

Cardiovascular Reviews

Editors-in-Chief

Bo Eklöf

University of Lund, Sweden

Yan Song

The First Affiliated Hospital of Zhengzhou University, China

BIO-BYWORD SCIENTIFIC PUBLISHING PTY LTD

(619 649 400)

Level 10

50 Clarence Street

SYDNEY NSW 2000

Copyright © 2025. Bio-Byword Scientific Publishing Pty Ltd.

Complimentary Copy



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.

About Publisher

Bio-Byword Scientific Publishing is a fast-growing, peer-reviewed and open access journal publisher, which is located in Sydney, Australia. As a dependable and credible corporation, it promotes and serves a broad range of subject areas for the benefit of humanity. By informing and educating a global community of scholars, practitioners, researchers and students, it endeavors to be the world's leading independent academic and professional publisher. To realize it, it keeps creative and innovative to meet the range of the authors' needs and publish the best of their work.

By cooperating with University of Sydney, University of New South Wales and other world-famous universities, Bio-Byword Scientific Publishing has established a huge publishing system based on hundreds of academic programs, and with a variety of journals in the subjects of medicine, construction, education and electronics.

Publisher Headquarter

BIO-BYWORD SCIENTIFIC PUBLISHING PTY LTD

Level 10

50 Clarence Street

Sydney NSW 2000

Website: www.bbwpublisher.com

Email: info@bbwpublisher.com

Table of Contents

- 1 Comparison of the Application Value of Treadmill Exercise Test and Dynamic Electrocardiogram in the Diagnosis of Coronary Heart Disease**
Yaqian Huang
- 7 A Bibliometric and Knowledge-map Analysis of Gut Microbiota in Cardiovascular Diseases from 2006 to 2024**
Rong Jing, Min Bai, Yan Liu, Hui Su, He Liu, Liming Hou
- 22 Key Points of“Treatment Algorithm for Pulmonary Arterial Hypertension” from the 7th World Symposium on Pulmonary Hypertension and Its Impact on PAH Treatment in China**
Songlin Zhang, Ashfaq Ahmad, Qian Ren, Heng Wang, Lingling Li, Xiaoyu Wang, Yajuan Du, Fenling Fan
- 28 Clinical Research on Musk Heart Drops for the Treatment of Ischemic Heart Failure (IHF) Complicated with Diabetes**
Jianfei Ye
- 35 A Study of Evidence-based Care Combined with Anticipatory Care in Patients Undergoing Cardiovascular Interventions**
Yongqiang Sun, Qianshui Zhang, Chaofan Sun, Qinhu Zhang
- 42 Analysis and Research on the Effect of Isosorbide Mononitrate Combined with Nicorandil in the Treatment of Myocardial Ischemia in Coronary Heart Disease**
Tianyu Zhou
- 49 Exploring the Diagnostic Value of Blood Tests Combined with Electrocardiogram and 24-Hour Ambulatory Blood Pressure Monitoring in Primary Hypertension with Myocardial Ischemia**
Yana Gao, Lang Liu
- 57 Application and Effect Analysis of Single-port and Multi-port Thoracoscopic Techniques in Lung Cancer Surgery**
Zhanquan Ji, Hongxing Niu, Jingbao Shi, Xueliang Yuan, Junfang Guo

63 Analysis of the Curative Effect of Sarkubactrovalsartan in the Treatment of Patients with Acute Anterior Myocardial Infarction after PCI

Dayuan He

Comparison of the Application Value of Treadmill Exercise Test and Dynamic Electrocardiogram in the Diagnosis of Coronary Heart Disease

Yaqian Huang*

¹Department of Cardiology, Yichang Central People's Hospital, The First College of Clinical Medical Science, China Three Gorges University, Yichang 443003, Hubei, China

²Hubei Key Laboratory of Ischemic Cardiovascular Disease, Yichang 443003, Hubei, China

³Hubei Provincial Clinical Research Center for Ischemic Cardiovascular Disease, Yichang 443003, Hubei, China

**Author to whom correspondence should be addressed.*

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Objective: To explore the application value of treadmill exercise test and dynamic electrocardiogram in diagnosing coronary heart disease. Methods: A total of 185 patients with suspected coronary heart disease admitted to the Department of Electrocardiography in Wujia District of Central People's Hospital from February 2023 to February 2024 were selected according to the inclusion and exclusion criteria, including 93 males and 92 females, aged from 38 to 75 years, with an average age of (55.86 ± 3.25) years. Treadmill exercise test and dynamic electrocardiogram were performed on all patients, and the results of coronary angiography were used as the gold standard. Results: The results of coronary angiography in 185 patients showed that 148 patients were diagnosed as positive, accounting for 80%. The coronary heart disease detection rate in the treadmill exercise test group was 97.30%, which was significantly higher than that in the Holter group, and the difference was statistically significant ($P < 0.05$). The accuracy, specificity, sensitivity, positive predictive value, and negative predictive value of the treadmill exercise test group were 95.68%, 89.19%, 97.30%, 97.30%, and 89.19%, respectively, which were significantly higher than those of the Holter group ($P < 0.05$). The misdiagnosis rate and missed diagnosis rate of the treadmill exercise test group were 10.81% and 2.70%, which were significantly lower than those of the dynamic electrocardiogram group, and the difference was statistically significant ($P < 0.05$). Conclusion: Both treadmill exercise testing and Holter have unique advantages and limitations. In clinical practice, treadmill exercise testing has a high application value in the diagnosis of coronary heart disease and can effectively reduce the misdiagnosis rate.

Keywords: Treadmill exercise test; Dynamic electrocardiogram; Coronary heart disease; Diagnosis; Value of application

Online publication: July 2, 2025

1. Introduction

Coronary heart disease (CAD) is a common and frequent disease of the cardiovascular system, and its early diagnosis is very important for the prognosis of patients and the formulation of treatment strategies. With the

continuous progress of medical technology, a variety of non-invasive examination methods have been widely used in the diagnosis of coronary heart disease, among which the treadmill exercise test (TET) and 24 h-ECG are two commonly used methods. Treadmill exercise testing involves the patient exercising on a treadmill-like device to gradually increase the load on the heart, thereby inducing possible myocardial ischemia and other problems. Doctors diagnose the heart condition by observing the changes of the electrocardiogram. This method is non-invasive, economical and convenient, and can monitor the electrocardiogram, exercise volume and blood pressure response in real time, which improves the safety^[1,2]. However, Holter requires patients to wear a small recording device to continuously record ECG for 24 hours or even longer, which can capture transient arrhythmia and provide key evidence for diagnosis and treatment^[3,4]. In recent years, there have been more and more studies on treadmill exercise tests and Holter in the diagnosis of coronary heart disease, but the comparison of the application value between the two is still controversial. Therefore, it is necessary to systematically compare and analyze these two methods to provide a more scientific basis for clinical decision-making.

2. Materials and methods

2.1. General information

Patients with suspected coronary heart disease admitted to the Department of Electrocardiography in Wujia District of Central People's Hospital from February 2023 to February 2024 were selected. Inclusion criteria: (1) patients with suspected coronary heart disease symptoms, such as chest pain, chest tightness, etc.; (2) age between 35 and 75 years old, regardless of gender; (3) no severe arrhythmia, acute myocardial infarction or other acute heart disease; (4) Patients agreed to undergo treadmill exercise test and Holter monitoring, and signed the informed consent. Exclusion criteria: (1) patients with unstable conditions such as severe heart failure and acute myocarditis; (2) patients who are weak and unable to complete exercise; (3) patients with pacemakers or other electronic medical devices; (4) patients who are allergic to exercise or have other diseases that are not suitable for exercise. A total of 185 patients with coronary heart disease who met the above inclusion and exclusion criteria were selected as the research objects, including 93 males and 92 females, aged 38–75 years old, with an average age of (55.86 ± 3.25) years old. The study was approved by the ethics committee.

2.2. Methods

2.2.1. Treadmill exercise test

All patients underwent treadmill exercise testing using the standard Bruce protocol. Before the test, the patient's medical history was inquired into in detail, and the basic vital signs such as blood pressure and heart rate were measured. The exercise volume was adjusted according to the patient's age, gender, weight, and other factors, and the exercise load was gradually increased until the target heart rate was reached or the patient developed angina and other symptoms. At the same time, the changes of the electrocardiogram were continuously monitored and recorded to observe the amplitude and duration of ST-segment depression or elevation. The criteria for positive results were as follows: the horizontal or oblique downward shift of the ST segment of the ECG during or after exercise ≥ 0.1 mV, lasting ≥ 2 min, or accompanied by typical angina symptoms^[5].

2.2.2. Dynamic electrocardiogram

All patients underwent continuous ECG monitoring using a 24-hour Holter recorder. During the recording period, patients were asked to maintain normal living habits and avoid strenuous exercise and mood swings. After recording,

the data were uploaded to the computer for analysis, focusing on the frequency, type and duration of myocardial ischemia, arrhythmia and other conditions. Positive results were defined as ST-segment depression ≥ 0.1 mV on ECG, lasting ≥ 1 min, and related to the patient's symptoms or activity [6].

2.3. Observation indicators

The main outcome measures included: the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of treadmill exercise test and 24-hour Holter in the diagnosis of coronary heart disease. The decision criteria were based on the results of coronary angiography as the gold standard. Sensitivity = true positive / (true positive + false negative) $\times 100\%$; Specificity = true negative / (true negative + false positive) $\times 100\%$; Positive predictive value = true positive / (true positive + false positive) $\times 100\%$; Negative predictive value = true negative / (true negative + false negative) $\times 100\%$; Accuracy = (true positive + true negative) / total number of cases $\times 100\%$.

2.4. Statistical methods

All the collected data were input into SPSS 26.0 software for statistical analysis. The counting data were recorded as the number of cases and percentage [n(%)], analyzed by χ^2 test and other methods, and the measurement data were recorded as the mean and standard deviation (mean \pm SD), analyzed by t test, and $P < 0.05$ was considered statistically significant.

3. Results

3.1. Comparison of the detection rate of coronary heart disease lesions between the two methods

The results of coronary angiography in 185 patients showed that 148 patients were diagnosed as positive, accounting for 80%. The coronary heart disease detection rate in the treadmill exercise test group was 97.30%, which was significantly higher than that in the Holter group, and the difference was statistically significant ($P < 0.05$). See **Table 1** below for details.

Table 1. Comparison of detection rates of coronary artery disease by two methods ($n = 148$)

Group of groups	Treadmill exercise test group	Holter group	χ^2	P
Single vessel disease	70 (47.30)	55 (37.16)	3.116	0.018
Double vessel disease	37 (20.95)	31 (37.16)	9.441	0.002
Multivessel disease	37 (25.00)	25 (16.89)	3.987	0.017
Sum up	144 (97.30)	111 (75.00)	30.832	0.000

3.2. Comparison of the diagnostic efficacy of the two methods for coronary heart disease

The results showed that the accuracy, specificity, sensitivity, positive predictive value and negative predictive value of the treadmill exercise test group were 95.68%, 89.19%, 97.30%, 97.30% and 89.19%, respectively, which were significantly higher than those of the Holter group ($P < 0.05$). The misdiagnosis rate and missed diagnosis rate of the treadmill exercise test group were 10.81% and 2.70%, which were significantly lower than those of the dynamic electrocardiogram group, and the difference was statistically significant ($P < 0.05$). See **Table 2** below for details.

Table 2. Comparison of diagnostic efficacy of the two tests for coronary artery disease

Group of groups	Treadmill exercise test group	Holter group	χ^2	P
Accuracy	95.68 (177/185)	64.32 (119/185)	56.824	0.000
Specificity	89.19 (33/37)	21.62 (8/37)	34.183	0.000
Sensitivity	97.30 (144/148)	75.00 (111/148)	30.832	0.000
Positive predictive value	97.30 (144/148)	79.29 (111/140)	23.006	0.000
Negative predictive value	89.19 (33/37)	17.78 (8/45)	41.419	0.000
Rate of misdiagnosis	10.81 (4/37)	78.38 (29/37)	34.183	0.000
Rate of missed diagnosis	2.70 (4/148)	25.00 (37/148)	30.832	0.000

4. Discussion

Treadmill exercise test, as a non-invasive examination method, evaluates cardiac function and cardiovascular health by allowing patients to exercise with a gradually increasing load on a device similar to a treadmill while monitoring changes in electrocardiogram ^[7]. This method can induce potential myocardial ischemia problems, especially in the diagnosis of occult coronary heart disease. Patients may be “exposed” to myocardial ischemia under exercise stress even if their ECG performance is normal in a quiet state, thus improving the accuracy of early diagnosis of CHD ^[8,9]. Treadmill exercise test can also effectively determine the patient’s exercise tolerance and cardiac response, providing a reliable basis for subsequent rehabilitation exercise ^[10]. However, this method has the possibility of false positives and false negatives, and is not suitable for patients with unstable conditions such as acute myocardial infarction and severe arrhythmia ^[11].

Holter examination provides more comprehensive information of cardiac electrical activity by continuously recording the changes of the electrocardiogram waveform for 24 hours or even longer. It can capture transient episodes of arrhythmia, such as paroxysmal supraventricular tachycardia, premature beats, etc., which may not appear within a few minutes of routine ECG examination ^[12-14]. For cases such as asymptomatic myocardial ischemia and coronary artery spasm, Holter can also provide detailed original records, to provide more comprehensive reference materials for clinical diagnosis, treatment evaluation and prognosis ^[15]. ST-segment change is the most common manifestation of dynamic electrocardiogram in patients with coronary heart disease, and it is also the hallmark change of myocardial ischemia in the early stage, which has good consistency with other methods, such as coronary angiography in the evaluation of myocardial ischemia ^[16]. However, the Holter also has the limitation that it cannot be monitored in real time, and if the patient has serious cardiac discomfort during the wearing period, it cannot be treated immediately ^[17].

The results of this study showed that in 148 patients with positive coronary angiography results, the treadmill exercise test showed higher sensitivity, accuracy, and specificity than Holter ($P < 0.05$). Meanwhile, the positive predictive value and negative predictive value of the former group were better than those of the latter group ($P < 0.05$), and the detection rate of lesions was higher, and the missed diagnosis rate and misdiagnosis rate were lower ($P < 0.05$). The reason is that although dynamic electrocardiogram can monitor heart rate and ST segment changes for 24 hours and assess the state of cardiac ischemia, it is easy to be interfered by factors such as changes in human posture and neurological dysfunction, resulting in difficulties in the identification of ST segment changes and affecting the accuracy of diagnosis. However, the ECG treadmill exercise test makes the diagnosis by allowing the

patient to gradually increase the cardiac load in the state of continuous exercise and observing the location, degree, and duration of the ECG ST segment changes^[18,19]. When the coronary artery stenosis exceeds 50%, the cardiac oxygen consumption increases with the increase of exercise load. If the coronary blood flow cannot meet the demand, symptoms such as angina pectoris and abnormal electrocardiogram will occur, to accurately reflecting the condition^[20].

Conclusion

In summary, treadmill exercise test and Holter have their own unique advantages and limitations. In practical clinical application, treadmill exercise test has a high application value in the diagnosis of coronary heart disease, which can effectively reduce the misdiagnosis rate.

Disclosure statement

The author declares no conflict of interest.

References

- [1] Li H, Li B, Cao Z, et al., 2024, The Diagnostic Value of the Modified STdmax/MET Criterion in Treadmill Exercise Electrocardiographic Test for Coronary Artery Disease in an Aged Population. *Alternative Therapies in Health and Medicine*, (3): AT10034.
- [2] Pintaningrum Y, Adipranoto D, Pramana K, 2024, Correlation Between Simplified Treadmill Score, Significantly Stenosed Blood Vessels and SYNTAX Score in CAD. *The British Journal of Cardiology*, 31(3): 028.
- [3] Melnychuk OI, Sharayeva LM, Bondarchuk MO, et al., 2024, Holter ECG Monitoring and Platelets Characteristics in Patients With Coronary Artery Disease and Atrial Fibrillation. *Wiadomosci Lekarskie (Warsaw, Poland : 1960)*, 77(5): 957–964.
- [4] Lin Y, 2023, Relationship Between Dynamic Electrocardiogram and CRP, IL-6, ET-1 Expression in Myocardial Ischemia Patients With Coronary Heart Disease. *Cellular and Molecular Biology (Noisy-le-Grand, France)*, 69(12): 52–56.
- [5] MDL, Sanjay D, Ankur G, et al., 2021, Role of Exercise Treadmill Testing in the Assessment of Coronary Microvascular Disease. *JACC. Cardiovascular Imaging*, 15(2): 312–321.
- [6] Magdalena F, Paweł R, Jacek Ł, et al., 2017, Evaluation of Sleep Apnea, Detected by 24-Hour ECG Holter Monitoring Analysis in Patients With Stable Coronary Artery Disease and Ischemic Heart Failure – Correlations With Clinical Data. *Polski Merkuriusz Lekarski: Organ Polskiego Towarzystwa Lekarskiego*, 42(252): 231–235.
- [7] Wenrong W, Qiang Z, 2021, Diagnostic Value of Scoring Model of Treadmill Exercise Test Combined With Dynamic Electrocardiogram for Latent Coronary Heart Disease. *Journal of Electrocardiology*, 69(prepublish): 82–86.
- [8] Naping L, Rongcheng Z, 2020, Effect of Coronary Computed Tomography Angiography Combined With Treadmill Exercise Test on the Recovery of Patients With Coronary Heart Disease. *Basic & Clinical Pharmacology & Toxicology*, 127: 153–153.
- [9] Sultan I, Mohammed A, Ali A, 2019, Exercise Treadmill Test Findings in Patients With Coronary Artery Disease in Salahaddin General Hospital, Tikrit, Iraq. *Indian Journal of Forensic Medicine & Toxicology*, 13(4): 276–282.
- [10] Kun D, Wentao C, Xiaoling J, et al., 2023, Analysis of Skin Cholesterol Determination Combined with ECG Treadmill Exercise in Diagnosis of Coronary Heart Disease in Patients with Atypical Chest Pain. *Journal of Practical*

Medicine / Shiyong Yixue Zazhi, 39(20): 51–56.

- [11] NPK, JBA, Jiwon K, et al., 2019, Impact of Mitral Regurgitation Severity and Cause on Effort Tolerance–Integrated Stress Myocardial Perfusion Imaging and Echocardiographic Assessment of Patients With Known or Suspected Coronary Artery Disease Undergoing Exercise Treadmill Testing. *Journal of the American Heart Association*, 8(5): e010974.
- [12] Yang B, Jia Z, 2024, Diagnostic Value of Nocturnal Trend Changes in a Dynamic Electrocardiogram for Coronary Heart Disease. *BMC Cardiovascular Disorders*, 24(1): 561–561.
- [13] International ME, 2024, Retracted: Application of 24 h Dynamic Electrocardiography in the Diagnosis of Asymptomatic Myocardial Ischemia With Arrhythmia in Elderly Patients With Coronary Heart Disease. *Emergency Medicine International*, (7): 9861978–9861978.
- [14] Qiu X, Liu R, Ren S, 2024, Interventional Effect Analysis of 24-Hour Dynamic Electrocardiogram on Coronary Heart Disease Arrhythmias and Ischemic Myocardium. *Journal of Biotech Research*, 24(2): 171–180.
- [15] Mathematical ACMIM, 2023, Retracted: Meta-Analysis of Dynamic Electrocardiography in the Diagnosis of Myocardial Ischemic Attack of Coronary Heart Disease. *Computational and Mathematical Methods in Medicine*, (9): 9838452–9838452.
- [16] Zongwei C, Hong T, Xuemei L, et al., 2022, Application of 24h Dynamic Electrocardiography in the Diagnosis of Asymptomatic Myocardial Ischemia With Arrhythmia in Elderly Patients With Coronary Heart Disease. *Emergency Medicine International*, (14): 3228023–3228023.
- [17] Wenting R, 2022, Meta-Analysis of Dynamic Electrocardiography in the Diagnosis of Myocardial Ischemic Attack of Coronary Heart Disease. *Computational and Mathematical Methods in Medicine*, 7(12): 3472413–3472413.
- [18] Haitao S, Jing L, Yue W, et al., 2022, Effect of Mobile Internet on Attitude and Self-Efficacy of Patients With Coronary Heart Disease Diagnosed by 12-Lead Holter ECG. *Journal of Healthcare Engineering*, (2) 3414178–3414178.
- [19] Pylova T, 2021, Results of Holter Monitoring in Patients With Coronary Heart Disease Depending on the Severity of Atherosclerotic Lesions of the Coronary Arteries. *ScienceRise: Medical Science*, 2021(3): 15–19.
- [20] Gupta G, Raina S, Bhatnagar M, et al., 2023, Usefulness of Exercise Stress Test in Early Diagnosis of Coronary Artery Disease in Diabetic Patients. *Journal of Medical Society*, 37(1): 20–25.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

A Bibliometric and Knowledge-map Analysis of Gut Microbiota in Cardiovascular Diseases from 2006 to 2024

Rong Jing^{1†}, Min Bai^{2†}, Yan Liu², Hui Su², He Liu^{3†*}, Liming Hou^{2†*}

¹First Cadet Regiment, School of Basic Medical Sciences, Air Force Medical University, Xi'an 710032, Shaanxi, China

²Department of Geriatrics, Xijing Hospital, Air Force Medical University, Xi'an 710032, Shaanxi, China

³Department of Microbiology and Pathogen Biology, School of Basic Medical Sciences, Air Force Medical University, Xi'an 710032, Shaanxi, China

† These authors contributed equally to this work and share the first authorship.

*Authors to whom correspondence should be addressed.

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Cardiovascular disease continues to be a leading cause of death and morbidity worldwide. The study employed bibliometric and knowledge-mapping analyses to explore research trends in cardiovascular disease, identifying emerging hotspots and offering new perspectives for scholars. The study conducted a comprehensive search within the WOSCC on December 28th, 2024, to retrieve articles and reviews that explore the association between gut microbiota and cardiovascular diseases. Citespace and VOSviewer were used to conduct the bibliometric and knowledge-map analysis. The analysis encompassed 1,680 studies published across 289 academic journals, authored by 9,865 researchers from 277 institutions spanning 103 countries/regions. The United States, China, Italy, and India emerged as the leading contributors, with the most cited institutions including the University of California system, INSERM, the Chinese Academy of Medical Sciences & Peking Union Medical College, and Southern Medical University (China). Among journals, *Nutrients* published the highest number of studies, while *Nature*, *Gut*, and the *American Journal of Clinical Nutrition* were the most frequently co-cited. The most prominent research focus centered on biochemistry and molecular biology, with four key cardiovascular conditions: heart failure, cardiometabolic disorders, infarction, and hypertension. GO and KEGG pathway analyses further revealed 30 critical biological processes and 21 signaling pathways linked to gut microbiota and cardiovascular disease. Additionally, PPI network analysis highlighted IFNG, IL10, TLR4, INS, TNF, IL6, IL1 β , APOE, and AGT as potential core therapeutic targets for future research. Our analyses elucidated key research trends linking gut microbiota to cardiovascular diseases, highlighting metabolic modulation and probiotic supplementation as promising therapeutic strategies.

Keywords: Gut microbiota; Cardiovascular diseases; Bibliometric; Knowledge map

Online publication: July 2, 2025

1. Introduction

Cardiovascular diseases are the leading cause of mortality, claiming 17.9 million lives annually, representing 31% of all deaths worldwide. Encompasses a range of conditions, including heart failure, atrial hypertension, coronary artery disease, and cardiomyopathies, despite significant strides in cardiovascular research over the past-century, these diseases continue to be the foremost health burden and the primary cause of death globally, with projections indicating a rise to over 23.6 million deaths per year by 2030 ^[1,2].

The human gut, a complex ecosystem teeming with microorganisms, contains an estimated 1014 bacteria, nearly ten times the number of human cells. This microbial community plays a pivotal role in maintaining health and has been considered as a special “microbial organ” and “second genome” ^[3]. In recent years, the gut microbiota has been implicated in a variety of diseases, including frailty, cognitive dysfunction, cardiovascular diseases etc. ^[4] Over the past decade, a surge of clinical and basic research has underscored the critical role of the “gut-heart-axis” in cardiovascular health ^[5–8].

Knowledge mapping, a bibliometric analytical technique, analyzes the systematic and quantitative features of literature to offer a graphical depiction of scientific knowledge. It serves as a pivotal tool for identifying seminal research, monitoring disease progression, bolstering evidence-based medical practices, and evaluating the efficacy of medical education ^[9]. It offers a means to identify influential research, track the progress of diseases, support evidence-based medicine, and assess the impact of medical education, and consequently, it is an essential asset for medical professionals and has been widely adopted both domestically and globally ^[10,11]. Previous bibliometric studies have concentrated their efforts on elucidating the role of gut microbiota in the context of obesity, cognitive function, and depressive disorders. However, the intricate relationship between gut microbiota and cardiovascular diseases has yet to be thoroughly explored ^[11–13].

The study applied the commonly used bibliometric software (Citespace and VOSviewer) to analyze a thorough synthesis of the characteristics, evolutionary patterns, research hotspots and prospective directions into the gut microbiota’s influence on cardiovascular diseases. The objective is to stimulate more diverse, insightful, and globally collaborative research data in this field.

