A deep neural network predicts atrial fibrillation from normal ECGs recorded on a smartphone-enabled device

Authors:
C Galloway¹, D Treiman¹, J Shreibati¹, M Schram¹, Z Karbaschi¹, A Valys¹, D Albert¹, S Stavrakis², ¹AliveCor - Mountain View - United States of America, ²University of Oklahoma - Oklahoma City - United States of America,

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Background: Electrocardiographic predictors of atrial fibrillation (AF) from a non-AF ECG—such as p wave abnormalities and supraventricular ectopy—have been extensively documented. However, risk prediction tools for AF utilize little if any of the wealth of information available from the ECG. Better AF prediction from the ECG may improve efficiency of screening and performance of AF risk tools. Deep learning methods have the potential to extract an unlimited number of features from the ECG to improve prediction of AF.

Purpose: We hypothesize that a deep learning model can identify patterns predictive of AF during normal sinus rhythm. To test the hypothesis, we trained and tested a neural network to predict AF from normal sinus rhythm ambulatory ECG data.

Methods: We trained a deep convolutional neural network to detect features of AF that are present in single-lead ECGs with normal sinus rhythm, recorded using a Food and Drug Administration (FDA)-cleared, smartphone-enabled device. A cohort of 27,526 patients with at least 50 ECGs recorded between January 7, 2013, and September, 19, 2018, and the FDA-cleared automated findings of Normal and Atrial Fibrillation associated with those ECGs, were used for model development. Specifically, we trained the deep learning model on 1,984,581 Normal ECGs from 19,267 patients with 1) only Normal ECG recordings, or 2) at least 30% ECGs with AF. Of the 27,526 patients, an internal set of 8,259 patients with 841,776 Normal ECGs was saved for testing (validation).

Results: Among 8,259 patients in the test set, 3,467 patients had at least 30% of their ECGs with an automated finding of AF. When the deep learning model was run on 841,776 Normal ECGs, it was able to predict whether the ECG was from a patient with no AF or with 30% or more AF, with an area under the curve (AUC) of 0.80. Using an operating point with equal sensitivity and specificity, the model’s sensitivity and specificity were 73.1%. Using an operating point with high specificity (90.0%), the model’s sensitivity was 48.0%. When the model was applied to a randomly-selected, broader cohort of 15,000 patients (at least 50 ECGs recorded, any amount of AF), a positive, non-linear relationship between neural network output and AF burden per patient was observed (Figure).

Conclusions: A deep learning model was able to predict AF from ECGs in normal sinus rhythm that were recorded on a smartphone-enabled device. The use of deep learning, if prospectively validated, may facilitate AF screening in patients with paroxysmal disease or warn patients who are at high risk for developing AF.
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