Predictive value of peak strain dispersion on left ventricular remolding in patients with ST-segment elevation myocardial infarction after primary percutaneous coronary intervention

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Abstract

Background: Left ventricular (LV) remolding is associated with a higher rate of heart failure hospitalization in patients with ST-segment elevation myocardial infraction (STEMI). The aim of the current study was to demonstrate the predictive value of peak strain dispersion (PSD) for LV remodeling.

Methods and results: 76 patients with STEMI undergoing primary PCI were prospectively included from June 2019 and August 2020. Patients underwent two-dimensional echocardiography within 48h of admission and 6 months after STEMI. LV remodeling was defined as an increase in the LV end-diastolic volume (LVEDV) ≥ 20% at 6 months after STEMI. According to the echocardiographic criteria used, 13 patients (17.1%) presented with left ventricular remolding after the index event. GLS and myocardial work parameters were similar in patients with left ventricular remolding and those without LV remolding, while patients with left ventricular remolding had a higher PSD than those without remolding ($p<0.01$).

Conclusion: PSD demonstrated incremental value in predicting left ventricular remodeling in STMEI patients undergoing primary PCI.

Introduction

Patients with acute ST-segment elevation myocardial infarction after emergency myocardial revascularization therapy still have a higher rate of heart failure hospitalization, which is related to myocardial remodeling[1–3].

Pathophysiology of left ventricular remodeling after ST elevation myocardial infarction correlated with infarct size and inflammatory response [4,5]. The inflammatory response may lead to wall thinning, increased wall stress, infarct expansion and left ventricular remolding. A recent study, which included 1995 ST-segment elevation myocardial infraction patients treated with primary PCI, demonstrated that 64% resented left ventricular remodeling, which was associated with a higher rate of heart failure hospitalization [3]. So, identifying patients with ST-segment elevation myocardial infraction at risk of LV remodeling before discharge is very important.

Recently, with the development of speck-tracking technology, a novel parameter, peak train dispersion (PSD) estimated by two-dimensional speckle-tracking echocardiography has emerged, which can evaluate cardiac function by combining cardiac deformation and uniformity of the maximum deformation [6]. Coronary artery disease (CAD) increased mechanical dispersion [7], and indicated elevated risk of ventricular arrhythmias after myocardial infarction [8]. However, studies concerned about the value of PSD for predicting left ventricular remodeling were still limited, so the aim of the current study was to demonstrate the predictive value of PSD for LV remodeling.

Methods

Study Population

Between June 2019 and August 2020, we prospectively enrolled 76 patients with STEMI treated with primary PCI. Patients underwent two-dimensional echocardiography within 48 h of admission and 6 months after STEMI. Clinical and echocardiographic data were collected retrospectively at the index event and 6 months after STEMI. Exclusion criteria included severe valvular disease and cardiac surgery before the index event. LV remodeling was defined as an increase in the LV end-diastolic volume (LVEDV) ≥ 20% at 6 months after STEMI. The study was approved by the institution enrolling board of Zhangjiagang Hospital Affiliated to Soochow University.

Echocardiography

The assessment of echocardiographic parameters was performed by two board-certified echocardiographers who finalized each measurement by consensus. The 2D echocardiographic imaging of all patients was performed by GE Vivid E9 and GE Vivid E95 equipment (Norway) 2.5 MHz transducer. The left atrial dimension was measured in the parasternal long-axis view at the ventricular end-systole. Mitral diastolic inflow was interrogated using pulsed-wave Doppler from the apical four-chamber view at the level of the mitral leaflet tips. Mitral early diastolic peak (E-wave) and late peak (A-wave) velocities and E/A ratio were measured. The septal and lateral mitral annulus early (e') velocity was measured by tissue Doppler imaging, and then the E/e' ration was calculated by mitral E wave to average e'. left ventricular end-diastolic diameters (LVDd) were obtained from the parasternal long-axis windows using two-dimensional echocardiography. left ventricular ejection fraction was measured using Simpson's biplane method.