2. Material and methods

2.1. Data collection

Data for this study were extracted and downloaded from the Web of Science Core Collection (WoSCC) on December 28th, 2024. Our search criteria were defined using the following formula: TS = (cardiac disease OR heart condition OR cardiovascular disorder OR heart ailment OR cardiac illness) AND TS = (gut microbiota OR intestinal flora OR intestinal microbiome OR gastrointestinal microbiota OR gut flora OR gut microbiome). The search spanned from 2006 to September 28th, 2024, and was confined to English-language publications. The study restricted the search to articles and reviews, yielding a total of 1,343 documents, averaging a yearly output of 68 publications.

2.2. Data analysis

This study employed a series of tools to manage, analyze, and visually represent data, including CiteSpace, VOSviewer, and Microsoft Office Excel 2010. CiteSpace, a leading visual analysis software in the field of bibliometrics, was utilized to dissect the literature from various perspectives. This software is adept at identifying research hotspots and trends within a defined academic sphere, presenting them in a visually engaging manner.

VOSviewer, a complimentary JAVA-based bibliometric mapping software, was also incorporated into our analytical framework. This tool excels in the visualization of scientific knowledge, offering a user-friendly interface for constructing and interpreting complex map. Its robust capacity to manage extensive datasets allows for the creation of large-scale, easily interpretable bibliometric maps, which are invaluable for uncovering the broader landscape of scholarly communication.

In addition, Microsoft Office Excel 2010 was employed for data management and to perform quantitative analyses of annual publication trends, complementing the visual insights provided by CiteSpace and VOSviewer. This comprehensive approach ensures a thorough and multifaceted exploration of the research topic.

3. Results

3.1. Global trend in publication output

There are 1680 papers adhered to our predefined inclusion and exclusion criteria, comprising 50.42% articles, 48.75% reviews, and a minor fraction of 0.83% classified as other (**Figure 1**). **Figure 1A** delineates a pronounced upward trajectory in the annual publication count, with the peak annual publication volume reached 276 articles in 2022. With the fastest growth rate in 2020–2021, indicating that research in this field has developed rapidly and is in a phase of rapid ascent. Significantly, the global scholarly community's interest in the microbiota's role in cardiac diseases peaked in 2021–2024, with a total of 1,025 publications over this 4-year period, which accounted for more than 61.01% of the total publications.

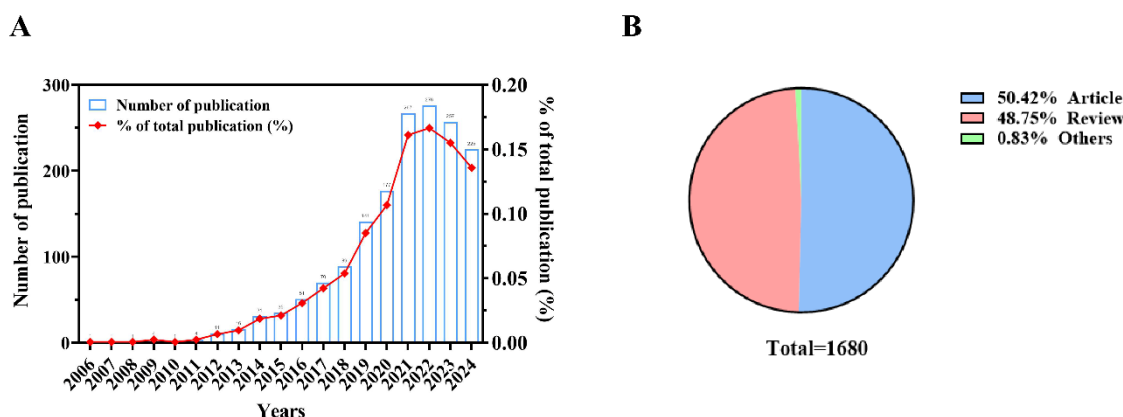


Figure 1. The trend of publication outputs.(A) The number of overall publications between 2006–2024; (B) The proportions of different article types.

3.2. Distribution of country, region, and institution

A total of 103 countries/regions and 277 institutions contributed to these scholarly publications. As detailed in **Table 1** and **Figure 2**, China emerged as the leading contributor (476, 28.3%), trailed by the United States (392, 23.3%), Italy (155, 9.2%) and India (80, 4.8%). Enhanced collaboration frequency is indicative of a nation's centrality within a collaborative network, as evidenced by Figures 2B and 2C, which map the cooperation networks across these countries/regions. The United States, China, Italy, and India were identified as the top five countries/regions based on their centrality, thereby establishing the United States and China as the most influential players in this field, as gauged by both publication volume and network centrality.

Table 1 and **Figure 2D** present the top 20 most prolific institutions. The University of California System published 52 papers and marking it as the foremost contributor to this area of research, succeeded by Institut National de la Sante et de la Recherche Medicale (Inserm), Chinese Academy of Medical Sciences-Peking Union Medical College, and Southern Medical University-China. The cooperation network among institutions, as shown in **Figure 2E**, reveals a vibrant landscape of collaborative efforts, with institutions such as the University of California System, Harvard University, and the Chinese Academy of Medical Sciences-Peking Union Medical College standing out for their active engagement in joint research endeavors.

Table 1. Top ten authors related to the research of gut microbiota on cardiovascular diseases

Authors	Country	Institution	Counts
W.H.Wilson Tang	Cleveland	Human Health, and Heart and Vascular Institute, Cleveland Clinic	11
Stanley L. Hazen	Cleveland	Department of Cellular and Molecular Medicine, Lerner Research Institute, Cleveland Clinic	10
Zeneng Wang	Cleveland	Department of Cardiovascular and Metabolic Sciences, Lerner Research Institute, Cleveland Clinic	5
Hamdi Jama	Australia	Hypertension Research Laboratory, School of Biological Sciences, Faculty of Science, Monash University Heart Failure Research Group, Baker Heart and Diabetes Institute	4
Bryan J. Neth	United States	Department of Internal Medicine- Gerontology and Geriatric Medicine, Wake Forest School of Medicine, Winston-Salem	4
Lars Gullestad	Norway	Department of Cardiology, Oslo University Hospital Rikshospitalet	4
Suzanne Craft	United States	Department of Internal Medicine, Section on Gerontology and Geriatric Medicine, Wake Forest School of Medicine	4
Asbjørn Svardal	Norway	Department of Clinical Science, University of Bergen Department of Heart Disease, Haukeland University Hospital	4
Amar B. Singh	United States	Department of Biochemistry and Molecular Biology, University of Nebraska Medical Center, Omaha	4
Marius Trøseid	Norway	Institute of Clinical Medicine, University of Oslo Research Institute of Internal Medicine, Sognsvannsveien 20, 0027 Oslo	4
Jeffrey Salomon	United States	Department of Pediatrics, University of Nebraska Medical Center	4

3.3. Distribution of authors

A total of 9,865 authors have made significant contributions to this field of study. **Table 1** highlights the top 10 most productive scholars. W.H. Wilson Tang stands out as the most prolific author, having contributed 11 publications, followed closely by Stanley L. Hazen and Zeneng Wang, both affiliated with the Cleveland Clinic. When considering the metric of total citations, W.H. Wilson Tang also secured the top position with an impressive 431 citations. Trailing behind Tang are Wang ZN and Cani PD, who have also made notable impacts in terms of citation counts (**Figure 3**).

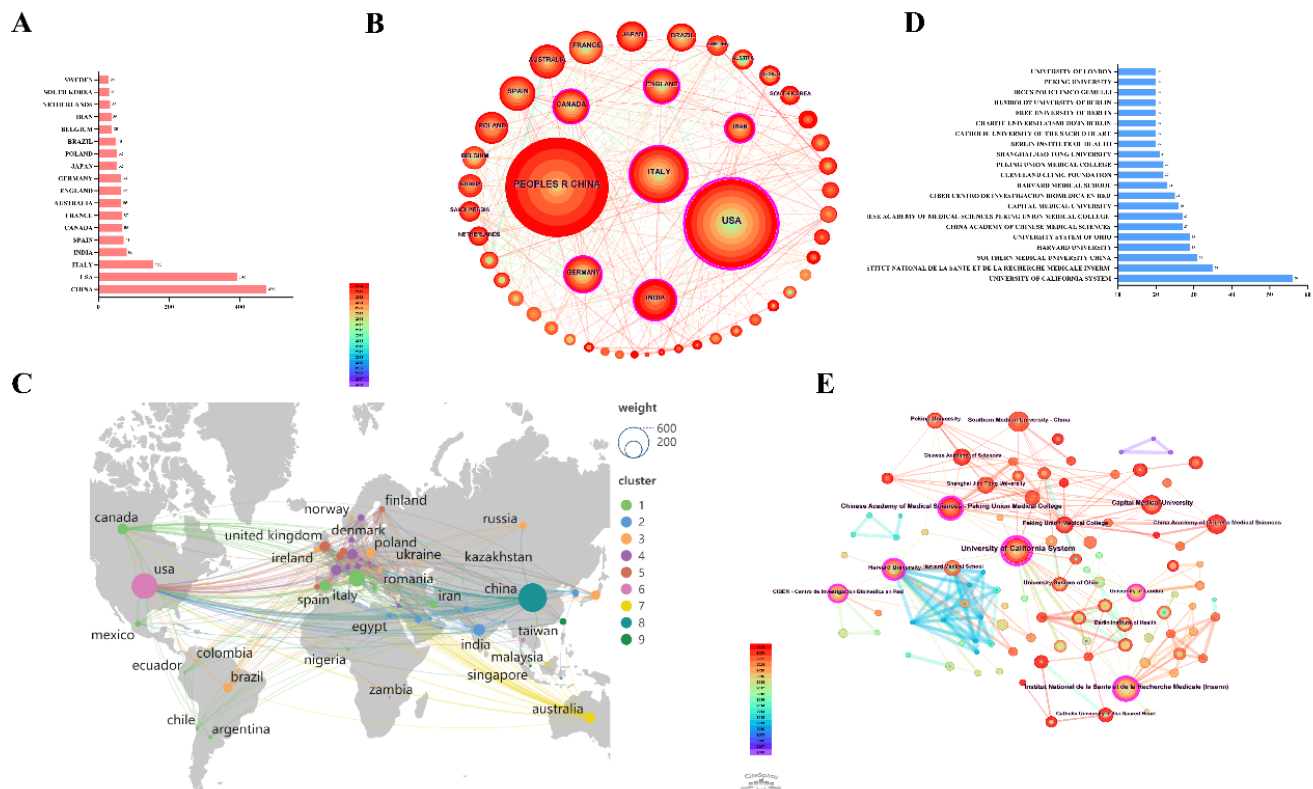


Figure 2. The co-occurrence map of countries/regions and institutions.(A, B, C: The co-occurrence map of countries/regions; D, E: The co-occurrence map of institutions).

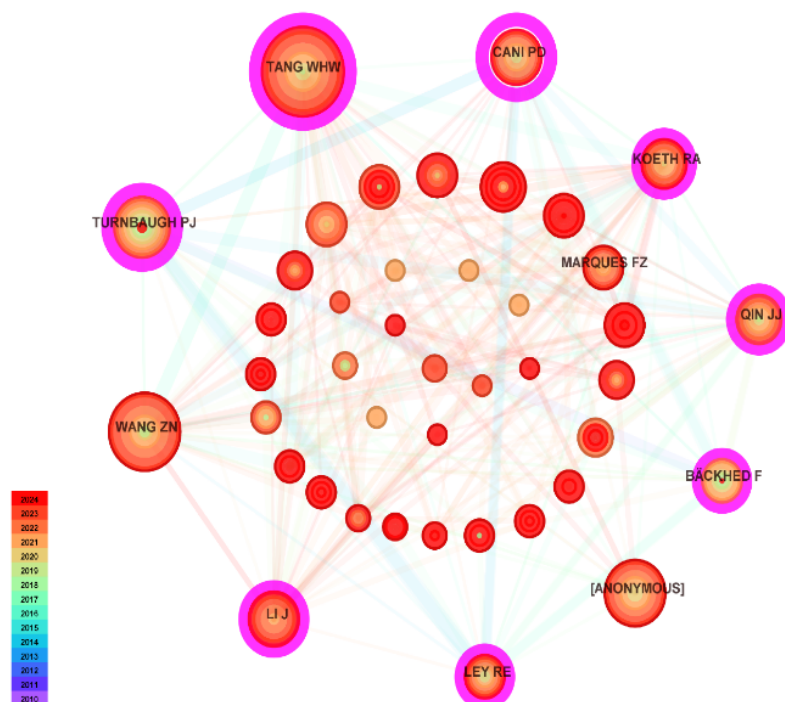


Figure 3. Co-citation author map for gut microbiota research in the cardiovascular diseases.

3.4. Distributions of journals and co-cited journals

Academic journals are pivotal platforms for disseminating the findings of scientific research. The publications under review were disseminated across 289 scholarly journals. **Table 2** delineates the attributes of the top 10 most productive journals in this context. These leading journals featured a total of 295 publications, representing 17.6% of the overall articles published in the field. When examining publication volume, the journal Nature emerged as the most influential, trailed by the American Journal of Clinical Nutrition and Gut. Notably, all of the top 10 journals are positioned within the first quartile, indicating their high impact and quality. Among them, six journals boasted an Impact Factor exceeding 20, underscoring their significance and prestige within the scientific community.

Table 2. Ranking of the top 10 journals and co-cited journals for gut microbiota research in the cardiovascular disease field

Journal	Count	IF	JCR	Co-cited journal	Co-citation	IF	JCR
Nutrients	67	4.8	Q1	Plos One	1159	2.9	Q1
International Journal of Molecular Sciences	51	4.9	Q1	Nature	1118	50.5	Q1
Scientific Reports	27	3.8	Q1	Scientific Reports	913	3.8	Q1
Frontiers in Cellular and Infection Microbiology	25	4.6	Q1	Proceedings of the National Academy of Sciences of The United States of America	906	9.4	Q1
Frontiers in Microbiology	25	4	Q2	Nutrients	833	4.8	Q1
Biomedicines	22	3.9	Q2	Circulation	781	35.5	Q1
Frontiers in Pharmacology	21	4.3	Q1	Gut	761	23	Q1
Frontiers in Cardiovascular Medicine	20	2.8	Q2	Science	743	44.7	Q1
Frontiers in Nutrition	20	4	Q2	Cell	741	45.5	Q1
Frontiers in Physiology	17	3.2	Q2	The New England Journal of Medicine	669	96.2	Q1

3.5. Co-cited references

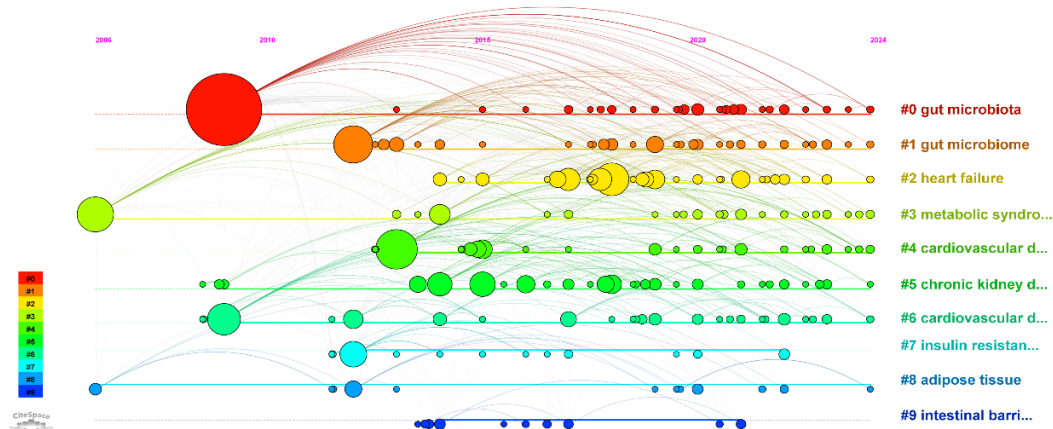
The analysis of co-cited references sheds light on the authoritative works that have shaped the field and the substantial contributions made by leading researchers. **Figure 5A** presents the largest nine clusters of references in a chronological view, highlighting the historical scientific significance of these co-cited references. The study identified 248 co-cited references pertaining to cardiovascular diseases and microbiota from the past decade. Each reference in the top twenty co-cited references garnered a minimum of 37 co-citations. Notably, Tang WHW's work from 2013 received the highest citation count, with a total of 64 citations, underscoring its seminal influence in this area of research (**Figure 5B**).

Top 20 Cited Journals with the Strongest Citation Bursts

Cited Journals	Year	Strength	Begin	End	2006 - 2024
NATURE	2006	56.47	2009	2018	
AM J CLIN NUTR	2006	36.98	2009	2018	
GUT	2006	34.09	2009	2017	
GASTROENTEROLOGY	2006	40.39	2011	2018	
P NATL ACAD SCI USA	2006	59.11	2012	2019	
SCIENCE	2006	40.57	2012	2018	
NEW ENGL J MED	2006	28.73	2012	2017	
DIABETES	2006	38.61	2013	2018	
PLOS ONE	2013	31.62	2013	2017	
J CLIN INVEST	2006	27.75	2014	2019	
J NUTR	2006	25.2	2014	2018	
BRIT J NUTR	2009	22.13	2015	2017	
APPL ENVIRON MICROB	2006	25.73	2017	2020	
ISME J	2018	41.96	2018	2021	
J LIPID RES	2006	27.15	2018	2021	
INT J OBESITY	2006	28.84	2020	2021	
FRONT CELL INFECT MI	2022	32.25	2022	2024	
EBIOMEDICINE	2022	31.48	2022	2024	
FRONT ENDOCRINOL	2022	24.52	2022	2024	
MICROORGANISMS	2022	24.38	2022	2024	

Figure 4. Top 20 cited journals with the strongest citation bursts.

A



B

Top 20 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End	2006 - 2024
Tang WHW, 2013, NEW ENGL J MED, V368, P1575, DOI 10.1056/NEJMoa1109400, DOI	2013	27.08	2014	2018	
Koeth RA, 2013, NAT MED, V19, P576, DOI 10.1038/nm.3145, DOI	2013	23.84	2014	2018	
Wang ZN, 2011, NATURE, V472, P57, DOI 10.1038/nature09922, DOI	2011	17.15	2014	2016	
Tremaroli V, 2012, NATURE, V489, P242, DOI 10.1038/nature11552, DOI	2012	14.66	2014	2016	
David LA, 2014, NATURE, V505, P559, DOI 10.1038/nature12820, DOI	2014	12.47	2015	2019	
Wang ZN, 2015, CELL, V163, P1585, DOI 10.1016/j.cell.2015.11.055, DOI	2015	16.33	2017	2020	
Tang WHW, 2015, CIRC RES, V116, P448, DOI 10.1161/CIRCRESAHA.116.305360, DOI	2015	13.61	2017	2020	
Zhu WF, 2016, CELL, V165, P111, DOI 10.1016/j.cell.2016.02.011, DOI	2016	21.09	2018	2021	
Tang WHW, 2017, CIRC RES, V120, P1183, DOI 10.1161/CIRCRESAHA.117.309715, DOI	2017	20.74	2019	2022	
Marques FZ, 2017, CIRCULATION, V135, P964, DOI 10.1161/CIRCULATIONAHA.116.024545, DOI	2017	17.19	2019	2022	
Jie ZY, 2017, NAT COMMUN, V8, P0, DOI 10.1038/s41467-017-00900-1, DOI	2017	16.72	2019	2022	
Li J, 2017, MICROBIOME, V5, P0, DOI 10.1186/s40168-016-0222-x, DOI	2017	16.03	2019	2022	
Yang T, 2015, HYPERTENSION, V65, P1331, DOI 10.1161/HYPERTENSIONAHA.115.05315, DOI	2015	12.37	2019	2020	
Cui X, 2018, SCI REP-UK, V8, P0, DOI 10.1038/s41598-017-18756-2, DOI	2018	11.84	2021	2024	
Witkowski M, 2020, CIRC RES, V127, P553, DOI 10.1161/CIRCRESAHA.120.316242, DOI	2020	22.32	2022	2024	
Fan Y, 2021, NAT REV MICROBIOL, V19, P55, DOI 10.1038/s41579-020-0433-9, DOI	2021	15.1	2022	2024	
Nemet I, 2020, CELL, V180, P862, DOI 10.1016/j.cell.2020.02.016, DOI	2020	15.1	2022	2024	
Tang TWH, 2019, CIRCULATION, V139, P647, DOI 10.1161/CIRCULATIONAHA.118.035235, DOI	2019	14.75	2022	2024	
Rinninella E, 2019, MICROORGANISMS, V7, P0, DOI 10.3390/microorganisms7010014, DOI	2019	12.63	2022	2024	
Bartolomeaus H, 2019, CIRCULATION, V139, P1407, DOI 10.1161/CIRCULATIONAHA.118.036652, DOI	2019	11.63	2022	2024	

Figure 5. Reference co-citation network knowledge map for research of gut microbiota in the cardiovascular disease from 2006 to 2024.(A: Timeline visualization map of the reference co-citation; B: Top20 references with the strongest citation burst).

3.6. Keywords with citation bursts

Keywords exhibiting citation bursts are those that have received a notable influx of citations over time from scholars active in related research domains. In the analysis, CiteSpace identified 293 keywords that experienced significant citation bursts, as depicted in **Figure 6A**. **Figure 6B** graphically represents these bursts with bars corresponding to specific years. The earliest notable activity is marked by a red bar in 2006, with the trend continuing up to 2024. The term “Adipose tissue” registered the most robust citation burst (strength = 5.17), closely followed by “insulin resistance” with a strength of 7.74. The top 15 keywords in this category spanned a burst strength range from 3.91 to 9.98, indicating their pivotal role in catalyzing research interest and discourse within the field.

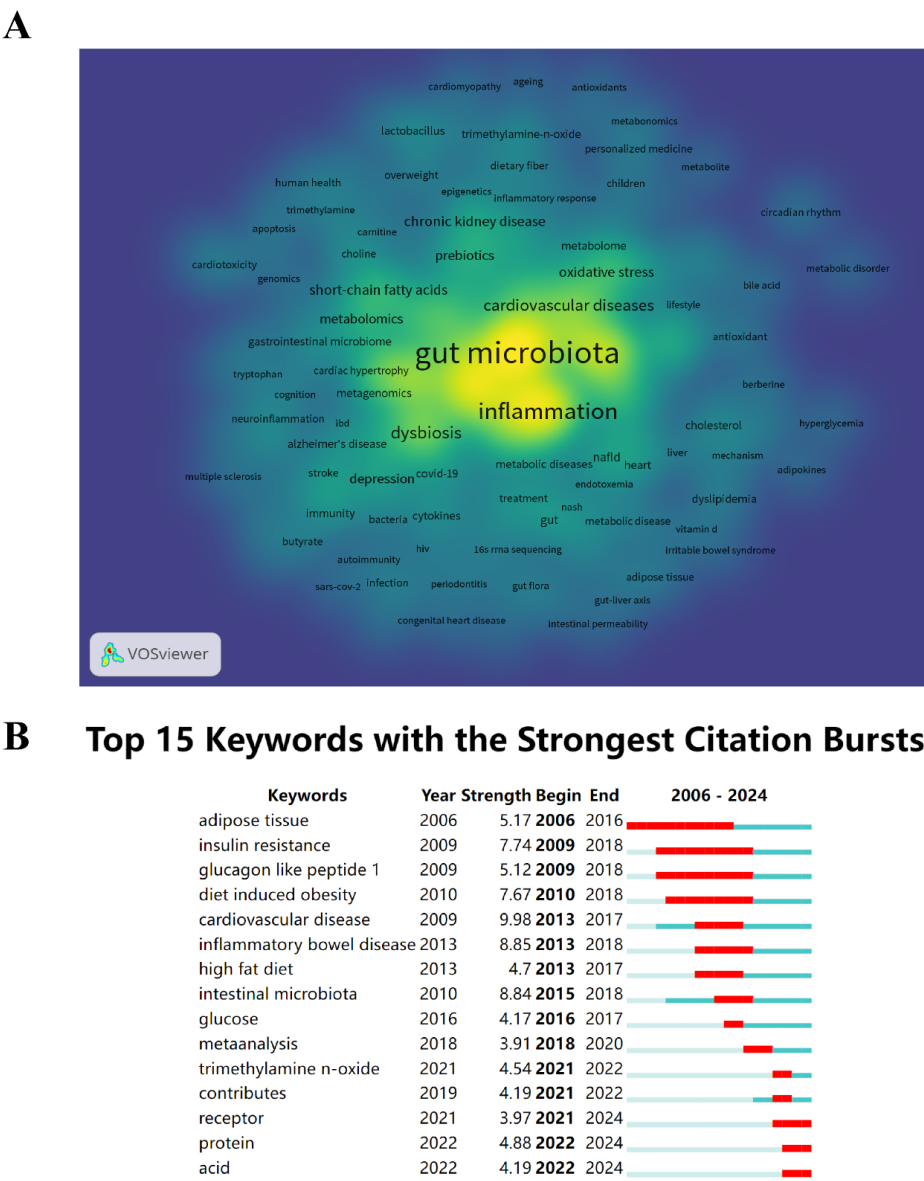


Figure 6. Keywords with citation bursts.(A: Visualization of keyword co-occurrence analysis from 2006 to 2024 based on the VOSviewer software; B: Top 15 keywords with the strongest citation bursts).

3.7. Hotspots and frontiers

By conducting a co-occurrence analysis of targeted keywords, the study could rapidly identify potential future research hotspots within the specified field. **Table 3** presents the top 15 high-frequency keywords, extracted from abstracts and titles that met our established criteria for the intersection of gut microbiota and cardiovascular diseases. The recurring emphasis on keywords such as “gut microbiota,” “cardiovascular disease,” and “adipose tissue,” each appearing more than 300 times, underscores the predominant research trajectory in this area of study.

