

A Recurrence Plot Based Method for the Detection of End of T-wave in Abnormal Non-invasive Fetal Electrocardiogram Signals

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Aims: This research aimed at developing an automatic algorithm to identify ends of T-waves within abnormal non-invasive fetal electrocardiogram (nfECG) signals.

Methods: Simultaneous Doppler Ultrasound (DUS) and nfECG recordings were collected in Tohoku University Hospital from 9 pregnant women at gestational age of 24-41 weeks. Data were collected from healthy and unhealthy fetuses who were diagnosed with at least one cardiac abnormality that included heart failure, heart anomaly, tachycardia and umbilical artery dysfunction. nfECG signals were filtered and segmented into intervals based on the location of the R peaks and then recurrence plots of these intervals were obtained to determine the ends of T-waves. In order to validate the results of the detection, QT and QTc of the nfECG signals were calculated based on the detected points and compared with the Q-Aortic closing (Q-Ac) and Q-Acc of the doppler signals. In addition, two correlation tests between QT and Q-Ac and between QTc and Q-Acc were performed in Matlab for the abnormal cases for further validation of the results.

Results: T-end points were detected within 321 beats in abnormal nfECG signals and 126 beats in normal nfECG signals and the results of QT and QTc are shown in the table below:

Results of QT and QTc calculations

Feature	Doppler		nfECG	
	Normal	Abnormal	Normal	Abnormal
QT(s)	0.238±0.027	0.25±0.043	0.237±0.030	0.23± 0.069
QTc(s)	0.37± 0.15	0.40±0.060	0.37±0.16	0.37±0.11

The correlation between QT and Q-Ac was 0.66 and was 0.63 between QTc and Q-Acc; also, the value of P was 0 in both cases.

Conclusion: Based on the results, recurrence plots proved to be effective in identifying location of end of T-waves within abnormal nfECG signals. However, more challenging nfECG signals need to be analyzed for further validation of the method.