Original Article

Accuracy of Left Bundle Branch Block Chronology and Electrocardiography Criteria for Acute Myocardial Infarction Diagnosis: A Systematic Review and Meta-analysis

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Abstract

Background: The diagnostic utility of new or presumed new left bundle branch block (LBBB) for acute myocardial infarction (AMI) in the setting of acute coronary syndrome (ACS) remains controversial.

Objective: To evaluate whether the timing of LBBB predicts AMI and to compare its diagnostic accuracy with ischemic electrocardiography (ECG) criteria, particularly the Modified Sgarbossa Criteria (MSC).

Methods: We searched PubMed and Scopus for studies involving patients with ACS with LBBB through December 2023. Sensitivity, specificity, positive (LR+) and negative (LR–) likelihood ratios, and diagnostic odds ratios (DOR) were calculated to assess diagnostic accuracy. Incidence and mortality data were also analyzed. Risk of bias was evaluated using the Newcastle-Ottawa Scale (NOS) and the revised Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool.

Results: A total of 51 studies were included. LBBB occurred in 3.3% of ACS presentations and was associated with higher in-hospital mortality. Differentiating new from old LBBB was diagnostically neutral: LR+ 1.30 (95% CI: 0.75 to 1.85), LR– 0.90 (95% CI: 0.79 to 1.02), and DOR 1.44 (95% CI: 0.93 to 2.24); all confidence intervals crossed the null value of 1.0. In contrast, MSC demonstrated 83.6% sensitivity (95% CI: 55.4 to 95.5%) and 92.6% specificity (95% CI: 78.9 to 97.7%) for angiographically confirmed occlusive AMI, with LR+ 11.34 (95% CI: 3.67 to 34.99) and LR– 0.18 (95% CI: 0.054 to 0.575).

Conclusion: LBBB chronology alone does not significantly impact the likelihood of AMI. Ischemic ECG criteria — especially the MSC — provide substantially greater diagnostic accuracy and should guide clinical decision-making in ACS patients with LBBB.

Keywords: Myocardial Infarction; Electrocardiography; Acute Coronary Syndrome.

Introduction

Patients presenting with suspected acute coronary syndrome (ACS) and left bundle branch block (LBBB) pose a complex clinical challenge. The presence of new or presumed new LBBB in this context has generated significant debate, particularly regarding its diagnostic and therapeutic implications. Whether new or presumably new LBBB should be considered an electrocardiographic (ECG) equivalent to ST-segment elevation myocardial infarction (STEMI) remains unclear, prompting further investigation into its clinical relevance.[1]

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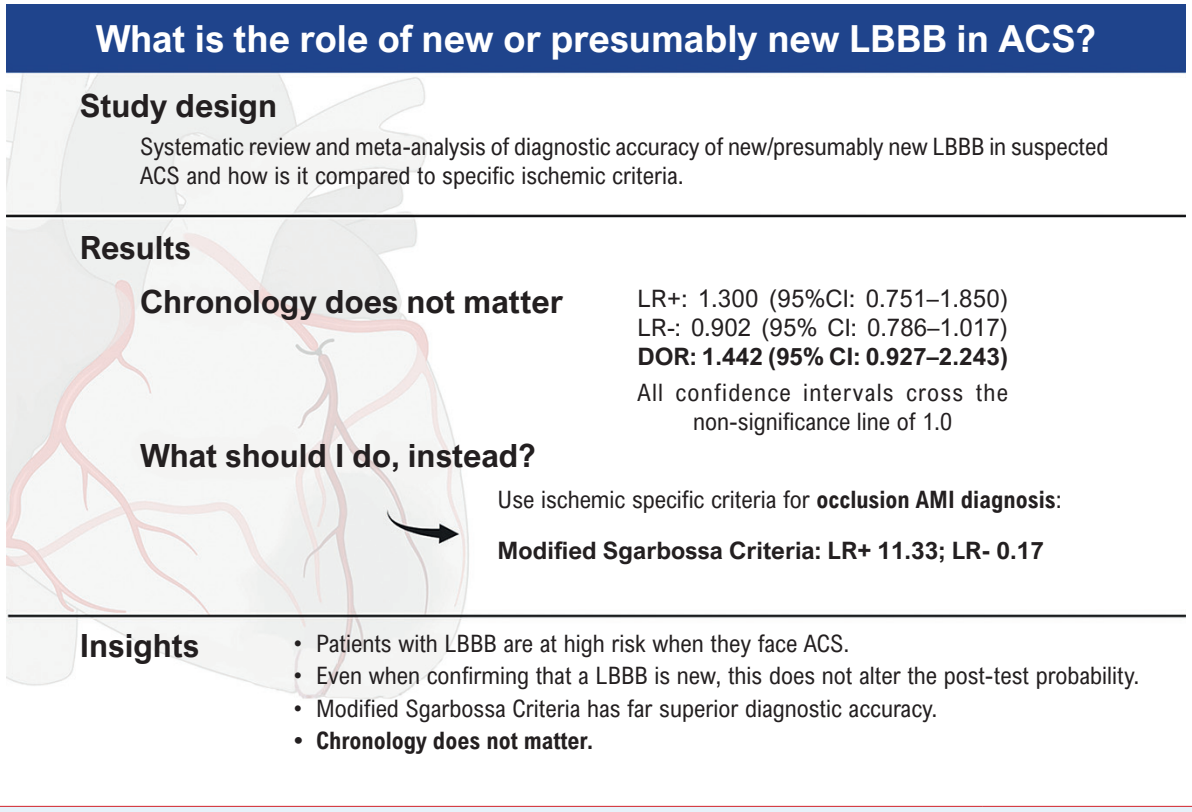
The 2004 guidelines from the American College of Cardiology (ACC) and the American Heart Association (AHA) initially recommended early reperfusion therapy — either fibrinolysis or percutaneous coronary intervention (PCI) — for patients with new or presumed new LBBB, assigning it a Class I indication.[2] However, this strategy has faced increasing scrutiny due to the high rate of cardiac catheterizations in patients without an occluded culprit artery, raising concerns about the risks of unnecessary fibrinolytic treatment and invasive procedures.[3]

These evolving perspectives underscore the need to reassess the role of LBBB in the diagnosis and management of acute myocardial infarction (AMI).[4] The most recent ACC/AHA guidelines no longer recognize LBBB as an automatic STEMI equivalent.[5] In contrast, the 2023 European guidelines recommend treating patients who present with LBBB and clinical features suggestive of ACS as STEMI cases, regardless of whether the conduction block is previously known.[6]

In addressing clinically relevant questions within a real-world context, this meta-analysis aimed to quantify

Central Illustration: Accuracy of Left Bundle Branch Block Chronology and Electrocardiography Criteria for Acute Myocardial Infarction Diagnosis: A Systematic Review and Meta-analysis



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LBBB: left bundle branch block; DOR: diagnostic odds ratio; AMI: acute myocardial infarction due to occlusion; LR+: positive likelihood ratio; LR–: negative likelihood ratio; ACS: acute coronary syndrome.

the prevalence of LBBB among patients presenting with suspected ACS. Additionally, by analyzing mortality data, we investigated whether patients with LBBB experience higher mortality rates compared to those with other conduction abnormalities or ECG findings.

