Three-dimensional speckle tracking echocardiography to evaluate left ventricular function in patients with acute ST-segment elevation myocardial infarction after percutaneous coronary intervention following Tongxinluo treatment

Wenjuan Qin | Ruimeng Tian | Jia Feng | Zijing Zhai | Zhen Wang | Lei Huang | Guilin Lu | Shanshan Dong

Department of Ultrasonography, First Affiliated Hospital, School of Medicine, Shihezi University, Shihezi, China

Abstract

Objective: Bying comparing the correlation between three-dimensional speckle tracking echocardiography (3D-STE) and troponin I (cTn I), three-dimensional left ventricular ejection fraction (3D-LVEF), to explore the 3D-STE to evaluate the left ventricle of patients with acute ST-segment elevation myocardial infarction (AMI) after percutaneous coronary intervention (PCI) following routine treatment with Tongxinluo drugs.

Methods: Altogether, 61 patients with AMI and 30 healthy adults were selected, and the patients were divided into the routine group and the Tongxinluo group. The serum creatine kinase isoenzyme (CK-MB) and troponin I (cTn I) levels were detected in all patients after admission. All patients underwent PCI, and routine echocardiography and 3D-STE assessments were performed for each group 72 h after PCI and 12 months after PCI to obtain the following left ventricular-related functional parameters: left ventricular end-diastolic diameter (LVEDD), end-ventricular septal end-diastolic thickness (IVSD), left ventricular posterior wall end-diastolic thickness (LVPWD), left ventricular short axis shortening fraction (LVFS), Simpson’s left ventricular ejection fraction (Simpson’s LVEF), three-dimensional left ventricular ejection fraction (3D-LVEF), global longitudinal strain (GLS), global circumferential strain (GCS), left ventricular twist angle (LVtw), Torsion (Tor), peak strain dispersion (PSD), and myocardial comprehensive index (MCI). The same parameters were collected in the control group, the results were compared. The correlation analysis between 3D-STE parameters and 3D-LVEF, cTn I was performed. A total of 10 individuals were selected for repeatability testing.

Results: Compared with the control group, the LVFS, LVEF (Simpson), 3D-LVEF, GLS, GCS, LVtw, Tor, and MCI significantly decreased in patients with STEMI after PCI, while the PSD significantly increased (p < 0.05). Compared with the values 72 h after PCI, the LVEDD, LVFS, LVEF (Simpson), 3D-LVEF, GLS, GCS, LVtw, Tor, and MCI significantly increased at 12 m after PCI, while PSD significantly decreased (p < 0.05).
No significant difference was observed between the two groups at 72 h after PCI ($p > 0.05$). At 12 months after PCI, the LVEF, GLS, GCS, LVtw, Tor, and MCI of the Tongxinluo group were higher than those of the routine group. The PSD was significantly lower in the Tongxinluo group ($p < 0.05$). MCI and 3D-LVEF, cTn I have the strongest correlation and the highest consistency, which can best reflect the changes in the left ventricular function in patients with AMI after PCI.

**Conclusion:** 3D-STE can be used to evaluate the protective effect of Tongxinluo on the left ventricular function in patients with AMI after PCI.

**KEYWORDS**
acute ST-segment elevation myocardial infarction, myocardial comprehensive index, three-dimensional speckle echocardiography, Tongxinluo

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1 | INTRODUCTION

Acute myocardial infarction (MI) is a common cardiovascular disease with a rapid onset and high fatality rate, and the age of onset has gradually become younger in the recent years.\(^1\,^2\) Acute ST-segment elevation MI (AMI) should be used when there is evidence of myocardial injury with necrosis in a clinical setting consistent with myocardial ischaemia.\(^3\) PCI and adjuvant drugs after PCI are the first choice in clinical treatment, and the treatment effect is better.\(^4\) Tongxinluo is one of the commonly used drugs after PCI in patients with AMI in traditional Chinese medicine. It protects myocardial cells and helps regenerate blood vessels, thereby promoting the recovery of cardiac function in patients.\(^5\,^6\) However, the current research on the long-term use of Tongxinluo drugs to promote the recovery of AMI after PCI remains insufficient. Traditional two-dimensional echocardiography can promptly obtain relevant parameters reflecting the patient’s cardiac function; however, its sensitivity is inadequate, and it is difficult to identify the subtle changes in cardiac structure and function after PCI.\(^7\) Three-dimensional speckle tracking echocardiography (3D-STE) can effectively avoid the interference of the measurement plane motion. It is a sensitive and repeatable and noninvasive detection method that can identify the changes in the patient’s left heart function early.\(^8\,^9\) Therefore, this study used 3D-STE to evaluate the changes in left ventricular function in patients with AMI who received Tongxinluo after PCI, and judged its clinical application value.

