Effect of Eye Acupuncture with Retained-Needle Exercise on Postoperative Heart Rate Variability and Prognosis in Patients Undergoing Percutaneous Coronary Intervention: Postprint

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Date: 2023-04-03T11:24:36+00:00

Abstract

Background Heart rate variability (HRV) is known to be a non-invasive indicator for evaluating cardiac autonomic nervous function and is commonly used to assess short-term prognosis of coronary artery disease. Percutaneous coronary intervention (PCI) is a commonly used surgical procedure for coronary artery disease; however, major adverse cardiovascular events (MACE) such as malignant arrhythmias and recurrent myocardial infarction are common postoperatively. Although dual antiplatelet therapy (DAPT) can reduce the occurrence of MACE to some extent, it is prone to be complicated by gastrointestinal bleeding and cannot continuously and effectively improve PCI prognosis. Eye acupuncture can effectively reduce the duration and frequency of chest pain, and exercise therapy can enhance cardiac and vascular function. The application of eye acupuncture combined with exercise therapy (eye acupuncture with needle-retained exercise) in post-PCI patients remains to be explored.

Objective To investigate the effects of eye acupuncture with needle-retained exercise on heart rate variability and prognosis in CHD patients after PCI.

Methods Thirty-two moderate- to low-risk CHD patients after PCI who presented to the Affiliated Hospital of Chengdu University of Traditional Chinese Medicine between September 2021 and August 2022 were selected as study subjects. They were randomly assigned to either the eye acupuncture with needle-retained exercise group or the medication group at a 1:1 ratio. The eye acupuncture with needle-retained exercise group received eye acupuncture with needle-retained exercise in addition to dual antiplatelet therapy, while the medication group received only dual antiplatelet therapy. All subjects in both groups completed the 2-week intervention. The following data were collected

from patients: (1) Baseline indicators: including sex, age, height, weight, blood pressure, respiratory rate, time interval since intervention, education level, occupation, severity of coronary artery disease, and number of underlying diseases. (2) Primary indicators: 24-hour ambulatory electrocardiography was used to evaluate heart rate variability (HRV) within 24 hours after PCI and on the day when the 2-week intervention ended. Recorded parameters included: standard deviation of all normal sinus beat RR intervals (SDNN), standard deviation of the average RR intervals every 5 minutes over 24 hours (SDANN), average of the standard deviations of RR intervals within each 5-minute period over 24 hours (SDNN index), root mean square of successive differences between adjacent RR intervals (rMSSD), percentage of adjacent RR intervals differing by >50 ms out of total heartbeats (PNN50), high frequency (HF), low frequency (LF), and low frequency/high frequency ratio (LF/HF). MACE was used to evaluate prognosis at 2, 4, and 8 weeks after intervention. Cardiac or all-cause death, malignant arrhythmias such as ventricular tachycardia and ventricular fibrillation, severe heart failure, recurrent myocardial infarction, repeat PCI, chest pain, and other conditions were recorded through telephone and outpatient consultations. (3) Secondary indicators: C-reactive protein (CRP), N-terminal pro-brain natriuretic peptide (NT-proBNP), creatine kinase-MB (CK-MB), and high-sensitivity troponin I (hs-TnI). (4) Safety indicators: occurrence of complications such as subcutaneous hematoma, skin lesions, muscle soreness, abnormal respiration, and stroke after PCI. All outcome indicators were measured within 24 hours after PCI and on the day when the 2-week intervention ended.

Results After 2 weeks of treatment, there were no statistically significant differences between the two groups in LF/HF, SDNN, SDANN, SDNN index, LF, HF, RMSSD, and PNN50 ($P>0.05$). Comparison of LF/HF, SDNN, and SDANN levels between the two groups showed statistically significant differences ($P<0.05$). Two weeks later, CRP in the medication group was higher than in the eye acupuncture with needle-retained exercise group ($P<0.05$); there were no statistically significant differences between the two groups in NT-proBNP, CK-MB, and hs-TnI ($P>0.05$). The incidence of MACE and adverse reaction rate in the eye acupuncture with needle-retained exercise group were lower than those in the medication group ($P<0.05$).

Conclusion Eye acupuncture with needle-retained exercise is more effective than medication in improving heart rate variability in CHD patients after PCI, with lower MACE incidence and better short-term postoperative prognosis.

Full Text

Effect of Ocular Acupuncture and Exercise Combination Therapy on Postoperative Heart Rate Variability and Prognosis in Patients Undergoing Percutaneous Coronary Intervention

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Abstract

Background: Heart rate variability (HRV) is a well-established non-invasive indicator of cardiac autonomic function commonly used to evaluate the short-term prognosis of coronary artery disease. Percutaneous coronary intervention (PCI) is a widely employed surgical treatment for coronary artery disease; however, major adverse cardiovascular events (MACE) such as malignant arrhythmias and recurrent myocardial infarction frequently occur postoperatively. While dual antiplatelet therapy (DAPT) can reduce MACE incidence to some extent, it is prone to gastrointestinal bleeding complications and cannot consistently improve PCI prognosis. Ocular acupuncture can effectively reduce the duration and frequency of chest pain, and exercise therapy can enhance cardiac and vascular function. The application of ocular acupuncture combined with exercise therapy (OAECT) in post-PCI patients remains to be explored.

Objective: To investigate the effect of OAECT on HRV and prognosis in coronary heart disease (CHD) patients after PCI.

Methods: Thirty-two moderate- to low-risk CHD patients who underwent PCI at the Hospital of Chengdu University of Traditional Chinese Medicine between September 2021 and August 2022 were enrolled. Participants were randomly assigned in a 1:1 ratio to either the OAECT group or the drug treatment group. The OAECT group received OAECT in addition to DAPT, while the drug treatment group received DAPT alone. Both groups completed a 2-week intervention. Patient data were collected as follows: (1) Baseline indicators: gender, age, height, weight, blood pressure, respiratory rate, interval between PCI and in-

tervention, education level, occupation, severity of coronary artery disease, and number of underlying diseases. (2) Primary indicators: HRV was assessed using 24-hour Holter monitoring within 24 hours post-PCI and on the final day of the 2-week intervention. Parameters included the standard deviation of all normal-to-normal RR intervals (SDNN), standard deviation of the average 5-minute RR intervals (SDANN), mean of the standard deviations of 5-minute RR intervals (SDNN index), root mean square of successive differences (rMSSD), percentage of adjacent RR intervals differing by >50 ms (PNN50), high frequency (HF), low frequency (LF), and LF/HF ratio. Prognosis was evaluated using MACE at 2, 4, and 8 weeks post-intervention, including cardiac or all-cause death, malignant arrhythmias (ventricular tachycardia and fibrillation), severe heart failure, recurrent myocardial infarction, repeat PCI, and chest pain, recorded via telephone and outpatient consultations. (3) Secondary indicators: C-reactive protein (CRP), N-terminal pro-B-type natriuretic peptide (NT-proBNP), creatine kinase-MB (CK-MB), and high-sensitivity troponin I (hs-TnI). (4) Safety indicators: complications such as subcutaneous hematoma, skin lesions, muscle soreness, respiratory abnormalities, and stroke. All outcome measures were assessed within 24 hours post-PCI and on the final day of the 2-week intervention.

Results: After 2 weeks of treatment, there were no significant differences between groups in LF/HF, SDNN, SDANN, SDNN index, LF, HF, rMSSD, or PNN50 ($P>0.05$). However, significant between-group differences were observed in LF/HF, SDNN, and SDANN levels ($P<0.05$). CRP levels were significantly higher in the drug treatment group compared to the OAECT group after 2 weeks ($P<0.05$), while no significant differences were found in NT-proBNP, CK-MB, or hs-TnI ($P>0.05$). The OAECT group had significantly lower MACE incidence and adverse reaction rates compared to the drug treatment group ($P<0.05$).

Conclusion: OAECT is more effective than drug treatment alone in improving HRV, reducing MACE incidence, and achieving better short-term prognosis in post-PCI CHD patients.

Keywords: Coronary disease; Percutaneous coronary intervention; Eye acupuncture therapy; Ocular acupuncture and exercise combination therapy; Heart rate variability; Major adverse cardiovascular events; Randomized controlled trial

Introduction

Coronary heart disease (CHD) is the leading cause of cardiovascular mortality, posing a serious threat to public health. The 2019 China Cardiovascular Health and Disease Report indicated a ratio of 1:30 between CHD and cardiovascular disease patients in China. Percutaneous coronary intervention (PCI) is an effective treatment for improving myocardial perfusion in CHD patients. However, post-PCI ischemia-reperfusion injury often leads to major adverse cardiovascular events (MACE) including malignant arrhythmias, recurrent myocardial

infarction, repeat PCI, chest discomfort, and even cardiac or all-cause death, resulting in poor prognosis.

Heart rate variability (HRV) is a non-invasive indicator for evaluating cardiac autonomic function, considered evidence of myocardial ischemia and arrhythmia, and used to assess short-term prognosis of coronary artery disease. Lower HRV indicates worse prognosis. Currently, dual antiplatelet therapy (DAPT) with aspirin and oral P2Y12 inhibitors remains the cornerstone for preventing thrombotic complications post-PCI. However, premature discontinuation is associated with stent thrombosis and adverse outcomes including death, while long-term use increases bleeding risk and cannot consistently improve PCI prognosis. The optimal duration of postoperative pharmacotherapy remains controversial, making it imperative to find better approaches to avoid or reduce stent thrombosis or bleeding events caused by medication.

Ocular acupuncture and exercise combination therapy is an emerging integrative rehabilitation approach performed during eye acupuncture needle retention. Ocular acupuncture is a micro-needle therapy based on the "Eight Region Theory" of traditional Chinese medicine meridian theory, involving needle manipulation along the orbital rim to unblock meridians, activate blood circulation, relieve pain, and regulate organ function. According to meridian theory, periorbital tissues are closely related to organ function, and ocular acupuncture at the "upper jiao region" and "heart region" can effectively reduce the duration and frequency of angina in CHD patients. Exercise therapy can enhance cardiac and vascular function, reduce MACE incidence in post-PCI CHD patients, and significantly improve muscle strength, endurance, balance, coordination, and quality of life, earning Class I evidence recommendation from the American Heart Association and European Society of Cardiology for cardiac rehabilitation programs.

Currently, ocular acupuncture and exercise combination therapy is primarily applied in post-stroke rehabilitation and was promoted nationwide by the National Administration of Traditional Chinese Medicine in 2018 as an appropriate TCM technique, though its application in other fields requires further exploration. Based on this foundation, our research team conducted a randomized controlled clinical study to investigate the effect of ocular acupuncture and exercise combination therapy on HRV and prognosis in CHD patients after PCI, aiming to develop a more effective and safer therapeutic approach to reduce MACE or postoperative complications and expand cardiac rehabilitation options after PCI.

Methods

Study Design and Participants

This study enrolled 32 moderate- to low-risk CHD patients who underwent PCI at the Hospital of Chengdu University of Traditional Chinese Medicine between

September 2021 and August 2022. Inclusion criteria were: (1) confirmed diagnosis of stable angina, non-ST-segment elevation myocardial infarction, or ST-segment elevation myocardial infarction; (2) age 45-80 years; (3) moderate- to low-risk status post-PCI (risk stratification criteria in); (4) stable vital signs within 24 hours post-PCI. Exclusion criteria included: (1) unstable vital signs; (2) severe complications such as malignant tumors, heart failure, respiratory failure, or shock; (3) cognitive impairment or severe hearing/vision deficits; (4) severe hepatic, renal, or immune dysfunction; (5) pregnancy or lactation; (6) contraindications to acupuncture; (7) inability to exercise. All participants provided informed consent before enrollment.