We also evaluated whether the clear identification of new LBBB — or the ability to estimate its timing — serves as a reliable marker for AMI, as determined by elevated cardiac necrosis markers or angiographically confirmed acute coronary occlusion (ACO), in patients with suspected ACS. Finally, we assessed whether specific ECG criteria for ischemia in the setting of LBBB offer sufficient diagnostic accuracy for routine clinical use.

This comprehensive analysis, conducted in accordance with Preferred Reporting Items for a Systematic Review and Meta-analysis of Diagnostic Test Accuracy Studies (PRISMA-DTA)[7,8] and Meta-analyses Of Observational Studies in Epidemiology (MOOSE)[9] guidelines, aims to provide a nuanced understanding of the role of LBBB in ACS and deliver meaningful insights to guide clinical decision-making.

Methods

In this systematic review, we included studies involving patients with ACS or suspected ACS in the presence of new or presumed new LBBB, ischemic LBBB, or LBBB due to pacing. Our primary objective was to assess the diagnostic accuracy of new LBBB or LBBB with ischemic ECG criteria, comparing sensitivity and specificity against reference standards such as cardiac biomarkers (CK-MB or troponin) and coronary angiography.

We also aimed to evaluate the prevalence and in-hospital mortality associated with LBBB in the context of ACS. Studies were included regardless of language and publication status, covering all records available from database inception through December 2023. The full search strategy is provided in Supplementary Material 1.

Our search was conducted through December 2023 using the PubMed and Scopus databases. The search strategy was specifically designed to capture studies relevant to LBBB in the context of ACS. Full search strings are detailed in the supplementary materials. The strategy was refined with specific filters to match our eligibility criteria, focusing on publication status and study type to ensure relevance and accuracy.

Two review authors (H.G. and G.L.) independently screened titles and abstracts. Discrepancies were resolved by a third review author (R.F.). Full-text screening was subsequently performed by two additional review authors (J.A. and M.M.). The screening process was managed using the HubMeta online tool.[10]

We applied strict exclusion criteria, omitting studies that focused on other conduction abnormalities, LBBB not related to acute ischemia, clinical guidelines, review articles, case reports, previous meta-analyses or systematic reviews, studies on chronic coronary disease, or those that addressed ACS without explicitly involving new or presumed new LBBB. Studies focusing on diagnostic methods other than resting ECG, as well as those addressing painful LBBB syndrome, were also excluded.

Definitions of index test and outcomes

LBBB was defined by a QRS duration ≥ 120 ms and characteristic QRS morphology, including notching or slurring in the middle third of the QRS complex in at least two of the following leads: V1, V2, V5, V6, I, and aVL. Diagnostic criteria also included a delayed R-wave peak in V5–V6 exceeding 60 ms. In the horizontal plane, findings included a QS or rS pattern in V1 with ST-segment elevation (STE) and a positive, asymmetrical T wave, as well as a prominent R wave in V6 accompanied by a negative, asymmetrical T wave. When the QRS duration is less than 140 ms, the T wave in V6 may appear positive.[11] However, due to the extended time span covered by this review, the definition of LBBB has evolved over the years. Therefore, we accepted the definition used by each study's original investigators at the time of their research.

Similarly, the definition of AMI has changed over time, incorporating different criteria. A biomarker-based diagnosis was generally accepted when there was an elevation in markers such as AST, ALT, CPK, CK-MB, or troponin. More recent studies adopted the universal definition of AMI, which includes ischemic ECG changes such as STE or new or presumed new LBBB.[12,13]

Another outcome evaluated was angiographically confirmed ACO, defined as the presence — or suspected presence — of an ACO on angiography. This is considered a surrogate composite outcome, typically involving a consistent clinical presentation, the presence of a coronary lesion, and markedly elevated troponin levels.[14] This more contemporary and precise definition was highlighted in the text whenever available.

Statistical analysis

For dichotomous outcomes such as prevalence and mortality, we performed random-effects meta-analyses using the Onlinemeta software (version 1.0: 2022.3.15).[15] Heterogeneity was assessed and illustrated using the Bayesian I^2 statistic,[16] with planned subgroup analyses based on population and methodological differences. High heterogeneity was defined as $I^2 > 75\%$.[17]

To assess potential publication bias, we used funnel plots along with Egger's[18] and Begg's[19] tests. A p-value < 0.05 was considered indicative of significant publication bias. All related plots and tests are presented in Supplementary Material 1.

For diagnostic test accuracy outcomes, we conducted a meta-analysis using the *mada* package in R, applying the bivariate Reitsma model.[20,21] We calculated pooled sensitivity, specificity, positive (LR+) and negative (LR–) likelihood ratios, and diagnostic odds ratios (DOR), each with 95% CIs estimated using the delta method.

Risk of bias was assessed using the Newcastle-Ottawa Scale (NOS)[22] for case-control studies and the revised Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2)[23] for diagnostic accuracy studies. Visualizations were generated using the *robvis* online tool.[24]

Results

The electronic database search yielded 2,700 articles. After removing duplicates, 1,967 unique records remained for initial screening. Title and abstract screening narrowed the selection to 146 articles. Following a thorough full-text review, 51 studies met the inclusion criteria and were included in the meta-analysis.

Details of the study selection process are presented in Figure 1 in the Results section. The complete search strings and baseline characteristics of the included studies are provided in Supplementary Material 1.

Prevalence of LBBB in ACS

A subset of 29 studies investigated the prevalence of new, presumed new, or established LBBB among 221,261 consecutive cases with suspected ACS.[25–53] Substantial heterogeneity in ACS diagnosis was observed, with an I^2 statistic of 99%. Overall, 3.3% (95% CI: 2.7% to 4.1%) of ACS cases presented with LBBB, regardless of its chronology. A graphical summary of these findings is shown in Figure 2.

