An EHR-Based Machine Learning Model Predicts Myocardial Infarction Better than an ECG-based Machine Learning Model and the Pooled Cohort Equations

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INTRODUCTION

• Patients at high risk for myocardial infarction (MI) benefit from treatments designed for primary prevention, especially cholesterol lowering therapy.

• The pooled cohort equations (PCE) are the most commonly used risk predictor for future atherosclerotic cardiovascular disease (ASCVD), but show only modest performance.

Hypothesis:

Electronic health record (EHR)-based, and ECG-based machine learning models are better at predicting MI as compared to PCE.

METHODS

Study Population

All Geisinger patients ages 40-79 who had 1) at least 1 clinically acquired ECG, 2) no history of MI and 3) had PCE scores calculated at the time of ECG.

Primary Endpoint: MI event within 10 years of ECG.

EHR Data and Machine Learning Models

1. XGBoost model with structured EHR data as input features

   - Demographics: age, sex, smoking
   - Vital signs: heart rate, BP, height, weight
   - Laboratory tests: hemoglobin, HbA1c, HDL, etc. (n=24)
   - ECG measures (e.g. RR interval, n=6) and patterns (e.g. atrial fibrillation, n=24)

2. Deep neural network (DNN) that used ECG voltage data (10 second, 8 independent leads), age, and sex as inputs

   - Models were evaluated by 5-fold cross-validation
   - Performances of different models were compared using area under the receiver operating characteristic curve (AUROC)

PERFORMANCES OF DIFFERENT MODELS

Models were evaluated by 5-fold cross-validation (CV). Performances of different models were compared using area under the receiver operating characteristic curve (AUROC).

RESULTS

A total of 103,933 ECGs from 34,932 patients had sufficient follow-up (occurrence of MI or 10 years follow-up in EHR). 21% of ECGs were followed by an MI event within 10 years.

<table>
<thead>
<tr>
<th>Age, yr</th>
<th>Heart Failure</th>
<th>MI</th>
</tr>
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<tbody>
<tr>
<td>62 (10)</td>
<td>5%</td>
<td></td>
</tr>
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</table>

6% of the total encounters were predicted to be 'high risk' by the EHR-based model and not by the pooled cohort equations.

- 10-year MI event rate in this group was 26%
- Only 40% of patients in this group were on a statin

<table>
<thead>
<tr>
<th>PCE+</th>
<th>XGB+</th>
<th>PCE+</th>
<th>XGB+</th>
<th>PCE+</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=35,818</td>
<td>PCE+</td>
<td>n=38,916</td>
<td>XGB+</td>
<td>PCE+</td>
</tr>
<tr>
<td>n=9,689</td>
<td>n=35,818</td>
<td>n=38,916</td>
<td>PCE+</td>
<td></td>
</tr>
</tbody>
</table>

| MI events | 14454 | 2495 |
| Event rate | 40% | 26% |
| % on statin | 50% | 42% |

20% (n=20,516) of encounters were predicted to be 'high risk' by the PCE and not by the EHR-based model. The event rate in that subgroup was 12%.

Limitations

- Retrospective data only
- PCE scores not available on all patients

SUMMARY

• An EHR-based XGBoost model, but not an ECG-based DNN, is superior to the PCE in predicting future MI.
• Patients identified as high risk by the EHR-based model, but low risk by the PCE, have a high rate of future MI.
• Statin use in that group is low, suggesting ample opportunity for intervention.

DISCLOSURES

Geisinger receives funding from Tempus for ongoing development of predictive modeling technology and commercialization. None of the Geisinger authors have ownership interest in any of the intellectual property resulting from the partnership. John Pfeifer, Brandon Fornwald and Sushravya Ragunath are Tempus employees.

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Note: operating points for XGB and DNN models were selected by matching PCE sensitivity.