

Cardiovascular Reviews

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Cardiovascular Reviews

Focus and Scope

Cardiovascular Reviews publishes peer-reviewed research articles across basic, translational, and clinical cardiovascular medicine. The journal aims to enhance insight into cardiovascular disease mechanisms and the prospects for innovation. The Journal covers all topics within cardiology and cardiovascular biology with an emphasis on studies that challenge the status quo of treatments, at the molecular, sub-cellular, cellular, organ, and organism level, and of clinical proof-of-concept and translational studies and practices in cardiovascular care or facilitate the translation of scientific advances into the clinic as new therapies or diagnostic tools. Manuscripts are expected to provide a significant contribution to the field with relevance for cardiovascular biology and diseases.

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Advances in the Study of Magnetocardiography in Cardiovascular Diseases

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Abstract: Cardiovascular diseases (CVDs) are one of the leading reasons for death and disability in patients worldwide. Their accurate diagnosis and assessment remain a considerable challenge in clinical settings. Magnetocardiography is a non-invasive, non-radioactive, and non-contact functional test. This examination has made significant progress in diagnosing and treating CVDs recently. However, most healthcare professionals are not aware of this new examination tool. In this review, we will summarize the development history and working principle of magnetocardiography, highlight its use in diagnosing, evaluating, and monitoring CVD treatment effects, and discuss the prospects for its application in clinical settings.

Keywords: Magnetocardiography; Cardiovascular disease; Coronary heart disease; Acute coronary syndrome; Arrhythmia; Coronary microcirculatory dysfunction; Restenosis after percutaneous coronary intervention; Myocarditis

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1. Introduction

Cardiovascular diseases (CVDs) are the leading reasons for death globally and in China; they account for 40% of the mortality rate of the Chinese population^[1,2]. Approximately 330 million Chinese people suffer from CVD. The burden of CVD will continue to increase because China faces the dual pressures of an aging population and a continuous increase in the prevalence of metabolic risk factors. Therefore, the accurate diagnosis and active treatment of CVDs have become particularly important^[3]. Magnetocardiography (MCG) has emerged as a non-invasive, non-radioactive, non-contact, and convenient CVD detection method. It can overcome the limitations of traditional examination methods owing to its high signal fidelity. This tool holds considerable significance for diagnosing, evaluating, and monitoring the treatment effects of CVDs. Therefore, MCG may become an essential tool for diagnosing, evaluating, and monitoring the treatment effects of CVDs in the future.

2. Principles and development history of MCG

The heart generates an electric current in the body, generating a magnetic field. The Earth's magnetic field is approximately 30,000,000 picotesla (pT), whereas the cardiac magnetic field is very small, with peaks of less than one-millionth of the strength of the Earth's magnetic field, i.e., approximately 50–100 pT. The Earth's magnetic field is strong but cannot completely mask the cardiac magnetic field because of its static properties. Small temporal variations in the Earth's magnetic field produce geomagnetic noise that can interfere with the heart's magnetic field. Furthermore, the strength of the cardiac magnetic field is considerably weaker than the magnetic field of magnetic resonance imaging. Nevertheless, the strength of the cardiac magnetic field, although small, can still be detected. MCG is used to detect the heart's magnetic field. A conventional MCG comprises superconducting quantum interference devices (SQUID) and its electronics system, a gradiometer, a non-magnetic moving bed, an electromagnetic shielding room, and a data acquisition and processing system. The SQUID is an extremely sensitive magnetometer used to detect weak cardiac magnetic fields, and the gradiometer helps SQUID distinguish cardiac magnetic fields from other magnetic fields. This enhances the detectability of cardiac magnetic field signals. In 1963, Gerhard Baule and Richard McFee measured the magnetic fields generated by the human body for the first time. They recorded the cardiac magnetic field, or MCG, at a site in Syracuse, New York. After Baule's and McFee's pioneering research, David Cohen also began investigating the cardiac magnetic field. In 1967, Cohen experimented in a magnetically shielded room, using a single coil to perform MCG. Around the 1970s, the SQUID magnetometer was invented to detect abnormally weak signals. Then, Cohen began working with James Zimmerman, one of the inventors of the SQUID, to measure biomagnetic fields for the first time using the SQUID in a magnetically shielded room. The SQUID had to be kept at ultra-cold temperatures to maintain its superconducting properties; therefore, it was placed in an insulated Dewar flask filled with liquid helium. Compared with wire-wound pickup coils, the SQUID has a smaller detector and higher sensitivity but without cryogenic technology^[4]. In the following decades, the SQUID magnetometer has become a state-of-the-art instrument for measuring biomagnetic fields.

3. Advantages of MCG in CVDs

MCG has been around for 60 years. However, it has not been routinely used in clinical settings because of the high cost associated with the equipment and maintenance. Current clinical studies have revealed that compared with traditional non-invasive electrocardiography (ECG), MCG is more effective in diagnosing coronary artery disease (CAD)^[5]. While ECG indirectly measures the electrical activity of the heart via electrodes placed on the skin, MCG is a non-contact method of recording the magnetic field generated by the electrophysiological activity inside the heart using a highly sensitive magnetic sensor placed outside the body. Unlike the heart's electrical signals, the magnetic permeability of the human body is constant, and the recording of the cardiac magnetic field by the MCG is not significantly affected by the differing conductivity and resistance of various body tissues between the heart and the surface sensor. This makes MCG more reliable than ECG for detecting biological phenomena. Furthermore, MCG has a better gain value owing to its higher sensitivity to tangential and eddy currents than ECG. In addition, MCG has a higher sensitivity in detecting improvements in cardiovascular function in patients with CVD, it can detect changes in cardiac function at an earlier stage compared with ECG^[6]. Single photon emission computed tomography poses a potential radiation risk, whereas MCG does not pose a potential radiation risk and demonstrates high accuracy in diagnosing myocardial injury^[7]. In a study comparing exercise ECG and MCG scores for detecting ST-segment fluctuations in CAD, researchers reported that exercise MCG was significantly

more accurate than exercise ECG for diagnosing coronary artery obstruction in patients with intermediate-to-high-risk CAD^[8]. Overall, these findings suggest the considerable application advantage of MCG for diagnosing CVDs.

4. Advances in the study of MCG for CVDs

4.1. Progress of MCG research in coronary heart disease

Ischemic heart disease is one of the leading reasons for death worldwide. Inadequate blood supply to the heart causes myocardial ischemia, resulting in abnormal repolarization and excitation wave conduction in the myocardial tissue; this ultimately results in arrhythmias and even sudden death. The current diagnosis of myocardial ischemia via 12-lead ECG has shortcomings because, in some cases, particularly non-ST-segment elevation myocardial infarction (NSTEMI), ECG may not demonstrate typical ST-segment changes. As a non-invasive, non-contact technique, MCG can be used for the early identification of myocardial ischemia. This helps in the risk stratification of myocardial ischemia. Erick A Perez Alday et al. used 12- and 36-lead ECGs and 36-lead MCG and investigated the signaling differences between regions in cardiac ischemia. They noted that both MCGs and ECGs exhibited region-dependent changes in cardiac ischemia. The differences between 36-lead ECG and MCG were more significant compared with 12-lead ECG (sensitivities of 34%, 37%, and 26%, respectively); however, MCG exhibited a stronger correlation to the response of cardiac ischemic region, providing an alternative method for diagnosing this condition^[9]. In clinical settings, accurately identifying patients with acute coronary syndrome (ACS) is often challenging, particularly when ECG does not exhibit typical ST-segment elevation. In a retrospective study, Kwon *et al.* selected 364 patients with suspected ACS without ST-segment elevation. They noted that the sensitivity of MCG was 84.0% of patients with CAD, compared with that of 44.7% for ECG. In patients with no significant abnormalities detected on ECG or biomarker tests, MCG exhibited a sensitivity of 73.5% and a specificity of 82.3%^[10]. Therefore, MCG is more conducive to the early diagnosis of patients with acute chest pain compared with ECG. Furthermore, MCG exhibits a better diagnostic rate for patients with acute chest pain who do not have significant abnormalities on ECG.

Lim *et al.* used 64-channel MCG to assess 20 patients with NSTEMI, 15 young individuals, and 13 age-matched healthy participants. They noted significant differences in all MCG parameters between the 28 healthy subjects and 20 patients with NSTEMI^[11]. None of the healthy subjects had more than four abnormal MCG parameters. In contrast, 19 patients with NSTEMI had more than four abnormal MCG parameters. Furthermore, significant differences were noted in the pairwise temporal activation maps and T-wave peaks in MCG parameters between healthy subjects and patients with NSTEMI. Collectively, these results suggest that MCG is sensitive to changes in myocardial repolarization after myocardial infarction (MI) and that MCG is a valuable tool for identifying patients with severe ischemia.

Peter *et al.* performed MCG at rest on 144 participants. Among the 144 participants, 50 were healthy, 43 had CAD without MI, 36 had MI, and 15 had spontaneous ventricular tachycardia (VT)^[12]. The percentage of patients with CAD without MI and patients with MI and QT interval magnetogram localization deviating from normal values was 67% and 85%, respectively. The number of trajectory diagrams deviating from normal values increased with disease severity. The distribution of QT interval duration was subsequently quantified using the smoothing index, exhibiting significant differences between healthy participants and patients without MI and between patients with MI with and without VT. This demonstrates that malignant arrhythmias owing to CAD can be assessed by analyzing MCG signals.

4.2. Progress of MCG in restenosis after percutaneous coronary intervention

The non-invasive testing of patients with restenosis after percutaneous coronary intervention (PCI) remains a clinical challenge. Most patients with recurrent chest pain after PCI still require coronary angiography or coronary computed tomography angiography (CTA). Furthermore, the 12-lead ECG results are often typical for patients with post-PCI restenosis. However, other non-invasive methods, such as stress ECG, radionuclide imaging, and echocardiography, are not as sensitive as coronary angiography in detecting restenosis^[13]. To avoid X-ray exposure and possible serious side effects, repeat angiography should be performed only if re-intervention is warranted. Coronary CTA, although a commonly used tool for post-procedural review at present, still exerts radiological and contrast-related side effects. The advent of MCG will be a practical addition to the traditional non-invasive modalities of routine examination. Hailer *et al.* evaluated the potential value of MCG in the outcome of post-PCI patients. They included 111 participants, including 54 patients with stable or unstable angina, all of whom were treated with PCI^[14]. The control group comprised 57 healthy participants. Fifty patients with CAD and 57 healthy participants were subjected to 12-lead ECG and 4-channel MCG recordings, and current density vector (CDV) maps were compared and categorized at pre-PCI, 24 h post-procedure, and 1 month post-procedure, with CDV maps categorized from category 0 (normal) to category 4 (severely abnormal). Compared with pre-PCI patients with CAD, most normal individuals had CDV maps classified as category 0, 1, or 2. At 24 h after PCI, more CDV maps of patients with CAD were classified as category 2, and only a few CDV maps of patients with CAD were classified as category 4. One month after PCI, the MCG results of patients with CAD improved further, with more CDV maps classified as categories 1 and 2. In contrast, fewer CDV maps were classified as category 4. ECG did not demonstrate significant changes in patients undergoing PCI. Hailer *et al.* have reported that MCG can monitor significant changes in CDV maps of patients with CAD during successful PCI by using MCG to reconstruct CDV maps during repolarization. Therefore, this method may be suitable for the follow-up of patients after PCI. Overall, these findings demonstrate that MCG is of great value in the post-PCI process. In the future, MCG may become an effective non-invasive tool for post-PCI patients during consultation and follow-up.

4.3. Advances in MCG in coronary microcirculatory dysfunction

Coronary microcirculation dysfunction (CMD) is also an important pathophysiological mechanism of ischemic heart disease. It is closely associated with adverse cardiovascular events, with patients with CMD experiencing a four-fold increase in mortality and a five-fold increase in major adverse cardiovascular events (MACE) compared with patients without CMD^[15]. In 2020, the European Society of Cardiology proposed more concise and practical diagnostic criteria for CMD in a consensus document on non-obstructive CAD^[16]. The classification of CMD was further refined into five types by the 2020 Chinese multidisciplinary expert consensus on the diagnosis and treatment of microvascular disease: primary CMD without myocardial disease or obstructive epicardial CAD, CMD with myocardial disease but without obstructive epicardial CAD, CMD with obstructive epicardial CAD, medically induced CMD, and post-transplantation CMD. At present, a shortage of time-saving, sensitive, accurate, and economical non-invasive adjuncts exists. Recent studies have revealed that MCG may be useful as an adjunctive diagnostic tool for CMD^[17]. At present, the application of MCG in CMD diagnosis remains in the exploratory stage, with further confirmation via more and larger sample size studies. Presumably, with technological advances and the popularity of clinical applications, MCG will play an essential role in CMD diagnosis.

4.4. Advances in MCG in cardiac arrhythmias

4.4.1. Progress of MCG in fetal arrhythmias

The dangers of arrhythmia are enormous. Patients with arrhythmia who are not timely and effectively diagnosed and treated may suffer serious consequences such as fainting or even sudden death. In particular, hereditary arrhythmias (fetal arrhythmias) are complex and harmful to diagnose. Although echocardiography has long been a routinely used technique for diagnosing fetal arrhythmias, the advent of MCG will help further improve the accuracy of diagnosis and risk assessment of fetal arrhythmias. At present, echocardiography cannot assess the electrophysiological activity of the fetal heart, and the clinical use of MCG may accelerate research progress on the electrophysiological activity of the fetal heart. Wacker-Gussmann *et al.* reviewed 215 pregnancies admitted to the Biomagnetism Laboratory at the University of Wisconsin-Madison over the past decade due to fetal arrhythmia or the presence of arrhythmia^[6]. They compared the diagnosis and treatment plan at the referral time with the fMCG diagnosis, focusing on 144 cases in three categories: tachycardia, bradycardia/atrioventricular block, and familial long QT syndrome. Based on the effect of the MCG diagnosis, 81 of the 144 patients experienced a significant change in diagnostic outcomes, and 35 experienced a significant change in the treatment plan. Similar to ambulatory ECG, MCG can monitor and record continuous heartbeats, which can help capture transient arrhythmias. Overall, the clinical use of MCG may enhance the prenatal and postnatal care of the fetus in hospitals.

4.4.2. Advances in MCG in atrial and ventricular arrhythmias

The weak magnetic field generated by the human heart is another manifestation of the heart's electrical activity. Theoretically, MCG can provide the non-invasive localization of the underlying electrical activity. Moshage *et al.* subjected 10 patients with spontaneous early-onset premature ventricular beats, 3 patients with ventricular tachycardia, and 4 healthy participants to MCG^[18]. The location of the ectopic pacing point detected in the MCG had an error of only a few millimeters compared with the location of the ectopic pacing point determined by the electrophysiological specimen catheter. This demonstrates that the MCG can non-invasively help locate the origin of ventricular arrhythmias.

Nakai *et al.* generated three-dimensional cardiac contours and conduction pathways using a 64-channel SQUID system. They evaluated the importance of MCG in managing patients with atrial flutter (AFL) and atrial fibrillation (AFIB)^[19]. The participants were 20 healthy volunteers, 3 patients with AFL, and 4 patients with AFIB. MCGs were recorded before and after the intervention to assess treatment efficacy. MCG revealed a counterclockwise rotational conduction pattern in patients with AFL and a random microreentrant conduction pattern in patients with AFIB. Sinus rhythm was restored in both patients with AFL and AFIB after the intervention. Evaluating the three-dimensional cardiac contour and conduction pathways in patients with AFIB via MCG may provide a more time-saving and effective non-invasive routine examination in managing patients with AFL and AFIB. In another study, Nakai *et al.* used MCG to perform three-dimensional spectral mapping in 16 patients with valvular heart disease who had chronic AFIB^[20]. These 16 patients with valvular heart disease and chronic AFIB were subjected to surgical pulmonary vein isolation (PVI) and valve repair. One year after surgery, sinus rhythm was restored in 7 patients but persistent AFIB remained in 9. Mean three-dimensional AFIB frequency before PVI in patients with restored sinus rhythm was compared with those with persistent AFIB after PVI, with significant differences. This suggests that three-dimensional spectral mapping using MCG may be a meaningful non-invasive screening strategy for patients with AFIB undergoing interventional procedures.

At present, differences in the electrical characteristics of the left and right atria after PVI in patients with AFIB remain unclear. Using MCG, Sato *et al.* investigated the effect of PVI on biventricular magnetic field changes and its association with clinical outcomes. MCG recordings at baseline, 1 day, 8 weeks, and 24 weeks after ablation were recorded in 71 patients with paroxysmal AFIB subjected to PVI^[21]. In addition, they compared the peak amplitude of left and right atrial segmental P waves before and after PVI. At 16 months after ablation, AFIB did not recur in 53 patients. The magnetic field intensity of the left atrium consistently decreased for 24 weeks in patients with no recurrence and was significantly lower than that in patients with recurrence at 8 weeks. Multifactorial analysis revealed that magnetic field strengths in the left and right atria could be significantly altered after PVI in patients with AFIB. However, the magnetic field strength in the right atrium at 8 weeks was the strongest predictor of AF recurrence. Therefore, persistent elevation of magnetic field strength in the right atrium may be an important predictor of AF recurrence after ablation.

Kandori *et al.* developed a whole-cardiac bull's-eye map to demonstrate current distribution on a circular map by MCG^[22]. Subsequently, MCG was recorded at rest in 16 patients with Brugada syndrome, 10 patients with complete right bundle branch block, and 12 members in the control group. They reported that the amplitude of the anterolateral right-superiorly oriented S-wave currents was higher in patients with Brugada syndrome than in patients in the control group on whole-heart bull's-eye maps. Furthermore, a small anomalous current was noted during ventricular depolarization in the patients with Brugada syndrome. This demonstrates that the whole-heart bull's-eye map can detect heart disease features.

4.5. Advances in the study of MCG in myocarditis

Viral myocarditis is an infectious inflammatory disease that is more common in patients of all ages and may have serious adverse consequences; if undetected, it can lead to sudden cardiac death^[23]. Inflammatory cardiomyopathy is one of the most common reasons for sudden cardiac death in young adults. The rapid screening of patients with suspected myocarditis has become essential to prevent serious adverse outcomes of myocarditis. Recently, Pille *et al.* reported that analyzing historical MCG and MCG device data using the Kullback–Leibler entropy method can help reliably distinguish patients with clinically suspected myocarditis from healthy controls. Pille *et al.* implemented automated feature selection based on linear discriminant analysis to replace the reliance on manually determined thresholds by observers in previous studies. This will potentially make MCG a rapid, non-invasive, and cost-effective screening test for patients with suspected myocarditis^[24]. Brala *et al.* reported that MCG can detect the response to immunosuppressive therapy in patients with myocarditis within 7 days. However, improvement was not detectable by echocardiography until after 30 days of immunosuppressive therapy in patients who responded to treatment. In patients with myocarditis, changes in MCG were significant at day 7 of immunosuppressive therapy (effect size: 30%)^[25]. MCG demonstrates high sensitivity in detecting patients with myocarditis in terms of clinical improvement. This suggests that MCG is more advantageous for the screening, diagnosis, individualized treatment, and prognostic assessment of patients with myocarditis.

5. Technological advances in MCG

In conventional MCG, a SQUID magnetometer is used to record the weak magnetic field generated by the heart, requiring liquid helium to maintain the necessary ultra-low temperature. However, liquid helium is a scarce and expensive resource, which is not conducive to clinical dissemination^[26]. The advantages of the optical pump

magnetometer (OPM), which does not require Dewar bottles as a cryogenic coolant, make system miniaturization possible and increase the flexibility of the sensor array arrangement for multichannel measurements^[27]. The spin-exchange relaxation free (SERF) magnetometer belongs to the vector OPM, a type of OPM^[28]. Recently, Yang *et al.* developed a wearable multichannel human MCG system based on a SERF magnetometer array. This MCG system comprises a magnetic shielding device, a wearable SERF magnetometer array, and a computer for data acquisition and processing, which denoises MCG data using independent component analysis and empirical mode decomposition^[29]. Tao *et al.* proposed an end-to-end deep learning architecture (referred to as MCG-Net), which integrates a convolutional neural network with transformer-based global context blocks for the fine-grained segmentation and diagnostic classification of Q-, R-, S-, and T-waves from MCG data^[30]. A new analysis system with an MCG with a resting 90-s scan demonstrates considerable potential for assessing coronary artery stenosis in patients with chest pain between observation units in the emergency room^[31]. Overall, technological advances in MCG are significant, and the future of MCG will largely depend on the continued advancement of new sensor technologies and improved data processing and analysis methods. These advances may soon provide more compact, cost-effective, portable, and wearable devices for unshielded MCGs or ambulatory patients in hospital settings.

6. Challenges and perspectives in the clinical application of MCG in CVDs

Despite the progress made in the clinical application of MCG in CVD, some challenges remain. For example, the cost of MCG remains high. Furthermore, professional technicians are needed for interpreting and analyzing the imaging results. In the future, studies should be undertaken to further optimize the MCG imaging technique to improve its feasibility and accuracy in the clinical application of CVDs.

MCG is an emerging non-invasive examination with broad research and clinical application prospects. With the continuous improvement of technology and methods, MCG will continue playing an important role in the diagnosis and research of CVDs and can provide more accurate and personalized diagnosis and treatment strategies for clinical settings.

Author contributions

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Disclosure statement

The authors declare no conflict of interest.

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Prevalence and Implications of Anxiety and Depression in Cardiovascular Outpatients Following the COVID-19 Pandemic

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Abstract: *Objective:* To investigate the prevalence of depression and/or anxiety among cardiovascular outpatients in a tertiary general hospital following the COVID-19 pandemic. *Method:* Patients were recruited consecutively from the cardiovascular outpatient department of Weinan Central Hospital, a comprehensive tertiary hospital in the region. Eligible participants were aged 18 years or older, conscious, provided informed consent, and were able to independently complete the questionnaire. On designated survey days, all participants completed a general information form, the three-question method questionnaire, and, for those identified as positive by the initial screening, additional GAD-7 and PHQ-9 assessments. *Results:* A total of 1,355 valid responses were obtained. Initial screening using the three-question method identified 379 positive cases, accounting for 27.97% (379/1,355). The prevalence of depression was approximately 2.89% (39/1,355), anxiety was 4.87% (66/1,355), and mixed anxiety and depression was 15.28% (207/1,355), indicating that mixed conditions were more common. Among patients presenting with cardiac-like symptoms but diagnosed with non-organic heart disease, over 36% were identified in the outpatient department. In this subgroup, the prevalence of anxiety, depression, and mixed conditions was approximately 25.25%, 23.35%, and 19.56%, respectively. These cases, often categorized as cardiac neurosis, are thought to be associated with emotional and psychological factors and are predominantly observed among young and middle-aged individuals. Among patients with organic heart disease, hypertension was the most prevalent condition, affecting approximately 47.75%, followed by coronary heart disease, heart surgery, arrhythmias, and heart failure. Patients with arrhythmias exhibited the highest rates of anxiety (27.71%), depression (26.51%), and mixed conditions (25.30%). Similarly, among hypertensive patients, the prevalence of anxiety, depression, and mixed conditions was approximately 16.23%, 14.06%, and 11.90%, respectively. These prevalence rates exceed national data from similar studies conducted prior to the COVID-19 pandemic. *Conclusion:* A high prevalence of anxiety and depression exists among cardiovascular outpatients in general hospitals, with an increasing trend observed after the pandemic. Establishing a psycho-cardiological medical model is essential for improving the diagnosis and treatment of these patients.

Keywords: COVID-19 pandemic; Psycho-cardiology; Anxiety; Depression

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1. Introduction

Cardiovascular diseases are frequently accompanied by emotional disorders such as anxiety and depression. The field of “psycho-cardiology” investigates and addresses the emotional, social, environmental, and behavioral factors associated with heart diseases ^[1]. Research increasingly highlights anxiety and depression as independent risk factors that influence the onset, progression, prognosis, and outcomes of cardiovascular conditions ^[2]. These two factors are both causes and consequences of one another, creating a mutually reinforcing relationship.

Since 1995, Hu and Liu have identified through research that a significant proportion of cardiology outpatients experience anxiety, depression, or both. Based on these findings, the dual-heart clinic and dual-heart ward round models for diagnosis and treatment were proposed. These models have been widely adopted by cardiology healthcare professionals and promoted nationwide. Over the past decade, psycho-cardiology has undergone rapid development, with extensive dual-heart data providing robust evidence to support clinical practice. Despite this progress, standardized psycho-cardiological diagnostic and treatment services have yet to be implemented in certain regions, including the area covered by this study.

The three-year COVID-19 pandemic significantly disrupted daily life, leading to heightened psychological stress and noticeable changes in emotional well-being ^[3-5]. As COVID-19 transitions to a category B management status, the psychological impact of the pandemic on individuals is becoming more evident in this post-pandemic era. Given the relatively underdeveloped state of psycho-cardiology in the region, this study aims to address this gap by implementing standardized dual-heart diagnosis and treatment models. These efforts will be informed by an assessment of the current prevalence of dual-heart conditions in the area, with the ultimate goal of advancing cardiovascular medicine within hospitals and the broader region.

2. Materials and Methods

2.1. General information

Patients attending the cardiology outpatient clinic at Weinan Central Hospital from May to September 2023 were selected for this study. Inclusion criteria: patients aged 18 years or older, conscious, capable of answering independently, and who provided informed consent. Exclusion criteria: patients who had previously participated in similar surveys, had a history of visiting psychiatric specialties, or were unable to complete the survey due to severe mental or physical dysfunction.

2.2. Methods

This hospital-based cross-sectional study was conducted following the ethical standards established by the Ethics Committee of Weinan Central Hospital. The study received approval from the committee (approval number: 2023Y006-1), and informed consent was obtained from all participants. All researchers and coordinators involved in the study underwent pre-survey training to ensure consistency in the experimental process.

Before or during consultations, coordinators distributed and guided patients in completing a screening questionnaire, which included general information such as age, gender, and occupation. Clinic doctors routinely inquired about the patient’s current medical history, past medical history, and medication use. Initial screening for potential issues was conducted using the Three-Question Method ^[6]. Patients were subsequently provided with self-assessment scales for anxiety and depression (GAD-7 and PHQ-9) to complete the screening process.

Patients identified with mild to moderate conditions based on the self-assessment scales received appropriate diagnoses and treatment. Patients with severe anxiety and/or depression were referred or consulted with psychologists as necessary. Statistical results were categorized into four groups: positive results from the Three-Question Method, pure anxiety, pure depression, and mixed anxiety and depression. Survey days were randomly selected during the study period.

2.3. Observation indicators and criteria

2.3.1. Three-Question Survey

The Three-Question Survey, derived from the 2020 Chinese Expert Consensus on Psychological Prescriptions for Patients Visiting Cardiovascular Medicine Departments, is an initial screening tool for identifying psychological concerns. The survey consists of three questions:

- (1) Sleep quality: Have you experienced poor sleep that significantly affects your daytime mental state or requires medication?
- (2) Emotional state: Have you felt restless or lost interest in previously enjoyable activities?
- (3) Physical discomfort: Have you experienced significant physical discomfort without any organic cardiovascular disease explanation despite multiple examinations?

Responses are limited to “yes” or “no.” Patients responding “yes” to two or more questions are considered positive for potential psychological concerns. The Three-Question Survey is valued for its brevity and efficiency in high-paced cardiovascular clinics ^[6]. Patients with positive results are advised to undergo further screening with self-assessment scales for anxiety and depression.

2.3.2. GAD-7 and PHQ-9 self-assessment scales ^[6–8]

The Generalized Anxiety Disorder 7-item scale (GAD-7) and the Patient Health Questionnaire 9-item scale (PHQ-9) are widely accepted for their reliability, validity, simplicity, and time efficiency.

- (1) GAD-7: This scale consists of seven items designed to assess anxiety. Each item is scored from 0 to 3, with total scores interpreted as follows: < 5 (normal), 5–9 (mild anxiety), 10–14 (moderate anxiety), 15–19 (moderately severe anxiety), and > 20 (severe anxiety).
- (2) PHQ-9: This scale comprises nine items aimed at detecting depression. Scoring is similar to GAD-7, with total scores categorized as < 5 (normal), 5–9 (mild depression), 10–14 (moderate depression), 15–19 (moderately severe depression), and > 20 (severe depression).

2.4. Statistical analysis

All patients completing the self-assessment scales were included in the epidemiological analysis. Prevalence rates are presented as percentages. Statistical analysis was performed using SPSS software, with a *P*-value of <0.05 considered statistically significant. This threshold determines the likelihood that observed differences are real rather than due to chance.

3. Results

3.1. General statistical results

A total of 1,377 questionnaires were distributed. After excluding 17 invalid questionnaires and five cases where participants did not provide consent, 1,355 valid responses were included in the analysis, yielding a completion

rate of approximately 98.40%. Among the participants, 680 were male (50.18%) and 675 were female (49.82%). Marital status distribution revealed that 1,271 participants were married (93.87%), 62 were unmarried (4.58%), and 21 fell into other marital categories (1.55%).

The age distribution was predominantly within the 41–60 age group, accounting for 44.58%, followed by the 61–80 age group, which comprised 33.06% (**Figure 1**). Regarding educational attainment, participants with a high school education or below accounted for 62.29%, while those with a college education comprised 23.99% (**Figure 2**). In terms of occupation, farmers constituted the largest group, accounting for 38.52% (**Figure 3**).

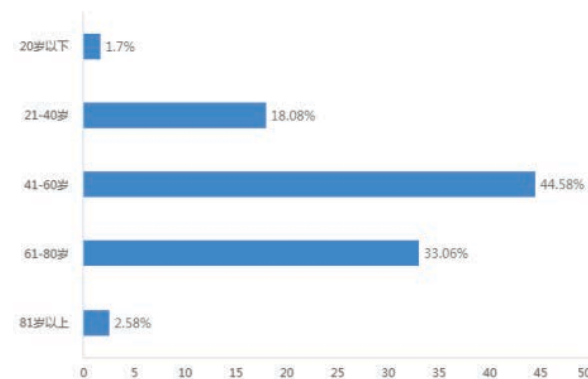


Figure 1. Age distribution of participants

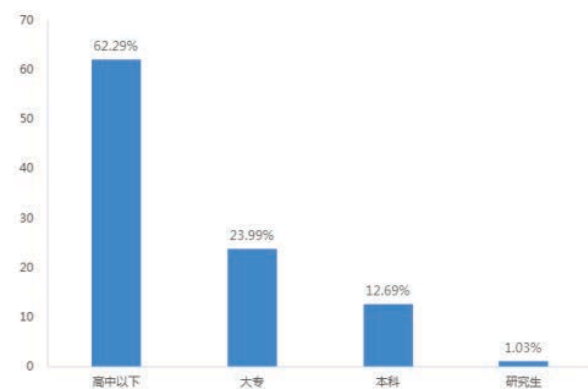


Figure 2. Educational level distribution of participants

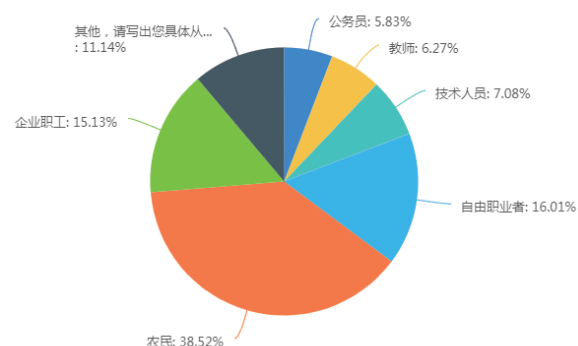


Figure 3. Occupational distribution of participants

3.2. Initial screening results using the Three-Question Survey method

Figure 4 shows that there were 379 positive patients who answered “yes” to two or more questions, accounting for 27.97% (379/1355), which corresponds to ①②+①③+②③+①②③ in **Figure 4**. Patients who answered “no” to all three questions accounted for 39.19%. Besides anxiety and/or depression, insomnia was a common issue: a total of 41.48% of patients reported insomnia, corresponding to ①+①②+①③+①②③ in **Figure 4**. Among them, 18.01% had pure insomnia, represented by ① in **Figure 4**, while 23.47% had mixed insomnia, represented by ①②+①③+①②③ in **Figure 4**.

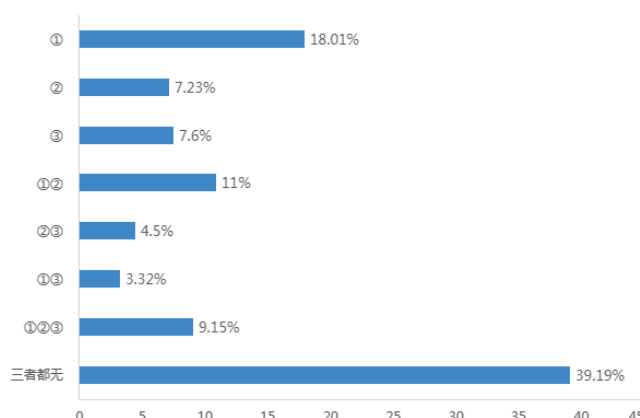


Figure 4. Statistical results from the Three-Question Survey method

3.3. Statistics of depression and/or anxiety state prevalence

A total of 379 valid questionnaires were analyzed. According to the classification statistics, 106 patients with GAD-7/PHQ-9 scores of ≤ 4 were identified as having no anxiety or depression, accounting for 27.97% of the sample. Among the remaining cases, 39 patients with PHQ-9 scores ≥ 5 were diagnosed with pure depressive states, with 35 patients scoring between 5 and 9, indicative of mild depressive states, comprising the majority at approximately 89.74%.

In addition, 66 patients with GAD-7 scores ≥ 5 were identified as having pure anxiety states. Of these, 53 patients scoring between 5 and 9 (mild anxiety) were the most common, accounting for approximately 80.30%. Furthermore, 207 patients with both GAD-7 and PHQ-9 scores ≥ 5 were categorized as having mixed anxiety and depressive states, representing 54.62%. Among these, 177 patients with scores between 5 and 14 (mild to moderate severity) constituted the largest subgroup, accounting for approximately 85.51%.

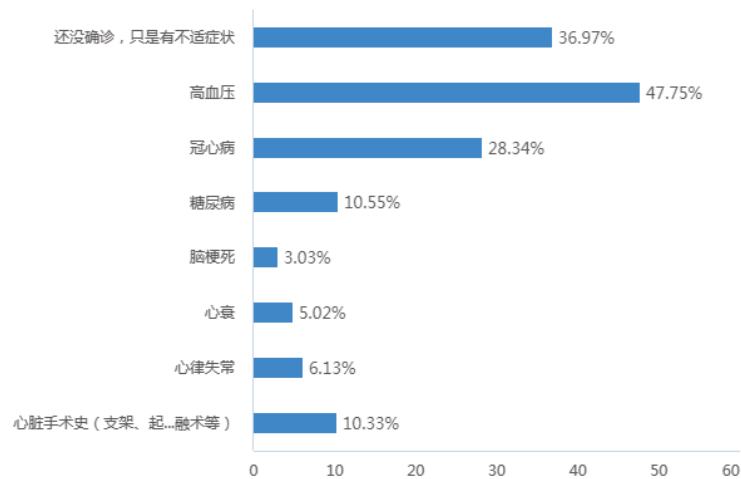
After adjustment, the total prevalence of pure depressive states among the cardiovascular outpatient population was approximately 2.88% (39/1,355), while pure anxiety states had a prevalence of approximately 4.87% (66/1,355). Mixed anxiety and depressive states were the most prevalent, with a rate of approximately 15.28% (207/1,355). The findings indicate that anxiety was more prevalent than depression, with mixed states being the most common, and most cases were classified as mild to moderate in severity. A summary of self-rating scale results for depression and/or anxiety is provided in **Table 1**.

Table 1. Statistical summary of depression/or anxiety self-rating scale results

GAD7	PHQ9				
	0-4	5-9	10-14	15-19	> 20
0-4	106	35	3	1	0
5-9	53	61	22	6	0
10-14	8	20	33	10	1
15-19	4	10	8	18	4
> 20	1	1	5	4	4

3.4. Statistical results of anxiety/depression prevalence among different cardiovascular diseases

As illustrated in **Figure 5**, hypertension was the most common condition, with 647 cases, accounting for approximately 47.75% of the sample. Undiagnosed organic heart disease was the second most prevalent, comprising 36.97%. Other conditions, ranked by frequency, included coronary heart disease, a history of heart surgery, arrhythmia, heart failure, and others.

**Figure 5.** Comorbidities of patients surveyed in this study

Among the disease categories, patients with arrhythmia (83 cases) exhibited the highest rates of comorbid anxiety and/or depression. Specifically, 23 cases (27.71%) were positive for anxiety, 22 cases (26.51%) for depression, and 21 cases (25.30%) for mixed anxiety and depression. Similarly, high rates of comorbid anxiety or depression were observed in common cardiovascular diseases such as hypertension and coronary heart disease. However, these rates were comparatively lower in patients with a history of heart surgery (including procedures such as stent placement or pacemaker implantation) and heart failure. Notably, over one-third of the patients were undiagnosed with organic heart disease, yet their rates of anxiety or depression were also significantly high. Detailed data are provided in **Table 2**.

Table 2. Prevalence of anxiety and depression across various cardiovascular diseases

Cardiovascular disease	Total cases (<i>n</i>)	GAD-7 score		PHQ-9 score		Anxiety and depression	
		Anxiety positive cases	Rate (%)	Depression positive cases	Rate (%)	Anxiety and depression positive cases	Rate (%)
Hypertension	647	105	16.23%	91	14.06%	77	11.90%
Coronary heart disease	384	59	15.36%	59	15.36%	50	13.02%
Heart surgery	140	16	11.43%	16	11.43%	14	10.00%
Arrhythmia	83	23	27.71%	22	26.51%	21	25.30%
Heart failure	68	7	10.29%	7	10.29%	4	5.88%
Undiagnosed	501	126	25.15%	117	23.35%	98	19.56%

4. Discussion

Variations in research methods, study populations, and other factors have led to significant differences in reported prevalence rates of depression and/or anxiety symptoms among cardiology patients in domestic studies ^[9]. A 2014 study by Li *et al.* ^[10] utilized a self-rated anxiety and depression questionnaire among 2,123 cardiology outpatients from 14 comprehensive tertiary hospitals in major cities. The results indicated a prevalence of depression and/or anxiety disorders of 14.37%, with depression accounting for 10.55% and anxiety disorders for 7.77%. These findings provide a relatively accurate and representative overview of the prevalence of these conditions among cardiology outpatients in tertiary hospitals across China.

This study followed the dual-mind investigation process recommended in the 2020 edition of the “Chinese Expert Consensus on Psychological Prescriptions for Cardiovascular Medicine Patients” ^[6]. A questionnaire survey was conducted among 1,355 cardiology outpatients from a comprehensive tertiary hospital using Wenjuanxing, an online survey tool. The data collected possesses a degree of regional representativeness. After adjustments, the total prevalence rates for pure depressive states, pure anxiety states, and mixed anxiety and depressive states were approximately 2.88%, 4.87%, and 15.28%, respectively. The findings indicate that mixed anxiety and depressive states were the most prevalent, with mild to moderate severity being predominant. Compared to previous studies ^[10], this group showed a slightly higher proportion of mixed anxiety and depressive states but a significantly lower proportion of pure anxiety or depressive states.

Two factors may contribute to these discrepancies. First, the self-rated questionnaire assesses the state of anxiety or depression rather than serving as a diagnostic tool, potentially resulting in false-positive or false-negative outcomes. Second, the impact of the COVID-19 pandemic cannot be overlooked. The pandemic caused widespread economic setbacks and life pressures, significantly increasing emotional stress and thereby exacerbating the risk of psychological disorders such as anxiety and depression ^[3–5].

Anecdotal observations from a tertiary hospital in a provincial capital suggested that over 50% of cardiology outpatients exhibited emotional disorders such as anxiety and depression, a figure substantially higher than reported here. Analysis suggests that repeated, unsuccessful medical visits at primary hospitals may increase emotional stress, leading to higher incidence and severity of anxiety or depression in these patients.

As one of the primary departments for the initial diagnosis of psychological and mental disorders, the

cardiology department plays a critical role in addressing anxiety and depression. This study revealed that over 36% of patients presenting with cardiac symptoms were found to have non-organic heart disease. Among these patients, the prevalence rates for anxiety, depression, and comorbid anxiety and depression were approximately 25.25%, 23.35%, and 19.56%, respectively. These patients, often diagnosed with cardiac neurosis, frequently have symptoms linked to emotional and psychological factors. Young and middle-aged individuals constituted the majority of this group, likely due to socio-economic pressures and heightened post-pandemic anxiety. Increased access to health information and greater health concerns may also contribute to the high prevalence in this demographic, along with a tendency to request coronary angiography during medical visits, which increases the burden on national healthcare resources.

Among patients with organic heart disease, those with arrhythmia exhibited the highest prevalence rates for anxiety (27.71%), depression (26.51%), and comorbid anxiety and depression (25.30%). However, the small sample size for this group could result in significant data deviations. Addressing emotional stressors, including anxiety and depression, is essential in the clinical management of arrhythmia. Similarly, the hypertension group, the largest cohort, exhibited notable rates of anxiety (16.23%), depression (14.06%), and comorbid anxiety and depression (11.90%). Emotional stress and blood pressure fluctuations can mutually influence one another, compounding the challenge of managing primary hypertension.

Low awareness and understanding of hypertension among Chinese patients highlight the need for improved education and promotion of cardiovascular disease prevention and treatment. Developing a dual-hearted medical model that incorporates psychological evaluation and intervention can enhance the quality of life and healthcare experience for patients, improve cardiovascular outcomes, and reduce medical costs and resource wastage.

Despite the rigorous design, subject selection, and standardized survey and analysis methods used in this study, certain limitations should be acknowledged. As a cross-sectional descriptive study, it cannot establish causal relationships between cardiovascular diseases and mental disorders such as anxiety and depression. Moreover, the inclusion of all outpatient cases on the study day ensured a large sample size but did not involve random sampling, which may introduce selection bias. The study population, drawn exclusively from tertiary hospitals in prefecture-level cities, excludes primary and secondary hospitals, thereby limiting its generalizability. Nevertheless, the findings provide valuable data for advancing dual-heart medical practices in the region and serve as a foundation for future analytical research.

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Disclosure statement

The authors declare no conflict of interest.

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Individualized Cardiac Rehabilitation in Elderly Patients with Coronary Heart Disease and Chronic Heart Failure

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Abstract: *Objective:* To study the changes and clinical effects of elderly patients with coronary heart disease and chronic heart failure after applying individualized cardiac rehabilitation. *Methods:* 85 cases of elderly patients with coronary heart disease and chronic heart failure admitted from June 2023 to May 2024 were divided into the control group (42 cases) and the experimental group (43 cases), and were given conventional rehabilitation guidance and individualized cardiac rehabilitation training programme respectively, comparing the indexes of exercise endurance, level of cardiac function, quality of life, and incidence of adverse cardiovascular events in the two groups. *Results:* Before intervention, the LVEF, LVEDD and LVESD of the control group and the experimental group were $(37.11 \pm 3.96)\%$, (62.15 ± 4.06) mm and (45.75 ± 4.33) mm and $(37.06 \pm 3.92)\%$, (2.20 ± 4.23) mm and (45.81 ± 4.27) mm, respectively, with no statistically significant difference. and test group LVEF increased and LVEDD and LVESD decreased by $(45.75 \pm 5.12)\%$, (55.18 ± 3.97) mm, (41.14 ± 3.29) mm and $(51.79 \pm 4.26)\%$, (48.23 ± 3.58) mm, (36.62 ± 3.75) mm, respectively, with statistically significant differences between the groups ($P < 0.05$). Before intervention, the 6 min walk test (6MWT) and maximum exercise load of the control group and the experimental group were (325.55 ± 37.79) m, (91.02 ± 15.74) W and (324.17 ± 37.68) m, (90.92 ± 14.78) W, respectively, and the difference was not statistically significant ($P > 0.05$). After intervention, all the indicators of both groups were significant ($P > 0.05$). After the intervention, all indicators in both groups were significantly higher, respectively (386.28 ± 42.95) m, (135.67 ± 22.75) W and (460.43 ± 39.91) m, (152.83 ± 25.64) W, and the difference between the groups was not statistically significant ($P < 0.05$). The quality of life scores of the experimental group on somatic symptoms, daily activities, psychological quality, and social functioning were respectively (80.01 ± 6.02) , (73.75 ± 7.32) , (80.56 ± 6.41) , (71.42 ± 6.87) , significantly higher than the control group's (67.03 ± 6.98) , (64.19 ± 7.16) , (63.78 ± 6.13) and (60.72 ± 6.47) , while the difference was statistically significant ($P < 0.05$). Cardiac arrhythmia occurred in the experimental group. The incidence of adverse cardiovascular events such as myocardial infarction was 4.65%, which was significantly lower than that of the control group (23.81%), and the difference was statistically significant ($P < 0.05$). *Conclusion:* Individualized cardiac rehabilitation exercise in elderly patients with coronary heart disease and chronic heart failure can promote the recovery of clinical symptoms, improve cardiorespiratory function, enhance exercise endurance, improve the quality of life, and effectively improve the prognosis.

Keywords: Coronary heart disease in the elderly; Chronic heart failure; Individualized cardiac rehabilitation

1. Introduction

Relevant surveys show that in the number of deaths caused by diseases in China, cancer does not occupy a dominant position, coronary heart disease and other cardiovascular diseases are the main factors causing death^[1]. Atherosclerosis leads to lumen narrowing and shock when blood pressure is significantly lowered, inducing myocardial ischaemia, which is the basic etiology of coronary heart disease combined with heart failure. With the increasing age of patients, primary or secondary cardiac ischaemia leads to a gradual reduction in myocardial blood supply, the heart's compensation ability significantly decreases, resulting in a lack of oxygen supply to the myocardium, ultimately leading to heart failure^[2]. According to various statistics, the number of people suffering from chronic heart failure (CHF) in China is increasing year by year, and the death rate is also rising. Cardiac rehabilitation, as a kind of non-pharmacological therapy, can significantly improve the cardiac function of patients with chronic heart failure, reduce the average length of hospital stay, and lower the rate of re-hospitalization through exercise, dietary guidance, control of cardiovascular risk factors, psychological intervention and other measures. In recent years, the application of individualized cardiac rehabilitation training in the field of cardiac rehabilitation has been widely promoted. Compared with traditional rehabilitation methods, individualized cardiac rehabilitation can develop personalized exercise programmes for patients' specific conditions, thus better meeting their rehabilitation needs. Through scientific exercise training, it can not only improve the patient's cardiovascular function and myocardial tolerance, but also strengthen the patient's psychological health and improve the quality of life. Individualized cardiac rehabilitation refers to some exercises that can reduce the probability of recurrence of cardiovascular events and facilitate the recovery of cardiac function. This study investigates the effect of applying individualized cardiac rehabilitation training interventions to elderly patients with coronary heart disease and chronic heart failure, and analyzes its effect on exercise tolerance, cardiorespiratory function and other aspects, which are reported as follows.

2. Information and methodology

2.1. General information

Eighty-five cases of elderly patients with coronary heart disease and chronic heart failure admitted from June 2023 to May 2024 were selected and divided into the control group and the study group, of which 42 cases were in the control group and 43 cases were in the experimental group. In the control group, there were 25 males and 17 females; age 62–82 years old, mean (72.32 ± 5.32) years old; disease duration 2–8 years, mean (5.88 ± 1.12) years; cardiac function classification: 22 cases of class II, 20 cases of class III. In the experimental group, there were 27 males and 16 females; age (70.56 ± 5.88) years old; disease duration 1–10 years, mean (5.54 ± 1.46) years; There were 24 cases of grade II and 19 cases of grade III. Comparing the baseline data of the two groups, the difference was not statistically significant ($P > 0.05$) and was comparable.

Inclusion criteria: (1) Meet the diagnostic conditions of chronic heart failure of coronary heart disease, that is age over 60 years, duration of heart failure over 6 months, and left ventricular ejection fraction less than 45%; (2) According to the American New York Heart Association (NYHA) cardiac function grading of class II–III; (3) The patient's family knowingly signed an informed agreement.

Exclusion criteria: (1) Combination of severe liver and renal function abnormalities; (2) Previous history of

cardiac surgery; (3) With diabetes mellitus, hypertension and other underlying diseases; (4) Presence of psychiatric disorders, communication disorders; (5) Withdrawal in the middle of the course.

2.2. Methodology

Control group: Intervention with standard anti-heart failure treatment and nursing measures and appropriate health education on the disease.

Trial group: Individualized cardiac rehabilitation training intervention based on conventional treatment. The cardiac rehabilitation training methods are as follows:

(1) Exercise mode

The main aerobic exercise rehabilitation training, the specific exercise is walking, bicycle rehabilitation training, Baduanjin exercise, etc., 20 min/time, 4 times/week. Based on the aerobic exercise rehabilitation training, moderate resistance training and limb flexibility training were added according to the individualization of patients. Flexibility training^[3]: including trunk distraction training (anterior flexion, posterior extension), upper limb distraction training (shoulder extension, shoulder abduction, shoulder anterior flexion), lower limb distraction training (anterior leg compression, “4” stretching, holding the knee), 10 min/times, 1 time/d, to local stretching painless is appropriate.

(2) Exercise intensity

According to the patient's tolerance to develop exercise intensity, to avoid affecting the patient's safety, as far as possible, let the patient in a smooth state. The overall principle of rehabilitation training to maintain a gradual and orderly progress, the amount of exercise should not be too large and too strong, adjust the intensity of exercise to adapt to the patient.

(3) Exercise frequency

All patients should keep at least 4d effective rehabilitation training, try to take multiple periods of short-time exercise methods, avoid continuous multi-day exercise rehabilitation training. On this basis, in order to improve the patients' cardiorespiratory function, the shortest aerobic exercise time should be maintained, and the shortest time is 30 min each time, which is completed in 3 groups, and gradually converted to be completed in 2 groups.

(4) Rehabilitation training guidance

Detailed understanding of the patient's daily exercise, assessment of the patient's physical condition, and each patient in the group to establish a more appropriate individualized training content. At the same time, patients should be correctly instructed during exercise, closely monitor patients for discomfort, and prepare rescue measures to fully ensure patient safety. In addition, according to the patient's preference, the training programme should be adjusted appropriately to improve the patient's interest. At the same time, through the WeChat group to patients to push health education courses, through WeChat punch card feedback exercise and health education content implementation, at any time to give the patient online question and answer, dynamic adjustment of exercise treatment and give timely individualized guidance.

2.3. Observation indicators

- (1) Cardiac function indicators: The cardiac function indexes of the patients were monitored using echocardiography. Specific indexes included left ventricular ejection fraction (LVEF), left ventricular end-diastolic internal diameter (LVEDD), and left ventricular end-systolic internal diameter (LVESD).

- (2) Exercise endurance: 6 min walking distance (6MWD) was used, and a load test was carried out by using a power bike.
- (3) Quality of life: A quality of life evaluation scale (SF- 36) was used ^[4]. This is to analyze the somatic symptoms of the two groups, daily activities, psychological quality and social functioning, with a total of 19 entries in 5 dimensions, and the higher the score, the higher the quality of life in this dimension.
- (4) The occurrence of adverse cardiovascular events: Record the occurrence of adverse events such as cardiac arrest, angina pectoris, myocardial infarction, and arrhythmia in the two groups. Incidence rate = number of cases/ total number of cases \times 100%.

2.4. Statistical methods

The software SPSS 23.0 was applied to statistically analyze the data of this study, and the count data were expressed as $n(\%)$, using the χ^2 test. The measurement data conforming to the normal distribution were expressed as mean \pm standard deviation (SD), using the t -test, and the difference was statistically significant at $P < 0.05$.

3. Results

3.1. Comparison of cardiac function between the two groups

After the intervention, LVEF increased and LVEDD and LVESD decreased in both groups, and LVEF was higher in the experimental group than in the control group, and LVEDD and LVESD were lower than in the control group ($P < 0.05$) (Table 1).

Table 1. Comparison of cardiac function between the two groups (mean \pm SD)

Groups	n	LVEF/%		LVEDD/mm		LVESD/mm	
		Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Control group	42	37.11 \pm 3.96	45.75 \pm 5.12*	62.15 \pm 4.06	55.18 \pm 3.97*	45.75 \pm 4.33	41.14 \pm 3.29*
Trial group	43	37.06 \pm 3.92	51.79 \pm 4.26*	62.20 \pm 4.23	48.23 \pm 3.58*	45.81 \pm 4.27	36.62 \pm 3.75*
t		0.059	5.918	0.056	8.808	0.064	5.902
P		0.954	< 0.01	0.956	< 0.01	0.949	< 0.01

Note: * $P < 0.05$ compared to pre-intervention in this group.

3.2. Comparison of exercise endurance between the two groups before and after intervention

After the intervention, 6MWD and maximal exercise load were significantly elevated in both groups, with a more significant increase in the experimental group ($P < 0.05$) (Table 2).

Table 2. Comparison of exercise endurance between the two groups (mean \pm SD)

Groups	n	6MWD/m		Maximum movement load/W	
		Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Control group	42	325.55 \pm 37.79	386.28 \pm 42.95	91.02 \pm 15.74	135.67 \pm 22.75

Trial group	43	324.17 ± 37.68	460.43 ± 39.91	90.92 ± 14.78	152.83 ± 25.64
t		0.169	8.248	0.030	3.261
P		0.867	< 0.01	0.976	0.002

Note: * $P < 0.05$ compared to pre-intervention in this group.

3.3. Comparison of quality of life between the two groups after intervention

After the intervention, the quality of life scores of somatic symptoms, daily activities, psychological quality, and social functioning of the test group were significantly higher than those of the control group, and the difference was statistically significant ($P < 0.01$) (Table 3).

Table 3. Comparison of quality of life (mean ± SD, points)

Groups	n	Somatic symptom	Routine	Psychological quality	Social function
Control group	42	67.03 ± 6.98	64.19 ± 7.16	63.78 ± 6.13	60.72 ± 6.47
Trial group	43	80.01 ± 6.02	73.75 ± 7.32	80.56 ± 6.41	71.42 ± 6.87
t		9.188	6.085	12.3296	7.389
P		< 0.01	< 0.01	< 0.01	< 0.01

3.4. Comparison of the incidence of adverse cardiovascular events between the two groups

After the intervention, arrhythmias occurred in the test group. The incidence of adverse cardiovascular events such as myocardial infarction was significantly lower than that of the control group, and the difference was statistically significant ($P < 0.05$) (Table 4).

Table 4. Comparison of the incidence of adverse cardiovascular events (n, %)

	n	Arrhythmia	Cardiac arrest	Angina pectoris	Myocardial infarction	Rate of occurrence
Control group	42	4	2	3	1	10 (23.81)
Trial group	43	1	0	1	0	2 (4.65)
χ^2						6.432
P						0.011

4. Discussion

CHF is relatively common in the clinic, with the middle-aged and elderly groups as the main incidence, and the incidence rate has continued to increase in recent years, which seriously affects the life of patients and leads to a decline in the quality of life, and needs to be paid attention to^[5]. At the same time, heart failure is not an independent disease, but the end stage of the development of various cardiovascular diseases. Especially in the elderly, there is a natural decline in body function, accompanied by multiple syndromes and coexisting risk factors, so the diagnosis, treatment, rehabilitation, and long-term management of this population are different from those of other populations^[6]. Currently, percutaneous coronary intervention is well known and is widely used in clinical treatment for its rapid onset of action and minimal trauma. However, as percutaneous coronary intervention may

bring some complications to patients during operation, and coronary atherosclerosis is difficult to reverse, it is difficult to eliminate the plaque in the blood vessel once it is formed ^[7]. Conventional rehabilitation guidance includes monitoring of the patient's vital signs, simple exercise rehabilitation training, etc. Although it can relieve some of the symptoms to a large extent, it is difficult for the patient to cooperate with the nursing care due to his age and memory loss.

Individualized cardiac rehabilitation, as a non-pharmacological treatment without increasing the burden on patients, has become a new means of adjuvant therapy for CHF patients. Although cardiac rehabilitation in China started late, the development is relatively slow and difficult, the popularity is not as good as neurological rehabilitation, but cardiac rehabilitation as a method of treating cardiac diseases, its main synergistic role, through targeted scientific training of patients, prompting patients to improve cardiac function, while enhancing physical fitness, to meet the patient's need for social participation, which can prevent the occurrence of adverse cardiovascular events and improve the Quality of life, has been generally recognized by the clinic ^[3].

The findings of this study indicate that the overall efficiency of rehabilitation was higher in the experimental group than in the control group and showed superiority in all assessed indicators. This suggests that a cardiac rehabilitation programme centred on individualized exercise training has a significant positive impact on the physical and psychological recovery of patients with chronic heart failure (CHF), including improvements in cardiac function, exercise tolerance and quality of life. This result is consistent with the findings of previous studies. National studies ^[8] have also pointed out that individualized exercise training can improve cardiac endurance and adaptability, and reduce the likelihood of coronary artery spasm and thrombosis. Individualized exercise training can reduce cardiac load by improving oxygen consumption and promoting a balance of cardiac function ^[9]. This helps protect the heart from further damage and improves cardiac function. In this study, by carrying out orderly and reasonable aerobic exercise and brisk walking, as well as adjusting the speed of brisk walking according to the 6-minute walking distance of the patients, the recovery and strengthening of the myocardium is promoted by gradually increasing the intensity and duration of the exercise, which prompts the myocardial tissues to better supply oxygen and eliminate metabolites, thus enhancing the pumping capacity of their hearts, the dilation and contraction of blood vessels, and so on. It helps to improve the cardiac function and overall cardiovascular health of patients with coronary heart disease ^[10]. Through feedback based on the actual situation of the patient, thus gradually increasing the exercise load, exercise frequency and intensity, it can help the patient to gradually improve the exercise endurance, individualized rehabilitation exercise to maintain the patient's organism function, improve muscle strength, and then improve the quality of life.

5. Conclusion

In conclusion, the application of individualized cardiac rehabilitation exercise in elderly patients with coronary heart disease and chronic heart failure can promote the recovery of clinical symptoms, strengthen cardiopulmonary function, enhance patients' exercise endurance, alleviate negative emotions, and effectively improve prognosis, which is worthy of being widely used in clinical treatment.

Disclosure statement

The authors declare no conflict of interest.

