; however, the segmentation of the LV itself still largely relies on manual segmentation. Novel automatic image segmentation techniques (4) have been developed, and deep learning (DL)-based image processing has become the mainstream of recent studies. In general, a convolutional neural network-based algorithm is utilized, and various original arrangements to convolutional layers, pooling layers, and fully connected layers are applied for better performance. In a study by Moccia et al. (5), higher performance was achieved using a fully convolutional neural network in scar segmentation in the manually predefined LV myocardium compared to direct segmentation from LGE images with a median Dice similarity coefficient (DSC) of 71.25%, suggesting the benefit of predefining the LV myocardium. In terms of DL-based segmentation for HCM, the potential of automatic segmentation for LGE imaging using deep convolutional neural networks was tested in a limited number of patients with HCM (6) and evaluated in a multicenter multivendor study (7). The DSCs were 54% for three-dimensional convolutional neural network (CNN) and 48% for two-dimensional CNN, requiring further improvement in DL-based segmentation.

In this issue of *JMRI*, the authors report a DL-based image fusion approach for the quantification of myocardial scarring in patients with HCM (8). In the present study, based on the high accuracy of DL-based LV segmentation on cine CMR (9), they studied two deep CNN models for scar segmentation with and without LGE-Cine fusion and used manual scar segmentation as the ground truth. The CNN model was based on the U-Net architecture and consisted of four multi-resolution processing levels, 3×3 convolutional kernels with maximum pooling at each resolution level, ReLU activation, batch normalization, and dropout layers. As a novel finding of this study, the performance of CNN with LGE-Cine fusion is more robust and more accurate than CNN without fusion, although the agreements with manual segmentation are comparably strong for both DL-based segmentations.

There are several concerns regarding the application of DL-based LGE segmentation in clinical practice. Because of the ambiguity of LGE in HCM, a relatively high variety in reference segmentation is expected. Therefore, a large number of training images are required, although the study demonstrated excellent performance in a CNN with a relatively small number of patients. It remains unclear whether the performance of the CNN with LGE-Cine fusion is similarly high in patients with arrhythmia. Furthermore, it is also questionable whether the CNN with LGE-Cine fusion works well in a mixed patient cohort with various cardiac diseases, both for training and testing. Nevertheless, this is an important step in improving the clinical practice of scar quantification by applying a new DL technique.

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