

Heart Rate Raised Before Epileptic Tonic-Clonic Seizure Motions

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Abstract— This study aims to illustrate how and when the heart rate changes along with epileptic seizures. The data was collected from a bracelet (NightWatch), which contains a photoplethysmography sensor and an accelerometer sensor. We show that heart rate (HR) changes could occur around 100 seconds before a tonic-clonic seizure showed motion features, and reaches the highest HR when the epileptic motions could be detected by the NW.

Clinical Relevance— The finding has the potential to be used as an early clinical sign for tonic-clonic seizures when using a wearable epilepsy monitoring device.

I. INTRODUCTION

In our previous work [1], to address the issue of daily monitoring epileptics, a commercial bracelet (NightWatch [2]) is designed and tested on the clinical dataset. The Nightwatch bracelet contains a photoplethysmographic (PPG) heart rate module and a 3-dimensional accelerometer. This designed approach proved a sensitive and convenient monitoring method for epileptics with convulsive seizures, especially for those who had more seizures at night while releasing their caregivers from accompanying the patients all day long. Moreover, this study also provided a new recording method for potential clinical diagnosis or warning.

Video-electroencephalography monitoring (VEM) is the gold standard for epileptic seizure monitoring. Compared with VEM, a wearable device is more comfortable for daily care if it is able to accurately detect or even predict seizures before their occurrence.

II. METHODS

The NightWatch can generate alarms based on the detected abnormal motions (from the accelerometer) through a thresholding method. We analyzed 111 seizure alarms from 6 patients raised by abnormal motion changes and recorded their onset times. At the same time, we identified the heartbeats and then extracted instant heart rate (HR) from the PPG signal (at a sampling rate of 100 Hz) synchronized with the motion data.

Multiple steps were done to preprocess the PPG signal, first, we used a Butterworth bandwidth filter from 0.5 Hz to 3.5 Hz to limit the heartbeat range from 30 beats per minute (bpm) to 210 bpm. This could help remove noise and frequencies that are not supposed to be real HR. Second, we got the instant HR by detecting the heartbeat peaks and calculating the RR intervals (and its reciprocal, the HR). Third, we located the time from 10 minutes before the motion seizure

onset to 10 minutes after the onset. Then we calculated the HR changes (%) by the following equation:

$$HR_changes (\%) = \frac{HR(i) - median_HR}{median_HR}, \quad (1)$$

where the HR(i) is the HR value at the time i ranging from 0 to 1200 (in total 20 minutes), and median_HR is the median value of the HR during 20 minutes. At last, we aligned the HR changes curve at the onset time.

III. RESULTS

Fig. 1 illustrates the changes in HR over time before and after tonic-clonic seizure alarms from NightWatch. In this figure, the blue line shows the mean HR changes, and the light blue shadow area shows the standard deviation of the HR changes. The red line is the onset recorded by the NightWatch, and the onset is defined as when the patient is having severe motion activities. The red dash line shows the HR changes start from around 100 seconds before the patient had motions in a tonic-clonic seizure. The HR increased the most at the time when seizure motions could be detected by the NightWatch.

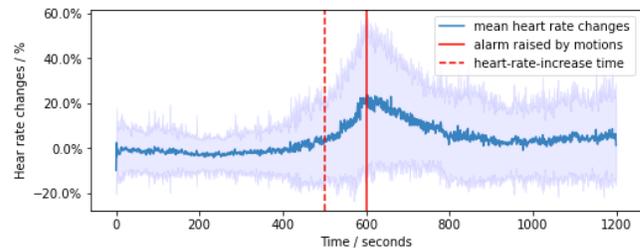


Figure 1. Heart rate changes before and after NightWatch seizure alarms.

IV. DISCUSSION & CONCLUSION

This study shows that tonic-clonic seizures correspond to HR changes around 100 seconds before the corresponding motion starts. This could be an early sign to detect or predict tonic-clonic seizures using a wearable epilepsy monitoring device.

REFERENCES

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