The peak systolic LVGLS magnitude was obtained using automated function imaging in standard 2D cine loops in apical 2-chamber, 3-chamber and 4-chamber. The regional speckle area of interest was manually adjusted to obtain optimal tracking results. LVGLS was calculated using a 17-segment model at the time in systole when the value peaked.

The methodology of myocardial work calculation from noninvasive left ventricular pressure-strain analysis along with its validation has previously been described [9]. In this method, we used a previously generated empiric reference curve for LV pressure assessment. This reference curve is individualized by scaling the amplitude using measured systolic cuff pressure. Subsequently, a pressure–strain curve is obtained by fitting the individualized reference curve in time according to aorta and mitral valve opening and closing. Based on the pressure–strain curve, the constructive and wasted work is measured at the segmental level and the global level; subsequently, the LVMWE is calculated as the ratio of constructive/(constructive plus wasted work). LVMWI and LVMWE are automatically calculated as the average of all segmental values. The percentage of wasted work is calculated as the ratio of wasted work and constructive work.

Peak strain dispersion was measured form the longitudinal strain bull's eye plots and was defined as the standard deviation (SD) of time-to-peak negative strain form 17 LV segments (Fig. 1).

Statistical analysis

Analyses were performed using the SPSS 26.0. Continuous variables which are normally distributed are presented as mean ± SD. Variables that are not normally distributed will be presented as median with inter-quartile ranges (IQR = 25th–75th percentile). T test and Mann–Whitney U test was used for comparison of groups. Categorical variables are expressed as absolute numbers and respective percentages, which were compared by chi squared tests. Predictors of LV remolding with p value < 0.10 in the univariate analysis were included in multivariate models, receiver operating characteristics (ROC) curves were created to evaluate the performance of the model in predicting LV remolding. A difference was considered significant when the p value was < 0.05.

Results

Study population and clinical characteristics

The study included 76 patients suffering from ST-segment elevation myocardial infarction treated with primary PCI. According to the echocardiographic criteria used, 13 patients (17.1%) presented with left ventricular remolding after the index event. The clinical characteristics and differences between those without and those with left ventricular remolding of the population are shown in Table 1. Patients with left ventricular remolding were significantly younger when compared with those without left ventricular remolding. There was no significant difference in gender, heart rate, hypertension, diabetes mellitus, CK-MB, troponin T, NT-proBNP and medications between patients with LV remolding and those without LV remolding (Table 1).

Table 1
Clinical characteristics of population

	No LV remolding (n = 63)	LV remolding (n = 13)	p
Age (years)	61.30 (10.96)	53.85 (14.16)	0.04
Male, n (%)	52 (82.54%)	12 (92.31%)	0.38
Heart rate (bpm)	67.00 (60.00, 75.00)	66.00 (62.00, 69.00)	0.99
BMI ($kg/m^{2)}$	24.40 (22.50, 26.70)	25.80 (24.20, 28.10)	0.17
Hypertension (%)	30 (47.62%)	6 (46.15%)	0.92
Dyslipidaemia (%)	18 (28.57%)	7 (53.85%)	0.08
Diabetes mellitus (%)	12 (19.05%)	2 (15.38%)	0.76
Current smoker (%)	38 (60.32%)	8 (61.54%)	0.93
CK-MB (ng/mL)	88.90 (30.50, 172.60)	116.80 (48.00, 312.00)	0.14
HS-TnT (pg/mL)	2625.50 (767.30, 8438.00)	5867.00 (1197.00, 7373.00)	0.38
NT-pro BNP (pg/mL)	469.50 (148.70, 1031.00)	756.80 (207.60, 1180.00)	0.54
Aspirin at discharge (%)	63 (100%)	13 (100%)	1.0
P2Y12 inhibitors at discharge (%)	63 (100%)	13 (100%)	1.0
Statin at discharge (%)	63 (100%)	13 (100%)	1.0
Beta-blocker at discharge (%)	51 (80.95%)	11 (84.62%)	0.76
ACE inhibitors or ARBs	43 (68.25%)	9 (69.23%)	0.95
Calcium channel blockers	5 (7.94%)	1 (7.69%)	0.98

LV: left ventricle; CK-MB: Creatine kinase-myocardial isoenzyme; Hs-cTnT high sensitivity cardiac troponin T. NT-proBNP: N-terminal pro-brain natriuretic peptide, ACE: Angiotensin-converting-enzyme; ARB: angiotensin II receptor blocker.

