

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

Seshadrinathan Pallaseena Seetharaman¹, Valarmathi Srinivasan^{2*}

¹ Senior Consultant Cardiologist, Department of Cardiology, Voluntary Health Services Hospital, Chennai, Tamil Nadu, India

^{2*} Research Officer (Statistics), Department of Epidemiology, The Tamil Nadu Dr. M.G.R. Medical University, Chennai, Tamil Nadu, India. Email: srisupri@hotmail.com (Corresponding Author)

Received: 2nd Mar, 2026 | Revised: 14th Mar, 2026 | Accepted: 4th Apr, 2026 | Available Online: 20th Apr, 2026

ABSTRACT

Background: Current guidelines rely on millimetric ST-elevation (STEMI) criteria to identify acute coronary occlusion, yet many patients with total occlusion do not meet these thresholds. This systematic review and meta-analysis was aimed to evaluate the diagnostic performance of the ECG criteria based on the Fourth Universal Definition of ST-elevation Myocardial infarction for identifying angiographic acute total coronary occlusion (TIMI 0) and to determine the prevalence of "hidden" Occlusion Myocardial Infarction (OMI) within the NSTEMI population.

Methods: Following PRISMA-DTA guidelines, a systematic search was conducted in PubMed, Embase, and Cochrane Library. Eleven studies were included for prevalence analysis of the NSTEMI group, and nine studies were used for diagnostic test accuracy (DTA) in a combined STEMI/NSTEMI cohort. Pooled estimates were calculated using a random-effects model and HSROC analysis. Clinical utility was tested using Decision Curve Analysis. Quality was assessed via QUADAS-2, and publication bias was evaluated using Egger's test.

Results: The pooled prevalence of OMI within the NSTEMI population was 39% (11 studies; $I^2 = 99.67\%$). In the DTA analysis, ST-elevation criteria demonstrated a pooled sensitivity of 0.65 (95% CI: 0.59–0.75) and a specificity of 0.59 (95% CI: 0.22–0.87). Forest plot analysis revealed a "sensitivity ceiling," with the majority of studies falling to the left of the 0.70 threshold. The HSROC AUC was 0.69, while the pooled LR+ (2.09), LR- (0.53), and NPV (0.73) indicated weak discriminative power. Decision Curve Analysis (DCA) showed that the ST Elevation ECG criteria failed to exceed the net benefit of "treat all" or "treat none" strategies across a 0–0.5 threshold range. Risk of bias was low, and Egger's test ($P=0.46$) showed no significant publication bias.

Conclusion: Standard ST-elevation criteria are a clinically inadequate gatekeeper, failing to identify one-third of the 39% of NSTEMI patients with an active total coronary occlusion. The low NPV and lack of net benefit in DCA provide a clear mandate to transition toward a more sensitive OMI/NOMI diagnostic framework to prevent dangerous delays in reperfusion.

Keywords: Occlusion Myocardial Infarction, OMI, TIMI 0, STEMI, NSTEMI, Diagnostic Test Accuracy, Coronary Angiography, ST-segment elevation, Sensitivity and Specificity.

How to cite this article: Seetharaman SP, Srinivasan V. Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis. *Int J Drug Deliv Technol.* 2026;16(33s):967-981. DOI: 10.25258/ijddt.16.33s.116

Source of support: Nil.

Conflict of interest: The authors declare no conflict of interest.

Introduction: infarction (1).Current guidelines recommend 12 lead electrocardiogram is the most commonly primary PCI within 12 hours for patients presenting with Acute ST elevation myocardial infarction . employed tool in the diagnosis of myocardial with Acute ST elevation myocardial infarction .

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

Based on the admission ECG, Acute myocardial infarction is presently classified as ST elevation or Non ST elevation types(2). ST elevation by ECG is universally defined as 1mm STE in any of two contiguous leads except in Leads V2 and V3 wherein >1.5 mm in women irrespective of age, >2.5 mm in men less than 40 years or >2mm in men above 40 years or a new left bundle branch block is stipulated for diagnosis of acute myocardial infarction by ECG(3,4,5). ECG ST elevation is also thought to represent and as a marker of acute total occlusion of the culprit coronary artery in ST Elevation Myocardial infarction, while NSTEMI myocardial infarction is thought to have partly occluded coronary arteries (6) and the decision for emergent reperfusion is primarily made based on the presence of acute ST elevation at ECG (2).

Acute total occlusion of infarcted myocardium and results in transmural ischemia of myocardium resulting in large infarct size and mortality. The magnitude of ST elevation correlates with size and complications of infarction including arrhythmias, cardiac rupture and cardiogenic shock (1). However ECG has reduced sensitivity to detect acute occlusions of coronary arteries (2), especially when the culprit arteries are LCX (50% of cases) and RCA (32% of cases) that supply the postero inferior territory of LV myocardium (1,7). Well developed collaterals that could prevent ST elevation LCX (left circumflex) occlusion have been implicated for false negative ST criteria in ECG to identify acute coronary occlusion

Non ST elevation myocardial infarction (NSTEMI) comprises of two thirds of myocardial infarction (2). NSTEMI is attributed to incomplete coronary thrombosis (8). However about 25-30% of NSTEMI (Non ST elevation myocardial infarction) have total occlusion demonstrated by early angiography (4,9), which are missed by applying ST elevation criteria alone by ECG (2,7,10-12).

It has been observed that such totally occluded NSTEMI patients have double the infarct size, 72% higher mortality at 6 months and higher event rates compared to NSTEMI patients without occluded culprit arteries (13). Moreover, ST elevation criteria is also found to be 15-20% falsely positive. Hence it is essential to identify those patients in the subgroup of NSTEMI to timely revascularize and save the myocardial jeopardy(3). Occlusive or Non occlusive

myocardial infarction paradigm may better identify the patients based on underlying pathology than risk stratifying the patients based only on whether ST elevation is present or absent in ECG for acute myocardial infarction patients(14) in order to reduce false negative patients stratified by ST elevation ECG criteria alone(2,4,9).

By incorporating subtle ECG findings beyond the traditional ST elevation mm criteria alone which are termed STEMI equivalents(4) namely, Wellens pattern, De Winter pattern, abnormal notching in terminal QRS, ST depression in V1-V4, hyper acute tall T waves, T-wave V1>V6, T inversion in aVL, ST elevation in aVR with diffuse ST depression in lateral leads, Aslanger pattern, South African Flag sign, modified smith sgarbossa criteria, shark fin sign, precordial swirl pattern, isolated posterior wall infarction pattern, Northern OMI pattern and ST elevation in aVR with widespread ST depression, an astute clinician can suspect potential acute coronary occlusion in addition to the standard ST elevation criteria alone in emergency settings. Hence some authorities strongly propose OMI (occlusion myocardial infarction) and NOMI (non occlusive myocardial infarction paradigm should replace the current ST/Non ST paradigm to identify and stratify patients for early revascularization in acute myocardial infarction (1,3,6-7,14-17) authorities and opine further that as ST elevation by ECG alone is a poor surrogate for acute total occlusion (2), analyzing together with clinical pretest probability and these subtle ECG finding(6), would improve diagnostic sensitivity to detect occluded MI early ("finding high risk needle in haystack") for timely reperfusion strategy (18).