Table 3. Ranking of the top 15 keywords for gut microbiota research in the cardiovascular disease in terms of frequency

Frequency	Keywords
816	gut microbiota
327	cardiovascular disease
219	adipose tissue
186	inflammation
176	intestinal microbiota
171	insulin resistance
167	diet induced obesity
166	atherosclerosis
160	heart failure
155	chain fatty acids
143	metabolic syndrome
135	body mass index
129	blood pressure
123	gut microbiome
122	oxidative stress

The study summarized the top 10 research directions and found that in the field of research related to the gut microbiome and cardiovascular diseases, and found that biochemistry molecular biology-related research ranks first with a total of 232 papers, followed by pharmacology pharmacy-related research with a total of 214 papers, and nutrition diabetics-related research with a total of 192 papers (Figure7A). **Figure 7B** illustrates the top 10 diseases with the highest number of published papers, with heart failure dominating the list, followed by cardiometabolic disorders, infarction, and hypertension. This distribution suggests that there is a substantial and ongoing demand for research into the diverse spectrum of cardiovascular diseases.

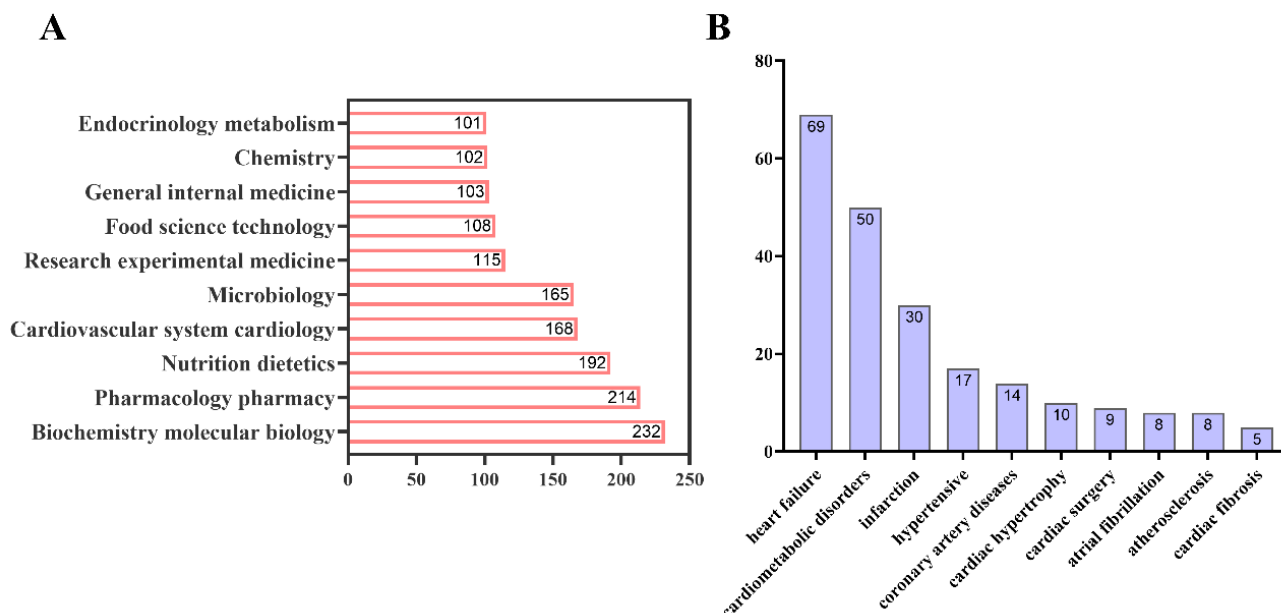


Figure 7. The top 10 research directions and diseases with the most papers.(A: The top 10 research directions; B: The top 10 diseases with the most papers).

3.8. Key gene cluster analysis

3.8.1. GO analysis

The study searched the targets for further analysis, and 135 potential targets were obtained. The 30 biological processes were mainly involved in biological process (BP), molecular function (MF), and cellular component (CC). The details are shown in **Figure 8A–C**. The process were, in the aspect of BP: regulation of inflammatory response (GO: 0050727), protein secretion (GO: 0009306), positive regulation of cytokine production (GO: 0001819), establishment of protein localization to extracellular region (GO: 0035592), and cellular response to lipopolysaccharide (GO: 0071222); in the aspect of MF: receptor ligand activity (GO: 0048018), signaling receptor activator activity (GO: 0030546), cytokine activity (GO: 0005125), cytokine receptor binding (GO: 0005126), and insulin-like growth factor receptor binding (GO: 0005159); and in the aspect of CC: endoplasmic reticulum lumen (GO: 0005788), phagocytic cup (GO: 0001891), blood microparticle (GO: 0072562), low density lipoprotein particle (GO: 0034362), and chylomicron (GO: 0042627).

3.8.2. KEGG pathway enrichment analysis

The study conducted KEGG pathway enrichment analysis on 136 targets and screened 21 signaling pathways: Malaria (hsa05144), Chagas disease (hsa05142), Pertussis (hsa05133), Yersinia infection (hsa05135), and Amoebiasis (hsa05146). The details are shown in **Figure 8D**.

3.8.3. PPI network analysis

As shown in **Figure 8E**, the study screened 136 targets and the top 20 targets were selected as the key targets. The main predicted targets were IFNG, IL10, TLR4, INS, TNF, IL6, IL1 β , APOE, and AGT.

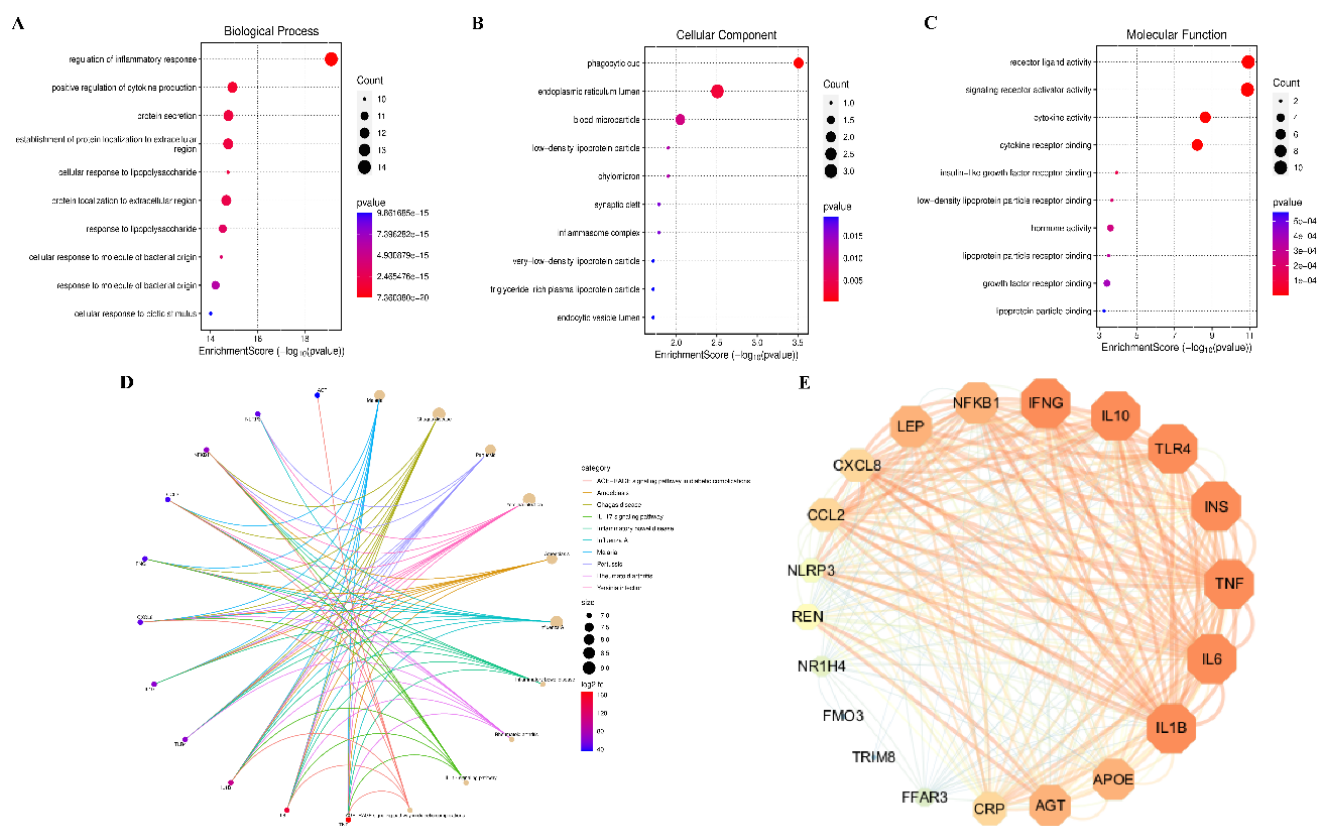


Figure 8. Key gene cluster analysis.(A–C: GO analysis; D: KEGG pathway enrichment analysis; E: PPI network analysis).

4. Discussion

4.1. Summary of the main findings

In this analysis, the study constructed a comprehensive landscape of global research on the interplay between cardiovascular diseases and gut microbiota over the past 2 decades, the study's focus has been on evaluating the current state of research, major key trends, and predicting forecasting emerging areas of interest and innovation.

The findings reveal a steady and significant rise in the annual publication count since the early 2000s, indicating a robust and promising field that is expected to continue expanding in the coming years. The United States, China, and Italy emerged as the most influential nations in terms of citation impact, while China also stands out as the most prolific contributor to the literature. The University of California System, Institut National de la Santé et de la Recherche Médicale (Inserm), and the Chinese Academy of Medical Sciences-Peking Union Medical College were identified as the top three most productive institutions, underscoring their pivotal roles in shaping the discourse in this domain. Among the leading researchers, W.H. Wilson Tang, Stanley L. Hazen, and Zeneng Wang from the Cleveland Clinic have made notable contributions, their work exemplifies the cutting-edge research that is driving the field forward. Regarding the most influential research themes, biochemistry and molecular biology, pharmacology and pharmacy, and nutrition and diabetes were the top 3 directions. These disciplines are at the forefront of uncovering the complex mechanisms linking epigenetics, gut microbiota, and cardiovascular health [5–7]. Furthermore, heart failure, cardiometabolic disorders, and myocardial infarction were identified as the cardiovascular conditions most closely associated with gut microbiota, highlighting the critical importance of these areas in future research endeavors [8]. The insights gained from this analysis not only chart

the current landscape but also provide a road for future investigations, potentially leading to breakthroughs in understanding and treating cardiovascular diseases through the lens of epigenetics and gut microbiota.

4.2. Identification of research trends

Keyword co-occurrence analysis functions as a reflective mirror, capturing the focal points and trends within academic disciplines. The analysis of keyword clusters delineates the underlying structure of knowledge, while the timeline view provides a dynamic visualization of the evolution of these research hotspots over time. As depicted in **Table 3**, the top 15 keywords appearing more than 100 times, have been identified as pivotal in the field of cardiovascular diseases and gut microbiota. The more representative keywords include gut microbiota, cardiovascular disease, adipose tissue, inflammation, intestinal microbiota, insulin resistance, diet-induced obesity, atherosclerosis, heart failure, chain fatty acids, metabolic syndrome, body mass index, blood pressure, gut microbiome, and oxidative stress. From an analysis of these keywords, the study can distill a comprehensive overview of the prevailing landscape within the associated fields:

- (1) Cardiovascular disease remains the leading cause of mortality worldwide, exerting a profound impact on both developed and developing nations. The research landscape in this field is vast and constantly evolving, with a focus on improving patient outcomes through novel treatments, risk stratification, and prevention;
- (2) Adipose tissue is recognized as an active participant in the pathogenesis of cardiovascular diseases, influencing the condition through a spectrum of mechanisms, including inflammation, oxidative stress, and direct effects on cardiac function. Moreover, the gut microbiota is suspected to modulate the metabolic impact of fatty acids, which could potentially influence cardiovascular health;
- (3) Inflammation is a key player in the development of atherosclerosis, and recent breakthroughs have demonstrated that targeted neutralization of IL-1 β can ameliorate cardiovascular outcomes, marking a significant step in understanding the role of inflammation in atherosclerotic disease;
- (4) Intestinal microbiota and gut microbiome have been linked to various metabolic diseases, and ongoing research is probing the therapeutic potential of medium-chain fatty acids in managing these conditions;
- (5) Diet-induced obesity models are extensively utilized to investigate the molecular aspects of obesity and its pathophysiological effects, including insulin resistance, coronary diseases and vascular dysfunction;
- (6) Atherosclerosis forms the basis of a variety of cardiovascular diseases;
- (7) Heart failure affects over 64 million people worldwide, with the incidence stabilizing in industrialized countries but increasing globally due to an aging population and enhanced survival rates for ischemic heart disease ^[9].

By distilling the top 10 research directions, the study can understand the scope and direction of research in this field. The most productive directions are biochemistry and molecular biology, with 232 literature, and then followed closely by pharmacology and pharmacy, which have yielded 214 publications. These trends underscore an escalating interest in deciphering the intricate dynamics between gut microbiota, metabolic health, and cardiovascular diseases, with a focus on developing novel therapeutic approaches to address these global health challenges.

4.3. The molecular mechanism of gut microbiota on cardiovascular disease

Given the rapid annual rise in mortality and morbidity rates attributed to cardiovascular diseases, the research of potential risk factors and innovative therapeutic strategies has become a critical imperative. Often referred to as the “forgotten organ”, the gut microbiota has been recognized as the largest endocrine organ in the human body. A

recent study revealed that distinct shifts in the microbial community's structure and function are associated with the occurrence and progression of cardiovascular diseases. However, discerning whether microbial alterations are the initiators of disease or merely consequences of pathological processes presents a complex and formidable challenge.

In patients with heart failure, the study often observes bowel wall edema and impaired barrier function, which can lead to the translocation of bacterial products into the host's circulation. Predominantly, these bacterial products are identified by toll-like receptors (TLRs), which are strategically located on the surface of immune cells, and trigger a signaling cascade that results in the release of pro-inflammatory cytokines after binding with the bacterial ligands^[9]. Furthermore, preliminary clinical intervention studies have demonstrated a correlation between increased fiber intake and a reduction in blood pressure, and short-chain fatty acids (SCFAs) exert a regulatory influence on blood pressure regulation. A multitude of subsequent studies have reinforced the idea that SCFAs, generated by gut microbiota, are instrumental in modulating the host's blood pressure. Recent studies have shed additional light on the role of SCFAs in various other cardiovascular state, including the mitigation of ischemia-reperfusion injury, facilitation of cardiac repair post-myocardial infarction, and the enhancement of arterial compliance^[14]. These findings underscore the multifaceted impact of the gut microbiota on cardiovascular health and highlight the potential therapeutic implications of modulating SCFA production in the context of CVD management^[15].

In 2011, the Nature reported the study from Cleveland Clinic have highlighted that TMAO (Trimethylamine N-oxide), the production of gut microbiota, could increase the risk of CVD, and have the potential of predict outcomes across a spectrum of CVD phenotypes in large-scale clinical cohorts, including peripheral artery disease, coronary artery disease, acute coronary syndrome and heart failure^[16,17]. Research has indicated that plasma TMAO levels exceeding approximately 6μM are predictive of an elevated risk of adverse cardiac events. A recent meta-analysis revealed that for every 10μM increase in TMAO, there is a 7.6% rise in all-cause mortality. Furthermore, it has been demonstrated that TMAO stimulates the expression of tissue factor (TF) in endothelial cells in vitro, thereby facilitating thrombosis and vascular inflammation^[18]. Seldin et al. reported that elevated TMAO activates MAPK signaling and NFκB nuclear translocation. And this effect is particularly pronounced in individuals with type 2 diabetes, who often present with elevated circulating TMAO levels^[19]. In addition, another production--phenylacetylglutamine (PAG), acts as an adrenergic receptor; they are crucially involved in heart disease and platelet function^[20].

4.4. Practical significance of bibliometric studies

Bibliometrics is the application of statistical methods that has become an increasingly valuable tool in the field of medical research and clinical practice. It involves the quantitative analysis of literature to identify trends, patterns, and the impact of research publications. This approach provides insights into the evolution of medical knowledge and the effectiveness of various research strategies. In medical research, bibliometrics helps to assess the productivity and citation impact of individual researchers, institutions, and countries. By analyzing the citation patterns, researchers can identify the most influential studies and the key players in a particular field. This information is crucial for funding decisions, research collaborations, and the allocation of resources. Moreover, bibliometric analysis can be used to track the progress of specific diseases or conditions over time^[21]. This can help in prioritizing research efforts and identifying gaps in knowledge that need to be addressed. In clinical practice, bibliometrics can aid in evidence-based medicine by identifying the most relevant and high-quality studies. By analyzing the citation frequency of clinical trials and systematic reviews, healthcare providers can make more informed decisions about treatment options and best practices. This can lead to improved patient outcomes and more efficient use of healthcare resources. Furthermore, bibliometrics can be employed to evaluate the effectiveness of medical education and

training programs. By assessing the publication output of graduates and the impact of their research, educational institutions can refine their curricula and teaching methods to better prepare future healthcare professionals ^[22].

4.5. Strengths and limitations

Bibliometrics plays a significant role in both medical research and clinical practice by providing a quantitative framework for understanding and evaluating the vast amount of medical literature. However, there are still exist following shortcomings: First, since the Web of Science is the most commonly used and comprehensive literature database, our data is sourced from it, thus, data not included in the Web of Science has been overlooked. Second, due to the quality differences among the included literature, our analysis may have a small degree of bias. Nevertheless, our research has unearthed the intrinsic connections between cardiovascular diseases and a series of studies on gut microbiota, and offers a means to identify influential research, track the progress of diseases, support evidence-based medicine, and assess the impact of medical education.

The study shows a steady upward trend in global research on the interplay between gut microbiota and cardiovascular diseases from 2006 to 2024. The cardiovascular system emerged as the predominant subject category, reflecting a concentrated focus within this area of study. The United States has been identified as a pivotal driver of research, highlighting its leading role in contributing to the scientific discourse. Interestingly, the analysis reveals a relatively modest level of collaboration among the constituents and authors, suggesting an opportunity for enhanced interdisciplinary cooperation. It serves as a valuable resource for identifying key research institutions and authors, pivotal journals, evolutionary trends, frontier research hotspots, and prospective directions within this dynamic field. Future research is anticipated to yield substantial breakthroughs in the development of innovative therapeutic strategies for the metabolic modulation of cardiovascular diseases.

Author contributions

Study design – Liming H and Min B

Draft preparation – Rong J and Min B

Literature review – Liming H and Min B

Data analysis – Liming H and Min B

Manuscript edit and review – Rong J and Min B

Supervision - LMH

Funding

This work was supported by the Boost Project of Xijing Hospital (Project No.: XJZT25QN40)

Disclosure statement

The authors declare no conflict of interest.

References

- [1] Leopold J, 2018, The Emerging Role of Precision Medicine in Cardiovascular Disease. *Circ Res*, 122: 1302–1315.
- [2] Fang N, Fan Y, 2023, Ideal Cardiovascular Health Metrics and Risk of Cardiovascular Disease or Mortality: A Meta-

Analysis. *Int J Cardiol*, 12: 279–283.

- [3] Witkowski M, Weeks T, 2020, Gut Microbiota and Cardiovascular Disease. *Circ Res*, 127: 553–570.
- [4] Yang J, Wang A, Shang L, et al., 2024, Prebiotics Improve Frailty Status in Community-Dwelling Older Individuals in a Double-Blind, Randomized, Controlled Trial. *J Clin Invest*, 134: e176507–e176515.
- [5] Rahman M, Harun-Or-Rashid, Mamun A, et al., 2022, The Gut Microbiota (Microbiome) in Cardiovascular Disease and Its Therapeutic Regulation. *Front Cell Infect Microbiol*, 12: 1–22.
- [6] Chen X, Ren S, Ding Y, et al., 2023, Gut Microbiota and Microbiota-Derived Metabolites in Cardiovascular Diseases. *Chin Med J (Engl)*, 136: 2269–2284.
- [7] Verhaar B, Nieuwdorp M, Muller M, 2020, Gut Microbiota in Hypertension and Atherosclerosis: A Review. *Nutrients*, 12: 2982–3004.
- [8] Wang Z, 2018, Gut Microbiota Derived Metabolites in Cardiovascular Health and Disease. *Protein Cell*, 9: 416–431.
- [9] Mao Y, Chen N, Fu Q, et al., 2023, A 2-Decade Bibliometric Analysis of Epigenetics of Cardiovascular Disease: From Past to Present. *Clin Epigenetics*, 15: 184–192.
- [10] Liang Y, Bai M, Tang M, et al., 2024, A Knowledge Map of the Relationship Between Diabetes and Stroke: A Bibliometric Analysis Study. *Cerebrovasc Dis*, 53: 270–287.
- [11] Miao L, Zhang Z, Wang S, et al., 2022, A Bibliometric and Knowledge-Map Analysis of CAR-T Cells From 2009 to 2021. *Front Immunol*, 13: 840956–840963.
- [12] Song L, Ma D, Fan Y, et al., 2022, A Bibliometric and Knowledge-Map Analysis of Macrophage Polarization in Atherosclerosis From 2001 to 2021. *Front Immunol*, 13: 910444–910461.
- [13] Zhang J, Miao L, 2022, A Bibliometric and Scientific Knowledge-Map Study of the Chimeric Antigen Receptor (CAR) Natural Killer (NK) Cell-Related Research From 2010 to 2022. *Front Immunol*, 13: 969196–969201.
- [14] Guan B, Hao H, Yang Z, et al., 2022, Bile Acid Coordinates Microbiota Homeostasis and Systemic Immunometabolism in Cardiometabolic Diseases. *Acta Pharm Sin B*, 12: 2129–2149.
- [15] Kaye D, Jama H, 2020, Deficiency of Prebiotic Fiber and Insufficient Signaling Through Gut Metabolite-Sensing Receptors Leads to Cardiovascular Disease. *Circulation*, 141: 1393–1403.
- [16] Wang Z, Bennett B, Koeth R, et al., 2011, Gut Flora Metabolism of Phosphatidylcholine Promotes Cardiovascular Disease. *Nature*, 472: 57–63.
- [17] Zhang Y, Ke B, Du J, 2021, TMAO: How Gut Microbiota Contributes to Heart Failure. *Transl Res*, 228: 109–125.
- [18] Tang W, Levison B, Koeth R, et al., 2013, Intestinal Microbial Metabolism of Phosphatidylcholine and Cardiovascular Risk. *N Engl J Med*, 368: 1575–1584.
- [19] Seldin M, Qi H, Zhu W, et al., 2016, Trimethylamine N-Oxide Promotes Vascular Inflammation Through Signaling of Mitogen-Activated Protein Kinase and Nuclear Factor- κ B. *J Am Heart Assoc*, 5: e002767–e002771.
- [20] Nemet I, Gupta N, Zhu L, et al., 2020, A Cardiovascular Disease-Linked Gut Microbial Metabolite Acts via Adrenergic Receptors. *Cell*, 180: 862–877.
- [21] Gosh S, Nagashima K, Takahashi S, 2017, Statistical Methods in the Journal — An Update. *N Engl J Med*, 376: 1086–1087.
- [22] Ninkov A, Maggio L, 2022, Bibliometrics: Methods for Studying Academic Publishing. *Perspect Med Educ*, 11: 173–176.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Key Points of “Treatment Algorithm for Pulmonary Arterial Hypertension” from the 7th World Symposium on Pulmonary Hypertension and Its Impact on PAH Treatment in China

Songlin Zhang¹, Ashfaq Ahmad¹, Qian Ren², Heng Wang¹, Lingling Li¹, Xiaoyu Wang¹, Yajuan Du¹,
Fenling Fan^{1*}

¹The First Affiliated Hospital of Xi'an Jiaotong University, Xi'an 710061, Shaanxi, China

²Sunshimiao Hospital, Beijing University of Chinese Medicine, Tongchuan 727000, Shaanxi, China

**Author to whom correspondence should be addressed.*

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Following the 7th World Symposium on Pulmonary Hypertension (WSPH) in 2024, the European Respiratory Journal published an updated treatment algorithm for pulmonary arterial hypertension (PAH) highlighting the emerging role of the activin signalling inhibitor (ASI) sotatercept, as a key therapeutic advancement. The updated plan underscores the importance of indicators such as World Health Organization functional class (WHO-FC) and 6-minute walk distance (6MWD) in risk assessment. It advocates for a personalized treatment approach based on risk stratification, encompassing both initial therapy selection and escalation strategies during follow-up. The anticipated introduction of the novel ASI sotatercept in China is expected to expand the therapeutic landscape for PAH management in the country.

Keywords: PAH; ASI; Sotatercept; WSPH; China

Online publication: July 2, 2025

1. Introduction

Following the 7th World Symposium on Pulmonary Hypertension (WSPH) in 2024, the European Respiratory Journal published an updated “Treatment algorithm for pulmonary arterial hypertension,” presenting revised treatment strategies informed by global expert consensus^[1]. Among these updates, the introduction of activin signalling inhibitors (ASI) marks a major therapeutic breakthrough, offering new directions for the global management of pulmonary arterial hypertension (PAH). This article summarizes the key points of the updated algorithm and seeks to encourage reflection among Chinese clinicians regarding the current landscape of PAH diagnosis and treatment in China.

