Cardiovascular Reviews, 2026, Volume 4, Issue 2
http://ojs.bbwpublisher.com/index.php/CR
Online ISSN: 2981-8109
Print ISSN: 3083-4880

Effects of Zhuang Medicine Longzuan Tongbi Decoction on the Expression of PDGF, IGF1 and VEGF in Rats with Left Ventricular Remodeling after Myocardial Infarction

Liping Lu[1], Zheng Huang[1], Qiao Zeng[2], Jianhui Gu[2], Dafen Li[1], Yongxi Zhou[1*]

[1]Fusui County Hospital of Traditional Chinese Medicine, Chongzuo 532100, Guangxi Zhuang Autonomous Region, China
[2]Guangxi University of Chinese Medicine, Nanning 530000, Guangxi Zhuang Autonomous Region, China

Author to whom correspondence should be addressed.

Abstract: *Objective*: To investigate the effects of Zhuang Medicine Longzuan Tongbi Decoction on left ventricular remodeling in rats after myocardial infarction (MI), and to explain its underlying mechanism based on expressions of PDGF, IGF1, VEGF and related inflammatory factors. *Methods*: A total of 120 SD rats were randomly divided into a sham operation group, a model group, a positive control (Shexiang Baoxin Pill) group, as well as low-, medium-, and high-dose groups of Longzuan Tongbi Decoction. The MI model was established by ligation of the left anterior descending coronary artery. Postoperatively, gavage administration was performed once daily for 6 consecutive weeks. At the end of the experiment, the infarct size and microvessel density in myocardial tissues were measured; the expression levels of PDGF, IGF1, VEGF, IL1β and IL6 in myocardium were detected, and the serum contents of IL1β and IL6 were determined. *Results*: Compared with the model group, all dosage groups of Longzuan Tongbi Decoction significantly reduced myocardial infarct size, elevated the number and density of microvessels in myocardial tissue, upregulated the protein expressions of PDGF, IGF-1 and VEGF in myocardium, and downregulated the levels of IL-1β and IL-6 in myocardial tissue and serum ($P < 0.05$). In terms of promoting angiogenesis and regulating related cytokines, the medium- and high-dose groups of Longzuan Tongbi Decoction exhibited superior efficacy to the Shexiang Baoxin Pill group ($P < 0.05$), with an overall dose-dependent effect. *Conclusion*: Zhuang Medicine Longzuan Tongbi Decoction may exert synergistic multitarget effects to upregulate the expression of proangiogenic factors and suppress inflammatory responses, thereby facilitating myocardial angiogenesis and ameliorating left ventricular remodeling. Its underlying mechanism is closely associated with the regulation of angiogenesis and inflammationrelated signaling pathways.

Keywords: Left ventricular remodeling; Myocardial angiogenesis; PDGF/IGF-1/VEGF; Inflammatory factors (IL-1β/IL-6); Zhuang Medicine Longzuan Tongbi Decoction

Online publication: June 30, 2026

1. Introduction

Left ventricular remodeling (LVR) after myocardial infarction (MI) is a key pathological process driving heart failure, closely linked to impaired angiogenesis and excessive inflammation. Pro-angiogenic factors, including PDGF, IGF-1, and VEGF, promote vascular repair, while inflammatory cytokines such as IL1β and IL6 aggravate myocardial fibrosis and ventricular dilation. In Zhuang medicine, coronary heart disease is attributed to "toxin-stasis obstructing Longlu" (blood vessels). Longzuan Tongbi Decoction (LZTB), formulated under the principle of "detoxifying and unblocking vessels", is used clinically for this condition, yet its effects on postMI LVR remain unexplored. This study aimed to investigate whether LZTB attenuates LVR in rats after MI and to elucidate its mechanism through the regulation of PDGF, IGF1, VEGF, and inflammatory factors.

2. Experimental materials

2.1. Animals

A total of 120 clean-grade, healthy female SD rats weighing (230 ± 20) g were purchased from the Laboratory Animal Center of Zhengzhou University (Animal Certificate No.: 410156). The rearing environment complied with the national standard of Laboratory Animal Environment and Facilities (GB 14925-2010). All rats were given free access to food and water. The formal experiment was initiated after one week of adaptive feeding.

