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Relationship of electrocardiographic changes and severity of acute cerebral ischemic stroke in old patients

A clinical observational study

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Abstract

There was a controversy for the electrocardiogram (ECG) changes and their relationship with disease severity in old patients with acute cerebral ischemic stroke (CIS). This study was aim to provide referential data for this topic.

Totally 200 old patients with acute CIS in our hospital from January 2017 to December 2019 were included into this study. According to the ST-T segment changes in ECG, these patients were divided into 3 groups: persistent ischemic group (n=38), transient ischemic group (n=106) and non-ischemic group (n=56). The characteristics and incidence of abnormal ECG and their relationship with disease severity, infarct size and prognosis were respectively analyzed under the severe, moderate and mild type of disease.

The ECG changes of patients were mainly characterized by myocardial ischemic ST-T segment changes with a abnormal ECG incidence of 72.00%, the arrhythmia with a abnormal ECG incidence of 9.50%, which were the second most common in clinical features. There were statistically significant differences of myocardial ischemic ST-T segment changes among different disease severity, infarct size and prognosis of acute CIS patients ($P<.05$). The ischemic ST-T segment changes of ECG reflected that the disease severity, and more ECG abnormalities indicated more severe pathological conditions in CIS patients.

The characteristics of ischemic ST-T segment changes have important reference value in the evaluation of severity and prognosis of acute CIS in old patients.

Abbreviations: CIS = cerebral ischemic stroke, ECG = electrocardiogram.

Keywords: cerebral infarction, cerebral ischemic stroke, electrocardiogram, prognosis

1. Introduction

Ischemic cerebral infarction, also known as cerebral ischemic stroke (CIS), results from cerebral deficient blood supply caused by cerebral vascular thrombosis, cerebral embolism or other causes.[1] During the acute stage of CIS, ischemic cerebral infarction is often associated with secondary heart impairment, which can further aggravate cerebral primary infarct lesions, even induce sudden death in some patients. Therefore, severity of myocardial damage detected through electrocardiogram (ECG) may reflect the severity of primary cerebral injury to a certain extent. Heart disease is mainly manifested as myocardial ischemic necrosis, ischemic ST-T segment changes were specific on ECG. However, some studies suggested that[2,3] most of the patients with ischemic cerebral infarction had no specific ECG changes, and ECG abnormities of CIS patients may often resulting from related factors such as primary cardiac diseases, age and physiological state. There was no correlation between ECG and neurological lesions. On the other hand, previous studies agured that the conditions of primary cerebral diseases can be reflected through characteristic ST-T segment changes, and some researchers[4–6] believe that CIS patients during acute stage should be observed through dynamic ECG within 24 to 48 hours for the detection of myocardial ischemic changes, so that severity and prognosis of primary CIS can be better assessed.

A number of studies have shown that[7,8] ECG changes of acute CIS patients were mainly manifested as ischemic ST-T segment changes, which were one of the most important clinical indicators to evaluate severity and prognosis of disease. However, dynamic characteristic ST-T segment changes were rarely reported in the current literatures. In recent years, with the development of all kinds of auxiliary diagnostic methods, such as imaging examinations and biochemical detection techniques, characteristic ST-T segment changes have aroused more attention in clinical practice. The purpose of this study is to explore the main features of ST-T segment changes of ECG and their relationships with severity of CIS, so as to verify its feasibility, and provide a referential data for prognostic assessments of CIS patients.

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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2. Method

2.1. Research objects

From January 2017 to December 2019, a number of 200 acute CIS patients with ST-T segment changes in our hospital were selected in this study. Of the 200 patients, there were 108 males and 92 females and the average age was 69.70±9.35 years, with a range of 60 to 79 years. From the perspective of comorbidities, there were 74 patients with diabetes, 56 patients with hypertension and 28 patients other underlying disease. All patients were diagnosed as acute CIS through head CT or MRI scan within 48 hours after the onset of disease, which was consistent with the diagnostic criteria for cerebrovascular diseases.[9] The inclusion criteria were as follows:

1. Patients who had complete CT record and 12-lead ECG record;
2. Patients without previous heart disease history and cerebrovascular disease;
3. Patients without abnormal ST-T segment, pathological Q wave and ECG abnormities in ECG in past 3 months.

The exclusion criteria were listed below:

1. Patients with with severe electrolyte disorder;
2. Patients with previous psychiatric diseases;
3. Patients with cancer or other severe comorbidities.

This study was approved by Ethics Committee of the Fenghua People's Hospital (No: AF/SC-12/01.0).

