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The Left Atrioventricular Coupling Index as a Predictor of Major Cardiovascular Events in Chronic Heart Failure Patients at Adam Malik Hospital Medan

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ABSTRACT

Introduction: Chronic heart failure (CHF) is a major global health challenge, with high prevalence and significant mortality, particularly in Indonesia, where it exceeds 5%. The left atrioventricular coupling index (LACI), a novel parameter combining left atrial (LA) and left ventricular (LV) metrics, has emerged as a potential predictor of major cardiovascular events (CVE) in CHF. This study investigates LACI's prognostic value in predicting CVE and mortality in CHF patients.

Methods: A retrospective case-control study was conducted at H. Adam Malik Hospital, Medan, from February 2025, involving 140 CHF patients meeting inclusion criteria (age ≥18 years, diagnosed with CHF due to hypertension or coronary artery disease, and underwent echocardiography). Exclusion criteria included atrial fibrillation, significant valvular disease, or prior coronary revascularization. LACI was calculated as the ratio of LA volume index (LAVI) to medial mitral annular velocity (a′). Major CVEs, including death, acute coronary syndrome, stroke, malignant arrhythmias, heart failure readmission, and revascularization, were assessed. Statistical analyses included descriptive statistics, normality tests, group comparisons (Mann-Whitney U or t-test), ROC curve analysis, and multivariate regression.

Results: Of 140 patients (82.9% male, mean age 56.44±9.92 years), 28.6% experienced CVEs. LACI >6.35 was significantly associated with CVEs (P=0.0001, OR: 5.021, 95% CI: 2.289–11.014), with an AUC of 0.736 (95% CI: 0.642–0.829), sensitivity of 65%, and specificity of 70%. Multivariate analysis confirmed LACI as an independent predictor (P=0.000, Exp(B)=5.382, 95% CI: 2.304–12.568).

Conclusion: LACI is a robust independent predictor of CVEs in CHF, supporting its role in early risk stratification and clinical management.

Keywords: Left Atrioventricular Coupling Index, Predictor of Major Cardiovascular Events, Chronic Heart Failure, LACI, CHF

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INTRODUCTION

Chronic heart failure (CHF) is a leading cause of mortality and a major public health issue, particularly among the elderly. CHF affects 1 – 2% of adults in developed countries, rising to ⩾10% in those aged >70 years. In Asia, the prevalence of CHF matches European rates (1-3%) but exceeds 5% in Indonesia. The increasing prevalence stems from acute cardiac injury, which progresses to CHF. The World Health Organization (WHO) has linked CHF to smoking, obesity, dyslipidemia, and lifts [1]. Cardiovascular disease (CVD) remains a major concern, with costs of $351.2 billion in 2015. While left ventricle (LV) parameters are often studied in CVD, research shows that CVD is not solely caused by LV disturbances. Left atrial (LA) dysfunction can impair cardiac performance, even with preserved LV systolic function [2]. Given the burden of heart failure, the American College of Cardiology/American Heart Association (ACC/AHA) guidelines reclassified CHF to include Stage A at-risk individuals without structural heart disease, emphasizing stroke prevention. To identify CHF risk early, studies have evaluated LA and LV structure and function using cardiovascular magnetic resonance (CMR). Studies suggest that heart failure is not exclusively caused by LV structure and function disturbances. Structural and functional LA parameters, such as LA volume and peak LA reservoir strain, are independent predictors of heart failure [3, 4]. This contrasts with acute heart failure, in which systolic dysfunction leads to increased residual LV end-diastolic volume and filling pressures [5].