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Analysis of the Impact of Different Intensities of Cardiac Exercise Rehabilitation on the Prognosis of Patients with Chronic Heart Failure

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Abstract: *Objective:* This study mainly focuses on the impact of different intensities of cardiac exercise rehabilitation on the prognosis of patients with chronic heart failure. *Method:* This study selected 108 patients with chronic heart failure admitted to the hospital between April 2022 and November 2022 as the subjects of this study. The patients were divided into high-intensity interval exercise group HIIT (37 cases), moderate-intensity continuous exercise group MICT (36 cases), and control group 35 cases. Among them, the high-intensity interval exercise group and moderate-intensity continuous exercise group received 6 months and 12 months of exercise rehabilitation intervention, respectively, while the control group did not receive any exercise rehabilitation intervention measures. Then, compare the changes in ejection fraction, six-minute walking distance, NT-proBNP, and other aspects among the three groups of patients. *Result:* Through research, it was found that the LVEF values of the high-intensity interval exercise group and the moderate-intensity continuous exercise group were higher than those of the control group. The six-minute walking distance of the high-intensity interval exercise group and the moderate-intensity continuous exercise group was higher than that of the control group. The values of NT-proBNP in the high-intensity interval exercise group and the moderate-intensity continuous exercise group were lower than those in the control group. The above research results indicate that the difference is statistically significant, $P < 0.05$. *Conclusion:* According to the research results, different intensities of cardiac exercise rehabilitation have a significant impact on the prognosis of patients with chronic heart failure. It can not only improve the LVEF and prolong the six-minute walking distance of patients, but also effectively reduce NT-proBNP. Therefore, it is worthy of clinical application and promotion.

Keywords: High-intensity interval exercise; Moderate intensity continuous exercise; Chronic heart failure patients; Prognosis

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1. Introduction

Chronic heart failure (CHF) is a common cardiovascular disease characterized by the inability of the heart to effectively pump blood, leading to poor perfusion of tissues and organs throughout the body. This disease is often accompanied by symptoms such as shortness of breath, fatigue, and edema, which seriously affect the quality of life of patients. In recent years, with the continuous promotion and application of cardiac rehabilitation exercise in clinical practice, more and more studies have shown that cardiac rehabilitation exercise has significant therapeutic effects on the prognosis of patients with chronic heart failure^[1]. This study aims to explore the impact of different intensities of cardiac exercise rehabilitation (such as high-intensity interval exercise, moderate-intensity continuous exercise, etc.) on the prognosis of patients with chronic heart failure, to provide a scientific basis for clinical treatment and rehabilitation, help patients improve cardiopulmonary function, enhance myocardial contractility, improve exercise ability and quality of life. The detailed report is as follows.

2. Basic resources and methods

2.1. Basic resources

108 patients with chronic heart failure admitted to the hospital between April 2022 and November 2022 were selected as the subjects of this study, and the patients were divided into high-intensity interval exercise group HIIT (37 cases), moderate-intensity continuous exercise group MICT (36 cases), and control group 35 cases. Among them, there were 22 males and 15 females in the high-intensity interval exercise group. The disease types included 8 patients with hypertension, 12 patients with coronary heart disease, 9 patients with diabetes, and 8 patients with rheumatic heart disease. From the perspective of exercise habits, 9 cases had exercise habits and 28 cases had no exercise habits. 19 cases were classified as grade I, 11 cases as grade II, and 7 cases as grade III. There were 21 males and 15 females in the moderate-intensity continuous exercise group. The disease types included 8 patients with hypertension, 11 patients with coronary heart disease, 8 patients with diabetes, and 9 patients with rheumatic heart disease. From the perspective of exercise habits, 9 cases had exercise habits and 27 cases had no exercise habits. 18 cases were classified as grade I, 11 cases as grade II, and 7 cases as grade III. There were 20 males and 15 females in the control group. The disease types included 7 patients with hypertension, 11 patients with coronary heart disease, 9 patients with diabetes, and 8 patients with rheumatic heart disease. From the perspective of exercise habits, 10 cases had exercise habits and 25 cases had no exercise habits. 17 cases were classified as grade I, 10 cases as grade II, and 8 cases as grade III. The three groups of patients are comparable, and the differences are statistically significant ($P > 0.05$).

Inclusion criteria: (1) Patients must be diagnosed with chronic heart failure, have a relatively stable condition, and be suitable for participating in cardiac rehabilitation exercises; (2) According to the New York Heart Association (NYHA) classification criteria for heart function, patients- included should have heart function between grade I and grade III; (3) Patients need to be able to complete the prescribed intensity and duration of exercise rehabilitation training according to the requirements of the research protocol; and (4) Both the patient and their family members have signed informed consent forms.

Exclusion criteria: (1) Simultaneously suffering from other serious diseases or having exercise contraindications, such as malignant tumors, severe liver and kidney dysfunction, acute myocardial infarction, unstable angina, severe arrhythmia, etc.; (2) Suffering from mental or cognitive disorders; and (3) Patients and their families cannot fully cooperate.

2.2 Method

The control group received routine medication treatment, dietary management, psychological guidance, and exercise guidance.

Based on implementing conventional treatment, the intervention group received exercise rehabilitation intervention.

- (1) Guidance on rehabilitation knowledge. After receiving conventional drug treatment, the intervention group needs to use various forms such as lectures, video teaching, and one-on-one consultations to explain in detail the pathological and physiological mechanisms of chronic heart failure, the importance of exercise rehabilitation, expected effects, and possible risks to patients and their families to make patients aware of the importance of exercise rehabilitation before taking corresponding exercise exercises. This will enable patients to have a comprehensive and systematic understanding of it, thereby increasing their participation in exercise rehabilitation.
- (2) Assessment before exercise. To ensure the safety of patients during exercise, it is necessary to scientifically evaluate the cardiac function status, exercise endurance, muscle strength, flexibility, balance ability, and other aspects of the intervention group patients. In the evaluation process, objective indicators such as electrocardiogram, echocardiogram, 6-minute walk test, grip strength test, etc. can be used, combined with the patient's subjective feelings for comprehensive evaluation ^[2].
- (3) The process of movement.
 - (A) From the perspective of exercise types, aerobic exercise (such as walking, jogging, cycling), resistance training (such as dumbbell exercises, elastic band training), or flexibility training should be selected according to the specific situation of the patient;
 - (B) From the perspective of exercise intensity, different intensities of exercise should be set according to the patient's cardiac function grading and evaluation results, such as medium intensity or high intensity, and the intensity should gradually increase to avoid overexertion;
 - (C) From the perspective of the exercise process, the high-intensity interval exercise group can start with a maximum exercise load of 20%, then train for 16 minutes to reach a maximum exercise load of 70%, and gradually transition to low intensity after resting for 3 minutes. The moderate-intensity continuous exercise group also starts with a maximum exercise load of 20%, then reaches the predetermined target intensity heart rate, and continues for 35 minutes before decreasing to low intensity. In terms of exercise frequency, it is recommended to exercise 3–5 times a week and maintain a training cycle of one year;
 - (D) After the exercise, the patient should make an objective and correct self-evaluation based on their actual situation, slowly adjust their breathing rhythm, replenish a small amount of water, relax, and massage the joints. After everything is stable, they can move on to the next step. Fourthly, health guidance after discharge. Develop a post-discharge exercise rehabilitation plan for patients and encourage them to continue exercising to consolidate their rehabilitation during hospitalization. At the same time, through telephone, WeChat, home visits and other methods, regularly understand the patient's exercise rehabilitation situation, answer their questions, and provide necessary guidance and support.

2.3. Observation indicators

Observe and compare the changes in ejection fraction, quality of life score, six-minute walking distance, NT-proBNP, and other aspects among the high-intensity interval exercise group, moderate-intensity continuous exercise group, and control group.

2.4. Statistical methods

Statistical software SPSS 26.0 was used for data analysis and processing, with mean \pm standard deviation (SD) representing metric data and K-S representing the normality test. Analysis of variance was used to compare the means between the three groups. The count data was analyzed by χ^2 test, and the difference was statistically significant with $P < 0.05$.

3. Result

3.1. Effect of different intensities of cardiac exercise rehabilitation on LVEF

This study analyzed the results of two-factor repeated measures ANOVA and found that the LVEF levels of the three groups of patients showed an increasing trend with time, with the HIIT group having the highest level and the control group having the lowest. This indicates that different intensities of cardiac exercise rehabilitation have a significant effect on improving patients' ejection fraction, with statistical significance $P < 0.05$ (Table 1).

Table 1. Comparison of LVEF among three groups of patients (mean \pm SD)

Group	Baseline	12 months	6 months
HIIT group ($n = 37$)	42.28 \pm 1.45	44.58 \pm 2.37	47.92 \pm 2.87
MICT group ($n = 36$)	41.47 \pm 1.44	43.77 \pm 0.47	44.00 \pm 2.13
Control group ($n = 35$)	41.84 \pm 1.49	42.54 \pm 2.05	43.14 \pm 2.05
F-value _{Time}		115.43	
P-value _{Time}			
F-value _{Group}		10.14	
P-value _{Group}			

Note: HIIT refers to the high-intensity interval exercise group; MICT is a moderate-intensity continuous exercise group.

3.2. Effect of different intensities of cardiac exercise rehabilitation on six-minute walking distance

This study analyzed the results of two-factor repeated measures ANOVA and found that the three groups of patients showed an increasing trend in the six-minute walking distance with time, with the HIIT group having the highest level and the control group having the lowest level. This indicates that different intensities of cardiac exercise rehabilitation have a significant effect on extending the six-minute walking distance, with statistical significance $P < 0.05$ (Table 2).

Table 2. Comparison of six-minute walking distance among three groups of patients (mean \pm SD)

Group	Baseline	12 months	6 months
HIIT group ($n = 37$)	362.53 \pm 8.78	405.7 \pm 8.04	440.10 \pm 9.64

MICT group ($n = 36$)	362.18 ± 11.65	388.04 ± 9.84	434.14 ± 8.01
Control group ($n = 35$)	361.48 ± 1.69	371.95 ± 4.87	378.32 ± 4.28
F-value _{Time}		599.12	
P-value _{Time}	< 0.001		
F-value _{Group}		9422.84	
P-value _{Group}	< 0.001		

Note: HIIT refers to the high-intensity interval exercise group; MICT is a moderate-intensity continuous exercise group.

3.3. Effect of different intensities of cardiac exercise rehabilitation on NT-proBNP

This study analyzed the results of two-factor repeated measures ANOVA and found that the three groups of patients showed a decreasing trend in NT-proBNP over time, with the HIIT group having the lowest level and the control group having the highest level. This indicates that different intensities of cardiac exercise rehabilitation have a significant effect on reducing NT-proBNP, with statistical significance $P < 0.05$ (Table 3).

Table 3. Comparison of NT-proBNP among three groups of patients (mean \pm SD)

Group	Baseline	12 months	6 months
HIIT group ($n = 37$)	2920.48 ± 2125.28	2538.14 ± 28.26	1138.34 ± 29.14
MICT group ($n = 36$)	2856.15 ± 2123.75	2508.04 ± 56.81	1508.13 ± 57.89
Control group ($n = 35$)	2874.52 ± 2126.64	2689.76 ± 53.65	2289.96 ± 54.65
F-value _{Time}		95.76 ^b	
P-value _{Time}	< 0.001		
F-value _{Group}		2.84	
P-value _{Group}	< 0.001		

Note: HIIT refers to the high-intensity interval exercise group; MICT is a moderate intensity continuous exercise group.

4. Discussion

Heart failure (CHF) is a difficult-to-cure disease that affects the lives of patients. Every year, many patients in the United States are diagnosed with chronic heart failure, which requires high medical costs and a low 5-year survival rate during treatment, posing a significant burden on the country. Heart failure is characterized by symptoms such as difficulty breathing and swelling of the ankle joint [3]. During the attack, the myocardium is damaged, heart function is reduced, and patients need to rest in bed with decreased exercise ability. In order to reduce the incidence of CHF, a multi-level comprehensive intervention evaluation is needed. Studies have found that cardiac rehabilitation (CR) can reduce recurrent cardiac events. Therefore, personalized exercise prescriptions should be developed for stable patients. Continuous training can increase cardiac output, improve left ventricular remodeling, enhance cardiac function while strengthening skeletal muscle strength and joint mobility, and improve exercise tolerance [4].

To clarify the impact of cardiac rehabilitation on patients with chronic heart failure, this study conducted in-depth research on the effects of different intensities of cardiac exercise rehabilitation on the prognosis of patients with chronic heart failure. Through research, it has been found that high-intensity interval exercise and moderate-

intensity continuous exercise have significant therapeutic effects on improving patients' LVEF, extending six-minute walking distance, and effectively reducing NT-proBNP, which can greatly improve patients' quality of life. Although different intensities of cardiac exercise rehabilitation can effectively alleviate the condition of patients with chronic heart failure, it is still necessary to continuously improve the diagnosis and treatment level of heart failure, and strengthen research in the field of cardiac rehabilitation, so that patients can improve their cardiac function through personalized exercise prescriptions and continuous rehabilitation training.

5. Conclusion

In summary, the treatment and rehabilitation of heart failure is a complex and long-term process that requires joint efforts from multiple aspects such as medical care, rehabilitation, and prevention. Related studies have shown that different intensities of cardiac rehabilitation have strong improvement effects on heart failure, greatly improving the quality of life of patients. Therefore, it is worth applying and promoting in clinical practice.

Disclosure statement

The authors declare no conflict of interest.

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Study on the Effect of Cardiac Rehabilitation Nursing after Coronary Heart Disease Interventional Therapy

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Abstract: *Objective:* To study the effect of cardiac rehabilitation nursing after coronary heart disease interventional therapy. *Methods:* 80 patients with coronary heart disease who underwent interventional treatment from January 2024 to August 2024 were selected as experimental subjects and randomly divided into 40 cases in each group. The patients in the Kanghu group received cardiac rehabilitation care after interventional treatment, and the patients in the relative group received clinical routine care after interventional treatment. Cardiac function indicators, 6-minute walking distance, quality of life, incidence of adverse cardiovascular events, and nursing satisfaction were compared and analyzed. *Results:* Before nursing, there was little difference in cardiac function indicators between groups and no statistical significance ($P > 0.05$); after nursing, the cardiac function indicators between groups were optimized, and the cardiac function indicators in the Kanghu group were better than those in the relative group, which was statistically significant ($P < 0.05$). Before surgery, the 6-minute walking distance between the groups was similar, which was not statistically significant ($P > 0.05$); after surgery, the 6-minute walking distance between the groups increased, and the 6-minute walking distance in the Kangwu group was longer than that in the relative group, which was statistically significant ($P < 0.05$). There was a large difference in the quality of life scores between the groups, and the quality of life score in the Kangwu group was higher than that in the relative group, which was statistically significant ($P < 0.05$). The incidence of adverse events in the Kangwu group was lower than that in the relative group, and the difference was statistically significant ($P < 0.05$). *Conclusion:* The effect of receiving cardiac rehabilitation care after interventional treatment for coronary heart disease is ideal, which is helpful to strengthen the cardiac function of patients and speed up the recovery speed.