This systematic review and meta-analysis was undertaken to evaluate the diagnostic utility of the Fourth Universal Definition of Myocardial Infarction ST-elevation ECG criteria in identifying acute total coronary occlusion (TIMI 0 flow). Specifically, this study aims to address the following research questions: Diagnostic Performance in Mixed Cohorts: What is the diagnostic accuracy of ST-elevation ECG criteria for identifying acute total coronary occlusion in a combined population of STEMI and NSTEMI patients? Prevalence of "Hidden" OMI: What is the pooled incidence of Occlusion Myocardial Infarction (OMI) within the subgroup of patients initially categorized as

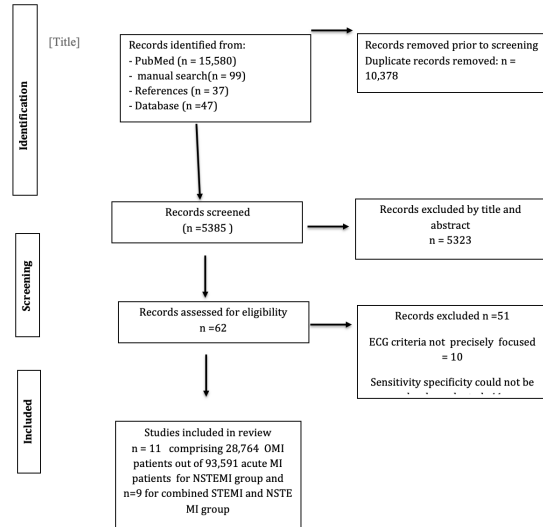
Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

NSTEMI? And Clinical Triage Risk: How effectively can ST-elevation alone serve as a gatekeeper for emergent reperfusion, and specifically, what proportion of patients with total coronary artery occlusion are missed (false negatives) when ST-elevation is absent on the admission 12-lead ECG?

METHODS :

SEARCH STRATEGY:

A systematic search was conducted across the PubMed, Embase, Google scholar, The Tamilnadu Dr. MGR medical university academic databases to identify studies in English language spanning years from 2008-2024 from any Geographical location evaluating the diagnostic accuracy of ST-elevation ECG criteria for occlusive myocardial infarction. The search strategy utilized a combination of official Medical Subject Headings (MeSH) and specific author keywords. The MeSH terms included Myocardial Infarction/diagnosis, Coronary Occlusion/diagnosis, Electrocardiography/standards, and Sensitivity and Specificity. Key terms included Occlusion Myocardial Infarction, OMI, TIMI 0, STEMI, NSTEMI, Diagnostic Test Accuracy, Coronary Angiography, ST-segment elevation, and Sensitivity and Specificity. The primary search string employed was as follows: ("Myocardial Infarction"[Mesh] OR "MI") AND ("ST-segment elevation" OR "STEMI") AND ("TIMI 0" OR "total occlusion" OR "complete occlusion") AND ("angiography" OR "CAG" OR "culprit"). Following the removal of duplicates and rigorous screening against pre-defined inclusion criteria, a total of 11 studies (19-29) were included in the final analysis. To ensure statistical homogeneity and clinical relevance, the data were analyzed in two distinct phases: Prevalence Analysis: All 11 studies addressing the NSTEMI group were utilized to calculate the pooled prevalence of OMI specifically within the NSTEMI population. Diagnostic Test Accuracy (DTA): A subset of 9 studies (20-25,27-29) addressing the combined STEMI and NSTEMI cohorts was used for the DTA analysis. The 2 remaining studies (19,26) were excluded from this phase as they focused exclusively on NSTEMI patients, which would have skewed the combined diagnostic performance metrics.



The meta-analysis was conducted and reported in accordance with the PRISMA-DTA statement which provides specific guidelines for the transparent reporting of diagnostic test accuracy studies and depicted in TABLE/FIG; PRISMA FLOW CHART1.

Table/fig 1: PRISMA Flow Chart

le/fig 2: Baseline characteristics

S. No	Author	Year	Study design	Country	Mean age	M	F	DM	HT N	HL P	Smoking	Prior MI		
1	Dixon WC et al (19)	2008	Retrospective	USA	66			759	195					
2	Marti D et al (20)	2014	Prospective	Spain	63	333	114	81	167	190	240	42		
3	Wang TY et al (21)	2016	Retrospective	USA	75	284	221	145				979		
4	Karwowski J et al (22)	2017	Prospective	Poland	63	471	235	155	469	284	5	2501		
5	Hillinger P et al (23)	2018	Prospective	Switzerland	60	216	101	51	187	149	117	76		
6	Aslanger EK et al (DIFFOCULT) (24)	2020	Retrospective	Turkey/USA	69	141	3	587	663	105	5	745	929	459
7	Aslanger EK et al (25)	2020	Retrospective	Turkey/USA	62	934	428	475	765	273	621	350		
8	Morawska I et al (26)	2021	Retrospective	Poland	71	293	106	162	332	159	114			
9	Tanaka T et al (27)	2021	Retrospective	Japan	72	178	53	101	174	109	115	38		
10	Meyers HP et al (28)	2021	Retrospective	USA										
11	Kola M et al (29)	2024	Retrospective	Albania	64	237	97	102	256	250				

Definitions are tabulated in TABLE/FIG; 3.

Table/fig 3: Definitions

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

S.no	Terminology	Definition
1	True positive STEMI	ECG with ST elevation and occlusive MI by angiography
2	True negative STEMI	ECG without ST elevation and non-occlusive MI
3	False positive STEMI	ECG with ST elevation but non occlusive MI
4	False Negative STEMI	ECG without ST elevation but occlusive MI
5	OMI	Angiographic culprit lesion with TIMI 0-2 flow
6	Aslanger pattern	STE in lead III alone, STD in V4-V6 with terminal positive T wave, STE in V1-V2
7	South African Flag sign	STE in I, aVL and V2 with reciprocal STD in inferior leads.
8	DeWinter pattern	Upsloping STD 1-3 mm in V1-V6 with hyperacute T waves.
9	Wellens pattern	Deeply inverted or biphasic T in V2-V3, isoelectric or minimally elevated ST segment, absent precordial Q wave with normal R wave progression in precordial leads
10	Modified Sgarbasso criteria	In LBBB concordant STE 1mm, concordant STD 1mm in V1-V3 discordant STE with ST/S >25%
11	Shark fin sign	Wide, rounded and large STE which resembles a shark fin
12	Hyperacute T waves	Tall and broad T waves in early occlusion phase.
13	Fragmented QRS	Multiple notches within the QRS
14	STE	ST segment elevation
15	STD	ST segment depression
16	TIMI	Thrombolysis in myocardial infarction
17	NOMI	Non occlusion myocardial infarction
18	NSTEMI	Non-ST segment myocardial infarction
19	Precordial swirl pattern	Mild STE aVR, STE V1-V2, STD V5-V6 isoelectric V3-V4
20	Isolated Posterior myocardial infarction	STD maximally in V1-V4
21	Northern OMI pattern	Any STE in aVR and aVL with negative T wave along with any STD in inferior and lateral leads with positive T wave.

The meta-analysis was framed as per PICOTTS Framework

P (Population): Adults presenting with acute myocardial infarction (AMI) who underwent urgent or early coronary angiography.

- **I (Index Test):** The 12-lead ECG ST-elevation criteria as defined by the Fourth Universal Definition of Myocardial Infarction.
- **C (Comparator):** Patients with acute myocardial infarction who did not meet the ST-elevation criteria (NSTEMI cohort).
- **O (Outcome):** Diagnostic accuracy metrics including Sensitivity, Specificity, Likelihood Ratios (LR+/-), Diagnostic Odds Ratio (DOR), PPV, NPV, and HSROC/Decision Curve Analysis.
- **T (Target Condition):** Angiographically confirmed acute total coronary occlusion (TIMI 0 flow).
- **T (Time):** Acute phase of presentation (from symptom onset to angiography).
- **S (Setting):** Cardiovascular centers with 24/7 cardiac catheterization laboratory capabilities

Inclusion criteria ;

Studies were included if they involved adult patients (≥ 18 years) presenting with acute myocardial infarction who underwent both 12-lead electrocardiography and coronary angiography within 24 hours of

presentation. Eligible studies were required to document the presence or absence of an angiographic culprit coronary artery occlusion and be available as full-text

English-language publications between 2008 and 2024. No restrictions were placed on geographical location or study design, ensuring a comprehensive synthesis of available evidence.

Exclusion criteria;

Studies were excluded if they involved animal models, consisted only of abstracts, or were limited to isolated case reports and narrative reviews. To ensure the specificity of the ECG analysis, patients with pre-existing conduction abnormalities (e.g., Left Bundle Branch Block), valvular heart disease, cardiomyopathies, or myocarditis were also excluded. Finally, any study providing inadequate ECG or angiographic detail to confirm the presence of a culprit occlusion was omitted from the final synthesis.

