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Research Article

Evaluation of Percutaneous Coronary Intervention for Acute ST-Segment Elevation Myocardial Infarction with Hypertension by Dynamic Electrocardiogram Feature Data

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This work was to study the application value of dynamic electrocardiogram (ECG) feature data in evaluating the curative effect of percutaneous coronary intervention in acute ST-segment elevation myocardial infarction with hypertension, so as to facilitate the early diagnosis and treatment of the disease. In this study, 90 patients with acute ST-segment elevation myocardial infarction accompanied by hypertension were selected as the study subjects and randomly divided into group A (oral aspirin antiplatelet therapy), group B (thrombolytic drug streptokinase (SK) therapy), and group C (percutaneous coronary intervention), with 30 cases in each group. In addition, a P-wave detection algorithm was introduced for automatic detection and analysis of electrocardiograms, and the efficacy of patients was assessed by Holter feature data based on the P-wave detection algorithm. The results showed that the diagnostic error rate, sensitivity, and predictive accuracy of the P-wave detection algorithm for ST-segment elevation myocardial infarction caused by acute occlusion of left main coronary artery (LMCA) were 0.24%, 95.41%, and 92.33%, respectively; the diagnostic error rate, sensitivity, and predictive accuracy for non-LMCA (nLMCA) ST-segment elevation myocardial infarction were 0.28%, 95.32%, and 96.07%, respectively; the proportion of patients with symptom to blood flow patency time <3 h in group C (55.3%) was significantly higher than that in groups A and B (22.1% and 22.6%) ($P < 0.05$). Compared with group A, the content of B-type natriuretic peptide (pre-proBNP) at 1 week, 2 weeks, and 3 weeks after treatment in groups B and C was significantly lower and group C was significantly lower than group B ($P < 0.05$). In summary, the P-wave detection algorithm has a high application value in the diagnosis and early prediction of acute ST-segment elevation myocardial infarction. Percutaneous coronary intervention in the treatment of acute ST-segment elevation myocardial infarction with hypertension can shorten the opening time of infarction blood flow, so as to effectively protect the heart function of patients.

1. Introduction

Acute ST-segment elevation myocardial infarction refers to acute myocardial ischemic necrosis, most of which occur on the basis of coronary artery disease with a sharp decrease in coronary blood supply or complete interruption, resulting in severe and lasting acute myocardial ischemia [1]. The common reason is secondary thrombosis based on unstable plaque rupture and erosion of coronary artery, resulting in continuous and complete occlusion of coronary artery. The disease was common in Europe and the United States. The annual incidence of the disease in the population aged 35–84 years old in the United States was about 7.1%. About 1 million people have acute myocardial infarction each year, and 450,000 people have remyocardial infarction. Recent research data show that the incidence of the disease in China is also gradually increasing [2, 3]. The incidence of sudden ST-segment elevation myocardial infarction, ventricular arrhythmia sudden death, and heart failure in hypertensive patients increased. For the treatment of acute ST-segment elevation myocardial infarction, drug thrombolysis therapy (plasminogen activator to activate fibrinogen in thrombus, so as to transform into fibrinolysin and dissolve thrombus in coronary artery) and percutaneous coronary intervention are widely used [4, 5]. The therapeutic principle is to restore myocardial perfusion as soon as possible, prevent myocardial infarction from expanding or narrowing the scope of myocardial ischemia, and protect heart function. Due to China's vast territory, large population, and scattered distribution, patients in some remote areas cannot be treated for thrombolysis and direct percutaneous coronary intervention within the prescribed time due to traffic inconvenience and other issues [6, 7].

Data from a related survey result showed that the mortality rate of acute myocardial infarction in China was significantly higher in remote areas than in urban and rural areas [8]. In view of the current medical status in remote areas, it is of great practical significance to explore a safer reperfusion strategy for patients with acute ST-segment elevation myocardial infarction. Early percutaneous coronary intervention after thrombolysis can not only achieve reperfusion to restore blood flow as early as possible but also strive for more reperfusion time for transport percutaneous coronary intervention, which has been widely recognized by domestic and foreign guidelines and is a feasible and suitable treatment strategy for ST-segment elevation myocardial infarction patients in China [9, 10].