Keywords: Coronary heart disease; Interventional treatment; Cardiac rehabilitation care; Incidence

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1. Introduction

Coronary heart disease, as one of the typical clinical heart diseases, is commonly seen in middle-aged and elderly people and has a very high incidence rate. Without timely intervention, it can lead to exacerbation of the disease, triggering symptoms such as heart failure and heart rupture, which can endanger the patient's life. Nowadays, interventional therapy has become the main treatment for patients with coronary heart disease, which can improve myocardial blood perfusion, reduce myocardial ischemia, and avoid an increase in the scope of infarction^[1]. To promote early recovery of patients with coronary heart disease, postoperative intervention is particularly important. Reports have clearly stated that the effect of cardiac rehabilitation nursing after interventional therapy for coronary heart disease is very prominent, which can not only strengthen heart function but also reduce adverse cardiovascular events^[2,3]. To verify this, this article specifically selects 80 patients with coronary heart disease who underwent interventional therapy from January 2024 to August 2024 as experimental subjects. We will compare and analyze heart function indicators, 6-minute walking distance, quality of life, incidence of adverse cardiovascular events, and nursing satisfaction between patients receiving cardiac rehabilitation nursing and clinical routine nursing after interventional therapy.

2. Materials and methods

2.1. Basic information

80 patients with coronary heart disease who underwent interventional therapy from January 2024 to August 2024 were selected as experimental subjects and randomly divided into two groups, with 40 patients in every group. The rehabilitation group received cardiac rehabilitation nursing after interventional therapy, while the control group received clinical routine nursing. The rehabilitation group consisted of 22 male patients and 18 female patients, aged between 50 and 74 years, with an average age of (62.37 ± 1.06) years old. The control group consisted of 23 male patients and 17 female patients, aged between 51 and 75 years old, with an average age of (62.06 ± 1.54) years old. The basic information of the study subjects showed little difference and was comparable ($P > 0.05$). Inclusion criteria: Approved by the ethics committee, the subjects met the "Guidelines for the Diagnosis of Coronary Heart Disease"^[4], were diagnosed by imaging examination, and agreed to participate in the experiment after being informed of its content. Exclusion criteria: Patients with infectious diseases, immune diseases, unconsciousness, mental abnormalities, or cancer^[5,6].

2.2. Methods

The control group implemented basic clinical nursing methods, instructing patients to remain bedridden for 24 hours after surgery, avoiding strenuous activities, advising patients to drink more water, eat scientifically, and monitor wound conditions. After the vital signs stabilized completely, patients were guided to perform rehabilitation exercises, following the principle of gradual progress and developing a rehabilitation plan based on patient tolerance.

The rehabilitation group implemented cardiac rehabilitation nursing methods. After implementing the basic clinical nursing methods, cardiac rehabilitation intervention was carried out, including the following:

- (1) On the day of surgery, patients were instructed to maintain a supine position for 6–8 hours after surgery. After the wound had completely stopped bleeding, patients were helped with sitting up and turning over training. If patients felt discomfort during training, they were guided to walk slowly along the bedside. If the pain was unbearable, patients were guided to perform bed activities with reduced training intensity to ensure stable breathing.

- (2) On the day after surgery, patients were guided to perform bed exercises such as turning over and sitting up independently, as well as simple resistance activities like squeezing a ball or stretching elastic bands, gradually increasing activity volume and intensity. In addition, patients were instructed on proper breathing techniques, maintaining a deep inhalation and slow exhalation rhythm to prevent breathing difficulties during training. If patients felt discomfort during training, the frequency was reduced or stopped.
- (3) 3–4 days after surgery, patients were guided to perform standing, squatting, and walking exercises. Nursing staff provided assistance to ensure patient safety, ensuring gentle movements to prevent affecting the patient's emotions and breathing. Patients walked about 100 meters along the ward, paying attention to moderate exercise to avoid negative effects.
- (4) 5–7 days after surgery, training difficulty was appropriately increased based on the patient's physical condition, extending walking distance and increasing walking speed. However, it was necessary to maintain a stable heart rate during training and stop immediately if discomfort occurred. Additionally, the training location could be shifted from indoors to outdoors, such as adding stair climbing training, and adjusting the training plan based on the physical condition of patients.
- (5) Before discharge, patients were guided to adjust training content based on heart rate changes. If discomfort occurred during early training, exercise volume was reduced, and then frequency was appropriately increased. If the heart rate increased by 15 beats per minute during early training, the later training volume remained the same as before.

2.3. Evaluation criteria

- (1) Cardiac function indicators LVESD, LVEF, and LVEDD (left ventricular end-diastolic diameter, left ventricular ejection fraction, left ventricular end-systolic diameter) were evaluated using transthoracic echocardiography ^[7].
- (2) The 6-minute walk test assessment criteria were used, with a distance > 425 m representing mild cardiopulmonary insufficiency; a distance < 150 m representing severe cardiopulmonary insufficiency; and a distance between the two representing moderate cardiopulmonary insufficiency ^[8].
- (3) The quality of life was assessed applying the sf-36 scoring scale, which included 8 items involving MH, RE, SF, VT, RP, BP, PF, and CH. The total score for each item was 100, and the score was directly proportional to the quality of life ^[9].
- (4) The occurrence of adverse cardiovascular events was observed and recorded, with an incidence rate calculated as the number of occurrences divided by the total number of cases, multiplied by 100%.

2.4. Statistical methods

SPSS 26.0 statistical software was used. Count data were expressed as (*n*, %) and tested using the chi-square test. Measurement data were expressed as mean ± standard deviation (SD) and tested using the *t*-test. The test criterion was $P < 0.05$, indicating statistical significance between groups.

3. Results

3.1. Comparison of cardiac function indicators between the rehabilitation group and the control group

Before nursing, there was a small difference in cardiac function indicators between groups, which was not

statistically significant ($P > 0.05$). After nursing, cardiac function indicators were optimized in both groups, with the rehabilitation group showing better cardiac function indicators than the control group, which was statistically significant ($P < 0.05$). See **Table 1**.

Table 1. Comparison of cardiac function indicators between the rehabilitation group and the control group (mean \pm SD)

Groups (n)	LVESD (mm)		LVEF (%)		LVEDD (mm)	
	Before nursing	After nursing	Before nursing	After nursing	Before nursing	After nursing
Rehabilitation group (n = 65)	48.37 \pm 2.38	35.45 \pm 3.53	46.37 \pm 5.22	65.46 \pm 6.44	63.47 \pm 2.24	40.44 \pm 4.56
Control group (n = 65)	48.28 \pm 2.56	39.27 \pm 4.27	46.36 \pm 5.84	54.11 \pm 5.36	63.33 \pm 2.35	45.55 \pm 4.11
t-value	0.456	6.067	0.535	5.657	0.503	7.067
p-value	> 0.05	< 0.05	> 0.05	< 0.05	> 0.05	< 0.05

3.2. Comparison of 6-minute walking distance between the rehabilitation group and the control group

Before surgery, the 6-minute walking distance was similar between the groups, with no statistical significance ($P > 0.05$). After surgery, the 6-minute walking distance increased in both groups, with the rehabilitation group having a longer 6-minute walking distance than the control group, which was statistically significant ($P < 0.05$). See **Table 2**.

Table 2. Comparison of 6-minute walking distance between the rehabilitation group and the control group (mean \pm SD, meters)

Groups (n)	1 day before surgery	1 week after surgery	2 weeks before surgery	4 weeks after surgery
Rehabilitation group (n = 65)	218.34 \pm 34.37	440.36 \pm 20.54	482.46 \pm 18.56	532.56 \pm 18.51
Control group (n = 65)	221.16 \pm 30.14	230.17 \pm 22.17	421.23 \pm 20.42	482.22 \pm 19.27
t-value	0.921	35.055	13.408	9.543
p-value	> 0.05	< 0.05	< 0.05	< 0.05

3.3. Comparison of quality of life between the rehabilitation group and the control group

There was a significant difference in the quality of life scores between the groups. The quality of life scores in the rehabilitation group were higher than those in the control group, which was statistically significant ($P < 0.05$). See **Table 3**.

Table 3. Comparison of quality of life between the rehabilitation group and the control group (mean \pm SD, points)

Groups (n)	Physiological function (PF)	Role physical (RP)	Bodily pain (BP)	Vitality (VT)	Mental health (MH)	Role emotional (RE)	Social functioning (SF)	General health (CH)
Rehabilitation group (n = 65)	92.58 \pm 3.38	93.25 \pm 3.65	93.72 \pm 3.38	92.83 \pm 3.17	93.49 \pm 3.49	92.17 \pm 3.04	93.38 \pm 3.28	95.61 \pm 3.12
Control group (n = 65)	80.42 \pm 2.17	82.47 \pm 2.54	80.81 \pm 2.67	83.36 \pm 2.28	82.22 \pm 2.65	81.67 \pm 2.87	85.49 \pm 2.15	83.38 \pm 2.37
t-value	6.185	5.295	7.142	5.286	6.037	5.284	7.596	6.097
p-value	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

3.4. Comparison of the incidence of adverse events between the rehabilitation group and the control group

The incidence of adverse events in the rehabilitation group was lower than that in the control group, and the difference was statistically significant ($P < 0.05$). See **Table 4**.

Table 4. Comparison of the incidence of adverse events between the rehabilitation group and the control group [cases (%)]

Groups (n)	Arrhythmia	Myocardial infarction	Angina pectoris	Repeat revascularization	Total
Rehabilitation group (n = 65)	0	0	0	1	1 (2.50)
Control group (n = 65)	2	1	1	2	6 (15.00)
χ^2 -value	6.381				
p-value	< 0.05				

4. Discussion

Shortness of breath and chest pain are the main symptoms of patients with coronary heart disease, accompanied by sweating, vomiting, and other symptoms, which affect health and lead to a decrease in quality of life^[10]. Interventional therapy can achieve revascularization, improve myocardial blood supply, and ensure smooth blood flow, thereby reducing symptoms and accelerating the recovery of heart function. However, due to factors such as pain and prolonged bed rest after surgery, the recovery of heart function is not ideal, so cardiac rehabilitation nursing is required^[11,12].

The advantages of cardiac rehabilitation nursing are very significant, which can not only strengthen heart function but also promote patients to return to normal life early. By guiding patients to perform passive training on the bed and independent activities off the bed, patients can quickly recover their physical strength after interventional therapy, promoting further strengthening of exercise endurance and improving their heart function. Additionally, adjusting the activity frequency and activity level based on changes in the patient's heart rate during training can effectively lessen the incidence of adverse cardiovascular events, promote better recovery of the patient's bodily functions, and enhance the quality of life. The experimental results are as follows: Before nursing, there was little difference in cardiac function indicators between groups; after nursing, cardiac function indicators were optimized in both groups, with the rehabilitation group showing better cardiac function indicators than the control group. Before surgery, the 6-minute walking distance was similar between groups; after surgery, the 6-minute walking distance increased in both groups, with the rehabilitation group having a longer 6-minute walking distance than the control group. There was a significant difference in quality of life scores between groups, with the rehabilitation group scoring higher than the control group; the incidence of adverse events was lower in the rehabilitation group compared to the control group. These findings are consistent with the research conclusions of many scholars such as Zhou^[13], Wu^[14], Wang^[15], etc., which fully verifies the significance of conducting this experimental study.

5. Conclusion

In summary, the effect of receiving cardiac rehabilitation nursing after interventional therapy for coronary heart

disease is ideal, which helps to strengthen patients' heart function and accelerate recovery, and is worthy of promotion.

Disclosure statement

The authors declare no conflict of interest.

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Enhancing Regional Healthcare Service Capability Through Cardiovascular Regional Medical Centers Under the DeepSeek Framework: A Systematic Analysis of Resource Integration, Technological Empowerment, and Collaborative Networks

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Abstract: Cardiovascular diseases (CVDs) remain a leading global health threat, and the establishment of regional medical centers is a critical strategy for optimizing healthcare resource allocation and enhancing grassroots service capabilities. Against this backdrop, China's National Health Commission launched the "Thousand-County Project," promoting resource decentralization and technological collaboration through the construction of cardiovascular regional medical centers. Guided by the DeepSeek systematic methodology, this study employs a tripartite model of "resource-technology-collaboration" to analyze the service capacity enhancement pathways of a cardiovascular regional medical center in the Pearl River Delta. Findings reveal that deep resource integration (equipment sharing rate increased by 41–97%), technology-enabled empowerment (AI-assisted diagnostic accuracy reached 96.5%), and collaborative network development (response time for remote consultations reduced by 89%) significantly optimized the timeliness of critical care (door-to-balloon [D2B] time decreased from 126 to 71 minutes) and improved the homogenization of grassroots diagnostics (guideline adherence rose from 58% to 82%). International practices, such as the American Heart Association's "Mission: Lifeline" program (reducing STEMI D2B time to under 90 minutes via regional networks) and the European Heart Network's (EHN) transnational data-sharing initiatives, validate the universal applicability of resource integration and technological innovation in healthcare system reform. Empirical evidence demonstrates that the integration of "emergency-chronic care-data networks" increased the number of grassroots hospitals independently performing PCI procedures from 2 to 11, extended annual utilization of advanced equipment by 1,600 hours, and achieved Pareto optimization in "capability enhancement-cost control-quality improvement." This study provides a theoretical framework and practical paradigm for addressing structural healthcare resource disparities, offering critical insights for advancing hierarchical diagnosis and treatment systems and realizing the Healthy China strategy.

Keywords: Cardiovascular regional medical center; DeepSeek; Healthcare service capability; Resource integration; Collaborative network

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1. Introduction

Cardiovascular diseases are the leading cause of mortality among Chinese residents, posing significant challenges to healthcare systems due to their time-sensitive and technically demanding nature. Traditional healthcare models concentrate on high-quality resources in urban tertiary hospitals, leaving grassroots institutions grappling with inadequate technology, workforce shortages, and insufficient equipment. This imbalance drives cross-regional patient flows and delays in critical care. In 2021, China's National Health Commission initiated the "Thousand-County Project," emphasizing the development of specialized regional medical centers, including cardiovascular centers, to decentralize resources and foster technological collaboration. This initiative aligns with ongoing efforts to address healthcare resource allocation and service capacity. For instance, Sichuan Province's compact county medical community pilot improved diagnosis and hospitalization rates through bundled medical insurance payments, advancing hierarchical care ^[1]. Similarly, studies in Chongqing highlighted geographic inequities in medical equipment distribution, underscoring the urgency of resource decentralization ^[2]. Medical alliances in China have adopted remote consultation systems to facilitate resource sharing and enhance grassroots service quality ^[3]. Zhejiang's county-level integrated healthcare reforms demonstrated that resource consolidation and capacity-building elevate service efficiency and quality ^[4]. Globally, South Korea's National Health Insurance adjustments during COVID-19 bolstered frontline resource allocation ^[5], while Poland's reforms strengthened county health centers to improve care coordination and equity ^[6]. In China, the COVID-19 pandemic further spotlighted the need for a balanced spatial distribution of tiered medical resources ^[7]. The DeepSeek methodology, emphasizing resource integration, technological advancement, and networked collaboration, provides a systematic framework for analyzing how cardiovascular regional medical centers enhance service capabilities. This study explores the "resource-technology-collaboration" model of a Pearl River Delta center, offering insights into systemic healthcare capacity improvement.