2 | MATERIALS AND METHODS

2.1 | Participants

This study is a prospective, non-randomized and single-blind study. 97 patients with AMI admitted from October 2019 to October 2020 were selected, and 61 patients finally met the inclusion criteria. All patients underwent emergency PCI. According to the wishes of the patients and their families, patients were treated with different drugs before and after PCI, and were divided into routine group ($n = 30$, 13 cases of anterior MI and 17 cases of inferior MI) and Tongxinluo group ($n = 31$, 12 cases of anterior MI and 19 cases of inferior MI) based on the types of drugs. Additionally, 30 healthy people were selected as the control group. The routine group was given conventional treatment drugs (aspirin enteric-coated tablets + ticagrelor tablets + statin lipid-lowering drugs + β-blocker) after emergency PCI. The Tongxinluo group was prescribed with eight capsules of Tongxinluo taken orally before emergency PCI, and prescribed with Tongxinluo in addition to the conventional treatment drugs after PCI (4 capsules/time, 3 times/day, continuous use for 12 months). Meanwhile, the routine group and Tongxinluo groups decided whether to choose angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, diuretics, and hypoglycemic drugs according to the needs of their conditions (Figure 1).

The inclusion criteria were as follows: (1) chest pain from acute infarction onset within 24 h, (2) meeting the diagnostic criteria for acute MI established by the European Society of Cardiology (ESC) in 2017,\(^3\) (3) all AMI patients after PCI, (4) myocardial reinfarction did not occur within 1 year after PCI, and (5) willingness to participate in this study.

The exclusion criteria were as follows:\(^3\): (1) non-ST-segment elevation MI, (2) with severe heart failure, uncontrollable arrhythmia,
severe liver and kidney diseases, severe infection, severe coagulation abnormality, malignant tumors, or suffering from neuropsychiatric illnesses. (3) Recurrent myocardial infarction within 1 year after PCI, and (4) the images obtained by the ultrasound are of poor quality and the complete study data of the patients cannot be obtained.

The institutional ethics committee approved the study protocol, and all patients and their families provided informed consent.

2.2 Instruments and Methods

Venous blood was collected from the patients after admission, and the levels of creatine kinase isoenzyme (CK-MB) and troponin I (cTn I) in the blood were detected by research instruments. The GE Vivid E9 ultrasound instrument (probe: 4 V, frequency: 1.5 ~ 4.0 MHz) was used in this study. The echocardiographic images of healthy people and patients 72 h and 12 months after PCI were collected and analyzed. The steps to collect images are as follows: the patient's information was recorded, and the patients were asked to assume the left decubitus position and breathe calmly. After connecting the cardiogram, the patients were asked to hold their breath. Obtain conventional echocardiographic parameters in 2D mode: left ventricular end-diastolic diameter (LVEDD), end-ventricular septal end-diastolic thickness (IVSD), left ventricular posterior wall end-diastolic thickness (LVPWD), left ventricular short axis shortening fraction (LVFS), and left ventricular ejection fraction (LVEF). After obtaining a clear two-dimensional image, the 4D mode was entered, and three consecutive and stable images were quickly collected. Image of the cardiac cycle and import it into the background to obtain research parameters: Additionally, the EchoPAC7.0 workstation and offline analysis software were used for post-processing to track the boundaries of the left ventricle endocardium and epicardium during the complete cardiac cycle to obtain the following 3D parameters: three-dimensional left ventricular ejection fraction (3D-LVEF), global longitudinal strain (GLS), global circumferential strain (GCS), left ventricular twist angle (LVtw), torsion (Tor) and peak strain dispersion (PSD), and the Myocardial Comprehensive Index (MCI) was calculated. All ultrasound images were acquired by two sonographers with more than 10 years of work experience. And all physicians conducting the data collection were unaware of the subjects' groupings. Select 10 study subjects, the intra-observer repeatability is obtained by comparing the difference of parameters obtained by two doctors, and the inter-observer repeatability is obtained by comparing the difference of parameters measured twice by the same doctor. The correlation analysis of cTn I levels and 3D-STE parameters of 61 patients was performed at 72 h after PCI, and the correlation analysis of 3D-STE parameters and 3D-LVEF parameters of patients at 12 m after PCI.

