TEMPORAL CHANGES IN LEFT ATRIAL FUNCTION AND LEFT ATRIOVENTRICULAR COUPLING ASSESSED BY 2D SPECKLE-TRACKING AND 3D ECHOCARDIOGRAPHY FOLLOWING PERCUTANEOUS CORONARY INTERVENTION IN ACUTE MYOCARDIAL INFARCTION

Le Thi Ngoc Han[1], Tran Duc Hung[1], Luong Cong Thuc[1]*

Abstract

Objectives: To assess temporal changes in left atrial (LA) function and left atrioventricular coupling (LAC) in patients with acute myocardial infarction (AMI) undergoing percutaneous coronary intervention (PCI) using advanced echocardiographic techniques. ***Methods:*** A prospective, descriptive, longitudinal, controlled study was conducted on 120 patients with AMI undergoing PCI and 50 control subjects without coronary artery disease, matched for age, sex, and cardiovascular risk factors. Echocardiography was performed to assess LA strain and left atrioventricular coupling index (LACI) in both groups, with the AMI group undergoing assessment at baseline (within 24 hours of admission), 7 days, 1 month, 3 months, 6 months, 9 months, and 12 months post-PCI. ***Results:*** Compared with controls, AMI patients showed impaired LA function, including lower LAEF (54.6% vs. 64.4%), LASr (28.9% vs. 44.3%), LAScd (14.2% vs. 21.9%), LASct (14.9% vs. 22.3%), all $p < 0.001$, while LACI was higher (19.2% vs. 15.1%; $p < 0.001$). Following PCI, LACI improved by 7 days (19.2% vs. 17.6%; $p = 0.027$), LAEF improved by 1 month (58.5% vs. 54.6%; $p = 0.001$), and LA strain improved by 3 months: LASr (38.7% vs. 28.9%), LAScd (17.9% vs. 14.2%), and LASct (20.8% vs. 14.9%), all $p < 0.001$. These trends continued up to 12 months post-PCI, with ongoing improvements in LACI ($p = 0.006$), LAEF ($p = 0.003$), and LA strain ($p < 0.001$). ***Conclusion:*** Patients with AMI had impaired LA function and LAC, which gradually improved following PCI. Serial assessment of LA strain and LACI provides valuable insight into cardiac recovery and risk stratification after AMI.

Keywords: Acute myocardial infarction; Left atrial function; Left atrial strain; Left atrioventricular coupling; Percutaneous coronary intervention; 2D speckle-tracking echocardiography; 3D echocardiography.

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[1]Cardiovascular Center, Military Hospital 103, Vietnam Military Medical University

[*]Corresponding author: Luong Cong Thuc (lcthuc@gmail.com)

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INTRODUCTION

Previous studies have demonstrated that LA function parameters are independent predictors of all-cause mortality, reinfarction, and hospitalization for heart failure (HF) in patients with AMI. LA strain analysis provides comprehensive insights into LA function, including reservoir function during ventricular systole, conduit and contraction function during ventricular diastole, and predicts non-invasive left ventricular (LV) filling pressure increase, and has shown significant prognostic value for adverse cardiovascular outcomes. LAC is the interplay between LA and LV functions throughout the cardiac cycle. Recently, Pezel et al. (2021) proposed the LACI determined by the ratio between the left atrial end-diastolic volume (LAEDV) and the left ventricular end-diastolic volume (LVEDV) assessed by cardiac magnetic resonance (CMR). Their findings suggested that LACI has prognostic value for HF, atrial fibrillation (AF), myocardial infarction (MI), stroke, and mortality in a population without a history of cardiovascular diseases [1]. Currently, limited data are available on LACI in patients after AMI. Several previous studies have shown that LACI is an independent predictor of major adverse cardiovascular events (MACE) in patients with AMI [2]. In Vietnam, there have been no published studies investigating the LA strain or LACI in patients with AMI. Therefore, this study aims to: *Assess temporal changes in LA function and LAC in patients with AMI undergoing PCI.*

MATERIALS AND METHODS

1. Subjects

Including 120 patients with AMI undergoing PCI and 50 control subjects without coronary artery disease, matched for age, sex, and cardiovascular risk factors.