LA dysfunction can disrupt cardiac performance with preserved LV systolic function. LA parameters may detect heart failure risk earlier than LV parameters. Research shows global atrioventricular strain potential in asymptomatic individuals with subclinical dysfunction. Both LV and LA parameters have prognostic value, but atrioventricular coupling may better reflect dysfunction [6, 7]. Noninvasive imaging assesses early heart failure changes but focuses on either the LA or LV. LA structural remodeling is associated with increased mortality in patients with HFpEF. The left atrioventricular coupling index (LACI) combines atrial and ventricular metrics to predict disease progression [8]. The LA-LV interaction suggests that an index evaluating both chambers may provide superior diagnostic value. During diastole, the LA and LV are directly connected with linked filling functions without valvular disease. Few studies have analyzed the LA/LV coupling index [9–11]. Pezel et al. found higher LACI independently associated with heart failure (HR 1.50; 95% CI [1.38–1.62]), severe cardiovascular disease (HR 1.23; 95% CI [1.13–1.34]), and coronary artery disease-related mortality (HR 1.29; 95% CI [1.15–1.45]; all $p<0.0001$) [3]. Lange et al. found LACI was higher in patients with major cardiovascular events ($p < 0.001$) [12]. Fortuni et al. showed LACI independently predicted outcomes (hazard ratio for 1-SD increase, 1.16; 95% CI, 1.06–1.28; $P = 0.002$) and improved diastolic dysfunction assessment (net reclassification improvement = 0.150, $P < 0.0001$) [13].

METHODS

This retrospective analytical case-control study aimed to investigate the relationship between the Left Atrioventricular Coupling Index (LACI) and its role as a predictor of mortality and its correlation with major cardiovascular events in patients with chronic heart failure (CHF) at H. Adam Malik Hospital, Medan. The research will be conducted from February 2025, and data collection will continue until the required sample size is reached. The study will involve patients who meet the inclusion criteria and will exclude those who meet any of the exclusion criteria. Data will be collected from patient records over the course of one year, starting in January 2024, until the desired sample size is reached. The sample size for this study was calculated using standard statistical methods based on previous studies and established formulae. After performing the necessary sample size calculations, we determined that the study would require a minimum of 40 patients for reliable results.

The inclusion criteria will include patients aged 18 years and older with signed informed consent, diagnosed with chronic heart failure (CHF), and who have undergone echocardiography. Only patients with CHF due to hypertension or coronary artery disease were included. Patients with atrial fibrillation, significant valvular disease, or those who underwent coronary revascularization will be excluded. The study will evaluate the Left Atrioventricular Coupling Index (LACI) as an independent variable, with the dependent variables being major cardiovascular events: death, acute coronary syndrome, stroke, malignant arrhythmias, heart failure readmission, and revascularization. Echocardiographic data will be analyzed to calculate the LACI, a predictor of heart failure outcomes. Statistical analyses will be performed using SPSS version 24. Descriptive statistics will be used to summarize the categorical variables. The Kolmogorov-Smirnov test was used to assess data normality. For normal distribution, means and standard deviations will be used; for non-normal data, medians and ranges will be reported. Group comparisons will be performed using the Mann-Whitney U test or independent t-test based on distribution. Statistical significance will be set at $P < 0.05$. Ethical approval was obtained from the Ethics Committee of the Faculty of Medicine, University of Sumatera Utara, Indonesia. This methodology provides a framework for assessing LACI's impact of LACI on major cardiovascular events in patients with CHF, offering insights into its prognostic value for improving the early detection and management of heart failure.

RESULTS

Demographic Characteristics of Study Subjects

We collected 140 samples that met the study criteria. Nominal data are presented as frequencies and percentages. Table 1 shows the participant demographics.

