ASSOCIATION OF THE LEFT ATRIOVENTRICULAR COUPLING INDEX WITH CLINICAL AND LABORATORY CHARACTERISTICS IN PATIENTS WITH ACUTE MYOCARDIAL INFARCTION UNDERGOING PERCUTANEOUS CORONARY INTERVENTION

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ABSTRACT

Objective: To investigate the relationship between left atrioventricular coupling and clinical, laboratory characteristics in patients with acute myocardial infarction (AMI) undergoing percutaneous coronary intervention (PCI). ***Subjects and methods***: A total of 170 participants were enrolled, including 120 patients with AMI undergoing PCI and 50 control subjects without coronary artery disease, matched for age, sex, and cardiovascular risk factors. Three-dimensional echocardiography (3DE) with left atrioventricular coupling index (LACI) measurement was performed in both groups. In the AMI group, echocardiography was conducted at baseline (within 24 hours of admission) and at 7 days, 1 month, 3 months, 6 months, 9 months, and 12 months after PCI. ***Results***: LACI was significantly higher in the AMI group compared with controls (19.2 ± 7.3% vs. 15.1 ± 6.4%; $p < 0.001$). LACI was higher in patients with multivessel disease than in those with single-vessel disease. In patients with AMI, LACI was positively correlated with age ($r = 0.2$; $p = 0.034$), TIMI risk score ($r = 0.38$; $p < 0.001$), GRACE score ($r = 0.27$; $p = 0.003$), NT-Pro BNP level ($r = 0.27$; $p = 0.006$), and left atrial volume index (LAVI; $r = 0.42$; $p < 0.001$). In contrast, LACI showed inverse correlations with left atrial ejection fraction (LAEF; $r = -0.51$; $p < 0.001$), LASr ($r = -0.41$; $p < 0.001$), LAScd ($r = -0.27$; $p = 0.003$), LASct ($r = -0.43$; $p < 0.001$), and LVGLS ($r = -0.23$; $p = 0.011$). ***Conclusion***: Patients with AMI undergoing PCI exhibited higher LACI compared with controls. In patients with AMI, LACI showed positive associations with age, TIMI risk score, GRACE score, NT-Pro BNP level and LAVI; whereas it was inversely associated with LAEF, left atrial strain, and LVGLS.

Keywords: *Acute myocardial infarction, left atrioventricular coupling, percutaneous coronary intervention, TIMI risk score, GRACE score, NT-Pro BNP, left atrial volume, left ventricular ejection fraction, left atrial strain, left ventricular global longitudinal strain.*

I. INTRODUCTION

The left atrium and left ventricle are directly connected during diastole, and in the absence of valvular heart disease, their function and filling pressures are closely coupled. Although left atrial and left ventricular parameters have independent prognostic value, combined assessment of left atrium/left ventricle coupling may better reflect left atrioventricular dysfunction and serve as a stronger predictor of cardiovascular outcomes. The left atrioventricular coupling index (LACI), defined as the ratio of left atrial (LA) end-diastolic volume to left ventricular (LV) end-diastolic volume, was first introduced by Pezel et al. in 2021 using cardiac magnetic resonance imaging (CMR). The authors demonstrated that LACI provided superior prognostic value for cardiovascular events in the general population compared with traditional risk factors as well as with

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individual left atrial or left ventricular parameters [7]. Several international studies have also shown that CMR-derived LACI is an independent predictor of cardiovascular events in patients with acute myocardial infarction (AMI) [3]. However, CMR is limited by availability, cost, and feasibility at the bedside. In contrast, three-dimensional echocardiography (3DE) is convenient, safe, cost-effective, and provides accurate left atrial and ventricular volume assessment comparable to CMR. Therefore evaluating LACI by 3DE promises to be a reliable method. However, data on 3DE-derived LACI in AMI remain limited. This study aimed to investigate the the relationship between LACI and clinical and laboratory characteristics in patients with AMI undergoing percutaneous coronary intervention (PCI).