Randomization and Blinding

Participants were randomly assigned in a 1:1 ratio to either the ocular acupuncture and exercise combination therapy group (16 cases) or the drug treatment group (16 cases) using computer-generated random sequences. The study was approved by the Hospital Ethics Committee of Chengdu University of Traditional Chinese Medicine in July 2021 (2021KL-028) and registered with the Chinese Clinical Trial Registry in July 2021 (ChiCTR2100048960), following the SPIRIT protocol and CONSORT reporting standards.

A dynamic block randomization method was employed with online application. Researchers sent a text message containing the participant's name pinyin initials, gender English abbreviation, and birth date to the central randomization system, which replied with an automatically generated random number and group assignment. Blinding was implemented through separation of researchers, operators, and statisticians. Researchers were unaware of individual treatment assignments; operators implemented treatment according to the centrally determined protocol; participants were unaware of alternative treatments; and statisticians remained blinded to grouping and treatment details throughout data collection and analysis. A separate researcher maintained the allocation schedule, which was concealed on computer and provided only to operators.

Interventions

Drug Treatment Group: Received conventional perioperative and postoperative antiplatelet and anticoagulant therapy for 2 weeks. According to the 2016 Chinese PCI Guidelines, baseline medications included: (1) Aspirin enteric-coated tablets: 100-300 mg orally 6 hours preoperatively, then 100 mg/d for 2 weeks postoperatively; (2) Clopidogrel bisulfate tablets: 300-600 mg orally >6 hours preoperatively, additional 600 mg at 2-6 hours preoperatively, then 75 mg/d for 2 weeks postoperatively. Cardiology specialists could add antihypertensive, lipid-lowering, or glucose-lowering medications as needed, with continued follow-up treatment after study completion.

Ocular Acupuncture and Exercise Combination Therapy Group: In addition to drug treatment, participants received continuous ECG monitoring

for 24 hours, followed by 2 weeks of ocular acupuncture and exercise therapy once vital signs stabilized. Following the National Standard of the People's Republic of China for Acupuncture Techniques—Eye Acupuncture, specialized eye acupuncture needles were applied at specific points "Upper Jiao Region" (ACU1) and "Heart Region" (ACU2) 2 mm outside the orbital rim. The operator fixed the periorbital skin with the pressing hand, grasped the needle handle with forceps, and inserted the needle at approximately 15° along the skin from the starting point to the endpoint of the eye acupuncture zone, reaching 5-8 mm into the dermis and subcutaneous tissue without deeper insertion. The needle handle was pressed to obtain qi and then fixed with adhesive tape.

Immediately after needle insertion, exercise therapy was initiated, including warm-up training, exercise training (aerobic, resistance, and flexibility exercises), and relaxation training (detailed in). After exercise, a 5-minute observation period preceded needle removal. The needle was withdrawn slowly by grasping the handle with forceps, rotating gently, removing halfway, then slowly pulling out completely, followed by immediate pressure on the needle hole with a dry cotton ball for >30 seconds. Eye acupuncture was performed once daily with 60 minutes of exercise, 5 days per week for 2 weeks, with 2 rest days during the period. Exercise intensity was adjusted in real-time based on patient sweating, respiration, pulse, and blood pressure.

Outcome Measures

(1) Baseline Indicators: Gender, age, height, weight, blood pressure, respiratory rate, interval between PCI and intervention, education level, occupation, coronary artery disease severity, and number of underlying diseases.

(2) Primary Indicators: HRV was assessed using 24-hour Holter monitoring within 24 hours post-PCI and on the final day of the 2-week intervention. Parameters recorded included: SDNN, SDANN, SDNN index, rMSSD, PNN50, HF, LF, and LF/HF ratio to evaluate cardiac autonomic function and post-PCI prognosis. MACE was assessed at 2, 4, and 8 weeks post-intervention via telephone and outpatient consultations, documenting cardiac or all-cause death, malignant arrhythmias (ventricular tachycardia and fibrillation), severe heart failure, recurrent myocardial infarction, repeat PCI, and chest pain.