At present, electrocardiogram (ECG) is a commonly used and effective early diagnosis method for acute ST-segment elevation myocardial infarction due to its advantages of high safety, low cost, and significant effect [11]. The main manifestation of the ECG is the presence of wide and deep malformed Q-waves, which are less altered relative to P-waves, and if comorbidities occur at a later stage, increased P-waves occur affecting right ventricular function [12, 13]. The detection of P-wave is of great significance for the ECG analysis of acute ST-segment elevation myocardial infarction and the characteristic point position analysis of ECG signal. Therefore, in this study, a P-wave detection algorithm is proposed to perform the automatic detection and analysis of ECG and realize the positioning of the initial point position of P-wave, so as to achieve the accurate and effective prediction and diagnosis of myocardial infarction. In addition, patients with acute ST-segment elevation myocardial infarction and hypertension were treated with percutaneous coronary intervention, and the clinical efficacy was evaluated by Holter characteristics data based on the P-wave detection algorithm.

2. Materials and Methods

2.1. General Information and Groupings. In this study, 90 patients with acute ST-segment elevation myocardial infarction with hypertension admitted to hospital from November 2018 to October 2020 were collected as the research subjects, including 48 male patients and 42 female patients. Patients were randomly divided into group A (oral aspirin antiplatelet therapy), group B (thrombolytic drug streptokinase (SK) therapy), and group C (percutaneous coronary intervention), with 30 patients in each group. The study was approved by medical ethics committee of hospital. Patients and their families understood the contents and methods of the study and agreed to sign the corresponding informed consent.

Inclusion criteria: patients without the history of cardiovascular surgery, such as percutaneous coronary intervention or coronary artery bypass grafting (CABG), age between 45 and 70 years old, and patients had not received other drugs and antibiotics at recent.

Exclusion criteria: patients with other system or organ lesions, patients with cardiomyopathy, patients with severe liver and kidney dysfunction, and patients with ECG ST-segment elevation less than 2 mm before treatment.

2.2. ECG Examination of Patients. All patients underwent 12-lead ECG before operation. ST-segment elevation was measured by mv, and TP segment (the end point of T-wave to the starting point of P-wave) was used as the measurement reference level. According to admission ECG ST-segment elevation, leads were divided into anterior wall leads (V_1–V_3), limited anterior wall leads (V_3–V_5, ± I, ± aVL), anterior lateral wall leads (V_5–V_7, aVL, I), extensive anterior wall leads (V_1–V_6, ± I, ± aVL), inferior wall leads (II, III, aVF), high lateral wall leads (I, aVL), and right ventricular leads (V_3R–V_7R).

2.3. ECG P-Wave Detection Algorithm. ECG was collected after the patient was placed in the horizontal supine position, the chest, wrists, and ankles were exposed, the skin was cleaned with alcohol, and electrodes were placed. The normal ECG signal consists of a certain sequence of P-waves (from the change of point position of atrial depolarization before atrial contraction), QRS-waves (from the change of ventricular depolarization before ventricular contraction), T-waves (the change of potential during ventricular repolarization), PR segments, PR intervals, ST-segments, QT intervals, and U-waves.

Wavelet packet analysis provided a more precise analysis method for ECG signals. The frequency bands were divided at multiple levels, and the high-frequency parts without subdivision in multiresolution analysis were further decomposed. According to the characteristics of the analyzed signals, the corresponding frequency bands can be adaptively selected to match the signal spectrum, so as to improve the time-frequency resolution. The signal was filtered by the wavelet packet algorithm, and then, the time domain boundary of the P-wave of the single-cycle ECG was determined, and the P-wave was extracted by extracting the waveform of the frequency range where the P-wave of the single-cycle ECG signal was located. The basic process of wavelet denoising is shown in Figure 1.

Wavelet threshold function selection is as follows.

$$\omega_\lambda = \begin{cases} \omega, |\omega| \geq \lambda, \\ 0, |\omega| < \lambda, \end{cases} \tag{1}$$

$$\omega_\lambda = \begin{cases} [\text{sign}(\omega)(|\omega| - \lambda), |\omega| \geq \lambda], \\ 0, |\omega| < \lambda, \end{cases} \tag{2}$$

where ω_λ represents the wavelet threshold function, and λ is the threshold. Equation (1) is the hard threshold function.