QUALITY ASSESSMENT;

The methodological quality of the included studies was independently assessed by the two authors using the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool. In accordance with the Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy, this tool evaluated four key domains: patient selection, index test, reference standard, and flow and timing. Each domain was assessed for risk of bias, and the first three domains namely patient selection, index test, and reference standard were assessed, rated and evaluated for applicability concerns. Each domain was categorized as having a 'low,' 'high,' or 'unclear' risk of bias based on signaling questions. For retrospective studies, particular attention was paid to whether the patient enrollment was consecutive and if the index test was interpreted blindly to the reference standard. Any disagreements between the two authors regarding the risk of bias ratings were resolved through discussion or by consultation with a third reviewer, if necessary, until a consensus was reached. The results of the quality assessment were summarized using a risk of bias table

Statistical Analysis

The relevant data for this study were collected and organised into a master chart using Microsoft Excel. To assess the diagnostic accuracy, sensitivity,

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

specificity, Positive likelihood ratio (LR+), negative likelihood ratio (LR-), and diagnostic odds ratio (DOR) were calculated for each study. Ninety-five per cent confidence intervals (95% CI) for sensitivity and specificity were computed using the normal approximation to the binomial distribution. Cochran's Q, τ^2 , and I^2 were used to assess between-study variability. The random-effects model was applied to obtain pooled estimates of sensitivity, specificity, LR+, LR-, and DOR. Heterogeneity was assessed using established thresholds, with I^2 values above 75% indicating substantial heterogeneity. To assess diagnostic accuracy across studies, a summary Receiver Operating Characteristic (ROC) curve. To summarise the overall diagnostic performance of the included studies, a Hierarchical Summary Receiver Operating Characteristic (HSROC) was constructed. The HSROC model incorporates the Moses-Littenberg model, and the Area Under the Curve (AUC) Decision curve analysis was used to assess the clinical utility of the diagnostic test All analyses and figures were generated using Python (version 3.11) with the following packages: pandas, NumPy, matplotlib, scikit-learn, and stats models. Microsoft Excel 11.0 was used for tables and supplementary calculations. Statistical significance was defined as $p < 0.05$.

RESULTS:

Study Characteristics

A total of 11 studies(19-29) comprising 3 prospective (20,22-23) and 8 retrospective studies (1,21,24-29) published in English between 2008 and 2024 were included in the diagnostic accuracy meta-analysis evaluating the prevalence of acute occlusive myocardial infarction in NSTEMI Myocardial infarction group(NSTEMI).Since two (19,26) of the 11studies dealt exclusively NSTEMI patients , a total of 9 studies(20-25,27-29) were evaluated for diagnostic accuracy of ST-segment elevation (STE) for identifying Occlusion Myocardial Infarction (OMI) in combined STE and NSTEMI myocardial infarction groups. Across all studies, a total of 63,541 patients with acute myocardial infarction patients were analysed in the studies addressing the NSTEMI group and 62,806 patients with acute myocardial infarction were analysed in the studies addressing the combined STEMI and NSTEMI groups and depicted in PRISMA flow chart TABLE/FIG:1 The baseline characteristics of study depicted in TABLE/FIG2

The mean age was found to be 65 +/-4.97 years. 36,799(57.9%) patients were male.it was noted that 25,320 (36.7 %) patients were diabetic and 27,225(34.9%) patients were hypertensive .

TABLE/FIG: 4 showed pooled prevalence of 39% OMI (occlusive myocardial infarction) in NSTEMI patients.. However Heterogeneity showed the high ($I^2 = 99.67\%$, $p < 0.001^*$;) indicates substation variation across the studies.

Table/fig 4: Diagnostic test accuracy metrics for combined ST and NSTEMI groups.

S.No	Name	Sensitivity	Specificity	LR+	LR-	DOR	DOR 95%	
							CI Lower	CI Upper
1	Marti D et al (20)	0.77	0.18	0.94	1.27	0.74	0.32	1.69
2	Wang TY et al (21)	0.66	0.75	2.68	0.45	5.93	5.70	6.18
3	Karwowski J et al (22)	0.80	0.55	1.78	0.36	4.98	4.49	5.53
4	Hillinger P et al (23)	0.57	0.98	34.60	0.43	79.79	24.26	262.45
5	Aslanger EK et al (DIFFOCULT)(24)	0.66	0.62	1.74	0.54	3.21	2.67	3.87
6	Aslanger EK et al (25)	0.68	0.87	5.37	0.37	14.62	11.02	19.39
7	Tanaka T et al (27)	0.86	0.62	2.28	0.23	9.96	5.12	19.38
8	Meyers HP et al (28)	0.44	0.23	0.57	2.40	0.24	0.16	0.36
9	Kola M et al (29)	0.59	0.78	2.76	0.52	5.33	3.05	9.30

TABLE/FIG5 depicts the diagnostic test accuracy metrics for combined ST elevation and Non- ST elevation myocardial infarction groups. The random-effect meta-analysis showed a pooled sensitivity of 0.65(95% CI:0.31-0.89) with no significant heterogeneity ($Q = 0.557$, $df = 8$, $p > 0.001$; $\tau^2 = 0.00$; $I^2 = 0.00\%$). The pooled specificity was 0.59 (95% CI: 0.22–0.87), with no significant heterogeneity ($Q = 1.726$, $df = 8$, $p < 0.001$; $\tau^2 = 0.00$; $I^2 = 0.00\%$).The pooled LR+* was 2.09 (95% CI: 1.59–2.76), with significant heterogeneity ($Q = 835.85$, $df = 8$, $p < 0.001^*$; $\tau^2 = 0.156$; $I^2 = 99.04\%$). The pooled LR-† was 0.53 (95% CI: 0.44–6.51), with significant heterogeneity ($Q = 220.824$, $df = 8$, $p < 0.001^*$; $\tau^2 = 0.761$; $I^2 = 96.38\%$). The pooled diagnostic odds ratio (DOR) was 4.21 (95% CI: 2.73–6.50), with significant heterogeneity ($Q = 368.04$, $df = 8$, $p < 0.001^*$; $\tau^2 = 0.369$; $I^2 = 97.83\%$).. The table above also shows that sensitivity ranged between 0.44 and 0.86, Except for one study LR+(positive likelihood ratio) was below 5.37 and 7 studies demonstrated values below 2.76.LR- (negative likelihood ratio) was found to be above 0.23 for all the studies. DOR values were below 10 for majority (8 out of 9) studies.

Table/fig 5: Predictive values for combined ST and NSTEMI groups.

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

S.No	Name	PPV	NPV	Accuracy
1	Marti D et al (20)	0.07	0.90	0.23
2	Wang TY et al (21)	0.57	0.82	0.72
3	Karwowski J et al (22)	0.64	0.73	0.68
4	Hillinger P. et al (23)	0.96	0.75	0.81
5	Aslanger EK et al (DIFFOCULT)(24)	0.56	0.72	0.64
6	Aslanger EK et al (25)	0.69	0.87	0.82
7	Tanaka T et al (27)	0.63	0.86	0.72
8	Meyers HP et al (28)	0.37	0.29	0.34
9	Kola M et al (29)	0.88	0.43	0.65