(3) Secondary Indicators: Fasting blood samples collected within 24 hours post-PCI and on the morning after the 2-week intervention were analyzed for CRP, NT-proBNP, CK-MB, and hs-TnI to assess myocardial function.

(4) Safety Indicators: Complications including subcutaneous hematoma, skin lesions, muscle soreness, respiratory abnormalities, and stroke were monitored.

Statistical Analysis

One researcher collected all data using case report forms and recorded them in a specially designed Excel spreadsheet, which was double-checked by a second

researcher. Paper and electronic data were stored at the Hospital of Chengdu University of Traditional Chinese Medicine and an independent network drive for ten years. Statistical analysis was performed using SPSS 23.0. Continuous variables were expressed as mean ± standard deviation and compared between groups using independent t-tests. Categorical variables were expressed as percentages and compared using chi-square tests. Multiple linear regression was used to explore correlations between MACE and HRV parameters. Mean differences or odds ratios with 95% confidence intervals were calculated. $P<0.05$ was considered statistically significant.

Results

Baseline Characteristics

Baseline data comparisons showed no significant differences between groups ($P>0.05$,).

HRV Parameters

At baseline, no significant differences existed between groups in SDNN, SDANN, SDNN index, rMSSD, PNN50, HF, LF, or LF/HF ($P>0.05$). After 2 weeks of treatment, no significant differences were observed between groups in LF/HF, SDNN, SDANN, SDNN index, LF, HF, rMSSD, or PNN50 ($P>0.05$). However, significant between-group differences were found in LF/HF, SDNN, and SDANN levels ($P<0.05$,).

Myocardial Function

Baseline comparisons showed no significant differences in CRP, NT-proBNP, CK-MB, or hs-TnI between groups ($P>0.05$). After 2 weeks, CRP levels were significantly higher in the drug treatment group compared to the OAECT group ($P<0.05$), while no significant differences were observed in NT-proBNP, CK-MB, or hs-TnI ($P>0.05$,).

MACE and Adverse Reactions

The OAECT group experienced 4 MACE cases: 2 cases of chest pain (at 2 weeks) and 2 cases of acute heart failure (at 4-week follow-up), plus 1 case of periorbital subcutaneous hematoma. The drug treatment group experienced 12 MACE cases: 6 cases of chronic heart failure (2 at 2 weeks, 2 at 4-week follow-up), 5 cases of palpitations, 1 case of acute heart failure resulting in death (at 8-week follow-up), plus adverse reactions including abdominal distension, melena, nausea, and pulmonary infection (2 cases each). The OAECT group had significantly lower MACE incidence (25%) (^{2}=2.41, P=0.016) and adverse reaction rate (12.5%) (^{2}=2.08, P=0.038) compared to the drug treatment group.

Correlation Between MACE Incidence and HRV

Binary logistic regression analysis with MACE incidence as the dependent variable and HRV parameters as independent variables revealed statistically significant effects of SDNN (B=-0.019, t=-3.72, P=0.002), SDANN (B=-0.019, t=-3.553, P=0.003), and LF/HF (B=-0.869, t=-2.225, P=0.043) on MACE incidence. SDNN (β=-0.705), SDANN (β=-0.689), and LF/HF (β=-0.511) were negatively correlated with MACE incidence.

Discussion

This study demonstrates that ocular acupuncture and exercise combination therapy is more effective than dual antiplatelet therapy alone in modulating HRV, reducing MACE incidence, and improving short-term prognosis in post-PCI CHD patients. The therapeutic advantages appear related to inhibiting sympathetic nerve activity, enhancing vagal nerve vitality, maintaining autonomic nervous system balance, and reducing myocardial inflammatory responses to promote myocardial cell repair and improve cardiac function.

