CAPÍTULO 3

Systematic review and meta-analysis of diagnostic test accuracy of ST-segment elevation for acute coronary occlusion

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This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

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ABSTRACT: Objective: To evaluate the diagnostic sensitivity and specificity of ST-segment elevation on a 12lead ECG in detecting ACO across any coronary artery, challenging the current STEMI-NSTEMI paradigm. Methods: Studies from MEDLINE and Scopus (2012—2023) comparing ECG findings with coronary angiograms were systematically reviewed and analyzed following PRISMA-DTA guidelines. QUADAS-2 assessed the risk of bias. Study selection: Studies included focused on AMI patients and provided data enabling the construction of con- tingency tables for sensitivity and specificity calculation, excluding those with non-ACS conditions, outdated STEMI criteria, or a specific focus on bundle branch blocks or other complex diagnoses. Data were extracted systematically and pooled test accuracy estimates were computed using MetaDTA software, employing bivariate analyses for within- and between-study variation. The primary outcomes measured were the sensitivity and specificity of ST-segment elevation in detecting ACO. Results: Three studies with 23,704 participants were included. The pooled sensitivity of ST-segment elevation for detecting ACO

was 43.6% (95% CI: 34.7%–52.9%), indicating that over half of ACO cases may not exhibit ST- segment elevation. The specificity was 96.5% (95% CI: 91.2%–98.7%). Additional analysis using the OMI-NOMI strategy showed improved sensitivity (78.1%, 95% CI: 62.7%–88.3%) while maintaining similar specificity (94.4%, 95% CI: 88.6%–97.3%). Conclusion: The findings reveal a significant diagnostic gap in the current STEMI-NSTEMI paradigm, with over half of ACO cases potentially lacking ST-segment elevation. The OMI-NOMI strategy could offer an improved diagnostic approach. The high heterogeneity and limited number of studies necessitate cautious interpretation and further research in diverse settings.

KEYWORDS*:*Electroc rdiography, Sensitivity, Specificity, Coronary occlusion, Myocardial infarction

INTRODUCTION

The introduction of the STEMI-NSTEMI paradigm in 2000 marked a significant advance in cardiovascular medicine. This paradigm provides an effective approach for stratifying risk and guiding reperfusion ther- apy [1].

While the STEMI-NSTEMI dichotomy facilitates early triage, it pre- dominantly focuses on individual ECG findings rather than directly addressing the fundamental pathophysiology of acute coronary occlu- sion (ACO). This approach potentially overlooks the critical importance of ACO as the primary pathological process underlying many cases of acute myocardial infarction.

Moreover, some of the foundational trials that supported the estab- lishment of this paradigm did not necessarily mandate ECG changes for patient inclusion [2,3], while others did mandate ST elevation (STE) as inclusion criterion, without specifying its measurement [4,5]. Signifi- cantly, the studies that laid the groundwork for defining the ST-segment elevation cut-offs for diagnosing acute coronary syndrome in the uni- versal definitions of myocardial infarction predominantly used necrosis markers as their reference standard [6,7]. These markers, while clini- cally significant, do not directly correspond to the ACO, the central pathophysiological event in many myocardial infarctions. This meth- odological choice might have inadvertently de-emphasized the impor- tance of identifying and understanding ACO in the clinical context,

leading to a potential underestimation of patients with critical occlusive events [8]. Remarkably, the widespread acceptance of the STEMI paradigm has resulted in a scarcity of literature examining the true ac- curacy of ST-segment elevation as a diagnostic marker for ACO.

Considering the critical importance of accurate ACO diagnosis in patients with acute coronary syndromes, this study aims to fill this data gap. Through rigorous meta-analysis, we evaluated the sensitivity and specificity of ST-segment elevation for the diagnosis of ACO. Our goal is to provide clinicians with more precise criteria for informed clinical decision-making.

METHODS

Search strategy and data sources

A comprehensive search was conducted using the MEDLINE and Scopus databases, covering articles published between 2012 and October 2023. The year 2012 was selected based on the establishment of the third universal definition of myocardial infarction. This review included studies published in any language to ensure a broad and in- clusive scope. The detailed search string can be found in the Supple- mentary Material. This review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Diagnostic Test Accuracy (PRISMA-DTA) guidelines [9,10].

Inclusion criteria

To determine the diagnostic accuracy of STE in ACO, we included studies in this meta-analysis based on specific methodological charac- teristics. Eligible studies included "cases" or defined "people with dis- ease" as having ACO or possible ACO and measured ST segment elevation sensitivity and specificity. Only studies that provided data allowing the construction of contingency tables to calculate sensitivity and specificity were selected, ensuring a rigorous and quantifiable analysis.

Participants

The study population included adult patients presenting with ACS.

Index tests for diagnosis

The primary index test evaluated was the ECG, focusing on the presence or absence of ST-segment elevation. This was defined accord- ing to the third or fourth universal definition of myocardial infarction, as follows: STE, measured at the J point relative to the PQ junction, ≥ 1.0 mm in all leads except for leads V2–V3, where the following thresholds apply: ≥ 2 mm in men aged 40 years or older; ≥ 2.5 mm in men younger than 40 years, or ≥ 1.5 mm in women, irrespective of age [11,12].

