Artificial Intelligence-Enabled Electrocardiogram Model for Screening of Bicuspid Aortic Valve

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INTRODUCTION

Bicuspid aortic valve (BAV) is the most common congenital heart condition. BAV complications include aortic valve surgery, aortic surgery, infective endocarditis, and aortic dissection. Due to its 10% chance of transmission to offspring and lifetime morbidity burden of >80%, screening of first-degree relatives is recommended for early detection. Several barriers to echocardiographic screening for BAV have been identified, therefore, a cheap and fast "rule-out" BAV tool is appealing.

OBJECTIVE

The objective of our study is to create an artificial intelligence (AI)-enabled electrocardiogram (ECG) model to aid the detection of BAV in suspected individuals.

METHODS

Between January 1, 1990, and June 30, 2023, 13,066 adults [mean age 58.3±17 years, 46.6% women] with both an ECG and an echocardiographic study within 6 months of each other, were identified from the Mayo Clinic database. Cases were selected as patients with a confirmed BAV diagnosis either by echocardiographic or pathologic report. Controls were selected as patients with an ECG indication of abnormal auscultation, rule out, suspected, or family history of BAV (Figure 1). A convolutional neural network was built using the Keras Framework under Tensorflow backend (Google;Mountain View,CA,USA).

METHODS

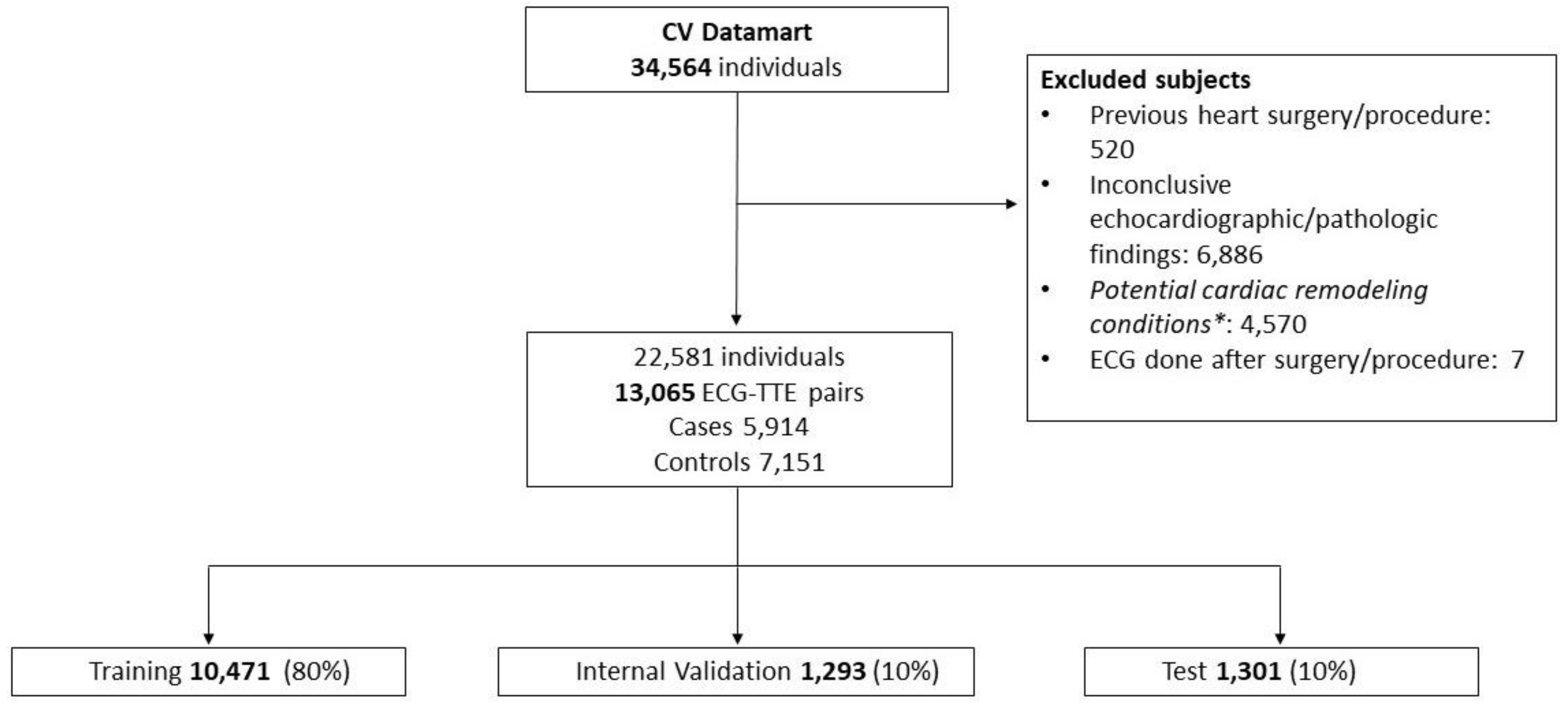
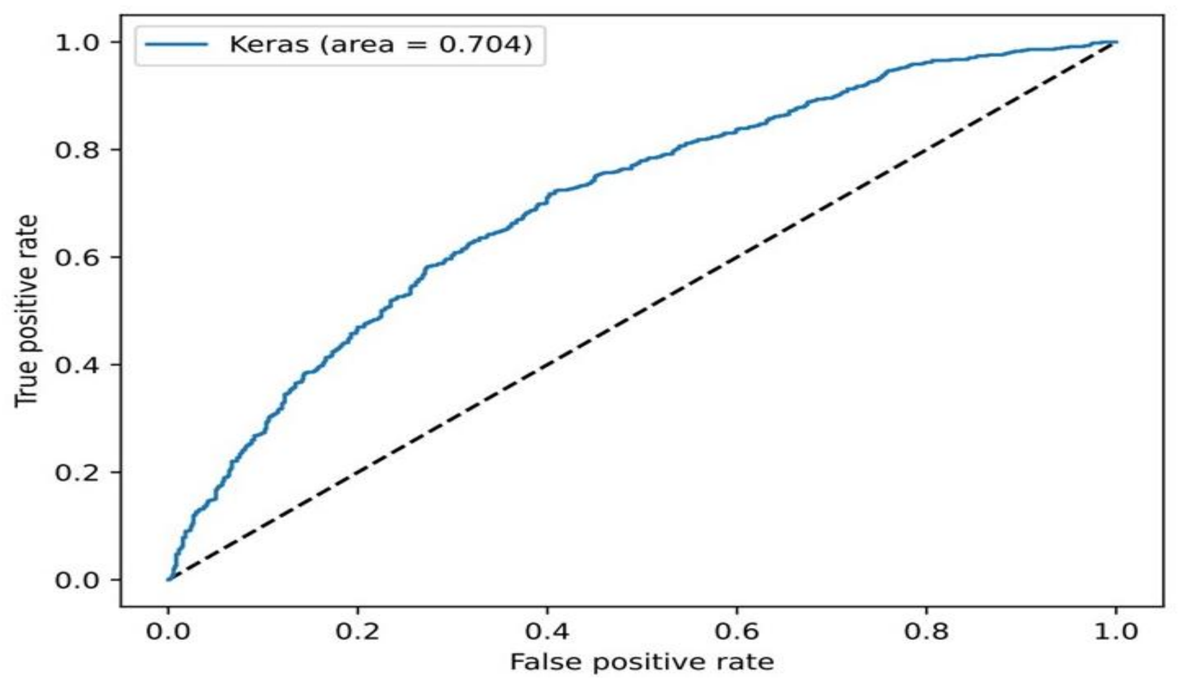