Table 1. Clinical Characteristics of Study Subjects

Parameter	n (140)
Gender (Male %)	116 (82.9)
Age (Years)	56.44 ± 9.92
Body Weight (Kg)	67 (35 – 105)
Height (cm)	165 (150 – 180)
BMI (kg/m²)	25.50 ± 4.04
Cardiovascular Events (CVE), n (%)	
Death	36 (25.7)
Cardiogenic Shock	1 (0.7)
Malignant Arrhythmia	1 (0.7)
Acute Heart Failure	12 (8.5)
Stroke	1 (0.7)
Risk Factors, n (%)	
Type 2 Diabetes (DM)	48 (34.3)
Hypertension	69 (49.3)
Alcohol Use	2 (1.4)
Chronic Kidney Disease (CKD)	22 (15.7)
Dyslipidemia	19 (13.6)
Smoking	80 (57.1)
Clinical Symptoms, n (%)	
Dyspnea on Exertion (DOE)	140 (100)
Paroxysmal Nocturnal Dyspnea (PND)	32 (22.9)
Rales	40 (28.6)
Respiratory Failure	1 (0.7)
Orthopnea	62 (44.3)
Anorexia-Kachexia	1 (0.7)
Medical Therapy, n (%)	
Diuretics	127 (90.7%)
Loop Diuretics	120 (94.8%)
Non-Loop Diuretics	7 (5.2%)
ARNi/ACE-i/ARB	138 (98.6%)
Beta-Blockers	131 (93.6%)
MRAs (Mineralocorticoid Receptor Antagonists)	133 (95%)
SGLT-2 inhibitors	30 (21.4%)
Laboratory Parameters	
Hb (g/dl)	13.53 ± 2.18
Hematocrit (%)	40.52 ± 6.72
Leukocytes (cells/mm³)	8490 (12 – 21550)
Urea (g/dl)	40 (12 – 157)
Creatinine (g/dl)	1.21 (0.5 – 21.5)
CrCl (ml/min)	67.32 ± 28.92
Na (mEq/l)	141.48 ± 5.28
K (mEq/l)	4.1 ± 0.54
Random Blood Glucose (mg/dL)	136.5 (59 – 533)
Fasting Blood Glucose (mg/dL)	129.55 ± 54.56
2-Hour Postprandial Blood Glucose (mg/dL)	169 (20 – 375)
Total Cholesterol (mg/dL)	171.38 ± 50.22
HDL (mg/dL)	40.41 ± 11.7
LDL (mg/dL)	111.91 ± 44.86
Triglycerides (mg/dL)	136.21 ± 54.58

Table 1. Continuous

Parameter	n (140)
Echocardiographic Parameters	
EF (%)	31 (10 – 58)
EF ≤ 40%	134 (95.7%)
EF > 40%	6 (4.3%)
TAPSE (mm)	18 (8 – 29)
TAPSE < 17 mm	51 (36.4%)
TAPSE ≥ 17 mm	89 (63.6%)
LVEDD (mm)	57 (37 – 69)
E/A	1.33 ± 0.76
E/A ≤ 1	131 (93.6%)
E/A > 1	9 (6.4%)
E/e’	14.32 (6.49 – 20.47)
E/e’ > 14	60 (42.9%)
E/e’ ≤ 14	80 (57.1%)
LAVi (ml/mm²)	39.16 ± 8.76
LAVi ≤ 34	48 (34.3%)
LAVi > 34	92 (65.7%)
TDI-a	7 (3.2 – 10)
TDI-a ≤ 10	138 (98.6%)
TDI-a > 10	2 (1.4%)
LACI	6.01 ± 2.03
LACI ≤ 6	84 (60%)
LACI > 6	56 (40%)

Differences in Parameters Between Subjects with Major Cardiovascular Events

Several parameters differed between participants with and without major cardiovascular events in patients with chronic heart failure. The events were more frequent in men. Type 2 diabetes was more prevalent in patients with major events (P = 0.037). Patients with orthopnea had an increased risk of major events (P = 0.0047). HDL levels and TAPSE values were lower in patients with major events (P = 0.002 and P = 0.02, respectively). LAVi values were elevated (P = 0.009), whereas TDI-α values were reduced (P = 0.003) in patients with major events. The LACI of patients with major events (7.29 ± 2.25) exceeded that of patients without major events (5.56 ± 1.71) (P = 0.0001). The findings are presented in Table 2.