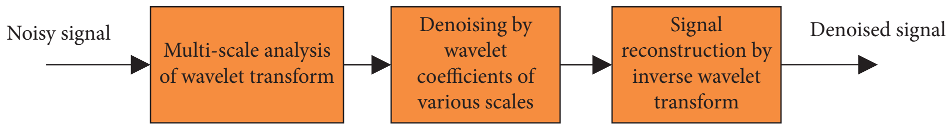


Figure 1: Wavelet denoising process.

Equation (2) is the soft threshold function, which effectively avoids discontinuity and ensures the smooth reconstruction signal. The wavelet threshold denoising process is shown in Figure 2.

Threshold calculation is estimated by QRS peak and noise. Whenever QRS is detected, it is added to an array that holds the latest 8 QRS peaks. In addition, each time a non-QRS-wave is detected, this non-QRS-wave is also added in an array that stores the latest 8 noises. The detection threshold is calculated from the median or average between the noise and the QRS-wave.

2.4. Treatment of Patients with Acute ST-Segment Elevation Myocardial Infarction. Patients in group A: antiplatelet therapy was used, patients received oral 300 mg aspirin, and P2Y12 receptor inhibitors were selected according to the specific circumstances of patients. Patients in group B: drug thrombolytic therapy was used, and streptokinase was used as the drug, which was intravenously infused at 1.5 million unit within 1 hour. During the infusion, attention should be paid to patient's chills, fever, and other allergic reactions. Patients in group C: percutaneous coronary intervention was used, and alteplase thrombolysis was followed by percutaneous transluminal coronary angioplasty.

2.5. Statistical Methods. The data in this study were analyzed by SPSS 19.0 statistical software. The measurement data were expressed as mean ± standard deviation ($\overline{x} \pm s$), and the enumeration data were expressed as percentage (%). Analysis of variance was used for pairwise comparison. $P < 0.05$ indicated that the difference was statistically significant.

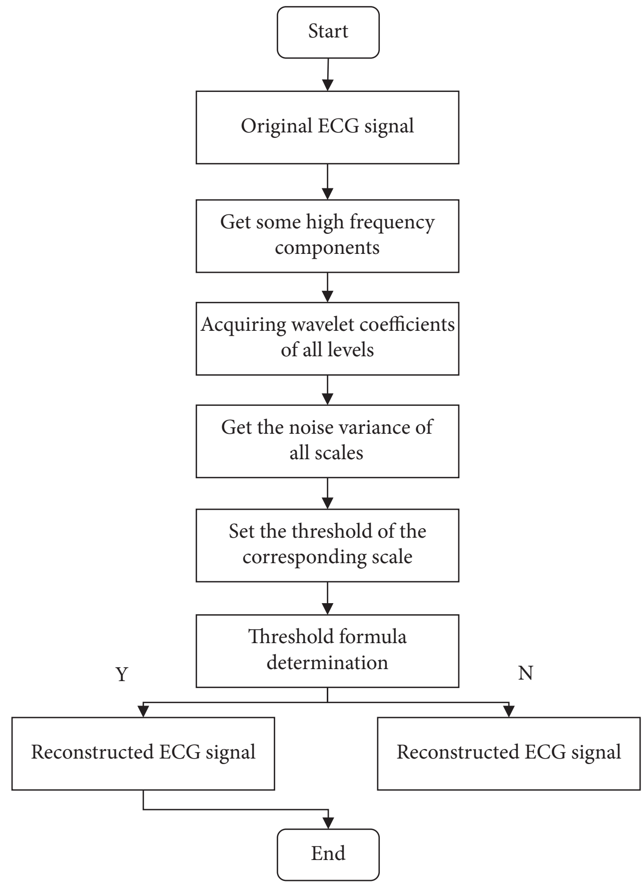


Figure 2: Wavelet threshold denoising process.