* *Inclusion criteria:*

AMI group: Patients diagnosed with AMI based on the Fourth Universal Definition of Myocardial Infarction (2018), including compatible clinical presentation, elevated cardiac biomarkers, and evidence of myocardial ischemia on electrocardiogram or imaging.

Control group: Individuals with no clinical or investigative evidence of coronary artery disease, matched for age, sex, and cardiovascular risk factors.

* *Exclusion criteria:* Moderate to severe valvular heart disease (either stenosis or regurgitation), cardiomyopathy, congenital heart disease, second-degree or higher atrioventricular block.

* *Time and location:* From August 2021 to December 2024, at the Cardiovascular Center, Military Hospital 103.

2. Methods

* *Study design:* A prospective, descriptive, longitudinal, controlled study.

* *Sampling method:* Participants were enrolled using a convenience sampling method.

** Data collection and study procedures:*

All participants underwent a detailed clinical evaluation, including medical history, physical examination, laboratory testing, electrocardiography, and transthoracic echocardiography. Patients with AMI underwent PCI and had echocardiography at baseline (within 24 hours of hospital admission), 7 days, 1 month, 3 months, 6 months, 9 months, and 12 months following PCI.

** Echocardiographic assessment:*

LA strain was assessed using 2D speckle-tracking echocardiography (2D-STE). Parameters, including left atrial strain reservoir (LASr), left atrial strain conduit (LAScd), and left atrial strain contraction (LASct), were measured.

LACI was evaluated using 3D echocardiography. LACI was calculated as the ratio of the LAEDV to LVEDV.

** Statistical analysis:* Statistical analysis was performed using SPSS software, version 22.0. Differences between two means were assessed using Student's T-test, whereas comparisons among more than three means were conducted using One-way ANOVA. A two-tailed p-value < 0.05 was considered statistically significant.

3. Ethics

The research complied with all regulations of Military Hospital 103. Military Hospital 103 granted permission for the use and publication of the research data. The authors declare to have no conflicts of interest in this study.

RESULTS

1. Characteristics of LA function and LAC in patients with AMI

Table 1. Characteristics of LA function and LAC in patients with AMI at baseline.

Variables	AMI group	Control group	p
LVEDV (mL)	115.3 ± 43.6	110.7 ± 25	> 0.05
LVESV (mL)	54.5 ± 28.3	42.1 ± 11.9	< 0.001
LVEF (%)	53.7 ± 8.1	62.4 ± 4	< 0.001
LAESV (mL)	49.6 ± 19.1	46.5 ± 16.6	> 0.05
LAEDV (mL)	22.4 ± 10.8	16.7 ± 8.5	< 0.001
LAEF (%)	54.6 ± 12.5	64.4 ± 10	< 0.001
LASr (%)	28.9 ± 16.4	44.3 ± 13.1	< 0.001
LAScd (%)	14.2 ± 8.7	21.9 ± 10.5	< 0.001
LASct (%)	14.9 ± 10	22.3 ± 7.2	< 0.001
LACI (%)	19.2 ± 7.3	15.1 ± 6.4	0.001

Patients with AMI had lower left atrial ejection fraction (LAEF) and LA strain (LASr, LAScd, LASct), and higher LAEDV and LACI compared with the control group.

