Assessment of left ventricular systolic function in patients with chronic coronary syndrome and heart failure with reduced ejection fraction after percutaneous coronary intervention

Dao Anh Tan[1]✉, Nguyen Lan Hieu[1,2], Do Thuy Can[3],Nguyen Do Quan[2]
Nguyen Cong Thanh[3], Tran Ngoc Cam[4], Le Thi Men[1], Nguyen Thi Hoa[3]

[1] Hanoi Medical University
[2] Hanoi Medical University Hospital
[3] Vietnam National Heart Institute
[4] VNU School Of Medicine and Pharmacy

▶ **Correspondence to**
Dr. Dao Anh Tan
Hanoi Medical University
Email: daoanhtan1997@gmail.com

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ABSTRACT

Objective: Describe the characteristic and change of left ventricular systolic function after percutaneous coronary intervention in patients with chronic coronary syndrome and heart failure with reduced ejection fraction after percutaneous coronary intervention.

Methods: This prospective study involved the monitoring of 40 patients who had an ejection fraction of 40% or less and were diagnosed with chronic coronary artery disease. These patients underwent a successful percutaneous coronary intervention at the Vietnam National Heart Institute and Hanoi Medical University Hospital between September 2022 and August 2023. The main objective is to evaluate the left ventricular systolic function following the intervention using 2D echocardiography.

Results: A total of 40 patients (34 male and 6 females) with a mean age of 68.3 ± 10.2, were assessed for left ventricular systolic function using 2D echocardiography before and after the intervention. In paired assessment at 90-day follow-up, baseline LVEF improved significantly (before intervention: 32.8 ± 7.2% and after: 38,7 ± 7,3%, $p < 0.01$). Left ventricular longitudinal strain improved significantly on all cross-sections such as: 4-chamber GLS (before: -10.4 ± 3.97%, after: -13.6 ± 4.3%, $p < 0.01$), 2-chamber GLS (before: -10.6 ± 3.8%, after: -13.1 ± 4.2%, $p < 0.01$), 3-chamber GLS (before: -9.8 ± 3.7%, after: -12.3 ± 4.6%, $p < 0.01$), GLS Avg (before: -10.3 ± 3.6%, after: -13 ± 4.1%, $p< 0.01$), basal GLS (before: -11.2 ± 3.8%, after: -14 ± 4.5%, $p < 0.01$), middle GLS (before: -9.3 ± 4.4%, after: -11.8 ± 3.9%, $p < 0.01$), apical GLS (before: -11.5 ± 5.1%, after: -14.3 ± 5.9%, $p < 0.01$). In comparison with the incomplete-revascularization group, there was a significant improvement in left ventricular systolic function in the complete-revascularization group (OR= 22.17, $p < 0.01$).

Conclusions: In patients with chronic coronary syndrome and a reduced left ventricular ejection fraction, the systolic function of the left ventricle was enhanced following percutaneous coronary intervention, particularly in the group that underwent complete revascularization.

Keywords: Heart failure with reduced ejection fraction (HFrEF), Global longitudinal strain (GLS), Chronic coronary syndrome (CCS), Percutaneous coronary intervention (PCI).

INTRODUCTION

The most common cause of heart failure with a reduced ejection fraction is chronic coronary artery disease (CAD). Despite continuing advances in medical therapy of heart failure, a poor prognosis of CAD substantially reduces both life expectancy and quality of life.[1–3] T The efficacy of percutaneous coronary revascularization in this patient group is primarily dependent on observational data and extrapolation from surgical trials.[4–6] The lack of scientific evidence has led to confusion in clinical practice. Coronary artery bypass grafting (CABG) or percutaneous coronary intervention (PCI) might be used to revascularize the coronary arteries. The 10-year STICH study demonstrated that CABG improved the all-cause mortality rate compared with medical treatment.[7]a total of 1212 patients with an ejection fraction of 35% or less and coronary artery disease amenable to CABG were randomly assigned to medical therapy alone (602 patients Besides CABG, PCI is an minimally invasive intervention method and very developed in the current intervention era. However, the efficacy of PCI in patients with chronic coronary syndrome with a reduced left ventricular ejection fraction has been remained controversial. In 2022, the REVIVED BCIS-2 trial researched on chronic coronary syndrome subjects with severe coronary artery damage and a left ventricular ejection fraction of 35%. After an average follow-up period of 41 months, it was concluded that PCI did not improve the mortality rate and the hospitalization rate due to heart failure. In addition, PCI did not improve left ventricular ejection fraction compared with medical treatment. [2] However, the REVIVED BCIS-2 research had limitations as it did not reveal the proportion of patients who had full revascularization and simply examined left ventricular systolic function based on left ventricular ejection fraction (EF).