No significant publication bias was detected, as demonstrated by the funnel plot available in Supplementary Material 1.

In-hospital mortality of LBBB in ACS

To assess in-hospital mortality among ACS patients, we conducted a random-effects meta-analysis of 14 studies involving 418,417 individuals presenting with chest pain.[27-29,32,34,39,42,44,45,49,54-57] The presence of LBBB did not result in a significantly higher mortality rate when compared to right bundle branch block (RBBB). However, comparisons between patients with LBBB and those with STEMI or with normal QRS complexes without STE revealed significantly increased unadjusted ORs.

Two studies specifically compared mortality between new and old LBBB. Of these, only one used angiographically confirmed ACO to define AMI.[39] Detailed results and data distributions are presented in Figure 3.

OR of LBBB for AMI

We analyzed the association between LBBB and the occurrence of angiographically confirmed ACO or biomarker-based AMI. Studies comparing these outcomes in patients with and without LBBB were pooled for analysis.[30,34,36,37,39,44,51,58-60]

ORs were calculated using a random-effects model to estimate the strength of association across studies.

For studies using angiography to confirm ACO, the pooled OR was 0.226 (95% CI: 0.092 to 0.557). For those using biomarker-based definitions, the pooled OR was 0.496 (95% CI: 0.358 to 0.689). The pooled overall OR across all studies was 0.336 (95% CI: 0.210 to 0.538), with $Tau^2 = 0.443$ and $I^2 = 89\%$, indicating substantial heterogeneity.

These findings are summarized in Figure 4. Funnel plots and publication bias assessments are presented in Supplementary Material 1.

Diagnostic test accuracy of new/presumably new LBBB

In studies evaluating the diagnostic accuracy of clearly new LBBB compared to old or indeterminate blocks,[36,40,61-65] a total of 1,229 patients were analyzed. The pooled sensitivity was 0.321 (95% CI: 0.240 to 0.402), specificity was 0.753 (95% CI: 0.612 to 0.894), LR+ was 1.30 (95% CI: 0.751 to 1.850), and LR– was 0.902 (95% CI: 0.786 to 1.017). The DOR was 1.442 (95% CI: 0.927 to 2.243), with all confidence intervals crossing the threshold of 1.0, indicating no meaningful discriminative power.

When indeterminate blocks were grouped together with new LBBB and compared against old LBBB in 848 patients,[40,61,62,64] the sensitivity was 0.633 (95% CI: 0.376 to 0.891), specificity 0.386 (95% CI: 0.326 to 0.446), LR+ 1.032 (95% CI: 0.653 to 1.411), and LR– 0.949 (95% CI: 0.343 to 1.556). The resulting DOR was 1.087 (95% CI: 0.520 to 2.271), again suggesting no significant diagnostic value.

Only one study[63] used angiographically confirmed ACO as the reference standard for AMI, reporting a sensitivity of 37.5% and specificity of 67.39%. Additional details are provided in Table 1 and Figure 5.

Diagnostic test accuracy of ECG criteria

This review also evaluated the diagnostic performance of established ECG criteria for AMI. These criteria, widely cited in the literature, were analyzed for their sensitivity and specificity in detecting biomarker-based or angiographically confirmed occlusive myocardial infarction (OMI). A summary of the findings is presented in Table 2. Forest plots and QUADAS-based risk of bias assessments are available in Supplementary Material 1.

The Modified Sgarbossa Criteria (MSC), developed to diagnose AMI in patients with LBBB, include concordant ST elevation >1 mm in leads with a positive QRS complex (score 5); concordant ST depression >1 mm in leads V1–V3 (score 3); and excessively discordant ST elevation >5 mm in leads with a negative QRS complex (score 2). A total score of ≥3 is considered diagnostic.[66]

Applied to 2,427 patients with LBBB, compared against those without AMI or angiographically confirmed ACO, the MSC demonstrated a sensitivity of 0.404 (95% CI: 0.227 to 0.610) and a specificity of 0.967 (95% CI: 0.922 to 0.987).[14,25,26,31,66-71]

In a sensitivity analysis restricted to studies that used angiographic confirmation of AMI and excluded those involving pacemaker patients, five studies comprising 1,369 patients yielded a LR+ of 11.315 and a LR− of 0.596.[14,25,26,67,71]

The MSC diagnose AMI in patients with LBBB based on the presence of any of the following findings: concordant ST elevation ≥1 mm in one or more leads; concordant ST depression ≥1 mm in leads V1–V3; or proportionally excessive discordant STE ≥1 mm in any lead, defined as ≥25% of the depth of the preceding S-wave.[14] Among 1,702 patients, these criteria demonstrated a sensitivity of 0.688 (95% CI: 0.362 to 0.895) and a specificity of 0.920 (95% CI: 0.841 to 0.961), with a LR+ of 8.576 (95% CI: 3.952 to 18.608) and a LR− of 0.340 (95% CI: 0.135 to 0.857).[14,31,53,67-69,71] When restricting the analysis to studies that used angiographically confirmed myocardial infarction as the reference standard and excluded pacemaker patients, four studies involving 1,161 patients yielded a sensitivity of 0.836 (95% CI: 0.554 to 0.955), specificity of 0.926 (95% CI: 0.789 to 0.977), LR+ of 11.337 (95% CI: 3.672 to 34.999), and LR− of 0.177 (95% CI: 0.054 to 0.575).[14,53,67,71]

The Barcelona Criteria define myocardial infarction in the presence of LBBB based on any of the following findings: concordant ST elevation ≥1 mm in any lead, concordant ST depression in any lead, or discordant ST deviation ≥1 mm in any lead where the R or S wave is ≤6 mm.[72] These criteria were evaluated in two studies comprising a total of 887 patients, compared against those with LBBB who did not meet the Barcelona Criteria for angiographically confirmed ACO.[67,72] The pooled sensitivity was 0.818 (95% CI: 0.403 to 0.968), and the specificity was 0.868 (95% CI: 0.790 to 0.919).

The Chapman's sign — defined by notching in the upstroke of the R wave in leads I, aVL, and V6[73] — was evaluated for its diagnostic utility in AMI based on biomarker confirmation in two studies from the 1980s, involving a total of 104 patients.[74,75] The pooled sensitivity was 0.190 (95% CI: 0.108 to 0.311), and specificity was 0.870 (95% CI: 0.739 to 0.940).