3. Results

3.1. Early ECG Manifestations of ST-Segment Elevation Myocardial Infarction. There was no typical single curve elevation of ST-segment and Q-wave formation in the early stage of ST-segment elevation myocardial infarction. There were only hyperacute injury changes such as increased T-wave broadening and mirror changes in corresponding leads. The early ECG of ST-segment elevation myocardial infarction showed elevated T-wave, widened base, increased amplitude, and accompanied by asymmetric ascending and descending branches of T-wave lasting for several minutes. ST-segment elevation developed into ST-T fusion. R-wave decreased (Figure 3).

3.2. Basic Information of Three Groups of Patients. Figure 4 shows the comparison results of age ratio and cardiac function grade among the three groups. There was no significant difference in the proportion of patients aged less than 50, 50–60, and greater than 60 in each group among the three groups ($P > 0.05$). There was no significant difference in the proportion of patients with cardiac function grade III and IV in each group ($P > 0.05$).

3.3. Patient ECG Signal Monitoring. Figure 5 shows the ECG signal detection results. The results suggest that the P-wave detection algorithm can mark the P-wave that may be submerged in strong interference, accurately locate the P-wave and T-wave peak of ECG signal, and detect the singular points of P-wave and T-wave. In this study, a wavelet packet P-wave detection algorithm was introduced to decompose the ECG lead I signal with a 12-layer wavelet packet. The wavelet packet basis is db4, and the binding point (12, 0) corresponds to the baseline drift signal. The baseline drift results are shown in Figure 5(b). The diagnostic error rate, sensitivity, and predictive accuracy of the P-wave detection algorithm for ST-segment elevation myocardial infarction caused by acute occlusion of the left main coronary artery (LMCA) were 0.24%, 95.41%, and 92.33%,

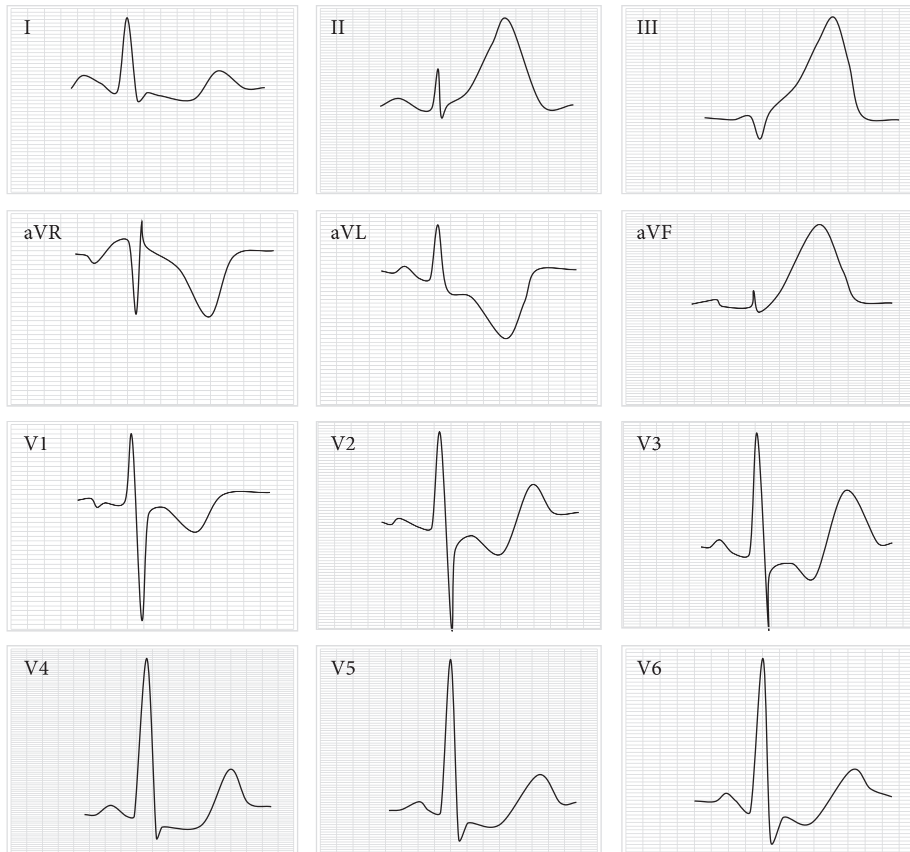
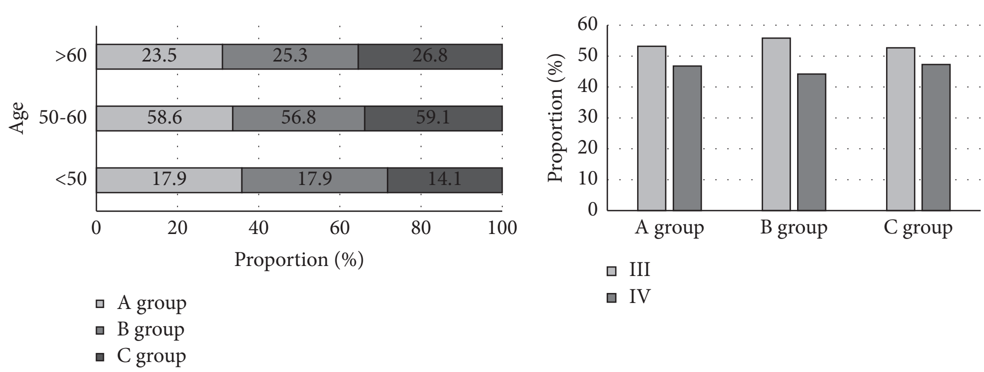