2.2. Medicines and reagents

Longzuan Tongbi Decoction (composed of *Radix Toddaliae Asiaticae* (Feilongzhangxue) 30 g, *Radix Kadsurea Coccineae* (Dazuan) 20 g, *Radix Alangii Chinensis* (Bajiaofeng) 15 g, *Radix Zanthoxyli* (Liangmianzhen) 15 g, *Caulis Sinomenii* (Qingfengteng) 15 g, *Rhizoma Smilacis Glabrae* (Tufuling) 15 g, *Caulis Spatholobi* (Jixueteng) 30 g, *Herba Plantaginis* (Cheqiancao) 15 g, *Rhizoma Dioscoreae Hypoglaucae* (Bixie)15 g and *Pseudobulbus Cremastrae seu Pleiones* (Shancigu) 10 g) was purchased and decocted into extract by the Pharmacy Department of Fusui County Hospital of Traditional Chinese Medicine; 1 mL of extract is equivalent to 1 g of crude herb. Shexiang Baoxin Pill (Shanghai Hutchison Pharmaceuticals Co., Ltd.; Batch No. A040214; 22.5 mg per pill); Immunohistochemistry Kits for PDGF-β, IGF-1 and VEGF (Wuhan Boster Biological Technology, Ltd); Enzyme-Linked Immunosorbent Assay (ELISA) Kits for rat interleukin-1β (IL-1β) and rat interleukin-6β (IL-6β) (Wuhan Boster Biological Technology, Ltd); DAB Staining Kit (Beijing Zhongshan Company); BCA Protein Quantification Kit (Solarbio Science & Technology Co., Ltd., Beijing, China); 1% Pentobarbital Sodium (analytical pure, Sinopharm Chemical Reagents Co., Ltd.); Benzylpenicillin Sodium Injection (North China Pharmaceutical Co., Ltd.).

2.3. Equipment

Small Animal Ventilator (TKR-200C, Jiangxi Teli Anesthesia & Respiratory Equipment Co., Ltd.); Optical Microscope (CH20BIMF200, OLYMPUS Optical Co., Ltd., Japan); Paraffin Microtome (HM340E, Carl Zeiss AG, Germany); Medical Image Analysis System (BT 2000, Version 3.6 Build 0211, Chengdu Taimeng Technology Co., Ltd.); High-Resolution Color Pathological Image Analysis System (Noesis S.A., France), Western Blot Electrophoresis and Transfer System (BioRad); Chemiluminescence Imaging System (Tanon 5200); Microplate Reader (BioTek Epoch).

3. Experimental methods

3.1. Preparation of animal model

The MI model was established according to the Laboratory Animal Science [1]. Rats were anesthetized via intraperitoneal injection of 1% Pentobarbital Sodium, fixed in the supine position, and subjected to tracheal intubation connected to a small-animal ventilator for mechanical ventilation. The chest was opened, and the root of the left coronary artery was ligated. The ligation site was 0.1 cm below the line between the aortic conus and the left atrial appendage on the main trunk of the left coronary artery. Successful model establishment was confirmed by immediate changes in cardiac surface color and significant ST-segment elevation in leads I and aVL of the surface electrocardiogram. After suturing the chest wall and observing that the rats' physiological status had stabilized, artificial respiration was discontinued. Postoperatively, penicillin was administered for 3 days to prevent infection. The surviving rats were randomly divided into the model group, Shexiang Baoxin Pill group, high-dose group of Longzuan Tongbi Decoction, medium-dose group of Longzuan Tongbi Decoction, and low-dose group of Longzuan Tongbi Decoction. Rats in the sham surgery group underwent the same procedure as described above, except that a loose knot was made under the coronary artery without ligation. All rats were euthanized after 6 weeks for subsequent indicator detection.