Discussion

Our detailed analysis found that LBBB was present in 3.3% (95% CI: 2.7% to 4.1%) of ACS presentations. Although this prevalence may appear modest, it warrants careful clinical consideration due to the potential for incorporation bias — a phenomenon in which the diagnostic criteria overlap between the index test and the reference standard.[76,77] In many studies, the presence of new or presumed new LBBB was itself considered diagnostic of ACS, which may have inflated the reported prevalence.

Our analysis of in-hospital mortality in ACS cohorts suggests that LBBB and RBBB are statistically comparable in terms of associated mortality risk. The unadjusted OR for in-hospital mortality among patients with LBBB was 1.135 (95% CI: 0.975 to 1.322), indicating no significant difference compared to RBBB.

Our findings challenge the prevailing notion that the presence of LBBB — regardless of its timing — should be treated as a de facto AMI requiring immediate reperfusion therapy. The pooled OR of 0.226 (95% CI: 0.092–0.557) suggests that LBBB alone does not inherently increase the likelihood of AMI. Even when using biomarker-based definitions — which

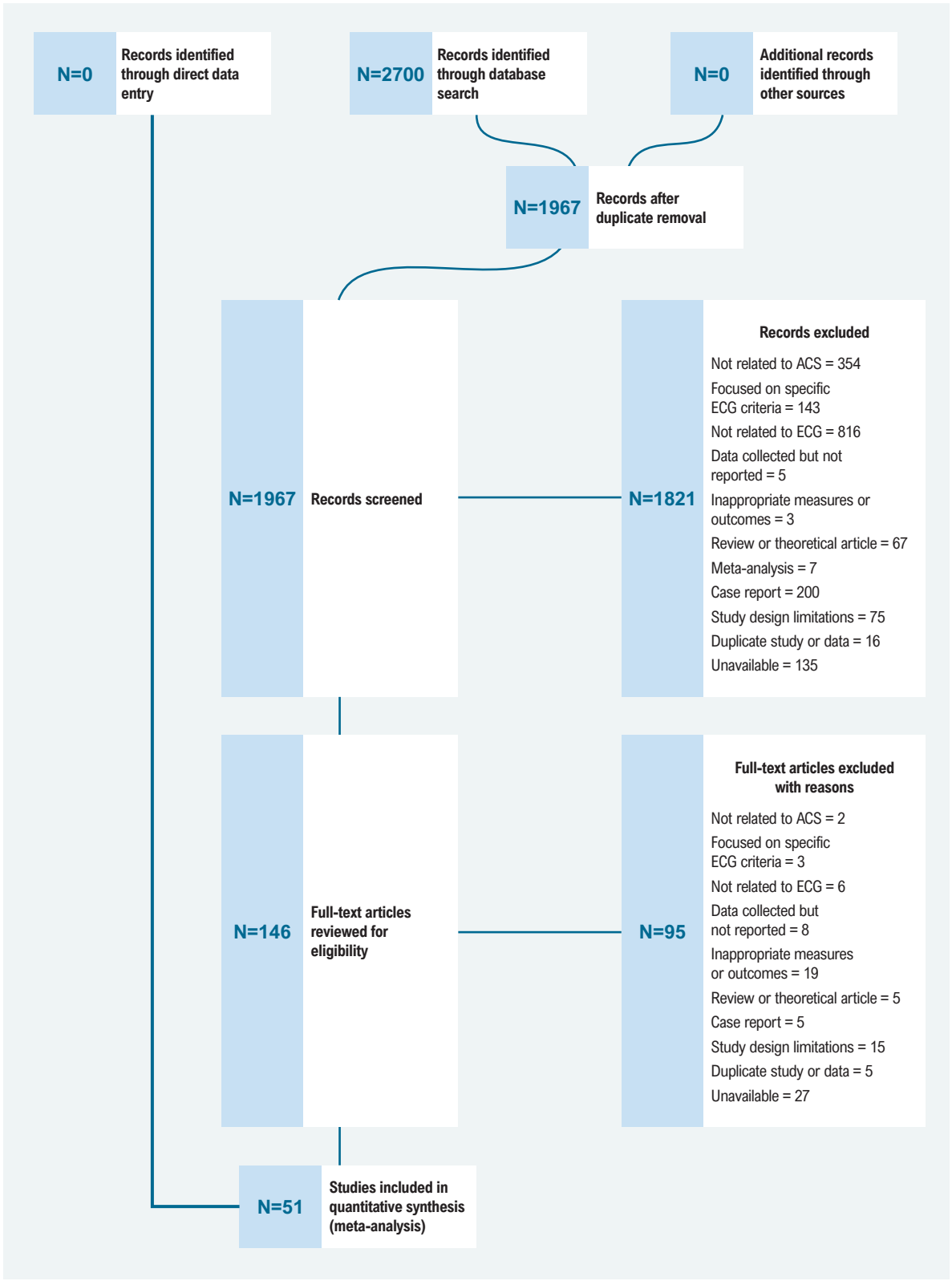


Figure 1 – *Flowchart of the study selection process from initial database search to the final inclusion of 51 studies in the meta-analysis.*