2. Temporal changes in LA function and LAC in patients with AMI following PCI

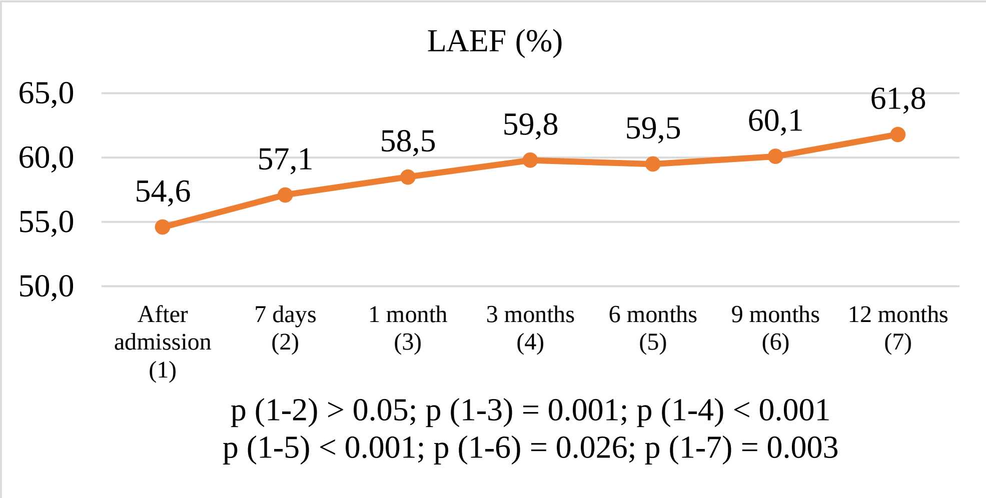

Figure 1. Changes in LAEF in patients with AMI.

LAEF in patients with AMI improved progressively from 1 month (p = 0.001) to 12 months after PCI, with statistically significant changes over time.

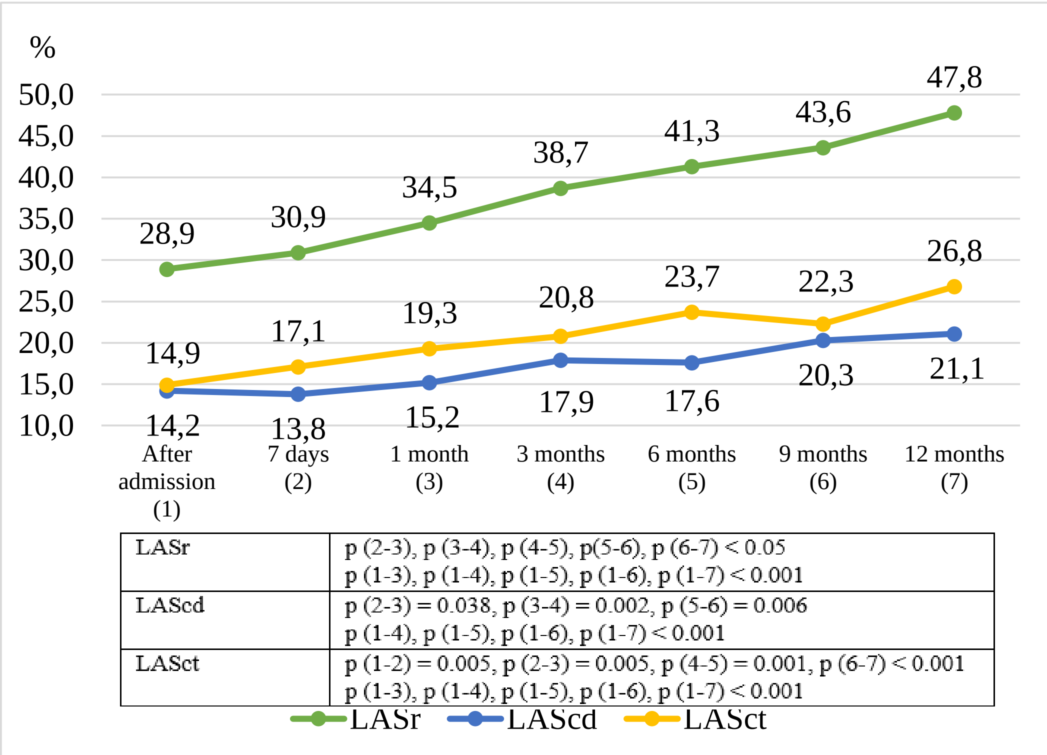

Figure 2. Changes in LA strain in patients with AMI.

After PCI, LASr ($p < 0.05$) and LASct ($p = 0.005$) improved as early as 7 days. LA strain parameters (LASr, LAScd, LASct) improved significantly after 3 months ($p < 0.001$) and continued to improve up to 12 months, with statistically significant changes over time.