FIGURE 3: Early ECG manifestations of ST-segment elevation myocardial infarction. Note: chest pain onset for 2–4 hours, sinus rhythm, II, III, aVF lead T-wave base widened, T-wave elevation, and asymmetry. I, aVL, V1–V6, lead mirror ST-segment depression 0.05–0.2 mV.



(a) (b)

FIGURE 4: Basic information of patients. (a) The age ratio of the three groups. (b) The cardiac function level of the three groups.

respectively; the diagnostic error rate, sensitivity, and predictive accuracy for non-LMCA (nLMCA) ST-segment elevation myocardial infarction were 0.28%, 95.32%, and 96.07%, respectively.

3.4. Changes of Cardiac Function Indexes in Patients. Figure 6(a) shows the changes of systolic blood pressure in three groups before treatment, 1 week, 2 weeks, and 3 weeks after treatment. With the extension of treatment time, the systolic blood pressure of the three groups decreased gradually. After 1 week of treatment, the systolic blood pressure of group B and group C was lower, while the systolic blood pressure of group A was higher. Compared with group A (140.3 ± 7.21 mmHg), systolic blood pressure of group B and group C (126.44 ± 9.38 mmHg and 116.02 ± 8.2 mmHg) was significantly lower after 2 weeks of treatment and group C was significantly lower than group B ($P < 0.05$). Figure 6(b) shows the diastolic blood pressure changes of the three groups before treatment, 1 week, 2 weeks, and 3 weeks after treatment. The diastolic blood pressure of group C was significantly lower at 1 week, 2 weeks, and 3 weeks after treatment