Reference standards

In our study, coronary angiography was used as the reference standard, recognizing the newly emerging and varied definitions of ACO in the literature, which reflect its evolving paradigm status. ACO was defined angiographically as an acute culprit lesion with a TIMI flow of 0 to 2 in patients presenting with chest pain. Clinically, ACO could be suspected based on criteria such as acute but non-occlusive culprit le- sions with large infarct sizes evidenced by elevated contemporary troponin levels, or, in the absence of angiography, significantly elevated troponin levels alongside new or presumed new regional wall motion abnormalities on echocardiography, or STE-positive ECG findings when death occurs before angiography can be performed.

Exclusion Criteria

- The exclusion criteria for studies were as follows:
- Non-focus on ECG for ACS diagnosis.
- Conditions other than ACS.
- Lack of angiographic occlusion as a comparator.
- Inability to estimate sensitivity and specificity.
- Use of outdated STEMI criteria in ECG.
- Exclusive focus on patients with bundle branch blocks or other complicated diagnoses.
- Exclusive concentration on the diagnostic precision of ECG or prev- alence of NSTEMI in occlusions pertaining to particular coronary arteries, such as the circumflex artery.

Screening and data extraction

Titles and abstracts were independently screened by two reviewers (M.S. and B.C.) to identify eligible studies and disagreements were resolved by a third reviewer (M.M.). Full-text evaluations were subse- quently conducted by J.A. and S.F. Data extraction facilitated by the HubMeta software [13], included general study characteristics such as authorship, publication year, country of origin, study design, diagnostic index test, and reference standard.

Risk of bias and certainty of evidence

The risk of bias was assessed using the Quality Assessment of Diag- nostic Accuracy Studies-2 Revised (QUADAS-2) tool [14,15].

Data synthesis

In our meta-analysis, we employed a bivariate random-effects model to pool sensitivity and specificity estimates across studies. This approach accounts for the potential heterogeneity and correlation between sensitivity and specificity within each study. The analyses were facili- tated by the MetaDTA software (version 2.0.5) [16,17], which is spe- cifically designed for diagnostic test accuracy meta-analyses and implements the bivariate method [18,19]. Forest plots were used to visually represent the sensitivity and specificity distributions across studies and their pooled estimates.

RESULTS

Study selection

The electronic database search yielded 1823 studies. After removing duplicates, 1381 unique studies were screened by title and abstract, resulting in the exclusion of 1356 studies. Subsequent full-text review of the remaining 25 studies led to the exclusion of 22 studies that did not meet the inclusion criteria. Ultimately, 3 studies were selected for in- clusion in the meta-analysis. The selection process and the PRISMA flow diagram are detailed in Fig. 1. The Supplementary Material provides detailed reasons for exclusion and a list of excluded studies.

Study characteristics

The meta-analysis included three studies, each set in a distinct clinical environment with varied participant demographics. The 2020 study by Aslanger et al. involved a retrospective evaluation of 3000 adult patients admitted to the Emergency Department (ED) with sus- pected ACS. However, for the analysis focusing on the outcome of in- terest, 2964 patients were analyzed. Notably, Aslanger et al. implemented a strategy to identify potential Acute Coronary Occlusion (ACO) cases among patients who might not have received an angio- graphic diagnosis. This approach aimed to capture a broader range of clinical presentations, with potential ACO cases defined as those with highly elevated troponin without angiographic occlusion or cardiac ar- rest in patients with clinical evidence of ACO.

While this strategy might introduce a potential selection bias that could decrease the sensitivity of the test, it reflects a real-world scenario. Under the current STEMI vs. NSTEMI paradigm, if a patient is incor- rectly classified as NSTEMI but has an occluded coronary artery, this pathophysiological event might remain undiscovered. The average age of the participants in this study was 61 (SD = 13) years [20].