2.2. Research methods

All patients underwent head CT scan and standard 12-lead ECG examination. CT scan was carried out by using SELECT-SP computed tomographic scanner (produced by the Germany Siemens Company). ECG examination was performed by using the ECG work station (produced by American DMS Company). The patients were placed in the horizontal position, and then the conventional 12-lead electrocardiograms were traced and recorded in the resting status. The ECGs were measured and analyzed through standardized methods, and the evaluation criteria for ST-T segment changes were shown as follows: when horizontal or downsloping ST-T change were not less than 0.5 mv, and T wave showed low-flat, double hump or inversion on conventional ECGs, it could be considered that ST-T segment changes were present. According to ischemic ST-T segment changes, all patients were divided into 3 groups: persistent ischemic group (n=38), transient ischemic group (n=106) and non-ischemic group (n=56). In the persistent ischemic group, the patients had electrocardiographic ischemic ST-T segment changes on admission, but showed aggravation or no improvement of ECG changes 7 days after admission. In the transient ischemic group, the patients had electrocardiographic ischemic ST-T segment changes on admission, but showed improvement and normalization of ECG changes 7 days after admission. In the non-ischemic group, the patients showed no ischemic ST-T segment changes on ECG examination on admission and 7 days after admission.

According to the classification of infarct size,[10] it can be classified into the following types:

1. Large infarct size (n=88), the infarct size was more than 3 cm^2, and blood supply areas of main great vessels were affected in 2 anatomical sites at least;
2. Small infarct size (n=45), the infarct size was between 1.5 to 3 cm^2, and vascular occlusion was noted in 1 branch of small vessels at least;
3. Lacunar infarction size (n=67), the infarct size was no more than 1.5 cm^2.

The severity of disease was divided into mild, moderate and severe types according to the evaluation criteria for neurologic defect under the National Institute of Health stroke scale (NIHSS).[11] Mild type: The score of neurologic defect was less than 4 points. Moderate type: The score of neurologic defect was between 5 and 15 points. Severe type: The score of neurologic defect was more than 16 points. The clinical efficacy of patients with cerebral infarct was divided into 5 levels: excellent recovery, significant improvement, improvement, no changes and deterioration. The formula for clinical effective rate was: (excellent recovery + significant improvement + improvement) / total number of patients × 100%, and the prognosis should be evaluated in 14 days after treatment.

2.3. Statistical analysis

The statistical analysis was performed by using the SPSS 25.0 statistical software. The numerical data was expressed as percentage (%). The ranked data was analyzed through rank sum test. Differences were considered statistically significant when *P* value was less than .05.

3. Results

3.1. Results of ECG examination in acute CIS patients

In this study, the ECG abnormalities of all 200 patients were typically characterized by ischemic ST-T segment changes, followed by arrhythmias. The patients with ischemic ST-T segment changes, arrhythmias, prolonged QT interval and bundle-branch block accounted for 72.00%, 9.50%, 6.50%, and 6.50% respectively in the total. The incidence of other abnormal findings, such as left axis deviation and low voltage, was 5.50% in the total. As shown in Table 1.

Table 1

Results of ECG examination in acute CIS patients n (%).

Group	Arrhythmia	Ischemic ST-T segment changes	Prolonged QT interval	Bundle branch block	Other abnormities (left axis deviation or low voltage)
Lacunar infarction (n=67)	7 (10.45)	47 (70.15)	5 (7.46)	5 (7.46)	3 (4.48)
Small infarction (n=45)	5 (11.1)	30 (66.67)	5 (11.11)	3 (6.67)	2 (4.44.)
Large infarction (n=88)	7 (7.95)	67 (76.14)	3 (3.41)	7 (7.95)	4 (4.55)
Total (n=200)	19 (9.50)	144 (72.00)	13 (6.50)	13 (6.50)	11 (5.50)

Table 2

Relationship of ECG changes and disease severity in acute CIS patients n (%).

Group	Mild	Moderate	Severe
Persistent ischemia (n=38)	2 (5.26)	10 (26.32)	26 (68.42)
Transient ischemia (n=106)	23 (21.70)	55 (51.89)	28 (26.42)*
Non-ischemia (n=56)	34 (60.71)*	19 (33.93)	3 (5.36)*
Total (n=200)	59 (29.50)	84 (42.00)	57 (28.50)

* Compared with the persistent ischemic group, $P<.05$.

Table 3

Relationship between ECG changes and infarct size in acute CIS patients n (%).