Table 2. Differences in Clinical Characteristics Between Subjects with and without Major Cardiovascular Events

Parameter	CVE		P-Value
	Yes (40)	No (100)	
Gender (Male %)	29 (72.5%)	87 (87%)	0.040a
Gender (Female %)	11 (27.5%)	13 (13%)	
Age (Years)	54.13 ± 11.34	57.37 ± 9.19	0.08c
Body Weight (Kg)	70 (35 – 100)	67 (45 – 105)	0.991d
Height (cm)	164.5 (150 – 178)	165 (150 – 188)	0.537d
BMI (kg/m²)	25.35 ± 4.69	25.56 ± 3.77	0.782c
Risk Factors			
Type 2 Diabetes (DM)	19 (47.5%)	29 (29%)	0.037a
Hypertension	19 (47.5%)	50 (50%)	0.789a
Alcohol	1 (2.5%)	1 (1%)	0.491b
Chronic Kidney Disease (CKD)	9 (25%)	13 (13%)	0.163a
Dyslipidemia	4 (11.1%)	15 (14.4%)	0.781b
Smoking	16 (40%)	57 (57%)	0.069a
Clinical Symptoms			
PND (Paroxysmal Nocturnal Dyspnea)	9 (25%)	23 (22.1%)	0.818b
Rales	13 (32.5%)	27 (27%)	0.515a
Respiratory Failure	0 (0%)	1 (1%)	1.000b
Orthopnea	23 (57.5%)	39 (39%)	0.047a
Anorexia-Kachexia	1 (2.5%)	0 (0%)	0.286b

Noted: a, Fisher's Exact Test; b, Mann-Whitney U Test; c, Independent Samples t-test; d, Mann-Whitney U Test

Table 2. Continuous

Parameter	CVE		P-Value
	Yes (40)	No (100)	
Medical Therapy			
Diuretics	37 (92.5%)	90 (90%)	0.758b
ARNi/ACE-i/ARB	39 (97.5%)	99 (99%)	0.491b
Beta-Blockers	39 (97.5%)	92 (92%)	0.446b
MRAs (Mineralocorticoid Receptor Antagonists)	38 (95%)	95 (95%)	1.000b
SGLT-2 inhibitors	6 (15%)	24 (24%)	0.241a
Laboratory Parameters			
Hb (g/dl)	13.74 ± 2.40	13.44 ± 2.08	0.491c
Hematocrit (%)	40.84 ± 7.33	40.37 ± 6.47	0.724c
Leukocytes (cells/mm³)	8100 (5210 – 21550)	8900 (1500 – 18220)	0.852d
Urea (g/dl)	39 (12 – 124)	36 (17 – 157)	0.071d
Creatinine (g/dl)	1.1 (0.5 – 2.69)	1.17 (0.68 – 3.03)	0.436d
CrCl (ml/min)	67.28 ± 27.78	67.34 ± 29.67	0.992c
Na (mEq/l)	141.11 ± 4.61	141.65 ± 5.6	0.629c
K (mEq/l)	4.13 ± 0.59	4.09 ± 0.52	0.692c
Total Cholesterol (mg/dL)	160.89 ± 52.44	175.48 ± 49.09	0.202c
HDL (mg/dL)	34.59 ± 9.31	42.53 ± 11.80	0.002c
LDL (mg/dL)	105.29 ± 49.83	114.26 ± 43.07	0.375c
Triglycerides (mg/dL)	139.22 ± 48.46	135.11 ± 56.92	0.739c
Echocardiographic Parameters			
EF (%)			
EF ≤ 40%	40 (100%)	94 (94%)	0.113a
EF > 40%	0 (0%)	6 (6%)	
TAPSE (mm)			
TAPSE < 17 mm	21 (52.5%)	30 (30%)	0.012a
TAPSE ≥ 17 mm	19 (47.5%)	70 (70%)	
E/A			
E/A ≤ 1	40 (100%)	91 (91%)	0.06a
E/A > 1	0 (0%)	9 (9%)	
E/e’			
E/e’ > 14	15 (37.5%)	45 (45%)	0.418a
E/e’ ≤ 14	25 (62.5%)	55 (55%)	
LAVi (ml/mm²)			
LAVi ≤ 34	9 (22.5%)	39 (39%)	0.06a
LAVi > 34	31 (77.5%)	61 (61%)	
TDI-a			
TDI-a ≤ 10	40 (100%)	98 (98%)	1.000d
TDI-a > 10	0 (0%)	2 (2%)	

