Indonesian Journal of Cardiology
Indonesian J Cardiol 2025:46:183-191
pISSN; 2830-3105 / eISSN: 2964-7304
doi: 10.30701/ijc.1894

Review Article

Accuracy of the YEARS Algorithm Compared to Thoracic Imaging for the Diagnosis of Pulmonary Embolism in Pregnant and Postpartum Patients

Hiradipta Ardining[1], Rido Mulawarman[1], Lesi Kurnia Putri[1], Vienna Rossimarina[2]

Abstract

Pulmonary Embolism (PE) continues to carry substantial morbidity and mortality, with recent data suggesting a rising trend. Diagnosis during pregnancy and the postpartum period is particularly complex because clinical features often overlap with normal physiological changes. The pregnancy-adapted YEARS algorithm, which integrates clinical probability assessment with D-dimer testing, has been proposed as a strategy to rule out PE while avoiding thoracic imaging and unnecessary radiation. In this systematic review and meta-analysis, we investigated the diagnostic accuracy of the pregnancy-adapted YEARS algorithm in pregnant and postpartum women suspected of PE. Eligible studies were identified through comprehensive searches of PubMed, Scopus, and Cochrane and required the use of CT Pulmonary Angiography (CTPA) or Ventilation–Perfusion (V/Q) scanning as the diagnostic reference standard. The quality of the included studies was assessed using the QUADAS-2 tool. Data from the eligible trials were synthesized in Meta-Disc with a random-effects model. In total, five studies involving 1,036 participants were analyzed, all of which showed a low risk of bias. The pooled results indicated a sensitivity of 1.00 (95% CI: 0.94–1.00), a specificity of 0.12 (95% CI: 0.10–0.14), and an AUC of 0.72, suggesting that the algorithm performs well in excluding PE but is less reliable for confirming the diagnosis. These results indicate that the pregnancy-adapted YEARS algorithm may serve as a safe screening approach to minimize radiation exposure for both mother and fetus. However, confirmatory thoracic imaging remains necessary in patients with positive findings.

(Indonesian J Cardiol, 2025;46;183-191)

Keywords: YEARS algorithm, pregnancy, postpartum, pulmonary embolism, CT Pulmonary Angiography, V/Q scan.

[1]Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia.
[2]Division of Intensive and Acute Cardiovascular Care, Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia.

Correspondence:
Hiradipta Ardining,

Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia.

Email: hiradipta@gmail.com

Introduction

Pulmonary Embolism (PE), a major contributor to maternal morbidity and mortality, accounts for up to 20% of maternal deaths.[1] Among pregnant women and those in the postpartum period, the risk of venous thromboembolism increases four- to five-fold due to physiological changes such as hypercoagulability, venous stasis, and vascular injury. However, clinical diagnosis is challenging because symptoms such as dyspnea and leg swelling often mimic normal physiological changes of pregnancy.

In the general population, diagnostic evaluation for PE typically includes clinical assessment, D-dimer testing, and thoracic imaging. However, these strategies are less reliable during pregnancy because D-dimer concentrations rise physiologically with gestation, leading to frequent reliance on imaging in suspected cases.[2] Since CT Pulmonary Angiography (CTPA) and Ventilation–Perfusion (V/Q) scans expose patients to ionizing radiation, their use during pregnancy raises safety concerns for maternal and fetal health.[3] To address this, the pregnancy-adapted YEARS algorithm was developed, integrating clinical criteria with D-dimer thresholds adjusted for gestational age. This strategy aims to reduce the need for thoracic imaging by safely excluding suspected PE in many cases. Although several studies have investigated its application in pregnant populations, the findings have been inconsistent.[4]

A prior meta-analysis evaluated the diagnostic accuracy of the YEARS algorithm in the general population. That review included nearly 14,000 patients across 10 studies and reported a sensitivity of 96%, specificity of 50%, and a 22% reduction in advanced imaging.[5] These findings support the safety of the YEARS algorithm as a rule-out tool while showing its limited value for ruling in PE. Notably, that analysis did not include pregnant women, leaving uncertainty about whether its diagnostic accuracy extends to pregnancy, a setting where physiological changes affect both pre-test probability and D-dimer interpretation.[6]

This systematic review and meta-analysis examines pregnant and postpartum women with suspected PE and assesses the diagnostic accuracy of the pregnancy-adapted YEARS algorithm compared with thoracic imaging as the reference standard