II. MATERIALS AND METHODS

1. Study population

This study included 170 participants treated at the Cardiovascular Center, Military Hospital 103 (Hanoi, Viet Nam), from August 2021 to December 2024. Participants were divided into two groups: (1) the AMI group, consisting of 120 patients with AMI undergoing PCI, and (2) the control group, comprising 50 individuals without coronary artery disease, matched for age, sex, and cardiovascular risk factors.

Inclusion criteria: Patients in the AMI group were diagnosed with acute myocardial infarction according to the Fourth Universal Definition of Myocardial Infarction (2018). Only first-time, type 1 AMI cases were enrolled. All patients underwent PCI following the 2021 ACC/AHA/SCAI guidelines. The control group consisted of individuals matched for age, sex, and cardiovascular risk factors, but without evidence of coronary artery disease.

Exclusion criteria: Patients with atrial fibrillation, second-degree or higher atrioventricular block, moderate to severe valvular heart disease (stenosis or regurgitation), cardiomyopathy, congenital heart disease, severe hepatic or renal dysfunction, poor-quality echocardiographic images, or those who declined to participate in the study.

2. Methods

Study design: This was a prospective, descriptive, longitudinal, controlled study.

Data collection and study procedures

All participants underwent conventional echocardiography and 3DE for assessment of LACI. In the control group, echocardiography was performed once after admission. In the AMI group, patients underwent coronary angiography and PCI, echocardiographic assessments were conducted at baseline (within 24 hours after admission), and subsequently at 7 days, 1 month, 3 months, 6 months, 9 months, and 12 months following PCI.

Echocardiographic examinations were performed using a Philips EPIQ 7C ultrasound system (Philips Inc., the Netherlands) equipped with a 2.5–5 MHz transducer and both two-dimensional (2D) and three-dimensional (3D) imaging capabilities. Full-volume 3D datasets of the left atrial and left ventricular chambers were obtained from the apical four-chamber view and analyzed using Dynamic HeartModel (DHM) software, an automated 3D analysis tool that enables comprehensive volumetric quantification of cardiac chambers. Left atrial end-diastolic volume (LAEDV) and left ventricular end-diastolic volume (LVEDV) were quantified from DHM analysis, and the left atrioventricular coupling index (LACI) was calculated as the ratio of LAEDV to LVEDV (LACI = LAEDV / LVEDV).

