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The effects of Dan Shen Chuanxiong qin injection on serum BNP and cardiac troponin levels in patients with acute coronary syndrome: A Biomechanical Perspective

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Abstract: Objective: This study aims to evaluate the clinical efficacy of Dan Shen Chuan xiong qin Injection in combination with conventional interventions for Acute Coronary Syndrome (ACS), emphasizing its biomechanical mechanisms and effects on serum levels of B-type natriuretic peptide (BNP) and cardiac troponin T (cTnT). **Methods:** This prospective cohort study involved 140 patients suffering from ACS, randomly divided into a control group and a treatment group. The control group received conventional Western pharmacotherapy, while the treatment group was additionally treated with Dan Shen Chuan xiong qin Injection. We measured serum BNP and cardiac troponin levels and analyzed their biomechanical relevance to cardiac function and hemodynamics on the 1st, 2nd, and 5th days post-treatment. **Results:** After treatment, particularly on the 5th day, the BNP levels in the treatment group receiving Dan Shen Chuan xiong qin Injection were significantly lower than those in the control group ($p < 0.05$). Both groups exhibited a downward trend in BNP levels on days 1, 2, and 5 ($p < 0.001$). Regarding troponin levels, the treatment group showed lower troponin levels on all days compared to the control group ($p < 0.05$), with statistically significant differences noted ($p < 0.05$). **Biomechanical Analysis:** The reduction in BNP and troponin levels suggests an improvement in cardiac function and hemodynamics, potentially indicating enhanced myocardial performance and reduced cardiac stress. The biomechanical implications of these biomarkers highlight their role in assessing cardiac workload and injury, reinforcing the cardioprotective effects of Dan Shen Chuanxiong Injection. **Conclusion:** The treatment group receiving Dan Shen Chuanxiong Injection demonstrated superior outcomes in clinical symptom relief, improvement in cardiac function, and reduction in biomarker levels compared to the control group. These findings indicate that Dan Shen Chuan xiong qin Injection possesses significant cardioprotective effects, reducing the risk of cardiac injury through biomechanical mechanisms. When used alongside conventional therapy, DSCXQ Injection shows potential for improving critical biomarkers related to ACS. This study provides valuable evidence for integrating traditional Chinese medicine with conventional Western approaches in managing ACS, emphasizing the importance of biomechanical analysis in understanding therapeutic effects.

Keywords: acute coronary syndrome; Dan Shen Chuan xiong qin injection; combination therapy; prospective cohort study; clinical efficacy; biomechanical mechanisms

1. Introduction

1.1. Introduction to acute coronary syndrome

Acute Coronary Syndrome (ACS) includes unstable angina and acute myocardial infarction (AMI), which can be categorized into ST-segment elevation myocardial infarction (STEMI) and non-ST-segment elevation myocardial infarction (NSTEMI) [1].

ACS is commonly caused by insufficient coronary blood flow, resulting in myocardial ischemia or necrosis. The principal mechanism underlying this condition is closely related to coronary artery atherosclerosis, where plaque rupture can lead to thrombosis, thereby exacerbating myocardial ischemia. Major risk factors for ACS include hypertension, hyperlipidemia, smoking, diabetes, obesity, physical inactivity, and family history [2]. Additionally, there is a notable trend towards younger age groups being affected by ACS; studies have observed that men under 45 years have a higher incidence compared to women, while women's risk significantly increases after menopause [3]. Furthermore, the incidence of ACS markedly rises in individuals over the age of 65.

According to statistics from the World Heart Federation, cardiovascular diseases ranked the first of cause of death and disability globally. Between 1990 and 2019, the number of deaths led by cardiovascular diseases increased nearly half to 18.6 million at 2019, with 9.6 million being male and 8.9 million females; ACS is a significant contributing factor [4]. In China, the incidence of ACS has been rising annually, particularly evident in the middle-aged and elderly populations. In recent years, it is estimated that the annual incidence of acute myocardial infarction has reached approximately 1 million cases.