2. Key points of “Treatment algorithm for pulmonary arterial hypertension”

2.1. Treatment goals and risk stratification

The updated treatment algorithm emphasizes that, among the various prognostic indicators for PAH, the World Health Organization functional class (WHO-FC), 6-minute walk distance (6MWD), and N-terminal pro-B-type natriuretic peptide (NT-proBNP), right ventricular imaging parameters, and hemodynamic measures possess the strongest prognostic value ^[2]. The core indicators and typically employed in PAH treatment guidelines to guide therapy selection, with the primary goal of achieving and maintaining a low-risk status. The current consensus continues to advocate for a treatment strategy guided by comprehensive risk assessment.

For initial treatment, the updated treatment algorithm recommends stratifying patients into high-risk and non-high-risk categories. At the first and subsequent follow-up evaluation, it endorses the use of the four-strata risk assessment model outlined in the 2022 ESC/ERS PH guidelines ^[3]. In addition to WHO-FC, 6MWD, and NT-proBNP, the algorithm emphasizes the importance of incorporating serial cardiac imaging and hemodynamic assessment for comprehensive risk reassessment, particularly when considering major therapeutic modifications.

The algorithm highlights that although the 6th WSPH recommended lowering the diagnostic threshold for mean pulmonary arterial pressure (mPAP) from ≥ 25 mmHg to > 20 mmHg ^[4], and the 2022 ESC/ERS guidelines proposed reducing the upper limit for abnormal pulmonary vascular resistance (PVR) from > 3 Wood Unit (WU) to > 2 WU ^[3], no approved therapies currently exist for patients either with mPAP in the range of 21–24 mmHg or PVR 2–3WU. Therefore, even when treatment is considered based on individual clinical scenarios, initial monotherapy is generally advised over combination therapy.

In terms of initiating treatment, the algorithm recommends tailoring therapy according to risk stratification at the time of diagnosis, dividing patients into high-risk and non-high-risk categories. For patients categorized as non-high-risk at baseline, initial combination therapy with an endothelin-1 receptor antagonist (ERA) and a phosphodiesterase-5 inhibitor (PDE-5i) is recommended. And patients classified as high-risk should receive initial therapy that includes parenteral prostacyclin pathway agents (PPA) in combination with ERA and PDE-5i. Additionally, early evaluation for lung transplantation and timely referral should be considered for high-risk patients, depending on patient-specific factors, institutional expertise, and regional accessibility. Importantly, based on findings from the TRITON trial, initial triple oral therapy with selexipag, PDE-5i, and ERA is not recommended ^[1].

2.2. Follow-up and treatment escalation plans

The updated treatment algorithm recommends early reassessment to guide treatment escalation. A follow-up at 3–4 months is considered appropriate for most patients ^[3], provided they are clinically stable or show signs of improvement. For those with clear clinical deterioration, immediate treatment intensification should be considered. In patients initially treated with monotherapy, the addition of a second agent, particularly in those who have not achieved a low-risk profile, should be evaluated at this point or even earlier. Evidence suggests that patients who received early intensification of therapy demonstrating better long-term outcomes than those who underwent delayed escalation ^[5].

Regarding the necessity of further treatment in patients classified as low risk during follow-up, the algorithm notes that many of these individuals continue to experience notable symptoms or reduced exercise capacity, and remain at risk for disease progression ^[6]. Although clinical trials have shown only modest short-term improvements in WHO-FC and 6MWD in this group ^[7], and a limited absolute reduction in clinical deterioration ^[8], individualized

treatment decisions are still encouraged. In this context, expanded therapeutic goals have been proposed, including achieving $\text{PVR} < 5 \text{ WU}$ ^[9], relative PVR reduction of $> 50\%$ – 60% ^[10–12], improvement in stroke volume index (SVI) or other hemodynamic parameters ^[13], and normalization or near-normalization of right heart size and function on cardiac imaging ^[14]. However, further longitudinal studies are needed to determine whether these additional targets offer prognostic value beyond standard low-risk criteria.

For patients reassessed as intermediate-low risk or higher during follow-up, intensification of targeted therapy is warranted. Those receiving initial oral combination therapy who remain in the intermediate-low category based on the four-strata risk model may benefit from additional or alternative treatments. These include the addition of sotatercept, oral or inhaled PPAs, or transitioning from PDE-5i to riociguat. Patients stratified as intermediate-high or high risk at their first follow-up should be considered for parenteral PPA or be considered for add-on sotatercept, while those at highest risk should receive a parenteral PPA, if not already receiving. Persistent intermediate-high or high-risk status across multiple follow-ups should prompt escalation to maximal medical therapy and referral for lung transplantation. Currently, maximal therapy includes quadruple therapy, with sotatercept added to the conventional triple combination targeting the endothelin, nitric oxide, and prostacyclin pathways. Clinical trials have demonstrated that patients already receiving triple therapy experienced additional clinical benefit upon the addition of sotatercept. In all patients who demonstrate progression or sustained high-risk features, timely evaluation for lung transplantation is strongly recommended. ^[1]

2.3. For patients with cardiopulmonary comorbidities and other PAH patients at higher risk of adverse drug reactions

Patients with PAH and concomitant cardiopulmonary comorbidities may experience a higher incidence of adverse events and demonstrate less stable responses to therapy, necessitating more cautious use of targeted treatment and closer clinical monitoring ^[15]. Therefore, monotherapy may be preferred in PAH patients with cardiopulmonary comorbidities.

2.4. Drug administration and adverse reactions

The updated treatment algorithm notes that although most adverse events associated with targeted therapies (such as peripheral edema, nasal congestion, anemia caused by ERA drugs; headache, flushing, indigestion, epistaxis caused by PDE-5i drugs; headache, indigestion, dizziness, hypotension caused by soluble guanylate cyclase stimulators; flushing, headache, jaw pain, nausea, diarrhea caused by PPA drugs; headache, diarrhea, epistaxis, bleeding events caused by sotatercept, etc.) can generally be managed with supportive care or dose adjustment, certain adverse effects warrant heightened attention. ^[1]

For sotatercept, which is about to be approved in China, treatment is initiated at $0.3 \text{ mg} \cdot \text{kg}^{-1}$, and then increased to $0.7 \text{ mg} \cdot \text{kg}^{-1}$ for subsequent doses administered every 3 weeks. Downtitration to $0.3 \text{ mg} \cdot \text{kg}^{-1}$ can be considered when required for adverse events (particularly for elevated haemoglobin) or tolerability. Monitoring is recommended for increased haemoglobin, reduced platelets and the development of new telangiectasias, and an increased risk of bleeding events has been seen in trials. In addition, sotatercept carries a risk of fetal harm, and may have the potential to reduce future fertility and males and females, based on animal studies ^[16].

3. The impact of “Treatment algorithm for pulmonary arterial hypertension” on

future PAH therapeutic approaches in China

The updated treatment algorithm outlines four major pathways targeted by pharmacologic therapy: (1) the endothelin receptor pathway; (2) the nitric oxide pathway; (3) the prostacyclin pathway; and (4) the activin signalling pathway. To date, only the first three classes of targeted therapies have been approved for clinical use in China. However, these therapy primarily exert their effects through vasodilation to alleviate symptoms; do not reverse pulmonary vascular remodeling. As a result, many patients continue to experience disease progression despite ongoing treatment. A 2022 national prospective multicenter registry study on PAH in China reported^[17] that the proportion of patients at intermediate/ high risk during follow-up reached 40.8%, and the 10-year survival rate for PAH patients was only about 63.2%, highlighting the urgent need for more effective therapies that can improve long-term outcomes. Sotatercept, a first-in-class ASI, effectively reduces pulmonary artery pressure and improves symptoms in PAH patients by rebalancing proliferative and antiproliferative signalling to modulate vascular proliferation. Currently, sotatercept has been approved for use in over 40 countries and regions, including the United States and the European Union. Although it has not yet received full regulatory approval in mainland China, it was approved for import as a clinically urgent drug in the Hainan Boao Lecheng Pilot Zone in January, 2025. Multiple clinical studies, including the PULSAR^[18], STELLAR^[19], and ZENITH^[20] studies, have evaluated the safety and efficacy of sotatercept in PAH patients across different risk levels (WHO-FC II, III, IV) receiving adequate background therapy. These studies demonstrated improvements in short-term indicators such as WHO-FC, 6MWD, and NT-proBNP, as well as hemodynamic parameters like PVR and mPAP. Additionally, sotatercept reduced the incidence of long-term events such as all-cause death, lung transplantation, and PAH-related hospitalizations of ≥ 24 hours. The ZENITH study^[20], a phase III, multicenter, randomized, double-blind, placebo-controlled trial, evaluated the efficacy and safety of sotatercept in patients with PAH (WHO-FC III or IV) receiving maximum tolerated background therapy and at high risk of death within 1 year. In the second half of 2024, the ZENITH study was terminated early due to significant efficacy observed in the interim analysis. The results, published on March 31, 2025, in the *New England Journal of Medicine*, showed that sotatercept reduced the composite risk of all-cause death, lung transplantation, or hospitalization for at least 24 hours due to worsening PAH by 76% compared to the placebo group. The Kaplan-Meier curves demonstrated early and significant separation. In the safety analysis of the ZENITH study, similar to the STELLAR study, the percentage of patients experiencing severe adverse events, adverse events leading to drug discontinuation, and adverse events resulting in death was lower in the sotatercept group compared to the placebo group. Additionally, the HYPERION study, which included newly diagnosed (less than 12 months) PAH patients, was also terminated early based on the positive interim results of the ZENITH study. In June 2025, positive results from the HYPERION study were announced, achieving its primary endpoint of time to clinical worsening (TTCW) as measured by a composite endpoint of all-cause death, the need for non-planned PAH-related hospitalization > 24 hours, atrial septostomy, lung transplantation, or PAH deterioration. To date, the strong clinical profile of sotatercept had been primarily established through previous studies in a prevalent patient population comprised of patients that were several years into their treatment journey. These positive results from HYPERION expand on the body of clinical evidence now including recently diagnosed adults, supporting the practice-changing potential of sotatercept in a broad spectrum of PAH patients, including those earlier in their treatment journey.

The 7th WSPH emphasized the translation of modern pulmonary vascular research, introduced novel therapeutic approaches targeting pulmonary vascular remodeling, and updated evidence-based treatment algorithms, highlighting the complementarity between different therapeutic methods^[1]. Regarding

updates to PAH treatment strategies, recommendations were primarily based on comprehensive analyses according to risk stratification ^[1]. The updated treatment algorithm specifically highlight that sotatercept, an activin signalling inhibitor, is the first targeted PAH therapy to act on a new pathway in nearly two decades and the addition of sotatercept to the treatment of PAH patients who are already receiving adequate background therapy with traditional vasodilator targeted drugs can still demonstrate further significant clinical benefits for them ^[1,18–20]. The recommendation of this drug in “Treatment algorithm for pulmonary arterial hypertension” brings optimistic expectations for the future treatment of PAH patients in China. The introduction of novel targeted therapies like sotatercept to China is expected to provide new strategies for the treatment of PAH, potentially breaking through current therapeutic bottlenecks and improving long-term patient outcomes as clinical experience and localized research accumulate.

Disclosure statement

The authors declare no conflict of interest.

Acknowledgements

I extend my sincere gratitude to Ying Yang from MSD China for her dedicated assistance in literature collection and organization, which has played a crucial role in the writing of this article.

References

- [1] Chin K, Gaine S, Gerges C, et al, 2024, Treatment Algorithm for Pulmonary Arterial Hypertension. *European Respiratory Journal*, 64(4): 2401325.
- [2] Sitbon O, Nikkho S, Benza R, et al, 2020, Novel Composite Clinical Endpoints and Risk Scores Used in Clinical Trials in Pulmonary Arterial Hypertension. *Pulm Circ*, 10: 2045894020962960.
- [3] Humbert M, Kovacs G, Hoeper M, et al, 2022, 2022 ESC/ERS Guidelines for the Diagnosis and Treatment of Pulmonary Hypertension. *Eur Heart J*, 43(38): 3618–3731.
- [4] Simonneau G, Montani D, Celermajer D, et al, 2019, Haemodynamic Definitions and Updated Clinical Classification of Pulmonary Hypertension. *Eur Respir J*, 53: 1801913.
- [5] Gaine S, Sitbon O, Channick R, et al, 2021, Relationship Between Time From Diagnosis and Morbidity/Mortality in Pulmonary Arterial Hypertension: Results From the Phase III GRIPHON Study. *Chest*, 160: 277–286.
- [6] Blette B, Moutchia J, Al-Naamani N, et al, 2023, Is Low-Risk Status a Surrogate Outcome in Pulmonary Arterial Hypertension? An Analysis of Three Randomised Trials. *Lancet Respir Med*, 11: 873–882.
- [7] Pan H, McClelland R, Moutchia J, et al, 2023, Heterogeneity of Treatment Effects by Risk in Pulmonary Arterial Hypertension. *Eur Respir J*, 62: 2300190.
- [8] Kim N, Fisher M, Poch D, et al, 2020, Long-Term Outcomes in Pulmonary Arterial Hypertension by Functional Class: A Meta-Analysis of Randomized Controlled Trials and Observational Registries. *Pulm Circ*, 10: 2045894020935291.
- [9] Benza R, Gomberg-Maitland M, Elliott C, et al, 2019, Predicting Survival in Patients With Pulmonary Arterial Hypertension: The REVEAL Risk Score Calculator 2.0 and Comparison With ESC/ERS-Based Risk Assessment Strategies. *Chest*, 156: 232–337.

- [10] Weatherald J, Boucly A, Chemla D, et al, 2018, Prognostic Value of Follow-Up Hemodynamic Variables After Initial Management in Pulmonary Arterial Hypertension. *Circulation*, 137: 693–704.
- [11] Badagliacca R, D’Alto M, Ghio S, et al, 2021, Risk Reduction and Hemodynamics With Initial Combination Therapy in Pulmonary Arterial Hypertension. *Am J Respir Crit Care Med*, 203: 484–492.
- [12] D’Alto M, Badagliacca R, Argiento P, et al, 2020, Risk Reduction and Right Heart Reverse Remodeling by Upfront Triple Combination Therapy in Pulmonary Arterial Hypertension. *Chest*, 157: 376–383.
- [13] Boucly A, Beurnier A, Turquier S, et al, 2024, Risk Stratification Refinements With Inclusion of Haemodynamic Variables at Follow-Up in Patients With Pulmonary Arterial Hypertension. *Eur Respir J*, 63: 2400197.
- [14] Veerdonk M, Kind T, Marcus J, et al, 2011, Progressive Right Ventricular Dysfunction in Patients With Pulmonary Arterial Hypertension Responding to Therapy. *J Am Coll Cardiol*, 58: 2511–2519.
- [15] McLaughlin V, Vachiery J, Oudiz R, et al, 2019, Patients With Pulmonary Arterial Hypertension With and Without Cardiovascular Risk Factors: Results From the AMBITION Trial. *J Heart Lung Transplant*, 38: 1286–1295.
- [16] United States Food and Drug Administration, 2024, Sotatercept, visited on July 2, 2024, www.accessdata.fda.gov/drugsatfda_docs/label/2024/761363s0001bl.pdf.
- [17] He J, et al, 2022, Characteristics, Goal-Oriented Treatments and Survival of Pulmonary Arterial Hypertension in China: Insights From a National Multicentre Prospective Registry. *Respirology*, 27(7): 517–528.
- [18] Humbert M, McLaughlin V, Gibbs J, et al, 2021, Sotatercept for the Treatment of Pulmonary Arterial Hypertension. *N Engl J Med*, 384: 1204–1215.
- [19] Hoeper M, Badesch D, Ghofrani H, et al, 2023, Phase 3 Trial of Sotatercept for Treatment of Pulmonary Arterial Hypertension. *N Engl J Med*, 388: 1478–1490.
- [20] Humbert M, McLaughlin V, Gibbs JSR, et al, 2025, Sotatercept in Patients With Pulmonary Arterial Hypertension at High Risk for Death. *N Engl J Med*, 392(20): 1987–2000.

Publisher’s note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Clinical Research on Musk Heart Drops for the Treatment of Ischemic Heart Failure (IHF) Complicated with Diabetes

Jianfei Ye*

Ningbo Fourth Hospital, Ningbo 315000, Zhejiang, China

**Author to whom correspondence should be addressed.*

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Objective: To study the clinical effect of Musk Heart Drops in the treatment of ischemic heart failure (IHF) complicated with diabetes. Methods: 120 patients with IHF and diabetes admitted to Xiangshan First People's Hospital from May 2023 to May 2025 were selected as the research subjects. They were divided into a control group and an observation group, with 60 patients in each group, using a random number method. The control group received standard treatment, while the observation group received standard treatment plus Musk Heart Drops. The treatment lasted for 3 months. The treatment effects, symptom scores, 6-minute walk distance, cardiac function, serum indicators, and blood glucose indicators were compared and analyzed. Results: The observation group demonstrated a significantly higher treatment efficacy compared to the control group ($P < 0.05$). Post-treatment assessments revealed that the observation group had lower symptom scores, a longer 6-minute walking distance, and improved left ventricular function, as indicated by a higher left ventricular ejection fraction (LVEF) and reduced left ventricular end-systolic diameter (LVESD) and end-diastolic diameter (LVEDD) ($P < 0.05$). Additionally, plasma NT-proBNP levels were significantly lower in the observation group ($P < 0.05$). Metabolic parameters also improved, with the observation group showing lower fasting blood glucose (Glu) and glycated hemoglobin (HbA1c) levels than the control group ($P < 0.05$). Conclusion: Musk Heart Drops combined with standard treatment can control the condition of patients with IHF and diabetes, improve symptoms, 6-minute walk distance, cardiac function, NT-proBNP, and blood glucose levels, demonstrating significant application value.

Keywords: Ischemic heart failure complicated with diabetes; Standard treatment; Musk Heart Drops

Online publication: July 2, 2025

1. Introduction

With the increasing number of patients with diabetes and cardiovascular disease, the incidence of comorbidities such as ischemic heart failure (IHF) complicated with diabetes is also rising^[1]. How to effectively treat IHF complicated with diabetes has become a key clinical research issue. Musk Heart Drops is a commonly used

Chinese medicine in cardiovascular medicine, originating from “Taiping Huimin Heji Ju Fang” Zhibaodan ^[2]. Based on clinical validation, Musk Heart Drops can play a significant role in the treatment of coronary heart disease and angina pectoris, which is conducive to improving heart function and relieving related symptoms. Some studies have pointed out that the main indication of Musk Heart Drops is coronary heart disease, but it can also achieve good benefits when used for the treatment of other types of cardiovascular diseases. Based on this, this study explored the therapeutic effect of Musk Heart Drops using 120 patients with IHF and diabetes as subjects.

2. Materials and methods

2.1. General information

From May 2023 to May 2025, 120 patients with IHF and diabetes admitted to Xiangshan First People’s Hospital were selected as subjects. They were divided into two groups using a random number method, with 60 patients in each group. The sample size was estimated using the formula $n1 = n2 = 2[(u\alpha + u\beta) / (\delta/\sigma)]^2 + 0.25 u\alpha^2$, and after sample size estimation, it was found that the observation group and control group each required 50 samples. This study required a minimum sample size of 100 patients. Considering factors such as sample loss, dropout, and exclusion during the study period, the sample size was increased by 20% on the original basis, resulting in a final sample size of 120 patients. The general information of the two groups was collected and verified for comparability ($P > 0.05$). This study was approved by the medical ethics committee.

2.2. Diagnostic Criteria

Refer to the diagnostic criteria for IHF in the “Chinese Guidelines for the Diagnosis and Treatment of Heart Failure 2014” ^[3]; refer to the diagnostic criteria for diabetes in the “National Guidelines for the Prevention and Management of Diabetes at the Primary Level (2022)” ^[4].

2.3. Inclusion and exclusion criteria

Inclusion criteria: (1) Meet the diagnostic criteria for IHF and diabetes mentioned above, with NYHA functional classification of I–IV; (2) Age ≥ 30 years old; (3) No limitation on disease duration; (4) Informed of medication content, research content, and signed informed consent.

Exclusion criteria: (1) Do not meet the disease inclusion criteria; (2) Have participated in other studies or participated in disease-related studies within 1 month before the study; (3) Suffer from neurological diseases or mental illnesses; (4) Pregnant or lactating; (5) Peripheral vascular disease; (6) Allergic constitution; (7) Combined with severe arrhythmia, acute myocardial infarction, cardiogenic shock, pulmonary embolism, etc.; (8) Detected malignant tumors; (9) Detected liver and kidney dysfunction; (10) Detected communication barriers, consciousness barriers, intellectual disabilities.

2.4. Method

Both groups of patients received standardized Western medicine treatment, including the use of cardiotonic, diuretic, hypoglycemic, and antiplatelet drugs based on the severity of the disease and symptoms. During medication, patients’ vital signs and disease indicators were monitored, adverse reactions were identified, and medication dosages were reasonably adjusted. The observation group was additionally treated with Musk Deer Heart Drops (Inner Mongolia Conba Pharmaceutical Co., Ltd. Shenglong Branch, National Medical Approval Number Z20080018, Specification: 35 mg * 18 pills), 2 pills once, 3 times a day, for 3 months.

2.5. Observation indicators

2.5.1. Clinical efficacy

Evaluate heart failure symptoms and cardiac function classification before and after treatment, and formulate a judgment based on actual changes ^[5]. Markedly effective: Symptoms are controlled, and cardiac function decreases by ≥ 2 grades; Effective: symptoms are relieved, and cardiac function decreases by 1 grade; Ineffective: no significant changes in symptoms and cardiac function, or the condition worsens; Treatment effectiveness rate = Markedly effective rate + Effective rate.

2.5.2. Symptom score

The main symptoms are chest tightness, shortness of breath, and palpitations, while the secondary symptoms are fatigue, cyanosis of lips and nails, lower extremity edema, and oliguria. The scoring system is 0 for absent, 1 for mild, 2 for moderate, and 3 for severe, with a total score ranging from 0 to 21. The lower the score, the less severe the symptoms.

2.5.3. 6-minute walk distance

Select a straight and unobstructed corridor in the department or a dedicated testing room as the venue, arrange patients to conduct the test, the nurse times, and the patient walks until the 6-minute timing is completed.

2.5.4. Cardiac function

Perform echocardiography before and after treatment to check left ventricular ejection fraction (LVEF), left ventricular end-systolic diameter (LVESD), and left ventricular end-diastolic diameter (LVEDD).

2.5.5. Serum indicators

Collect 3 mL of fasting venous blood samples to detect plasma amino-terminal pro-brain natriuretic peptide (NT-proBNP).

2.5.6. Blood glucose indicators

Collect 3 mL of fasting venous blood samples to test fasting blood glucose (Glu) and glycated hemoglobin (HbA1c).

2.6. Statistical methods

The statistical analysis was performed using SPSS 26.0. Categorical variables were presented as percentages (%) and analyzed with the chi-square (χ^2) test. Normally distributed continuous data were reported as mean \pm standard deviation (SD) and compared using the t-test or ANOVA (F-test). A p-value of less than 0.05 was considered statistically significant.

3. Results

3.1. Comparison of general information

The comparison of general information between the two groups is shown in **Table 1**.

Table 1. General information of two groups [n/(mean \pm SD)]

Group	Cases	Male/Female (n)	Age (years)	BMI (kg/m ²)
Study group	60	36/24	63.98 \pm 6.52	25.43 \pm 1.52
Control group	60	33/27	63.21 \pm 6.35	25.18 \pm 1.36
<i>t</i> / χ^2 value	-	0.307	0.655	0.949
<i>P</i> value	-	0.580	0.514	0.344

3.2. Comparison of clinical efficacy

The comparison of clinical efficacy between the two groups is shown in **Table 2**.

Table 2. Clinical efficacy of the two groups (n/%)

Group	Cases	Markedly effective (n)	Effective (n)	Ineffective (n)	Effective rate (%)
Study group	60	38	21	1	98.33
Control group	60	26	27	7	88.33
<i>t</i> / χ^2 value	-	-	-	-	4.821
<i>P</i> value	-	-	-	-	0.028

3.3. Comparison of symptom scores

The comparison of symptom scores between the two groups is shown in **Table 3**.

Table 3. Symptom scores of the two groups (mean \pm SD, score)

Group	Cases	Before treatment	After 1 month	After 2 months	After 3 months
Study group	60	14.98 \pm 1.78	11.04 \pm 1.32	8.02 \pm 1.17	5.43 \pm 1.02
Control group	60	14.62 \pm 1.65	12.54 \pm 1.47	10.15 \pm 1.32	7.45 \pm 1.13
<i>t</i> value	-	1.149	5.881	9.354	10.279
<i>P</i> value	-	0.253	< 0.001	< 0.001	< 0.001

3.4. Comparison of 6-minute walking distance

The comparison of 6-minute walking distance between the two groups is shown in **Table 4**.

Table 4. 6-minute walking distance of the two groups (mean \pm SD, m)

Group	Cases	Before treatment	After 1 month	After 2 months	After 3 months
Study group	60	228.31 \pm 14.16	260.12 \pm 16.75	295.65 \pm 17.82	338.78 \pm 18.71
Control group	60	230.67 \pm 14.58	245.42 \pm 16.42	270.46 \pm 17.35	303.21 \pm 18.46
<i>t</i> value	-	0.899	4.854	7.845	10.483
<i>P</i> value	-	0.370	< 0.001	< 0.001	< 0.001

3.5. Comparison of cardiac function and serum indicators

The comparison of cardiac function and serum indicators between the two groups is shown in **Table 5**.