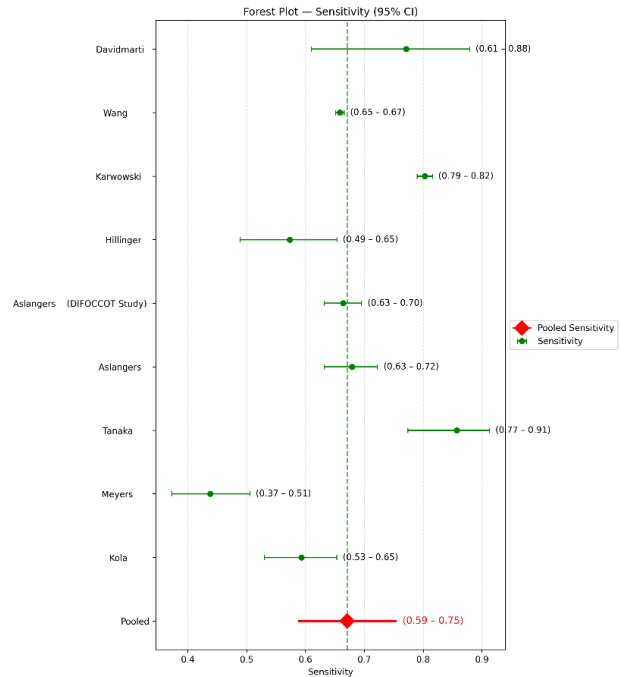
TABLE/FIG6 which depicts predictive values for combined ST elevation and Non- ST elevation myocardial infarction groups. showed a pooled PPV of 0.58(95% CI:0.50-0.65) with significant heterogeneity ($Q = 433.85$, $df = 8$, $p < 0.001^*$; $\tau^2 = 0.17$; $I^2 = 98.13\%$). The pooled NPV was 0.73 (95% CI: 0.65–0.80), with significant heterogeneity ($Q = 516$, $df = 8$, $p < 0.001^*$; $\tau^2 = 0.29$ $I^2 = 98.16\%$). The pooled Accuracy was 0.63 (95% CI: 0.56–0.70), with significant heterogeneity ($Q = 804.98$, $df = 8$, $p < 0.001^*$; $\tau^2 = 0.18$; $I^2 = 99.01\%$).

Table/fig 6: Pooled Prevalence of OMI for NSTEMI group.

S.No	Name	Year	Total AMI	OMI	NOMI	Prevalence OMI	CI 95%	
							CI lower	CI Upper
1	Dixon WC et al (19)	2008	30336	7199	23187	0.24	0.23	0.24
2	Marti D et al (20)	2014	447	35	412	0.08	0.05	0.10
3	Wang TY et al (21)	2016	50632	16584	34084	0.33	0.32	0.33
4	Karwowski J et al (22)	2017	7068	3672	3396	0.52	0.51	0.53
5	Hillinger P et al (23)	2019	317	136	181	0.43	0.37	0.48
6	Aslanger EK et al (DIFFOCULT)(24)	2020	2000	840	1160	0.42	0.40	0.44
7	Aslanger EK et al (25)	2020	1362	405	957	0.30	0.27	0.32
8	Morawska I et al (26)	2021	399	136	261	0.34	0.29	0.39
9	Tanaka T et al (27)	2021	231	98	133	0.42	0.36	0.49
10	Meyers HP et al (28)	2021	415	210	205	0.51	0.46	0.55
11	Kola M et al (29)	2024	334	241	93	0.72	0.67	0.77

TABLE /FIG 7; The forest plot analysis reveals a 'sensitivity ceiling' near 0.70, with the **majority of studies falling to the left** of this threshold; this visually demonstrates that standard criteria consistently fail to identify at least one-third of occlusions across diverse clinical settings."

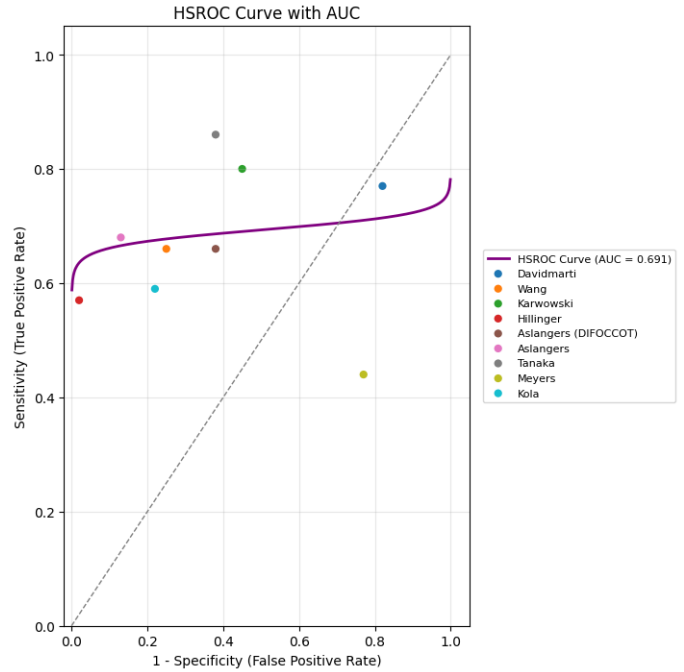
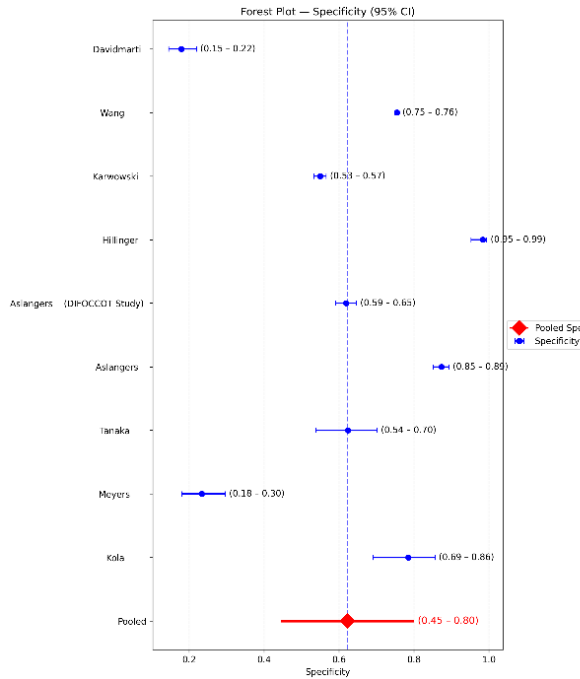
Table/fig 7 : Forest plot for sensitivity



The forest plot for specificity TABLE/FIG8; confirms a moderate and inconsistent diagnostic performance, with the pooled diamond centered near 0.60. The studies demonstrate significant variability: three studies fell to the left of this estimate (lower specificity), four studies fell to the right, and three studies intersected the vertical line of the pooled estimate. This balanced but wide distribution visually underscores the criteria's inability to reliably identify non-occlusive events."

Table/fig 8 : Forest plot for specificity

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis



The **HSROC (Hierarchical Summary Receiver Operating Characteristic) analysis** TABLE/FIG;9 yielded an **Area Under the Curve (AUC)** of 0.69, indicating a modest discriminative capacity. While the curve demonstrates performance superior to random chance, it remains below the threshold typically required for a clinically robust diagnostic tool. This value reflects the trade-off between the **pooled sensitivity of 0.65** and **specificity of 0.59**, confirming that standard criteria lack the precision necessary for definitive clinical decision-making.

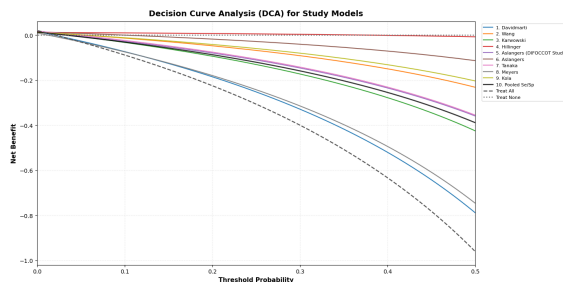
Table/fig 9: HSROC Curve

HSROC approximation parameters: intercept=0.815, slope=0.066, AUC=0.691

DECISION CURVE ANALYSIS;

The clinical utility of ST-elevation ECG criteria was evaluated using Decision Curve Analysis (DCA) TABLE/FIG;10 across a threshold probability range of 0 to 0.5. Within this clinically relevant window, the net benefit of the ST-elevation ECG criteria failed to exceed the default "treat all" and "treat none" strategies. This indicates that the criteria provide no additional benefit for guiding reperfusion decisions over default clinical assumptions in the emergency setting.