Traditional Chinese medicine has gained increasing attention in the management of ACS. Among these methods, Dan Shen Chuan xiong qin Injection (DSCXQ) has been extensively studied due to its unique pharmacological properties. Dan Shen has been found has ability to promote micro circulation and remove blood stasis, while Chuanxiong effectively alleviates myocardial ischemia and enhances blood flow [5,6]. Research has shown that Dan Shen Chuan xiong qin Injection can reduce myocardial enzyme levels and thereby improve cardiac function [7]. Furthermore, its protective effects against myocardial ischemia and heart failure have been confirmed through multiple clinical trials. This herbal formulation serves as an adjunct to standard Western pharmacotherapy and can significantly enhance therapeutic outcomes, providing a more comprehensive approach for ACS patients. Due to the advantages of convenience and low side effects, the use of Chinese patent medicines is gaining a higher status in disease management. A multicenter study conducted by Bai et al. [8]. analyzed the role of Chinese patent medicines in patients with ACS undergoing percutaneous coronary intervention (PCI). The study found a significant reduction in cardiovascular adverse events during the 36-month follow-up period, as well as an improvement in patients' quality of life.

1.2. Research progress on DSCXQ

As an injectable preparation made from extracts of the herbs Dan Shen and Chuanxiong, the active components of these herbs offer multiple protective effects on the cardiovascular system, including antioxidant, anti-inflammatory effects [9,10], and improvement of endothelial function. These actions effectively mitigate reperfusion injury during myocardial ischemia. Numerous prospective and retrospective studies indicate that DSCXQ can significantly improve cardiac function in ACS patients, alleviate chest pain, and reduce the frequency of angina attacks. For instance, a meta-analysis [11] demonstrated that when Dan Shen Chuan xiong qin Injection is used in combination with standard Western medication for ACS treatment, there is a significant

enhancement in patient quality of life and notable improvements in cardiac function indicators.

Furthermore, some studies have observed the auxiliary effects of Dan Shen Chuan xiong qin Injection during the combination of standard Western pharmacotherapy. For example, a study by Li et al. [12] indicated that Dan Shen Chuan xiong qin Injection can significantly lower the levels of cardiac injury biomarkers (such as troponin and BNP), demonstrating its efficacy in myocardial protection. This further supports the potential of Dan Shen Chuan xiong qin Injection as an adjunctive treatment for ACS. In terms of safety, the use of Dan Shen Chuan xiong qin Injection is generally considered safe, with minimal side effects, rendering it suitable for adjunctive therapy in ACS [13].

2. Methods

2.1. Study design and participants

This study aims to assess the clinical efficacy and safety of Dan Shen Chuan xiong qin Injection in combination with standard Western pharmacotherapy for ACS, as well as its effects on serum levels of *B*-type natriuretic peptide (BNP) and cardiac troponin T (cTnT). This is a prospective cohort study conducted from August 2022 to February 2023 at Fuyuan Rehabilitation Hospital in Jinan, involving a total of 140 patients diagnosed with ACS. Participants were randomly allocated into a treatment group ($n = 70$) and a control group ($n = 70$) using simple randomization techniques to ensure unbiased comparisons between the two groups; specifically, patients were sequentially assigned to either the treatment or control group.

Sample size determination was based on the estimated prevalence of potential patients, considering that around 10% of a population of 72,000 individuals are expected to fall within the criteria for inclusion, calculated based on Jinan's total population (approximately 7 million) and the annual incidence of new ACS diagnoses. This sample size was validated through comparisons with similar studies in the field, specifically referencing the findings of Wu et al. [14] regarding the use of Dan Shen Chuan xiong qin Injection in 98 ACS patients.

2.2. Intervention measures

In terms of intervention, the treatment group received standard ACS pharmacotherapy supplemented with intravenous administration of 5 ml of DSCXQ diluted in 250 ml of normal saline, administered through intravenous infusion once every morning for 5 days according to the instruction for use of DSCXQ. The control group received only the standard Western medical treatment regimen, which included dual antiplatelet therapy, anticoagulation, statins, and antihypertensive medications tailored based on the patient's blood pressure and renal function. Aspirin enteric-coated tablets 100 mg PO (per os) once daily, Atorvastatin calcium 10 mg PO twice daily, Clopidogrel tablets 75 mg PO once daily, Amlodipine 5 mg PO twice daily, Metoprolol tartrate tablets 25 mg PO twice daily.