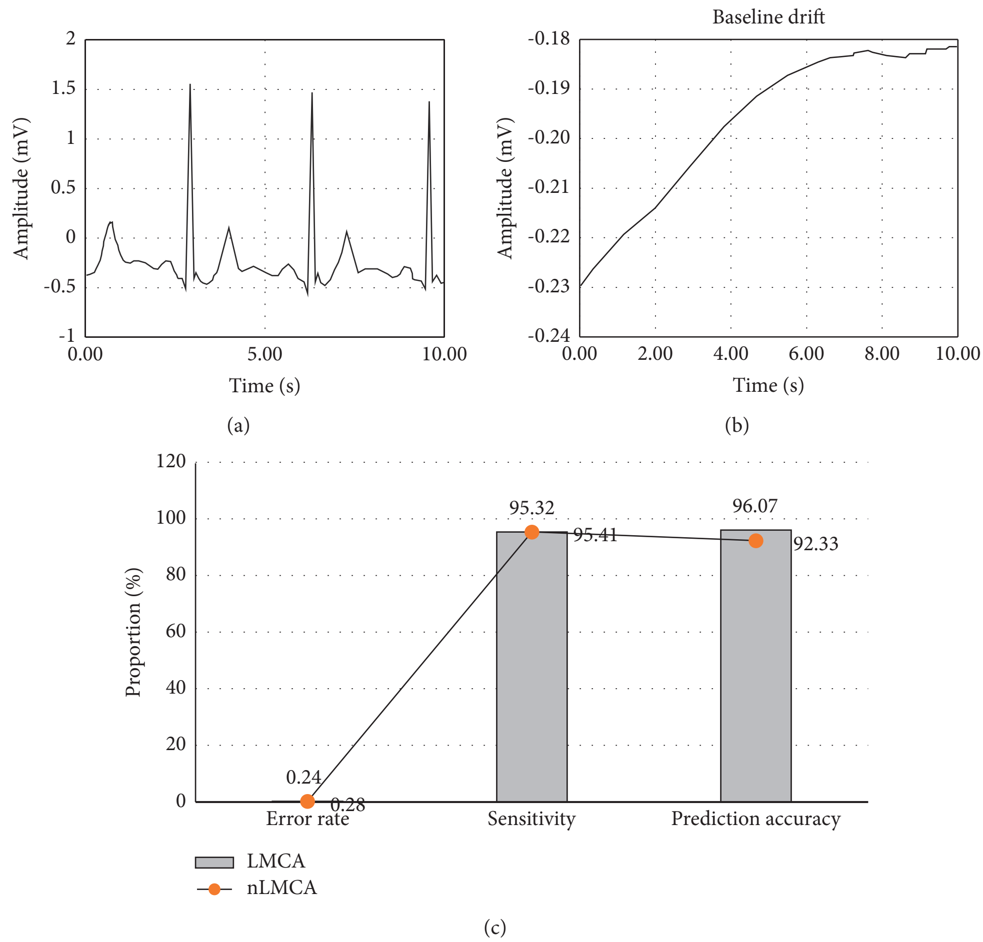


Figure 5: ECG signal detection results. (a) ECG acquisition waveform. (b) Baseline drift. (c) Diagnostic effect.

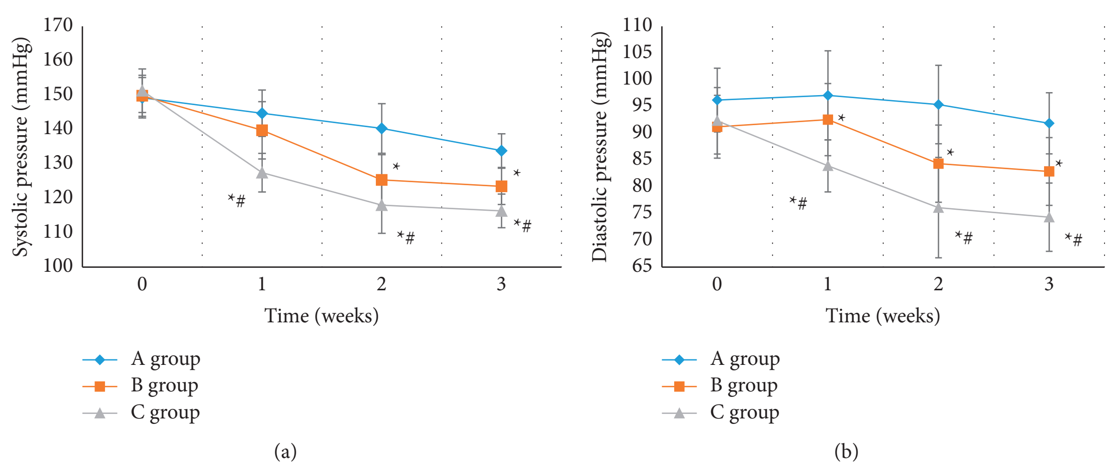


Figure 6: Changes of cardiac function indexes. (a) Systolic blood pressure. (b) Diastolic pressure. ∗Significant difference compared with group A ($P < 0.05$). #Significantly different compared with group B ($P < 0.05$).

($P < 0.05$). After 2 weeks of treatment, diastolic blood pressure of group B and group C (88.15 ± 8.2 mmHg and 74.12 ± 9.38 mmHg) was significantly lower than that of group A (95.38 ± 7.33 mmHg) and group C was significantly lower than that of group B ($P < 0.05$).