2. Theoretical framework: DeepSeek methodology in regional medical center development

Under the DeepSeek framework, the construction of regional medical centers requires strategic approaches to address structural contradictions in healthcare resource allocation. The core of the DeepSeek methodology lies in its "deep resource integration" dimension, which aims to dismantle the prevalent "resource silos" in traditional research and development models. This approach emphasizes the systematic restructuring of research and innovation systems, focusing on equipment sharing and talent collaboration. Deep resource integration is critical for optimizing healthcare resource utilization and enhancing service efficiency. By fostering a collaborative environment, regional medical centers can share resources and expertise, thereby improving accessibility to high-quality healthcare. This pathway aligns with open innovation principles, which advocate addressing healthcare challenges through the integration of external stakeholders and resources ^[8]. Resource integration encompasses not only physical assets but also the coordination of human resources and knowledge systems, playing a pivotal role in driving innovation and improving clinical outcomes ^[9]. Beyond resource integration, the DeepSeek framework prioritizes the enabling role of digital transformation in strengthening medical center capabilities. Digital technologies enhance the efficiency of resource management and utilization, enabling real-time data sharing and decision support ^[10]. This feature is particularly vital in resource-scarce regions, where digital tools bridge healthcare gaps through innovative diagnostic and treatment solutions ^[11].

Furthermore, the development of regional medical centers under the DeepSeek framework demands a profound understanding of local healthcare ecosystems, including the evaluation of resource allocation equity and accessibility ^[12]. The framework also underscores the importance of policy support and governance systems to sustain integration outcomes and ensure the long-term viability of regional medical centers ^[13]. Overall, the DeepSeek methodology provides a systematic framework for regional medical center development by integrating resources, applying digital technologies, and fostering multi-stakeholder collaboration. This approach not only resolves structural resource allocation challenges but also holistically improves the efficiency and effectiveness of healthcare service systems ^[14].

3. Functional roles of cardiovascular regional medical centers under the DeepSeek framework

3.1. Core hub for emergency and critical care

These centers specialize in the emergency interventional and surgical treatment of acute cardiovascular events, such as myocardial infarction and aortic dissection. This aligns with findings from case studies demonstrating that comprehensive therapies combining coronary revascularization and extracorporeal membrane oxygenation (ECMO) significantly improve survival rates for patients with acute type A aortic dissection ^[15]. Notably, novel diagnostic approaches integrating deep learning models with electrocardiograms (ECGs) and laboratory indicators have been validated to enhance diagnostic accuracy for acute aortic dissection and myocardial infarction, further strengthening the capacity of such centers in critical care ^[16].

3.2. Regional technological empowerment center

Through remote consultation and training systems, these centers enhance the diagnostic and therapeutic capabilities of grassroots healthcare institutions. This model shares similarities with remote implementation support strategies for integrating mental health services into primary care, offering transferable insights for improving the reach and quality of cardiovascular interventions ^[17]. Studies confirm that telemedicine significantly enhances short-term care quality for acute myocardial infarction patients, underscoring its potential in cardiovascular disease management ^[18].

3.3. Data integration and innovation platform

These centers consolidate regional cardiovascular health data to support disease prevention, control, and scientific innovation. The development of medical big data platforms has proven effective in constructing multidimensional healthcare resource databases, facilitating clinical services, research innovation, and operational management ^[19]. Similarly, cardiovascular studies leveraging electronic health records highlight the potential of data-driven insights to improve patient outcomes ^[20]. The American Heart Association's scientific statement on interoperability for dynamic cardiovascular monitoring data emphasizes that establishing cross-system interoperability frameworks—encompassing platform deployment, sensor integration, and software applications—is pivotal for advancing innovation in cardiovascular disease prevention and treatment ^[21]. Furthermore, the application of multi-omics technologies in discovering biomarkers for acute aortic dissection exemplifies the catalytic role of integrated data platforms in cardiovascular research and clinical practice ^[22].

In summary, cardiovascular regional medical centers optimize critical care delivery through a tripartite functional architecture—emergency networks, technology diffusion systems, and data hubs—while continuously

enhancing cardiovascular disease management systems via technological innovation and data integration.

4. International best practices

Globally, the promotion and advancement of cardiovascular health have been pivotal priorities in healthcare systems worldwide. The efforts of the American Heart Association (AHA) and the European Heart Network (EHN) offer valuable insights and references for other nations.

4.1. AHA's "Mission: Lifeline" program

Since its inception, the American Heart Association (AHA) has been dedicated to the prevention and treatment of cardiovascular diseases. The "Mission: Lifeline" program is a nationwide initiative aimed at improving care for acute myocardial infarction (STEMI) patients by establishing regional collaborative networks. Through optimized emergency care systems, enhanced inter-hospital coordination, and public awareness campaigns, the program has significantly reduced door-to-balloon (D to B) times for STEMI patients to under 90 minutes, improving survival rates and quality of life ^[23]. Key strategies include refining ambulance dispatch protocols, implementing real-time data-sharing technologies during emergencies, and fostering efficient hospital communication. Additionally, "Mission: Lifeline" emphasizes healthcare provider training to enhance emergency response capabilities. These measures have elevated STEMI care efficiency, reduced mortality and complication rates, and established the program as a global benchmark for emergency care systems. Furthermore, AHA's international collaborations advance global cardiovascular health, particularly in prevention, resuscitation, and health equity ^[24].

4.2. European Heart Network (EHN)

The European Heart Network (EHN) is an organization committed to fostering transnational collaboration in cardiovascular health. By coordinating and supporting member states' cardiovascular health initiatives, EHN promotes disease prevention and management ^[25]. Beyond Europe, EHN collaborates with international organizations to advance global cardiovascular health ^[26]. For instance, partnerships with the European Society of Cardiology (ESC) have yielded standardized guidelines and protocols for cardiovascular care. Through harmonized diagnostic and treatment workflows, EHN has elevated the overall quality of cardiovascular health management in Europe, reducing disease burdens and providing scientific and practical guidance for global cardiovascular health ^[26]. By adopting lessons from the AHA and EHN, nations can refine cardiovascular health policies and drive global progress. These international experiences not only offer critical guidance for disease prevention and treatment but also lay the groundwork for achieving global health equity ^[27, 28].

5. Implementation mechanisms: Triple pathways for enhancing service capability in cardiovascular regional medical centers under the DeepSeek framework

To enhance the service capabilities of cardiovascular regional medical centers, three key mechanisms are essential: resource integration, technological empowerment, and collaborative networking. These mechanisms facilitate a shift from fragmented resource management to centralized integration, from experience-driven healthcare to intelligence-driven innovation, and from linear collaboration models to ecosystem-based networked mechanisms.

5.1. Resource integration as the foundation

Integrating healthcare resources across tiers enables optimal allocation and utilization, minimizes waste, and improves service efficiency ^[29]. In China, the establishment of remote consultation systems within medical alliances exemplifies successful resource integration, enabling cross-institutional sharing of high-quality resources ^[29].

5.2. Technological empowerment for quality enhancement

Digital transformation and technological innovation elevate the intelligence of healthcare services, enhancing patient experiences ^[30]. For instance, India's digital health infrastructure in primary care demonstrates how technology-driven solutions boost service efficiency ^[31]. Additionally, digital technologies strengthen circular economy practices through supply chain management and collaboration ^[32].

5.3. Collaborative networking for ecosystem evolution

Multi-stakeholder networks foster knowledge sharing and technology diffusion, driving systemic improvements in healthcare delivery ^[33]. In Australia, evaluations of innovation platforms in Indigenous primary healthcare highlight the effectiveness of collaborative networks in enhancing service quality ^[34]. In summary, by leveraging resource integration, technological empowerment, and collaborative networking, cardiovascular regional medical centers can elevate service capabilities to better meet patient needs and achieve sustainable development.

6. Future perspectives

While China has achieved significant progress in constructing cardiovascular regional medical centers, three critical challenges remain in their transformation:

- (1) Data governance dilemmas: Insufficient integration of multi-source heterogeneous medical data (only 63% comply with the HL7 FHIR standard) and high privacy-preserving computation costs necessitate the development of a federated learning-powered “regional health brain” to establish a distributed AI architecture where “data remains localized while models migrate.”
- (2) Incentive mechanism gaps: Conflicts of interest between tertiary hospitals and grassroots institutions hinder referral motivation (e.g., tertiary hospitals experience an 8% annual revenue decline). Future efforts should innovate “technology support option” models to tightly link capacity-building with performance-based incentives.
- (3) Techno-ethical risks: Ambiguities in AI diagnostic accountability demand a comprehensive governance framework incorporating “algorithm impact assessment, dual-review verification, and blockchain-based evidence preservation.”

To optimize the cardiovascular healthcare system, future strategies should focus on four key directions:

- (1) Deepening digital transformation: Develop AI diagnostic systems based on the “Huangdi Neijing” knowledge graph, integrate multi-omics data with wearable device monitoring, and build a “prevention-emergency-rehabilitation” intelligent lifecycle management network.
- (2) Policy system refinement: Adopt Poland's county health center reform experience to establish a hybrid payment model combining “acute-phase DRG + rehabilitation-phase APG,” alongside targeted incentives such as “awarding 500,000 RMB for training certified physicians” at grassroots institutions.

- (3) Cross-regional collaborative innovation: Reference the EU EHN's transnational collaboration mechanism to promote interprovincial cardiovascular data alliances and standardized quality control metrics with interoperability frameworks.
- (4) Localization of global practices: Enhance the AHA's "Mission: Lifeline" model by integrating 5G and mixed reality technologies to create a "digital catheterization lab" network for real-time cross-institutional guidance in emergency PCI procedures.

Notably, aging populations demand novel approaches to cardiovascular disease management, such as Japan-inspired "community-embedded" rehabilitation systems and evidence-based integration of traditional Chinese medicine. Additionally, emerging technologies like quantum computing and brain-computer interfaces may disrupt traditional paradigms, requiring proactive development of "medical metaverse" training systems and ethical governance frameworks. Only through synergistic advancements in technological innovation, institutional reform, and cultural adaptation can cardiovascular care transition from a "disease treatment" to a "health empowerment" paradigm, offering Chinese wisdom to global healthcare system reform.

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Observation on the Efficacy of Combined External Treatment of Traditional Chinese Medicine in Intervening Hypertension with Kidney-Yang Deficiency by Regulating the RASS System

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Abstract: *Objective:* To observe the efficacy of combined external treatment of traditional Chinese medicine (TCM) in intervening hypertension with kidney-Yang deficiency by regulating the RASS system. *Methods:* A total of 61 patients with subacute hypertension and kidney-Yang deficiency admitted to our hospital from December 2024 to March 2025 were selected. The western medicine treatment group was treated with amlodipine benzenesulfonate and instructed to take antihypertensive western medicine regularly. The TCM external treatment group received auricular acupuncture, auricular point pressing with beans, and acupoint application based on the treatment of the Western medicine group. Laboratory indicators (including angiotensin II, aldosterone, and renin), blood pressure changes, and TCM syndrome scores were compared between the two groups after 4 weeks of treatment. *Results:* After treatment, there were no statistically significant differences in angiotensin II, aldosterone, and renin between the TCM external treatment group and the Western medicine treatment group ($P < 0.05$). There was no statistical significance in blood pressure measurements from the 1st to the 8th time between the two groups ($P > 0.05$). However, both systolic and diastolic blood pressures in the TCM external treatment group showed statistically significant differences between the 8th and 1st measurements ($P < 0.05$), while only systolic blood pressure in the western medicine treatment group showed a statistically significant difference ($P < 0.05$). The blood pressure in the TCM external treatment group decreased steadily from the 1st to the 8th measurement, whereas it did not decrease significantly in the Western medicine treatment group. The TCM external treatment group had significantly better scores in terms of headache and dizziness, cold limbs or back, frequent or involuntary nocturia, fatigue and laziness to speak, shortness of breath and weakness, and other TCM syndromes compared to the control group ($P < 0.05$). *Conclusion:* The combination of TCM external treatment and Western medicine has a good antihypertensive effect in treating subacute hypertension with kidney-Yang deficiency and can effectively improve clinical symptoms.

Keywords: Traditional Chinese Medicine external treatment; Kidney-Yang deficiency; Hypertension

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1. Introduction

Hypertension is a common disease with high morbidity and mortality rates, and there is currently no definitive cure ^[1]. In recent years, due to factors such as socio-economic development and changes in lifestyle, the number of patients with subacute hypertension in China has been increasing, and the condition has become more complex and diverse, making treatment more challenging ^[2]. Clinically, patients with kidney-Yang deficiency hypertension experience symptoms such as headache and dizziness, cold limbs or back, frequent or involuntary nocturia, fatigue and laziness to speak, shortness of breath and weakness, spiritual malaise, pale and swollen tongue with tooth marks, white and slippery or greasy tongue coating, and deep, thin, weak, or floating pulses. To further understand the etiology and current treatment status of this disease, the author conducted a related observational study on 61 patients with kidney-Yang deficiency hypertension admitted to our hospital from December 2024 to March 2025. The results found that adding TCM external treatment on the basis of western medicine antihypertensive therapy can effectively relieve clinical symptoms and lower blood pressure levels, with significant efficacy. The report is as follows.

2. Materials and methods

2.1. General information

A total of 61 patients with subacute hypertension and kidney-Yang deficiency admitted to our hospital from December 2024 to March 2025 were selected. Exclusion criteria included: (1) patients with secondary hypertension; (2) patients with hypertension grade 3 or complicated with hypertensive encephalopathy, hypertensive crisis, and other critical illnesses; (3) patients aged < 20 or > 70 years; (4) patients with severe cardiovascular, liver, kidney, blood system, and neurological diseases; (5) patients with malignant tumors; (6) patients with mental illness; (7) pregnant or lactating women; (8) patients with poor compliance who did not take medication as prescribed. Diagnosis was based on the patients' clinical symptoms and signs. Among them, 31 patients were in the western medicine treatment group (18 males and 13 females), and 30 patients were in the TCM external treatment group (13 males and 17 females). There were no statistically significant differences in gender, hypertension grading, and hypertension-related indicators (angiotensin II, aldosterone, renin) between the two groups ($P > 0.05$), indicating comparability. See **Table 1** for details.

