A novel deep learning model for a coronary computed tomography angiography diagnosis of plaque erosion

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Background: Plaque erosion is the underlying pathology in up to 50% of patients with non-ST-segment elevation acute coronary syndromes (ACS). Previous studies suggest that patients with erosion might be treated conservatively without stenting. Currently, a diagnosis of plaque erosion requires invasive intracoronary imaging.

Purpose: We sought to develop a deep learning (DL) model that enables an accurate diagnosis of plaque erosion using coronary computed tomography angiography (CTA).

Methods: A total of 532 coronary CTA scans (143 coronary CTA scans with plaque rupture, 113 with plaque erosion, and 276 with reference segment) from 395 patients were included to develop a model: 426 coronary CTA scans from 316 patients for training and internal validation, and 106 separate scans from 79 patients for test set validation. Among ACS patients, the diagnosis of plaque rupture or erosion identified by OCT was used as the ground truth, and the corresponding site on the CTA image matched with OCT image was determined to be the culprit lesion. A novel DL, Momentum Distillation Composite Transformer Attention (MD-CTA) model, was developed that can effectively process the whole CTA scans to diagnose plaque erosion.

Results: The novel DL model showed diagnostic performance in the five-fold cross-validation with an area under the receiver-operating characteristic curve (AUC) of 0.901 (0.873-0.930), a sensitivity of 81.2 (72.8-88.0), and a specificity of 86.6 (82.4-90.2), all of which were significantly higher than those of convolutional neural network (CNN) model with an AUC of 0.621 (0.567-0.675), the sensitivity of 59.8 (50.1-69.0), and specificity of 60.2 (54.5-65.7) in training validation. Similarly, in the test set validation, the AUC, sensitivity, and specificity of the MD-CTA model were 0.899 (0.841-0.957), 87.1 (70.2-96.4), and 85.3 (75.3-92.4), respectively, higher than those of 0.724 (0.622-0.826), 71.0 (52.0-85.8), and 68.0 (56.2-78.3) of the CNN model. At the slice level, the MD-CTA model was also superior in the five-fold cross-validation and the test set validation compared to the CCN model. This model significantly outperformed experienced cardiologists, especially for sensitivity.

Conclusions: The newly developed DL model enables an accurate CTA diagnosis of plaque erosion, which might enable the cardiologist to provide tailored therapy without invasive procedures. This algorithm might lead to a major shift in managing millions of patients with plaque erosion each year.

Table 1
Figure 1. Diagnostic performances of the deep learning model for the patient-level and the slice-level predictions.

(A) True Positive Rate vs. False Positive Rate for the MD-CTA model (AUC = 0.901) and the CNN model (AUC = 0.621).

(B) True Positive Rate vs. False Positive Rate for the MD-CTA model (AUC = 0.899) and the CNN model (AUC = 0.724) compared to the performances of three readers.

(C) True Positive Rate vs. False Positive Rate for the MD-CTA model (AUC = 0.891) and the CNN model (AUC = 0.729).

(D) True Positive Rate vs. False Positive Rate for the MD-CTA model (AUC = 0.897) and the CNN model (AUC = 0.757).