Noted: a, Fisher's Exact Test; b, Mann-Whitney U Test; c, Independent Samples t-test; d, Mann-Whitney U Test (for skewed data)

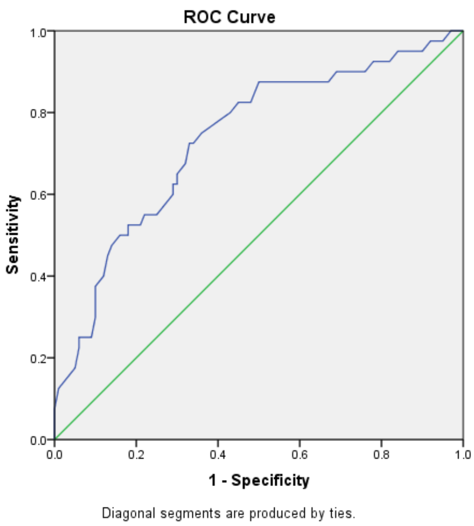

Figure 1. ROC Curve Analysis

Table 3. AUC, Sensitivity, and Specificity for LACI as a Predictor of Major Cardiovascular Events

Parameter	Threshold	AUC	P Value	Sensitivity	Specificity	95% CI
LACI	6.35	0.736	0.0001	65%	70%	0.642 – 0.829

ROC Curve Analysis for LACI as a Predictor of Major Cardiovascular Events

Receiver operating characteristic (ROC) curve analysis was performed to assess the threshold value of LACI as a predictor of major cardiovascular events in patients with chronic heart failure. The analysis showed that LACI had a moderate predictive ability, with a P-value of 0.0001, AUC of 0.736, and 95% CI of 0.642–0.829. The threshold value of LACI at 6.35 exhibited a sensitivity and specificity of 65% and 70%, respectively. An AUC value above 0.5 indicates meaningful predictive power, with values closer to 1 indicating a stronger predictive capability. The results are shown in Figure 1.

Bivariate Analysis of LACI as a Predictor for Major Cardiovascular Events

A bivariate analysis was performed to examine the relationship between the threshold value of LACI (6.35) and the incidence of Major Cardiovascular Events. Among the 40 patients with LACI values exceeding 6.35, 26 (65%) experienced Major Cardiovascular Events. Conversely, only 14 of 40 patients (35%) with LACI values below 6.35 encountered such events. This difference was statistically significant (P = 0.0001, OR: 5.021, 95% CI: 2.289 – 11.014), indicating that LACI serves as a robust predictor of Major Cardiovascular Events. The results are presented in Table 4.

Table 4. Bivariate Analysis of LACI as a Predictor for Major Cardiovascular Events

Parameter	Major Cardiovascular Events		P Value	OR	95% CI
	Yes (n=40)	No (n=100)			
LACI ≥ 6.35	26 (65%)	27 (27%)	0.0001	5.021	2.289 – 11.014

Multivariate Analysis

Multivariate analysis was conducted to ascertain the independent predictors of Major Cardiovascular Events. The findings indicated that LACI, with a threshold value of 6.35, emerged as an independent predictor of Major Cardiovascular Events (P = 0.000, Exp(B) = 5.382, 95% CI: 2.304 – 12.568). Other variables, such as sex, orthopnea, TAPSE, and diabetes, were not significant independent predictors in this model. The results are presented in Table 5.

Table 5. Multivariate Analysis for Predictors of Major Cardiovascular Events

Parameter	P Value	Exp (B)	95% CI
Gender	0.060	2.721	0.957 – 7.735
Orthopnea	0.073	2.139	0.932 – 4.914
LACI	0.000	5.382	2.304 – 12.568
TAPSE	0.215	1.799	0.711 – 4.555
Diabetes	0.143	1.918	0.803 – 4.581

DISCUSSION

This study involved 140 participants and investigated various factors related to the occurrence of Major Cardiovascular Events (CVE) in patients with chronic heart failure over a 1-year follow-up period. A significant finding of this study was that male patients experienced a higher incidence of CVE than female patients. This result is consistent with previous studies that demonstrated a higher incidence of cardiovascular events among men, even after adjusting for risk scores, such as the HEART score, where men with low scores still had a significantly higher risk of CVE [14].