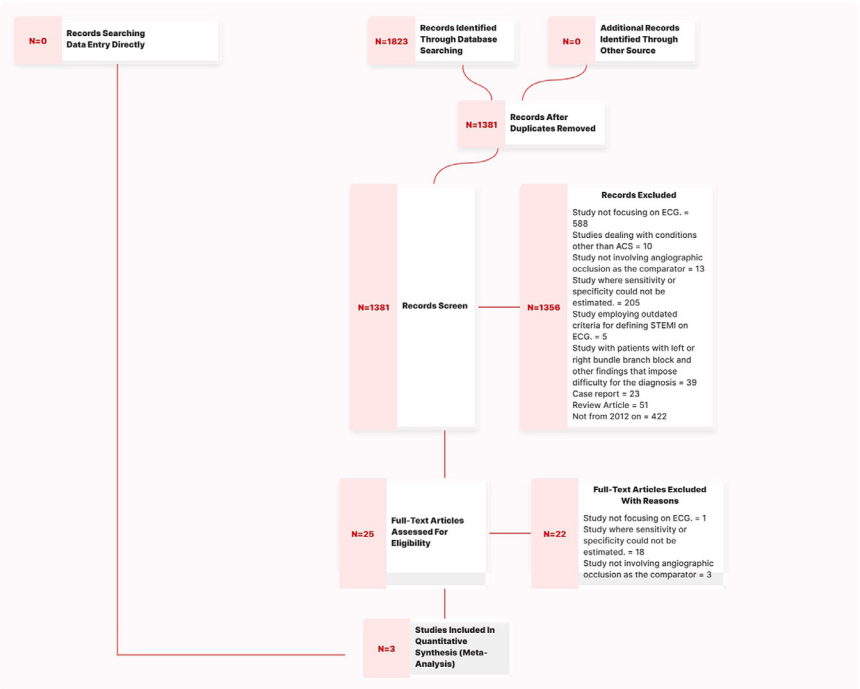

Fig. 1. PRISMA flow diagram of study selection process.

This figure illustrates the systematic search and screening process undertaken in this meta-analysis. It details the number of records identified, screened, assessed for eligibility, and ultimately included in the quantitative synthesis, with reasons for exclusions at each stage.

The 2021 study by Meyers et al. followed, involving 808 patients presenting to the ED with symptoms suggestive of potential ACS. This retrospective study used ECG as the index test and angiographic coro- nary occlusion as the reference standard. Meyers et al. also expanded their definition of "cases" beyond angiographic outcomes, addressing the limitations of the current STEMI-NSTEMI paradigm, where some patients with occlusive conditions might not undergo timely angiog- raphy. The mean age of the participants was 62 (SD = 14) years [21].

The 2021 study by Lindow et al., with the largest sample size of 19,932 patients over 30 years of age presenting with chest pain and undergoing ECG within 4 h of admission, offers significant insights. This retrospective study had a mean participant age of 59.7 (SD = 15.5) years [22]. Various analyses were conducted in the study by Lindow et al., including the assessment of patients with AMI and coronary occlusion or severe stenosis at angiography and those experiencing clinically rele- vant events such as the decision for ad hoc percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG). Each of these analyses yielded different sensitivity and specificity values. For our meta-analysis, we selected the most conservative outcome from Lindow et al., which focused solely on AMI and coronary occlusion. This choice was made to maintain consistency with the clinical focus of the other studies and align with our research objective. Interestingly, the approach to the index test (ECG) in Lindow et al.'s study was notably distinct, as it utilized automated measurement for STE. This study was included in the analysis nonetheless, believing it reflects the analysis as described by the universal definitions of myocardial infarction.

All the included studies provided comprehensive datasets, facili- tating the calculation of true positives, false positives, false negatives, and true negatives. These comprehensive data are crucial for accurately determining the diagnostic accuracy of STE in diagnosing ACO.

A notable absence in our analysis is the study by Hillinger et al., which conducted an excellent examination of the accuracy of STE in identifying adjudicated ST-segment elevation myocardial infarctions [23]. However, the article itself does not readily provide data on the definitive accuracy of ECG in diagnosing acute coronary occlusion, due in part to ambiguity in defining the healthy population: whether it comprised individuals with non-occlusion myocardial infarction (NOMI) or the entire population presenting with chest pain without a final diagnosis of ACO. More precise data is discussed in an editorial by Smith and Meyers in 2019 [24]. Unfortunately, this study did not meet our inclusion criteria for analysis, as it is an editorial.

Risk of bias and applicability

Table 1 summarizes general characteristics of the included studies, including the index tests and reference standards employed. Addition- ally, Fig. 2 provides a visual summary of the QUADAS-2 risk of bias assessment for the three studies.

For patient selection, all studies were considered to have a high risk of bias due to their retrospective nature. This retrospective design may

introduce selection bias, affecting the representativeness and generalizability of the findings.

Regarding the index test, the study by Lindow et al. was determined to have a high risk of bias due to the use of automated measurement for ST-segment elevation. This method, while efficient, lacks the nuanced interpretation that a human cardiologist might provide, potentially affecting the accuracy of the ECG readings.

For the reference standard, the methodologies employed by Aslanger et al. and Meyers et al. to determine "cases" differed from that of Lindow et al. for using a broader clinical definition that included elevated troponin levels and other clinical indicators of ACO, while Lindow's study used a more conservative approach, focusing solely on angio- graphic occlusion. This variation in methodology might impact the comparability of the results across studies.

In terms of flow and timing, Lindow's study was considered to have a high risk of bias because patients with obvious STE bypassed the Emergency Department (ED) and were directly taken for catheteriza- tion, thus not being included in the study. This could lead to an un- derrepresentation of cases and true positives and potentially skew the study's sensitivity.

Heterogeneity

To assess heterogeneity among the included studies, we estimated the following statistics:

- Area of the ellipse: 0.995.
- I^2 for sensitivity: 0.96.
- I^2 for specificity: 0.66.