Table/fig 10: Decision Curve Analysis



RISK OF BIAS ASSESSMENT; TABLE/FIG11:

Methodological quality was independently validated by two observers using the **QUADAS-2 tool**,

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

revealing an overall **low risk of bias** across all 11 studies (19-29) comprising 3 prospective (20,22-23) and 8 retrospective studies (1,21,24-29). The domains of **patient selection, index test interpretation, reference standard accuracy, and flow and timing** were consistently rated as low risk, supported by robust protocols such as consecutive sampling and appropriate **blinding** between ECG interpretation and angiographic findings. Furthermore, **applicability concerns** were low across all domains, indicating that the study populations and diagnostic methods are highly representative of real-world clinical practice in the evaluation of suspected **OMI**.

the results are not significantly influenced by publication bias, ensuring the pooled estimates remain robust and representative of the available evidence.

Table/fig 11: Risk of Bias Results

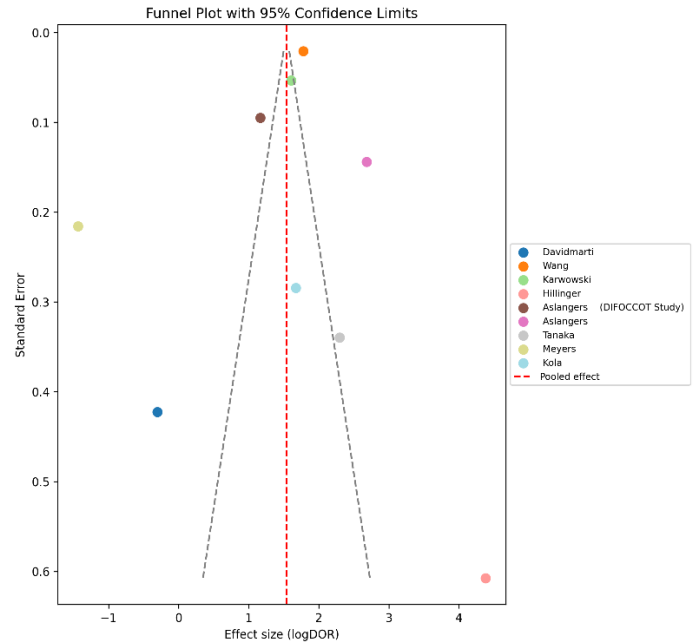
Low risk = ○ High risk = ● Unclear risk = ?

y	Year	Risk of Bias				Applicability Concerns			
		Patient Selection	Index Test	Reference Standard	Flow & Timing	Patient Selection	Index Test	Reference Standard	overall risk of bias
n WC (19)	2008	○	○	○	○	○	○	○	○
i D et)	2014	○	○	○	○	○	○	○	○
g TY et l)	2016	○	○	○	○	○	○	○	○
owski al (22)	2017	○	○	○	○	○	○	○	○
gger P (23)	2018	○	○	○	○	○	○	○	○
gger et al FOCU (24)	2020	○	○	○	○	○	○	○	○
gger et al	2020	○	○	○	○	○	○	○	○
wska l (26)	2021	○	○	○	○	○	○	○	○
ka T (27)	2021	○	○	○	○	○	○	○	○
rns HP (28)	2021	○	○	○	○	○	○	○	○
M et 9)	2024	○	○	○	○	○	○	○	○

PUBLICATION BIAS;

Publication bias and small-study effects were evaluated to ensure the robustness of the meta-analytic findings. The funnel plot TABLE/FIG ;12 demonstrated that the majority of studies were positioned within the 95% confidence intervals and clustered around the pooled estimate, suggesting moderate consistency across the literature. While a slight visual asymmetry was noted, Egger's regression test yielded a non-significant intercept of -2.24 (P = 0.46), confirming a lack of meaningful asymmetry. Collectively, these findings indicate that

Table/fig 12: Funnel Plot



DISCUSSION:

Under current guidelines, acute myocardial infarction is classified as either STEMI or NSTEMI based on the initial ECG (8). Emergency revascularization is prioritized for the STEMI group, as ST-elevation thought to be a surrogate for acute total coronary artery occlusion (8,30)—a condition linked to significantly higher mortality. This meta-analysis investigated whether standard ST-elevation criteria effectively identify all cases of angiographically proven total coronary occlusion. Furthermore, it tested the assumption that "STEMI" and "total culprit occlusion" are clinically interchangeable by quantifying the prevalence of "hidden" occlusions that fail to meet traditional millimetric ECG thresholds.

The meta-analysis revealed a 39% pooled prevalence of total coronary occlusion within the NSTEMI cohort, reinforcing observations by Knoery C (31) et al. that such occlusions are remarkably common in this population. These findings, consistent with studies by Tzikas D (8) et al and Hung CS (32) et al. establish a clear clinical mandate for highly sensitive screening tools. Since nearly four out of ten NSTEMI patients actually

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

present with a totally occluded culprit artery, current triage criteria must be robust enough to identify this high-risk subgroup early, as emphasized by Hung CS (32) et al.

This meta-analysis yielded a pooled sensitivity of 0.65 for ST-elevation criteria in detecting acute total coronary occlusion, consistent with findings by Sankardas MA (13) et al and Meyers HP (33) et al. This sensitivity reveals a critical "one-third gap" in diagnostic practice: 35% of acute occlusions are missed by formal STEMI criteria. This significant diagnostic failure aligns with the observations of Aslanger EK (15) et al. and is further corroborated by Barros V (7) et al, Tzikas D (8) et al, Zhong Z (11) et al., Neto JNA (34) et al., Al-Zaiti S (35) et al and Ayyad M (36) et al, all of whom observed that standard ECG criteria are insufficiently sensitive to identify complete vessel occlusion.

Furthermore, the meta-analysis yielded a pooled specificity of 0.59, a remarkably low value for a primary diagnostic standard. This indicates a high frequency of "false alarms," where non-occlusive conditions mimic acute injury patterns; consequently, even if ST-elevation is present, we cannot reliably confirm an acute total occlusion. This finding aligns with observations by Cahill J (4) et al and Aslanger EK (15) et al., who stipulated that the traditional STEMI/NSTEMI paradigm lacks the necessary sensitivity and specificity to accurately identify acute coronary occlusion. Ultimately, because these criteria are deficient in both measures, they cannot reliably rule in or rule out a total occlusion, suggesting that current millimetric thresholds are an insufficient standalone gatekeeper for emergency reperfusion therapy.

The meta-analysis yielded a pooled positive likelihood ratio (LR+) of 2.09, a statistically weak value indicating that the presence of ST-elevation only marginally increases the probability of a true occlusion. Consequently, meeting formal STEMI criteria is an unreliable "rule-in" tool and should not be the sole factor used to confirm the need for emergent intervention. This correlated with a pooled negative likelihood ratio (LR-) of 0.53, which confirmed a similarly poor "rule-out" capability. This finding aligns with observations by Neto JNA (34) et al., reinforcing that the absence of ST-elevation does not reliably exclude a complete coronary occlusion. Therefore, these criteria cannot

safely be used to defer angiography, as they provide a false sense of security while leaving a high residual risk of missed pathology. Ultimately, current ST-elevation thresholds are insufficient for either confirming or excluding acute total occlusion in clinical practice.

A pooled diagnostic odds ratio (DOR) of 4.2 further demonstrated the poor discriminative performance of standard ST-elevation ECG criteria for predicting acute total coronary occlusion. This relatively low value reinforces the conclusion that these criteria struggle to effectively differentiate patients with an acute occlusion from those with non-occlusive coronary artery disease. Consequently, the standard ECG thresholds failed to achieve the high level of diagnostic accuracy required for a definitive triage tool in the acute setting.

The pooled PPV of 0.58 indicated that when standard ECG criteria were met, there was only a 58% probability of an underlying acute coronary occlusion. In clinical practice, this translates to a high 'false alarm' rate, where approximately 42% of emergent catheterization laboratory activations for suspected OMI may be unnecessary. This low predictive power likely stems from the poor specificity (0.59) of the criteria, as non-occlusive conditions frequently mimic the ST-elevation patterns required by traditional guidelines.