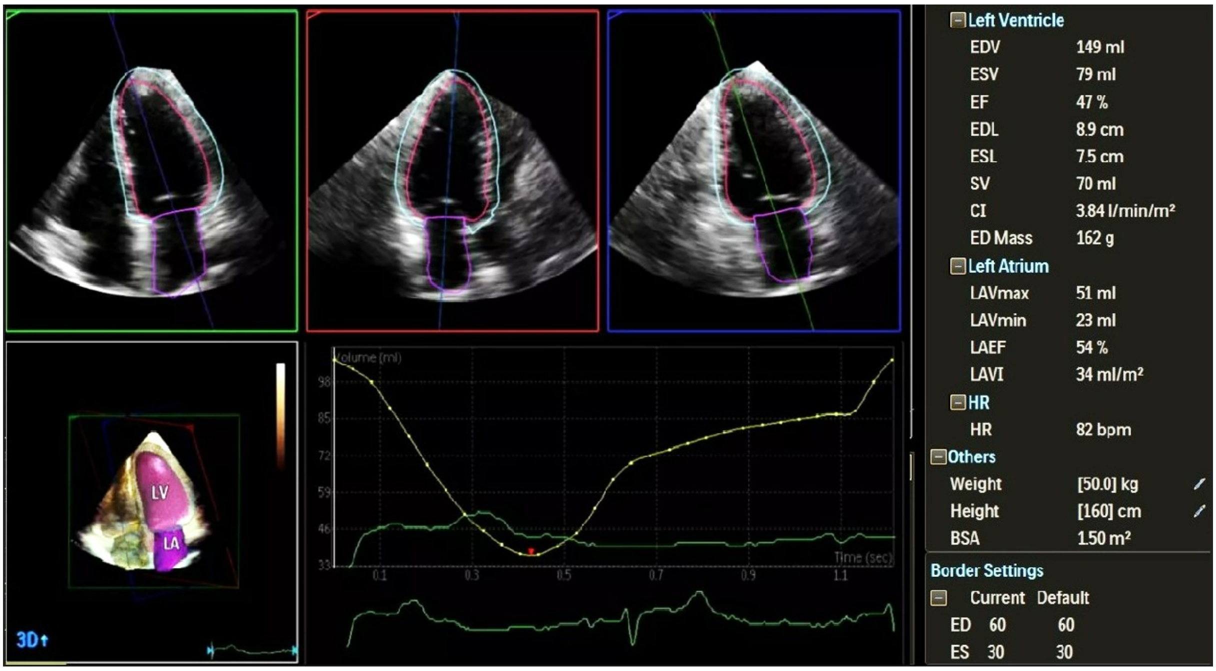

Figure 1. ***3DE assessment of the LACI in a patient with AMI. The LACI measured 15.4%.***
Source: Patient L.B.Th., 63 years old; study number: 20.

Statistical analysis: Data were analyzed using SPSS version 22.0. A p-value < 0.05 was considered statistically significant.

3. Ethics: The study protocol was reviewed and approved by the Ethics Committee for Biomedical Research at 103 Military Hospital, Vietnam Military Medical University.

III. RESULTS

Table 1. ***Characteristics of left atrioventricular coupling in patients with acute myocardial infarction at baseline***

Variable	AMI group	Control group	p value
LVEDV (ml)	115.3 ± 43.6	110.7 ± 25	> 0.05
LAEDV (ml)	22.4 ± 10.8	16.7 ± 8.5	**< 0.001**
LACI (%)	19.2 ± 7.3	15.1 ± 6.4	**0.001**

Left atrial end-diastolic volume (LAEDV) and the left atrioventricular coupling index (LACI) were higher in the AMI group compared with the control group.

Table 2. ***Association between LACI and age and sex in patients with acute myocardial infarction***

Variable	Age groups			p value
	36-59 years	60-69 years	70-89 years	
LACI (%)	16.3 ± 5.1	18.9 ± 7.4	21.2 ± 7.7	**0.029**
	Sex			
	Male		Female	
LACI (%)	18.3 ± 6.3		22.5 ± 9.6	0.056

LACI was higher in older patients with AMI. No significant difference in LACI was observed between male and female patients.

Table 3. *Association between LACI at different time points and GRACE risk score groups*

Time point \ LACI (%) ($\bar{X}$ ± SD)	GRACE risk score groups			p value
	< 109	109 - 140	> 140	
Baseline	16.4 ± 5.3	20 ± 6.4	22.4 ± 11.7	**0.016**
7 days post-PCI	15.2 ± 5.1	18.2 ± 7.1	19.7 ± 5.5	**0.048**
1 month post-PCI	14.5 ± 5.5	16.9 ± 5.4	22.6 ± 11.1	**0.001**
3 months post-PCI	14.5 ± 5.3	16.4 ± 4.9	18.6 ± 4.7	**0.046**
6 months post-PCI	14.2 ± 6.2	16.1 ± 5.1	19.8 ± 5.3	**0.007**
9 months post-PCI	15 ± 5.4	16.2 ± 4.9	18.7 ± 6.6	> 0.05
12 months post-PCI	14 ± 6.2	16.3 ± 4.5	16.4 ± 4.2	> 0.05

LACI was higher in patients with GRACE score >140 compared with those with GRACE score 109–140 and <109. Although LACI improved over time, it remained significantly higher in the high GRACE score group at 7 days, 1 month, 3 months, and 6 months after PCI.