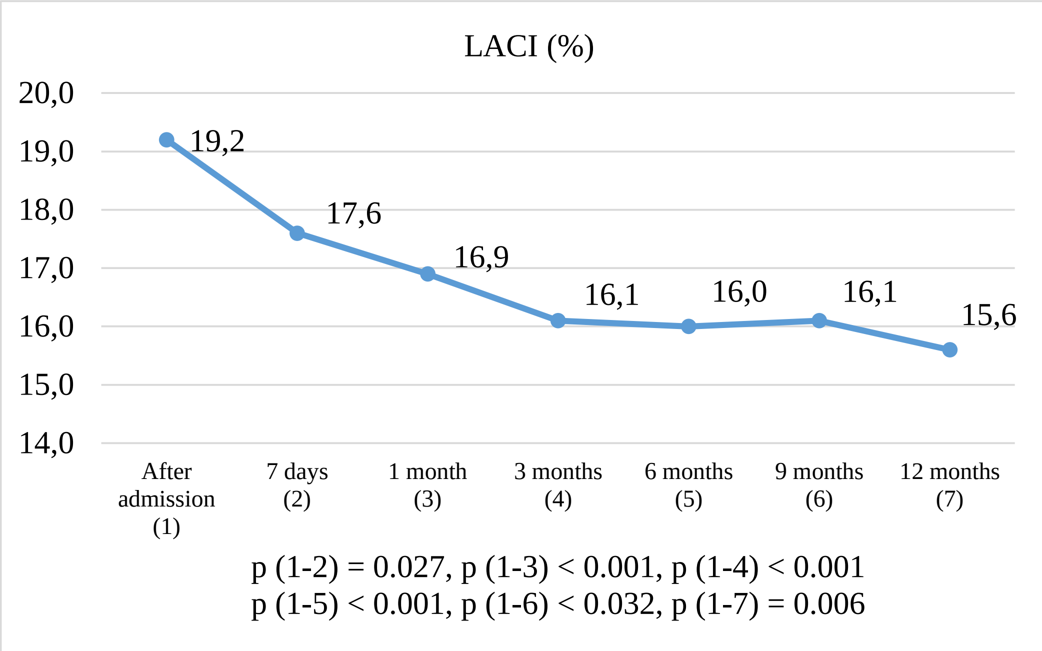

Figure 3. Changes in LACI in patients with AMI.

After PCI, LACI in patients with AMI demonstrated a progressive improvement, with a significant decreased observed at day 7 ($p = 0.027$) and further improvement through 12 months, with statistically significant changes over time.

DISCUSSION

1. Characteristics of LA function and LAC in patients with AMI

** Characteristics of LAEF in patients with AMI:*

In our study, patients with AMI had significantly lower 3D LAEF (54.6% vs. 64.4%; $p < 0.001$) compared with controls. Antoni et al. (2011) also reported a decrease in LAEF in AMI patients compared with controls (56% vs. 61%, $p = 0.005$). Interestingly, left atrial passive emptying fraction (LApEF) was significantly reduced in AMI patients, which was compensated by an increased left atrial active emptying fraction (LAaEF), thus maintaining LV stroke volume. Zhang et al. (2022) found that LAEF was reduced in both anterior and non-anterior MI patients compared with controls [3].

** Characteristics of LA strain in patients with AMI:*

Previous studies have shown that the LA strain is useful in patients with cardiovascular disease. In particular, the assessment of LA reservoir function post-AMI by direct evaluation of LA strain may provide clinically relevant information. LA reservoir function is influenced by the relaxation and the stiffness of the LA, and the contraction of the LV, which occurs through the descent of the LV base during systole. LASr reflects all these components by directly evaluating myocardial deformation, thus allowing accurate assessment of LA reservoir function. Our study results showed a decline in LA reservoir, conduit, and contraction function in patients with AMI, as shown by a decrease in LA strain compared with controls: LASr was 28.9% vs. 44.3%, LAScd was 14.2% vs. 21.9%, and LASct was 14.9% vs. 22.3%; $p < 0.001$. Leng et al. (2020) also reported a reduction in LASr and LAScd in AMI patients compared with controls (23% vs. 35% and 11% vs. 18%, respectively; $p < 0.001$) [4]. Recently, studies by Jiang et al. (2023) using CMR and Scarlatescu et al. (2023) based on 3D STE echocardiography also reported significantly reduced LA strain in AMI patients compared with controls [5, 6]. LV filling pressure increases following AMI, with increases in LA wall tension and LA pressure, leading to decreased LA compliance, as demonstrated by decreased LA strain.