3.5. Time from Symptoms to Blood Flow Opening. Figure 7 shows three groups of patients after oral aspirin antiplatelet therapy, thrombolytic drug streptokinase therapy, and percutaneous coronary intervention in three ways of treatment, patients with myocardial infarction

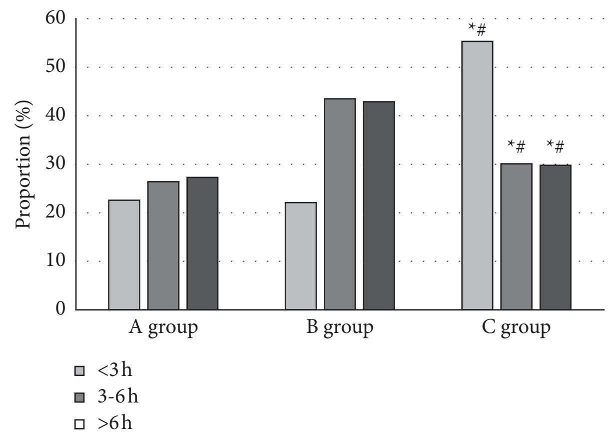


FIGURE 7: Time from symptom to blood flow opening. ∗Significant difference compared with group A ($P < 0.05$). #Significantly different compared with group B ($P < 0.05$).

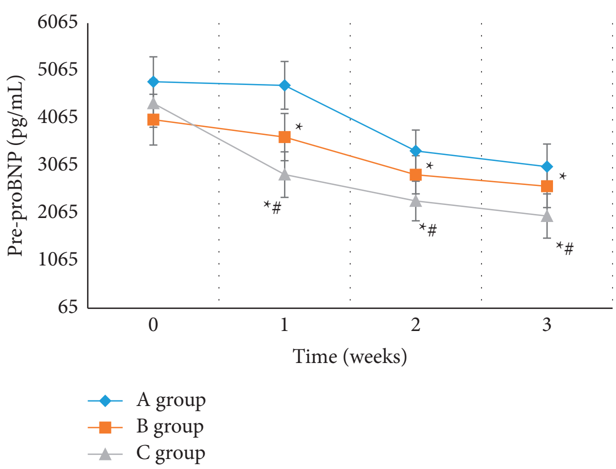


FIGURE 8: Changes of pre-proBNP in patients. ∗Significant difference compared with group A ($P < 0.05$). #Significant difference compared with group B ($P < 0.05$).

symptoms to blood flow opening time comparison results. The proportion of patients with symptoms to blood flow opening time <3 h in group C (55.3%) was significantly higher than that in group A and group B (22.1% and 22.6%), and the difference was statistically significant ($P < 0.05$).

3.6. Changes in Pre-ProBNP Levels in Patients. Figure 8 shows the changes of cardiac marker B-type natriuretic peptide (pre-proBNP) in the three groups after treatment with different methods. There was no significant difference in pre-proBNP content before treatment among the three groups ($P > 0.05$), and with the extension of treatment time, pre-proBNP content gradually decreased in all three groups and decreased faster in group C. Compared with group A, the pre-proBNP levels of patients in groups B and C were significantly lower at 1 week, 2 weeks, and 3 weeks after treatment and were significantly lower in group C than in group B ($P < 0.05$).

4. Discussion

In recent years, great achievements and progress are made in the diagnosis and treatment of acute ST-segment elevation myocardial infarction complicated with hypertension [14]. In addition, with the construction and popularization of chest pain centers in China, patients with acute myocardial infarction can be treated in a timely and effective manner. Early diagnosis and early opening of infarct blood vessels are of great significance for the prognosis of patients with acute ST-segment elevation myocardial infarction [15, 16]. For patients with chest pain suspected of acute ST-segment elevation myocardial infarction, 12-lead electrocardiogram (inferior or posterior wall) should be recorded within 10 minutes after the first medical exposure, and V_3R–V_5R and V_7–V_9 leads should be added to myocardial infarction [17, 18]. The early ECG of typical patients with acute ST-segment elevation myocardial infarction showed that the ST-segment arch was elevated (showing a one-way curve) with or without pathological Q-wave and R-wave reduction (when posterior wall myocardial infarction, the ST-segment change could not be obvious). Ultraacute ECG can show abnormal high and two asymmetric T-waves [19, 20]. When the first ECG cannot confirm the diagnosis, it needs to be reexamined after 10–30 minutes. Comparison with previous ECGs is helpful in the diagnosis. When myocardial infarction occurs in patients with left bundle branch block, ECG diagnosis is difficult and careful judgment is required in combination with clinical conditions to start ECG monitoring as early as possible to avoid the occurrence of malignant arrhythmia [21].

