

Estimating AF burden from wrist-measured PPG

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Background: In the past decade the diagnosis of atrial fibrillation (AF) has been developing away from merely the presence of AF towards measuring the duration or the severity of the AF periods. While treatment suggestions have yet to take it into account, AF burden has become an important measure of a patient's AF. With advances in non-invasive monitoring technology it has become possible to estimate AF burden.

Purpose: We evaluated the feasibility of estimating AF burden with continuous wrist-worn rhythm measurement using photoplethysmography (PPG). We used a wearable solution for arrhythmia detection which provided the possibility of tracking AF burden over a long period of time. As PPG-based rhythm assessment is prone to artifacts, especially from movement, the AF burden cannot be stated directly from the PPG signal.

Methods: We recruited 30 subjects (average age: 63, range: 32 – 83) with diagnosis of paroxysmal, persistent or permanent AF. The subjects used the PPG-based arrhythmia monitor and a Holter ECG for reference for an average of 47 hours (range: 31 – 53 hours). The PPG data was run through proprietary AF detection algorithms and the Holter ECG data was visually analyzed for AF. The PPG-based data was labelled in 1-minute windows as AF, sinus rhythm or undetermined. With the assumption that AF with a heavy burden is uniformly distributed, the ratio of AF windows in certain data was then multiplied by the uncertainty ratio for the whole measurement. This estimate was then compared with the total duration of AF seen in the reference.

Results: A total of 1,415 hours of continuous PPG data was recorded. 13 subjects showed AF during the measurement. The AF burden estimation flagged 16 subjects as having AF. The estimated AF burden percentages for the false positives were 1%, 1% and 2%. Out of the 13 subjects with AF, one was estimated having AF burden of 7% while the actual burden was only 2%. For the rest of the cases, the AF burden estimation achieved an average accuracy of 88%. Nine cases had an accuracy better than 90% (with 5 having an accuracy of 99%). The last three cases had accuracies of 46%, 68% and 71%.

Conclusion: The inaccuracies in the estimation are a result from the assumption that a subject's AF episodes are uniformly distributed, and that the PPG-based arrhythmia detection picks up a representative sample. When the true AF burden is small, the estimation has a higher chance of either not picking up short periods or overestimating their prevalence. As the true AF burden increases, the estimation also approaches the true value. The same is assumed to happen when the monitoring period is extended. Based on the accuracy achieved here, it can be concluded that AF burden could be estimated from noisy PPG-based data. Further development should focus on handling of outliers and artifacts in the PPG measurement and the uncertainty that they cause especially in cases with low true AF burden.