The area of the ellipse at 0.995 suggests a high degree of dispersion in the sensitivity and specificity estimates across the studies, indicating diverse clinical settings and methodologies. A larger area implies that the true sensitivity and specificity might vary substantially from one study to another, underscoring the need to consider individual study contexts when interpreting the pooled results.

Results of individual studies

Data from individual studies reported the following key metrics:

Study	Year of Study	Clinical setting	Study design	Sample size	Age (SD)	Index test	Reference standard	Funding sources
Aslanger et al.	2020	Adult patients admitted to emergency department with a clinical picture suggestive of acute coronary syndrome.	Retrospective	2964	61 (13)	Fourth Universal Definition of Infarction ECG.	Angiographic occlusion with elevated troponin, a highly elevated troponin without angiographic occlusion, or cardiac arrest in patients with clinical evidence of ACO.	No.
Lindow et al.	2021	Patients >30 years old with a chief complaint of chest pain who had an ECG recorded within 4 h. Patients with conduction abnormalities (right or left bundle branch block), left ventricular hypertrophy and previous CABG were excluded.	Retrospective	19,932	59.7 (15.5)	measurement of STE according to the Fourth Universal Definition of Infarction ECG.	Acute myocardial infarction with Angiographic Coronary occlusion	Region Kronoberg, Region Skane, Swedish AFL grants and Swedish Heart- Lung Foundation
Meyers et al.	2021	Patients who presented to the ED with symptoms suggestive of possible ACS	Retrospective	808	62 (14	Fourth Universal Definition of Infarction ECG.	Angiographic coronary occlusion defined as TIMI 0–2 flow or presumed ACO with significant cardiac outcome defined as acute but non-occlusive culprit artery or regional echocardiographical wall motion abnormality with elevated troponin, or STEMI(+) ECG with death before angiogram	No.

This table provides an overview of the three studies included in the meta-analysis. It details their year of study, clinical settings, study designs, sample sizes, average participant ages (with standard deviations), the index tests used (ECG), reference standards for diagnosis, and funding sources. The table encapsulates key aspects of each study, highlighting the diversity in settings and demographics across the studies.

Table 1 Summary of study characteristics.

- Aslanger et al.: Sensitivity of 54.40%, Specificity of 99.00%, Accu- racy of 81.21% [20].
- Lindow et al.: Sensitivity of 34.85%, Specificity of 93.40%, Accuracy of 92.82% [22].
- Meyers et al.: Sensitivity of 40.8%, Specificity of 93.7%, Accuracy of 76.36% [21].

Synthesis of results

In this meta-analysis, we evaluated the diagnostic accuracy of ST- segment elevation, as defined by the third and fourth universal defini- tions of AMI, in identifying ACO. Analyzing data from three studies with a total of 23,704 participants, we obtained the following pooled results:

- Sensitivity: The overall sensitivity for detecting ACO based on ST- segment elevation criteria was 43.6%, (95% CI: 34.7% to 52.9%), reflecting the proportion of true positive cases correctly identified as having the disease.
- Specificity: 96.5% (95% CI: 91.2% to 98.7%).

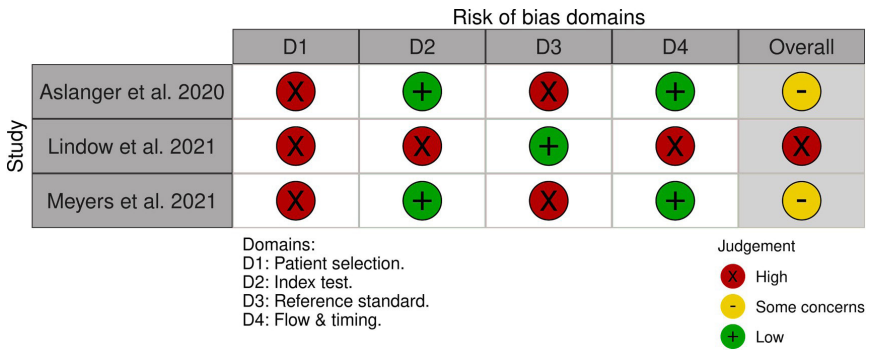

Fig. 2. QUADAS-2 risk of bias. Visual summary of the risk of bias for patient selection, index test, reference standard, and flow and timing across the studies included in the meta-analysis.

- Positive Likelihood Ratio (LR+): Calculated at 12.517 (95% CI: 3.953 to 39.638), indicates the increase in odds of having ACO with ST-segment elevation on ECG.

- Negative Likelihood Ratio (LR-): Found to be 0.585 (95% CI: 0.481 to 0.711), demonstrating the decrease in odds of ACO in the absence of ST-segment elevation on ECG.

To visually represent these findings, forest plots are included in Figs. 3 and 4, which illustrate the distribution and confidence of these diagnostic metrics. Additionally, a comprehensive summary of the combined studies' findings is presented in Table 2, providing an over- view of the pooled results and their clinical implications.

Additional analysis

Sensitivity analysis was conducted to determine the impact of indi- vidual studies on the overall meta-analysis results by sequentially excluding each study.