The pooled NPV of 0.73 is perhaps the most clinically concerning metric. This indicates that even when the ECG was 'negative' for ST-elevation, there remained a 27% residual risk—more than one in four patients—of an underlying total vessel occlusion. In the context of emergency cardiology, a reliable rule-out tool must achieve a significantly higher NPV to ensure patient safety and avoid treatment delays. Consequently, an NPV of only 0.73 provided a concerning level of false reassurance, potentially leading to the misclassification of high-risk OMI patients as lower-priority NSTEMI.

These findings are reflected in a pooled predictive accuracy of 0.63, indicating that standard ST-elevation criteria correctly identify acute total coronary occlusion in only 63% of cases. This result aligns with observations by Fitrah K (14) et al., highlighting a significant diagnostic gap where nearly 40% of occlusions remain undetected. Furthermore, the HSROC analysis yielded an AUC of 0.69, confirming that standard ECG criteria

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

possess only moderate discriminatory capacity for diagnosing total occlusion. Together, these metrics correlate to underscore that current millimetric thresholds lack the diagnostic precision required to serve as a definitive gatekeeper for emergency reperfusion therapy."

The Decision Curve Analysis (DCA) further confirmed the poor clinical utility of standard ECG ST-elevation criteria. The net benefit curve for the ECG criteria failed to exceed both the 'treat-all' and 'treat-none' strategies across the range of relevant threshold probabilities, suggesting that these traditional thresholds do not provide additional decision-analytic value over a universal intervention strategy. Consequently, relying solely on standard ST-elevation criteria for triage may lead to suboptimal clinical outcomes compared to a more inclusive approach to emergency angiography.

Consequently, traditional ST-elevation criteria demonstrate critically low sensitivity for identifying occlusive myocardial infarction (OMI), particularly within the NSTEMI cohort. The combined findings of a pooled sensitivity of 0.65, an AUC of 0.69, and a predictive accuracy of 0.63—compounded by weak likelihood ratios—underscore the suboptimal clinical utility of these thresholds. This limitation is further corroborated by Decision Curve Analysis, which indicates that these criteria fail to offer a significant net benefit over 'treat-all' or 'treat-none' strategies, rendering them an unreliable gatekeeper for emergent intervention. This aligns with the stipulations of Aslanger EK (15) et al., who postulated that STEMI criteria were not originally designed to diagnose acute coronary occlusion, a conclusion corroborated by Rocha D (2) et al., and Cahill J (4) et al and Barros V (7) et al.

The extreme heterogeneity observed in this study reflects the inherent complexity of the OMI spectrum and the natural diversity of coronary anatomy. Such variation suggests that the performance of standard criteria is highly context-dependent, underscoring the necessity of transitioning from binary millimetric thresholds to a more objective, physiologically-based OMI/NOMI paradigm. This shift is strongly stipulated by Aslanger EK (15) et al. and further corroborated by Tzikas D (8) et al., McLaren J (37) et al., and De Alencar JN (38)

Ultimately, this meta-analysis provides a compelling mandate for clinicians to look beyond the millimetric constraints of the Fourth Universal Definition. The evidence demonstrates that traditional ST-elevation criteria serve as an insufficient standalone surrogate for acute coronary occlusion, frequently failing to identify a significant proportion of high-risk patients. To improve diagnostic precision, clinicians should integrate clinical features and subtle ECG markers—such as reciprocal ST-depression in lead a VL, hyperacute T-waves, and de Winter's patterns—alongside AI-based ECG biomarkers and point-of-care echocardiography. Following the guidelines stipulated by Aslanger EK (15) et al. and corroborated by Knoery C (31) et al, De Alencar JN (38) et al and Ricci F (39) et al. The implementation of these tools offers a promising path toward a more precise, physiologically-based OMI/NOMI paradigm. By rejecting a standalone reliance on ST-elevation, the clinical community can bridge the current diagnostic gap, ensuring that the nearly one-third of 'hidden' occlusion patients receive the urgent reperfusion therapy required to improve survival outcomes.

STUDY LIMITATIONS:

While the findings of this meta-analysis offer significant insights, they should be considered alongside certain inherent limitations. The study period (2008–2024) covers nearly two decades of technological progress; earlier data may reflect the use of older, non-computerised ECG models that relied on manual measurements, whereas later studies utilised automated digital algorithms. Such a transition, combined with the inclusion of diverse geographical populations—where ECG patterns can vary by race and age—may introduce a degree of measurement and biological variability. Furthermore, the diagnostic accuracy of the ECG is fundamentally constrained by the dynamic nature of coronary occlusion, as patterns can evolve rapidly with thrombus formation or spontaneous dissolution. Finally, the reliance on human interpretation introduces the potential for interobserver variation, reflecting the subjective nature of identifying ischemic changes. These factors, alongside the mix of prospective and retrospective study designs, should be acknowledged when translating these results into clinical practice.

CONCLUSION;

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

The meta-analysis demonstrated that with a 39% prevalence of OMI in NSTEMI and a suboptimal pooled sensitivity of 0.65 in the combined cohort, standard ST-elevation criteria lack the necessary net clinical benefit and diagnostic precision to serve as a reliable gatekeeper,

In the future, the implementation of AI-based ECG tools, body surface potential mapping, and novel cardiac biomarkers may offer a transformative solution to bridge this substantial diagnostic gap, necessitating a transition toward a physiologically-based OMI/NOMI paradigm to ensure timely reperfusion for all patients with acute coronary occlusion; however, larger prospective studies remain essential to validate these findings and their long-term impact on clinical outcomes.

References:

1. López SDE, Martinez FP, Munoz AMB, Valbuena ACV, Gonzalez JSH et al. High-risk electrocardiographic patterns in acute myocardial infarction: Early recognition, clinical implications, and therapeutic decision-making. *Int J Med Sci Clin Res Stud.* 2025;5(6):951–5. doi:10.47191/ijmscrs/v5-i06-24
2. Rocha D, Simões P, Gouveia J, Ferreira C, Franco F. Acute inferior myocardial infarction: Beyond the ST-segment elevation. *Casos clinicos case reports .SPMI case reports publicacao especial.2024;2(suplemento)/ABR/JUN, doi /10.60591/crspmi.173*
3. Asatryan B, Vaisnora L, Manavifar N. Electrocardiographic diagnosis of life-threatening STEMI equivalents when every minute counts. *Editorial Comment.JACC Case Reports .* 2019; 1(4):666-8, doi:epdf/10.1016/j.jaccas.2019.10.030
4. Cahill J, Parker WE, Mills MT. Beyond the ST segment: Recognising acute complete coronary occlusion in non-ST elevation myocardial infarction. *Brit J Hosp Med.* 2025;86(10) , doi:10.12968/hmed.2025.0423
5. Barbosa RR, Tolentino JG, de Loyola BFB, Ulina RD, Calenzani HE, Viana MEVG, et al. Acute myocardial infarction with Aslanger pattern. *J Bras Med Emerg.* 2024;4(4):e24034, doi:10.54143/jbmede.v4i4.202
6. Frick WH, Meyers HP, Smith SW. occlusion myocardial infarction :a revolution in acute coronary syndrome. *Adv interv Cardiol;2025;21,2(80):139-43, doi:10.5114/aic.2025.151161*
7. Barros V, Narvaez A, Navarro A, Cardona C, Senior J, et al. Aslanger pattern: A sign of an acute coronary occlusion. *Cureus.* 2025;17(5):e84818, doi:10.7759/cureus.84818
8. Tzikas D, Chalikias G, Al-Lamee R, Kaski JC. Total coronary occlusion is not ST elevation myocardial infarction: Time to change our paradigm? *Int J Cardiol.* 2021;329:1-8 ,doi.org/10.1016/j.ijcard2020.12.082
9. Bishop AJ, Meadley BN. Occlusion myocardial infarction and artificial intelligence: A perspective on out-of-hospital ECG interpretation. *Sage Journals Paramedicine* 2025;22(6):291-98, doi:10.1177/27536386251371078
10. Agnese MAVD, Copetti AS, Filho SFDF et al. Aslanger’s pattern with acute lesion in the left coronary system: A case report. *J Electrocardiol.* 2024;87:153807, doi:10.1016/j.jelectrocard.2024.153807
11. Zhong Z. Aslanger pattern: A case report. *J Int Med Res.* 2025;53(3):1–8. doi:10.1177/03000605251327380
12. Liu MH, Li H, Li A, Liu R, et al. A patient with acute myocardial infarction with electrocardiogram Aslanger’s pattern. *BMC cardiovascular disorders.*2024;24(3):1-6, doi:10.1186/s12872-023-03678-x
13. Sankardas MA, Ramakumar V, Farooqui FA, Of occlusions, inclusions, and exclusions: Time to reclassify infarctions? *Circulation.* 2021;144(5):333-335, doi:epub/10.1161/CIRCULATIONAHA.121.055827
14. Fitrah K, Mamasta A, Sianturi A. Diagnostic accuracy and clinical outcomes in acute coronary syndrome of OMI/NOMI vs STEMI/NSTEMI: a systematic review.

