Screening ST Segments in Patients with Cardiac Autonomic Neuropathy

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Abstract

Given the elevated risk of cardiovascular events and the higher prevalence of silent ischaemia in diabetic patients, it is important to screen those patients for cardiac autonomic neuropathy (CAN). Early detection of CAN in diabetic patients, and hence timely intervention, are of critical importance towards preventing sudden cardiac death. The aim of this study is to assess whether myocardial ischaemia is common in diabetic patients with CAN by screening the ST heights of ECG signals. ST depression indicates myocardial ischaemia. The heights of ST segments of ECG signals (lead II) of 10 subjects without CAN (CAN-) [age: 61±16 years (4 males and 6 females)] and 10 subjects with CAN (CAN+) [age: 64±11 years (4 males and 6 females)] were extracted in LabChart. Episodes of ST segment depression were seen in 6 CAN+ patients (60%) but were not more common in CAN- patients. The ST heights of CAN+ group (-0.0116±0.04 mV) were found to be significantly (p=0.02) lower than that of CAN- group (0.07±0.13 mV).

1. Introduction

Symptomatic manifestations of CAN include sinus tachycardia, exercise intolerance and orthostatic hypotension. The severe complications associated with cardiac autonomic neuropathy (CAN) are considered one of the major causes of death for patients with diabetes. Around 75% of diabetes patients die due to cardiovascular diseases such as heart attack and stroke. Most of diabetes patients suffering from CAN are not aware of the disease and eventually they die due to the disease complication. The early detection of CAN increases the possibility of preventing its further development making its treatment easier. A non-invasive Ewing test battery used for CAN diagnosis is composed of five tests and the results of the five tests allow the determination of the severity of the disease; however, this method requires the cooperation of patients. In addition, the Ewing battery cannot be performed due to comorbidities in the patients and it is less effective in detecting changes associated with cardiac autonomic neuropathy compared to spectral methods[1,2].

CAN patients are at the risk of developing myocardial ischaemia, a complication results in the unexpected death of the patients eventually. The parasympathetic withdrawal has been reported in the early stages of CAN, while a sympathetic dysfunction was observed in more advanced stages [2]. Yet, the prevalence of CAN in diabetic patients based on the assessment of abnormal cardiovascular autonomic function tests is not consistent across studies and varies from 30% to 70% depending also on diabetes duration and age [3,4]. Amongst other potential explanations for cardiac associated death are the prolongation of the QT interval [4], and ischemia leading to an increased susceptibility to ventricular arrhythmias and sudden cardiac death (SCD) [5]. The aim of this study is to screen whether there is any changes in the ST heights of ECG in CAN patients which is a key indicator of the existence of myocardial ischaemia in CAN patients.

2. Methods

2.1. Subjects

All the subjects in this study had diabetes and they were enrolled in the Diabetes Complications Research Initiative (DiScRi) at CharlesSturt University. Data were collected from the subjects after they consented to being tested. The research protocol was approved by Charles Sturt University Ethics in Human Research Committee (03/164). All patients performed Ewing battery testing and five cardiac autonomic nervous system function tests as described by Ewing were recorded. Patients were divided into two groups, patients with CAN (CAN+) and without CAN (CAN-). The criterion for CAN- was that all five cardiac autonomic nervous system function tests had to be within the normal range. Definite CAN+ was defined as two or more abnormal heart rate tests. CAN+ subjects consisted of four males and six females and had ages in the range

of 64±11 years old. Similarly, CAN- subjects consisted of four males and six females and had ages in the range of 61±16 years old.

2.2. ECG records and statistical analyses

Records of 20 minutes using II lead ECG were collected from 20 subjects using the Maclab software (ADInstruments, Australia). The power-line interference in the data was reduced by applying a digital notch filter with 50 Hz. The ECG signals were stored on Macintosh Chart version 5 with a sampling rate of 400 Hz. A total of fifteen features have been extracted from the ECG signals using the ECG Analysis toolbox in Labchart . Those features were RR Interval, Heart Rate (HR), PR Interval, P Duration, QRS Interval, QT Interval,QTc, JT Interval, T peak T end Interval, Q Amplitude, R Amplitude, P Amplitude, S Amplitude, ST Height and T Amplitude. Both groups of CAN have been compared in terms of the mentioned fifteen features of ECG, the type of distribution their data follow and the follow up ECG.