- Excluding Aslanger's Study: Sensitivity: 38.2% (95% CI: 33.9% - 42.7%); Specificity: 93.4% (95% CI: 93.1% - 93.7%).
- Excluding Lindow's Study: Sensitivity: 47.7% (95% CI: 38.1% - 57.5%); Specificity: 97.5% (95% CI: 91.2% - 99.3%)
- Excluding Meyers' Study: Sensitivity: 44.6% (95% CI: 31.4% - 58.6%); Specificity: 97.3% (95% CI: 90.5% - 99.3%).

It is to understand that the Sensitivity Analysis excluding Lindow's study combines the results of two studies, Aslanger and Meyers, that evaluated both angiographic and clinical diagnoses of ACO.

Additionally, we conducted an analysis focusing on the occlusion myocardial infarction – non occlusion myocardial infarction (OMI- NOMI) strategy, which includes other electrocardiographic equivalents of occlusion. This analysis incorporated data from the Meyers et al. and Aslanger et al. studies, where this particular comparison was made [20,21]. The OMI-NOMI strategy considers the presence of other electrocardiographic equivalents of occlusion, such as hyperacute T waves,terminal QRS distortion, and other findings that have been recently discovered and tested. The results of this specific analysis revealed the following in 3772 participants:

	Positive	Negative	Total
Cases	820	825	1645
Healthy	1354	20,705	22,059
Total	2174	21,530	23,704

This table displays the aggregated data from the included studies, illustrating the distribution of positive and negative cases for ST-segment elevation as an indi- cator of acute coronary occlusion (ACO).

Table 2 Summary of findings.

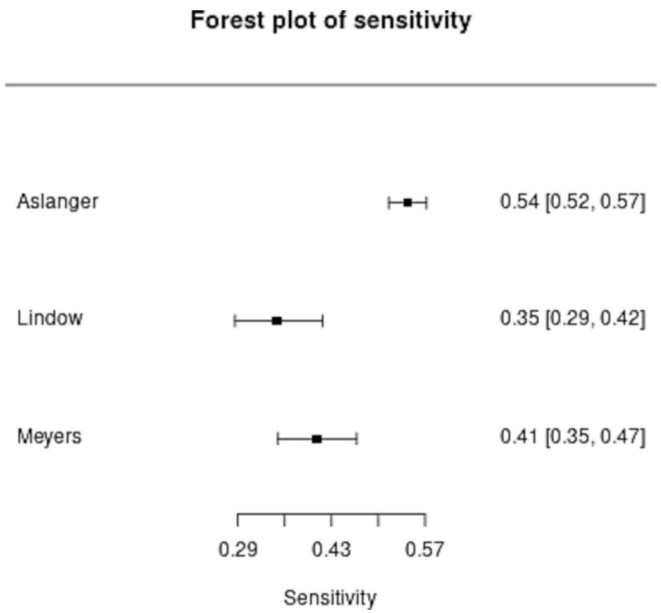

Fig. 3. Forest plot of sensitivity.

Sensitivity estimates for each study—Aslanger et al., Lindow et al., and Meyers et al.—with their corresponding 95% confidence intervals, illustrating the variability in the diagnostic sensitivity of the ECG for detecting OMI across different clinical settings.

- Sensitivity: The pooled sensitivity for detecting OMI using the OMI- NOMI strategy was found to be 78.1% (95% CI: 62.7% to 88.3%). This indicates a substantial increase in the ability to correctly iden- tify true positives among cases when employing this strategy.
- Specificity: The specificity was 94.4% (95% CI: 88.6% - 97.3%).
- Positive Likelihood Ratio (LR+): 13.835 (95% CI: 7.796 to 24.554).
- Negative Likelihood Ratio (LR-): 0.232 (95% CI: 0.135 to 0.401).

These results demonstrate a substantial improvement in the negative likelihood ratio, indicating that with OMI-NOMI strategy, a patient with a negative result has a significantly reduced probability of having an ACO and being falsely classified as 'negative'.

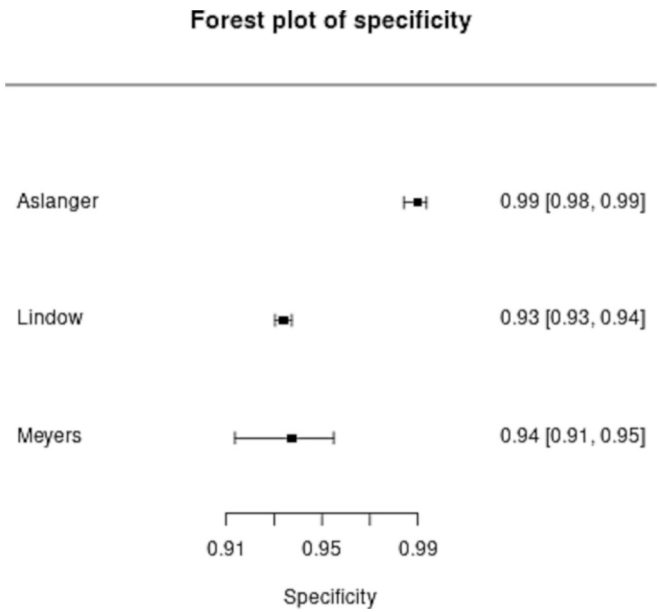

Fig. 4. Forest plot of specificity.