Table 5. Cardiac function and serum indicators of the two groups (mean \pm SD)

Group	Cases	LVEF (%)		LVESD (mm)		LVEDD (mm)		NT-proBNP (ng/L)	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Study Group	60	34.10 \pm 3.56	52.98 \pm 4.71	52.87 \pm 4.85	40.78 \pm 4.01	63.87 \pm 4.95	47.43 \pm 4.12	1945.23 \pm 356.76	703.12 \pm 180.21
Control Group	60	34.75 \pm 3.77	46.23 \pm 4.35	52.21 \pm 4.70	45.38 \pm 4.35	63.12 \pm 4.80	53.76 \pm 4.35	1921.32 \pm 352.18	998.23 \pm 195.45
<i>t</i> value	-	0.971	8.155	0.757	6.023	0.843	8.184	0.369	8.598
<i>P</i> value	-	0.334	< 0.001	0.451	< 0.001	0.401	< 0.001	0.713	< 0.001

Note: Compared with the same group before treatment, $P < 0.05$.

3.6. Comparison of blood glucose indicators

The comparison of blood glucose indicators between the two groups is shown in **Table 6**.

Table 6. Blood glucose indicators of the two groups (mean \pm SD)

Group	Cases	Glu (mmol/L)		HbA1c (%)	
		Before treatment	After treatment	Before treatment	After treatment
Study group	60	7.99 \pm 1.37	5.65 \pm 0.62	7.40 \pm 1.05	5.32 \pm 0.55
Control group	60	7.67 \pm 1.30	6.11 \pm 0.73	7.65 \pm 1.19	5.89 \pm 0.61
<i>t</i> value	-	1.312	3.720	1.220	5.376
<i>P</i> value	-	0.192	< 0.001	0.225	< 0.001

Note: Compared with the same group before treatment, $P < 0.05$.

4. Discussion

Heart failure is one of the major public health challenges globally, affecting over 37.7 million patients. With the increasing aging population, the burden of heart failure is expected to continue to rise in the coming years ^[6]. Studies ^[7] have indicated that ischemic heart disease is the main cause of heart failure, and ischemic heart failure (IHF) is a common type. Insulin resistance, a typical marker of metabolic disorder and systemic inflammation, has been proven to be significantly associated with atherosclerotic cardiovascular disease and can induce poor prognosis. Insulin resistance plays an important role in the occurrence and progression of IHF. High levels of insulin resistance can increase the risk of heart failure, regardless of whether patients have type 2 diabetes, which is the main reason for the increasing number of patients with IHF and diabetes. In the past, standard treatments for patients with IHF and diabetes were often implemented regarding relevant guidelines and consensus. However, the disease is difficult to cure and prone to relapse. Although standard treatment can alleviate the condition, long-term medication has limited effects and is prone to problems such as drug resistance.

In recent years, Chinese proprietary medicines have been widely used in the treatment of cardiovascular diseases and have achieved good results ^[8]. Musk deer heart-dropping pills are composed of cow bezoar, salvia

miltiorrhiza, and musk, which have the effects of promoting blood circulation to relieve pain, warming yang, and benefiting the heart. They play a positive role in the recovery of cardiovascular diseases ^[9]. This study is a controlled trial where two different treatment regimens were used in the two groups. After treatment, all indicators in the observation group were better, suggesting that the combination of musk deer heart-dropping pills and standard treatment has more practical value. The reason is that IHF and diabetes are mostly induced by insufficient coronary blood supply, myocardial ischemia and hypoxia, and high insulin resistance. Musk deer heart-dropping pills have the effect of promoting blood circulation, which can reduce myocardial ischemia, restore coronary blood supply, improve heart function ^[10], indirectly reduce insulin resistance, and regulate blood glucose levels. Therefore, the combination of standard treatment has a prominent effect.

5. Conclusion

In summary, the combination of musk deer heart-dropping pills and standard treatment can improve the treatment effect of IHF and diabetes, improve clinical symptoms, motor function, heart function, NT-proBNP, and blood glucose.

Disclosure statement

The author declares no conflict of interest.

References

- [1] Huang X, Xu Y, Sun T, et al., 2024, Prognostic Value of Triglyceride-Glucose Index in Patients With Ischemic Heart Failure Complicated With Type 2 Diabetes Mellitus Undergoing Interventional Therapy. *Journal of Cardiovascular and Pulmonary Diseases*, 43(3): 215–221.
- [2] Ni J, 2023, Musk Deer Heart-Dredging Dropping Pills Combined With Western Medicine in Treating 43 Cases of Chronic Ischemic Heart Failure. *Chinese Journal of Traditional Medical Science and Technology*, 30(2): 352–354.
- [3] Chinese Guidelines for the Diagnosis and Treatment of Heart Failure 2014, 2016, Proceedings of the 2016 Academic Conference of the Internal Medicine Branch of the Hubei Medical Association, 94–114.
- [4] Diabetes Basic Prevention and Treatment Expert Guidance Committee of the China Association of Chinese Medicine, 2023, National Guidelines for the Management of Diabetes at the Basic Level of Chinese Medicine (2022). *Chinese Journal of Diabetes*, 15(2): 100–117.
- [5] Quan L, Niu W, Zhao J, et al., 2022, Exploring the Potential Mechanism of Musk Deer Heart-Dredging Dropping Pills in Treating Heart Failure Based on Network Pharmacology. *Chinese Journal of Integrative Medicine on Cardio-/Cerebrovascular Disease*, 20(1): 11–18.
- [6] Zu X, Qu C, Ye M, et al., 2023, Effects of Canagliflozin on Insulin Resistance and Diastolic Function in Elderly Patients With Type 2 Diabetes Mellitus and Heart Failure With Preserved Ejection Fraction, and Cardiovascular Outcomes. *China Medicine*, 18(6): 810–814.
- [7] Yao J, Guo S, Huang M, et al., 2024, Musk Deer Heart-Dredging Dropping Pills Improve Coronary Microvascular Remodeling in Rats With Heart Failure. *Chinese Traditional and Herbal Drugs*, 55(23): 8091–8100.
- [8] Liu Y, Zhang J, Zhang X, et al., 2023, Clinical Observation of Musk Deer Heart-Dredging Dropping Pills Combined With Nicorandil Tablets in the Treatment of Myocardial Ischemia-Reperfusion Injury After PCI. *Journal of Difficult*

and Complex Cases, 22(6): 572–577.

- [9] Feng H, Ma X, Zhao J, 2024, Research Progress on the Mechanism of Musk Deer Heart-Dredging Dropping Pills in Treating Chronic Heart Failure. *Shaanxi Journal of Traditional Chinese Medicine*, 45(3): 424–426.
- [10] Ying X, Jia CL, He H, et al., 2023, Clinical Observation on the Efficacy of Musk Deer Heart-Dredging Dropping Pills Combined With Sacubitril/Valsartan in Patients With Chronic Heart Failure. *Zhejiang Medical Journal*, 45(6): 617–620.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

A Study of Evidence-based Care Combined with Anticipatory Care in Patients Undergoing Cardiovascular Interventions

Yongqiang Sun, Qianshui Zhang, Chaofan Sun, Qinhu Zhang*

Shaanxi Provincial People's Hospital, Xi'an 710000, Shaanxi, China

*Author to whom correspondence should be addressed.

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: *Objective:* To investigate the application value of evidence-based nursing combined with anticipatory nursing in patients undergoing cardiovascular intervention. *Methods:* 68 patients who received percutaneous coronary intervention therapy in the Department of Cardiology of a hospital between May 2024 and April 2025 were selected, and were divided into the control group and the observation group according to the nursing needs, each with 34 cases. The control group was given routine clinical care, and the observation group added evidence-based care combined with anticipatory care on this basis, comparing the pain (VAS), quality of life, incidence of adverse events, and indicators of nursing satisfaction between the two groups under different nursing programs. *Results:* The VAS score of patients in the observation group (4.85 ± 0.63) was lower than that of the control group (6.12 ± 0.56); the somatic function (17.67 ± 3.49), mental health (17.24 ± 5.41), and social function (20.08 ± 2.40) of the observation group were higher than those of the control group (15.48 ± 3.57), (14.55 ± 3.29), (17.08 ± 2.40), (14.55 ± 3.29), and (17.08 ± 2.40). 3.29 points, (17.89 ± 1.43) points, ($P < 0.05$). The complication rate of heart failure, arrhythmia, hypotension and coronary artery occlusion in patients of the observation group was 2.94%, which was significantly lower than that of 23.53% in the control group, and the difference was statistically significant ($P < 0.05$). The nursing satisfaction of patients in the observation group (97.06%) was significantly higher than that of the control group (73.53%), and the difference was statistically significant ($P < 0.05$). *Conclusion:* The implementation of evidence-based nursing combined with anticipatory nursing for cardiovascular interventional therapy patients can effectively improve their pain status, reduce the risk of complications such as heart failure, arrhythmia, hypotension, coronary artery occlusion, and thus further improve their quality of life, which has high clinical application value.

Keywords: Cardiovascular disease; Evidence-based care; Anticipatory care; Interventional therapy; Rehabilitation

Online publication: July 2, 2025

1. Introduction

Cardiovascular diseases, with their high morbidity and mortality rates, continue to threaten global human

health, and cardiovascular interventional techniques, such as coronary intervention (PCI), have become a key means of saving patients' lives and improving their prognosis due to their minimally invasive and highly effective advantages ^[1]. However, the high risk of complications such as heart failure, arrhythmia, hypotension, and coronary artery occlusion accompanying the procedure itself and in the perioperative period poses a serious challenge to nursing care. Traditional care models tend to focus on responding to problems that have already occurred, with limitations in proactively preventing complications and optimizing patient experience and long-term prognosis. In this context, Evidence-Based Nursing (EBN) emphasizes the integration of the best current scientific evidence, nurses' professional skills, and patients' values and wishes to provide a scientific cornerstone for clinical decision-making ^[2]; while Predictive Nursing (PN) focuses on early identification and accurate prognosis of patients' condition evolution and potential risks. Predictive Nursing (PN), on the other hand, focuses on the early identification and precise prediction of the evolution of the patient's condition and potential risks, and the proactive implementation of interventions to prevent adverse outcomes. The in-depth combination of the two, in essence, is to move forward the active intervention under the guidance of scientific evidence, to form a strong synergy of "evidence-based foresight", which can not only significantly enhance the scientific and targeted nursing measures, but also effectively break the limitations of passive response, and realize the transition from "treating the disease" to "preventing the disease." It can also effectively break the limitations of passive response and realize the upgrade of nursing care from "treating the disease" to "preventing the disease" ^[3]. This study aims to explore the application value of evidence-based care combined with the anticipatory care model in cardiovascular interventional therapy patients through clinical trials, hoping to provide a new evidence-based practice path for optimizing the cardiovascular interventional nursing program, reducing the incidence of related complications and accelerating the recovery process of patients.

2. Information and methods

2.1. General information

Sixty-eight patients who underwent percutaneous coronary intervention in the Department of Cardiology of a hospital between May 2024 and April 2025 were selected, and were divided into a control group and an observation group of 34 cases each according to nursing needs. In the control group, there were 19 males and 15 females with an age range of 16–75 years old and a mean of (64.26 ± 3.27) years old; in the observation group, there were 21 males and 13 females with an age range of 15–75 years old and a mean age of (65.39 ± 3.75) years old. The study was approved by the Ethics Committee and the general information of the patients was not statistically significant ($p > 0.05$).

Inclusion criteria: (1) diagnosed with coronary artery disease by coronary angiography, receiving percutaneous coronary intervention for the first time, and the vital signs were stable 24 hours after the procedure without acute complications; (2) $15 \text{ years old} \leq \text{age} \leq 75 \text{ years old}$; (3) conscious, with basic language comprehension, able to cooperate with the nursing measures and evaluation of the effect; (4) voluntarily signing the informed consent for the study, and committing to completing the full follow-up.

Exclusion criteria: (1) the presence of end-stage hepatic or renal insufficiency, malignant tumors, and immune system disorders; (2) those who have been diagnosed with Alzheimer's disease, schizophrenia, major depression, and other disorders that affect adherence to care; (3) those who have received prior coronary artery bypass grafting (CABG) or secondary PCI; and (4) women who are pregnant or lactating.

1.2 Methodology

The control group implements conventional nursing interventions and gives basic medical support and health management.

- (1) Basic nursing care: Postoperative dynamic monitoring of patients' vital signs, including heart rate, blood pressure, respiration, body temperature, and other core indicators. At the same time, an individualized nutritional intervention program is implemented, dietary structure is adjusted according to the disease state, and oral hygiene and skin care are strengthened to maintain basic physiological homeostasis.
- (2) Health education: Teaching patients and caregivers the pathological mechanisms of cardiovascular disease, treatment principles and self-management strategies through structured educational pathways, and distributing standardized health manuals to strengthen patients' and family members' practical skills such as symptom recognition, emergency treatment and rehabilitation training, so as to enhance health decision-making ability.
- (3) Psychological support: Adoption of emotional scales to assess psychological status and implementation of cognitive behavioral interventions to alleviate treatment-related anxiety. At the same time, a cooperative psychological support system for family members is established to enhance the effectiveness of family members' emotional support through communication skills training and to improve the level of patients' psychological adaptation.
- (4) Drug management: Strictly follow the doctor's instructions to implement the drug administration program, monitor drug efficacy and adverse drug reactions, and adjust the drug regimen when necessary. At the same time, we carry out pharmacy education programs to analyze the mechanism of drug action, medication standardization and risk warning indicators, so as to ensure the safety and compliance of medication.
- (5) Discharge guidance: Individualized discharge plan is formulated, and detailed discharge guidance is given to patients before discharge, including drug use plan, lifestyle intervention suggestions, follow-up pathway and emergency response process. At the same time, we strengthen the family care ability through scenario simulation training to realize the seamless integration of in-hospital and family care.

The observation group carried out evidence-based care combined with anticipatory care based on the control group, which included:

- (1) Evidence-based nursing: An individualized nursing program is developed based on patients' postoperative vital signs status. Dynamic optimization of drug selection, nutrition and metabolism support in nursing management, and assessment of patients' physiological and psychological status through the construction of a quantitative assessment system of physiological parameters + psychological scales, and implementation of precise nursing interventions to ensure the safety and effectiveness of nursing care.
- (2) Anticipatory nursing: Identify high-risk factors through risk prediction models and establish preventive interventions. At the same time, we utilize digital health media to carry out stratified education, empowering patients with early warning and self-palliative abilities.
- (3) Interdisciplinary teamwork: Establishing an integrated care model (ICM) through close collaboration of a multidisciplinary team, realizing multidimensional data sharing among physicians, pharmacists, and rehabilitators with the electronic medical record as the pivot, and formulating interprofessional intervention plans through a case conference system to ensure continuity of care throughout the cycle.

- (4) Post-discharge follow-up: Regularly follow up patients by phone or WeChat group and provide continuous care guidance, forming a closed-loop management system of “monitoring-feedback-optimization” to ensure patients’ long-term health.

2.3. Observation indicators

- (1) Pain level: The patients’ pain level was assessed using the Pain Visual Analog Scale (VAS) with a total score of 10, with higher scores indicating more severe pain;
- (2) Quality of life: Patients’ somatic functioning, mental health, and social functioning were quantitatively assessed using the Quality of Life Scale (WHOQOL-BREF), with a total score of 25 for each dimension, with higher scores indicating better quality of life for patients;
- (3) Incidence rate of related complications: Observe and record the occurrence of heart failure, arrhythmia, hypotension, coronary artery occlusion and other complications during the treatment of the two groups, incidence rate = number of cases/total number of cases \times 100%;
- (4) Nursing satisfaction: The hospital’s satisfaction questionnaire was used to investigate the nursing staff’s satisfaction with the nursing operation, health education, nurse-patient communication, etc. The patients ticked the boxes of very satisfied, more satisfied or dissatisfied according to their inner real feelings, and the total satisfaction = number of cases (very satisfied + more satisfied)/total number of cases \times 100%.

2.4. Statistical methods

The data were statistically analyzed using SPSS 22.0 software, and the count data were expressed as % and compared with χ^2 test, and the measure data were expressed as mean \pm standard deviation (SD) and compared with t -test, and the difference of $P < 0.05$ was considered statistically significant.

3. Results

3.1. Comparison of VAS scores and quality of life WHOQOL-BREF scores between the two groups of patients

The VAS score of patients in the observation group was lower than that of the control group, and the quality of life scores of somatic function, mental health, and social function were higher than that of the control group, and the difference was statistically significant ($P < 0.05$), as shown in **Table 1**.

Table 1. Comparison of VAS scores and quality of life scores between the two groups after nursing intervention (mean \pm SD, points)

Groups	VAS	Quality of life WHOQOL-BREF score		
		Body function	Mental health	Social function
Control group ($n = 34$)	6.12 \pm 0.56	15.48 \pm 3.57	14.55 \pm 3.29	17.89 \pm 1.43
Observation group ($n = 34$)	4.85 \pm 0.63	17.67 \pm 3.49	17.24 \pm 5.41	20.08 \pm 2.40
t	8.7854	2.5578	2.4772	4.5541
p	< 0.001	0.0128	0.0158	< 0.001

3.2. Comparison of the incidence of relevant complications between the two groups

The complication rates of heart failure, arrhythmia, hypotension and coronary artery occlusion in patients of the observation group were significantly lower than those of the control group, and the difference was statistically significant ($P < 0.05$), see **Table 2**.

Table 2. Comparison of the incidence of related complications between the two groups (n, %)

Groups	Heart failure	Arrhythmia	Low blood pressure	Coronary occlusion	Gross
Control group (n = 34)	1 (2.94)	3 (8.82)	3 (8.82)	1 (2.94)	8 (23.53)
Observation group (n = 34)	0	0	1 (2.94)	0	1 (2.94)
χ^2					4.610
<i>p</i>					0.032

3.3. Comparison of nursing satisfaction between the two groups

The patient care satisfaction (%) of the observation group was significantly higher than that of the control group (%), and the difference was statistically significant ($P < 0.05$), see **Table 3**.

Table 3. Comparison of nursing care satisfaction between the two groups (n, %)

Groups	Very happy	More satisfied	Unsatisfactory	Job satisfaction
Control group (n = 34)	11 (32.35)	14 (41.18)	9 (26.47)	25 (73.53)
Observation group (n = 34)	20 (58.82)	13 (38.24)	1 (2.94)	33 (97.06)
χ^2				7.503
<i>p</i>				0.006

4. Discussion

Cardiovascular disease (CVD) is one of the major causes of death worldwide, and its morbidity and mortality rates have remained high, becoming a major global public health problem ^[4]. With the continuous development of medical technology, cardiovascular interventional therapy has become one of the core diagnostic and therapeutic tools for CVD, such as coronary heart disease, by its minimally invasive characteristics and the advantages of rapid postoperative recovery. However, the complexity of this technology, the individual variability of patients, and the high risk of potential complications in the perioperative period have put forward higher requirements for nursing practice. Nursing staff need to balance intraoperative immediate response monitoring with postoperative long-term rehabilitation management in patient care management to optimize patient prognostic outcomes ^[5].

Evidence-based nursing (EBN) is based on the best current research evidence, integrates nursing expertise with individualized patient needs and wishes, and provides a reliable basis for decision-making in complex clinical situations, which significantly improves the science and efficacy of nursing practice. Xi (2022) ^[6] explored the impact of evidence-based nursing on postoperative complications in patients undergoing cardiovascular interventions through a clinical trial, and found that the implementation of evidence-based nursing in patients undergoing cardiovascular interventions significantly reduced the incidence of postoperative

complications such as bleeding from the puncture site, hematomas, and vagal nerve reflexes, and effectively enhanced the perioperative safety of the patients and the quality of care. Yang *et al.* (2022) ^[7] found that the application of evidence-based nursing in the perioperative management of patients undergoing percutaneous coronary intervention in cardiovascular medicine can effectively reduce patients' anxiety and depression, shorten hospitalization time, and improve patients' knowledge of the disease and adherence to treatment. Anticipatory nursing (AN), on the other hand, focuses on the dynamic assessment and early warning of the trajectory of patients' disease evolution and potential risks, emphasizes proactive intervention instead of reactive response, and has outstanding advantages in identifying high-risk groups and preventive management of complications such as hypotension or bleeding. Li (2020) ^[8] found through clinical practice research that the implementation of anticipatory nursing interventions such as risk assessment, rehydration and expansion, and psychological counseling for elderly patients undergoing cardiovascular interventional therapy can effectively reduce the incidence of postoperative reflex hypotension and mitigate the severity of its episodes. Hao (2024) ^[9] pointed out that for patients prone to postoperative reflex hypotension after cardiovascular interventions, early identification of risk factors, development of individualized prevention programs and dynamic monitoring can significantly reduce hypotensive events and improve the hemodynamic stability of the patient, which can help to shorten the length of hospital stay. However, many current studies are limited to the application of a single nursing model, failing to fully integrate the scientific decision-making core of EBN and the risk prevention and control essence of AN to form a systematic, structured and comprehensive intervention system, which restricts the release of nursing's potential to comprehensively improve the quality, safety and long-term prognosis of cardiovascular interventional patient care.

In this study, through the joint use of evidence-based care and anticipatory care model to implement the nursing management of cardiovascular interventional therapy patients, it was found that the patients in the observation group had lower VAS scores and lower incidence of related complications than those in the control group ($P < 0.05$), while the patients' quality of life scores of physical function, mental health, social function and nursing satisfaction were significantly higher than those in the control group ($P < 0.05$). The reasons were attributed to the significant advantages of the joint nursing program: first, the scientific decision-making core of evidence-based nursing and the risk forward concept of anticipatory nursing were deeply integrated to realize the early warning of high-risk factors, and the two synergistically formed the closed-loop management of "evidence-guided practice, early warning-driven intervention," which reduced the occurrence rate of preventable complications from the source. The two collaborate to form a closed-loop management of "evidence-guided practice and early warning-driven intervention," reducing preventable complications at the source.

Secondly, this joint care model breaks through the limitations of traditional passive response and builds a proactive care pathway of "assessment-prediction-intervention." This dynamically adapted intervention strategy significantly improved patients' pain perception, accelerated functional recovery, and ultimately helped patients achieve simultaneous improvement of physiological indicators and psychological status ^[10].

Third, in the practice of evidence-based care and anticipatory care, evidence-based care ensures the scientific articulation of interventions at all stages of the patient care cycle, and anticipatory care realizes the seamless transition of the nursing focus through continuous risk monitoring, and the structural integration of the two not only reduces the blind spot of nursing care, but also comprehensively improves the patient's somatic function, social role adaptation, and subjective satisfaction through the design of systematic and standardized

processes, and finally the result is a multi-dimensional optimization of healthcare quality, safety and experience.

5. Conclusion

In summary, the clinical effect of evidence-based nursing combined with anticipatory nursing intervention for cardiovascular interventional therapy patients is remarkable, and it has positive clinical value in improving patients' pain, enhancing their quality of life, and reducing the risk of related complications.

Disclosure statement

The authors declare no conflict of interest.

References

- [1] She S, Hu Y, Shi L, et al., 2025, Research on the Application of Evidence-Based Care Combined with Anticipatory Care in Patients Undergoing Cardiovascular Intervention. *Journal of Chronic Disease*, 26(5): 770–772 + 776.
- [2] Han D, 2023, Application Effect of Anticipatory Care in Patients with Reflex Hypotension Caused by Cardiovascular Disease Intervention. *Cardiovascular Disease Prevention and Control Knowledge*, 13(2): 61–63.
- [3] Wang Y, 2022, Evidence-Based Nursing in Patients Undergoing Percutaneous Coronary Intervention—A Review of Clinical Nursing Thinking and Practice in Cardiovascular Disease. *China Medical Equipment*, 19(3): 205–206.
- [4] Zheng A, 2021, Study on the Preventive Effect of Anticipatory Nursing on the Occurrence of Reflex Hypotension in Elderly Patients Undergoing Cardiovascular Intervention. *Electronic Journal of Integrated Cardiovascular Disease of Chinese and Western Medicine*, 9(3): 157–159.
- [5] Wang T, 2020, Analysis of the Application Effect of Evidence-Based Nursing Administered in the Perioperative Period of Cardiovascular Disease Intervention. *China Community Physician*, 36(23): 153–154.
- [6] Xi H, 2022, Effect of Evidence-Based Nursing on Postoperative Complications in Patients Undergoing Interventional Therapy for Cardiovascular Disease. *Electronic Journal of Integrated Cardiovascular Disease of Chinese and Western Medicine*, 10(36): 113–116.
- [7] Yang F, Zhang X, Zhang Y, et al., 2022, Clinical Application of Evidence-Based Nursing in the Perioperative Period of Patients Undergoing Percutaneous Coronary Intervention in Cardiovascular Medicine. *Electronic Journal of Integrated Cardiovascular Disease of Chinese and Western Medicine*, 10(31): 10–13.
- [8] Li X, 2020, Preventive Effect of Anticipatory Care on the Occurrence of Reflex Hypotension in Elderly Patients Undergoing Cardiovascular Intervention. *Tibetan Medicine*, 41(2): 110–112.
- [9] Hao W, Han J, Xu M, et al., 2024, Analyzing the Application Significance of Anticipatory Care to Patients with Reflex Hypotension Caused by Cardiovascular Disease Intervention. *Proceedings of the Fifth National Pharmaceutical Research Forum (II)*, Yulin Medical Association: 6.
- [10] Xia L, 2019, Impact of Anticipatory Care Combined with Evidence-Based Care on Quality of Care and Satisfaction in the Operating Room. *Electronic Journal of Practical Clinical Nursing*, 4(52): 130.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Analysis and Research on the Effect of Isosorbide Mononitrate Combined with Nicorandil in the Treatment of Myocardial Ischemia in Coronary Heart Disease

Tianyu Zhou*

Hailun People's Hospital, Heilongjiang Province, Hailun 152300, Heilongjiang, China

**Author to whom correspondence should be addressed.*

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Objective: To study the efficacy of isosorbide mononitrate combined with nicorandil in the treatment of myocardial ischemia in coronary heart disease. Methods: 100 patients with myocardial ischemia due to coronary heart disease who visited our hospital from January 2022 to January 2025 were selected as samples and randomly divided into two groups. Group A received isosorbide mononitrate combined with nicorandil, while Group B received isosorbide mononitrate only. The efficacy, electrocardiogram, cardiac function, and complications were compared between the two groups. Results: The efficacy of Group A was higher than that of Group B ($P < 0.05$). The electrocardiogram indicators of Group A were better than those of Group B ($P < 0.05$). The cardiac function indicators of Group A were better than those of Group B ($P < 0.05$). The complication rate of Group A was lower than that of Group B ($P < 0.05$). Conclusion: The combination of isosorbide mononitrate and nicorandil in the treatment of myocardial ischemia in coronary heart disease can improve cardiac function, reduce myocardial ischemia load, and is safe and efficient.

