Seismocardiographic measurement of systolic time intervals in left ventricular dysfunction: validation with transthoracic echo

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Topic(s):
Remote Patient Monitoring and Telemedicine

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Background:
Systolic time intervals (STI) measured using Transthoracic Echo (TTE) have been shown to be sensitive indicators of contractile performance, but TTE is limited to a hospital setting. Recent advances in technology have enabled the simultaneous measurement of Electrocardiograms (ECG) and Seismocardiograms (SCG) using wearable devices. However, the use SCG to measure STIs has not been validated in a mobile setting, or on pathological subjects.

Purpose:
To test the validity of an automated algorithm for measuring STIs using a wearable device recording ECG and SCG, in subjects with varying degrees of left ventricular dysfunction.

Methods:
179 Patients with suspected left ventricular dysfunction were assessed using TTE performed by a Cardiologist. Patients were simultaneously fitted with a novel wearable device worn on a chest strap, recording SCG and single-lead ECG data, while the cardiologist measured the pre-ejection period (PEP) and left ventricular ejection time (LVET) with the patient in a supine position. Of these subjects 29(16.2\%) were diagnosed with Dilated cardiomyopathy (DCM), and 109 (60.8\%) had Ischemic Heart disease.

The SCG and ECG data recorded on the wearable device was then analysed using a peak-detection algorithm, which detected the Q,R,S points on the ECG, and then determined the 4 most prominent peaks in the SCG signal corresponding to each R-peak. Heart rate, patient’s age, gender and SCG time intervals were then used in a DecisionTree algorithm to determine the values of PEP and LVET, which were were then compared against those determined by the cardiologist using TTE.

Results:
The correlation coefficient (r\textsuperscript{2}) between PEP calculated using TTE, and the values obtained from the algorithm analyzing SCG data was 0.92 while the mean error was 7.47\%. The r\textsuperscript{2} between the LVET calculated using the TTE and the algorithm was 0.75, while the mean error was 8.53\% (p-value<0.001 for all cases).

Conclusion:
The algorithm-derived STIs measured by SCG correlate well with those measured by TTE across most patient groups, including those with Dilated Cardiomyopathy and Ischemic Heart Disease, opening prospects for continuous remote monitoring of STIs in a mobile setting.

<table>
<thead>
<tr>
<th></th>
<th>All Subjects</th>
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<tr>
<td>Number of Subjects</td>
<td>178</td>
<td>109</td>
<td>69</td>
<td>29</td>
<td>149</td>
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<tr>
<td>PEP ($r^2$)</td>
<td>0.92</td>
<td>0.89</td>
<td>0.94</td>
<td>0.88</td>
<td>0.91</td>
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<td>PEP (%age error)</td>
<td>7.47</td>
<td>7.50</td>
<td>7.42</td>
<td>6.99</td>
<td>7.56</td>
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<tr>
<td>LVET ($r^2$)</td>
<td>0.75</td>
<td>0.81</td>
<td>0.66</td>
<td>0.55</td>
<td>0.83</td>
</tr>
<tr>
<td>LVET (%age error)</td>
<td>8.53</td>
<td>6.69</td>
<td>11.4</td>
<td>20.42</td>
<td>6.16</td>
</tr>
</tbody>
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DCM - Dilate Cardiomyopathy, IHD - Ischemic Heart Disease