Which part of the P-QRS-T is best when developing linear ECG-lead transformations for the performance assessment of patch based electrocardiographic devices?

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***Background:*** An increasing number of wearable patch based electrocardiographic devices are being developed. These devices record non-standardized short-distance bipolar (SDB) ECG-leads. The SDB ECG-leads that are recorded by these devices can produce ECG morphologies that are different when compared to standard ECG-leads. A comprehensive performance assessment of these SDB devices requires a sufficiently large sample of device-specific SDB ECG-leads. Gathering such a large sample of device-specific data is cumbersome. Linear ECG-lead transformations, that estimate SDB ECG-leads from the standard 12-lead ECG, were recently proposed as an alternative to the collection of large device-specific SDB ECG databases. More precisely, it has been proposed to utilize estimated SDB ECG-leads for the performance assessment of SDB devices. SDB devices are typically developed for rhythm monitoring applications that utilize upon QRS or P-QRS data. It is therefore desirable that the used linear ECG-lead transformations accurately estimate these ECG intervals. Whether the utilization of different parts of the P-QRS-T complex, for the development of the linear ECG-lead transformations, has an influence on the estimation performance of these transformations has not yet been reported. We have investigated whether a specific part of the P-QRS-T complex should be used when developing linear ECG transformations for the performance assessment of SDB devices.

***Methods:***We extracted standard 12-lead ECGs and two SDB ECG-leads from body surface potential maps (BSPM) of n=726 subjects (left ventricular hypertrophy, n=232; old myocardial infarction, n=265; normal subjects, n=229). Our ECG dataset was randomly divided into one training (DTrain, n=545) and one testing dataset (DTest, n=181). DTrain was used to generate four linear ECG-lead transformation matrices for each of the two SDB ECG-leads. Transformation matrices were developed using P-wave, QRS-complex P-QRS and QRS-T data.

***Results:*** Table 1. Differences between the recorded and derived SDB ECG-leads. The RMSE values were computed for the P-wave and the QRS complex of the 181 subjects in DTest.

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| --- | --- | --- | --- | --- | --- |
| Short-lead placement | Training dataa | Mean RMSE P-waveb | Std. RMSEP-wavec | Mean RMSE QRS-complexb | Std. RMSEQRS-complexc |
| Upper left chest at 45 degree | P | 10.42 | 5.93 | 196.70 | 122.64 |
| *QRS* | 13.87 | 7.52 | 94.16 | 57.74 |
| P-QRS | 13.51 | 7.26 | 94.58 | 58.12 |
| QRS-T | 13.83 | 7.41 | 93.96 | 57.34 |
| Center of chest vertical on sternum | P | *18.53* | *11.04* | *338.67* | *263.47* |
| QRS | *26.13* | *13.29* | *222.36* | *135.93* |
| P-QRS | *25.75* | *12.99* | *222.58* | *135.87* |
| QRS-T | *25.33* | *12.05* | *223.44* | *136.66* |

Note: RMSE values are provided in $μ$V. aData that was used to develop the linear ECG-lead transformations, bmean of RMSE differences, cstandard deviation of RMSE differences.

***Conclusion*:** Our findings suggest that it is possible to optimize linear ECG-lead transformations for the P-wave. However, this comes at the cost of a substantially reduced QRS estimation performance. We therefore recommend developing the linear ECG transformations for the performance assessment of SDB devices using QRS, P-QRS or QRS-T data.

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