Keywords: Myocardial ischemia in coronary heart disease; Nicorandil; Isosorbide mononitrate; Efficacy

Online publication: July 2, 2025

1. Introduction

Coronary heart disease is caused by partial or complete blockage of blood vessels due to coronary atherosclerotic plaques, which can lead to insufficient blood and oxygen supply and necrosis of the myocardium over time. It has a certain mortality rate. Some patients with myocardial ischemia due to coronary heart disease choose surgical treatment, but cardiac surgery has high risks, high costs, and difficulties in promotion. With the deepening of clinical research on the treatment of coronary heart disease, there are various types of anti-myocardial ischemia drugs available, and the number of patients choosing drugs such as isosorbide mononitrate and nicorandil for treatment has increased. Isosorbide mononitrate is administered intravenously to rapidly stimulate blood vessel

dilation and correct myocardial ischemia, but its effect on improving cardiac function is limited when used as a single drug. Nicorandil is administered orally and can reduce coronary artery spasms, improve coronary blood flow, and has a low impact on blood pressure and heart rate when used long-term ^[1]. Based on this, this article explores the efficacy of isosorbide mononitrate combined with nicorandil using 100 patients with myocardial ischemia due to coronary heart disease who visited our hospital from January 2022 to January 2025 as samples.

2. Materials and methods

2.1. Materials

100 patients with myocardial ischemia due to coronary heart disease who visited our hospital from January 2022 to January 2025 were selected as samples and randomly divided into two groups. There was no statistically significant difference in baseline data between Group A and Group B ($P > 0.05$) (**Table 1**).

Table 1. Information on myocardial ischemia in coronary heart disease

Group	<i>n</i>	Gender (%)		Age (years)		Duration of illness (months)	
		Male	Female	Range	Mean	Range	Mean
Group A	50	21 (42.00)	29 (58.00)	41–79	63.82 ± 2.15	11–27	18.42 ± 1.88
Group B	50	22 (44.00)	28 (56.00)	41–78	63.79 ± 2.13	11–28	18.39 ± 1.92
χ^2/t	-	0.0408		0.0701		0.0789	
<i>P</i>	-	0.8399		0.9443		0.9372	

2.2. Inclusion and exclusion criteria

Inclusion criteria: (1) Coronary angiography indicating moderate stenosis of coronary arteries (stenosis degree < 70%); (2) Signed informed consent; (3) ECG results showing ST segment depression of 0.1 mV.

Exclusion criteria: (1) Clear surgical indication; (2) Psychiatric diseases; (3) Taking medications that may affect myocardial blood supply before enrollment.

2.3. Treatment methods

Observation group: Intravenous infusion of isosorbide mononitrate injection, single dose of 20 mg, once per day; oral administration of nicorandil tablets, single dose of 5 mg, twice per day. The medication was administered for 2 weeks.

Control group: Intravenous infusion of isosorbide mononitrate injection, single dose of 20 mg, once per day. The medication was administered for 2 weeks.

2.4. Observation indicators

- (1) Curative effect: increased exercise tolerance, ECG prompted exercise/resting ST segment recovery \geq (1) mV in clinical treatment, marked as effective; improved exercise tolerance, ECG prompted ST segment recovery, but did not meet the health standards, marked as valid; unable to perform normal activities, ECG did not improve, marked as invalid.
- (2) ECG: Record the number of ST segment depressions and myocardial ischemia load.
- (3) Cardiac function: Color Doppler ultrasound was used to record cardiac output, cardiac output index, stroke volume, and left ejection fraction.

(4) Complications: Record the incidence of angina pectoris, arrhythmia, and heart failure.

2.5. Statistical analysis

SPSS 23.0 was used to process the data. Count data were described using percentages (%) and analyzed using the chi-square test (χ^2 test). Measurement data were described using mean \pm standard deviation (SD) and analyzed using the t-test. Statistical differences were considered significant at $P < 0.05$.

3. Results

3.1. Efficacy

The efficacy of group A was higher than that of group B, with $P < 0.05$ (Table 2).

Table 2. Efficacy of coronary heart disease with myocardial ischemia (n, %)

Group	Markedly effective	Effective	Ineffective	Effective rate
Group A ($n = 50$)	38 (72.00)	11 (22.00)	1 (2.00)	49 (98.00)
Group B ($n = 50$)	30 (60.00)	13 (26.00)	7 (14.00)	43 (86.00)
χ^2	-	-	-	4.8913
P	-	-	-	0.0270

3.2. ECG

After medication, the ECG indicators of group A were better than those of group B, with $P < 0.05$ (Table 3).

Table 3. ECG indicators of coronary heart disease with myocardial ischemia (mean \pm SD)

Group	ST-segment depression frequency (times/h)		Myocardial ischemia load (mm·min)	
	Before medication	After medication	Before medication	After medication
Group A ($n = 50$)	7.19 \pm 0.81	2.01 \pm 0.11	84.15 \pm 6.82	25.41 \pm 4.26
Group B ($n = 50$)	7.21 \pm 0.79	3.72 \pm 0.49	84.16 \pm 6.79	43.99 \pm 5.81
t	0.1250	24.0773	0.0073	18.2361
P	0.9008	0.0000	0.9942	0.0000

3.3. Cardiac function

After medication, the cardiac function indicators of group A were better than those of group B, with $P < 0.05$ (Table 4).

Table 4. Cardiac function indicators of coronary heart disease with myocardial ischemia (mean \pm SD)

Group	Cardiac output (L/min)		Cardiac index (L/min·m ²)		Stroke volume (mL)		Left ejection fraction (%)	
	Before	After	Before	After	Before	After	Before	After
Group A ($n = 50$)	2.79 \pm 0.46	4.17 \pm 0.26	1.81 \pm 0.25	2.57 \pm 0.44	44.06 \pm 2.41	58.61 \pm 4.19	44.16 \pm 2.18	54.29 \pm 3.81
Group B ($n = 50$)	2.81 \pm 0.51	3.39 \pm 0.37	1.83 \pm 0.24	2.14 \pm 0.31	44.09 \pm 2.39	50.36 \pm 3.87	44.19 \pm 2.21	48.61 \pm 3.22
t	0.2059	12.1964	0.4081	5.6491	0.0625	10.2277	0.0683	8.0514
P	0.8373	0.0000	0.6841	0.0000	0.9503	0.0000	0.9457	0.0000

3.4. Complications

The complication rate of group A was lower than that of group B, with $P < 0.05$ (**Table 5**).

Table 5. Complications of coronary heart disease with myocardial ischemia (n, %)

Group	Angina pectoris	Arrhythmia	Heart failure	Incidence rate
Group A ($n = 50$)	0 (0.00)	1 (2.00)	0 (0.00)	1 (2.00)
Group B ($n = 50$)	1 (2.00)	3 (6.00)	3 (6.00)	7 (14.00)
χ^2	-	-	-	4.8913
P	-	-	-	0.0270

4. Discussion

The pathological features of coronary heart disease mainly include coronary stenosis, which cannot provide sufficient blood to the heart, leading to reduced heart perfusion and myocardial metabolic disorders, which can induce a series of diseases^[2]. Analyzing the common risk factors for myocardial ischemia in coronary heart disease, abnormally elevated blood pressure increases myocardial load, which can exacerbate coronary atherosclerosis; elevated blood lipids and blood glucose damage vascular endothelium, which can cause a large number of plaques to form in coronary arteries; long-term smoking stimulates vascular endothelium with nicotine, which can accelerate endothelial damage and increase thrombus production; and those with a family history of heart disease have a higher risk of developing myocardial ischemia in coronary heart disease. Further analysis of the pathological mechanism of myocardial ischemia in coronary heart disease is related to platelet aggregation and inflammatory stimulation, damaging the vascular endothelium, leading to exacerbated arteriosclerosis; it is also related to massive lipid deposition under the influence of multiple factors, generating coronary plaques and blocking coronary blood vessels to cause the disease.

After the occurrence of myocardial ischemia in coronary heart disease, the common symptom is chest pain, clinically known as angina pectoris, accompanied by a sense of urgency and oppression, and severe pain during disease attacks, involving the left arm, left shoulder, and back. The pain intensifies during overeating, emotional distress, and overexertion. Some patients experience relief after rest or sublingual administration of nitroglycerin. As the course of myocardial ischemia in coronary heart disease progresses, patients develop symptoms of dyspnea after activity, and even shortness of breath at rest. In severe cases, there is insufficient blood supply to the whole body, which can lead to symptoms such as palpitations, dizziness, and fatigue due to myocardial ischemia. After the onset of myocardial ischemia in some patients with coronary heart disease, there is excessive concern about secondary acute myocardial infarction, which can easily lead to severe anxiety and depression. Therefore, medication should be started as early as possible to restore coronary blood perfusion and optimize vascular function^[3].

Isosorbide mononitrate is a nitrate ester drug that stimulates coronary dilation and smooth muscle relaxation, which can restore normal myocardial blood perfusion and help reduce the occurrence of angina pectoris. Additionally, intravenous infusion of isosorbide mononitrate can regulate venous system function, reduce blood return, and reduce left ventricular pressure, resulting in reduced venous circulation resistance and increased cardiac output^[4]. However, during actual drug treatment for myocardial ischemia in coronary heart disease, a few patients experience symptoms such as orthostatic hypotension, dizziness, and headache, and even develop

resistance to nitrate ester drugs, affecting the effectiveness of coronary heart disease management. Nicorandil has a chemical structure similar to traditional nitrate ester drugs, but it belongs to a combined efficacy agent. After oral administration, it can exhibit the pharmacological effects of nitrate ester drugs and potassium ion opening. Taking nicorandil reasonably as prescribed can improve the body's hemodynamic indicators, reduce ventricular volume, and reduce coronary resistance, which is beneficial for stabilizing coronary blood flow. Long-term medication does not affect heart rate and has high safety; it can also expand potassium ion channels, accelerate the efflux of potassium ions from cells, thereby relaxing vascular smooth muscle and protecting the vascular endothelium; it can also improve coronary blood flow, restore coronary vascular filling, and reduce the occurrence of angina pectoris ^[5].

Based on the data analysis in this article, the efficacy of coronary heart disease and myocardial ischemia treatment in Group A is higher than that in Group B, with $P < 0.05$. The reason for this is the combined therapy with nicorandil. The active ingredients of the medication target intracellular guanylate cyclase, enhancing its enzymatic activity. This leads to an increase in cyclic guanosine monophosphate (cGMP) levels in the patient's body, which subsequently reduces intracellular calcium ions. This exerts multiple effects such as expanding coronary arteries, relaxing smooth muscles, stimulating vasodilation, and improving microvascular circulation. Consequently, myocardial oxygen consumption decreases while myocardial oxygen supply increases, benefiting the improvement of stress responses caused by myocardial ischemia and the repair of vascular endothelial damage due to coronary artery blockage, thereby enhancing myocardial function. Additionally, when combined with isosorbide mononitrate, it rapidly alleviates patient symptoms and restores exercise tolerance, exhibiting excellent efficacy ^[6].

Another set of data indicates that the electrocardiographic indicators of Group A are superior to those of Group B, with $P < 0.05$. The reason for this is that changes in the ST segment observed during electrocardiographic examination serve as a basis for physicians to analyze the degree of myocardial ischemia in patients. If the myocardial blood supply is inadequate, it affects myocardial electrical activity, manifesting as ST-segment depression. The degree of ST-segment depression directly reflects the severity of myocardial ischemia. Myocardial ischemia load is an important indicator for quantitatively analyzing the condition of patients with coronary heart disease. It comprehensively reflects changes in ST-segment depression amplitude, as well as the duration and frequency of single ST-segment depressions. This can predict adverse cardiac events and guide clinical treatment ^[7]. In this article, the nitrate drug isosorbide mononitrate is selected for treatment. After entering the body, it releases large amounts of nitric oxide, which accelerates smooth muscle relaxation by enhancing guanylate cyclase activity. This stimulates vasodilation, reduces cardiac load, and is beneficial for reducing the degree of myocardial ischemia and the occurrence of angina pectoris. Nicorandil can optimize the body's microcirculation state, further regulate myocardial ischemia load, and is conducive to preventing cardiovascular adverse events ^[8].

Another set of data shows that the cardiac function indicators of Group A are better than those of Group B, with $P < 0.05$. The reason for this is that cardiac output, measured in minutes, records the total amount of blood pumped by the heart and objectively reflects heart's pumping function. If myocardial ischemia damages myocardial contractility, it can lead to a decrease in cardiac output, impaired pumping function, and subsequently reduced blood supply to bodily tissues and organs. The cardiac index can also assist physicians in evaluating heart pumping status. This index is directly proportional to heart's pumping function, and values below normal indicate reduced blood supply to peripheral organs and tissues. Stroke volume refers to the amount of blood pumped out per heartbeat, directly reflecting changes in cardiac output. A decrease in this indicator after myocardial ischemia

suggests abnormal heart function. The left ejection fraction provides feedback on ventricular contraction status. In patients with myocardial ischemia, due to reduced heart pumping and weakened myocardial contractility, this indicator decreases. The combination therapy of isosorbide mononitrate and nicorandil in this article stimulates myocardial contraction and corrects myocardial ischemia, thereby increasing the amount of blood pumped by the heart per minute and improving the relationship between the body and various organs and tissues. This is beneficial for improving cardiac output and cardiac index ^[9].

Furthermore, isosorbide mononitrate treatment for coronary heart disease and myocardial ischemia can restore coronary blood flow, reduce myocardial load, and subsequently restore heart pumping capacity. The combination with nicorandil corrects microcirculation disorders, further optimizing myocardial blood supply and improving heart function. These two drugs improve heart function through different mechanisms, rapidly increasing left ventricular ejection fraction, enhancing left ventricular systolic function, and elevating stroke volume. This is conducive to enhancing the efficiency of heart pumping ^[10]. The final set of data demonstrates that the complication rate in Group A is lower than that in Group B, with $P < 0.05$. The reason for this is the combined therapy of isosorbide mononitrate and nicorandil. These two drugs have different mechanisms of action and do not exhibit mutual toxic effects, enabling rapid improvement of heart function safely and efficiently. However, patients with coronary heart disease and myocardial ischemia should reduce their intake of sodium salt and preserved foods while increasing their intake of vitamins and trace elements during medication to meet the body's nutritional needs and reduce oxidative stress responses.

5. Conclusion

Patients with coronary heart disease and myocardial ischemia receiving combined therapy with isosorbide mononitrate and nicorandil can achieve improved heart function, reduced frequency of electrocardiographic ST-segment depression, and decreased severity of myocardial ischemia. This treatment approach holds promise for widespread application.

Disclosure statement

The author declares no conflict of interest.

References

- [1] Zhang L, Liu Y, 2024, Analysis of the Effect of Nicorandil Combined with Isosorbide Mononitrate in the Treatment of Coronary Heart Disease and Angina Pectoris. Chinese and Foreign Medical Research, 3(3): 51–53.
- [2] Chen X, 2022, Clinical Efficacy of Metoprolol Sustained-Release Tablets Combined with Isosorbide Mononitrate Sustained-Release Tablets in the Treatment of Severe Coronary Heart Disease With Myocardial Ischemia. Systems Medicine, 7(17): 102–105.
- [3] Wang C, 2023, Clinical Observation of Nicorandil Combined with Isosorbide Mononitrate in the Treatment of Coronary Heart Disease and Angina Pectoris. Chinese Journal of Modern Drug Application, 17(1): 82–84.
- [4] Zhao W, 2023, Analysis of the Effect of Nicorandil Combined with Isosorbide Mononitrate in the Treatment of Coronary Heart Disease and Angina Pectoris. Chinese Community Doctors, 39(30): 65–67.
- [5] Shan Y, 2021, Efficacy of Nicorandil Combined with Isosorbide Mononitrate in the Treatment of Chronic Heart

Failure Caused by Coronary Heart Disease. *Medical Information*, 34(21): 153–155.

- [6] Guan Y, 2020, Efficacy Analysis of Diltiazem Hydrochloride Tablets Combined with Isosorbide Mononitrate in the Treatment of Patients with Coronary Heart Disease and Angina Pectoris. *Huaxia Medical Journal*, (2): 58–61.
- [7] Gao H, Chen Y, Li P, et al., 2023, Efficacy of Xiangdan Injection Combined with Nicorandil in the Treatment of Stable Exertional Angina Pectoris Caused by Coronary Heart Disease. *Journal of Guizhou Medical University*, 48(8): 986–992.
- [8] Yang X, 2022, Clinical Effect Analysis of Isosorbide Mononitrate in the Treatment of Asymptomatic Myocardial Ischemia Caused by Coronary Heart Disease. *Chinese and Foreign Women's Health Research*, (17): 51–52.
- [9] Cheng M, Wu W, Wang X, et al., 2022, Clinical Effect of Isosorbide Mononitrate Combined With Nicorandil in the Treatment of Unstable Angina Pectoris with Mild to Moderate Stenosis. *Chinese Medical Innovation*, 19(2): 1–5.
- [10] Jia Q, Qi Q, Liu J, 2022, Efficacy of Isosorbide Mononitrate Combined with Salvianolate in Patients With Coronary Heart Disease and Angina Pectoris. *Henan Medical Research*, 31(3): 527–530.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Exploring the Diagnostic Value of Blood Tests Combined with Electrocardiogram and 24-Hour Ambulatory Blood Pressure Monitoring in Primary Hypertension with Myocardial Ischemia

Yana Gao¹, Lang Liu^{2*}

¹School of Clinical Medicine, Xianning Medical College, Hubei University of Science and Technology, Xianning 437000, Hubei, China

²The Second Affiliated Hospital of Hubei University of Science and Technology, Xianning 437000, Hubei, China

**Author to whom correspondence should be addressed.*

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: *Objective:* To evaluate the diagnostic value of blood tests combined with dynamic electrocardiogram (DCG) and 24-hour ambulatory blood pressure monitoring (ABPM) for patients with primary hypertension and myocardial ischemia. *Methods:* 55 patients with primary hypertension and myocardial ischemia who visited our hospital from September 2021 to September 2023 were included in Group A, and 55 healthy individuals who underwent physical examination during the same period were included in Group B. Both groups received blood tests, DCG, and ABPM for diagnosis. *Results:* The blood test indicators, diurnal and nocturnal blood pressure, diurnal and nocturnal heart rate, ST segment depression duration, and ST segment depression were all higher in Group A than in Group B ($P < 0.05$). *Conclusion:* The combination of blood tests, DCG, and ABPM can be used to diagnose primary hypertension with myocardial ischemia. Changes in blood indicators, blood pressure, and electrocardiogram indicators can provide insights into the condition of hypertension with myocardial ischemia, guiding clinical diagnosis.

Keywords: Myocardial ischemia; Primary hypertension; Blood tests; 24-hour ambulatory blood pressure monitoring; Dynamic electrocardiogram

Online publication: July 8, 2025

1. Introduction

Cardiovascular disease is currently the leading cause of death globally^[1]. It is estimated that there are 245 million people with hypertension in China^[2]. Compared to those with normal blood pressure, patients with hypertension have greater blood shear force on their vessel walls, making them more susceptible to damage and increasing the risk of vascular disease. In the early stages of myocardial ischemia, patients often have

no obvious symptoms due to the insidious onset of the disease. However, as the duration of injury increases, once patients experience symptoms such as chest tightness and pain, myocardial ischemia often progresses to angina pectoris, myocardial infarction, and other stages, posing a high risk of death. Therefore, early diagnosis of primary hypertension with myocardial ischemia is crucial. Coronary angiography is the gold standard for diagnosing myocardial ischemia and can screen for early asymptomatic patients. However, it is an invasive diagnostic method with high costs and risks, making it difficult to promote widely. Therefore, exploring noninvasive and efficient diagnostic techniques is essential. Examinations such as blood pressure monitoring and electrocardiogram are low-cost and easy to perform, providing an initial assessment of the patient's condition. DCG can overcome the limitation of short monitoring time in conventional electrocardiograms. Through continuous electrocardiogram monitoring, it can comprehensively reflect myocardial ischemia. ABPM provides information on diurnal and nocturnal changes in systolic and diastolic blood pressure, serving as a basis for physicians to evaluate patients' blood pressure fluctuations. Additionally, myocardial ischemia can cause myocardial damage in patients with primary hypertension, leading to changes in myocardial-specific indicators. Hence, blood tests can aid in the diagnosis of myocardial ischemia. This study aims to investigate the diagnostic value of DCG and ABPM using 55 patients with primary hypertension and myocardial ischemia and 55 healthy individuals as samples from September 2021 to September 2023.

2. Materials and methods

2.1. Materials

55 patients with primary hypertension accompanied by myocardial ischemia who visited between September 2021 and September 2023 were included in Group A; 55 healthy individuals who underwent physical examination during the same period were included in Group B. Baseline data of Group A were compared with those of Group B, with $P > 0.05$. See **Table 1**.

Table 1. Baseline data analysis

Group	<i>n</i>	Gender (%)		Age (years old)		Course of disease (years old)	
		Male	Female	Range	Mean	Range	Mean
Group A	55	30 (54.55)	25 (45.45)	40–74	56.25 ± 3.81	3–16	4.28 ± 1.09
Group B	55	31 (56.36)	24 (43.64)	41–75	56.29 ± 3.79	-	-
χ^2/t	-	0.0368		0.0552		-	
<i>P</i>	-	0.8479		0.9561		-	

2.2. Inclusion and exclusion criteria

Inclusion criteria: (1) Meet the hypertension criteria in the 2017 version of the “Chinese Expert Consensus on the Diagnosis and Treatment of Hypertension in the Elderly”^[31]; (2) Informed consent; (3) Imaging examination suggests myocardial ischemia.

Exclusion criteria: (1) Severe myocardial infarction; (2) Angina pectoris; (3) Presence of a cardiac pacemaker in the body; (4) Secondary hypertension; (5) Abnormal vital signs.

2.3. Methods

Blood test: One day before the test, the subjects were fasted from food and water. The next day, 5 mL blood sample was taken on an empty stomach, centrifuged, and allowed to stand for 15 minutes. The supernatant was taken, and indicators such as CtnT, Mb, CK-MB, and RDW were tested using an automatic biochemical analyzer. During ABPM blood pressure monitoring, a matching cuff was prepared and fixed on the patient's left upper limb, with the lower edge of the cuff preferably 2 cm away from the elbow fossa. Patient comfort was evaluated, and the cuff tightness was adjusted appropriately, with 1–2 fingers inserted into the cuff as appropriate. Blood pressure was monitored every 30 minutes from 8 am to 10 pm, and every hour from 10 pm to 8 am. During DCG monitoring, ECG data were collected under the patient's daily living conditions and daily routine, and the data were summarized using matching software to obtain monitoring results.

2.4. Statistical analysis

SPSS 21.0 was used to process hypertension and myocardial ischemia data. Hypertension and myocardial ischemia count data were recorded as percentages (χ^2 test), and hypertension and myocardial ischemia measurement data were recorded as mean \pm standard deviation (t -test). Comparisons were considered statistically significant at $P < 0.05$.

3. Results

3.1. Comparison of diurnal and nocturnal blood pressure and heart rate

Both diurnal and nocturnal blood pressure and heart rate were higher in Group A than in Group B, with $P < 0.05$. See Table 2.

