Screening for Cardiac Relaxation Abnormalities Using Surface ECG Wavelets for Identifying High-Risk Cardiac Phenotypic Abnormalities

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**Introduction**

- Left ventricular diastolic dysfunction (LVDD) is recognized to play a major role in the pathophysiology of heart failure.
- As echocardiography can be expensive as a screening tool, clinical tools for selection of the right patients for echocardiography remain to be established.
- We developed machine learning algorithms that directly estimate myocardial relaxation using body-surface signal processed electrocardiogram (spECG) as a first step of LVDD screening.

**Methods**

**Study Flow Chart**

- From 3 centers in the North America, total 1109 patients (including 81 healthy subjects) with various degrees of heart failure were prospectively enrolled to the study.
- Technicians performed spECG simultaneously with normal 12-lead ECG without taking extra time or effort.
- Echocardiography was performed on the same day as the spECG.

**Machine learning algorithms**

- Among over 500 features obtained from continuous wavelets transform of spECG, meaningful features were selected using topicalological data analysis (Ayasdi Workbench v7.4).
- Patients were divided into training, validation, and test set.
- Using cloud-based (PSC Bridge) H2O AutoML packages, machine learning regression with stacking algorithms were developed in the training and validation set. After stratified-5-fold cross validation, the performance of the developed models were evaluated in the test set.

**Results**

- spECG: Illustrative Cases

**Patient Characteristics: Overall**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Low estimated e'</th>
<th>High estimated e'</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>Overall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, years</td>
<td>58 (56 - 66)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral e'</td>
<td>10.8 (9.0 - 13.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Septal e'</td>
<td>9.6 (8.0 - 11.2)</td>
<td></td>
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</tr>
<tr>
<td>LV end-diastolic dimension, mm</td>
<td>46 (34 - 51)</td>
<td></td>
<td></td>
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<tr>
<td>LV ejection fraction, %</td>
<td>63 (58 - 67)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LV area, m²</td>
<td>45 (39 - 50)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA volume, ml</td>
<td>82 (66 - 97)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TR maximum velocity, m/s</td>
<td>0.6 (0.4 - 0.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted LVDD stage ≥C, n (%):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>26 (25.5)</td>
<td>50 (46.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Female</td>
<td>21 (20.6)</td>
<td>31 (28.0)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

**Prediction of LV Diastolic and Systolic Function Using Estimated e’ Values**

- Using cloud-based (PSC Bridge) H2O AutoML packages, machine learning regression with stacking algorithms were developed in the training and validation set. After stratified-5-fold cross validation, the performance of the developed models were evaluated in the test set.

**Conclusions**

- A quantitative estimation of myocardial relaxation can be performed using features that are relatively easily obtained using body-surface spECG.
- This cost-effective strategy may be a valuable first clinical step for assessing the presence of LV systolic and diastolic dysfunction and potentially aid early diagnosis and management of heart failure patients.

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**Appendix A: Study Flow Chart**

**Appendix B: Prediction of LV Diastolic and Systolic Function Using Estimated e’ Values**

**Appendix C: Incremental Value of spECG upon Traditional Findings**

- **AUC**
  - **95% CI**
  - **Specificity**
  - **Sensitivity**
  - **p-value**

**Clinical findings:**

- **LV diastolic (age, obesity, and hypertension)**
  - **AUC**
  - **95% CI**
  - **Specificity**
  - **Sensitivity**
  - **p-value**

- **LV systolic dysfunction (age, obesity, and hypertension)**
  - **AUC**
  - **95% CI**
  - **Specificity**
  - **Sensitivity**
  - **p-value**

**Adding estimated lateral e’ to logistic regression models showed significant improvement of prediction of LVDD.**

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**Disclosure:** Dr. Sengupta - Consultant/Advisor for Heart Sciences and Ultronics. Other authors have nothing to disclose.