Speckle tracking echocardiography has demonstrated to be a non-invasive exploration technique that exhibits notable sensitivity and specificity when evaluating early-stage alterations in the function of the left ventricle and early-stage treatment efficacy[8,9] In Vietnam, there have been no studies evaluating changes in left ventricular systolic function after percutaneous coronary intervention in patients with chronic coronary syndrome with heart failure and reduced left ventricular ejection fraction.

METHODS

Study population

40 patients diagnosed with chronic coronary syndrome and heart failure with reduced left ventricular ejection fraction (biplane EF ≤ 40%) who received successful percutaneous coronary intervention at Vietnam Heart Institute and Hanoi Medical University Hospital from September 2022 to August 2023.

Methods

Study design: Prospective study.

Selection criteria:

• Patients diagnosed heart failure with reduced ventricular ejection fraction (biplane EF≤ 40%) on 2D echocardiography.

• Diagnosis of chronic coronary syndrome based on exploratory test: MSCT, excercise test, invasive coronary angiography (Significant CAD was defined by invasive coronary angiography as ≥ 50% stenosis of the left main stem, ≥ 70% stenosis in another coronary vessel).

• Successful percutaneous coronary intervention: final TIMI flow grade 3 and residual stenosis ≤20%.[10]often treated conservatively due to revascularization risks. Revascularization outcomes are largely unknown in SCAD presenting with ST-segment elevation myocardial infarction (STEMI

• Completeness of revascularization was defined as revascularization of all lesions with significant stenosis in a major epicardial coronary artery or in their major branch.[11]

• 2D echocardiography assessed left ventricular systolic function, left ventricular longitudinal strain (GLS index) before intervention and 90 days after intervention. Left ventricular ejection fraction (EF) improved significantly if the improvement in biplane EF after 90 days compared to the initial time was ≥ 5%. [12]

Statistical analysis

• The collected data were stored in Excel and analyzed by Stata 17.

• Results are presented as mean ± standard deviation for normally distributed variables, median and interquartile range for non-normally distributed variables. Compare the mean value of normally distributed variables using T-test while non-normally distributed variables use Wilcoxon–Mann–Whitne. Compare two qualitative variables using the Chi-square test. A p value <0.05 is considered statistically significant.

RESULTS

Patients characteristics

Among 40 patients in the study, 85% of patients were male, the average age was 68.3 ± 10.2, the lowest age was 41, the highest age was 85. Proportion of risk factors cardiovascular diseases such as hypertension, diabetes, dyslipidemia, smoking, overweight and obesity are 72.5%, 37.5%, 10%, 52.5%, 17.5% respectively. Baseline characteristics of study patients are presented in detail in table 01.

***Table 01**. Patient's characteristics*

Age (years)	68.3 ± 10.2
Sex	
Male	34 (85%)
Female	6 (15%)
Risk factor	
Hypertension	29 (72.5%)
Diabetes	15 (37.5%)
Dyslipidemia	4 (10%)
Smoking	21 (52.5%)
Outweighed, Obesity (BMI≥23)	7 (17.5%)
Clinical characteristic	
NYHA III/IV	17 (42,5%)
CCS III/IV	23 (57.5%)
Systolic (mmHg)	133.8 ± 21.1
Diastolic (mmHg)	80.1 ± 12.3
Heart rate (bpm)	82.2 ± 14.7
Biochemical parameters	
NT-proBNP (pg/mL)	1534 (450-3622)
Creatinine (umol/L)	95.5 (87-127)
Troponin Ths (ng/L)	15.79 (9.7-23.5)
Characteristics of coronary artery disease	
1 coronary branch	9 (22.5%)
2 coronary branches	15 (37.5%)
3 branches or LM	16 (40%)
Complete revascularization	17 (42.5%)
Number of stents per patient	1 (1-2)

Alteration of clinical symptoms after PCI

***Table 02**. Alteration of clinical symptoms after PCI*

	Before intervention	After intervention	p
NYHA	2.6 ± 0.7	2.2 ± 0.5	0.002
I, II, III, IV	23 (57,5%)	38 (95%)	
	17 (42.5%)	2 (5%)	
CCS	2.6 ± 0.7	1.7 ± 0.5	<0.001
I, II, III, IV	17 (42.5%)	39 (97.5%)	
	23 (57.5%)	1 (2.5%)	

Of 40 patients, 42.5% of them had NYHA level III or IV (30% NYHA III, 12.5% NYHA IV). At 90 days after intervention, only 5% of patients had NYHA level III and 0% of patients had NYsHA level IV (P=0.002). In the study patient group, the level of chest pain decreased from 57.5% of patients with CCS level III or IV to 2.5% of CCS level III and 0% of CCS level IV (P<0.01).