The OAECT approach consists of two components: ocular acupuncture and exercise therapy. Ocular acupuncture, developed by Professor Peng Jingshan of Liaoning University of Traditional Chinese Medicine, is based on ancient Five-Ring and Eight-Region theories and the relationship between the eyes and viscera/meridians. By needling eight regions and thirteen points around the eyes, it regulates visceral, meridian, and qi-blood balance. Traditional texts such as *Taiping Holy Prescriptions for Universal Relief* document the correspondence between the five eye rings and five viscera, while *Longshu Bodhisattva's Eye Treatise* describes the Eight-Region theory, reflecting the holistic and syndrome differentiation concepts of TCM. Exercise therapy emphasizes combining passive training with active exercise to regulate neural activity, improve vascular endothelial function, enhance aerobic metabolism, increase exercise tolerance and cardiopulmonary function, improve muscle strength and proprioception, increase joint range of motion and stability, and promote motor and nerve damage repair—making it a core modern rehabilitation treatment widely used in musculoskeletal, endocrine, cardiovascular, cerebrovascular, and nervous system diseases.

Our findings show that after 2 weeks of intervention, HRV parameters in the OAECT group increased toward normal ranges (except HF), while the drug treatment group showed slight decreases. Significant between-group differences in SDNN, SDANN, and LF/HF—reflecting sympathetic function and autonomic balance—demonstrated that OAECT more effectively influenced autonomic activity, significantly reducing MACE risk and weakening sympathetic activity. The negative correlation between MACE incidence and SDNN, SDANN, and LF/HF further confirms that OAECT's superiority in cardiovascular rehabilitation after PCI is achieved primarily by reducing sympathetic activity and

promoting autonomic balance to regulate HRV.

In addition to HRV effects, OAECT reduced elevated myocardial function markers, particularly CRP ($P<0.05$), though improvements in CK-MB, hs-TnI, and NT-proBNP were not statistically significant compared to drug treatment. This may reflect different sensitivities of these markers: CK-MB peaks at 12-24 hours post-acute myocardial infarction and normalizes within 2-3 days; hs-TnI reflects minor myocardial damage more sensitively and is recommended as the preferred cardiac injury marker; NT-proBNP increases with ventricular volume or pressure load and is essential for heart failure diagnosis; while CRP, synthesized by hepatocytes during inflammation, is closely associated with acute cardiovascular endothelial injury and is an independent, powerful predictor of cardiovascular events. The significant CRP reduction suggests OAECT's anti-inflammatory effects surpass drug treatment, while its comparable effects on other markers indicate equivalent efficacy in promoting myocardial repair and reducing ventricular load.

Limitations

This randomized controlled study targeted post-PCI CHD patients (including unstable angina, ST-segment elevation myocardial infarction, and non-ST-segment elevation myocardial infarction). Due to the acute nature of these conditions, most patients—particularly those undergoing emergency PCI—did not receive preoperative 24-hour Holter monitoring. Therefore, we only compared post-PCI HRV parameters, MACE incidence, cardiac function markers, and adverse reactions between groups; differences between pre- and post-PCI treatment effects remain unclear. Future studies with stricter inclusion criteria recruiting elective PCI patients could address this gap.

Additionally, while the between-group CRP difference confirms OAECT's anti-inflammatory efficacy, the negative findings regarding myocardial repair and ventricular load reduction warrant attention. With increased sample sizes, these conclusions may change. Future research incorporating Doppler echocardiography, cardiac PET-CT, or cardiac MRI could provide more intuitive myocardial function indicators. Furthermore, due to sample size limitations, correlation analysis between MACE incidence and HRV was limited to binary logistic regression; future larger-scale studies could employ multivariate logistic regression to identify the most critical HRV risk factors for MACE and further explore mechanisms underlying OAECT's effects on autonomic nervous system and myocardial function.

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Received: November 16, 2022; Revised: March 18, 2023
Edited by: CUI Sha

Note: Figure translations are in progress. See original paper for figures.