The diagnostic criteria for “kidney-Yang deficiency hypertension” in this study were developed based on the “Guiding Principles for Clinical Research of New Chinese Medicinal Drugs” ^[3]: (1) meet the western medical diagnostic criteria for hypertension, with hypertension graded as 1–2; (2) TCM syndrome differentiation as kidney-Yang deficiency; (3) aged 20–70 years; (4) patients who have provided informed consent and signed the informed consent form.

Table 1. Clinical data

Group		Traditional Chinese Medicine External Treatment Group (<i>n</i> = 30)	Western Medicine Treatment Group (<i>n</i> = 31)	t/χ^2	<i>P</i>
Gender	Male	13 (43.33)	18 (58.06)	1.324	> 0.05
	Female	17 (56.67)	13 (41.94)		
Hypertension Classification	Grade I	14 (46.67)	15 (48.39)	0.018	> 0.05
	Grade II	16 (53.33)	16 (51.61)		
Three Indices of Hypertension	Angiotensin II	48.99 ± 20.09	52.00 ± 18.41	0.610	> 0.05
	Aldosterone	137.84 ± 109.60	115.94 ± 72.95	0.922	> 0.05
	Renin	90.29 ± 226.81	20.97 ± 27.29	1.670	> 0.05

2.2. Methods

The Western medicine treatment group was given amlodipine besylate treatment, and patients were instructed to regularly take Western medicine to lower blood pressure. The external treatment group of traditional Chinese medicine was treated with external treatment of traditional Chinese medicine on the basis of the Western medicine treatment group. The main acupoints for moxibustion treatment were Baihui and ear acupoints, each time for twenty minutes. The main acupoints for auricular acupressure were: kidney, ear apex, liver, and hypotensor points, with supporting acupoints being: pillow, forehead, shenmen, and subcortex. Press 4–8 times a day, each acupoint for 5 minutes. 15–21 days is a course of treatment. Acupoint application uses powdered *Eucommia ulmoides* and cinnamon, mixed with vinegar, and applied to the Yongquan acupoint. The treatment course is 4 weeks.

2.3. Observation indicators

2.3.1. Detection of plasma renin activity (PRA), angiotensin II (Ang II), and aldosterone (ALD) levels

Both groups of patients had 3 mL of venous blood drawn in a fasting state, in a supine position, at 6 to 8 in the morning. PRA, Ang II, and ALD were quantitatively detected using antigen-antibody specific binding and enzyme substrate luminescence. The detection method strictly followed the instructions. Detection was performed once before treatment and once at the end of treatment.

2.3.2. Blood pressure measurement

Before measuring blood pressure, patients were asked to rest quietly for 15 minutes. Then, a standard mercury blood pressure monitor was used to measure blood pressure. Each measurement was taken three consecutive times, and the average of the three systolic and diastolic blood pressure readings was recorded. Measurements were taken before treatment, at the end of treatment, and twice a week during treatment. The dosage of antihypertensive drugs was adjusted based on blood pressure levels.

2.3.3. Traditional Chinese medicine syndrome score

Refer to the “Guiding Principles for the Clinical Research of New Chinese Medicines (Trial)” regarding vertigo, and use the traditional Chinese medicine syndrome rating scale to rate five main syndromes: headache and dizziness, cold limbs or back, frequent or involuntary urination at night, fatigue and laziness, and shortness of breath. The syndromes were rated on a scale of 0 to 3 (none, mild, moderate, severe). The higher the score, the more severe the condition, with a total score range of 0 to 15.

2.4. Statistical methods

SPSS 22.0 software was used for statistical analysis of the data. Measurement data were expressed as mean \pm standard deviation (SD) and analyzed using the *t*-test. Count data were analyzed using the χ^2 test, and grade testing was performed using the Z-test. A *P*-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of laboratory indicators between the two groups

There was no statistically significant difference in angiotensin II, aldosterone, and renin between the external treatment group of traditional Chinese medicine and the Western medicine treatment group ($P > 0.05$), as shown in Table 2.

Table 2. Comparison of laboratory indicators between the two groups (mean \pm SD)

Group	Angiotensin II (pg/mL)	Aldosterone (pg/mL)	Renin (uIU/mL)
Traditional Chinese Medicine External Treatment Group ($n = 30$)	49.80 \pm 18.25	105.23 \pm 45.45	67.55 \pm 182.36
Western Medicine Treatment Group ($n = 31$)	48.92 \pm 21.23	107.50 \pm 55.39	37.38 \pm 64.63
<i>t</i>	0.173	0.175	0.867
<i>P</i>	> 0.05	> 0.05	> 0.05

3.2. Comparison of blood pressure changes between the two groups

There was no statistically significant difference in blood pressure measurements from the 1st to the 8th time between the external treatment group of traditional Chinese medicine and the Western medicine treatment group ($P > 0.05$). However, there was a statistically significant difference in both systolic and diastolic blood pressure in the external treatment group of traditional Chinese medicine when comparing the 8th measurement to the 1st ($P < 0.05$). In the Western medicine treatment group, there was a statistically significant difference in systolic blood pressure when comparing the 8th measurement to the 1st ($P < 0.05$), but no statistically significant difference in diastolic blood pressure ($P > 0.05$). Additionally, the external treatment group of traditional Chinese medicine showed a steady decrease in blood pressure from the 1st to the 8th measurement, while the decrease was not significant in the Western medicine treatment group. See **Table 3** for details.

Table 3. Comparison of blood pressure changes between the two groups (\pm SD, mmHg)

Group	Traditional Chinese Medicine External Treatment Group ($n=30$)	Western Medicine Treatment Group ($n=31$)	<i>t</i>	<i>P</i>
1st Measurement	Systolic Blood Pressure	145.13 \pm 11.54	144.06 \pm 16.80	0.289 > 0.05
	Diastolic Blood Pressure	89.40 \pm 13.53	89.19 \pm 15.23	0.056 > 0.05
2nd Measurement	Systolic Blood Pressure	141.37 \pm 17.82	138.00 \pm 10.57	0.901 > 0.05
	Diastolic Blood Pressure	88.133 \pm 11.80	85.87 \pm 10.54	0.791 > 0.05
3rd Measurement	Systolic Blood Pressure	141.600 \pm 11.73	137.55 \pm 10.98	1.392 > 0.05
	Diastolic Blood Pressure	88.433 \pm 11.61	85.03 \pm 10.49	1.201 > 0.05
4th Measurement	Systolic Blood Pressure	136.63 \pm 14.17	136.45 \pm 10.30	0.057 > 0.05
	Diastolic Blood Pressure	87.20 \pm 11.21	84.97 \pm 9.80	0.829 > 0.05
5th Measurement	Systolic Blood Pressure	134.47 \pm 12.92	136.97 \pm 10.04	0.846 > 0.05
	Diastolic Blood Pressure	85.67 \pm 9.97	85.58 \pm 9.26	0.035 > 0.05
6th Measurement	Systolic Blood Pressure	130.97 \pm 14.14	136.10 \pm 9.86	1.648 > 0.05
	Diastolic Blood Pressure	84.47 \pm 9.17	85.13 \pm 9.19	0.282 > 0.05
7th Measurement	Systolic Blood Pressure	132.60 \pm 15.16	135.45 \pm 9.43	0.885 > 0.05
	Diastolic Blood Pressure	84.84 \pm 9.36	85.43 \pm 10.06	0.239 > 0.05
8th Measurement	Systolic Blood Pressure	131.33 \pm 16.13 ^a	135.68 \pm 10.20 ^a	1.262 > 0.05
	Diastolic Blood Pressure	83.37 \pm 8.45 ^b	84.74 \pm 9.20 ^b	0.607 > 0.05
<i>t</i>	3.811 ^a 2.071 ^b	2.374 ^a 1.393 ^b		
<i>P</i>	0.000 ^a 0.043 ^b	0.021 ^a > 0.05 ^b		

Note: a and b represent the comparison of systolic and diastolic blood pressure, respectively, between the 8th and 1st measurements.

3.3. Comparison of traditional Chinese medicine syndrome scores between the two groups

The external treatment group of traditional Chinese medicine showed significantly better scores in traditional Chinese medicine syndromes such as headache and dizziness, cold limbs or back, frequent or involuntary urination at night, fatigue and laziness, and shortness of breath compared to the control group ($P < 0.05$). The difference was statistically significant, as shown in **Table 4**.

Table 4. Comparison of traditional Chinese medicine syndrome scores between the two groups (mean \pm SD, points)

Group	Headache and Dizziness	Coldness in Limbs or Back	Frequent or Incontinent Nocturia	Fatigue and Lazy to Speak	Shortness of Breath and Weakness
External Treatment Group of Traditional Chinese Medicine ($n = 30$)	1.34 \pm 0.67	1.21 \pm 0.89	1.87 \pm 0.54	1.98 \pm 0.76	1.12 \pm 0.93
Western Medicine Treatment Group ($n = 31$)	2.11 \pm 0.72	2.54 \pm 0.76	2.65 \pm 0.68	2.45 \pm 0.81	2.02 \pm 1.02
<i>t</i>	4.327	3.128	5.221	2.543	3.876
<i>P</i>	0.000	0.002	0.000	0.013	0.000

4. Discussion

Hypertension refers to a condition where the blood pressure exceeds 140/90 mmHg (1 mmHg = 0.133 kPa) in three separate measurements taken on different days without the use of antihypertensive medications. The main clinical manifestations include dizziness, blurred vision, palpitations, insomnia, and elevated systemic arterial blood pressure (systolic and/or diastolic pressure) with systolic pressure greater than or equal to 140 mmHg and diastolic pressure greater than or equal to 90 mmHg^[4]. The etiology of this disease is often attributed to deficiencies in kidney Yang energy, phlegm and blood stasis, and hyperactivity of liver Yang in traditional Chinese medicine. Currently, clinical treatments mainly include non-pharmacological and pharmacological therapies. Non-pharmacological therapies include physical exercise, psychotherapy, dietary control, etc., while pharmacological therapies primarily involve five major types of antihypertensive drugs^[5]. Western medicine currently lacks effective treatments for hypertensive sub-emergencies, whereas traditional Chinese medicine, with its theoretical foundation of “seeking the root cause of the disease,” possesses unique advantages in the treatment of hypertension^[6]. Studies have shown that integrated traditional Chinese and Western medicine can better improve patients’ clinical symptoms, blood pressure levels, and quality of life^[7].

Hypertension falls under the categories of “headache” and “vertigo” in traditional Chinese medicine^[8]. According to the “Ling Shu Jing Mai,” various wind-induced tremors and vertigo are all attributed to the liver, indicating that liver and kidney deficiencies are significant factors causing dizziness and blurred vision. The “Su Wen Sheng Qi Tong Tian Lun” emphasizes the importance of Yang energy to the human body, stating that Yang energy dominates the exterior during the day, and its decline is associated with the rise of Yin energy. Insufficient kidney Yang energy can lead to improper warming of body fluids, resulting in water and dampness stagnation, abnormal qi transformation, and disrupted ascending and descending functions, ultimately causing elevated blood pressure. The primary treatment focuses on warming and nourishing the Yang, specifically targeting the kidneys. Clinically, hypertension is often treated from the perspective of the liver, using methods such as calming the liver and extinguishing wind or soothing the liver and purging fire. However, the efficacy of these treatments has been less than satisfactory. The liver is considered a Yang organ in traditional Chinese medicine, responsible for growth,

dispersion, regulation, and blood storage. It is closely related to the kidneys, giving rise to the saying “the liver and kidneys share the same origin.” When kidney Yang deficiency is the root cause, and liver Yang hyperactivity is the manifestation, it leads to the formation of kidney Yang deficiency-type hypertensive disorder. Patients with this type may experience dizziness, vertigo, tinnitus, palpitations, soreness and weakness of waist and knees, frequent urination, clear urine, nocturia, pale tongue with white coating, and a thin and weak pulse. Kidney Yang deficiency is a fundamental pathological feature and an important cause of this disease.

The results of this study showed no statistically significant differences in angiotensin II, aldosterone, and renin levels between the external treatment group of traditional Chinese medicine and the Western medicine treatment group after treatment ($P < 0.05$). Additionally, there were no statistically significant differences in blood pressure measurements from the 1st to the 8th measurement between the two groups ($P > 0.05$). However, both systolic and diastolic blood pressures in the external treatment group of traditional Chinese medicine showed statistically significant differences when comparing the 8th measurement to the 1st ($P < 0.05$), while only systolic blood pressure in the Western medicine treatment group showed a statistically significant difference ($P < 0.05$). Moreover, the external treatment group of traditional Chinese medicine demonstrated a steady decrease in blood pressure from the 1st to the 8th measurement, whereas the decrease was not significant in the Western medicine treatment group. Furthermore, the external treatment group of traditional Chinese medicine had significantly better scores in symptoms such as headache, dizziness, cold limbs or back, frequent or involuntary urination at night, fatigue and laziness, and shortness of breath compared to the control group ($P < 0.05$). These findings suggest that external treatment methods in traditional Chinese medicine have a good therapeutic effect on kidney Yang deficiency-type hypertension with fewer side effects. This study indicates that the combination of external treatment methods in traditional Chinese medicine and Western medicine is significantly more effective than Western medicine alone, highlighting the high clinical value of integrated traditional Chinese and Western medicine in the treatment of kidney Yang deficiency-type hypertension. Compared to Western medicine alone, the combination of traditional Chinese and Western medicine can better control blood pressure levels without causing adverse reactions, demonstrating safety and efficacy. This conclusion is supported by literature citations^[9,10]. Additionally, some scholars have pointed out that patients with kidney Yang deficiency-type hypertension can also be treated with methods such as soothing the liver and relieving depression, clearing heat and draining dampness, in addition to antihypertensive medications^[11]. Moreover, it is recommended to appropriately increase physical activity and enhance nutrient intake based on individual differences among patients to achieve more ideal blood pressure-lowering effects.

As a relatively common treatment method, external treatment in traditional Chinese medicine has been widely used in the clinical treatment of hypertension in recent years, achieving good results and providing an important reference for the integrated treatment of hypertension with traditional Chinese and Western medicine^[12,13]. However, it should be noted that due to the lack of a standardized clinical evaluation system for external treatment methods in traditional Chinese medicine, there is currently no unified standard for evaluating their efficacy. Therefore, clinical attention should be paid to exploring related issues to further clarify their clinical efficacy.

5. Conclusion

In summary, the combination of external treatment methods in traditional Chinese medicine and antihypertensive medications can achieve better therapeutic effects in patients with kidney Yang deficiency-type hypertension, with high safety, making it worthy of promotion and application.

Disclosure statement

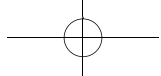
The author declares no conflict of interest.

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