Figure 1 Inclusion/exclusion criteria used for the model. ECGs by patient were randomly shuffled into mutually exclusive training, internal validation and test data sets.

*Conditions such as cardiomyopathies, chemotherapy/radiation, autoimmune disease (SLE & RA), previous known congenital heart disease (VSD, ASD, PDA, MVP), heart failure, myxomas, pacemaker, endocarditis, rheumatic heart disease, heart transplant

RESULTS



Test prevalence	45%
Sensitivity %	65%
Specificity%	64.8%
PPV %	60.1%
NPV %	69.4%
False positive	252
False negative	205
AUC (Confidence interval)	0.704 (0.676-0.732)

Figure 2 Performance characteristics of AI-enabled ECG model in the BAV cohort.
AUC – Area under the curve; PPV – Positive predictive value; NPV – Negative predictive value

RESULTS

BAV prevalence in the model's development was 45%. In the test group, the AI-enabled ECG model achieved an area under the curve (AUC) of 0.704 with the following (Figure 2).

Model prevalence	Positive predictive value %	Negative predictive value %
45	60.1	69.4
15	24.6	91.3
10	17	94.3
6.4	11.2	96.4
3	5.4	98.4
2	3.6	98.9
1	1.8	99.5

Table 1 Theorical calculation of PPV and NPV of the AI-ECG model based on prevalence.
PPV- Positive predictive value; NPV- Negative predictive value; AI- Artificial intelligence; ECG- Electrocardiogram

CONCLUSION

An AI-enabled ECG model has shown modest diagnostic performance in detecting BAV. When assuming a prevalence of 10% (chance of transmission to offspring), the NPV increases to 94.3% with decreased PPV of 17%. This also works assuming a prevalence of 1-2% (same as general population) were the NPV increases to 98.9-99.5% (Table 1). This approach could save a major number of echocardiograms for "ruling-out" BAV, but needs external validation.