Echocardiographic Parameters

Left atrial diameter, E/A ration, E/e', TR peak velocity, left ventricular ejection fraction, LVDd, GLS and myocardial work parameters were similar in patients with left ventricular remolding and those without LV remolding, while patients with left ventricular remolding had a higher PSD than those without remolding ($p < 0.01$) (Table 2).

Table 2
Echocardiographic parameters in the study groups defined by left ventricular remolding

	No LV remolding	LV remolding	p
LA diameter	36.95 (3.73)	37.31 (2.69)	0.75
Mitral E (cm/s)	70.21 (17.49)	70.23 (17.15)	1.00
Mitral A (cm/s)	75.47 (23.59)	63.92 (18.43)	0.10
E/A ratio	0.91 (0.74, 1.32)	1.11 (0.83, 1.27)	0.29
E/e'	10.00 (8.00, 13.00)	11.90 (10.10, 13.70)	0.46
TR peak velocity (m/s)	2.45 (0.30)	2.39 (0.29)	0.53
LVDd (mm)	50.00 (47.00, 53.00)	50.00 (46.00, 51.00)	0.25
LVEF (%)	53.32 (8.52)	51.69 (7.33)	0.52
GLS	16.90 (20.80, 12.20)	14.95 (17.50, 13.00)	0.38
PSD	52.74 (16.61)	68.50 (26.65)	< 0.01
GWI	1562.57 (639.34)	1354.00 (325.68)	0.28
GCW	1746.79 (714.88)	1557.25 (361.94)	0.38
GWW	93.00 (63.00, 178.00)	95.00 (68.00, 118.50)	0.86
GWE	93.00 (81.00, 96.00)	91.50 (85.00, 94.00)	0.55

LV: left ventricle, LA: left atrium; LVEDV: left ventricular end-diastolic volume; LVEF: left ventricular ejection fraction; GLS: global longitudinal strain; PSD: peak strain dispersion, GWI: global myocardial work index, GCW: global constructive work, GWW: global wasted myocardial work, GWE: global work efficiency.

Correlation Between Psd And Left Ventricular Remolding

After adjustment for dyslipidaemia, age and PSD remained significant in predicting LV remolding. The model combined by PSD, age and dyslipidaemia demonstrated an accurate diagnostic performance in predicting left ventricular remolding (AUC: 0.791, $p < 0.001$) (Table 3, Fig. 2.).

Table 3
the factors associated with left ventricular remolding in univariate analysis and multivariate analysis.

	Univariate analysis		Multivariate analysis	
variables	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Age	0.95 (0.90-1.00)	0.04	0.93 (0.86, 1.00)	0.04
Dyslipidaemia	2.92 (0.86–9.88)	0.09	0.85 (0.19, 3.81)	0.83
PSD	1.04 (1.01–1.07)	0.02	1.05 (1.02, 1.10)	< 0.01

Discussion

In the current study we demonstrate that patents with STEMI undergoing primary PCI who developed LV remolding had increased PSD before discharge. The model included age, PSD and dyslipidaemia can predicted LV remolding with high accuracy. PSD demonstrated incremental value in predicting left ventricular remodeling in STMEI patients undergoing primary PCI, but GLS and myocardial work parameters can't.

Our study shows that the LV remodeling patients were younger than patients without LV remolding. It may be explained that the younger patients have decreased GLS in the current study, so they have an increased risk rate to have LV remolding. In a recent study, the LV remolding group also have reduced age than patients without left ventricular remolding, which in consistent with our study, but there was no statistically significant differences between the two groups [10]. Previous studies have demonstrated that GLS and myocardial work can predict LV remolding in patients with STEMI [10,11]. In the present study, GLS, `GWI, GCW and GWE were reduced and GWW was increased in patients with LV remolding without statistically significant differences. It may on account of the limited population of our study.