Table 4. *Association of LACI at different time points with the number of affected coronary vessels and LAVI groups*

Time point \ LACI (%) ($\bar{X}$ ± SD)	Number of affected coronary vessels		p value	LAVI groups		p value
	1 vessel	≥ 2 vessels		< 34 ml/m²	≥ 34 ml/m²	
Baseline	17.7 ± 5.4	20.3 ± 8.3	**0.045**	17.5 ± 5.4	23.2 ± 9.5	**0.003**
7 days post-PCI	16.1 ± 5.5	18.8 ± 7.3	**0.032**	16.4 ± 5.3	20.6 ± 8.6	**0.014**
1 month post-PCI	15.8 ± 5.4	17.8 ± 7.5	> 0.05	15.5 ± 4.8	20.3 ± 9.1	**0.007**
3 months post-PCI	14.2 ± 3.5	17.5 ± 5.7	**<0.001**	15.3 ± 4.1	18.3 ± 6.6	**0.027**
6 months post-PCI	14.5 ± 4.8	17.2 ± 6.1	**0.014**	15.1 ± 5	18.4 ± 6.4	**0.013**
9 months post-PCI	14.6 ± 5.1	17.3 ± 5.2	**0.03**	14.8 ± 4.7	19.2 ± 5.2	**0.002**
12 months post-PCI	13.1 ± 3.3	17 ± 5.5	**0.001**	14.5 ± 4.3	17.6 ± 5.8	**0.036**

LAVI: left atrial volume index

LACI was higher in AMI patients with multivessel coronary artery disease compared with those with single-vessel disease. After 12 months of PCI, LACI improved but remained higher in the multivessel disease group. LACI was also higher in patients with LAVI ≥34 ml/m² than in those with LAVI <34 ml/m², and it persisted at higher levels in the left atrial enlargement group from 7 days to 12 months post-PCI.

Table 5. Correlation of LACI with clinical and laboratory characteristics

Variable	LACI		Variable	LACI	
	r	p		r	p
Age	0.2	0.034	LAEF	-0.51	< 0.001
TIMI risk score	0.38	< 0.001	LASr	-0.41	< 0.001
GRACE score	0.27	0.003	LAScd	-0.27	0.003
Log NT-Pro BNP	0.27	0.006	LASct	-0.43	< 0.001
LAVI	0.42	< 0.001	LVGLS	-0.23	0.011

LAEF: left atrial ejection fraction, LASr: left atrial strain reservoir, LAScd: left atrial strain conduit, LASct: left atrial strain contraction, LVGLS: left ventricular global longitudinal strain

LACI showed a positive correlation with age, TIMI risk score, GRACE score, NT-Pro BNP level, and LAVI, while demonstrating an inverse correlation with LAEF, left atrial strain, and LVGLS.

IV. DISCUSSION

To the best of our knowledge, this is the first study in Vietnam to evaluate LACI using 3D echocardiography. The mean LACI value in patients with AMI was 19.2 ± 7.3%, which was significantly higher than that in the control group (p = 0.001). Langen et al. (2023) reported a LACI of 21.4% (15.9–29.2%) using CMR [3]. The differences between their findings and ours may be attributed to variations in imaging modality (3D echocardiography vs. CMR), timing of measurement, and patient characteristics. Our findings are consistent with the study by Liu et al. (2025), which also demonstrated elevated LACI in AMI patients compared with controls [4]. A higher LACI reflects a greater disparity between LA and LV end-diastolic volumes, indicating more pronounced impairment of left atrioventricular coupling in patients with AMI.

**** Association between LACI and Age***

Our study demonstrated that LACI was higher in older AMI patients, with values of 16.3%, 18.9%, and 21.2% in the age groups 36–59 years, 60–69 years, and 70–89 years, respectively (p = 0.029). There was a positive correlation between age and LACI in patients with AMI (r = 0.20; p = 0.034). Similarly, the MESA study involving 2,112 individuals without cardiovascular disease also demonstrated a significant positive association between LACI and age. Furthermore, multivariate linear regression analysis in the MESA cohort revealed that increasing age was independently associated with higher LACI (OR = 1.47; 95% CI: 1.09–1.85; p < 0.001). With increased age, there are changes in LA volume or function and LV filling. Older individuals tend to have larger LA volumes, smaller LV volumes, and consequently a higher LA-to-LV end-diastolic volume ratio (LACI). These findings suggest that age-related structural and functional remodeling of the left atrium and ventricle contributes to impaired atrioventricular coupling, which may partly explain the increased cardiovascular risk observed in older individuals.