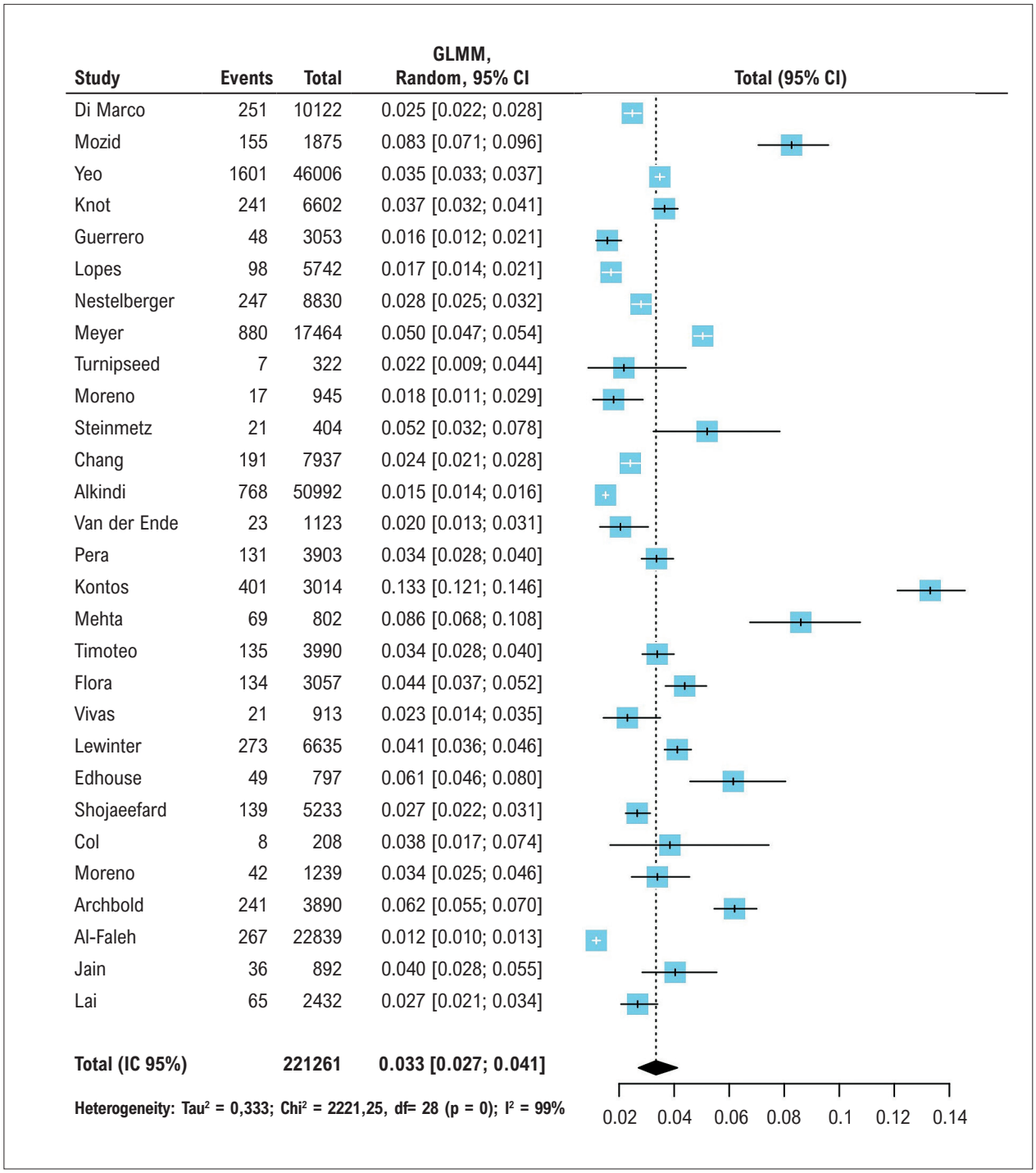


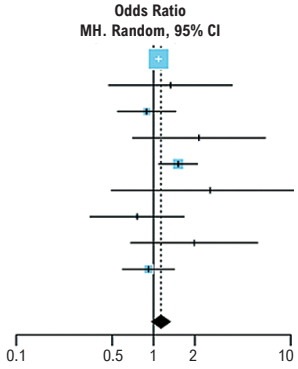
Figure 2 – *Forest plot of the prevalence of LBBB among patients with ACS across 29 studies. Individual study estimates are shown with corresponding 95% CIs along with the overall pooled prevalence and heterogeneity statistics. ACS: acute coronary syndrome; LBBB: left bundle branch block.*

are less precise indicators of infarction — the OR rises only to 0.496 (95% CI: 0.358–0.689), still insufficient to justify an elevated diagnostic suspicion of AMI. Interestingly, several primary studies included in our analysis inferred a high risk of AMI based solely on the absolute number of AMIs observed among patients with LBBB, without adequately comparing these findings to non-LBBB populations. This comparative approach was essential to arriving at a more accurate and nuanced interpretation. These pooled ORs must be considered in light of two key sources of bias. First, many of the included

LBBB vs. RBBB

Study	Events	Total	Events	Total	Weight	Odds Ratio MH. Random, 95% CI
Go 1998	4512	19967	4222	19967	55.1%	1.089 [1.038; 1.142]
Brilakis 2001	9	53	8	60	2.1%	1.330 [0.473; 3.737]
Knot 2012	31	241	48	338	8.4%	0.982 [0.549; 1.449]
Guerrero 2005	7	48	7	95	1.8%	2.146 [0.706; 6.521]
Meyer 2020	113	880	65	732	16.1%	1.512 [1.095; 2.087]
Jones 1977	14	23	3	8	0.8%	2.593 [0.494; 13.612]
Timoteo 2018	11	135	18	172	3.5%	0.759 [0.346; 1.666]
Vivas 2010	6	21	20	119	2.0%	1.980 [0.685; 5.725]
Lewinter 2015	50	273	51	260	10.2%	0.919 [0.596; 1.417]
Total (95% CI)		**21641**		**21751**	**100.0%**	**1.135 [0.975; 1.322]**

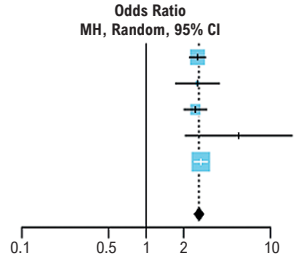
Heterogeneity: $Tau^2 = 0.010$; $Chi^2 = 9.83$, df = 8 (p = 0.28); $I^2 = 19\%$
Test for overall effect: Z = 1.63 (p = 0.10)



LBBB vs. STEMI

Study	Events	Total	Events	Total	Weight	Odds Ratio MH, Random, 95% CI
Yeo 2011	213	1601	2486	44405	31.3%	2.588 [2.228; 3.006]
Knot 2012	31	241	186	3446	4.3%	2.587 [1.726; 3.879]
Meyer 2020	113	880	885	15852	16.1%	2.492 [2.022; 3.070]
Moreno 2002	7	17	104	928	0.7%	5.546 [2.067; 14.884]
Eme 2016	371	2295	1707	26090	47.6%	2.754 [2.439; 3.110]
Total (95% CI)		**5034**		**90721**	**100.0%**	**2.664 [2.450; 2.897]**

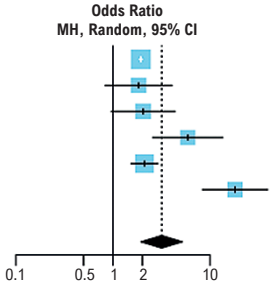
Heterogeneity: $Tau^2 = 0$; $Chi^2 = 2.97$, df = 4 (p = 0.56); $I^2 = 0\%$
Test for overall effect: Z = 22.92 (p < 0.01)