Peak strain dispersion can be used more accurately evaluated left ventricular systolic synchrony and evaluate myocardial function than GLS by studying whether the peak time of the long axis strain of the myocardium is consistent and to evaluate the coordination and synchronization of myocardial mechanical movement [7]. PSD has been proved to predict ventricular arrhythmias and sudden death in population with myocardial infarction [8,12]. While studies about the predictive value of PSD on LV remolding in STEMI patients undergoing primary PCI were limited. In the current study, we demonstrated that PSD predicted LV remodeling in STEMI patients undergoing primary PCI with high accuracy, suggesting that PSD was valuable in the prognostic evaluation in patients ST- segment elevation myocardial infraction. The increasing PSD in STEMI patients can be explained by macro- and microvascular ischaemia 13,14, which results in left ventricular contraction heterogeneity.

Conclusion

In STEMI patients treated with primary PCI, Peak strain dispersion before discharge in independently associated with LV remolding. PSD may be a useful assessment to guide follow-up of STEMI patients and tailor their medical therapy to prevent adverse LV remodeling.

Abbreviations

LV:Left ventricular;STEMI:ST-segment elevation myocardial infraction;PSD:Peak strain dispersion;PCI:Primary percutaneous coronary intervention;LVEDV:Left ventricular end-diastolic volume;GLS: Global longitudinal strain;CAD:Coronary artery disease;SD:Standard deviation;ROC:Receiver operating characteristics;CK-MB: Creatine kinase-myocardial isoenzyme; Hs-cTnT:High sensitivity cardiac troponin T;NT-proBNP: N-terminal pro-brain natriuretic peptide;ACE: Angiotensin-converting-enzyme;ARB: Angiotensin II receptor blocker;LVEF: Left ventricular ejection fraction;GLS: Global longitudinal strain;GWI:Global myocardial work index;GCW:Global constructive work;GWW:Global wasted myocardial work;GWE: Global work efficiency

Declarations

Acknowledgements

Not applicable.

Authors' contributions

All authors have contributed significantly in this study. Li wang as the first author contributed to manuscript drafting, revisions for important intellectual content and data analysis. long kuang and junjie xu as the second author conducted the work of data collection and analysis. Jiaxian song,ren chen and xuesong qian revised it for statistical analysis and sample size calculation. Fang xu as corresponding author contributed to initiative concept, research design, manuscript revisions and final manuscript approval.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Zhangjiagang Hospital Affiliated to Soochow University. All methods were carried out in accordance with relevant guidelines and regulations. The informed consent form was signed by all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

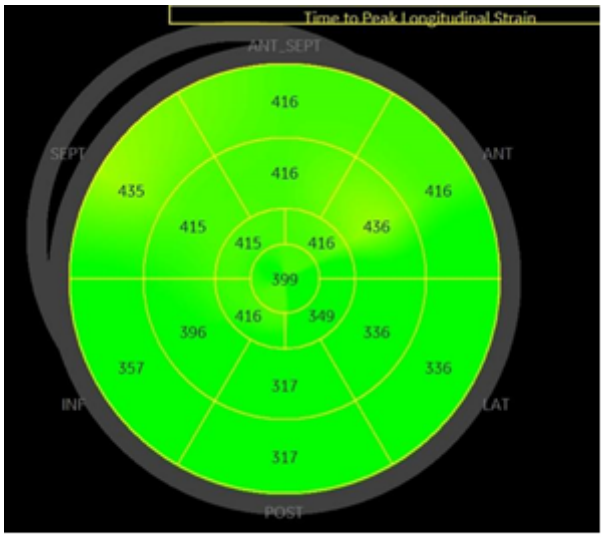

Figure 1

Bull's eye of the left ventricle, derived from the speckle tracking of a patient with left ventricular remolding.