2.3 Statistical analysis

Statistical analysis was performed using the SPSS 22.0 software. Non-normally distributed data were analyzed by χ² test, and normally distributed data were analyzed using t-tests, respectively. Data comparison between two groups was conducted by LSD-t test, and data comparison between multiple groups was conducted by one-way analysis of variance (ANOVA). The Pearson correlation coefficient was used to evaluate the relationship. The reproducibility test was evaluated using intra-group correlation coefficient (ICC), ICC >0.75 indicates high reproducibility. Statistical significance was defined as P < 0.05.

| TABLE 1 Comparison of basic data between groups |
|-----------------------------------------------|
|                                | Control group (n = 30) | Routine group (n = 30) | Tongxinluo group (n = 31) | Test | P       |
|-----------------------------------------------|
| Sex (m/f)                                  | 27/3                  | 28/2                  | 27/4                       | χ² = 0.666 | 0.717   |
| Age (years)                                | 55.03 ± 8.98          | 56.17 ± 9.67          | 55.33 ± 11.06              | F = 0.100  | 0.905   |
| BMI (kg/m²)                                | 22.97 ± 2.72          | 22.97 ± 2.24          | 23.62 ± 2.56               | F = 0.657  | 0.521   |
| HR (bmp)                                   | 75.07 ± 8.31          | 73.70 ± 9.45          | 72.13 ± 7.23               | F = 0.930  | 0.399   |
| SBP (mmHg)                                 | 119.90 ± 12.26        | 117.03 ± 12.43        | 120.13 ± 15.14             | F = 0.487  | 0.616   |
| DBP (mmHg)                                 | 81.60 ± 9.74          | 76.97 ± 10.00         | 79.47 ± 12.20              | F = 1.408  | 0.250   |
| Auxiliary medication situation (cases)     |                       |                       |                            |        |
| ACEI/ARB                                    | –                     | 9                     | 11                         | χ² = 0.018 | 0.893   |
| β-blocker                                   | –                     | 16                    | 12                         | χ² = 0.027 | 0.869   |
| Diuretics                                   | –                     | 13                    | 10                         | χ² = 1.352 | 0.244   |
| Hypoglycemic drugs                          | –                     | 12                    | 9                          | χ² = 0.396 | 0.529   |
| Number of stents implanted during PCI (cases) |                       |                       |                            |        |
| Stent                                       | –                     | 49                    | 47                         | χ² = 1.022 | 0.600   |

Abbreviations: ACEI, angiotensin-converting enzyme inhibitors; and ARB, angiotensin receptor blockers; BMI, body mass index; DBP, diastolic blood pressure; HR, heart rate; SBP, systolic blood pressure.
TABLE 2   Serum myocardial enzyme levels of the routine group, Tongxinluo group, and control group

|                    | Control group (n = 30) | Routine group (n = 30) | Tongxinluo group (n = 31) | F   | p    |
|--------------------|------------------------|------------------------|---------------------------|-----|------|
| CK-MB (U/L)        | 2806.5 ± 225.3         | 2756.9 ± 234.5         | 0.01                      | 0.403|
| cTn I (μg/L)       | 5.02 ± 1.35            | 5.04 ± 1.33            | 0.71                      | 0.909|

Abbreviations: CK-MB, creatine kinase isoenzyme (CK-MB); cTn I, troponin I.