Group	Lacunar infarction	Small infarction	Large infarction
Persistent ischemia (n=38)	2 (5.26)	7 (18.42)	29 (76.32)
Transient ischemia (n=106)	36 (33.96)	31 (29.25)	39 (36.79)*
Non-ischemia (n=56)	29 (51.79)*	7 (12.50)	20 (35.71)*
Total (n=200)	67 (33.50)	45 (22.50)	88 (44.00)

* Compared with the persistent ischemic group, $P<.05$.

3.2. Relationship between ECG changes and disease severity in acute CIS patients

There were statistically significant differences in ECG changes among the mild, moderate, severe type of disease severity ($P<.05$). Of the 3 groups, the patients with severe type of disease had a majority (68.42%) in the persistent ischemic group, which was significantly higher than those of the transient ischemic group (26.42%) and the non-ischemic group (5.36%), ($P<.05$); These patients with mild type of disease had a majority (60.71%) in the non-ischemic group, which was significantly higher than that of the persistent ischemic group (5.26%), ($P<.05$). There were no statistically significant differences in moderate type of disease among the 3 groups ($P>.05$). As shown in Table 2.

3.3. Relationship between ECG changes and infarct size in acute CIS patients

There were statistically significant differences in infarct size among the 3 groups ($P<.05$). Of the 3 groups, the patients with large infarction had a majority (76.32%) in the persistent ischemic group, which was significantly higher than those in the transient ischemic group (36.79%) and the non-ischemic group (35.71%) ($P<.05$); the patients with lacunar infarction had a majority (51.79%) in the non-ischemic group, which was significantly higher than that in the persistent ischemic group (5.26%), ($P<.05$). There were no statistically significant differences in small infarction among the 3 groups ($P>.05$). As shown in Table 3.

3.4. Relationship between ECG changes and prognosis in acute CIS patients

The ECG re-examination after the 7-day treatment showed that there were statistically significant differences in prognosis among the 3 groups ($P<.05$). The effective rate in the non-ischemic group (96.43%) was significantly higher than those in the persistent ischemic group (31.58%) and in the transient ischemic group (73.58%), ($P<.05$). As shown in Table 4.

4. Discussion

The acute CIS results from cerebral deficient blood supply caused by cerebral vascular thrombosis, cerebral embolism or other causes.[12] Lacunar infarction may exacerbate to small infarction, even to large infarction, and some CIS can also cause acute hemorrhagic cerebral infarction during the recovery of blood flow. Cerebral deficient blood supply caused by local dysaemia typically results in ischemic necrosis or cerebral malacia of partial brain tissues, the severity of which is associated with neurologic defect.[13] The CIS was often related to secondary heart impairment during the acute stage, and was typically characterized by ST-T segment changes in electrocardiogram following myocardial ischemic necrosis.[14] Because ST-T segment changes and myocardial ischemic impairment were highly specific, and myocardial damage from brain-derived vessel disease was associated with severity of disease. In addition, patients with acute CIS also had myocardial ischemic necrosis at autopsy.[15] Many studies have also shown that characteristic ischemic ST-T segment changes can often reflect severity of acute CIS indirectly on the basis of the detection of myocardial ischemic changes.[16–18]

Some studies suggested that ECG abnormities of CIS patients may often result from related factors such as age, physiologic and pharmacologic factors, and not just from neurogenic lesions. It was also reported that CIS is typically seen in aged people, and the incidence of acute CIS is 28% to 90% in old patients.[19,20] However, normal old people can also have age-related ECG abnormities mostly characterized by arrhythmias, and ST-T segment abnormalities. But it was generally believed that pathological changes were usually caused by natural functional decline or tissue lesions in the old people, and it always showed good prognosis and reversibility. In this study, the 2 were mostly characterized by ST-T segment changes, and followed by arrhythmias. For other clinical manifestations, such as prolonged QT interval, block conduction disorders, left axis deviation and low voltage, were not very common. According to the literatures,[21] the incidence of myocardial ischemic ST-T segment changes was more than 70.1% in acute CIS patients. In addition, acute CIS patients typically present with consciousness disorders, hemiplegia and coma due to neurologic impairment, and lack of

Table 4

Relationship between ECG changes and prognosis in acute CIS patients n (%).

