Identifying patients with atrial fibrillation during sinus rhythm on ECG: confirming the utility of artificial intelligence algorithm in a small-scale cohort without structural heart diseases

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Background: Detection of atrial fibrillation (AF) out of electrocardiograph (ECG) on sinus rhythm (SR) using artificial intelligence (AI) algorithm has been widely studied within recent couple of years. Generally, it is believed that a huge number of ECGs are necessary for developing an AI-enabled ECG to be adequate to correspond to a lot of minor variations of ECGs. For example, structural heart diseases have typical ECG characteristics, but they could be a noise for the purpose of detecting the small signs of electrocardiographic signature of AF. We hypothesized that when patients with structural heart diseases are excluded, AI-enabled ECG for identifying patients with AF can be developed with a small number of ECGs.

Methods: We developed an AI-enabled ECG using a convolutional neural network to detect the electrocardiographic signature of AF present during normal sinus rhythm (NSR) using a digital, standard 10-second, 12-lead ECGs. We included all patients who newly visited the Cardiovascular Institute with at least one NSR ECG between Feb 1, 2010, and March 31, 2018. We classified patients with at least one ECG with a rhythm of AF as positive for AF (AF label) and others as negative for AF (SR label). We allocated ECGs to the training, internal validation, and testing datasets in a 7:1:2 ratio. We calculated the area under the curve (AUC) of the receiver operating characteristic curve for the internal validation dataset to select a probability threshold, which we applied to the testing dataset. We evaluated model performance on the testing dataset by calculating the AUC and the sensitivity, specificity, F1 score, and accuracy with two-sided 95% confidence intervals (CIs).

Results: We totally included 19170 patients with 12-lead ECG. After excluding patients with structural heart diseases, 12825 patients with NSR ECGs at the initial visit were identified (1262 were clinically diagnosed as AF anytime during the time course and 11563 were never diagnosed as AF). Of 11563 non-AF patients, 1818 patients who were followed over 1095 days were selected for the analysis with the SR label, to secure the robustness for maintaining SR. Of 1262 AF patients, 251 patients were selected for the analysis with the AF label, of whom a NSR ECG within 31 days before or after the index AF ECG (the first AF ECG during the time course) could be obtained. In the patients with AF label, the NSR ECG of which the date was the nearest to the index AF ECG was selected for the analysis. The AI-enabled ECG showed an AUC of 0.88 (0.84–0.92) with sensitivity 81% (72–88), specificity 80% (77–83), F1 score 50% (43–57), and overall accuracy 80% (78–83).

Conclusion: An AI-enabled ECG acquired during NSR allowed identification of patients with AF in a small population without structural heart diseases.