TABLE 3   Conventional two-dimensional ultrasound parameters of the routine group, Tongxinluo group, and control group

| Parameters          | Control group (n = 30) | Routine group (n = 30) | Tongxinluo group (n = 31) | 72 h after PCI | 12 m after PCI |
|---------------------|------------------------|------------------------|---------------------------|----------------|----------------|
| LVEDD (mm)          | 46.69 ± 5.16           | 47.14 ± 5.09*          | 50.56 ± 4.87*             | 46.41 ± 5.46* | 50.33 ± 4.65*  |
| IVSD (mm)           | 8.51 ± 0.54            | 8.49 ± 0.85            | 8.45 ± 0.49               | 8.67 ± 0.62   | 8.45 ± 0.47    |
| LVFWS (mm)          | 8.45 ± 0.49            | 8.62 ± 0.89            | 8.48 ± 0.41               | 8.65 ± 0.95   | 8.52 ± 0.50    |
| LVFS (%)            | 40.46 ± 2.80           | 30.14 ± 2.95*          | 32.90 ± 2.52**            | 30.56 ± 2.80* | 32.30 ± 2.46** |
| LVEF (Simpson) (%)  | 66.46 ± 5.74           | 50.21 ± 5.30*          | 54.93 ± 5.49**            | 51.19 ± 5.87* | 55.23 ± 5.32** |

*Compared with the control group, P<0.05. **Compared with the same group at 72 h after PCI, P<0.05. Abbreviations: IVSD, end-ventricular septal end-diastolic thickness; LVEDD, left ventricular end-diastolic diameter; LVEF (Simpson), left ventricular ejection fraction (Simpson); LVFS, left ventricular short axis shortening fraction; LVPWD, left ventricular posterior wall end-diastolic thickness.

TABLE 4   Strain parameters and 3D-LVEF of the routine group, Tongxinluo group, and control group (x±s)

| Parameters          | Control group (n = 30) | Routine group (n = 30) | Tongxinluo group (n = 31) | 72 h after PCI | 12 m after PCI |
|---------------------|------------------------|------------------------|---------------------------|----------------|----------------|
| 3D-LVEF (%)         | 63.31 ± 3.78           | 47.78 ± 4.05*          | 55.21 ± 4.01***           | 48.14 ± 3.89* | 58.91 ± 4.08***|
| GLS (%)             | 22.18 ± 2.05           | 13.47 ± 1.92*          | 16.35 ± 1.96***           | 13.59 ± 1.91* | 18.06 ± 1.82***|
| GCS (%)             | 24.16 ± 2.39           | 15.00 ± 2.15*          | 17.89 ± 2.10***           | 15.27 ± 2.20* | 20.08 ± 2.09***|
| LVtw (C14°/cm)      | 14.41 ± 1.80           | 10.21 ± 2.12*          | 11.22 ± 1.82**            | 10.36 ± 2.04* | 12.75 ± 1.86***|
| Tor (C14°/cm)       | 1.80 ± 0.20            | 1.19 ± 0.24*           | 1.41 ± 0.19**             | 1.20 ± 0.21*  | 1.58 ± 0.23***|
| PSD (ms)            | 23.36 ± 4.12           | 41.09 ± 4.07*          | 33.91 ± 4.17***           | 40.62 ± 3.95* | 31.08 ± 3.60***|
| MCI(%)              | 318.40 ± 41.33         | 137.14 ± 33.18*        | 184.72 ± 43.34***         | 139.50 ± 28.23*| 231.24 ± 46.66***|

*Compared with the control group, P<0.05. **Compared with the same group at 72 h after PCI, P<0.05. ***Compared with the routine group at 12 m after PCI, P<0.05. Abbreviations: GLS, global longitudinal strain; GCS, global circumferential strain; LVtw, left ventricular twist angle; MCI, myocardial comprehensive index; PSD, peak strain dispersion; Tor, torsion; 3D-LVEF, three-dimensional left ventricular ejection fraction.

FIGURE 2   GCS in patients with AMI and healthy people. A. Control group. B. Routine group 72 h after PCI. C. Routine group 12 m after PCI. D. Tongxinluo group 72 h after PCI. E. Tongxinluo group 12 m after PCI. (Panels B and C were from the same typical patient. Panels D and E were from the same typical patient).
FIGURE 3  GLS in patients with AMI and healthy people. A. Control group. B. Routine group 72 h after PCI. C. Routine group 12 m after PCI. D. Tongxinluo group 72 h after PCI. E. Tongxinluo group 12 m after PCI. (Panels B and C were from the same typical patient. Panels D and E were from the same typical patient).

FIGURE 4  LVtw in patients with AMI and healthy people. A. Control group. B. Routine group 72 h after PCI. C. Routine group 12 m after PCI. D. Tongxinluo group 72 h after PCI. E. Tongxinluo group 12 m after PCI. (Panels B and C were from the same typical patient. Panels D and E were from the same typical patient).