LBBB vs. no BBB

Study	Events	Total	Events	Total	Weight	Odds Ratio MH, Random, 95% CI
Go 1998	4512	19967	33996	259511	22.5%	1.937 [1.870; 2.006]
Moreno 1999	8	42	136	1197	14.2%	1.836 [0.833; 4.047]
Brilakis 2001	9	53	71	781	14.6%	2.045 [0.959; 4.362]
Guerrero 2005	7	48	82	2910	13.7%	5.888 [2.565; 13.518]
Lewinter 2015	50	273	586	6102	20.6%	2.111 [1.535; 2.901]
Timoteo 2018	11	135	18	3683	14.4%	18.062 [8.353; 39.055]
Total (95% CI)		**20518**		**274184**	**100.0%**	**3.169 [1.943; 5.169]**

Heterogeneity: $Tau^2 = 0.277$; $Chi^2 = 39.25$, df = 5 (p = 0.01); $I^2 = 87\%$
Test for overall effect: Z = 4.62 (p < 0.01)



nLBBB vs. oLBBB

Study or subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Odds ratio IV, Random, 95% CI
subgroup = subgroup1						
Brilakis 2001	9	35	5	55	18.8%	3.46 [1.05; 11.40]
Pera 2018	14	131	194	3772	81.2%	2.21 [1.24; 3.91]
Total (IC 95%)		**166**		**3827**	**100.0%**	**2.40 [0.26; 22.41]**
Heterogeneity: $Tau^2 = 0$; $Chi^2 = 0.45$, df = 1 (p = 0.50); $I^2 = 0\%$						
Total (95% CI)		**166**		**3827**	**100.0%**	**2.40 [0.26; 22.41]**

Heterogeneity: $Tau^2 = 0$; $Chi^2 = 0.45$, df = 1 (p = 0.50); $I^2 = 0\%$
Test for subgroup differences: Z = 0.00, df = 0 (p = NA)

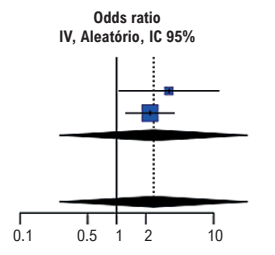


Figure 3 – *Forest plots of unadjusted ORs for in-hospital mortality in patients with ACS across different ECG presentations. First box: Comparison between LBBB and RBBB shows no significant heterogeneity (I2 = 19%). Second box: Comparison between LBBB and ST-elevation myocardial infarction (STEMI) also shows no significant heterogeneity. Third box: Comparison between LBBB and patients without BBB demonstrates high heterogeneity (I2 = 87%). Fourth box: Comparison between nLBBB and oLBBB, with heterogeneity not assessed. Each plot displays individual study estimates with 95% CIs and overall pooled ORs, highlighting the variability in mortality outcomes according to ECG findings at presentation. ACS: acute coronary syndrome; BBB: bundle branch block; ECG: electrocardiography; LBBB: left BBB; nLBBB: new LBBB; oLBBB: old LBBB; RBBB: right bundle branch block; STEMI: ST-elevation myocardial infarction.*

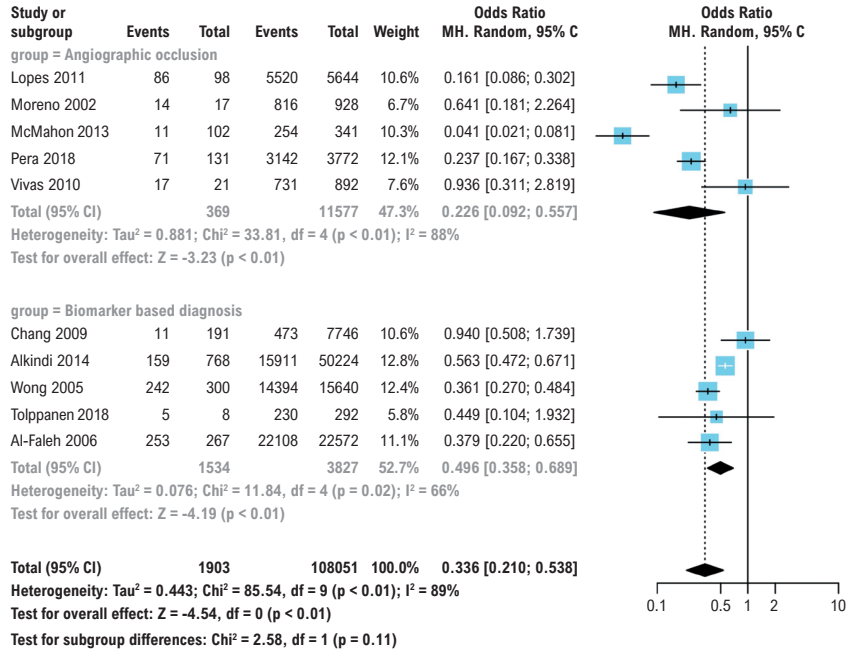


Figure 4 – *Forest plot of ORs for LBBB in predicting angiographically confirmed ACO and biomarker-based AMI. ACO: acute coronary occlusion; AMI: acute myocardial infarction; LBBB: left bundle branch block.*

Table 1 – Diagnostic test accuracy of LBBB chronology in identifying AMI. Comparison of new vs. indeterminate or old LBBB, and new or indeterminate vs. old LBBB, including sensitivity, specificity, and likelihood ratios based on patient-level data

Strategy	n	Sensitivity (95% CI)	Specificity (95% CI)	LR+ (95% CI)	LR– (95% CI)
New LBBB vs. Indeterminate and old LBBB	1,229	0.321 (0.240 to 0.402)	0.753 (0.612 to 0.894)	1.3 (0.751 to 1.850)	0.902 (0.786 to 1.017)
New or Indeterminate LBBB vs. old LBBB	848	0.633 (0.376 to 0.891)	0.386 (0.326 to 0.446)	1.032 (0.653 to 1.411)	0.949 (0.343 to 1.556)

LBBB: left bundle branch block.

studies were conducted during a period when "new or presumed-new LBBB" was still listed in STEMI guidelines as an indication for emergent catheterization. As a result, numerous patients were taken to the catheterization lab based solely on chest pain and the presence of LBBB, with the same ECG finding sometimes being accepted as diagnostic of AMI — an example of classical incorporation bias.[78] Second, a likely counteracting work-up bias[79] must also be acknowledged: only patients deemed ill enough — or managed at centers favoring an invasive approach — were referred for angiography or had serial biomarkers collected. Consequently, some true occlusions in both LBBB and non-LBBB groups may not have undergone the reference test. Overall, data do not support routine activation of the catheterization lab based solely on the presence of LBBB. These findings underscore how guideline-driven activation protocols may result in a substantial number of "false positives" while still missing silent occlusions in patients without LBBB.