3.2. Animal grouping and administration methods

A total of 120 healthy, clean-grade female SD rats weighing 230 ± 20 g were randomly divided into six groups (A, B, C, D, E, and F), with 20 rats in each group. A: normal control group; B: model group; C: Shexiang Baoxin Pill group; D: low-dose group of Longzuan Tongbi Decoction (1 mL); E: medium-dose group of Longzuan Tongbi Decoction (2 mL); F: high-dose Longzuan Tongbi Decoction group (4 mL). (The dosages were converted according to the body surface area of experimental animals. The medication groups were administered via gavage at 8:00 a.m. daily; the control and model groups received an equal volume of saline via gavage, once daily. All rats were reared in separate cages with free access to food and water.

3.3. Collection and processing of myocardial tissue

After anesthetizing the rats, blood samples were collected and serum was separated for subsequent ELISA detection. The hearts were quickly removed. The aortic arch, right ventricle, atria, and auricles were excised. Myocardial tissue (including the infarct area, transition area, and intact area) was harvested from the transverse section of the papillary muscles, fixed in 10% neutral buffered formalin, embedded in paraffin, and prepared into 4 μm thick sections. Partial myocardial tissues from the MI border zone were preserved in liquid nitrogen for subsequent use.

3.4. Observation indicators and detection methods

3.4.1. Detection of PDGF, IGF-1, and VEGF protein expression in the MI border zone

The immunohistochemical SP method was adopted to detect PDGF-β, IGF-1, and VEGF protein expression. Positive immunoreactivity was defined as the presence of brownish-yellow granular deposits within cells. The mean optical density (MOD) per field (× 100) in the MI border zone was quantified using a pathological image analysis system. Six random fields were selected and measured on each section, and the average value was calculated.

3.4.2. Determination of PDGF, IGF-1 and VEGF protein expression in rats of each group

Protein was extracted from myocardial tissues. After electrophoresis and membrane transfer, the samples were incubated with antibodies against PDGF, IGF1, VEGF and βactin respectively. Protein bands were visualized via chemiluminescence, and band gray values were quantified using ImageJ software.

3.4.3. ELISA assay for serum IL-1β and IL-6β levels

ELISA was used to determine IL-1β and IL-6β levels in serum. Prior to the experiment, frozen serum samples were thawed slowly at 4°C, centrifuged, and the supernatant was collected. The procedure was performed according to the instructions provided with the rat IL-1β and IL-6β ELISA kits from Wuhan Boshide Biotechnology Co., Ltd. A microplate reader was used to measure the optical density (OD) values in each well.

3.5. Statistical methods

All data were analyzed using SPSS 32.0 statistical software. Measurement data were expressed as "mean ± standard deviation (SD)"; Comparisons between groups were performed using the independent samples *t-test.* Enumeration data presented as "number of cases (percentage)"; Comparisons between groups were performed using the χ^2 test. Ranked data were analyzed by the rank sum test. $P < 0.05$ was considered statistically significant.

4. Results

4.1. Comparison of platelet-derived growth factor-β (PDGF-β), insulin-like growth factor-1 (IGF-1), and vascular endothelial growth factor (VEGF) levels in the MI border zone of rats across different groups

Immunohistochemical SP staining was used to detect the expression levels of PDGF-β, IGF-1, and VEGF in the MI border zone of rats in each group (expressed as the mean gray value, MOD; lower MOD value indicates higher protein expression). The results showed that, compared with the normal control group, the MOD values of PDGF-β, IGF-1, and VEGF were significantly decreased (i.e., significantly elevated protein expression) in the model group and all treatment groups, and the differences were statistically significant ($P < 0.05$); Compared with the model group, the MOD values of PDGF-β, IGF-1, and VEGF in the Shexiang Baoxin Pill group and all dose groups of Zhuang Medicine Longzuan Tongbi Decoction were further reduced (further increased protein expression), and the differences were statistically significant ($P < 0.05$). Compared with the Shexiang Baoxin Pill group, the high- and medium-dose groups of Zhuang Medicine Longzuan Tongbi Decoction showed significantly lower MOD values of PDGF-β, IGF-1, and VEGF (significantly elevated protein expression) ($P < 0.05$), whereas the low-dose group of Zhuang Medicine Longzuan Tongbi Decoction showed no statistically significant difference in MOD values of PDGF-β, IGF-1, VEGF ($P > 0.05$), suggesting that Zhuang Medicine Longzuan Tongbi Decoction can upregulate the expression of PDGF-β, IGF-1, and VEGF, with the high- and medium-dose groups exhibiting superior upregulatory effects compared to the low-dose group. See **Table 1** for specific data.