Group	Excellent recovery	Significantly improvement	Improvement	No changes	Deteriorated	Effective rate
Persistent ischemia (n=38)	2 (5.26)	5 (13.16)	5 (13.16)	14 (36.84)	12 (31.58)	12 (31.58)
Transient ischemia (n=106)	24 (22.64)	33 (31.13)	21 (19.81)	14 (13.21)	14 (13.21)	78 (73.58)*
Non-ischemia (n=56)	27 (48.21)	17 (30.36)	10 (17.86)	2 (3.57)	0 (0.00)	54 (96.43)*
Total (n=200)	53 (26.50)	55 (27.50)	36 (18.00)	30 (15.00)	26 (13.00)	144 (72.00)

* Compared with the persistent ischemic group, $P<.05$.

verbal expression of uncomfortable symptom ECG examination should be observed through dynamic ECG during early stage.

Heart injury may deteriorate to myocardial ischemic necrosis in acute CIS patients, which was clinically manifested as ischemic ST-T segment changes. The possible causes of above symptoms as follow: Firstly, the sympathoadrenal dysfunction and abnormally increased synthesized catecholamine which were caused by hypothalamic dysfunction from acute cerebral infarction. It can promote the increase of contraction and spasm of intracoronary small vessels, resulting in myocardial ischemia and anoxia which then cause different impairments of heart and myocardial ischemic necrosis; Secondly, CIS patients often presented with different levels of cerebral edemas, typically resulting in increased intracranial pressure, increasing intracranial pressure can lead to functional disorders of bulbar cardiovascular center, resulting in myocardial ischemia and anoxia, which then cause neurogenic myocardial ischemic necrosis; thirdly, in patients with acute CIS, the activation of thrombin system can often promote abnormal increase of thrombin with secondary coagulation. After that, the subsequent anticoagulant therapies usually lead to fibrinolytic disorder and blood hypercoagulabale state, resulting in decreased blood supply of coronary artery, which then cause myocardial ischemia and anoxia. These above 3 factors can cause myocardial ischemic necrosis in acute CIS patients.

There was a mutual causality between cerebrovascular diseases and heart disease, this relationship may be related with brain-heart axis.[22] In a study performed by Li et al[23] have shown that characteristic ST-T segment changes were related to site, size and severity of in CIS patients. Therefore, when ischemic ST-T segment changes regularly occurred in clinic, all the factors, such as primary cerebral diseases, primary cardiac diseases or other cause-induced heart disease should be considered. Yu et al[24] who explored the importance of characteristic ST-T segment changes in the diagnosis of old patients with acute CIS, suggested that characteristic ST-T segment changes were important in the diagnosis of diseases. ECG abnormalities in acute CIS patients were mainly characterized by myocardial ischemic ST-T segment changes, and may be accompanied by many other ECG abnormalities. All above studies supported that acute ischemic ST-T segment changes have important reference value in the evaluation of CIS patients.

This study found that acute CIS patients who were mainly characterized by ischemic ST-T segment changes, including the features such as simple T-wave changes, T-wave deep inversion, ST depression and ST-T segment changes. The abnormal ECG changes showed the highest incidence (72.00%), followed by arrhythmia with a high proportion of 9.50%. The study showed that other clinical manifestations, such as QT interval prolongation, bundle-branch block and other ECG abnormalities were also seen, severity of disease was associated with multiple ECG abnormalities. The ischemic ST-T segment changes showed that the severe CIS patients had a majority in the persistent ischemic group, the rate of which was significantly higher than that in the transient ischemic group and the non-ischemic group (68.42% vs 26.42% vs 5.36%), this indicating severe myocardial damage along with severe cerebral infarction. In addition, the larger infarct size represented the higher incidence of abnormal ischemic ST-T segment changes, indicating that the acute CIS patients might experience a shift from lacunar infarction to small infarction even to large infarction, and the severity of damages of cerebral and cardiac tissues was correlated with each other. What is more, this study also found that the 38 patients with persistent ischemic ST-T segment changes in the persistent ischemic group showed poorer prognosis and lower clinical effective rate, which was more than those in transiently ischemic and non-ischemic ST-T segment changes (31.58% vs 73.56% vs 96.43%), which were similar to the findings of Lyu et al.[25]

This study showed that the characteristic ischemic ST-T segment changes, which may be useful in helping physicians for treatment, were clinically important in the evaluation of severity and prognosis of acute CIS in old patients. Therefore, intensive electrocardiogram monitoring may have clinical significance for preventing deterioration of disease and death risk of patients. Due to ischemic ST-T segment changes were not only caused by isolated neurogenic lesions, the close medical observation should be performed through dynamic ECG combined with clinical manifestations. Furthermore, the sample in this study were relatively small, which may lead to the statistical bias, the results needs to be further verified in large sample study.

Author contributions

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