Alteration in the function of the left ventricle after PCI

***Table 03**. Alteration in the function of the left ventricle before and after 90 days of intervention*

	Before intervention	After 90 days of intervention	p
Dd (mm)	56.4 ± 6.9	54 ± 6.9	<0.001

	Before intervention	After 90 days of intervention	p
Ds (mm)	45.3 ± 8.8	42.1 ± 8.6	<0.001
Vd (ml)	160.4 ± 44.2	146.4 ± 43.1	<0.001
Vs (ml)	100.3 ± 43	91.3 ± 44.6	0.003
FS (%)	19.6 ± 7.9	22.3 ± 7.2	0.021
IVSd (mm)	9.6 ± 1.9	9.5 ± 1.8	0.898
IVSs (mm)	12.3 ± 2.3	12.1 ± 2.2	0.629
LVPWd (mm)	9.1 ± 1.7	9.1 ± 1.5	0.921
LVPWs (mm)	12.9 ± 2.5	13.0 ± 2.0	0.645
LVMi (g/m3)	126.3 ± 40.6	121.4 ± 36.6	0.405
EF biplane	32.8 ± 7.2	38.7 ± 7.3	<0.001
GLSA4C	-10.4 ± 3.97	-13.6 ± 4.3	<0.001
GLSA2C	-10.6 ± 3.8	-13.1 ± 4.2	<0.001
GLSA3C	-9.8 ± 3.7	-12.3 ± 4.6	<0.001
GLSAvg	-10.3 ± 3.6	-13 ± 4.1	<0.001
GLS basal	-11.2 ± 3.8	-14 ± 4.5	<0.001
GLS mid	-9.3 ± 4.4	-11.8 ± 3.9	<0.001
GLS apical	-11.5 ± 5.1	-14.3 ± 5.9	0.005

Left ventricular ejection fraction before and after 90 days of intervention were 32.8 ± 7.2% and 38.7 ± 7.3% respectively, the difference was statistically significant (p<0.001). The average values of total left ventricular longitudinal strain before intervention and 90 days after intervention were -10.3 ± 3.6% and -13 ± 4.1%, respectively, the difference was statistically significant (<0.01). Like other strain indices such as 2-chamber, 3-chamber, 4-chamber longitudinal strain, strain in the base, middle and apical regions of the left ventricle after intervention all improved compared to before intervention group and the difference was significant.

Correlation between complete revascularization and improved ejection fraction

***Table 04**. Correlation between complete revascularization and improved ejection fraction*

Improved LVEF ≥ 5%	Complete revascularization		Total
	Yes	No	
Yes	14	4	18
No	3	19	22
Total	17	23	40

The rates of significant and insignificant LVEF improvement were 4.67 (14/3) and 0.21 (4/19), with OR=22.17 (p < 0.001), for the complete-revascularization and non-complete-revascularization groups, respectively. Thus, patients with complete coronary revascularization have a significantly higher ability to improve LVEF than the group of patients without complete coronary revascularization (OR=22.17; p<0.001).

DISCUSSION

This study was designed to assess alterations in the systolic function of the left ventricle among patients who underwent successful percutaneous coronary intervention and had chronic coronary syndrome accompanied by a reduced ejection fraction of the left ventricle. In conclusion, a considerable improvement in left ventricular systolic function is observed in both LVEF and GLS following to the intervention. There are number of studies have yielded consistent findings. In a research conducted by Yusuke Adachi, a cohort of 47 patients with heart failure with reduced ejection fraction (HFrEF) who had revascularization procedures such as percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG) were examined. The study revealed a significant improvement in left ventricular ejection fraction (LVEF), with an increase from an average of 35.7 ± 8.6% to 44.3 ± 12.6% (p < 0.01).[13] Furthermore, the mean LVEF improved from 24.8 ± 9.9% to 31.4 ± 13.3% after higher-risk percutaneous coronary intervention in patients with ischemic cardiomyopathy, according to a study of 689 patients by Juan J. Russo. This represents a net increase of 6.5 ± 10.8% (p < 0.001). The findings of this study align with those of Kirschbaum (2010) in patients with multivessel disease and impaired left ventricular function. Complete revascularization resulted in a significant improvement in ejection fraction (EF), from 46 ± 12% to 51 ± 13% (p < 0.0001). However, incomplete revascularization did not lead to any change in EF, as indicated by values remaining at 49 ± 11% to 49 ± 10% (p < 0.88). Similarly, unsuccessful revascularization did not result in any significant change in EF, with values decreasing from 49 ± 13% to 47 ± 13% (p <

0.11).[14] Therefore, the use of percutaneous coronary intervention in individuals diagnosed with chronic coronary syndrome accompanied by a reduced left ventricular ejection fraction leads to improved left ventricular systolic function throughout a 90-day monitoring period. Additionally, total revascularization demonstrates notable efficacy in this scenario.

CONCLUSION

Percutaneous coronary intervention in chronic coronary syndrome and reduced left ventricular ejection fraction patients had improved left ventricular systolic function, especially in the complete-revascularization group.

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