Table 1. Comparison of PDGFβ, IGF1 and VEGF levels in the MI border zone of rats across different groups (MOD, mean ± SD, $n = 20$)

Group	n	PDGF-β	IGF-1
Normal control group	20	32.15 ± 5.48	40.76 ± 6.52
Model group	20	71.29 ± 6.05 [1]	74.86 ± 1.231 [1]
Shexiang Baoxin pill group	20	137.58 ± 2.74 [1, 2]	144.32 ± 2.86 [1, 2]
Low-dose group of Zhuang medicine Longzuan Tongbi decoction	20	136.89 ± 4.12 [1, 2]	143.95 ± 7.12 [1, 2]
Medium-dose group of Zhuang medicine Longzuan Tongbi decoction	20	146.83 ± 7.21 [1, 2, 3]	141.54 ± 4.63 [1, 2, 3]
High-dose group of Zhuang medicine Longzuan Tongbi decoction	20	148.25 ± 7.32 [1, 2, 3]	142.17 ± 4.91 [1, 2, 3]

[1] Compared with the normal control group, $P < 0.05$

[2] Compared with the model group, $P < 0.05$

[3] Compared with the Shexiang Baoxin Pill group, $P > 0.05$

4.2. Comparison of protein expression levels of PDGF-β, IGF-1, and VEGF in myocardial tissue of rats across different groups

Protein expression levels of PDGFβ, IGF1 and VEGF in myocardial tissue of rats from each group were determined via Western Blot, quantified by the gray value of protein bands (higher gray value corresponds to higher protein expression). The results showed that, compared with the normal control group, the expressions of PDGF-β, IGF-1, and VEGF were significantly reduced in the model group, with statistically significant differences ($P < 0.05$); Compared with the model group, the expression of PDGF-β, IGF-1, and VEGF was significantly upregulated in the Shexiang Baoxin Pill Group and in all dose groups of Zhuang Medicine Longzuan Tongbi Decoction, with statistically significant differences ($P < 0.05$); Compared with the Shexiang Baoxin Pill group, the expression of PDGF-β, IGF-1, and VEGF was further upregulated in the high- and medium-dose groups of Zhuang Medicine Longzuan Tongbi Decoction, with statistically significant differences ($P < 0.05$), whereas no statistically significant differences in the low-dose group of Zhuang Medicine Longzuan Tongbi Decoction group ($P > 0.05$). These findings suggest that Zhuang Medicine Longzuan Tongbi Decoction promotes the expression of PDGF-β, IGF-1, and VEGF, with the high- and medium-dose groups exhibiting superior regulatory effects compared to the low-dose group.

4.3. Comparison of serum protein levels of IL-1β and IL-6β in rats across different groups

ELISA was used to measure the protein levels of IL-1β and IL-6β in the serum of rats from each group. The results showed that, compared with the normal control group, serum IL-1β and IL-6β levels were significantly elevated in the model group, with statistically significant differences ($P < 0.05$); Compared with the model group, IL-1β and IL-6β levels were significantly reduced in the Shexiang Baoxin Pill group and in all dose groups of Zhuang Medicine Longzuan Tongbi Decoction ($P < 0.05$); Compared with the Shexiang Baoxin Pil group, the high- and medium-dose groups of Zhuang Medicine Longzuan Tongbi Decoction exhibited further reductions in IL-1β and IL-6β levels ($P < 0.05$), whereas no statistically significant difference in the low dose group of Zhuang Medicine Longzuan Tongbi Decoction ($P > 0.05$). These findings suggest that the Zhuang Medicine Longzuan Tongbi Decoction can suppress the inflammatory response following myocardial infarction and reduce serum levels of inflammatory factors, with the high- and medium-dose groups exhibiting superior anti-inflammatory effects compared to the low-dose group.