The specificity estimates for the included studies— Aslanger et al., Lindow et al., and Meyers et al. The 95% confidence intervals highlight the consistency of the ECG's ability to correctly identify patients without ACO.

DISCUSSION

The limited number of studies included in our meta-analysis was anticipated, reflecting the constraints imposed by the current STEMI- NSTEMI paradigm. Many studies have focused on defining the accu- racy of ST-segment elevation in comparison with necrosis markers such as troponin, CKMB, or CPK, rather than angiographic data. Additionally, numerous studies based their diagnosis on the clinically adjudicated definition of STEMI or ACS, which, due to incorporating the test result itself into the diagnosis, can suffer from incorporation bias [25,26]. Our research methodology deliberately excluded these studies, as they did not align with our objective of assessing diagnostic test accuracy, spe- cifically in relation to angiography.

Moreover, we excluded studies that solely focused on the prevalence of angiographic occlusion in patients with NSTEMI. Such studies, lack- ing comparative groups, do not enable the generation of contingency tables

or the subsequent calculation of sensitivity and specificity, thereby limiting their utility in our meta-analysis. This criterion was essential for preserving the integrity and specific focus of our study.

Additionally, we chose to exclude studies focusing on the ECG accuracy or NSTEMI prevalence in occlusions of specific coronary arteries, such as the circumflex, or particular locations, such as the basal lateral segments of the ventricles. This decision was made to more accurately reflect the real clinical scenario of 12lead ECG's ability to determine ACO, irrespective of the coronary artery involved.

Our meticulous approach in study selection reflects our commitment to provide a robust assessment of the diagnostic accuracy of ST-segment elevation within the evolving OMI-NOMI paradigm.

Our findings revealed that while STE is a specific indicator for ACO, its sensitivity is limited to 43.6%. This implies that 56.4% of patients with ACO may not exhibit this classical ECG sign, a significant revela- tion, suggesting the need for revised diagnostic strategies.

From a probabilistic perspective, a negative likelihood ratio (LR-) of 0.58 indicates that the absence of STE on the ECG reduces the likelihood of ACO by no more than half. Conversely, the presence of STE (LR+ of 12.771) increased the likelihood of ACO by >12 times.

Employing the OMI-NOMI strategy, which includes additional electrocardiographic findings, both the positive and negative likelihood ratios improved. The probability of ACO increases by >14 times (LR+ of 14.267) in the presence of any OMI-NOMI findings, while the absence of these findings decreases the probability of OMI almost fivefold (LR- of 0.232). This enhancement in diagnostic likelihood ratios highlights the effectiveness of the OMI-NOMI strategy, demonstrating its potential to improve the diagnostic accuracy of ACO.

LIMITATIONS

Our study has several limitations. Given the novelty of the OMI- NOMI paradigm, variation in the reference test across studies necessi- tated careful analysis of our article's findings and the sensitivity analyses conducted. It is imperative that efforts be made to standardize the diagnosis of ACO, thereby improving its replicability in future studies. Moreover, the retrospective nature of all three included studies in- troduces a potential selection bias, which may affect the representa- tiveness of the patient populations and, consequently, the generalizability of our findings. The

risk of bias, as evaluated using the QUADAS-2 tool, showed variability among studies, although the overall impact on our conclusions remains uncertain. Additionally, despite our comprehensive review process, it is possible that not all pertinent research was captured, potentially leaving gaps in our evidence base.

Another significant limitation is the high heterogeneity observed in our study. We believe that differences in the methodologies of each study and the limited number of studies contributed to this heteroge- neity. The area of the ellipse and the variances of the logit of sensitivity and specificity reveal a broad dispersion in the diagnostic performance across the included studies. This suggests diverse clinical settings, methodologies, and possibly different patient populations, which can affect the applicability of the pooled results to a wider context [27,28]. To address these challenges and reduce heterogeneity, more data, particularly from prospective studies with more standardized method- ologies, are needed. Such future research would not only provide a more reliable estimate of the diagnostic accuracy of STE in identifying ACO but also enhance the clinical applicability of the OMI-NOMI paradigm.

FUTURE PERSPECTIVES

Emerging technologies, particularly in the realm of artificial intelli- gence, hold promising prospects for enhancing the diagnostic accuracy of AMI management. AI applications, such as advanced algorithms for ECG interpretation and predictive modeling, have the potential to revolutionize the diagnosis and management of AMI. As we witness the evolution of diagnostic methods, it becomes clear that an integrated multifaceted approach is essential. This approach could combine tradi- tional diagnostic techniques with AI tools, supported by interdisci- plinary collaboration, to achieve a more accurate and efficient management of MI.