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

- Jurnal Locus Penelitian & Pengabdian. 2025;11(4):11072-86.
15. Aslanger EK, Meyers PH, Smith SW. STEMI: A transitional fossil in classification? *J Electrocardiol.* 2021;65:163-69. doi:10.1016/j.jelectrocard.2021.02.001
 16. Aslanger EK, Aggul B, Yildirimturk O, Karabay CY, Meyers PH et al DIFOCULT-3 Study Investigators. A diagnostic paradigm shift in acute myocardial infarction: rationale and design of the DFOCCULT-3 trial. *JACC Advances.*2025;4(11):1-14, doi:epdf/10.1016/j.jacadv.2025.102227
 17. Simon A. A proposal for better visualization of Aslanger pattern. *JElectrocardiol.* 2023;81:41–3, doi:10.1016/j.jelectrocard.2023.07.009
 18. de Silva R, Steg PG. Identifying patients with acute total coronary occlusion in NSTEMI: finding the high-risk needle in the haystack. *Eur Heart J.* 2017;38:3090–3093. doi:10.1093/eurheartj/ehx520
 19. Dixon WC, Wang TY, Dai D, Shunk KA, Peterson ED, Roe MT. Anatomic distribution of the culprit lesion in patients with non-ST-segment elevation myocardial infarction undergoing percutaneous coronary intervention: Findings from the National Cardiovascular Data Registry. *J Am Coll Cardiol.* 2008;52(16):1347–48. doi:10.1016/j.jacc.2008.07.029
 20. Martí D, Mestre JL, Salido L, Esteban MJ, Casas E, Pey J, Sanmartín M, Hernández-Antolín R, Zamorano JL. Incidence, angiographic features and outcomes of patients presenting with subtle ST-elevation myocardial infarction. *Am Heart J.* 2014;168(6):884–90. doi:10.1016/j.ahj.2014.08.009
 21. Wang TY, McCoy LA, Bhatt DL, Rao SV, Roe MT, Resnic FS, Cavender MA, Messenger JC, Peterson ED. Multivessel vs culprit-only percutaneous coronary intervention among patients 65 years or older with acute myocardial infarction. *Am Heart J.* 2016;172:9–18. doi:10.1016/j.ahj.2015.10.017
 22. Karwowski J, Gierlotka M, Gąsior M, Poloński L, Ciszewski J, Bęćkowski M, Kowalik I, Szwed H. Relationship between an infarct-related artery, acute total coronary occlusion, and mortality in patients with ST-segment and non-ST-segment myocardial infarction. *Pol Arch Intern Med.* 2017;127(6):401–11. doi:10.20452/pamw.4018
 23. Hillinger P, Strebel I, Abächerli R, Twerenbold R, Wildi K, Bernhard D, Nestelberger T, Boeddinghaus J, Badertscher P, Wussler D, Koechlin L, Zimmermann T, Puelacher C, Gimenez MR, du Fay de Lavallaz J, Walter J, Geigy N, Keller DI, Reichlin T, Mueller C; APACE Investigators. Prospective validation of current quantitative electrocardiogram criteria for ST-elevation myocardial infarction. *Int J Cardiol.* 2019;292:1–12. doi:10.1016/j.ijcard.2019.04.041
 24. Aslanger EK, Yıldırım Türk Ö, Şimşek B, Bozbeğolu E, Şimşek MA, Karabay CY, Smith SW, Değertekin M. Diagnostic accuracy of electrocardiogram for acute coronary occlusion resulting in myocardial infarction (DIFOCULT Study). *IJC Heart Vasc.* 2020;30:100603. doi:10.1016/j.ijcha.2020.100603
 25. Aslanger E, Yıldırım Türk Ö, Şimşek B, Sungur A, Cabbar AT, Bozbeğolu E, Karabay CY, Smith SW, Değertekin M. A new electrocardiogram pattern indicating inferior myocardial infarction. *J Electrocardiol.* 2020;61:41–6., doi:10.1016/j.jelectrocard.2020.04.008
 26. Morawska I, Niemiec R, Stec M, Wrona K, Banka P, Swinarew A, Wybraniec M, Mizia-Stec K. Total occlusion of the infarct-related artery in non-ST-elevation myocardial infarction (NSTEMI)—How can we identify these patients? *Medicina.* 2021;57:1196. doi:10.3390/medicina57111196
 27. Tanaka T, Miki K, Akahori H, Imanaka T, Yoshihara N, Kimura T, Yanaka K, Asakura

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

- M, Ishihara M. Comparison of coronary atherosclerotic disease burden between ST-elevation myocardial infarction and non-ST-elevation myocardial infarction: Non-culprit Gensini score and non-culprit SYNTAX score. *Clin Cardiol.* 2021;44:238–43. doi:10.1002/clc.23534
28. Meyers HP, Bracey A, Lee D, Lichtenheld A, Li WJ, Singer DD, Rollins Z, Kane JA, Dodd KW, Meyers KE, Shroff GR, Singer AJ, Smith SW. Accuracy of OMI ECG findings versus STEMI criteria for diagnosis of acute coronary occlusion myocardial infarction. *IJC Heart Vasc.* 2021;33:100767. doi:10.1016/j.ijcha.2021.100767
29. Kola M, Shuka N, Meyers HP, Zaimi E, Smith SW. OMI/NOMI: Time for a new classification of acute myocardial infarction. *J Clin Med.* 2024;13:5201. doi:10.3390/jcm13175201
30. Aslanger EK, Meyers PH, Smith SW. Time for a new paradigm shift in myocardial infarction. *Anatol j cardiol.*2021;25:156-62 , doi:10.5152/Anatoljcardiol.2021.89304
31. Knoery C , McEwan KA, Manktelow M, Watt J,Smith J et al. Using latent class analysis to identify clinical features of patients with occlusive myocardial infarction: Preangiogram prediction remains difficult. *Clin Card* 2021;45:231-8, doi:10.1002/clc.23755
32. Hung CS, Chen YH, Huang CC ,Lin MS, Yeh CF,Li HY,Kao HL. Prevalence and outcome of patients with non-ST segment elevation myocardial infarction with reduced ‘culprit artery’ – a systematic review and meta-analysis. *Crit Care.* 2018;22:34. doi:10.1186/s13054-018-1944-x
33. Meyers HP, Bracy A, Lee D, Lichtenheld A et al. Comparison of the ST-elevation myocardial infarction (STEMI) vs. non-STEMI and occlusion MI(OMI) vs NOMI paradigms of acute MI. *j Emer Med.* 2020;60(3);273-84, doi.org/10.1016/j.jemermed.2020.10.026
34. Neto JNA,Scheffer MK, Correia BP, Franchini SP,Felicioni SP,DeMarchi MFN, Systematic review and meta-analysis of diagnostic test accuracy of ST-segment elevation for acute coronary occlusion. *Int J Cardiol.* 2024;402:131889 doi:10.1016/j.ijcard.2024.131889
35. Al-Zaiti S, Macleod R,Smith SW,Birnbaum Y. Emerging ECG methods for acute coronary syndromes detection: recommendations & future opportunities. *J Electrocardiol.* 2022;74:65–72. doi:10.1016/j.jelectrocard.2022.08.003 available from <https://www.sciencedirect.com/science/article/pii/S002207362030173X>
36. Ayyad M, Albandak M, Gala D, Alqeeq B, Baniowda M, Pally J, Allencherril J.Reevaluating STEMI: The utility of the occlusive myocardial infarction classification to enhance management of acute coronary syndromes. *Curr Cardiol Rep.* 2025;27(75):1-12 ,doi:10.1007/s11886-025-02217-8
37. McLaren J, de Alencar JN, Aslanger EK, Meyers HP, Smith SW. From ST-segment elevation MI to occlusion MI: The new paradigm shift in acute myocardial infarction. *JACC Adv.* 2024;3(11):1-11, doi:10.1016/j.jacadv.2024.101314
38. De Alencar JN, Feres F, DeMarchi MFN, Franchini KG,et al. Beyond STEMI-NSTEMI paradigm: Dante Pazanense’s proposal for occlusion myocardial infarction diagnosis. *Arq Bras Cardiol.* 2024;121(5):e20230733 , doi:10.36660/abc.2023073.3i
39. Ricci F, Martini C, Scordo DM,Rossi D, Gallina S et al ECG patterns of occlusion myocardial infarction: A narrative review. *Cardiology Rev Article. Annals of Emerg med* 2025;85(4):330-40 , doi:10.1016/j.annemergmed.2024.11.019
40. Khan AR, Golwala H, Tripathi A, Abdulhak AB, Bavishi C, Riaz H, et al. Impact of total occlusion of culprit artery in acute non-ST elevation myocardial infarction: a systematic review and meta-analysis. *Eur*

