

Predictors of Left Atrial Appendage Thrombus on Transesophageal Echocardiography before Elective Cardioversion

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ABSTRACT

Objective: To determine the frequency of left atrial appendage thrombus(LAA), and its predictors on transesophageal echocardiography(TEE) before elective cardioversion.

Study Design: Cross-sectional study.

Place and Duration of Study: Sheikh Mohammad Bin Zayed Al-Nahyan Institute of Cardiology, Quetta Pakistan, from Oct 2025 to Jan 2026.

Methodology: Overall, fifty-five patients with non-valvular atrial fibrillation or atrial flutter, aged 18-80 years and referred for elective cardioversion, were recruited and non-probability consecutive sampling was employed. Comprehensive clinical assessment was done, and CHA₂DS₂-VASc score, baseline lab parameters, and TEE to assess LAA thrombus and associated echocardiographic parameters were documented for all the selected patients. Cases with valvular atrial fibrillation, recent stroke or systemic embolism, or contraindications to TEE were excluded.

Results: Majority participants were males 39(70.9%), and a composite median age was 62.00(55.00-68.00) years. LAA thrombus was detected in 5(9.1%) patients. Patients with thrombus had significantly ($p<0.05$) higher CHA₂DS₂-VASc scores [4.00(4.00-5.00) vs 2.00(1.00-3.00)], lower left ventricular ejection fraction(LVEF) [35.00%(35.00-40.00) vs 58.00%(50.00-60.00)], larger left atrial volume index (LAVI) [47.84(43.09-95.06) vs 37.29 (30.53-42.83)ml/m²], and markedly reduced left atrial emptying velocity [15.00(15.00-20.00) vs 48.00(40.00-55.00)cm/s]. Higher CHA₂DS₂-VASc score (aOR=2.16; 95%CI: 1.01-4.41; $p=0.049$), LVEF (aOR=0.88; 95%CI: 0.85-0.97; $p=0.04$), increased left atrial diameter (aOR=1.86; 95%CI: 1.14-2.87; $p=0.005$), and higher LAVI (aOR=1.05; 95%CI: 1.004-1.07; $p=0.023$), emerged as independent predictors of LAA thrombus.

Conclusion: LAA thrombus remains prevalent in patients undergoing pre-cardioversion TEE and is influenced by both clinical and echocardiographic factors. Integration of echocardiographic parameters with clinical risk scores may improve thromboembolic risk stratification before elective cardioversion.

Keywords: Elective Cardioversion, Left Atrial Appendage, Thrombus, Transesophageal Echocardiography.

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INTRODUCTION

For more than two decades, international guidelines for the management of atrial fibrillation (AF) have emphasized the role of transesophageal echocardiography (TEE) before elective cardioversion in selected patients, particularly when at least three weeks of uninterrupted oral anticoagulation has not been ensured.¹ This recommendation is based on the well-established risk of thrombus formation within the left atrial appendage (LAA) during AF, which may result in systemic embolization following cardioversion.² Transesophageal echocardiography is considered the gold standard modality for direct

visualization of the LAA and detection of thrombus or spontaneous echo contrast, both of which are markers of increased thromboembolic risk.³

Several studies have evaluated the prevalence and predictors of LAA thrombus in patients undergoing TEE prior to cardioversion.^{4,5} Large observational data have shown that LAA thrombus may be present in a small but clinically significant proportion of patients, even in those with low clinical risk scores.⁶ Factors such as enlarged left atrial size, reduced left ventricular ejection fraction, impaired LAA emptying velocity, and certain electrocardiographic parameters have been associated with thrombus formation. Although clinical risk stratification tools like CHADS₂ and CHA₂DS₂-VASc scores are widely used to estimate thromboembolic risk, emerging evidence suggests that these scores

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alone may not reliably predict the presence of LAA thrombus. Importantly, LAA thrombus has been reported in patients categorized as low risk based on these scoring systems.^{7,8}

According to the invasive nature, cost, and limited availability of TEE, identifying patients who are most likely to harbor LAA thrombus remains clinically relevant. Insight regarding clinical and echocardiographic predictors may help optimize patient selection for pre-cardioversion TEE, improve anticoagulation decision-making, and potentially reduce procedure-related thromboembolic complications. Therefore, the present study was designed to determine the frequency of left atrial appendage thrombus and to evaluate its clinical and echocardiographic predictors in patients undergoing elective cardioversion for atrial fibrillation.

METHODOLOGY

This cross-sectional study was conducted to determine the frequency of left atrial appendage thrombus and its predictors on transesophageal echocardiography prior to elective cardioversion. The study was conducted at Sheikh Mohammad Bin Zayed Al-Nahyan Institute of Cardiology, Quetta, over a period of three months after obtaining ethical approval from the Research Ethical Committee of institute under Itr number ICQ-QTA-DME-RES-05/AL15 (Dated: 1st Oct, 2025). Consecutive sampling technique was used to gather a sample size of 55 patients which was calculated using the WHO sample size calculator by taking a population proportion of 3.7% for LAA thrombus on TEE,⁵ with a 95% confidence level and a 5% margin of error.

The study population was comprised of patients with atrial fibrillation or atrial flutter who were planned for elective cardioversion and required transesophageal echocardiography for exclusion of left atrial appendage thrombus.

Inclusion Criteria: Patients of both genders aged between 18 and 80 years with non-valvular atrial fibrillation (paroxysmal, persistent, or permanent) or atrial flutter were included.

Exclusion Criteria: Patients with valvular atrial fibrillation such as moderate to severe mitral stenosis or prosthetic mitral valves, those with a history of stroke or systemic embolism within the preceding three months, and patients with contraindications to transesophageal echocardiography including

esophageal varices, strictures, or severe esophagitis were excluded from the study.

Patients' consent was taken before initiation of data collection. After selection of eligible patients, all of them underwent a detailed pre-procedural evaluation that included comprehensive history taking and physical examination, with particular attention to comorbid conditions such as hypertension, diabetes mellitus, heart failure, and previous stroke or transient ischemic attack. Thromboembolic risk assessment was performed using the CHA₂DS₂VASc score. Transthoracic echocardiography was performed to assess left atrial size, LVEF, and the presence of any associated structural heart disease.

Transesophageal echocardiography (TEE) was performed by an experienced cardiologist in accordance with standard institutional protocols. The LAA was examined keenly for the presence or absence of thrombus. Additional echocardiographic parameters, including spontaneous echo contrast, left atrial emptying velocity, and left atrial diameter and volume, were documented. Based on TEE findings, further management was decided. In patients with detected LAA thrombus, elective cardioversion was deferred and anticoagulation therapy with either warfarin or direct oral anticoagulants was initiated or optimized for at least three weeks before reassessment. In patients without evidence of thrombus, cardioversion was performed according to standard clinical protocols. All patients continued guideline-directed anticoagulation therapy following cardioversion to reduce the risk of thromboembolic complications. Patient confidentiality and anonymity were maintained throughout the study, and all collected data were used exclusively for research purposes.

Data were entered and analyzed using IBM Statistical Package for Social Sciences (SPSS) version 23. The Shapiro-Wilk test was used to assess normality of quantitative variables. Continuous variables (age, LA size, LVEF, LA velocity) were expressed as Mean±SD or median with interquartile range, while categorical variables were presented as frequencies and percentages. Associations between categorical variables (gender, presence of thrombus, comorbidities) and the presence of LAA thrombus were assessed using the chi-square test or Fisher's exact test as appropriate. Independent t-test or Mann-Whitney U test was applied to compare continuous variables (age, LA size, LVEF, LA velocity) based on thrombus status.

Regression analysis was performed to identify strong predictors of left atrial appendage thrombus. A p -value of ≤ 0.05 was considered statistically significant.

RESULTS

The baseline characteristics of the study participants presented in Table-I showed that, of the 55 patients, majority were males 39(70.9%), with a composite median age of 62.00(55.00–68.00) years. Hypertension was the most prevalent comorbidity, present in 52(94.5%) patients. The median CHA₂DS₂-VASc score was 2.00(1.00–4.00) and echocardiographic findings showed mean left atrial diameter of 39.47±4.30 mm, mean left atrial volume of 69.77±21.55 ml, and median left atrial volume index of 37.47(30.69–48.07) ml/m². Median LVEF was 55.00(45.00–60.00)%, and left atrial appendage emptying velocity was 46.00 cm/s (38.00–54.00).

Table-I: Baseline clinical, laboratory, and echocardiographic characteristics of the study participants (n=55)

Variables	Values
Gender	
Male	39(70.9%)
Female	16(29.1%)
Age (years) [Median(IQR)]	62.00(55.00-68.00)
Comorbids	
Diabetes Mellitus	18(32.7%)
Hypertension	52(94.5%)
Smoker	17(30.9%)
Congestive Heart Failure	16(29.1%)
History of CAD	18(32.7%)
History of Stroke/TIA	2(3.6%)
CKD	5(9.1%)
Structural Heart Disease	19(34.5%)
Hemoglobin (mg/dL) [Median(IQR)]	13.5(13.00-14.20)
Serum Creatinine (mg/dL) [Median(IQR)]	1.00(0.90-1.20)
CHA ₂ DS ₂ -VASc Score [Median(IQR)]	2.00(1.00-4.00)
LVEF (%) [Median(IQR)]	55.00(45.00-60.00)
Left Atrial Dimentions	
LA Diameter (mm) (Mean±SD)	39.47±4.30
LA Volume (ml) (Mean±SD)	69.77±21.55
LAVI (ml/m ²) [Median(IQR)]	37.47(30.69-48.07)
LA Emptying Velocity (cm/s) [Median(IQR)]	46.00(38.00-54.00)

CAD= Coronary Artery Disease; LAVI=Left Atrial Volume Index; TIA=Transient Ischemic Attack; CKD=Chronic Kidney Disease; LVEF=Left Ventricular Ejection Fraction

According to the findings of Table-II, LAA thrombus was identified in 5 patients (9.1%). There was no significant association between thrombus presence and demographics (gender and age; $p>0.05$). Congestive heart failure was significantly more common among patients with thrombus 4(80.0%) compared to those without thrombus 12(24.0%), $p=0.02$. Similarly, chronic kidney disease was present in 3(60.0%) patients with thrombus versus 2(4.0%) patients without thrombus ($p=0.004$), and structural heart disease was observed in all patients with

thrombus 5(100%) compared to 14(28.0%) patients without thrombus ($p=0.003$). Patients with thrombus had higher hemoglobin levels [15.80 (15.00–16.20) vs 13.50 (13.00–14.00), $p=0.028$] and higher CHA₂DS₂-VASc scores [4.00 (4.00–5.00) vs 2.00 (1.00–3.00), $p=0.046$]. A significantly lower LVEF was observed in patients with thrombus [35.00% (35.00–40.00) vs 58.00% (50.00–60.00), $p=0.006$]. Spontaneous echo contrast was noted in all patients with thrombus 5(100%) compared to 16(32.0%) patients without thrombus ($p=0.006$). Echocardiographic parameters revealed significantly larger LA volume (79.07±38.78 ml vs 68.84±19.48 ml, $p=0.022$), higher LAVI [47.84 (43.09–95.06) vs 37.29(30.53–42.83), $p=0.031$], and markedly reduced LAA emptying velocity [15.00 cm/s (15.00–20.00) vs 48.00 cm/s (40.00–55.00), $p<0.001$] in patients with thrombus.

Table-II: Association of clinical and echocardiographic variables with left atrial appendage thrombus on TEE (n=55)

Variables	LAA Thrombus		p -value
	Present (n=5)	Absent (n=50)	
Gender			
Male	3(60.0%)	36(72.0%)	0.62
Female	2(40.0%)	14(28.0%)	
Age	55.00(55.00-75.00)	62.00(58.00-67.00)	0.943
Comorbids			
Diabetes Mellitus	1(20.0%)	17(34.0%)	1.00
Hypertension	5(100.0%)	47(94.0%)	1.00
Smoker	2(40.0%)	15(30.0%)	0.64
CHF	4(80.0%)	12(24.0%)	0.02
History of CAD	2(40.0%)	16(32.0%)	1.00
History of Stroke/TIA	1(20.0%)	1(2.0%)	0.175
CKD	3(60.0%)	2(4.0%)	0.004
Structural Heart Disease	5(100.0%)	14(28.0%)	0.003
Hemoglobin [Median (IQR)]	15.80(15.00-16.20)	13.5(13.00-14.00)	0.028
Serum Creatinine [Median (IQR)]	1.30(0.80-1.50)	1.00(0.90-1.20)	0.579
CHA ₂ DS ₂ -VASc Score [Median (IQR)]	4.00(4.00-5.00)	2.00(1.00-3.00)	0.046
LVEF [Median (IQR)]	35.00(35.00-40.00)	58.00(50.00-60.00)	0.006
Spontaneous Echo Contrast	5(100.0%)	16(32.0%)	0.006
Left Atrial Dimensions			
LA Diameter (mm) (Mean±SD)	45.20±2.94	38.90±4.00	0.454
LA Volume (ml) (Mean±SD)	79.07±38.78	68.84±19.48	0.022
LAVI (ml/m ²) [Median (IQR)]	47.84(43.09-95.06)	37.29(30.53-42.83)	0.031
LA Emptying Velocity (cm/s) [Median (IQR)]	15.00(15.00-20.00)	48.00(40.00-55.00)	<0.001

CAD= Coronary Artery Disease; LAVI=Left Atrial Volume Index; CKD=Chronic Kidney Disease; LVEF=Left Ventricular Ejection Fraction

Figure-1 illustrates the frequency of LAA thrombus and spontaneous echo contrast among the study participants. LAA thrombus was detected in 5(9.1%) patients, while spontaneous echo contrast was observed in 21(38.2%) patients, reflected a substantial proportion of patients with impaired atrial flow dynamics despite the absence of overt thrombus. Figure-2 depicts the reasons for not performing

cardioversion in 31 patients. The most common reasons included detection of LAA thrombus or spontaneous echo contrast on TEE 3(9.7%), highlighting the clinical impact of pre-procedural imaging on cardioversion decision-making. However, 13(41.9%) patients did not consent to cardioversion.

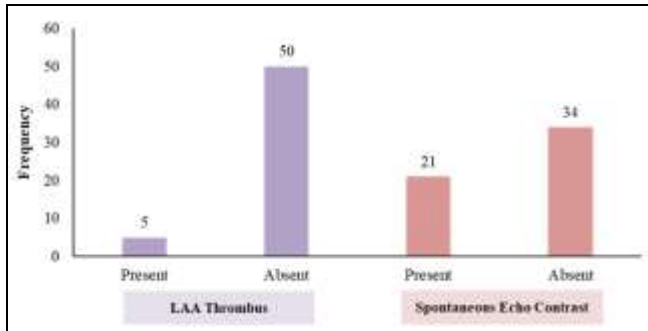


Figure-1: Frequency of left atrial appendage thrombus and spontaneous echo contrast on TEE (n=55)

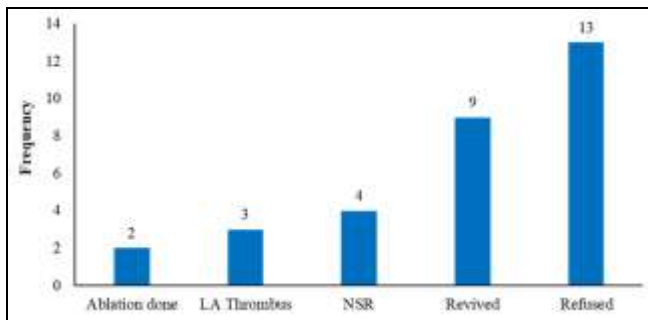


Figure-2: Reasons for deferring elective cardioversion among study subjects (n=31)

Table-III: Univariate and multivariable logistic regression analysis of predictors of left atrial appendage thrombus (n=55)

Variables	uOR(95%CI)	P-value	aOR(95%CI)	P-value
CHF	0.08(0.008-0.776)	0.029	0.07(0.005-1.67)	0.32
CKD	0.03(0.003-0.27)	0.002	0.03(0.004-1.26)	0.38
Structural Heart Disease	0.00(0.00-0.00)	0.998	-	-
Hemoglobin	3.14(1.15-8.59)	0.026	3.22(0.99-7.98)	0.54
CHA ₂ DS ₂ VASc Score	2.08(0.98-4.40)	0.05	2.16(1.01-4.41)	0.049
LVEF	0.89(0.81-0.98)	0.014	0.88(0.85-0.97)	0.04
Spontaneous Echo Contrast	0.00(0.00-0.00)	0.998	-	-
LA Diameter (mm)	1.83(1.15-2.90)	0.01	1.86(1.14-2.87)	0.005
LA Volume (ml)	1.02(0.98-1.06)	0.31	-	-
LAVI (ml/m ²)	1.03(1.003-1.06)	0.026	1.05(1.004-1.07)	0.023
LA Emptying Velocity (cm/s)	0.00(0.00-0.00)	0.994	-	-

CHF=Congestive Heart Failure; LAVI=Left Atrial Volume Index; CKD=Chronic Kidney Disease; LVEF=Left Ventricular Ejection Fraction

Table-III findings revealed higher CHA₂DS₂-VASc score was independently associated with thrombus formation (aOR=2.16; 95%CI: 1.01-4.41; $p=0.049$). Lower LVEF was still a significant predictor after adjusting for covariates (aOR=0.88; 95%CI: 0.85-0.97; $p=0.04$). Increased left atrial diameter (aOR=1.86; 95% CI: 1.14-2.87; $p=0.005$) and higher left atrial

volume index (aOR=1.05; 95% CI: 1.004-1.07; $p=0.023$) were also independently associated with the presence of LAA thrombus.

DISCUSSION

The present study evaluated the frequency and predictors of left atrial appendage (LAA) thrombus in patients undergoing transesophageal echocardiography prior to elective cardioversion and evaluated that LAA thrombus was present in 9.1% of the study sample. Reduced LVEF, higher CHA₂DS₂VASc score, increased left atrial diameter, and higher LAVI independently predicts LAA thrombus. This observation holds clinical value, as it indicates that a considerable proportion of patients remain at thromboembolic complications risk despite prompt anticoagulation practices. The noted frequency is comparable to that reported by Khan *et al.*, from Pakistan,⁹ who documented LAA thrombus in 9.8% of their study sample, although their study population was younger and predominantly female. In contrast, our study subjects consisted mainly of older male patients, indicating that demographic variations may influence thrombus prevalence across different populations. Internationally, the reported frequency of LAA thrombus varies widely, ranging from 3.7% in the study by Wegner *et al.*,¹⁰ to 14% reported by Segan *et al.*,¹¹ and 11.3% by Ruzieh *et al.*,¹² likely reflecting differences in patient selection, comorbidity burden, and anticoagulation status.

In our study population, patients with LAA thrombus had significantly higher CHA₂DS₂VASc scores [4.00 (IQR: 4.00-5.00) vs 2.00 (IQR: 1.00-3.00), $p=0.046$], reflected an association between clinical risk burden and thrombus formation. However, CHA₂DS₂VASc score alone was insufficient as a reliable predictor. This finding is consistent with Wegner *et al.*,¹⁰ who reported LAA thrombus in patients with CHA₂DS₂-VASc scores of 0 and 1, and found no significant association between higher scores and reduced LAA emptying velocity. Similarly, Ellis *et al.*,⁶ reported LAA thrombus in 5.3% (199/3,768) of patients and emphasized that clinical scores should be complemented with imaging parameters for accurate risk stratification, as also supported by other studies.¹³⁻¹⁵

Left ventricular systolic dysfunction emerged as a strong determinant of LAA thrombus in our study. Patients with thrombus demonstrated significantly lower LVEF [35.00% (IQR: 35.00-40.00) vs 58.00% (IQR: 50.00-60.00), $p=0.006$], and reduced LVEF

remained an independent predictor on multivariable analysis (aOR=0.88; 95% CI: 0.85–0.97; $p=0.04$). These findings are in agreement with Ayirala *et al.*,⁴ who reported that reduced LVEF was a key predictor of thrombus in 15.6% of patients, and with Kaufmann *et al.*,¹⁶ who demonstrated that LVEF $\leq 48\%$ and LVEF-to-LAVI ratio ≤ 1.1 were strong predictors of LAA thrombus (OR 6.77; $p<0.001$). Similar associations were also observed by Ruzieh *et al.*,¹² where patients with thrombus had markedly lower LVEF (29.9% vs 43.5%; $p<0.001$).

Structural remodeling of the left atrium was another important finding in our study. Patients with LAA thrombus had significantly higher left atrial volume [79.07 $\pm$ 38.78 ml vs 68.84 $\pm$ 19.48 ml, $p=0.022$] and higher left atrial volume index [47.84 ml/m² (IQR: 43.09–95.06) vs 37.29 ml/m² (IQR: 30.53–42.83), $p=0.031$]. Increased left atrial diameter was independently associated with thrombus formation (aOR=1.86; $p=0.005$). These results parallel findings by Wang *et al.*,¹⁷ who identified left atrial diameter (OR=1.094) and LAA maximum caliber (OR=1.238) as independent predictors of thrombus and spontaneous echo contrast. Chen *et al.*,¹⁸ also reported that left atrial enlargement and reduced LAA emptying velocity were independently associated with LAA thrombus (AUC 0.88).

Marked impairment of LAA mechanical function was evident in our patients with thrombus, who had significantly lower LAA emptying velocity [15.00 cm/s (IQR: 15.00–20.00) vs 48.00 cm/s (IQR: 40.00–55.00), $p<0.001$]. This finding aligns with Chen *et al.*,¹⁸ who reported LAA emptying velocity ≤ 21.5 cm/s as an independent predictor of thrombus, and with Wegner *et al.*,⁵ where reduced LAA flow velocity (≤ 20 cm/s) was observed in 8% of patients. The consistent association across studies indicates that LAA flow velocity is a key functional marker of thromboembolic risk.^{19,20}

Spontaneous echo contrast was present in all patients with LAA thrombus in our study (100% vs 32%, $p=0.006$), reinforcing its role as a surrogate marker of blood stasis and hypercoagulability. Similar associations were reported by Wang *et al.*,¹⁷ who found SEC in 3.9% of patients, and by Chen *et al.*,¹⁸ where SEC was an independent predictor of thrombus formation.

Overall, the findings of this study support existing evidence that LAA thrombus formation is multifactorial and cannot be reliably predicted using

clinical risk scores alone. The integration of echocardiographic parameters, particularly left ventricular systolic function, left atrial size, LAA emptying velocity, and spontaneous echo contrast, provides a more comprehensive assessment of thromboembolic risk. Clinically, these results reinforce the importance of pre-cardioversion TEE, especially in patients with ventricular dysfunction, atrial remodeling, renal impairment, or structural heart disease, to guide individualized management and reduce thromboembolic complications.

LIMITATION OF STUDY

The cross-sectional design was unable to establish causal relationships between identified predictors and LAA thrombus formation. Detailed evaluation of anticoagulation status and duration prior to TEE was not done, which could have impact on the prevalence of thrombus. Additionally, interobserver variability in echocardiographic measurements was not assessed. Despite these limitations, the study provides valuable local data and highlights clinically relevant predictors of LAA thrombus.

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CONCLUSION

Left atrial appendage thrombus remains a clinically significant finding in patients experiencing TEE before elective cardioversion. Reduced LVEF, increased left atrial size, higher LAVI, reduced left atrial emptying velocity, and higher CHA₂DS₂VASc score were associated with an increased risk of thrombus formation. These results depict that clinical risk scores alone may be not sufficient for the assessment of thromboembolic risk and emphasize the importance of integrating echocardiographic parameters in patient evaluation.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

TH & MS: Data acquisition, data analysis, critical review, approval of the final version to be published.

UF & P: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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