The study of Kwon (2020) [22] found that although the implementation of opening infarct-related artery in patients with advanced myocardial infarction could not effectively improve myocardial cell necrosis and reduce infarct size, it could avoid further expansion of the infarcted area and reduce myocardial electrical instability, which had a positive effect on the improvement of cardiac function and long-term prognosis of patients.

In this study, a P-wave detection algorithm for automatic detection and analysis of the ECG was raised to locate the starting point of the P-wave, so as to achieve accurate and effective prediction and diagnosis of myocardial infarction. In addition, patients with acute ST-segment elevation myocardial infarction and hypertension were treated with percutaneous coronary intervention, and the clinical efficacy was evaluated by Holter characteristics data based on the P-wave detection algorithm. Results of this study are that the P-wave detection algorithm could accurately locate the P-wave and T-wave peaks of ECG signal and detect the singular points of P-wave and T-wave; the diagnostic error rate, sensitivity, and prediction accuracy of ST-segment elevation myocardial infarction caused by acute occlusion of LMCA were 0.24%, 95.41%, and 92.33%, respectively; the diagnostic error rate, sensitivity, and prediction accuracy of ST-segment elevation myocardial infarction of nLMCA were 0.28%, 95.32%, and 96.07%, respectively. It suggests that the P-wave detection algorithm proposed in this study has a high application value in the diagnosis and early prediction of acute ST-segment elevation myocardial infarction. After oral aspirin antiplatelet therapy, thrombolytic drug streptokinase therapy, and percutaneous coronary intervention, the proportion of patients with symptom to blood flow patency time < 3 h in group C (55.3%) was significantly higher than that in groups A and B (22.1% and 22.6%), and the difference had a statistical significance ($P < 0.05$). The results revealed that the implementation of percutaneous coronary intervention after drug thrombolysis can effectively reduce the blood flow patency time, thereby restoring myocardial blood perfusion and effectively protecting cardiac function. Compared with group A, the pre-proBNP content in groups B and C was significantly lower at 1 week, 2 weeks, and 3 weeks after treatment and significantly lower in group C than in group B ($P < 0.05$); the study found that atrial fibrillation, arrhythmia, pulmonary hypertension, asthma, pneumonia, and other diseases could cause abnormal increase of pre-proBNP [23], that is, the decrease of proBNP content could reflect that the patient's cardiac function was improved to a certain extent.

5. Conclusion

In this study, a P-wave detection algorithm was introduced to perform automatic detection and analysis of ECG and to locate the starting point of P-wave, so as to achieve accurate and effective prediction and diagnosis of myocardial infarction. In addition, patients with acute ST-segment elevation myocardial infarction complicated with hypertension were treated with percutaneous coronary intervention, and the clinical efficacy was evaluated by dynamic ECG feature data based on the P-wave detection algorithm. The results showed that the P-wave detection algorithm had a high application value in the diagnosis and early prediction of acute ST-segment elevation myocardial infarction. Percutaneous coronary intervention in the treatment of acute ST-segment elevation myocardial infarction with hypertension can shorten the opening time of infarction blood flow, so as to effectively protect the heart function of patients. However, this study lacks comparison with other intelligent algorithms, and the samples included in the study are less and the representativeness is low. Therefore, an improvement and optimization in this aspect will be made in the subsequent experiments to further analyze the application value of dynamic ECG feature data in the evaluation of percutaneous coronary intervention for acute ST-segment elevation myocardial infarction with hypertension. In conclusion, this study provides a reference for the early diagnosis and treatment of cardiovascular diseases such as myocardial infarction.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Guoqiang Wang and Yu Wang contributed equally to this work.

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