FIGURE 5  Tor in patients with AMI and healthy people. A. Control group. B. Routine group 72 h after PCI. C. Routine group 12 m after PCI. D. Tongxinluo group 72 h after PCI. E. Tongxinluo group 12 m after PCI. (Panels B and C were from the same typical patient. Panels D and E were from the same typical patient).
3 | RESULTS

3.1 | Baseline characteristics of the study population

The baseline characteristics of the study population are summarized in Table 1. Altogether, 61 patients and 30 healthy people were included in this study. No significant differences in sex, age, body mass index, heart rate, systolic blood pressure, diastolic blood pressure, and adjuvant medication among all groups ($P > 0.05$)(Table 1).

3.2 | Serum myocardial enzyme

No significant differences in serum myocardial enzyme levels between routine group and Tongxinluo group ($p > 0.05$). (Table 2).

![FIGURE 6](image1.png) Scatter plots depicting the relationships between 3D-LVEF and 3D-STE parameters. A. GCS, B. GLS, C. LVtw, D. Tor, and E. MCI

![FIGURE 7](image2.png) Scatter plots depicting the relationships between cTn I and 3D-STE parameters. A. GCS, B. GLS, C. LVtw, D. Tor, and E. MCI
3.3 | Conventional two-dimensional ultrasound parameters

Compared with the control group, the LVFS, LVEF (Simpson) at 72 h after PCI in patients with AMI were significantly lower ($p < 0.05$). Meanwhile, the LVFS and LVEF (Simpson) at 12 m after PCI are lower in patients with AMI than those in the control group, and LVEDD was significantly higher in the patients than that in the control group ($p < 0.05$). No significant difference in parameters between Tongxinluo group and routine group at the same time (Table 3).

3.4 | 3D-STE strain parameters and 3D-LVEF

Compared with the control group, the 3D-LVEF, GLS, GCS, LVtw, Tor, and MCI of patients with AMI after PCI significantly decreased, and the PSD significantly increased ($p < 0.05$).
No significant difference in parameters between the Tongxinluo group and the routine group (p > 0.05) were observed 72 h after PCI. At 12 m after PCI, the values of 3D-LVEF, GLS, GCS, LVtw, Tor, and MCI of the Tongxinluo group were significantly higher than those of the routine group, while PSD was significantly lower than that of the routine group (p < 0.05).

Compared with the values at 72 h after PCI, the 3D-LVEF, GLS, GCS, LVtw, Tor, and MCI values at 12 m after PCI in patients all significantly increased, and the PSD value significantly decreased (p < 0.05) (Table 4 and Figures 2–5).

3.5 Correlation analysis between 3D-LVEF, cTn I and three-dimensional strain parameters

At 72 h after PCI, GCS, GLS, LVtw, Tor, and MCI were negatively correlated with cTn I. The absolute value of its correlation was: MCI > Tor > LVtw > GLS > GCS, and the correlation between MCI with 3D-LVEF was the strongest (Figure 6).

At 12 m after PCI, GCS, GLS, LVtw, Tor, and MCI were positively correlated with 3D-LVEF. The absolute value of its correlation was: MCI > Tor > LVtw > GLS > GCS, and the correlation between MCI with 3D-LVEF was the strongest (Figure 7).

3.6 Reliability and repeatability testing

Evaluating the measurement results of the same observer revealed that the ICC values of GCS, GLS, LVtw, Tor, PSD, and MCI were 0.813, 0.897, 0.841, 0.920, 0.811, and 0.918, respectively. The ICCs of GCS, GLS, LVtw, Tor, PSD, and MCI detected by different observers were 0.845, 0.891, 0.895, 0.931, 0.836, and 0.934, respectively. All comparisons indicated good repeatability (Figures 8 and 9).

4 DISCUSSION

Acute MI is one of the leading causes of mortality in developed countries and can be seriously life-threatening. AMI is the acute onset stage of MI, the preferred treatment for it is PCI, and the mortality rate of patients with AMI who received early PCI treatment is significantly reduced. However, drug adjuvant treatment is still needed after PCI to prevent complications, deterioration, and recurrence, and promote the recovery of the patients’ cardiovascular function. Tongxinluo is a Chinese patent medicine made of insects and herbs. It has the functions of protecting the myocardium and vascular cells, dilating blood vessels, stabilizing atherosclerotic plaques, and improving patient hemodynamics. Can be used in the treatment of various cardiovascular diseases. And it can also effectively prevent restenosis after PCI and the occurrence of cardiovascular events.