Table 2. Analysis of diurnal and nocturnal blood pressure and heart rate in patients with hypertension and myocardial ischemia and healthy individuals (mean \pm standard deviation, SD)

Group	SBP (mmHg)		DBP (mmHg)		HR (times/min)	
	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime
Group A($n=55$)	137.52 \pm 2.41	126.88 \pm 1.89	102.44 \pm 1.98	93.11 \pm 1.48	78.41 \pm 2.11	69.25 \pm 1.36
Group B($n=55$)	131.44 \pm 2.25	120.43 \pm 1.42	93.28 \pm 1.42	88.06 \pm 1.25	75.36 \pm 2.06	65.33 \pm 1.07
t	13.6760	20.2345	27.8805	19.3326	7.6706	16.7998
P	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

3.2. Comparison of blood test indicators

Blood test indicators such as CtnT, Mb, CK-MB, and RDW were higher in Group A than in Group B, with $P < 0.05$. See Table 3.

Table 3. Blood test indicators

Group	CtnT (ug/L)	Mb (ug/L)	CK-MB (IU/L)	RDW (%)
Group A (<i>n</i> = 36)	0.06 ± 0.02	64.11 ± 2.69	32.81 ± 1.96	20.53 ± 2.11
Group B (<i>n</i> = 36)	0.02 ± 0.01	32.26 ± 1.85	15.66 ± 1.21	14.61 ± 1.16
<i>t</i>	10.7331	58.5343	44.6729	14.7518
<i>P</i>	0.0000	0.0000	0.0000	0.0000

3.3. Comparison of ECG indicators

ST-segment depression duration and ST-segment depression were higher in Group A than in Group B, with $P < 0.05$. See **Table 4**.

Table 4. Analysis of ECG indicators in patients with hypertension and myocardial ischemia and healthy individuals (mean ± SD)

Group	ST-segment depression time (min)		ST-segment depression (mV)	
	Daytime	Nighttime	Daytime	Nighttime
Group A (<i>n</i> = 55)	2.88 ± 0.79	6.15 ± 1.22	0.22 ± 0.06	0.11 ± 0.03
Group B (<i>n</i> = 55)	1.05 ± 0.52	1.53 ± 1.03	0.11 ± 0.04	0.04 ± 0.01
<i>t</i>	14.3497	21.4592	11.3129	16.4165
<i>P</i>	0.0000	0.0000	0.0000	0.0000

4. Discussion

Hypertension is a common chronic disease among middle-aged and elderly people in China, and it carries a high risk of myocardial ischemia. However, myocardial ischemia often presents with nonspecific symptoms, making diagnosis difficult and potentially affecting patient prognosis. The inducing factors of myocardial ischemia secondary to primary hypertension can be summarized as follows^[4]:

- (1) Myocardial hypertrophy: Persistent elevation of blood pressure can lead to myocardial hypertrophy, increasing the myocardial demand for nutrients and oxygen. If blood perfusion is impeded, myocardial ischemia may occur.
- (2) Coronary artery spasm: Excessively high blood pressure can stimulate spasmodic contraction of the coronary arteries, reducing local blood flow and inducing myocardial ischemia.
- (3) Coronary atherosclerosis: As hypertension progresses, it can damage vascular endothelial cells, leading to the continuous deposition of lipids on the vessel walls. This can result in coronary atherosclerosis and even plaque formation, causing vascular blockage or stenosis, which in turn restricts myocardial blood perfusion.
- (4) High blood viscosity: Abnormal blood pressure can lead to increased blood viscosity, affecting blood circulation and causing or exacerbating myocardial ischemia. Blood tests, including indicators such as CtnT, Mb, CK-MB, and RDW, can assist physicians in initially evaluating the state of myocardial ischemia and guide diagnosis by providing insights through fluctuations in these indicators.

Diagnostic techniques combining DCG and ABPM enable real-time, dynamic display of blood pressure

and heart rate fluctuations. This is beneficial for physicians to assess fluctuations in catecholamine levels in patients, thereby improving the accuracy of myocardial ischemia diagnosis. Additionally, real-time and dynamic monitoring of changes in patient blood pressure, heart rate, and other indicators through DCG and ABPM techniques can provide feedback on disease progression. Dynamic observation of electrocardiogram changes allows for early detection of heart rate abnormalities and arrhythmias. By observing changes in the ST-T segment, physicians can assess the condition of myocardial ischemia, serving as a basis for clinical diagnosis.

During routine electrocardiogram (ECG) examination, only a snapshot of the patient's condition at a specific time point can be obtained for those with primary hypertension and myocardial ischemia. This approach fails to provide a dynamic observation of changes in various indicators, posing a risk of missed diagnosis and limiting the diagnostic results. Changes in human ECG and blood pressure fluctuations exhibit rhythmic characteristics and can be influenced by physiological states, leading to potential deviations in test results at different times. Therefore, in clinical diagnosis, relying solely on data from a specific time point makes it difficult to accurately reflect changes in patients' heart rate and blood pressure. In this paper, we selected DCG+ABPM technology for diagnosis, which allows for the acquisition of 24-hour ECG changes and blood pressure pulsation information. By combining this data with other examination results for comprehensive analysis, it becomes possible to assess the magnitude of blood pressure fluctuations and the degree of myocardial ischemia in patients, which is beneficial for guiding clinical treatment. Additionally, ABPM technology provides a clear representation of diurnal blood pressure variations in patients with primary hypertension, revealing fluctuations that occur during nighttime.

Through DCG diagnosis, it has been found that patients often experience myocardial ischemia in the early morning hours, posing a risk of sudden death. Therefore, strengthening nighttime monitoring, early identification of abnormal heart rate and blood pressure events, and prompt treatment can ensure the safety of diagnosis and treatment for patients with hypertension and myocardial ischemia. Compared to routine clinical spot blood pressure measurements, ABPM offers the following advantages:

- (1) Continuous 24-hour monitoring of blood pressure, capturing numerous blood pressure fluctuation data points and minimizing the influence of occasional factors on blood pressure readings.
- (2) Analysis of monitoring results allows for the recording of average blood pressure values during both waking and sleeping states.
- (3) Continuous dynamic monitoring aids physicians in accurately identifying masked hypertension and white-coat hypertension.
- (4) Recording blood pressure fluctuations over a 24-hour period provides insight into real-life blood pressure changes in patients during their daily routines.
- (5) Measuring nocturnal blood pressure accurately reflects issues such as excessive nocturnal blood pressure dips and nocturnal hypertension.
- (6) Provides an honest representation of blood pressure fluctuation patterns at different times of the day.
- (7) Dynamic evaluation of blood pressure changes not only reflects the effectiveness of antihypertensive treatment but also enables early identification of cardiovascular and cerebrovascular diseases.

Based on the data analysis in this article, Group A with hypertension and myocardial ischemia had higher diurnal and nocturnal blood pressure and heart rate compared to Group B, with $P < 0.05$. The reason for this is that hypertension is an independent risk factor for cardiovascular complications. Utilizing ABPM technology for dynamic observation of blood pressure pulsations can facilitate early detection of abnormal blood pressure. It

can also serve as a basis for physicians to analyze diurnal fluctuations in SBP and DBP indicators, maintaining a steady decline in blood pressure indicators, thereby enhancing blood pressure management effects, reducing the degree of cardiac function impairment, and facilitating the prevention of adverse cardiovascular events ^[5]. Additionally, during medication treatment for patients with primary hypertension, inappropriate medication regimens or dosages can trigger hypotensive events and increase the risk of cerebrovascular disease. Therefore, dynamic monitoring with ABPM technology can evaluate the antihypertensive effect and predict the risk of myocardial ischemia. Some patients with myocardial ischemia may not have obvious symptoms but experience elevated blood pressure during the night. Dynamic blood pressure monitoring can assist physicians in identifying myocardial ischemia and guiding clinical treatment. HR fluctuations can also provide feedback on the condition of primary hypertension, enabling assessment of target organ damage and disease progression. If elevated HR levels are detected in hypertensive patients, it may be related to increased catecholamine levels activating the sympathetic nervous system. Therefore, monitoring changes in HR levels can evaluate hypertension progression. During diagnosis with DCG+ABPM technology, analyzing HR fluctuations and types of arrhythmias can provide feedback on blood pressure fluctuations, resulting in high diagnostic sensitivity ^[6,7].

Furthermore, continuous dynamic monitoring with ABPM can assist physicians in accurately identifying occult hypertension and white coat hypertension. It can also record blood pressure fluctuations within 24 hours, capturing real blood pressure changes in patients' daily lives. Additionally, it can measure nocturnal blood pressure, accurately reflecting issues such as excessive nocturnal blood pressure dips and nocturnal hypertension. Another set of data indicates that blood test indicators such as CtnT, Mb, CK-MB, and RDW were higher in Group A compared to Group B, with $P < 0.05$. The reason for this is that after myocardial ischemia, myocardial metabolism becomes disordered, disrupting cell membrane integrity. As a result, cytosolic free CtnT enters the bloodstream, and the degree of ischemia is directly proportional to the rate of CtnT output from degenerated cardiomyocytes. Within 1-3 hours of myocardial ischemia, Mb rapidly enters the bloodstream through damaged cells, also directly proportional to the degree of ischemia. CK-MB originates from the outer sarcoplasmic layer of cardiomyocytes and rapidly increases within 4-6 hours of myocardial ischemia. RDW is associated with oxidative stress and inflammatory responses, and its elevated levels can affect the heterogeneity of peripheral blood erythrocytes, impacting overall health.

The final set of data shows that ST-segment depression duration and ST-segment depression indicators were higher in Group A patients with hypertension and myocardial ischemia compared to Group B, with $P < 0.05$. This suggests that diagnosis with DCG+ABPM technology can capture transient electrocardiographic changes, reducing the likelihood of missed diagnoses. The reason for this is that fluctuations in electrocardiographic indicators in patients with primary hypertension and myocardial ischemia are related to excessive secretion of catecholamines and corticosteroids in the body. This leads to platelet aggregation, which in turn inhibits fibrinolytic activity and anticoagulant function, resulting in the progression of myocardial ischemia. Diagnosis with DCG + ABPM technology can quickly identify transient myocardial ischemia signals and is highly sensitive to myocardial ischemia symptoms. It can accurately reflect fluctuations in electrocardiographic indicators and diurnal variations in blood pressure, facilitating the prevention and control of myocardial ischemia ^[8,9]. Additionally, the combined diagnosis of blood tests, DCG, and ABPM, simultaneously monitoring blood pressure, heart rate, and blood indicator fluctuations, can precisely predict and identify patient condition fluctuations ^[10].

5. Conclusion

In summary, the diagnosis of primary hypertension with myocardial ischemia using blood tests, DCG, and ABPM technology, combined with observation of diurnal and nocturnal blood pressure, heart rate changes, and electrocardiographic indicator fluctuations, reveals significant differences compared to healthy individuals. This approach can serve as a basis for physicians to diagnose the disease. It is affordable and can be performed in hospitals at various levels, making it valuable for widespread implementation.

Funding

Internal Cultivation Project of Scientific Research Development Fund, Hubei University of Science and Technology (Project No.: 2025-26X08)

Disclosure statement

The authors declare no conflict of interest.

References

- [1] Xu H, Niu L, Wen X, et al., 2023, Observation on the Therapeutic Effect of Acupuncture Combined with Scraping Therapy along Meridians on Primary Hypertension and Its Influence on 24-Hour Ambulatory Blood Pressure. *Shanghai Journal of Acupuncture and Moxibustion*, 42(5): 459–465.
- [2] Zheng L, Zhang Z, Wang X, 2023, Predictive Effectiveness of P-wave Dispersion and Tp-e Interval in Dynamic Electrocardiogram Combined with Blood Pressure Variability on Ventricular Arrhythmia Susceptibility in Patients with Primary Hypertension. *Chinese Journal of Cardiovascular Research*, 21(6): 538–543.
- [3] Professional Committee of Cardio-Cerebrovascular Diseases of China Gerontology and Geriatrics Society, Cardiovascular Physicians Branch of Chinese Medical Doctor Association, 2017, Chinese Expert Consensus on the Diagnosis and Treatment of Hypertension in the Elderly (2017 Edition). *Chinese Journal of Internal Medicine*, 56(11): 885–893.
- [4] Zhou Q, Zuo S, 2022, Study on 24-hour Ambulatory Electrocardiogram and 24-hour Ambulatory Blood Pressure Monitoring Indices in Patients with Hypertension Accompanied by Acute Cerebral Infarction. *Trauma & Critical Care Medicine*, 10(2): 128–130.
- [5] Zheng Y, Wang X, Zhao T, 2023, Analysis of the Clinical Value of 24-hour Ambulatory Blood Pressure Monitoring in the Diagnosis of Newly-onset Hypertension in Young and Middle-aged Patients. *Chinese Scientific Journal Database (Full-text Version) Medicine and Health*, 2023(9): 89–92.
- [6] Liu C, Zhang S, 2022, Evaluation of the Effect of Synchronous Monitoring of 24-hour Ambulatory Electrocardiogram and Ambulatory Blood Pressure in Patients with Gestational Diabetes Mellitus Combined with Gestational Hypertension. *Medical Diet Therapy and Health*, 20(9): 185–188.
- [7] Lou Y, 2021, Application of 24-hour Ambulatory Electrocardiogram Monitoring Combined with Holistic Nursing in Elderly Patients with Latent Myocardial Ischemia. *Medical Equipment*, 34(5): 147–148.
- [8] Yang Y, 2021, Application Value of Dynamic Electrocardiogram in the Diagnosis of Myocardial Ischemia and Arrhythmia in Patients with Primary Hypertension. *Primary Medical Forum*, 25(19): 2772–2773.
- [9] Di X, Gao M, Li J, et al., 2022, Relationship between Ambulatory Blood Pressure Monitoring Indices and Estimated

Glomerular Filtration Rate Abnormalities in Patients with Primary Hypertension. Chinese Journal of Clinical Healthcare, 25(6): 811–814.

- [10] Yang Z, 2023, Application of Synchronous Monitoring of Dynamic Electrocardiogram and Dynamic Blood Pressure in Patients with Primary Hypertension. Chinese Scientific Journal Database (Full-text Version) Medicine and Health, 2023(5): 26–29.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Application and Effect Analysis of Single-port and Multi-port Thoracoscopic Techniques in Lung Cancer Surgery

Zhanquan Ji*, Hongxing Niu, Jingbao Shi, Xueliang Yuan, Junfang Guo

Anyang District Hospital, Puyang 455000, Henan, China

*Corresponding author: Zhanquan Ji, 13837272299@163.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: *Objective:* To evaluate the difference in efficacy between single-port and multi-port thoracoscopic techniques for lung cancer surgery. *Methods:* 82 patients with lung cancer who were admitted to the hospital between February 2023 and February 2025 and underwent lobectomy were selected. They were randomly divided into two groups using a random number table. The experimental group underwent single-port thoracoscopic surgery, while the control group underwent multi-port thoracoscopic surgery. The efficacy and other indicators were compared between the two groups. *Results:* There was no difference in the total effective rate between the two groups ($P > 0.05$). The operation time of the experimental group was longer than that of the control group, and the intraoperative blood loss was less than that of the control group. On days 1 and 3 postoperatively, the pain scores of the experimental group were lower than those of the control group. Two months postoperatively, the short-term quality of life score of the experimental group was higher than that of the control group ($P < 0.05$). *Conclusion:* Performing single-port thoracoscopic surgery for lung cancer patients can reduce intraoperative blood loss, relieve postoperative pain symptoms, and improve short-term quality of life. However, the operation time is longer, and it requires higher technical requirements for the operator.

Keywords: Single-port thoracoscopic technique; Multi-port thoracoscopic technique; Lung cancer surgery; Perioperative indicators; Short-term quality of life

Online publication: July 9, 2025

1. Introduction

Lung cancer is a common malignant tumor of the respiratory system, and its causes include environmental changes, irregular work and rest, and long-term smoking. In the early stages of the disease, patients may not have obvious symptoms, and regular physical examinations are the main means of detecting early lung cancer. Therefore, it is easy to miss the opportunity for early treatment^[1,2]. Surgical operation is a commonly used method for lung cancer, which can remove the lung lobe to eliminate cancer cells and prolong the patient's survival time. Endoscopic technology is a new method for lobectomy, which can accurately perform surgical treatment. At this

stage, both single-port and multi-port thoracoscopy are minimally invasive techniques for lung cancer surgery. The former completes the surgical operation through a single port, while the latter requires two or more small holes. Although their surgical principles are the same, their surgical effects are different. Therefore, this study selected 82 patients with lung cancer to evaluate the effectiveness of single-port and multi-port thoracoscopic surgery.

2. Materials and methods

2.1. General information

Eighty-two patients who underwent lobectomy from February 2023 to February 2025 were selected. They were randomly divided into two groups using a random number table. The experimental group consisted of 41 patients, including 25 males and 16 females, aged between 32 and 82 years old, with a mean age of (52.16 ± 3.74) years old. The tumor diameter ranged from 1.06 to 2.41 centimeters, with a mean diameter of (1.85 ± 0.64) cm. The control group consisted of 41 patients, including 27 males and 14 females, aged between 30 and 84 years old, with a mean age of (52.35 ± 3.70) years old. The tumor diameter ranged from 1.01 to 2.45 cm, with a mean diameter of (1.91 ± 0.69) cm. There was no significant difference in data between the two groups ($P > 0.05$).

Inclusion criteria: (1) Diagnosed with lung cancer after percutaneous lung biopsy before surgery; (2) Met the indications for lobectomy; (3) Met the indications for endoscopic treatment; (4) Able to tolerate surgical treatment; informed consent for the study.

Exclusion criteria: (1) History of thoracic surgery; (2) Communication disorders; (3) Abnormal heart, liver, and kidney function; (4) Distant metastasis of the lesion; mental illness; (5) Withdrawal in the middle of the study.

2.2. Methods

The control group underwent multi-port thoracoscopic surgery: general anesthesia was administered, and patients were positioned in a lateral decubitus position. An incision of 1 cm was made between the 7th and 8th ribs in the axillary midline region, serving as the observation port for the thoracoscope. Another incision of 3 to 4 cm was made between the 4th ribs in the anterior axillary line region, serving as the main operating port. A 1 cm incision was made between the 6th ribs in the posterior axillary line region, serving as the auxiliary operating port. The thoracoscope was inserted into the chest cavity at a 30° angle, and wedge resection was performed to appropriately remove the lesion. Intraoperative pathological examination was conducted, and lobectomy was performed if lung cancer was confirmed. An ultrasonic knife was used to clean the lymph nodes and stop bleeding quickly. After ensuring no bleeding, a drainage tube was placed in the observation port.

The experimental group underwent single-port thoracoscopic surgery. After anesthesia, patients were positioned in a lateral decubitus position. An incision of 3 to 4 cm was made between the 4th ribs in the anterior axillary region, and the thoracoscope was placed at a 30° angle to fully explore the lung cancer lesion. After locating the lesion, endoscopic staplers were used to perform wedge resection of the lesion tissue. Lobectomy was performed after pathological confirmation, followed by subsequent operations similar to the control group.

2.3. Observation indicators

- (1) Perioperative indicators: Observe multiple indicators such as operation time and hospital stay.
- (2) Pain score: Use the Visual Analog Scale (VAS) to evaluate pain before surgery, 1 day and 3 days after surgery. The score ranges from 0 to 10, with a higher score indicating greater pain.
- (3) Short-term quality of life score: Use the Functional Assessment of Cancer Therapy-Lung (FACT-L) scale,

which includes daily activities (7 items), social/family life (7 items), emotions (6 items), and physical ability (7 items). Each item is scored from 0 to 4, with a higher score indicating a better short-term quality of life.

2.4. Statistical analysis

Data processing was performed using SPSS 28.0 software. Measurement values were compared and tested using t-values, while count values were compared and tested using chi-square values. The criterion for statistical significance was set at $P < 0.05$.

3. Results

3.1. Comparison of perioperative indicators between the two groups

The operation time of the experimental group was longer than that of the control group, while the intraoperative blood loss was less ($P < 0.05$). There were no differences in other perioperative indicators between the two groups ($P > 0.05$) (Table 1).

Table 1. Comparison of perioperative indicators between the two groups [mean \pm standard deviation (SD)]

Group	<i>n</i>	Operative time (min)	Intraoperative blood loss (mL)	Drain retention duration (days)	Hospital stay (days)	Lymph nodes dissected (<i>n</i>)
Test group	41	137.53 \pm 8.65	671.59 \pm 18.52	3.54 \pm 0.77	7.21 \pm 1.39	14.53 \pm 2.54
Control group	41	122.05 \pm 8.32	742.68 \pm 19.04	3.71 \pm 0.82	7.28 \pm 1.43	15.01 \pm 2.63
<i>t</i> -value		8.259	17.138	0.968	0.225	0.841
<i>P</i> -value		< 0.001	< 0.001	0.336	0.823	0.403

3.2. Comparison of pain scores between the two groups

There was no difference in pain scores between the two groups before surgery ($P > 0.05$). However, the pain scores of the experimental group were lower than those of the control group at 1 and 3 days after surgery ($P < 0.05$) (Table 2).

Table 2. Comparison of pain scores between the two groups (mean \pm SD, points)

Group	<i>n</i>	Pre-op	Post-op Day 1	Post-op Day 3
Test group	41	4.42 \pm 0.58	1.79 \pm 0.53	0.97 \pm 0.27
Control group	41	4.45 \pm 0.61	2.90 \pm 0.59	1.71 \pm 1.08
<i>t</i> -value		0.228	8.962	4.256
<i>P</i> -value		0.820	< 0.001	< 0.001

3.3. Comparison of short-term quality of life scores between the two groups

There was no difference in short-term quality of life scores between the two groups before surgery ($P > 0.05$). However, the short-term quality of life score of the experimental group was higher than that of the control group at 2 months after surgery ($P < 0.05$) (Table 3).

Table 3. Comparison of short-term quality of life scores between the two groups (mean \pm SD, points)

Group	<i>n</i>	Daily activities		Social/Family life		Emotion		Mobility	
		Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op
Test	41	12.23 \pm 2.64	20.15 \pm 2.43	17.65 \pm 2.10	22.51 \pm 1.42	10.25 \pm 1.53	19.32 \pm 2.84	17.53 \pm 2.16	23.25 \pm 1.76
Control group	41	12.29 \pm 2.60	17.37 \pm 2.40	17.61 \pm 2.13	20.15 \pm 1.30	10.21 \pm 1.62	16.52 \pm 2.77	17.51 \pm 2.23	21.05 \pm 1.68
<i>t</i> -value		0.104	5.212	0.086	7.849	0.115	4.519	0.041	5.790
<i>p</i> -value		0.918	<0.001	0.932	<0.001	0.909	<0.001	0.967	<0.001

4. Discussion

Lung cancer, originating from the bronchial epithelial or alveolar epithelial cells, is a common malignant tumor of lung tissue. Its common pathological types are small cell lung cancer and non-small cell lung cancer. Early stages of the disease often present no obvious symptoms, and risk factors include air pollution and long-term smoking. Surgical resection, especially lobectomy combined with lymph node dissection, is frequently performed for patients with this disease. This surgical approach can completely remove the tumor lesion, halt disease progression, prevent distant metastasis of the tumor, and prolong the patient's survival.

Multi-port thoracoscopic surgery is a commonly used minimally invasive technique for lobectomy, providing a broad surgical field of view, avoiding obscuration, detecting occult lesions, and improving surgical success rates [3]. Additionally, multi-port thoracoscopy enables comprehensive lymph node dissection, facilitating easier surgical operations and higher treatment feasibility. However, lung cancer patients often have low immunity and a hypercoagulable blood state, leading to average tolerance for surgical treatment. Multi-port thoracoscopic surgery requires three incisions, which can be more traumatic to the patient's body and result in longer incision healing times, hindering early postoperative recovery. To fully leverage the advantages of minimally invasive treatment, single-port thoracoscopic technology has been widely implemented. This technique requires only one incision, providing a clear and open surgical field that allows for multi-angle evaluation of tumor lesions using the thoracoscope. The simplified surgical procedure enables precise lesion removal with high surgical safety.

Results indicate that both single and multi-port thoracoscopy can rapidly locate tumor lesions using high-definition cameras to observe the thoracic cavity and collect pathological tissue using a wedge resection method, followed by targeted lobectomy. The operating principles and resection scope of the two techniques are largely consistent, resulting in similar surgical efficacy. The experimental group exhibited a longer surgical time and less intraoperative blood loss compared to the control group ($P < 0.05$). This difference is attributed to the limited operating space during single-port thoracoscopic surgery, where all procedures are completed through a single incision without additional assistance, increasing surgical difficulty and requiring higher precision. Consequently, operators need to be more cautious and meticulous, thus prolonging the operation time [4,5]. However, single-port surgery reduces bleeding from multiple incisions, minimizes interference with intrathoracic organs, and decreases intraoperative blood loss. At 1 and 3 days postoperatively, the pain scores of the experimental group were lower than those of the control group ($P < 0.05$). This difference arises from the reduced number of incisions in single-port thoracoscopy, with a single incision length of 3 to 4 centimeters, alleviating postoperative incision pain. Moreover, the incision location in single-port surgery is at the anterior intercostal line, where there are wider bony gaps and fewer nerves and blood vessels, further reducing postoperative pain. Conversely, multi-port surgery incisions are located in areas with dense nerve and blood vessel tissue, resulting in stronger pain sensations

and longer recovery periods. The short-term quality of life score at 2 months postoperatively was higher in the experimental group ($P < 0.05$). This is because single-port surgery has a less negative impact on the patient's immune system, reduces physiological stress responses caused by surgery, minimizes surgical trauma, and shortens postoperative recovery time^[6]. The small incision length in single-port surgery limits tissue damage to a specific intercostal space, minimizing the impact on physiological functions and enhancing the patient's quality of life. Additionally, single-port surgery barely affects respiratory system function, allowing for early functional training and faster immune system recovery, thereby preventing various complications and improving the patient's quality of life^[7,8].

