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Combining deep learning method with optical coherence tomography for ablation lesion assessment

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Background: The immediate effect of radiofrequency catheter ablation (RFA) on the tissue is not directly visualized. Optical coherence tomography (OCT) is an imaging technique that uses light to capture histology-like images with a penetration depth of 1-3 mm in the cardiac tissue. There are two specific features of ablation lesions in the OCT images: the disappearance of birefringence artifacts in the lateral and sudden decrease of signal at the bottom (Figure panel A and D). These features can not only be used to recognize the ablation lesions from the OCT images by eye, but also be used to train a machine learning model for automatic lesion segmentation. In recent years, deep learning methods, e.g. convolutional neural networks, have been used in medical image analysis and greatly increased the accuracy of image segmentation. We hypothesize that using a convolutional neural network, e.g. U-Net, can locate and segment the ablation lesions in the OCT images.

Purpose: To investigate whether a deep learning method such as a convolutional neural network optimized for biomedical image processing, could be used to segment ablation lesions in OCT images automatically.

Method: 8 OCT datasets with ablation lesions were used for training the convolutional neural network (U-Net model). After training, the model was validated by two new OCT datasets. Dice coefficients were calculated to evaluate spatial overlap between the predictions and the ground truth segmentations, which were manually segmented by the researchers (its value ranges from 0 to 1, and "1" means perfect segmentation).

Results: The U-Net model could predict the central parts of lesions automatically and accurately (Dice coefficients are 0.933 and 0.934), compared with the ground truth segmentations (Figure panel B and E). These predictions could reveal the depths and diameters of the ablation lesions correctly (Figure panel C and F).

Conclusions: Our results showed that deep learning could facilitate ablation lesion identification and segmentation in OCT images. Deep learning methods, integrated in an OCT system, might enable automatic and precise ablation lesion visualization, which may help to assess ablation lesions during radiofrequency ablation procedures with great precision.

Figure legend: Panel A and D: the central OCT images of the ablation lesions. The blue arrows indicate the lesion bottom, where the image intensity suddenly decreases. The white arrows indicate the birefringence artifacts (the black bands in the grey regions). Panel B and E: the ground true segmentations of lesions in panel A and D. Panel C and F: the predictions by U-Net model of the lesions in panel A and D. A scale bar representing 500 μm is shown in each panel.

Abstract Figure