Before the initiation of treatment and on the 2nd and 5th days post-treatment, serum levels of BNP and cardiac troponin were measured in all patients to assess myocardial injury and cardiac function. Additionally, routine electrocardiograms (ECG) and

echocardiograms (ECHO) were performed at admission and on the 5th day to evaluate cardiac function, with particular focus on changes in ejection fraction. Secondary observational indices included vital signs (blood pressure, heart rate, respiratory rate) recorded on day 1 and day 5, collected through case records.

All participants signed informed consent forms after completing the informed consent process to ensure voluntary participation in this study. Furthermore, the research obtained ethical approval from the hospital's ethics committee to ensure compliance with ethical standards and to protect the rights of participants.

3. Outcome measurement

The primary outcomes include the measurement of serum BNP and cardiac troponin levels at baseline, on the 2nd day, and on the 5th day. Secondary outcomes include demographic characteristics such as age, gender, and blood pressure.

B-type Natriuretic Peptide (BNP) is a cardiac-secreted hormone primarily synthesized and released by ventricular myocardial cells, which has several key functions: it promotes diuresis, vasodilation, decreases blood pressure, reduces cardiac workload, and inhibits the renin-angiotensin-aldosterone system, further aiding in the reduction of blood pressure and cardiac strain [15]. ACS is often associated with cardiac injury and heart failure, making BNP levels a crucial biomarker for cardiac function and reflecting ventricular wall tension. Generally, elevated BNP levels indicate myocardial stress or damage. In clinical practice, BNP detection can assist in diagnosing acute heart failure and other cardiac-related conditions [16]. For patients with ACS, elevated BNP levels may signal potential myocardial injury or heart failure and assist in developing precise treatment plans. Increases in BNP levels are correlated with adverse prognoses in ACS patients, and the dynamic changes in BNP levels can reflect a patient's response to treatment, which is significant for guiding clinical management and evaluating the effectiveness of various treatment regimens.

Troponin is an essential regulatory protein in cardiac and skeletal muscle, primarily consisting of troponin *I* (TnI), troponin *T* (TnT), and troponin *C* (TnC). Cardiac-specific troponins (typically referring to TnI and TnT) are released into the bloodstream following cardiac injury, thus serving as vital biomarkers for heart disease. In ACS, myocardial injury due to ischemia causes troponin release into the circulatory system, making elevated serum troponin levels a sensitive and specific marker of myocardial injury. The rapid rise of troponin levels in ACS patients aids in the early diagnosis of myocardial infarction, with elevated levels correlating closely with adverse outcomes in ACS patients [17]. High levels of troponin typically indicate more severe myocardial damage and a higher risk of mortality. A decline in troponin levels after treatment generally indicates an improvement in myocardial injury, and variations in troponin levels can assist in stratifying patient risk in statistical analyses.

4. Statistical analysis

Statistical analyses were carried out using SPSS (IBM Corp. Version 26.0. Armonk, NY). To compare baseline characteristics and key outcome variables between the treatment and control groups, the Mann-Whitney U test was utilized. Chi-square tests assessed the distribution of categorical data, including gender and other nominal

variables, across the two groups. Changes in serum biomarkers BNP and troponin were analyzed at various time points (baseline, day 2, and day 5) using repeated measures ANOVA. The Wilcoxon signed-rank test was employed to evaluate changes in parameters between the groups over time. A p -value of less than 0.05 was considered statistically significant.

5. Results

No significant differences in demographics like age, gender and blood pressure were observed between the two groups ($p > 0.05$), and all patients completed their treatment and follow-up. The BNP assay showed no notable differences in levels on days 1 and 2 ($p > 0.05$), but by day 5, the treatment group had significantly lower BNP levels compared to the control ($p < 0.05$). A significant downward trend in BNP levels for both groups across days 1, 2, and 5 was observed ($p < 0.001$).

Regarding troponin (T) levels, the treatment group consistently showed lower levels than the control group on days 1, 2, and 5 ($p < 0.05$). Although no significant differences were found between groups on days 1 and 2 ($p > 0.05$), levels on these days were significantly lower than on day 5 ($p < 0.001$). The control group also showed a decreasing trend in troponin levels, while the treatment group maintained lower levels overall, indicating potential protection against myocardial damage. While both groups experienced a decline in troponin, the treatment group's more significant reduction suggests additional benefits from the intervention, indicating potential cardiac protective advantages.