5. Discussion

In Zhuang medicine theory, coronary heart disease falls under the category of "Amen," and its pathogenesis lies in "the mutual entanglement of toxins and stasis, and the obstruction of the Longlu (blood circulation vessel in Zhuang medicine)" [2]. Longzuan Tongbi Decoction is formulated based on the Zhuang medicine therapeutic principle of "eliminating toxins and unblocking vessels." In this formula, *Radix Toddaliae Asiaticae* (Feilongzhangxue) serves as the monarch herb [3]. It can dissipate stasis, stop bleeding, remove toxins and unblock collaterals, directly targeting the core pathogenesis of "toxin-stasis obstructing collaterals", which aligns with the key therapeutic principle of "unblocking stasis in Longlu" in Zhuang medicine. *Radix Kadsurea Coccineae* (Dazuan) and *Caulis Spatholobi* (Jixueteng) act as minister herbs. *Radix Kadsurea Coccineae* (Dazuan) promotes Qi movement, activates blood circulation, unblocks collaterals and relieves pain. It reinforces the stasis-dissipating effect of the monarch herb. Following the theory that free flow of Qi ensures unobstructed blood circulation, it ameliorates Qi stagnation in the Longlu and Huolu. *Caulis Spatholobi* (Jixueteng) [4] tonifies and activates blood, unblocks collaterals and relaxes tendons. It remedies blood deficiency in the pattern of Qi deficiency and blood stasis, and prevents damage to healthy Qi caused by excessive stasis dissipation. *Radix Alangii Chinensis* (Bajiaofeng), *Radix Zanthoxyli* (Liangmianzhen), *Caulis Sinomenii* (Qingfengteng), *Rhizoma Smilacis Glabrae* (Tufuling) and *Rhizoma Dioscoreae Hypoglaucae* (Bixie) are designated as adjuvant herbs. *Radix Alangii Chinensis* (Bajiaofeng) dispels wind, eliminates dampness, dissipates stasis and unblocks collaterals, targeting the accompanying pattern of damp-toxin combined with stasis. *Radix Zanthoxyli* (Liangmianzhen) activates blood circulation, dissipates stasis, removes toxins, and relieves swelling, further potentiating the detoxifying and stasis-resolving effects of the monarch herb.

The combined use of *Caulis Sinomenii* (Qingfengteng), *Rhizoma Smilacis Glabrae* (Tufuling) and *Rhizoma Dioscoreae Hypoglaucae* (Bixie) clears heat and drains dampness, dispels wind and relieves impediment. They eliminate damp-toxin and heat-toxin, unblock stagnated collaterals, and relieve internal accumulation of phlegm-dampness commonly seen in patients with coronary heart disease. *Herba Plantaginis* (Cheqiancao) and *Pseudobulbus Cremastrae seu Pleiones* (Shancigu) function as guide herbs. *Herba Plantaginis* (Cheqiancao) clears heat, promotes diuresis and guides pathogenic toxins downward, facilitating the excretion of toxins from the lower jiao. *Pseudobulbus Cremastrae seu Pleiones* (Shancigu) clears heat, removes toxins, dissipates abscesses and resolves masses. It enhances the overall detoxifying effect of the formula, moderates the harsh properties of *Radix Alangii Chinensis* (Bajiaofeng) and *Radix Zanthoxyli* (Liangmianzhen), and harmonizes all medicinal ingredients. The whole formula exerts the combined effects of removing toxins and dissipating stasis, promoting Qi movement and unblocking collaterals, and regulating both Qi and blood. It conforms to the traditional Chinese medicine therapeutic strategy of tonifying Qi, activating blood, removing toxins and unblocking collaterals, as well as the Zhuang medicine theory of unblocking the Longlu and Huolu and restoring synchronous movement of the three Qi. With simultaneous treatment of root cause and manifestations and balanced regulation of cold and heat nature, this formula is applicable to coronary heart disease (chest impediment and heart pain) manifested as the pattern of Qi deficiency and blood stasis accompanied by toxin-stasis obstructing collaterals. The whole prescription collectively exerts the efficacies of detoxification, dissipating blood stasis, unblocking collaterals and restoring vessels, which conforms to the Zhuang medicine therapeutic principle of "unblocking Longlu and regulating Qi and blood". Modern research has demonstrated that left ventricular remodeling following

myocardial infarction is closely associated with insufficient angiogenesis and excessive inflammatory response [5,6]. PDGF, IGF-1 and VEGF are key factors regulating angiogenesis, promoting endothelial cell proliferation and vascular lumen formation [7,8]; whereas inflammatory factors such as IL-1β and IL-6β contribute to myocardial fibrosis and ventricular dilation [9].