However, it's important to note that both single and multi-port thoracoscopic techniques have their advantages and disadvantages. Single-port surgery offers high incision aesthetics, minimal damage to intercostal nerves, and prevention of chronic postoperative pain. Yet, it demands high technical proficiency in vascular management and lymph node dissection, resulting in a longer learning curve for operators. Moreover, its application in patients with thoracic deformities or obesity requires caution due to its limited indications. In contrast, multi-port surgery is more traumatic, prone to postoperative complications, and has a longer recovery period. However, it boasts simpler surgical operations and broader indications^[9]. Therefore, in treating lung cancer patients, it's crucial to comprehensively evaluate their disease status, physical fitness, and treatment needs, taking their subjective preferences into account to select the most suitable thoracoscopic technique.

5. Conclusion

In summary, single and multi-port thoracoscopic techniques exhibit comparable overall treatment efficacy for lung cancer patients. However, single-port surgery offers advantages such as less intraoperative blood loss, reduced postoperative pain, and improved short-term quality of life. Its higher surgical feasibility makes it a preferred thoracoscopic technique for lobectomy.

Disclosure statement

The authors declare no conflict of interest.

References

- [1] Dai T, Yan Q, 2022, Progress and Reflections on the Application of Single-Port Thoracoscopy in Non-Small Cell Lung Cancer Surgery. *Journal of Southwest Medical University*, 45(2): 93–97.
- [2] Wang Q, Wang H, Yang Z, 2024, Application of 3D Reconstruction Technique in Single-Port Thoracoscopic Segmentectomy for Early Stage Non-Small Cell Lung Cancer Patients. *Chinese Journal of Practical Medicine*, 51(8): 54–57.
- [3] Xu W, Xu C, Ding C, et al., 2020, Clinical Effect Analysis of Single-Port and Single-Operating Port Thoracoscopic Techniques in Surgical Treatment of Lung Cancer. *Chinese Journal of Lung Cancer*, 23(7): 561–567.
- [4] Li Y, Zhang Y, Zhi X, et al., 2023, Application of 3D-CTBA Combined with Perfusion Zone Identification Technology in Single-Port Thoracoscopic Complex Segmentectomy. *Chinese Journal of Lung Cancer*, 26(1): 17–21.
- [5] Huang H, Lin Y, Wu C, et al., 2024, Clinical Efficacy of Single-Port Thoracoscopic Surgery for Non-Small Cell Lung Cancer Patients. *Shenzhen Journal of Integrated Traditional Chinese and Western Medicine*, 34(19): 70–73.

- [6] Bian Q, Xu X, 2024, Observation on the Effect of Single-Port and Three-Port Thoracoscopic Lobectomy for Lung Cancer. *Contemporary Medical Forum*, 22(1): 61–64.
- [7] Hu S, Xie S, Ning C, 2024, Comparison of the Efficacy of Single-Port Thoracoscopic Anatomic Segmentectomy and Lobectomy for Non-Small Cell Lung Cancer. *Journal of Cancer Basis and Clinic*, 37(2): 154–158.
- [8] Cao Z, Hu G, 2024, Comparison of the Efficacy of Single-Port and Multi-Port Thoracoscopic Segmentectomy for Non-Small Cell Lung Cancer Patients. *Big Doctor*, 9(4): 1–3.
- [9] Dong Y, Lv X, Li Y, et al., 2024, Comparative Analysis of the Effects of Single-Port or Multi-Port Thoracoscopic Lobectomy on Lung Function and Rehabilitation Process in Non-Small Cell Lung Cancer Patients. *Capital Food and Medicine*, 31(21): 52–54.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Analysis of the Curative Effect of Sarkubactrovalsartan in the Treatment of Patients with Acute Anterior Myocardial Infarction after PCI

Dayuan He*

Zhangye People's Hospital Affiliated to Hexi University, Zhangye 734000, Gansu, China

*Corresponding author: Dayuan He, hdydoctor@qq.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: *Objective:* To study the clinical value of sacubatravalsartan in patients with acute anterior myocardial infarction (AAMI) after percutaneous coronary intervention (PCI). *Methods:* 124 patients with AAMI from April 2022 to June 2024 were randomly divided into study group (56 cases) and control group (68 cases). Both groups were given aspirin during the treatment, the control group was given enalapril after operation, and the study group was given sacubatravalsartan after operation, both of which were treated for 2 months. Before and after treatment, CRP, IL-6, TNF - α , Hcy, BNP and other serological indicators were detected, HR, LVEDd, LVEF and other cardiac function indexes were detected, and postoperative complications and adverse drug reactions were compared between the two groups. *Results:* before treatment, there was no significant difference in each index level between the two groups ($P > 0.05$); after treatment, CRP, IL-6, TNF - α , Hcy, BNP, HR and LVEDd in the study group were lower than those in the control group ($P < 0.05$), and LVEF was higher than that in the control group ($P < 0.05$); the incidence of postoperative complications in the study group was lower than that in the control group ($P < 0.05$); there was no significant difference in the total adverse reaction rate between the two groups ($P > 0.05$). *Conclusion:* sacubatrovalsartan can effectively improve the cardiac function of patients with AAMI after PCI, reduce the incidence of postoperative complications, and has high safety.

Keywords: Acute anterior myocardial infarction; PCI; Sarkubatrovalsartan; Cardiac function

Online publication: July 11, 2025

1. Introduction

Acute anterior myocardial infarction (AAMI) is a common critical emergency in cardiovascular medicine, characterized by its sudden onset and high risk. If not treated promptly, it can be life-threatening^[1]. The clinical treatment of AAMI mainly focuses on anticoagulation and thrombolysis, with both medications and surgery showing certain efficacy. Among them, percutaneous coronary intervention (PCI) can directly clear and dilate the blocked coronary arteries, thereby alleviating coronary obstruction and reducing patients' clinical symptoms^[2]. However, various complications can occur after surgery, so patients need to be treated with medication after PCI

to improve surgical efficacy. Studies have pointed out that the dual-acting angiotensin receptor complex inhibitor, Sacubitril/Valsartan, has a good therapeutic effect on AAMI patients after PCI, which can improve patients' clinical symptoms and reduce postoperative complications^[3]. Currently, there is no unified view on the scientific nature and effectiveness of Sacubitril/Valsartan for AAMI patients after surgery. Based on this, this study adopts Sacubitril/Valsartan treatment for AAMI patients after PCI, aiming to provide a reference for clinical medication.

2. Materials and methods

2.1. General information

A total of 124 AAMI patients admitted to the cardiology department of our hospital from April 2022 to April 2024 were included as research subjects. They were divided into a study group (56 cases) and a control group (68 cases) using a random number table method. Control group: 39 males and 29 females; aged 58–74 years old, with an average age of (64.55 ± 3.69) years old; New York Heart Disease Association (NYHA) cardiac function classification^[4]: 28 cases in grade II, 40 cases in grade III. Study group: 32 males and 24 females; aged 59–77 years old, with an average age of (65.22 ± 3.80) years old; NYHA cardiac function classification: 25 cases in grade II, 31 cases in grade III. This study was approved by the medical ethics committee of the hospital. There were no statistically significant differences in general information (gender, age, cardiac function classification, etc.) between the two groups ($P > 0.05$), indicating comparability.

Inclusion criteria: (1) Meet the diagnostic criteria for AAMI in “Emergency Treatment of Acute Myocardial Infarction”^[5], and satisfy any two of the following criteria: (1) Asymptomatic or presence of sudden severe chest pain, fever, nausea, arrhythmia, abdominal distension, and other symptoms of varying degrees; (2) Dynamic evolution of ST and ST-T visible on electrocardiogram; (3) Creatine kinase isoenzyme (CK-MB) ≥ 6.3 ng/mL and troponin I (cTnI) $\geq 0.5\mu\text{g/L}$; (4) History of ischemic chest pain; (5) Stable basic vital signs, able to walk and move limbs without impediment within 5 meters; (6) All patients underwent PCI surgery in our hospital; (7) Agreed to sign the informed consent form for this study.

Exclusion criteria: (1) Patients with severe liver, kidney, or other organ dysfunction; (2) Patients with hypotension, electrolyte imbalance, and severe endocrine system diseases; (3) Patients with severe consciousness disorders, affective disorders, expression disorders, and history of mental illness; (4) Patients allergic to contrast agents or medications; (5) NYHA cardiac function class \geq IV.

2.2. Methods

Both groups were given aspirin (Bayer Healthcare, J20130078, 100mg/tablet) 4 days before PCI surgery, at a dose of 300 mg/day preoperatively and 100mg/day postoperatively as a maintenance dose. The control group was given an angiotensin-converting enzyme inhibitor (ACEI) - enalapril (Yangzijiang Pharmaceutical, H32026567, 10 mg/tablet) postoperatively, at a dose of 5 mg per time, twice a day with warm water. The study group was given sacubitril/valsartan (Novartis Pharma, J20171054, 100 mg/tablet) postoperatively, starting at a dose of 100 mg per time, twice a day. After 2 weeks of medication, the dose was adjusted to 150 mg per time, twice a day and maintained for another 2 weeks. Then, the dose was increased to 200mg per time, twice a day until the end of treatment. One month was considered as one course of treatment, and both groups were treated continuously for two courses.

2.3. Observation indicators

(1) Biological indicators

Fasting elbow venous blood (5 mL) was collected from the subjects before and after treatment. C-reactive

protein (CRP) was detected using immunoturbidimetry, and interleukin-6 (IL-6), tumor necrosis factor- α (TNF- α), homocysteine (Hcy), and brain natriuretic peptide (BNP) were detected using enzyme-linked immunosorbent assay. The analysis was performed using a SIEMENS ASVIA1800 fully automated biochemical analyzer. CRP and TNF- α reagents were produced by Thermo Fisher Scientific, while IL-6, Hcy, and BNP reagents were produced by Ningbo Meikang Biological Co., Ltd.

(2) Cardiac function indicators

Before and after treatment, the subjects' cardiac function indicators, including left ventricular ejection fraction (LVEF) and left ventricular end-diastolic dimension (LVEDD), were measured using a Mindray DC-N3S Doppler color ultrasound diagnostic instrument. Heart rate (HR) was detected using a Zoncare iE90 electrocardiograph.

(3) Postoperative complications

The occurrence of postoperative complications after PCI was compared between the two groups, which may include arrhythmia, heart failure, vascular bleeding, vascular hematoma, thrombus formation, contrast-induced nephropathy, slow coronary flow, coronary occlusion, coronary perforation, etc. The total complication rate was calculated as the sum of all complications divided by the total number of patients $\times 100\%$.

(4) Adverse reactions

Adverse reactions during treatment were recorded in both groups, which may include cough, nausea, abdominal pain, fever, dizziness, gastrointestinal bleeding, hyperkalemia, hypotension, renal failure, etc. The total adverse event rate was calculated as the sum of all adverse events divided by the total number of patients $\times 100\%$.

2.4. Statistical methods

The statistical data in this study were processed using SPSS 22.0 software. Count data and measurement data were represented by n (%) and mean \pm standard deviation (SD), respectively, and were tested using chi-square (χ^2) and t -test, respectively. Statistical significance was determined at $P < 0.05$.

3. Results

3.1. Serological indicators

There were no statistically significant differences in the levels of various indicators between the two groups before treatment ($P > 0.05$). After treatment, the levels of CRP, IL-6, TNF- α , Hcy, and BNP in the study group were lower than those in the control group ($P < 0.05$). See **Table 1** for details.

Table 1. Comparison of serological indicators before and after treatment between the two groups (mean \pm SD)

Group	<i>n</i>	Time	CRP (mg/L)	IL-6 (pg/mL)	TNF- α (pg/mL)	Hcy (μ mol/L)	BNP (pg/L)
Study group	56	Before treatment	8.13 \pm 0.95	36.47 \pm 10.97	36.75 \pm 11.58	12.25 \pm 1.82	1232.21 \pm 61.85
		After treatment	4.27 \pm 0.23* [#]	24.85 \pm 4.69* [#]	22.88 \pm 6.61* [#]	6.36 \pm 0.86* [#]	523.59 \pm 49.32* [#]
Control group	68	Before treatment	8.55 \pm 1.04	35.05 \pm 11.12	35.43 \pm 11.32	11.96 \pm 1.90	1229.36 \pm 61.67
		After treatment	6.27 \pm 0.95* [#]	30.52 \pm 6.23* [#]	28.52 \pm 8.33* [#]	8.59 \pm 0.95* [#]	682.46 \pm 52.58* [#]

Note: * $P < 0.05$ compared to the same group before and after treatment; [#] $P < 0.05$ compared to the other group at the same time point.

3.2. Cardiac function indicators

There were no statistically significant differences in the levels of various indicators between the two groups before treatment ($P > 0.05$). After treatment, the HR and LVEDD in the study group were lower than those in the control group ($P < 0.05$), while the LVEF was higher than that in the control group ($P < 0.05$). See **Table 2** for details.

Table 2. Comparison of cardiac function indicators before and after treatment between the two groups (mean \pm SD)

Group	n	LVEF (%)		HR (beats/min)		LVEDD (mm)	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Study group	56	33.21 \pm 5.97	43.51 \pm 4.96*	114.22 \pm 11.11	73.32 \pm 8.65*	54.09 \pm 4.72	45.20 \pm 3.80*
Control group	68	33.45 \pm 6.11	38.23 \pm 4.63*	113.88 \pm 10.98	79.66 \pm 10.23*	54.76 \pm 4.32	50.23 \pm 3.60*
t		0.194	5.430	0.152	3.353	0.536	5.901
P		0.846	0.000	0.879	0.001	0.593	0.000

Note: * $P < 0.05$ compared to the same group before and after treatment.

3.3. Postoperative complications

The total incidence of postoperative complications in the study group was lower than that in the control group ($P < 0.05$). See **Table 3** for details.

Table 3. Comparison of postoperative complications after PCI between the two groups [n, (%)]

Group	n	Arrhythmia, n (%)	Heart failure, n (%)	Vascular hematoma, n (%)	Thrombosis, n (%)	Total complications, n (%)
Study group	56	2 (3.57)	1 (1.79)	1 (1.79)	1 (1.79)	5 (8.93)
Control group	68	6 (8.82)	3 (4.41)	3 (4.41)	4 (5.88)	16 (23.53)
χ^2		1.153 ^a	0.312 ^a	0.312 ^a	1.149 ^a	6.375
P		0.283	0.577	0.577	0.284	0.012

Note: ^a represents the continuity correction χ^2 value.

3.4. Adverse drug reactions

There was no statistically significant difference in the total incidence of adverse reactions between the two groups during treatment ($P > 0.05$). See **Table 4** for details.

Table 4. Comparison of adverse reactions during treatment between the two groups [n, (%)]

Group	n	Nausea	Diarrhea	Cough	Dizziness	Hypotension	Total adverse reactions
Study Group	56	2 (5.00)	1 (2.50)	2 (5.00)	2 (5.00)	1 (2.50)	8 (20.00)
Control Group	68	3 (5.00)	2 (3.33)	2 (3.33)	4 (6.67)	2 (3.33)	13 (21.67)
χ^2		0.105 ^a	0.005 ^a	0.056 ^a	0.041 ^a	0.005 ^a	0.085
P		0.746	0.943	0.813	0.840	0.943	0.771

Note: ^a represents the continuity correction χ^2 value.

4. Discussion

AAMI is a severe cardiovascular disease with high morbidity and mortality rates. The direct cause of this disease is abnormal heart function resulting from the death of myocardial cells due to ischemia and hypoxia caused by changes in coronary blood flow^[6]. The pathogenesis of AAMI is complex and can be caused by abnormalities in blood, blood vessels, and hemodynamics, leading to narrowing and blockage of cerebral arteries. Modern medical research has confirmed that various factors such as systemic diseases, overexertion, hypertension, hyperlipidemia, high cholesterol, and imbalance in dietary structure can all cause coronary artery blockage or rupture, thereby triggering AAMI^[7]. Currently, clinical treatment for AAMI mainly focuses on thrombolysis, improving blood circulation in the coronary arteries, and reducing the risk of embolism. Commonly used drugs include tirofiban, aspirin, beta blockers, etc., and surgical treatment is primarily PCI. Although these treatments can provide good efficacy and rapidly relieve patients' conditions, PCI surgery can easily affect the blood circulation and microenvironment balance of the coronary arteries, leading to various complications such as coronary spasms, perforations, occlusions, contrast-induced nephropathy, and bleeding. Therefore, clinical treatment often requires medication after PCI surgery to reduce the impact of complications on surgical efficacy^[8].

Qian *et al.*^[9] pointed out that CRP is a protein that regulates the body's immune function. It can enhance the body's immune response by strengthening the phagocytosis of phagocytic cells. Its expression level in the blood rises sharply during the initial stage of immune enhancement, making it a useful indicator for the early diagnosis of various diseases. IL-6 is a cytokine that acts between immune cells. Its level increases rapidly when the body experiences an inflammatory response, and an increase in inflammatory symptoms can burden the heart and elevate the risk of microcirculatory disorders^[10]. TNF- α is a proinflammatory cytokine produced by macrophages in the human body. Excessive amounts of TNF- α can be detected in the blood of AAMI patients due to the activation of inflammatory states^[11]. Hcy is an intermediate metabolite of sulfur-containing amino acids in the body. It is often used as an independent risk factor for cardiovascular and cerebrovascular diseases, and its expression level in the blood is closely related to the body's microcirculation^[12]. BNP is mainly produced by ventricular myocytes and has effects such as promoting urination and sodium excretion, dilating blood vessels, and resisting vasoconstriction. Its expression level increases with the severity of cardiac function damage^[13]. The results of this study showed that after treatment, the levels of CRP, IL-6, TNF- α , Hcy, and BNP in the study group were lower than those in the control group, which is similar to the results reported by Xiong *et al.*^[14]. This suggests that sacubitril/valsartan can effectively reduce the risk of coronary thrombosis and embolism in AAMI patients after PCI surgery. This may be due to sacubitril/valsartan's dual action as an angiotensin receptor complex inhibitor, which has a better blocking effect on the renin-angiotensin-aldosterone system (RAAS) than ACEI drugs. This further inhibits the process of myocardial fibrosis and thickening while reducing the expression levels of related cytokines, thereby lowering the expression of various indicators in the patients' blood. The results also showed that after treatment, the HR and LVEDD in the study group were lower than those in the control group, while the LVEF was higher. The total incidence of postoperative complications was also lower in the study group compared to the control group, which is consistent with the findings of Chen *et al.*^[15], further supporting the effectiveness of sacubitril/valsartan. Additionally, there was no statistically significant difference in the incidence of adverse reactions between the two groups during treatment, indicating that sacubitril/valsartan not only provides better treatment effects than ACEI drugs but also has high safety.

5. Conclusion

In summary, sacubitril/valsartan can effectively improve cardiac function levels in AAMI patients after PCI surgery, reduce the incidence of postoperative complications, and has high safety, making it clinically valuable for promotion.

Funding

Innovation Project of Gansu Higher Education Institutions (Project No.: 2022B-185)

Disclosure statement

The author declares no conflict of interest.

References

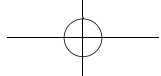
- [1] Lippolis A, Buzzi P, Romano I, et al., 2019, Unexpected Reappearance of ST Elevation in the Anterior Precordial Leads Shortly After an Acute Anterior Myocardial Infarction. *Journal of Electrocardiology*, 52(6): 75–78.
- [2] Li D, Zhang G, Zhang M, et al., 2018, Study on the Effect of Nicorandil on No-Reflow in Coronary Arteries Before Acute Anterior Myocardial Infarction Surgery. *Chinese Journal of Cardiovascular Rehabilitation Medicine*, 27(2): 160–163.
- [3] Li J, Chen H, Chai Q, et al., 2020, The Effect of Sacubitril/Valsartan on Cardiac Function After Emergency Coronary Intervention for Acute Myocardial Infarction. *Chinese Journal of Clinical Research*, 33(9): 1200–1203.
- [4] Zan W, Yan P, Li Y, et al., 2018, The Effect of PCI Treatment on NYHA Cardiac Function Classification in Patients with Chronic Heart Failure Due to Coronary Heart Disease. *Guizhou Medical Journal*, 42(7): 806–807.
- [5] Liu L, Wang X, 2016, Emergency Treatment of Acute Myocardial Infarction. *Chinese Journal for Clinicians*, 44(2): 10–13.
- [6] Wei M, Zheng M, Liu G, et al., 2019, Effects of New Active Peptide on Heart Rate Variability and Cardiac Function in Patients with Acute Anterior Myocardial Infarction Undergoing Emergency PCI. *Chinese Journal of Integrative Medicine on Cardio-/Cerebrovascular Disease*, 17(6): 876–878.
- [7] Gulinal B, Ma Y, Zheng Y, et al., 2018, The Impact of the Establishment of a Chest Pain Center on the Diagnosis and Treatment Trends of Acute Anterior Myocardial Infarction. *Journal of Xinjiang Medical University*, 41(12): 7–10 + 16.
- [8] Gao H, Chen H, Guo C, et al., 2018, The Effect of Early T-Wave Inversion After Emergency Coronary Intervention for Acute Anterior Myocardial Infarction on Prognosis. *Journal of Cardiopulmonary Vascular Diseases*, 37(8): 743–746.
- [9] Zhang Q, Wang C, Shi S, et al., 2019, Relationship Between Left Ventricular Thrombus Formation and Adverse Outcomes in Patients with Acute Anterior Myocardial Infarction Treated with Primary Percutaneous Coronary Intervention. *Clinical Cardiology*, 42(1): 69–75.
- [10] Yan M, Liu Q, Jiang Y, et al., 2020, Evaluation of Serum Vaspin and IL-6 Levels on Left Ventricular Remodeling After Acute Myocardial Infarction. *Progress in Modern Biomedicine*, 20(10): 1858–1863.
- [11] Claeys M, Coussement P, Dubois P, et al., 2019, Clinical Effects of Cyclosporine in Acute Anterior Myocardial Infarction Complicated by Heart Failure: A Subgroup Analysis of the CIRCUS Trial. *American Heart Journal*, 216:

147–149.

- [12] Chen Z, Zhang L, Huang X, et al., 2019, Relationship Between IL-6, Cys-C, Hcy, and Acute Myocardial Infarction. *Prevention and Treatment of Cardio-/Cerebrovascular Diseases*, 19(4): 347–348 + 351.
- [13] Li B, Li Y, Ma J, et al., 2019, Relationship Between ADAMTS-1 Expression Level and Acute Myocardial Infarction Area and Cardiovascular Outcomes. *Journal of Practical Medicine*, 35(7): 1088–1091.
- [14] Xiong Z, Man W, Li Y, et al., 2020, Clinical Efficacy of Sacubitril/Valsartan in Patients with Heart Failure After Myocardial Infarction. *Heart Journal*, 161(1): 34–38.
- [15] Chen C, Qian W, Ding H, et al., 2019, The Effect of Sacubitril/Valsartan on the Short-Term Prognosis of Patients with Acute Anterior Myocardial Infarction After Emergency PCI Surgery Complicated by Cardiac Insufficiency. *Progress in Modern Biomedicine*, 19(19): 3720–3725.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Integrated Services Platform of International Scientific Cooperation

Innoscience Research (Malaysia), which is global market oriented, was founded in 2016. Innoscience Research focuses on services based on scientific research. By cooperating with universities and scientific institutes all over the world, it performs medical researches to benefit human beings and promotes the interdisciplinary and international exchanges among researchers.

Innoscience Research covers biology, chemistry, physics and many other disciplines. It mainly focuses on the improvement of human health. It aims to promote the cooperation, exploration and exchange among researchers from different countries. By establishing platforms, Innoscience integrates the demands from different fields to realize the combination of clinical research and basic research and to accelerate and deepen the international scientific cooperation.

Cooperation Mode



Clinical Workers



In-service Doctors



Foreign Researchers



Hospital



University



Scientific institutions

OUR JOURNALS



The *Journal of Architectural Research and Development* is an international peer-reviewed and open access journal which is devoted to establish a bridge between theory and practice in the fields of architectural and design research, urban planning and built environment research.

Topics covered but not limited to:

- Architectural design
- Architectural technology, including new technologies and energy saving technologies
- Architectural practice
- Urban planning
- Impacts of architecture on environment

Journal of Clinical and Nursing Research (JCNr) is an international, peer reviewed and open access journal that seeks to promote the development and exchange of knowledge which is directly relevant to all clinical and nursing research and practice. Articles which explore the meaning, prevention, treatment, outcome and impact of a high standard clinical and nursing practice and discipline are encouraged to be submitted as original article, review, case report, short communication and letters.

Topics covered by not limited to:

- Development of clinical and nursing research, evaluation, evidence-based practice and scientific enquiry
- Patients and family experiences of health care
- Clinical and nursing research to enhance patient safety and reduce harm to patients
- Ethics
- Clinical and Nursing history
- Medicine



Journal of Electronic Research and Application is an international, peer-reviewed and open access journal which publishes original articles, reviews, short communications, case studies and letters in the field of electronic research and application.

Topics covered but not limited to:

- Automation
- Circuit Analysis and Application
- Electric and Electronic Measurement Systems
- Electrical Engineering
- Electronic Materials
- Electronics and Communications Engineering
- Power Systems and Power Electronics
- Signal Processing
- Telecommunications Engineering
- Wireless and Mobile Communication

