Risk stratification of coronary artery disease using the artificial intelligence-enabled electrocardiogram

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Background: Atherosclerotic cardiovascular disease (ASCVD), of which coronary artery disease (CAD) is the primary manifestation, is the leading cause of death worldwide. The AHA/ACC Pooled Cohort Equation (PCE) facilitates risk stratification and initiation of primary prevention of ASCVD, however their performance is suboptimal.

Purpose: We develop an artificial intelligence-based electrocardiogram (ECG) analysis (AI-ECG) algorithm to detect different stages of CAD and assessed the value of AI-ECG over PCE to predict incident myocardial infarction (MI) and survival over 3-years.

Methods: Using electronic health record data from approximately 7 million patients seen at over 70 hospitals and clinics across 5 states in the USA, we created independent AI-ECG models to identify elevated coronary artery calcium (CAC) by computer tomography, the presence of obstructive CAD by stress test or angiography, and left ventricular regional akinesis by echocardiogram, presumed to represent prior MI. Deep structured data, AI-enabled natural language processing of unstructured data were used to ensure cohort, and physician review of labeling were used to ensure cohort accuracy. These models were ensembled into a single model that was used to assess the utility of AI-ECG for predicting new occurrence MI in PCE- and age-stratified cohorts of patient with no prior history of ASCVD, over a 3-year timeframe using Cox’s proportional hazards analysis.

Results: A total of 6,080 patients (15,192 ECGs) were labeled positive for CAC ≥ 300, 12,561 patients (18,915 ECGs) positive for obstructive CAD, and 10,767 patients (23,870 ECGs) positive for regional akinesis. AI-ECG for identifying elevated CACS, obstructive CAD, and regional akinesis achieved AUROCs of 0.86, 0.80, and 0.93, respectively. All AI-ECG models identifies increased 3-year risk for MI and death in AI-ECG positive versus AI-ECG negative patients and subgroups with 2 or 3 positive results had stepwise increased risk (Figure A). In a 3-year survival analysis of all-comer patients, the hazard ratio for those that tested positive on 1, 2, or 3 versus 0 positive disease-specific models were 1.61 (1.53-1.69), 2.40 (2.27-2.55), 3.42 (3.21-3.65), respectively. Risk stratification was also observed in cohorts without prior history of ASCVD stratified by low and high PCE-derived 10-year ASCVD risk (Figure B) and in cohorts stratified by age, including under the age of 40.

Conclusions: AI-ECG has potential to address unmet need for accessible risk stratification in patients in whom PCE under, over, or insufficiently estimate ASCVD risk, and in whom risk assessment over periods of time shorter than 10 years is desired.