CONCLUSIONS

Our meta-analysis provides useful insights into cardiology, especially in how we understand the changing nature of AMI. The results suggest that it is time to move from the old STEMI-NSTEMI model to the newer OMI-NOMI approach. This change fits better with the complex nature of AMI. It is important not just in theory, but it could also help diagnose ACO more accurately and improve how they treat patients.

The OMI-NOMI paradigm encourages clinicians to consider a wider array of diagnostic indicators, including those beyond ST-segment elevation, which could lead to improved patient outcomes, consid- ering recent

advancements in diagnostic technologies and AMI treat- ments. It is imperative to further validate and refine this paradigm and examine how it can be effectively integrated into clinical practice. Future research should also focus on developing and validating new diagnostic tools, particularly those incorporating emerging technolo- gies, such as artificial intelligence, to increase the precision of AMI diagnosis and management.

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CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Jose´ Nunes de Alencar Neto: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Matheus Kiszka Scheffer:** Writing – review & editing, Investigation, Formal analysis, Data curation. **Bruno Pinotti Correia:** Writing – re- view & editing, Formal analysis, Data curation. **Kleber Gomes Fran- chini:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Sandro Pinelli Felicioni:** Writing – review & editing, Investigation, Formal analysis, Data curation. **Mariana Fuziy Nogueira De Marchi:** Writing – review & editing, Su- pervision, Investigation, Formal analysis, Data curation.

DECLARATION OF COMPETING INTEREST

There is no conflict of interest to disclose.

APPENDIX A. SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijcard.2024.131889.

REFERENCES

1. J.S. Alpert, K. Thygesen, E. Antman, J.P. Bassand, Myocardial infarction redefined– a consensus document of The Joint European Society of Cardiology/American College of Cardiology Committee for the redefinition of myocardial infarction,

2. J. Am. Coll. Cardiol. 36 (3) (2000) 959–969, https://doi.org/10.1016/s0735-1097(00)00804-4. Randomised trial of intravenous streptokinase, oral aspirin, both, or neither among 17,187 cases of suspected acute myocardial infarction: ISIS-2. ISIS-2 (Second International Study of Infarct Survival) Collaborative Group, Lancet (Lond.,

Engl.) 2 (8607) (1988) 349–360.

3. R.G. Wilcox, G. von der Lippe, C.G. Olsson, G. Jensen, A.M. Skene, J.R. Hampton, Trial of tissue plasminogen activator for mortality reduction in acute myocardial infarction. Anglo-Scandinavian study of early thrombolysis (ASSET), Lancet. 2 (8610) (1988) 525–530, https://doi.org/10.1016/s0140-6736(88)92656-6.

4. A.P. Maggioni, M.G. Franzosi, C. Fresco, F. Turazza, G. Tognoni, GISSI trials in acute myocardial infarction. Rationale, design, and results, Chest. 97 (4 Suppl) (1990) 146S–150S.

5. Indications for fibrinolytic therapy in suspected acute myocardial infarction: Collaborative overview of early mortality and major morbidity results from all randomised trials of more than 1000 patients. Fibrinolytic Therapy Trialists' (FTT) Collaborative, Lancet (Lond., Engl.) 343 (8893) (1994) 311–322.

6. I.B. Menown, G. Mackenzie, A.A. Adgey, Optimizing the initial 12-lead electrocardiographic diagnosis of acute myocardial infarction, Eur. Heart J. 21 (4) (2000) 275–283, https://doi.org/10.1053/euhj.1999.1748.

7. P.W. Macfarlane, D. Browne, B. Devine, et al., Modification of ACC/ESC criteria for acute myocardial infarction, J. Electrocardiol. 37 (Suppl) (2004) 98–103, https:// doi.org/10.1016/j.jelectrocard.2004.08.032.

8. E.K. Aslanger, H.P. Meyers, S.W. Smith, STEMI: a transitional fossil in MI classification? J. Electrocardiol. 65 (2021) 163–169, https://doi.org/10.1016/j. jelectrocard.2021.02.001.

9. J.P. Salameh, P.M. Bossuyt, T.A. McGrath, et al., Preferred reporting items for systematic review and meta-analysis of diagnostic test accuracy studies (PRISMA- DTA): explanation, elaboration, and checklist, BMJ. 370 (2020) m2632, https:// doi.org/10.1136/bmj.m2632.

10. J.F. Cohen, J.J. Deeks, L. Hooft, et al., Preferred reporting items for journal and conference abstracts of systematic reviews and meta-analyses of diagnostic test accuracy studies (PRISMA-DTA for abstracts): checklist, explanation, and elaboration, BMJ. 372 (2021) n265, https://doi.org/10.1136/bmj.n265.

11. K. Thygesen, J.S. Alpert, A.S. Jaffe, M.L. Simoons, B.R. Chaitman, H.D. White, Third universal definition of myocardial infarction, Circulation. 126 (16) (2012) 2020–2035, https://doi.org/10.1161/CIR.0b013e31826e1058.