*** Association between LACI and Sex**

Among our cohort, women accounted for 23.3% of the cohort, with ages ranging from 57 to 87 years, and all female patients with AMI were postmenopausal. We observed a trend toward higher LACI values in women compared with men (22.5% vs. 18.3%), although this difference did not reach statistical significance (p = 0.056). Similarly, the MESA study reported no significant sex-related difference in LACI at baseline; however, over a 10-year follow-up period, the deterioration of left atrioventricular coupling, as reflected by changes in LACI, was more pronounced in women than in men [8]. This phenomenon may be related to the impact of menopause status and circulating sex hormone concentrations on left atrioventricular coupling. Pezel et al. (2022) reported that postmenopausal women had higher LACI values than premenopausal women, and LACI was inversely correlated with estradiol levels (r = –0.52; p = 0.022) [6]. Previous studies have also demonstrated that menopause was independently associated with lower LV end-diastolic volumes [2] and played a significant role in LA remodeling, including atrial enlargement. These findings together suggest that sex hormones and menopausal status contribute to sex-specific differences in atrioventricular coupling dynamics, which may become more evident over time.

*** Association Between LACI and GRACE and TIMI Risk Scores**

In the present cohort of AMI patients, LACI was significantly higher in the high-risk group (GRACE score > 140) compared with the intermediate-risk group (GRACE score 109–140) and the low-risk group (GRACE score < 109), with values of 22.4 ± 11.7%, 20.0 ± 6.4%, and 16.4 ± 5.3%, respectively (p = 0.016). Although LACI improved over time, it remained significantly higher in patients with greater GRACE scores at 7 days (p = 0.048), 1 month (p = 0.001), 3 months (p = 0.046), and 6 months (p = 0.007) following PCI. In addition, LACI was positively associated with both the GRACE score (r = 0.27; p = 0.003) and the TIMI risk score (r = 0.38; p < 0.001). These findings indicate that impaired left atrioventricular coupling in patients with AMI is associated with an adverse clinical risk profile. LACI may provide complementary information for risk stratification beyond traditional clinical scores and help identify patients at higher risk of future cardiovascular events.

*** Association Between LACI and the Number of Affected Coronary Vessels**

In our study, LACI was higher in AMI patients with multivessel coronary artery disease compared with those with single-vessel disease (20.3 ± 8.3% vs. 17.7 ± 5.4%; p = 0.045). After 12 months following PCI, LACI improved in both groups but remained significantly higher in patients with multivessel disease (17.0 ± 5.5% vs. 13.1 ± 3.3%; p = 0.001). In patients with multivessel coronary artery disease, the increase in LA end-diastolic volume (LAEDV) is not only a compensatory response to acute LV functional changes induced by acute myocardial ischemia, but also may reflect chronic ischemic burden associated with non-culprit coronary lesions. Consequently, LAEDV increases to a greater extent in these patients, leading to more pronounced impairment of left atrioventricular coupling.

*** Association Between LACI and NT-proBNP**

NT-proBNP is a well-established biomarker with strong prognostic value in patients with AMI. Elevated NT-proBNP concentrations are associated with increased mortality, even among patients without clinical heart failure (HF), and have been linked to a higher risk of recurrent MI as well as the development or worsening of HF. In our study, LACI was positively correlated with NT-proBNP levels in patients with AMI (r = 0.27; p = 0.006). Consistent with our findings, the MESA study demonstrated that individuals with higher LACI values had significantly elevated NT-proBNP concentrations, and LACI was independently associated with NT-proBNP levels after multivariable adjustment (p < 0.001) [7]. Likewise, Fortuni et al. (2024) reported that patients with HF in the highest tertile of LACI had significantly higher NT-proBNP concentrations compared with those in the lower tertiles (p < 0.001) [1]. This association may be explained by the fact that elevated NT-proBNP reflects increased myocardial wall stress, elevated left ventricular filling pressures, and adverse cardiac remodeling. These pathophysiological changes lead to an increased mechanical load on the left atrium, promoting atrial enlargement and impairing atrioventricular coupling. Consequently, higher NT-proBNP concentrations are closely associated with greater LACI values, highlighting the interplay between hemodynamic stress and structural remodeling in the context of AMI.