Repeated measures ANOVA revealed that BNP and troponin (T) levels in the treatment group were significantly lower than in the control group on days 1, 2, and 5 ($p < 0.05$). As treatment progressed, BNP levels decreased in both groups, while troponin (T) levels initially rose before declining. This pattern was statistically significant for time, group allocation, and their interaction ($p < 0.05$). The analysis highlighted significant differences in BNP and troponin levels over time, confirming a consistent improvement in key indicators for the treatment group and supporting the potential clinical benefits of Dan Shen Chuan xiong qin Injection in treating acute coronary syndrome (**Table 1**).

Table 1. BNP and T of two groups.

Parameters	Group				Time effect	
		Day 1	Day 2	Day 5	F	p
BNP	Treatment	504.68 ± 151.62	472.48 ± 138.71	209.56 ± 75.08	47.680	< 0.001
	Control	512.52 ± 164.74	506.41 ± 163.99	493.49 ± 348.28		
T	Treatment	0.07 ± 0.02	0.16 ± 0.19	0.01 ± 0.01	15.676	< 0.001
	Control	0.32 ± 0.36	0.34 ± 0.4	0.29 ± 0.39		

In terms of safety assessment, no patients experienced serious adverse reactions. No significant abnormalities in liver and kidney function were observed in either the treatment group or the control group. Some patients reported mild adverse reactions such as vomiting and diarrhea, but there was no significant difference between the two groups ($P > 0.05$).

6. Discussion

The results of this study demonstrate that the treatment group exhibited positive improvements across multiple key indicators, with significant reductions in BNP and troponin levels by day 5 compared to the control group. These biomarkers play a crucial role in the diagnosis and monitoring of ACS, suggesting that DSCXQ may enhance biochemical characteristics and promote cardiac function improvement in ACS patients. A systematic review revealed that Chinese patent medicines can improve long-term outcomes for non-ST-elevation acute coronary syndromes [18]. The main components of DSCXQ are Danshen and Chuanxiong, according to previous research reports. Danshen and Chuanxiong may enhance blood flow and microcirculation, reducing cardiac stress and, consequently, the release of BNP and troponin [19]. The antioxidant effects of Chuanxiong can protect myocardial cells from oxidative stress, which is linked to heart failure and elevated BNP levels [20]. The study does have some limitations. The sample size of 70 patients per group might be too small to fully support the generalizability of the findings, which could affect external validity. Additionally, the follow-up duration was limited to 5 days, making it difficult to assess the long-term efficacy and safety of DSCXQ treatment. The absence of a double-blind design may also introduce some selection bias, which could influence the reliability of the conclusions. Moreover, the study didn't thoroughly consider potential confounding factors like other medications or therapies, and it did not evaluate the specific impact of the intervention on clinical symptoms, quality of life, or patient functional status. These points suggest that larger studies with longer follow-up and more rigorous designs would be beneficial to better understand the efficacy and safety of DSCXQ as an adjunctive treatment for ACS. Future research could aim to confirm these initial findings and explore the broader implications of DSCXQ in ACS management.

7. Conclusion

The study findings indicate that the treatment group receiving standard therapy with Dan Shen Chuan xiong qin Injection demonstrated significant improvements in BNP and troponin levels when compared with those received conventional therapy. This study emphasizes the possible benefits of combining traditional Chinese and Western medicine for ACS, indicating that DSCXQ may enhance key clinical outcomes. Nevertheless, additional research is required to fully evaluate the long-term safety and effectiveness of this integrative treatment approach. These results advocate for a nuanced understanding of traditional Chinese medicine, positioning it not merely as an alternative but as a complementary therapy that could provide added advantages alongside standard treatments.

Author contributions: Conceptualization, XZ and MGL; methodology, XZ; software, XZ; validation, XZ and MGL; formal analysis, XZ; investigation, XZ; resources, XZ; data curation, XZ; writing—original draft preparation, XZ; writing—review and editing, MGL; visualization, XZ; supervision, MGL; project administration, MGL; funding acquisition, XZ and MGL. All authors have read and agreed to the published version of the manuscript.

Ethical approval: The study was conducted in accordance with the Declaration of Helsinki and was approved by Medical Ethics Committee of Jinan Fuyuan Rehabilitation Hospital. Ethical Review No:2023-LW-02.

Conflict of interest: The author declares no conflict of interest.

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