12. K. Thygesen, J.S. Alpert, A.S. Jaffe, et al., Fourth universal definition of myocardial

infarction (2018), Eur. Heart J. 40 (3) (2018) 237–269, https://doi.org/10.1093/eurheartj/ehy462.

13. P. Steel, H. Fariborzi, R. Hendijani, An Application of Modern Literature Review Methodology: Finding Needles in Ever-Growing Haystacks, 2023, https://doi.org/10.4135/9781529667417.

14. P.F. Whiting, A.W.S. Rutjes, M.E. Westwood, et al., QUADAS-2: a revised tool for the quality assessment of diagnostic accuracy studies, Ann. Intern. Med. 155 (8) (2011) 529–536, https://doi.org/10.7326/0003-4819-155-8-201110180-00009.

15. L.A. McGuinness, J.P.T. Higgins, Risk-of-bias VISualization (robvis): an R package and shiny web app for visualizing risk-of-bias assessments, Res. Synth. Methods (2020) n/a(n/a), https://doi.org/10.1002/jrsm.1411.

16. S.C. Freeman, C.R. Kerby, A. Patel, N.J. Cooper, T. Quinn, A.J. Sutton, Development of an interactive web-based tool to conduct and interrogate meta- analysis of diagnostic test accuracy studies: MetaDTA, BMC Med. Res. Methodol. 19 (1) (2019) 81, https://doi.org/10.1186/s12874-019-0724-x.

17. V.N. Nyaga, M. Arbyn, Comparison and validation of metadta for meta-analysis of diagnostic test accuracy studies, Res. Synth. Methods 14 (3) (2023) 544–562, https://doi.org/10.1002/jrsm.1634.

18. H. Chu, S.R. Cole, Bivariate meta-analysis of sensitivity and specificity with sparse data: a generalized linear mixed model approach, J. Clin. Epidemiol. 59 (12) (2006) 1331–1332, author reply 1332-1333, https://doi.org/10.1016/j. jclinepi.2006.06.011.

19. R.M. Harbord, J.J. Deeks, M. Egger, P. Whiting, J.A.C. Sterne, A unification of models for meta-analysis of diagnostic accuracy studies, Biostatistics. 8 (2) (2007) 239–251, https://doi.org/10.1093/biostatistics/kxl004.

20. E.K. Aslanger, O¨ . Yıldırımtürk, B. S¸ ims¸ek, et al., DIagnostic accuracy oF electrocardiogram for acute coronary OCClUsion resuLTing in myocardial infarction (DIFOCCULT study), Intern. J. Cardiol. Heart Vascul. 30 (2020) 1–7, https://doi.org/10.1016/j.ijcha.2020.100603.

21. H.P. Meyers, A. Bracey, D. Lee, et al., Accuracy of OMI ECG findings versus STEMI criteria for diagnosis of acute coronary occlusion myocardial infarction, IJC Heart Vasc. 33 (2021) 100767, https://doi.org/10.1016/j.ijcha.2021.100767.

22. T. Lindow, H. Engblom, O. Pahlm, et al., Low diagnostic yield of ST elevation myocardial

infarction amplitude criteria in chest pain patients at the emergency department, Scand. Cardiovasc. J. 55 (3) (2021) 145–152, https://doi.org/ 10.1080/14017431.2021.1875138.

23. P. Hillinger, I. Strebel, R. Ab¨acherli, et al., Prospective validation of current quantitative electrocardiographic criteria for ST-elevation myocardial infarction, Int. J. Cardiol. 292 (2019) 1–12, https://doi.org/10.1016/j.ijcard.2019.04.041.

24. H.P. Meyers, S.W. Smith, Prospective, real-world evidence showing the gap between ST elevation myocardial infarction (STEMI) and occlusion MI (OMI), Int. J. Cardiol. 293 (2019) 48–49, https://doi.org/10.1016/j.ijcard.2019.07.043.

25. Tanaka A, Matsuo K, Kikuchi M, et al. Systematic review and meta-analysis of diagnostic accuracy to identify ST-segment elevation myocardial infarction on interpretations of prehospital electrocardiograms. Circ. Rep. 4(7):289–297. doi:htt ps://doi.org/10.1253/circrep.CR-22-0002.

26. W.J. Brady, S.A. Syverud, C. Beagle, et al., Electrocardiographic ST-segment elevation: the diagnosis of acute myocardial infarction by morphologic analysis of the ST segment, Acad. Emerg. Med. 8 (10) (2001) 961–967, https://doi.org/ 10.1111/j.1553-2712.2001.tb01094.x.

27. M.N. Plana, T. Pe´rez, J. Zamora, New measures improved the reporting of heterogeneity in diagnostic test accuracy reviews: a metaepidemiological study, J. Clin. Epidemiol. 131 (2021) 101–112, https://doi.org/10.1016/j. jclinepi.2020.11.011.

28. P. Schlattmann, Tutorial: statistical methods for the meta-analysis of diagnostic test accuracy studies, Clin. Chem. Lab. Med. (CCLM). 61 (5) (2023) 777–794, https:// doi.org/10.1515/cclm-2022-1256.