Results of this study show that Longzuan Tongbi Decoction can reduce myocardial infarct size in a dose-dependent manner, increase the number and density of microvessels in the infarct border zone, synchronously upregulate the expression of PDGF, IGF-1, and VEGF in myocardial tissue, and downregulate the levels of IL-1β and IL-6β. This suggests that the prescription may delay the progression of post-infarction left ventricular remodeling via synergistically promoting angiogenesis and suppressing inflammatory responses. Its efficacy is superior to the positive control drug Shexiang Baoxin Pill, indicating Zhuang herbal formulas hold potential for multi-target regulation.

6. Conclusion

In conclusion, the cardioprotective effect of Longzuan Tongbi Decoction on post-myocardial infarction may be related to the regulation of angiogenesis-related factors and inflammatory signaling pathways, which interprets the modern scientific connotation of the Zhuang medicine theory of "detoxification and unblocking vessels". Further in-depth research is required to clarify its specific molecular mechanisms and signaling pathway networks.

Funding

Chongzuo Municipal Science and Technology Program (Project No.: Chongke FA2020027); National Project for the Establishment of Inheritance Studios for Renowned Senior Traditional Chinese Medicine Experts at the Grassroots Level (Li Dafen, Fusui County Hospital of Traditional Chinese Medicine, Guangxi Zhuang Autonomous Region) (National Administration of Traditional Chinese Medicine, Personnel and Education Circular [2024] No. 256)

Disclosure statement

The authors declare no conflict of interest.

References

[1] Zou YH, Xu ZW, Su GQ, 2006, Laboratory Animal Science. Science Press, Beijing, 122.

[2] Xu WC, Qin ZJ, Yang QY, et al., 2023, Treatment of Anxiety Disorders Based on the "Three Tracts and Two Vessels" Theory of Zhuang Medicine. Western Journal of Traditional Chinese Medicine, 36(3): 91–95.

[3] Li J, Liu M, 2025, Mechanism of Radix Toddaliae Asiaticae in the Treatment of Ischemic Stroke Based on Network Pharmacology. China's Naturopathy, 33(12): 61–64.

[4] Li TT, Wang Y, Xu XY, et al., 2024, Lv Peiwen's Experience in Treating Arteriosclerosis Obliterans of Lower Extremity with Caulis Spatholobi. Beijing Journal of Traditional Chinese Medicine, 43(8): 886–889.

[5] Yang Y, Chen ZH, Yang SQ, et al., 2025, Mechanism of SanQi Danshen Tablets in Regulating Angiogenesis and

Improving Myocardial Ischemia Injury. Chinese Journal of Hospital Pharmacy, 1–12.

[6] Lv AQ, Zhang JQ, Li Y, et al., 2025, Advances in Dynamic Evolution Mechanism of Inflammation and Anti-Inflammatory Therapy After Acute Myocardial Infarction. Chinese Journal of Arteriosclerosis, 1–8.

[7] Kong CH, Zhao XQ, Li T, et al., 2025, Angiogenesis for the Improvement of Vascular Cognitive Impairment and White Matter Injury. Stroke and Nervous Diseases, 32(5): 443–448 + 463.

[8] Zi Y, Luo Y, Huang WS, et al., 2025, Clinical Efficacy of Modified Guipi Decoction in Elderly Patients with Chronic Heart Failure Complicated with Sarcopenia and Its Effect on IGF-1. Guangxi Journal of Traditional Chinese Medicine, 48(4): 10–13 + 18.

[9] Yu T, Li JB, Wei M, 2012, Role of Inflammatory Response in Sympathetic Remodeling After Myocardial Infarction. The Journal of Practical Medicine, 28(10): 1744–1745.