Detection of atrial fibrillation using a deep learning with wearable pulse wave sensor

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Introduction: Atrial fibrillation (AF) is one of the most frequent arrhythmias in Japan, and it has been widely recognized that AF is the independent risk for the stroke. In order to prevent AF-related strokes, it is desirable to detect AF in its early phase and to start preventive therapy. However, it is difficult to find the paroxysmal AF especially when the AF is asymptomatic. Long-term monitoring of heart rate or pulse rate is considered useful for detecting asymptomatic AF. In this study, we recorded the peak-to-peak interval (PPI) and average pulse rate (PR) using the wearable pulse wave recording system (Silmee: TDK Corporation, and, iAide: TOKAI Corporation). We applied deep learning with convolution neural network on PPI or PR recordings, and examined its accuracy to detect AF.

Methods: Wristwatch-based pulse wave sensor was applied to 19 AF patients. Holter electrocardiogram recording was simultaneously done to identify AF. Both recordings were performed for 8 to 14 hours. The pulse wave sensor recorded peak to peak interval (PPI) and average pulse rate per 1 minute (PR). Based on Holter electrocardiogram evaluation, the patients were classified into sinus rhythm group (SR group), atrial fibrillation group (AF group), and a group containing both of sinus rhythm and paroxysmal atrial fibrillation (mixed group). The PPI of SR group and AF group was analyzed with a block consisting of 32, or 64, or 128 beats. The PR was analyzed with a block for 8 or 16 minutes. These recording blocks were utilized for dataset for learning. We constructed a one-dimensional deep convolutional neural network (CNN) and learned the binary discrimination whether the input data is from AF group or SR group. The recording of mixed group was used as evaluation data set. The accuracy, sensitivity and specificity were evaluated in comparison with Holter electrocardiogram recording.

Result: When the deep learning was done with dataset of PPI with 32 beats, the accuracy of the CNN was 81.0%, sensitivity was 91.9%, and specificity was 65.3%. The evaluation from data set of PPI with 64 beats showed 86.8% of accuracy, 95.0% of sensitivity, and 74.9% of specificity. The evaluation from dataset of PPI with 128 beats showed 86.8% of accuracy, 93.4% of sensitivity, and 74.9% of specificity. When the deep learning was done with dataset of PR for 8 minutes, the accuracy was 69.0%, the sensitivity was 78.0%, and the specificity was 54.7%. The evaluation with PR for 16 minutes showed 77.6% of accuracy, 88.2% of sensitivity, and 60.1% of specificity. The deep learning with CNN using PPI showed higher accuracy than the using PR.

Conclusion: In this evaluation of PPI recording by wearable pulse wave sensor, CNN had high sensitivity and specificity to detect AF.