Our primary objective was to assess the diagnostic accuracy of definitively new or presumed new LBBB in identifying AMI. While many clinicians have encountered patients with LBBB during an infarction, its diagnostic utility must be defined through accuracy studies — by constructing contingency tables, comparing cases and controls, and calculating true and false positives and negatives. To reflect real-world clinical decision-making — where physicians, often influenced by outdated guidelines, may seek prior ECGs — we conducted two parallel analyses. In one, indeterminate LBBB was treated as "presumably new"; in the other, as "old." The resulting sensitivities and specificities generated likelihood ratios that offer meaningful insights. In both analyses, the LR+ and LR− were close to 1.0, suggesting that identifying a definitively new

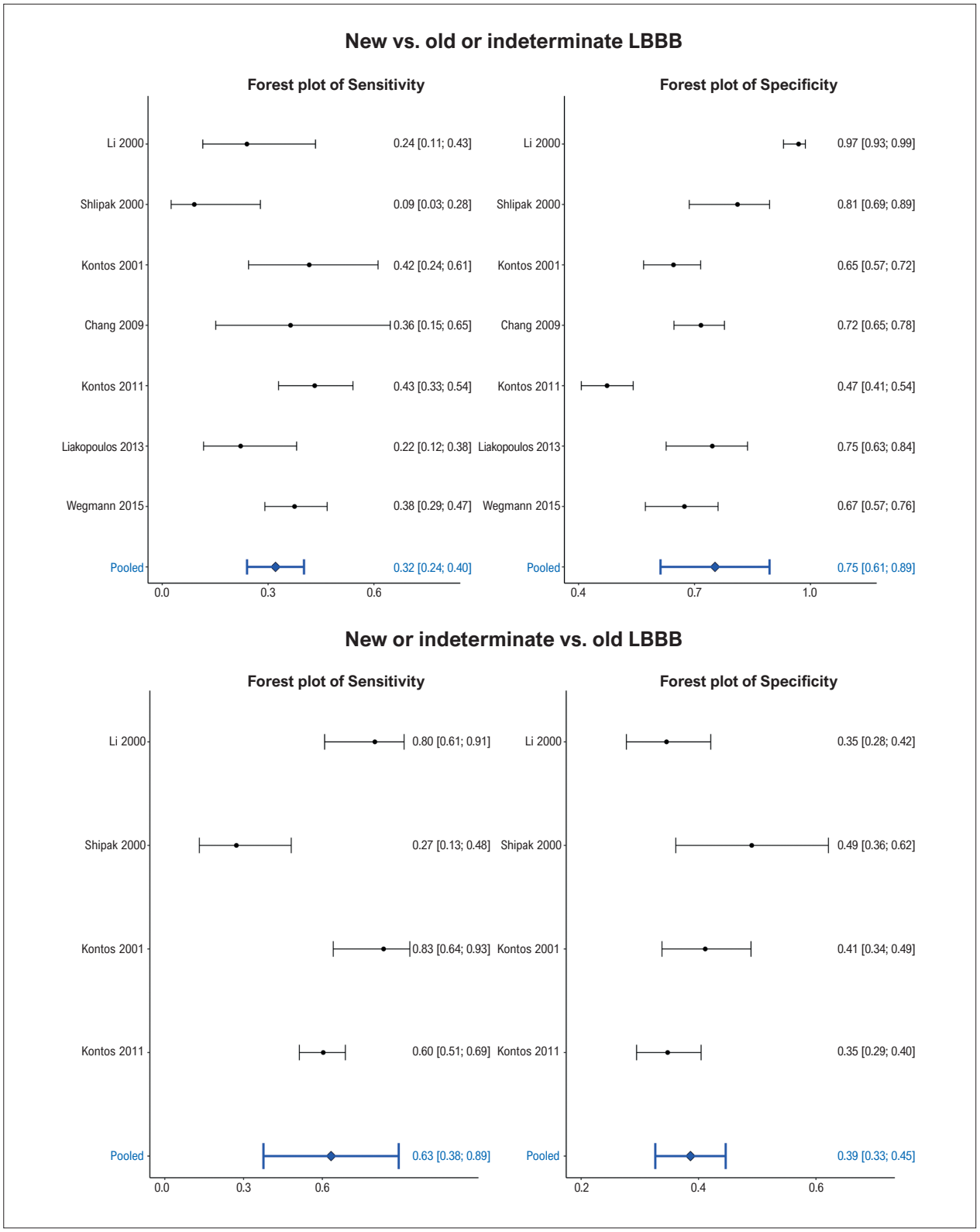


Figure 5 – *Forest plots showing pooled sensitivity and specificity with 95% CIs for two diagnostic comparisons involving LBBB chronology. Top panels: Comparison between new or presumably new LBBB and indeterminate or old LBBB. Bottom panels: Comparison between new or indeterminate LBBB and old LBBB. Both analyses were conducted in patients presenting with chest pain and evaluated for angiographically confirmed ACO or biomarker-based AMI. ACO: acute coronary occlusion; AMI: acute myocardial infarction; LBBB: left bundle branch block.*

Table 2 – Comparative diagnostic accuracy of ECG criteria for AMI in patients with LBBB. Sensitivity, specificity, and likelihood ratios (LR+ and LR–) are shown for the Sgarbossa criteria, MSC, Barcelona Criteria, and Chapman's sign

Criteria/Sign	n	Sensitivity (95% CI)	Specificity (95% CI)	LR+ (95% CI)	LR– (95% CI)
Sgarbossa Criteria	2,427	0.404 (0.227 to 0.610)	0.967 (0.922 to 0.987)	12.384 (5.426 to 28.265)	0.616 (0.445 to 0.854)
Sgarbossa – ACO	1,369	0.426 (0.305 to 0.557)	0.962 (0.859 to 0.991)	11.315 (2.677 to 47.825)	0.596 (0.471 to 0.754)
MSC	1,702	0.688 (0.362 to 0.895)	0.920 (0.841 to 0.961)	8.576 (3.952 to 18.608)	0.340 (0.135 to 0.857)
Modified Sgarbossa – ACO	1,161	0.836 (0.554 to 0.955)	0.926 (0.789 to 0.977)	11.337 (3.672 to 34.999)	0.177 (0.054 to 0.575)
Barcelona Criteria	887	0.818 (0.403 to 0.968)	0.868 (0.790 to 0.919)	6.182 (2.815 to 13.577)	0.210 (0.042 to 1.049)
Chapman's sign	104	0.190 (0.108 to 0.311)	0.870 (0.739 to 0.940)	1.454 (0.582 to 3.635)	0.932 (0.788 to 1.102)