*** Association Between LACI and Left Atrial Volume Index (LAVI)**

Our analysis revealed that LACI was significantly higher in patients with left atrial enlargement (LAVI ≥ 34 ml/m²) compared with those with normal LAVI (< 34 ml/m²) (23.2 ± 9.5% vs. 17.5 ± 5.4%; p = 0.003). This difference persisted over time, with LACI remaining significantly higher in patients with left atrial enlargement from 7 days (p = 0.014) up to 12 months (p = 0.036) following PCI. Furthermore, a significant positive correlation was observed between LACI and LAVI in patients with acute myocardial infarction (r = 0.42; p < 0.001). These findings are consistent with those of the MESA study, which reported higher LAVI values in individuals with increased LACI and identified a strong positive correlation between these two parameters (r = 0.65; p < 0.001) [8]. Similarly, 2D echocardiography studies in patients with heart failure have demonstrated a significant positive association between LACI and LAVI (r = 0.59; p < 0.001) [5], and patients with higher LACI had greater LAVI [1]. Taken together, these results highlight that LACI closely reflects LA structural remodeling and hemodynamic burden in the setting of AMI. As LA volume increases in response to chronic pressure and volume overload, the ratio of LA to LV end-diastolic volume rises, indicating impaired atrioventricular coupling.

*** Association Between LACI and Left Atrial Ejection Fraction (LAEF)**

Analysis of our AMI patient cohort demonstrated that LACI was inversely correlated with left atrial ejection fraction (LAEF) (r = -0.51; p < 0.001). In line with these findings, Liu et al. documented an inverse correlation between LACI and LAEF in AMI patients (r = -0.61; p < 0.01) [5], while Langen et al., in a study of 1,046 AMI patients, reported a similarly significant inverse correlation (r = -0.67; p < 0.001) [4]. Elevated LACI reflects a growing disparity between LA and LV end-diastolic volumes, highlighting an aspect of cardiac dysfunction, particularly impaired left atrial performance.

*** Association Between LACI and Left Ventricular Global Longitudinal Strain (LVGLS) and Left Atrial Strain**

In patients with AMI, LACI was inversely correlated with left ventricular global longitudinal strain (LVGLS) (r = -0.23; p = 0.011) and left atrial strain parameters, including LASr (r = -0.41; p < 0.001), LAScd (r = -0.27; p = 0.003), and LASct (r = -0.43; p < 0.001). These findings are consistent with previous studies. Liu et al. (2025) reported similar inverse correlations between LACI and LASr (r = -0.43; p < 0.01), LAScd (r = -0.31; p < 0.01), and LASct (r = -0.42; p < 0.01) in AMI patients [4]. Likewise, Langen et al. (2023) observed a substantial inverse correlation between LACI and LASr (r = -0.58; p < 0.001) [3]. Moreover, the MESA study demonstrated that individuals with higher LACI values had lower LASr, with a significant inverse correlation (r = -0.23; p < 0.001) [8]. Collectively, these results indicate that impaired left atrioventricular coupling is associated with both LV systolic dysfunction and LA mechanical dysfunction in AMI patients.

V. CONCLUSION

The left atrioventricular coupling index was significantly higher in patients with acute myocardial infarction than in controls.

In AMI patients, LACI correlated positively with age, TIMI and GRACE scores, NT-proBNP, and left atrial volume index, and inversely with left atrial ejection fraction, left atrial strain, and left ventricular global longitudinal strain. LACI may provide complementary prognostic information beyond conventional clinical, laboratory, and individual left atrial or ventricular parameters, helping to identify patients at higher risk of adverse cardiovascular events.

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