The data were analyzed utilizing three different statistical analysis methods: t-test paired two sample for means, ANOVA test and Kruskal-Wallis test. Three statistical methods were used in this study in order to get an accurate value of p for each feature. Calculating the p value defines the significant features that could indicate the presence of CAN in a diabetes patient. After defining the significant features the follow up ECG for each subject was periodically tested to investigate whether the patients condition deteriorates or remains stable.

3. Results

While testing the data using the t-test paired two samples of means and the ANOVA test, it was found that the ST segment does not follow a normal distribution. Therefore, it was required to conduct the Kruskal-Wallis test to get the p value for the ST segment. After conducting the tests, the p-value was obtained for all the fifteen features. Table1 shows the mean and standard deviation (std) of the fifteen features.

It was found, using the Kruskal-Wallis test, that the only significant feature was the ST segment which had a p-value of 0.02. Comparing the CAN+ and CAN- groups results, the CAN+ group had an ST segment of -0.012±0.04 mV while the CAN- group had an ST segment of 0.07± 0.13 mV. Figure 1 displays these results plotted. It is revealed that the ST segment height of one of the CAN+ patients is approaching |0.05|mV distance from the J point. If the J point reaches 0.05 and exceeds it, the patient may suffer from a stroke.

Table 1. Mean and std of the ECG features

Feature	CAN-(mean±std)	CAN+(mean±std)
RR interval	0.92±0.18	0.92± 0.10
HR	72±8.6	66± 7.3
PR interval	0.18±0.019	0.17± 0.033
P duration	0.098±0.014	0.088± 0.030
QRS interval	0.080±0.025	0.087± 0.012
QT interval	0.33±0.079	0.35 ± 0.086
QTc	0.36±0.072	0.37 ± 0.089
JT interval	0.25±0.091	0.26± 0.090
T peak T end	0.056±0.017	0.056± 0.021
P amplitude	0.082±0.093	0.076±0.075
Q amplitude	-0.12±0.18	-0.042 ± 0.068
R amplitude	0.83±0.29	0.64 ± 0.23
S amplitude	-0.16±0.18	-0.067± 0.050
∗ ST height	0.080±0.13	-0.012 ± 0.040
T amplitude	0.12±0.29	0.13± 0.13

∗ P-value = 0.02

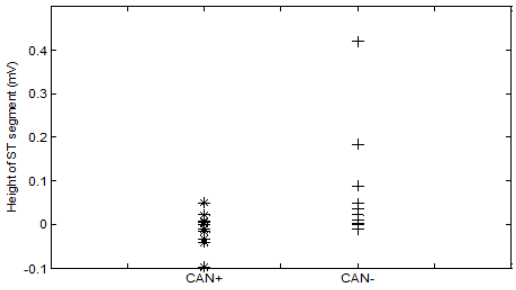

Figure 1. ST segment height vs. CAN+ and CAN- patients

4. Discussion

Not all of the CAN patients had history of cardiovascular diseases (CVDs); yet the results of the analyses performed in their ECG data revealed that there are potential risks associated with them. Furthermore, all of the CAN+ subjects who performed follow up ECG showed depression in the ST height over the time. The ST segment for the CAN+ group was shown to have a lower value than the ST segment of the CAN- group. The depression of the ST segment was indicated by the absolute value of the J point which was below the base line, approaching 0.05 mV. When the ST segment reaches an absolute value of 0.05 mV, it illustrates that the patient suffered from a stroke which in this case it may be a future possibility.

Silent/asymptomatic ST segment depression has been shown to be linked to hemodynamic and metabolic factors such as cholesterol levels [7]. ST depression may be an early marker for coronary artery disease and linked to changes in the autonomic nervous system function. Both

CAN and coronary artery disease (CAD) are associated with a change in metabolic factors such as an increase in cholesterol and increase in free radicals and inflammatory markers, leading to damage of the autonomic nervous system, and manifesting as CAN and perfusion abnormalities manifesting as ST segment depression.

5. Conclusion

The results of this study showed that the ST heights were found to be depressed in CAN patients which could indicate the presence of silent myocardial ischaemia. Early detection of the ST depression could prevent further heart complications in CAN patients.However, this study needs to be done on larger sample of CAN patients for further verification.

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