Wrist-wearable photoplethysmograph for atrial fibrillation detection

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Introduction

Atrial fibrillation

Atrial fibrillation (AF) is the most common sustained arrhythmia affecting 1-2 % of the population in the Western countries. AF increases the risk of stroke, congestive heart failure, hospitalization, and death [1]. The episodes of AF can be asymptomatic which introduces a challenge for the detection and diagnosis of the condition. Long-term monitoring with implantable devices increases the detection rate [2], but is costly and invasive. We evaluated the detection performance of an unobtrusive wrist-wearable device during controlled and daily life measurements.

Methods

Data

Measurements:
- Photoplethysmogram from the wrist
- Accelerometer for motion detection
- Electrocardiogram (raw signal/beat times) as reference

Electrical cardioversion
- Approximately 1 h before and 1 h after the cardioversion procedure

<table>
<thead>
<tr>
<th>N. patients</th>
<th>M/F</th>
<th>Age (years)</th>
<th>Rec. length AF/non-AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>10/8</td>
<td>75 ± 11</td>
<td>16 h 26 min/13 h 41 min</td>
</tr>
</tbody>
</table>

24-hour monitoring
- 24 hours during standard 12-lead Holter examination

<table>
<thead>
<tr>
<th>N. patients (AF)</th>
<th>M/F</th>
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</tr>
</thead>
<tbody>
<tr>
<td>16 (4)</td>
<td>10/6</td>
<td>65 ± 14</td>
<td>89 h 57 min/236 h 32 min</td>
</tr>
</tbody>
</table>

Detection of atrial fibrillation

- Pulse detection from PPG signal
- Inter-beat interval (IBIs) extraction from the pulses
- Motion detection from accelerometer
- Discarding segments corrupted by motion
- Irregularity estimation of IBIs in 30 s windows (figure A) by using Shannon entropy [3]

Classification to AF or non-AF based on IBI irregularity level

Results

Electrical cardioversion

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without motion detection</td>
<td>98.3 ± 1.8 %</td>
<td>47.2 ± 35.9 %</td>
<td>76.2 ± 15.3 %</td>
</tr>
<tr>
<td>With motion detection</td>
<td>99.2 ± 1.5 %</td>
<td>52.9 ± 38.1 %</td>
<td>80.8 ± 16.5 %</td>
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</table>

24-hour monitoring

<table>
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<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
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</thead>
<tbody>
<tr>
<td>Without motion detection</td>
<td>98.1 ± 0.8 %</td>
<td>75.1 ± 3.1 %</td>
<td>79.6 ± 2.9 %</td>
</tr>
<tr>
<td>With motion detection</td>
<td>97.3 ± 5 %</td>
<td>83.9 ± 5.4 %</td>
<td>86.6 ± 3.3 %</td>
</tr>
</tbody>
</table>

Conclusions

Atrial fibrillation was detected with high sensitivity and moderate to high specificity when measuring mid-term and long-term PPG from the wrist. The moderate specificity after the cardioversion is possibly due to presence of a large number of premature beats in some patients. After removing segments affected by motion, the detection accuracy improved with approximately 15 %. A wrist-wearable device measuring PPG provides promising unobtrusive means for long-term atrial fibrillation monitoring during daily life which is required for higher detection rate of asymptomatic or occasional atrial fibrillation events.

References: