Původní sdělení | Original research article

# Early-LVT Risk Score – A new Clinical Risk Score for Early Left Ventricular Thrombus Prediction Following Anterior ST-Segment Elevation Myocardial Infarction

**Joana Laranjeira Correia[a,*], Vanda Devesa Neto[a,b,*], João Gouveia Fiuza[a], Luísa Gonçalves[a]**

[a] *Centro Hospitalar Tondela-Viseu, Viseu, Portugal*
[b] *Universidade da Beira Interior, Covilhã, Portugal*
** Both authors contributed equally to this work.*

ARTICLE INFO

*Article history:*
Submitted: 19. 12. 2023
Revised: 3. 1. 2024
Accepted: 6. 1. 2024
Available online: 4. 6. 2024

*Klíčová slova:*
Infarkt myokardu přední stěny
Infarkt myokardu s elevacemi úseku ST
Levokomorový trombus
Skóre rizika

SOUHRN

**Kontext:** Přes veškerý pokrok v léčbě infarktu myokardu s elevacemi úseku ST (STEMI) je riziko vzniku trombu v levé komoře (left ventricular thrombus, LVT) i nadále zdrojem značných obav vzhledem k možným embolickým komplikacím. Pro vedení léčebných intervencí a zlepšení klinických výsledků je proto naprosto nezbytné časné vyhledání pacientů s vysokým rizikem vzniku LVT.
**Cíl:** Cílem této studie bylo vypracovat praktické a v klinické praxi použitelné skóre rizika (Early-LVT Risk Score), které by s použitím snadno dostupných demografických, klinických a echokardiografických parametrů umožnilo předpovídat časný vznik LVT po STEMI přední stěny.
**Metody:** Byla provedena subanalýza údajů monocentrické randomizované kontrolované studie, které byly získány od pacientů po STEMI přední stěny a s echokardiografickým vyšetřením v prvních sedmi dnech po příhodě. Byly shromážděny demografické, klinické a diagnostické údaje. Pro každého pacienta bylo po identifikaci proměnných významně spojených se vznikem LVT vypočteno nově navržené skóre (s postupně přičítanými body pro každou proměnnou podle poměru šancí). Pro výpočet skóre se používá věk, klinické projevy (klasifikace podle Killipa a Kimballa), infarkt myokardu v anamnéze a nález z echokardiografického vyšetření (apikální aneurysma). Pro posouzení predikční hodnoty skóre byla provedena analýza křivky ROC.
**Výsledky:** Do studie bylo zařazeno celkem 68 pacientů průměrného věku 66,1 ± 13,5 roku; 81 % účastníků představovali muži. Apikální trombus byl nalezen u 19 % hodnocené populace. Vypracované skóre rizika prokázalo jednoznačnou spojitost se vznikem trombu (16 % vs. 3 %; $p < 0{,}01$; $\chi^2$ 7,07). Analýza křivky ROC prokázala spolehlivost skóre v predikci časného vzniku trombu (plocha pod křivkou 0,83; 95% CI 0,71–0,95; $p < 0{,}01$).
**Závěr:** Z uvedených údajů lze usuzovat, že skóre rizika časného vzniku levokomorového trombu účinně stratifikuje pacienty podle jejich rizika po STEMI přední stěny a lze jej používat v každodenní praxi při vyhledávání pacientů vyžadujících důkladnější vyšetření.



ABSTRACT

**Background:** Despite advancements in the management of ST-segment elevation myocardial infarction (STEMI), the risk of left ventricular thrombus (LVT) remains a significant concern due to its potential for embolic complications. Early identification of patients at high risk for LVT is crucial for guiding therapeutic interventions and improving clinical outcomes.
**Aim:** This study aimed to develop a practical and clinically applicable risk score (Early-LVT Risk Score) that integrates readily available demographic, clinical, and echocardiographic parameters to predict the likelihood of early LVT formation post anterior STEMI.
**Methods:** A sub-analysis of a single-center randomized controlled trial was conducted among patients with anterior STEMI and performed echocardiography in the first seven days following the event. Demographical, clinical, and diagnostic data were collected. The newly designed score was calculated for each patient, after identification of the variables significantly associated with LVT formation (points attributed for each variable according to odds ratio). The score incorporates age, clinical presentation (Killip–Kimball classification), history of previous myocardial infarction and echocardiographic findings (apical aneurysm). ROC curve analysis was performed to evaluate the predictive value of the score.

**Address:** Vanda Devesa Neto, Cardiology Department, Tondela-Viseu Hospital Centre, Av. Dom Duarte, 3504-509 Viseu, Portugal, e-mail: vandadevesaneto@gmail.com
**DOI:** 10.33678/cor.2024.004

**Please cite this article as:** Correia JL, Neto VD, Fiuza JG, Gonçalves L. Early-LVT Risk Score – A new Clinical Risk Score for Early Left Ventricular Thrombus Prediction Following Anterior ST-Segment Elevation Myocardial Infarction. Cor Vasa 2024;66:323–327.

*Keywords:*
Anterior myocardial infarction
Left ventricular thrombus
Risk score
ST-elevation myocardial infarction

**Results:** A total of 68 patients were included in the study; mean age was 66.1±13.5 years, with 81% of patients being male. Apical thrombus was identified in 19% of the population. The developed risk score demonstrated a clear association with thrombus formation (16% vs 3%; $p$ <0.01; $\chi^2$ 7.07). ROC curve analysis revealed that the score had a robust predictive performance for early thrombus detection (area under the curve 0.83, 95% CI 0.71–0.95 $p$ < 0.01).

**Conclusion:** These findings suggest that the Early-LVT Score effectively stratifies patients based on their risk of developing LVT following anterior STEMI and could be used in daily practice to determine which patients should be aggressively investigated.

## Introduction

The introduction of primary percutaneous coronary has resulted in a reduction in mortality rates associated with acute myocardial infarction (AMI). However, post-infarct complications continue to contribute to worse prognosis. Despite significant advances in the diagnosis and treatment of cardiovascular diseases, the management of left ventricular thrombus (LVT) remains challenging.[1] Although its incidence has decreased significantly due to advancements in reperfusion techniques and antithrombotic therapies, the presence of LVT still poses a substantial risk of embolic events.[1–3] In fact, the one-year risk of stroke associated with LVT can reach up to 10% of cases, even with anticoagulation therapy.[4]

The development of thrombus following an AMI, particularly in cases of anterior ST-elevation myocardial infarction (STEMI), is influenced by three primary factors: endothelial injury resulting from myocardial infarction, blood stasis caused by LV dysfunction, and hypercoagulability induced by the inflammatory state.[1,2] Anterior STEMI typically occurs due to occlusion of the left anterior descending artery and is associated with a worse prognosis compared to other coronary territories, primarily due to the larger area of myocardial supplied.[3,5] One common complication of anterior STEMI is LV apical akinesia, which leads to blood stasis and subsequent thrombus formation. This often occurs within 24 hours after AMI and mostly within the first 2 weeks.[1–3,6,7]

Early identification of patients at high risk for LVT is crucial for guiding appropriate anticoagulant treatment and improving clinical outcomes.[8,9]

To the best of our knowledge and based on the conducted research, there are currently no validated scores for predicting which patients will develop LVT following anterior STEMI. This study aimed to develop a practical and clinically applicable risk score (Early-LVT Risk Score) that integrates readily available demographic, clinical, and echocardiographic parameters to predict the likelihood of early LVT formation post anterior STEMI.

## Methods

### *Study design and participants*

A sub-analysis of a randomized control trial population that included patients admitted to the Cardiac Intensive Care Unit at a Portuguese Center, due to anterior STEMI, between November 2021 and January 2023. The study received approval from the institution's ethics committee. Anterior STEMI definition was in accordance with the 4th universal definition of myocardial infarction with ST-segment elevation by the European Society of Cardiology. The exclusion criteria were patients younger than 18 years who did not undergo echocardiographic or coronary angiographic evaluation, cardiogenic shock, and previously known thrombus or allergic contrast reaction. Informed consent was obtained from all patients enrolled in this study.

Patients were submitted to a contrast TTE procedure or a conventional TTE as part of their initial diagnostic assessment and when doubts persisted, based on the attending physician's judgment, a subsequent contrast TTE could be performed.

For the contrast TTE procedure, the SonoVue® ultrasound agent and the GE i9® echocardiograph machine was utilized. The procedure was conducted by a team of four cardiologists specialized in ultrasound imaging, who were aware of the study protocol. The minimum amount of ultrasonographic contrast necessary for effective opacification of the left ventricle was employed.

Demographic and clinical information for each participant was collected by reviewing the electronic medical records, following the research protocol approved by our institution. This information included age, anthropometric data, cardiovascular risk factors, family history of cardiovascular disease or sudden death at a young age, history of cerebrovascular disease, history of atrial flutter/fibrillation, and bleeding history.

Late presentation of myocardial infarction was defined as more than 12 hours after symptom onset of symptoms and admission. Echocardiographic LV function was assessed using Simpson's biplane method. LV thrombus was defined as an echo dense mass in the LV, distinct from the endocardium and adjacent to an area of hypokinetic or akinetic myocardium, with a complete absence of contrast uptake after injection of ultrasound contrast (when indicated).

### *Statistical analysis and score creation*

We reviewed and analyzed data from this cohort of patients to develop a score to predict the early LVT following anterior STEMI.

General characteristics were reported as mean ± standard deviation (SD) and frequencies (percentages) for continuous and categorical variables, respectively. Comparisons between groups were performed using the Chi-square test and the Student's t-test or Mann–Whitney test for independent groups, for categorical, and continuous variables, respectively, where appropriate. Logistic binary regression analysis was run, taking LVT formation as the outcome. Statistically significant variables at univariate analysis were included in a multivariate analysis. The

strength of the association between variables and LVT was reported as odds ratios (ORs) with their 95% confidence intervals (95% CI). Early-LVT Score was constructed based on the coefficients from the logistic model, as the sum of each variable multiplied by its own OR. Receiver Operating Characteristic (ROC) analysis was used to determine the accuracy of the Early-LVT Score in predicting LVT and to find the corresponding cut-off value (**Table 1**). A ROC analysis was also performed to assess Early-LVT Score accuracy in predicting LVT formation. *P* values <0.05 were considered significant for all the tests. SPSS statistics version 29 (IBM Corp., Armonk, NY) was used for statistical analyses.

## Results

### *Features of the enrolled population*

A total of 68 patients were included in the study, with 13 patients with LVT detection.

Demographic, clinical, and procedural data demonstrated similarity between the two groups (**Table 1**). Among the enrolled patients, the mean age was 66.1 (±13.5) years, 80.9% (n = 55) were male, 20.6 % (n = 14) had diabetes, 58.8% had arterial hypertension, 51.5% (n = 35) had dyslipidemia, and 50% (n = 34) had history of smoking (30.9% with active smoking and 19.1% of former smokers). Late presentation occurred in 6.7% and 10.5% of the patients in the study and control group, respectively.

Fibrinolysis was performed in 18% of the overall population and was associated with fewer cases of thrombus, although not statistically significant (24% vs. 5.5%; $p$ = 0.08; $\chi^2$ 2.912). Across the entire patient cohort, successful reperfusion was observed in 92.6% of cases, with primary percutaneous coronary intervention (PCI) performed in 67.6% of patients, rescue PCI after thrombolysis in 11.8%, and bypass surgery in 1.5%. Patients with thrombus were treated with anticoagulation, namely, 31% with non-vitamin K antagonist oral anticoagulants, 46% with vitamin K antagonists, and 23% with enoxaparin.

The overall mortality rate was 1.5% (n = 1), corresponding to a patient who died due to nosocomial pneumonia.

### *Score creation and validation*

Multivariate regression analysis showed that age > 65 years, Killip–Kimball class at admission, late presentation, previous myocardial infarction and LV apical aneurysm were associated with a higher rate of LVT (**Table 2**).

Early-LVT Score, based on the multivariable regression, showed a good predictive power in prediction of LVT in setting of acute myocardial infarction (area under a receiver operating characteristic curve [AUC] = 0.83, 95% CI 0.71–0.95 $p$ <0.01) (**Fig. 1**).

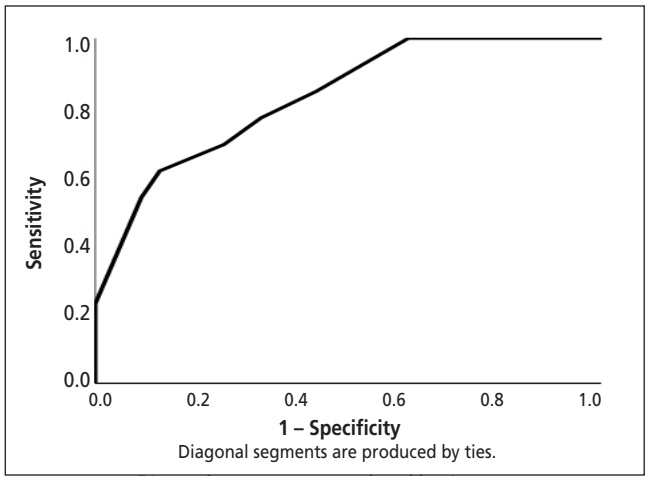


**Fig. 1 – Receiver operating characteristic (ROC) analysis of Early-LVT Score in predicting LVT after anterior ST-segment elevation myocardial infarction.**

**Table 1 – Demographic and clinical characteristics**

| | LVT formation (n = 13) | No LVT formation (n = 55) | *p*-value |
|---|---|---|---|
| Male gender – n (%) | 12 (92) | 43 (78.2) | 0.23 |
| Age – median (IQR) (years) | 63 (13) | 66.8 (14) | 1.00 |
| Hospitalization days – median (IQR) (days) | 11 (9) | 7.3 (4) | 0.81 |
| BMI – median (IQR) (kg/m$^2$) | 27 (18) | 33 (25) | 0.49 |
| Arterial hypertension – n (%) | 5 (38.5) | 35 (64) | 0.09 |
| Diabetes – n (%) | 3 (23.1) | 11 (20) | 0.23 |
| Dislipidemia – n (%) | 5 (38.5) | 30 (55) | 0.80 |
| Alcohol abuse – n (%) | 3 (23.1) | 7 (12.7) | 0.29 |
| Family history of cardiovascular disease in young age or sudden cardiac death – n (%) | 1 (7.7) | 3 (5.5) | 0.58 |
| Prior stroke – n (%) | 0 | 2 (3.6) | 0.65 |
| Chronic kidney disease – n (%) | 0 | 4 (7.3) | 0.42 |
| Chronic liver disease – n (%) | 0 | 3 (5.5) | 0.52 |
| Chronic obstructive pulmonary disease – n (%) | 2 (15.4) | 2 (3.6) | 0.9 |
| Heart failure – n (%) | 1 (7.7) | 0 | 0.19 |
| Atrial fibrillation/flutter – n (%) | 0 | 4 (7.3) | 0.25 |

% – percentage; BMI – body mass index; IQR – interquartile range; n – number.

**Table 2 – Multivariate regression model for predicting left ventricular thrombus**

| Variables | Odds ratio (95% CI) | *p*-value |
|---|---|---|
| Age > 65 years | 1.856 (1.093–3.149) | 0.02 |
| Killip–Kimball class | 1.247 (1.130–1.376) | <0.01 |
| Late presentation | 5.212 (3.373–8.054) | <0.01 |
| Previous myocardial infarction | 1.099 (1.039–1.235) | 0.05 |
| Left ventricular apical aneurysm | 6.796 (3.622–12.753) | <0.01 |

**Table 3 – Early-LVT Score**

| Variables | Points |
|---|---|
| Age >65 years | 1 |
| Killip–Kimball class | 0.5 |
| Late presentation | 2.5 |
| Previous myocardial infarction | 0.5 |
| Left ventricular apical aneurysm | 3.5 |

The ROC analysis allowed defining 3 points as the most accurate cut-off in predicting LVT (sensitivity of 100% and a specificity of 62%. LVT Score >3 was significantly associated with LVT formation (16% vs 3%; $p$ <0.01; $\chi^2$ 7.07).

No association was found regarding 12 months mortality and Early-LVT Score > 3 ($p$ = 0.37).

## Discussion

Despite advancements in the management of STEMI, the risk of LVT formation remains considerable. The presence of LVT significantly elevates the risk of embolic complications and is correlated with higher intra-hospital and overall mortality rates.[1–3,10] Timely identification of patients with a high risk of developing LVT is crucial for guiding therapeutic interventions and enhancing clinical outcomes.

Numerous factors contribute to the development of LV thrombus in this scenario, including blood stasis, which is more pronounced in cases of LV aneurysms, large infarct areas, and reduced LV ejection fraction. Furthermore, subendocardial damage resulting from prolonged ischemia and a hypercoagulable state induced by the inflammatory response also contribute to thrombus formation.[7,11–14] The detection of LV thrombus is paramount for initiating suitable anticoagulant treatment and enhancing clinical outcomes.[8,9]

In this study, we aimed to develop a practical and clinically applicable risk score, termed the Early-LVT Risk Score, to predict the likelihood of early LVT formation in post anterior STEMI. The developed Early-LVT Risk Score incorporates readily available demographic, clinical, and echocardiographic parameters, providing a comprehensive tool for risk stratification. The variables included in the score were age, clinical presentation (Killip–Kimball classification), history of previous myocardial infarction, and the presence of an echocardiographic finding – an apical aneurysm.

Our analysis revealed no substantial differences in demographic and clinical characteristics between the two groups (with LVT formation and without LVT formation), suggesting a reasonable baseline comparability.

The results of this study demonstrated a clear association between the Early-LVT Risk Score and LVT formation. Patients with a higher Early-LVT Score had a significantly higher incidence of LVT compared to those with a lower score (16% vs. 3%; $p$ <0.01; $\chi^2$ 7.07). The robust predictive performance of the score was further confirmed by ROC curve analysis, with an AUC of 0.83 (95% CI 0.71–0.95; $p$ <0.01). This suggests that the Early-LVT Risk Score effectively stratifies patients based on their risk of developing LVT following anterior STEMI.

The individual components of the Early-LVT Risk Score also provided valuable insights. Age (higher than 65 years), higher Killip–Kimball class at admission, late presentation, history of previous myocardial infarction, and the presence of a LV apical aneurysm were identified as independent predictors of LVT formation. These findings align with the known pathophysiology of LVT development following anterior STEMI.

The clinical applicability of the Early-LVT Risk Score is highlighted by its ability to guide early intervention strategies. Patients identified as high risk by the score may benefit from more aggressive investigation and timely initiation of anticoagulant therapy. This proactive approach could potentially reduce the incidence of embolic events associated with LVT, ultimately improving clinical outcomes.

Importantly, the Early-LVT Risk Score provides a valuable contribution to the field as, to the best of our knowledge, there are currently no validated scores for predicting LVT specifically following anterior STEMI. Our study addresses this gap and offers a practical tool that can be readily employed in daily clinical practice.

## Limitations

Interpreting our study's results requires careful consideration of its limitations that need to be considered.

The research was conducted at a single center, which may limit the applicability of our findings to other healthcare environments. The results may not be universally applicable to diverse populations treated in different clinical settings. Therefore, caution should be exercised when extrapolating these findings to a broader patient population. The authors emphasize the imperative need for the score to undergo validation in a larger external cohort.

Our center experiences a significant number of cases involving fibrinolysis therapy. This is attributed to our status of Percutaneous Coronary Intervention (PCI) Center that serves a vast territorial area. Moreover, we provide support to two non-PCI centers located more than 120 minutes away. This might introduce variations in the clinical characteristics and management strategies, potentially influencing the generalizability of our findings to centers with different reperfusion rates and patient demographics.

Additionally, the study included a relatively small sample, which may not fully capture the complexity and

diversity of clinical and demographic factors influencing LVT development post anterior STEMI. Larger cohorts are necessary to enhance the robustness and generalizability of the Early-LVT Risk Score.

The Early-LVT Risk Score, although showing promise in this study, lacks external validation in independent cohorts. Further validation in external populations is crucial to confirm the score's performance and reliability across different healthcare settings.

Lastly, our study exclusively concentrated on the acute phase of the disease. The relatively short time gap between AMI and the TTE performance could potentially affect the detectability of the LV thrombi.

To obtain more meaningful results, further research using larger, multicenter studies with long-term follow-up is necessary to validate our findings and determine the clinical benefits and cost-effectiveness of incorporating ultrasound contrast into routine management for patients with anterior STEMI.

## Conclusion

In conclusion, the Early-LVT Risk Score exhibited robust predictive performance for early LVT detection following anterior STEMI and holds potential utility in daily practice for identifying patients who warrant aggressive investigation. Through the integration of age, clinical presentation, history, and echocardiographic findings, this score offers a comprehensive and practical tool for identifying individuals at a heightened risk of LVT formation. However, further validation studies in diverse populations are essential to confirm the generalizability and effectiveness of the Early-LVT risk score in various clinical settings.

**Conflict of interest**
The authors have nothing to declare.

**Funding sources**
The authors have nothing to declare.

**References**

1. Levine GN, McEvoy JW, Fang JC, et al. Management of Patients at Risk for and With Left Ventricular Thrombus: A Scientific Statement From the American Heart Association. Circulation 2022;146:e205–e223.
2. Camaj A, Fuster V, Giustino G, et al. Left Ventricular Thrombus Following Acute Myocardial Infarction. J Am Coll Cardiol 2022;79:1010–1022.
3. Rehan A, Kanwar M, Rosman H, et al. Incidence of post myocardial infarction left ventricular thrombus formation in the era of primary percutaneous intervention and glycoprotein IIb/IIIa inhibitors. A prospective observational study. Cardiovasc Ultrasound 2006;4:20.
4. Ali Z, Isom N, Dalia T, et al. Direct oral anticoagulant use in left ventricular thrombus. Thromb J 2020;18:29.
5. Gianstefani S, Douiri A, Delithanasis I, et al. Incidence and Predictors of Early Left Ventricular Thrombus After ST--Elevation Myocardial Infarction in the Contemporary Era of Primary Percutaneous Coronary Intervention. Am J Cardiol 2014;113:1111–1116.
6. Kobayashi N, Maehar A. Left anterior descending artery wrapping around the left ventricular apex predicts additional risk of future events after anterior myocardial infarction. Anatol J Cardiol 2019;21:259–260.
7. Delewi R, Zijlstra F, Piek JJ. Left ventricular thrombus formation after acute myocardial infarction. Heart 2019;98:1743–1749.
8. Habash F, Vallurupalli S. Challenges in management of left ventricular thrombus. Ther Adv Cardiovasc Dis 2017;11:203–213.
9. Abdelmoneim SS, Pellikka PA, Mulvagh SL. Contrast echocardiography for assessment of left ventricular thrombi. J Ultrasound Med 2014;33:1337–1344.
10. Huang L, Tan Y, Pan Y. Systematic review of efficacy of direct oral anticoagulants and vitamin K antagonists in left ventricular thrombus. ESC Heart Fail 2022;9:3519–3532.
11. Rodriguez JBC, Okajima K, Greenberg BH. Management of left ventricular thrombus: a narrative review. Ann Transl Med 2021;9:520.
12. Massussi M, Scotti A, Lip GYH, et al. Left ventricular thrombosis: new perspectives on an old problem. Eur Heart J Cardiovasc Pharmacother 2020;7:158–167.
13. Niazi AK, Kassem H, Shalaby G, et al. Incidence and Predictors of Left Ventricular (LV) Thrombus after ST-Elevation Myocardial Infarction (STEMI) in the Holy Capital of Saudi Arabia. J Saudi Heart Assoc 2021;33:101–108.
14. Albaeni A, Chatila K, Beydoun HA, et al. In-hospital left ventricular thrombus following ST-elevation myocardial infarction. Int J Cardiol 2020;299:1–6.