Early detection of patient deterioration in patients with infection or sepsis

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Appendix B

Technical details of the data preprocessing algorithm

Supplementary material to **CHAPTER 8**

Recall that the ECG preprocessing algorithm consists of four steps: (1) Filtering of baseline wander, noise, power line and movement artifacts from the raw signal, (2) R-peak detection, (3) detection and correction of ectopic heartbeats, (4) detection and correction of other non-sinus rhythm and atrial fibrillation. The technical details for each step are described in detail below.

The R-peak detection was performed using a wavelet transformation. The signal was transformed using the Daubechies 4 (Db4) wavelet with five levels. The transformed signal was then reconstructed using only levels four and five, thereby removing baseline wander, power line artifacts and partially movement artifacts. The reconstructed signal was squared to amplify the R-peaks in the signal. After squaring, a moving window threshold was used for R-peak detection adapted from the Pan Tompkins algorithm[1]. After this peak detection step, the time between two successive R-peaks was calculated, i.e. the R-R interval.

Since ectopic heart beats and other non-sinus rhythm beats may result in a significant overestimation of the HRV, these beats needed to be corrected. In our algorithm, we differentiated between (1) ectopic heartbeats, (2) atrial fibrillation and (3) other non-sinus rhythms. Ectopic heartbeats were detected when two consecutive R-R intervals differed more than 20% from the previous R-R intervals. The detected ectopic beat intervals were replaced using linear interpolation based on the mean of the three normal R-R intervals before the detected ectopic beats.

After correcting the R-R intervals for ectopic heart beats, we used the algorithm developed by Tuboly *et al* for the detection of atrial fibrillation[2]. This algorithm divides the R-R interval series into non-overlapping 30 R-R interval windows and calculates the dispersion for each window. When the dispersion is over the threshold of 0.06, the window may contain atrial fibrillation or another arrhythmia. To differentiate the type of arrhythmia further, the algorithm performs k-means clustering on the window using between 2 to 10 clusters. When the window does not contain well-defined clusters, the R-R intervals in the window are classified as atrial fibrillation. In case the dispersion in the window was over the threshold, but the R-R intervals could be clustered using between 2 and 10 clusters, we classified the R-R intervals as being non-sinus rhythm. These windows contain arrhythmias that are neither ectopic beats nor atrial fibrillation, but can originate from other arrhythmias or artifacts that were not filtered by the previous steps. The R-R intervals in both windows classified as atrial fibrillation and non-sinus rhythm were deleted before the calculation of the HRV features, since they represent long-term periods of the signal with non-sinus rhythm, for which interpolation would result in artificial changes to the HRV features[3].

REFERENCES

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