** Characteristics of LAC in patients with AMI:*

LACI was defined as the ratio of LA end-diastolic volume to LV end-diastolic volume. Previous studies have calculated LACI using CMR. Given that 3D echocardiography can assess LA and LV volumes with accuracy comparable to CMR, LACI in the present study was calculated using 3D echocardiography. To our knowledge, this is the first study in Vietnam to investigate LACI with this modality. In our study, LACI in AMI patients was higher than that in the control group (19.2% vs. 15.1%; $p = 0.001$). Our findings were in line with those of the CMR study by Liu et al. (2025), which demonstrated significantly reduced LA strain and elevated LACI in patients with AMI compared with controls [7]. Langen et al. (2023) found that the mean LACI of patients with AMI was 21.4% (15.9 - 29.2%) [2]. A higher LACI expresses greater disproportion between the LA and LV volumes at LV end-diastole, reflecting greater impairment of LAC in patients with AMI.

2. Temporal changes in LA function and LAC in patients with AMI following PCI

Our study showed that after PCI, LAEF in patients with AMI improved after 1 month (58.5% vs. 54.6%; $p = 0.001$) and continued to improve after 12 months (61.8% vs. 54.6%; $p = 0.003$). Bozkurt et al. (2007) also reported that LAaEF increased significantly at the first and third months after MI compared with admission ($p < 0.001$). Similarly, Su et al. (2019) demonstrated a significant increase in LAEF at 1 and 3 months after revascularization, reflecting the improvement of cardiac function and patient prognosis. Currently, LAEF is recognized as an important prognostic factor in patients with AMI. It is known that in AMI, poorer outcomes in patients with increased LA volume are associated with preexisting increased filling pressure. In contrast, LAEF seems to reflect both longstanding LV disease and acute instantaneous changes in LV function, which probably explains the strong prognostic value of LAEF in patients with AMI. Modin et al. (2020) found that LAEF (HR = 1.25, $p = 0.043$) was a strong and independent predictor of HF and death after AMI, and LAEF was superior to LA volumes in predicting HF and death [8]. Nayyar et al. (2021) demonstrated that LAEF was independently associated with death, recurrent MI, HF, stroke, and ventricular arrhythmia in patients with AMI. LAEF (AUC = 0.69) provided an accurate prediction of MACE with a LAEF cutoff of 38.5% ($p < 0.001$) [9].

In our study, LASr ($p < 0.05$) and LASct ($p = 0.005$) showed significant improvement as early as 7 days after PCI. LA strain parameters (LASr, LAScd, LASct) improved significantly after 3 months ($p < 0.001$) and continued to improve after 12 months: LASr (47.8% vs. 28.9%; $p < 0.001$); LAScd (21.1% vs. 14.2%; $p < 0.001$); and LASct (26.8% vs. 14.9%; $p < 0.001$). Previous studies have also shown that LASr improves after PCI in patients with AMI. Hristova et al. (2014) showed that at 4 months after PCI, there was an increase in LASr along with improvement in LVGLS and LVEF. Bayat et al. (2016) found that after PCI, LA strain in AMI patients improved after 24 hours. According to Leng et al. (2020), each 1% increase in LASr reduces the risk of MACE by 16%, while each 1% increase in LAScd reduces the risk of MACE by 19% [4]. Improved LA strain after PCI suggests effective revascularization and improved outcomes in AMI patients. We found that after PCI, LACI in patients with AMI improved after 7 days (17.6% vs. 19.2%; $p = 0.027$) and continued to improve after 12 months (15.6% vs. 19.2%; $p = 0.006$). Decreased LACI with improvement in LVEF, LAEF, LVGLS, and LA strain suggests effective revascularization and improved cardiac function in patients with AMI.

CONCLUSION

In patients with AMI, LA function and LAC were significantly impaired at baseline but demonstrated progressive improvement from 1 month to 12 months following PCI. Serial assessment of LA strain and LACI may provide valuable insight into cardiac recovery and risk stratification after AMI.

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