ACO: acute coronary occlusion; AMI: acute myocardial infarction; ECG: electrocardiography; LBBB: left bundle branch block; MSC: Modified Sgarbossa Criteria.

or presumably new LBBB does not meaningfully change the probability of infarction compared to an old block. Moreover, the 95% confidence intervals for LR+, LR−, and DOR all crossed the null value of 1.0, indicating considerable statistical uncertainty. In fact, some data even suggest a potential inverse correlation between new LBBB and the likelihood of AMI.[80] The observation that the confidence intervals for both DOR and LR+ include 1.0 implies insufficient statistical evidence to conclude that a new or presumably new LBBB meaningfully increases — or decreases — the probability of AMI.[81] A DOR or LR+ that includes 1.0 in its confidence interval implies insufficient statistical confidence to conclude whether the presence of a new or presumably new LBBB meaningfully increases or decreases the probability of AMI. Therefore, distinguishing between new and old LBBB based solely on ECG chronology does not provide clinically useful information for decision-making in patients presenting to the emergency department with chest pain. In practical terms, this suggests that in the acute setting, the distinction between new and old LBBB lacks both clinical relevance and diagnostic value. Chronology adds no meaningful diagnostic information.

We also evaluated established ECG criteria for diagnosing AMI in the setting of LBBB, focusing on the presence of ischemic signs as a tool to guide clinical decision-making. Our analyses highlighted the diagnostic value of the Sgarbossa and MSC, particularly due to their high LR+, which reflect their strong confirmatory potential when positive. In a sensitivity analysis limited to studies that defined AMI angiographically, the MSC demonstrated especially strong performance. This refined approach yielded a higher LR+ of 11.337 and a lower LR− of 0.177, outperforming other ECG criteria in both confirming and excluding occlusive coronary artery events.

In an analysis framed within the OMI-NOMI paradigm,[82,83] which defines myocardial infarction based on angiographically confirmed occlusions, only Wegmann et al.[63] used angiographically confirmed ACO as the reference standard when evaluating the diagnostic value of LBBB chronology. That study reported a sensitivity of 37.5%, specificity of 67.39%, LR+ of 1.15, and LR− of 0.93. These likelihood ratios suggest that the classification of LBBB as new or old provides neither clinically nor statistically meaningful diagnostic information for identifying OMI — a finding consistent with the broader body of evidence. In contrast, five studies applied OMI as the outcome or reference standard when evaluating the Sgarbossa and MSC, thereby offering stronger methodological support and greater clinical relevance for these ECG-based tools. Both the original and modified criteria demonstrated superior diagnostic performance, with significantly higher LR+ and lower LR− values, meaningfully altering the post-test probability of disease and reinforcing their clinical utility in identifying ACO.

We also evaluated the diagnostic accuracy of the Barcelona Criteria. However, the validity of this approach has been questioned due to methodological concerns — particularly its selection criteria and the reference standard, which defines myocardial infarction based on the presence of any angiographic lesion accompanied by troponin elevation.[84] These limitations raise concerns about the reliability of the findings. This is further reflected in the high risk of bias identified through the QUADAS-2 assessment (Supplementary Material 1). Consequently, the diagnostic performance of the Barcelona Criteria should be interpreted with caution, and new prospective studies are needed to validate its clinical utility.

Our study strongly supports the clinical utility of actively assessing ischemic signs in patients with LBBB using the Sgarbossa or MSC. This strategy provides significantly greater statistical and clinical value than attempting to determine whether the LBBB is new or old — a distinction shown to be diagnostically uninformative (Central Illustration).

Prioritizing ischemic ECG criteria aligns more closely with clinical imperatives and enhances diagnostic accuracy in the evaluation of ACO.

Limitations of the study

Several limitations of this study must be acknowledged. First, there was substantial heterogeneity in the definitions and diagnostic criteria for both LBBB and myocardial infarction across the included studies, reflecting changes in clinical practice over time. This variability may have influenced both the estimated prevalence and the diagnostic accuracy outcomes in our meta-analysis. Second, our analysis of in-hospital mortality relied on unadjusted data, as adjusted estimates were not consistently reported across studies. As a result, our findings may not fully account for potential confounders such as comorbidities or differences in treatment strategies. Readers should interpret these mortality estimates with caution, recognizing that other clinical variables not captured in the analysis may influence outcomes. Third, although we employed rigorous methodology and followed established systematic review guidelines, we cannot entirely exclude the possibility of missed studies. Despite our efforts to conduct a broad search, relevant publications — particularly those not indexed in the selected databases or published in other languages — may have been overlooked. Finally, the validity of our results is inherently dependent on the quality of the studies. As with any meta-analysis, the strength of our conclusions is shaped by the methodological rigor and reporting standards of the primary data sources.

Conclusion

Our comprehensive analysis supports current guidelines that no longer consider LBBB — regardless of its timing — as a direct equivalent of AMI. Applying specific ECG criteria to identify ischemic signs in patients with LBBB improves both diagnostic accuracy and clinical decision-making. In this context, the MSC stand out as a reliable and effective diagnostic tool. These findings contribute meaningfully to the evolving landscape of cardiac care and underscore the importance of a more rational and evidence-based approach in the evaluation of suspected ACS. This study has the potential to influence future guideline revisions that continue to treat new or presumed new LBBB as indicative of ACO, and to inform clinical practice by discouraging reliance on outdated diagnostic assumptions.

Author Contributions

Conception and design of the research: Alencar JN, De Marchi MFN; Acquisition of data: Alencar JN, Lima GWF, Geraldo HAS, Fernandes RC, Scheffer MK, Felicioni SP; Analysis and interpretation of the data, Statistical analysis and Writing of the manuscript: Alencar JN; Critical revision of the manuscript for content: Alencar JN, Felicioni SP, De Marchi MFN.

Potential conflict of interest

No potential conflict of interest relevant to this article was reported.

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Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Data Availability

All datasets supporting the results of this study are available upon request from the corresponding author

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*Supplemental Materials

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