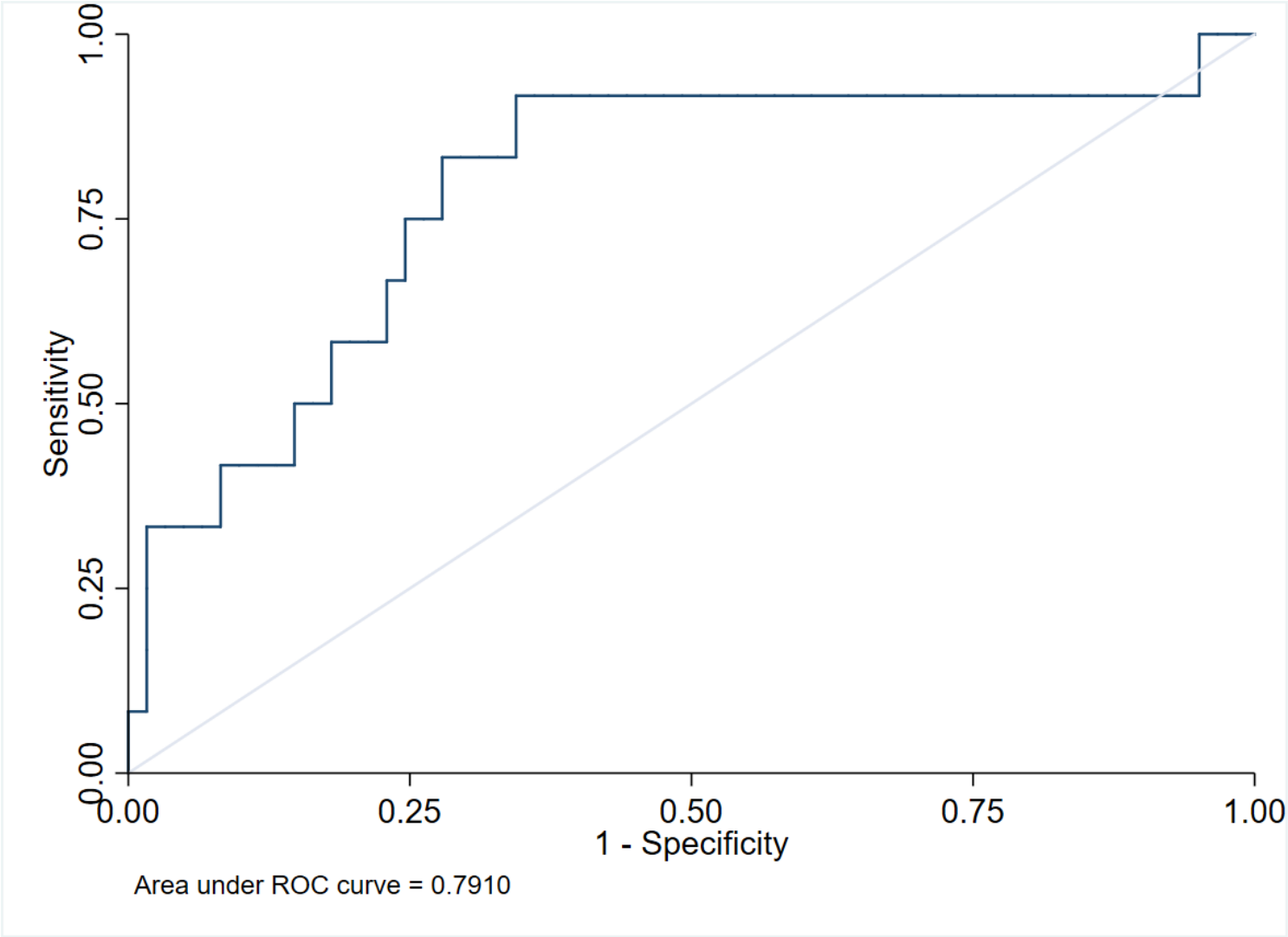

Figure 2

Receiver operating characteristic curve of the logistic analysis model for predicting LV remolding