In this study, type 2 Diabetes Mellitus (DM) was statistically identified as a risk factor for CVE occurrence. Several studies support this association, emphasizing the role of type 2 DM in the development of atherosclerosis and myocardial dysfunction, which are critical for heart failure progression. A meta-analysis indicated that patients with type 2 DM and coronary artery disease (CAD) are at a higher risk for CVE, with type 2 DM severity independently linked to CVE development [15]. Furthermore, patients with heart failure and type 2 DM have been shown to have an increased all-cause mortality rate, with variations depending on geographic region, population characteristics, and disease severity [16].

The study also observed that patients with lower HDL cholesterol levels had a higher incidence of CVE. A U-shaped relationship between HDL cholesterol levels and CVE risk has been observed, in which both low and high levels of HDL are associated with poor cardiovascular outcomes. Recent studies have highlighted that both low and very high HDL levels are linked to an increased risk of major adverse cardiovascular events (MACE), including death, myocardial infarction, stroke, and heart failure [17].

The TAPSE value was significantly lower in patients with CVE than in those without. TAPSE is a measure of right ventricular function, and its reduction indicates right ventricular dysfunction, which often results from the left ventricular failure. Right heart failure (RHF) in ischemic heart disease is typically caused by the inability of the right ventricle to pump blood effectively into the lungs, often as a consequence of left ventricular failure. A study in Nigeria reported that TAPSE values below 16 mm were indicative of right ventricular dysfunction and associated with a worse prognosis in patients with heart failure patients [18-19].

Additionally, the study found that the Left Atrial Volume index (LAVi) was higher in patients who experienced CVE, and TDI-a was lower. This is consistent with the role of left atrial function in chronic heart failure, where a decrease in left atrial function and volume often correlates with worse outcomes. A study by Benfari et al. found that an LAVi threshold of ≥34 mL/m² was independently associated with advanced heart failure signs and higher mortality, further supporting the utility of LAVi as a prognostic marker [20].

The left atrial contraction index (LACI) was significantly higher in patients with CVE, correlating with worse outcomes. LACI has shown potential as a predictive marker for heart failure after STEMI (ST-Elevation Myocardial Infarction), with several studies confirming its association with adverse cardiovascular events and long-term mortality [21]. Pezel et al. demonstrated that LACI and changes in LACI were independently linked to heart failure incidence, improving risk prediction models [1]. Furthermore, Kasa et al. showed that patients with higher LACI values had poorer outcomes, further validating the importance of this index in the prognosis of heart failure.

The findings of this study align with the existing literature, confirming that male sex, type 2 DM, low HDL, and several echocardiographic parameters, such as TAPSE, LAVi, and LACI, are significant predictors of CVE in patients with chronic heart failure. These parameters could be valuable tools for early risk stratification and improved management of patients.

CONCLUSION

In conclusion, the study identified the Left Atrial Contraction Index (LACI) with a threshold of 6.35 as a significant independent predictor of major cardiovascular events (CVE) in patients with chronic heart failure. These findings suggest that LACI not only shows a strong predictive value for CVE but also serves as an effective tool for early risk stratification. Patients with higher LACI values exhibited a notably higher incidence of CVE, highlighting the utility of this parameter in clinical practice. Given its predictive accuracy, LACI can be a valuable marker for managing chronic heart failure and mitigating the risk of cardiovascular complications over time.

DECLARATIONS

None

CONSENT FOR PUBLICATION

The Authors agree to be published in the Journal of Society Medicine.

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The authors declare no conflicts of interest in this case report.

AUTHORS' CONTRIBUTIONS
All authors contributed to the work, including data analysis, drafting, and reviewing the article. They approved the final version and were accountable for all aspects.

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