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

- Heart J.* 2017;38:3082–89. doi:10.1093/eurheartj/ehx418
41. Abubasharekh M, Abela JR, Kampf J, Dykun I, Souri K, Backmann V, S, Al-Rashid F, Alexander R, et al. Acute coronary occlusion with vs. without ST elevation: impact on procedural outcomes and long-term all-cause mortality. *Eur Heart J.* 2024;10:402-410. doi:10.1093/ehjqcco/qcae003
 42. Herman R, Meyers HP, Smith SP, Bertolone TD, Leone A, Bermpeis K, Viscusi MM, et al. International evaluation of Artificial intelligence-powered electrocardiogram detecting acute coronary occlusion Myocardial infarctionculprit *Eur Heart J.* 2024;5:123–33. doi:10.1093/ehjdh/ztad074
 43. Rhinhardt J, Brady WJ, Perron AD, Mattu A. electrocardiographic manifestations of wellens syndrome. *Am j Emer Med.* 2022;20:638-643.
 44. Verouden NJ, Koch KT, Peters RJ, Henriques JP, Baan J, Schaaf RJV, Vis MM, Tijssen JG, Piek JJ, Wellens HJ, Wilde AA, de Winter RJ. Persistent precordial “hyperacute” T-waves signify proximal left anterior descending artery occlusion. *Heart.* 2009;95:1701-6, doi:10.1130/hrt.2009.174557
 45. Niu T, Fu P, Jia C, Dong Y., Liang C, Cao Q, Yang Z, et al. The delayed activation wave in non-ST-elevation myocardial infarction. *Int J Cardiol.* 2013;162:107-11, doi:10.1016/j.ijcard.2011.05.063
 46. Wall J, Vlok RA, Melhuish TM, White LD. Acute myocardial infarction and STEMI-equivalent patterns. *Int J Internal Med Papers.* 2016;1:7-11.
 47. Tewelde SZ, Mattu A., Brady WJ. Pitfalls in electrocardiographic diagnosis of acute coronary syndrome in low-risk chest pain. *West J Emerg Med J.* 2017;18(4):601-6, doi:10.5811/westjem.2017.1.32699
 48. Cipriani A, Iliceto S, D’Amico G, Brunello G, Marra MP et al. The electrocardiographic “triangular QRS-ST-T waveform” pattern in patients with ST-segment elevation myocardial infarction: Incidence, pathophysiology, and clinical implications. *J Electrocardiol.* 2018;51:8-14, doi.org/10.1016/j.jelectrocard.2017.08.023
 49. Figueras J, Otaegui I, Marti G, Domínguez E, Bañeras J, Ortega B, et al. Area at risk and collateral circulation in first acute myocardial infarction with occluded culprit artery. STEMI vs non-STEMI patients. *Int J Cardiol.* 2018;259:14-19, doi.org/10.1016/j.ijcard.2018.01.047
 50. Aslanger EK, Meyers HP, Smith SW. Recognizing electrocardiographically subtle occlusion myocardial infarction and differentiating it from mimics: Ten steps to or away from cath lab. *Turk Kardiyol Dern Ars.* 2021;49(6):488-500. doi:10.5543/tkda.2021.21026
 51. Aslanger EK, Meyers HP, Bracey A, Smith SW. The STEMI/NSTEMI dichotomy needs to be replaced by occlusion MI vs. non-occlusion MI. *Int J Cardiol.* 2021;330:15, doi.org/10.1016/j.ijcard.2021.02.015
 52. Aslanger EK, Smith SW. Response to: A novel electrocardiographic parameter reflecting infarct myocardial mass. *J Electrocardiol.* 2022;73:148-49, doi:10.1016/j.jelectrocard.2020.11.005
 53. McLaren JTT, Meyers HP, Smith SW, Chartier LB. From STEMI to occlusion MI: Paradigm shift and ED quality improvement. *Can J Emerg Med.* 2022;24:250–55. doi:10.1007/s43678-021-000255-z
 54. Miyauchi E, Kuwazuru K, Arikawa R, Tokutake D, chaen H, Oketani N, Ohishi M. Clinical features of the Aslanger pattern to compensate the limitation of ST-elevation myocardial infarction (STEMI) criteria. *Cureus* 2023;15(1):e33227 doi:10.7759/cureus.33227
 55. Aslanger E. Beyond the ST-segment in occlusion myocardial infarction (OMI): Diagnosing the OMI-nous. *Turk J Emerg Med.* 2023;23(1):1-4, doi:10.4103/2452-2473.357333

Diagnostic Performance of ST-Elevation ECG Criteria for the Identification of Occlusive Myocardial Infarction: A Systematic Review and Meta-Analysis

56. Herman R, Kisova T, Belmonte M, Wilgenhof A et al. Artificial intelligence-powered electrocardiogram detecting culprit vessel blood flow abnormality : AI-ECG TIMI study design and Rationale journal for cardiovascular angiography & interventions JSCAI ;2025;4:102494 doi:10.106/j.jscai.2024.102494
57. Karim S Helseth HC, Baker PO, Keller GA, Meyers HP, Herman R, Smith SW. Artificial intelligence detection of occlusive myocardial infarction from electrocardiograms interpreted as 'normal' by conventional algorithms. J Pers Med ; 2025;15,130, doi 10.3390/jpm15040130
58. Schmitt C, Lehman G, Schmieder S, Karch M et al. Chest.2001;120(5):1540-46
59. Chen YZ, Yao ZY, Lin LW, Luo QY, Li R, Zhao XJ. Case report: The Aslanger pattern as an indicator of severe acute coronary syndrome. *Front Cardiovasc Med.* 2025,doi:10.3389/fcvm.2025.1633562
60. Nair A, Athira CN, Nair A. Unveiling the Aslanger pattern: A lifesaving key to hidden inferior myocardial infarctions. *Indian J Emerg Med.* 2025;11(2):83-88, doi:10.21088/ijem.2395.311X.11225.2
61. Aslanger EK, Ekici F. Another single frontal lead ST-segment elevation pattern in a patient with lateral myocardial infarction :A reverse Aslanger mechanism J Electrocardiol. 2025;92:154054, doi:10.1016/j.jelectrocard.2025.154054
62. Smith SW. ST-elevation Acute myocardial infarction : A critical but difficult Electrocardiographic Diagnosis. *Academic Emergency Medicine* 2001;8(4):382-5