This study’s results indicated that compared with the control group, the conventional ultrasound parameters LVEDD, LVFS, LVEF (Simpson), and 3D-LVEF of patients with AMI after PCI decreased. Although these parameters have changed, LVEF (Simpson) remains the most commonly used conventional ultrasound parameter in clinical practice. The change of this parameter indicates that patients with AMI and PCI may have impaired left heart function. It is plaque rupture and thrombosis in patients with coronary atherosclerosis, causing coronary artery blockage and reduced blood supply, leading to ischemia of the myocardium in the blood supply area, and ultimately causing cardiac function damage. Compared the value at 72 h after PCI, the LVEF (Simpson) measured at 12 m after PCI improved, although complete recovery to normal levels is not possible. At 72 h and 12 m after PCI, no significant difference in conventional ultrasound parameters was observed between the Tongxinluo group and the routine group. Thus, although we can confirm that long-term drug treatment after PCI may promote the recovery of left ventricular function, it may be difficult to determine the difference of LV function between Tongxinluo patients and conventionally treated patients using conventional echocardiography. Therefore, a more sensitive inspection method to assess changes in left ventricular structure and function is necessary.

3D-STE has the ability to analyze mechanics. By tracking the movement of the entire left ventricular wall, it can avoid imaging limitations, angle dependence and interference caused by the heart’s own beat as much as possible, so as to detect the patient’s left ventricle more sensitively and clearly. Changes in structure and function should be observed to obtain early information on changes in left ventricular function after PCI in AMI patients. GLS and GCS are commonly used 3D-STE strain parameters in clinical diagnosis and treatment. This study’s results suggest that the 12 m strain parameters GLS and GCS of patients in the Tongxinluo group and the routine group are higher than those in the control group. The 72 h after PCI parameter value increased (p < 0.05), indicating that long-term (≥12 m) drug treatment after PCI in patients with AMI can promote the recovery of left ventricular function in patients with AMI. Moreover, at 12 m after PCI, the GLS and GCS values of the Tongxinluo group were higher than those of the routine group (p < 0.05), and no difference was noted 72 h after PCI. Hence, the effect of adding Tongxinluo drugs in the short term is not apparent. However, the long-term (≥12 m) after PCI addition of Tongxinluo drugs has better effects on promoting the recovery of left ventricular systolic function than conventional treatment without Tongxinluo drugs. This is because the use of drug therapy after PCI can gradually restore the structural function of ischemic myocardium, while reducing the direct damage of PCI to the patient’s myocardium. At 72 h after PCI, the medication time is short, and the cumulative dose in the body is insufficient. Therefore, the changes in the heart structure and function of the patient cannot be accurately observed at this time. The onset time of the drug in the patient’s body is long and the cumulative dose is sufficient at 12 months after PCI. The effects of different drugs on the structure and function of the left ventricle were observed by ultrasound. The study’s results consistent with the results of Zhang Xiaoyu et al., that is, Tongxinluo has the function of promoting the recovery of left ventricular function in patients after PCI, and the
Moreover, the correlation analysis results indicate that the correlation between GLS and LVEF is higher than that of GCS. This may be due to the reason that when the coronary artery is blocked, the inner myocardium of the coronary blood supply area is the first to be affected, including the longitudinally arranged deep spiral muscles. The most evident involvement is that GLS is reduced, which causes a decrease in myocardial contractility. Meanwhile, GLS can also reflect the relationship between heart strain and time, so the use of GLS has a high diagnostic value in assessing left ventricular function.

Studies have revealed that the left ventricle function may be related to the myocardial rotation ability. Therefore, we collected the patient's LVtw to determine the rotation of the left ventricle. During the acquisition process, we found that measurement errors often occur when locating the LVtw of different patients. Thus, to reduce this difference as much as possible, we used Tor as another indicator to evaluate left ventricular systolic function. Compared with 72 h after PCI, the LVtw and Tor values of STEMI patients at 12 m after PCI increased, and that of the Tongxinluo group increased more significantly than the routine group (p < 0.05). This result is consistent with the results of the strain parameters, which indicates that LVtw and Tor, similarly with GLS and GCS, can reflect the changes in the patient's left ventricular exercise capacity. However, unlike GLS and GCS, LVtw and Tor reflect heart movements. The torsion ability of myocardial cells in the process may be caused by the myocardium of the left ventricle, which tends to move obliquely. When the ventricle contracts or relaxes, the spirally arranged myocardium moves clockwise (diastole) or counterclockwise (systole). During the direction rotation, the cardiomyocytes under the inner membrane of the center dominate the process, causing the circulatory torsion deformation of the left ventricle. When coronary atherosclerosis causes vascular obstruction and insufficient blood supply to the myocardium, the subendocardial myocardial cells are the first to be involved, resulting in the subepicardial myocardial cells gradually occupying the leading role in the heart movement, causing the left ventricular rotation angle or the radian changes, and the angle can be measured on the short-axis view of the left ventricle. This study's results also indicate that the repeatability of Tor is higher than that of GCS, GLS, and LVtw, and the repeatability within and between observers is better, so that the accuracy of evaluating the movement of the left ventricle is higher.

Based on the above research results, the heart may be a complex form of motion. Hence, we introduced a new parameter, MCI, which combines LVtw and GLS and reflects the patient's myocardial rotation and strain ability. The MCI values measured at 12 m after PCI in patients with AMI were higher than those in the routine group, and at the same time higher than the parameter values obtained in this group at 72 h after PCI. It reflects the changes of left ventricular function in patients with and without Tongxinluo in different periods. The CK-MB and cTn I value were proportional to the severity of myocardial damage, and cTn I is more sensitive. So we collected the CK-MB and cTn I in serum to assess cardiac damage in patients with AMI. Studies have shown that cardiac magnetic resonance (CMR) imaging is the gold standard for judging left ventricular function in patients, and 3D-LVEF and CMR-LVEF have an evident correlation. 3D-LVEF is fast, convenient, and highly feasible, so it has been used in clinical diagnosis and treatment. Thus, 3D-LVEF is often used as a reliable indicator for evaluating left ventricular function of patients. The correlation analysis results of this study reveal that MCI has the highest correlation with cTn I and 3D-LVEF. The reliability and repeatability test results of this study reveal that MCI has the best repeatability within and between observers. Therefore, MCI can help the early detection of the recovery of left ventricular structure and function in patients with STEMI after PCI and supplemented with medications, and provide a basis for guiding medication and evaluating drug efficacy. These results support the theory of Feng et al.

PSD can reflect the synchrony of the movement of the subject's heart in various stages and may be related to the GLS of each layer of the heart. The results of the PSD parameters in this study showed that the PSD measured after PCI in AMI patients was significantly higher than that of the control group, and the PSD value decreased with the prolongation of drug use, and the Tongxinluo group decreased more significantly (p < 0.05). This means that in patients with AMI after PCI, the movement synchronization between the segments of the left ventricular wall is reduced, and the degree of dispersion is increased. This may be because AMI is often accompanied by localized myocardial injury and causes local myocardium. The torsion and strain capacity changes, which may cause unsynchronized and uncoordinated movement of the ventricular wall. This movement can be assessed on the basis of the PSD values. However, after long-term drug adjuvant treatment, the synchronized movement of the left ventricle gradually recovered, especially in patients who took Tongxinluo.

5 LIMITATIONS

Firstly, the sample size of the study was small. Secondly, we did not directly compare and analyze cardiac magnetic resonance. Lastly, human subjective factors may have an impact on the image collection and data measurement. These factors may cause certain errors in the results of this study.

We will expand the sample size in a follow-up research and combine it with CMR to conduct further in-depth research on the results of this research.

6 CONCLUSIONS

The addition of Tongxinluo drugs on the basis of conventional drug treatment can improve the long-term (≥12 months) prognosis of patients with STEMI after PCI. In the 3D-STE, higher left ventricular function changes after PCI were noted in patients with AMI who received Tongxinluo, indicating its clinical application value.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in PubMed at https://pubmed.ncbi.nlm.nih.gov/.

ORCID

Ruimeng Tian https://orcid.org/0000-0001-6988-5466
Jia Feng https://orcid.org/0000-0003-1437-7813

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