Methods

Strategy and Study Selection

This study was conducted as a systematic review and meta-analysis in accordance with PRISMA guidelines. The search strategy covered three major databases (PubMed, Scopus, and the Cochrane Library) and included the keywords "pregnancy," "YEARS algorithm," and "pulmonary embolism." Duplicate records were removed prior to screening. Two reviewers (HA and RM) independently evaluated titles and abstracts to exclude ineligible

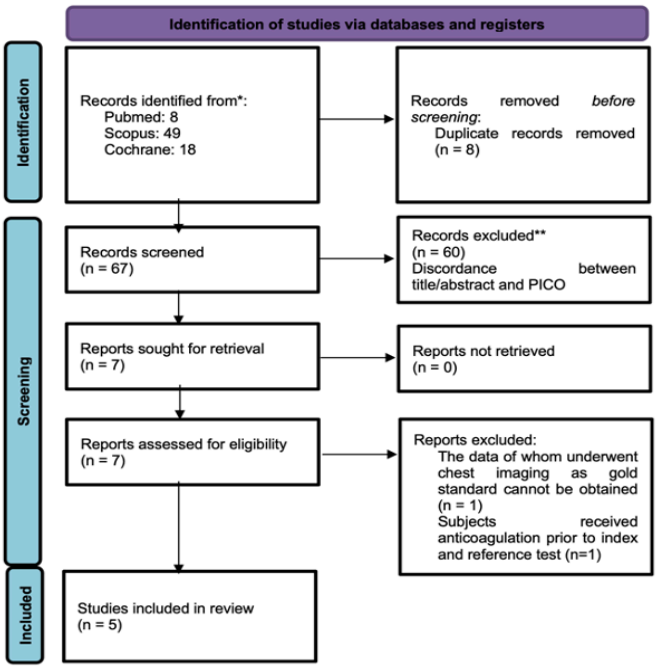

Figure 1. PRISMA flowchart.

Table 1. Study characteristics.

Author	Design	Population	Inclusion criteria	Exclusive criteria	Index text	Reference text	Mean age (y)	Obstetric period	PE Prevalence	Reported D-dimer	Number of subjects	Risk of bias
Langlois E, 2019[5]	Retrospective cohort	Pregnant women suspected of PE	Outpatient pregnant women presenting with a suspected PE at 11 centers in France and Switzerland between August 2008 and July 2016	• Decline to participate • Unable to provide consent • Allergy to contrast • On full-dose anticoagulation • No D-dimer test	YEARS algorithm	CTPA	31.1 + 6.1	1st trimester: 21.8%, 2nd: 43.9%, 3rd: 35.3%	6.5%	Not reported	294	Low risk
Mileto A, 2024[6]	Retrospective cohort	Pregnant women suspected of PE	Pregnant patients ≥18 years of age who presented to the ED with chief complaints consistent with a suspected PE	• Did not receive a D-dimer test as part of their clinical workup • Worked up for a PE outside their pregnancy period	YEARS algorithm	CTPA	27.9 (19–38)	1st trimester: 21.6%, 2nd: 36.4%, 3rd: 41.9%	2.7%	Not reported	35	Low risk
Oweidat KA, 2020[4]	Cross-sectional	Pregnant women suspected of PE	Pregnant woman age >18 years	• Missing data needed to deter- mine YEARS criteria • Anticoagulation treatment before doing D-dimer • Diagnosis of deep vein thrombosis with Doppler ultrasound	YEARS algorithm	CTPA or ventilation-perfusion (V/Q) scan	30.4 ± 5.7	1st trimester: 4.5%, 2nd: 15,2%, 3rd: 80.4%	4.5%	Median: 0.3/0.4/ 1.32 µg/mL (1st/2nd/3rd trimester)	112	Low risk
Potgieter R, 2022[3]	Cross-sectional	Pregnant and postpartum women suspected of PE	In-patients presenting with suspected pulmonary embolism in the pregnancy and puerperal periods who underwent CT pulmonary angiogram at Kalafong Provincial Tertiary Hospital Radiology Department from 1 June 2017 to 1 June 2020	D-dimer was not performed	YEARS algorithm	CTPA	Not reported	Pregnancy & puerperium	5.9%	Not reported	101	Low risk
van der Pol, 2019[7]	Prospective cohort	Pregnant women suspected of PE	Consecutive pregnant women with clinically suspected pulmonary embolism screened at the 18 participating hospitals	• Received anticoagulant treatment >= 24 hour before eligibility assessment •Were not pregnant • Had contraindication for CTPA • Did not undergo d-dimer testing	YEARS algorithm	CTPA	30 ± 5.8	1st trimester: 15%, 2nd: 39%, 3rd: 46%	4%	Median: 505/730/ 1120 ng/mL (1st/2nd/3rd trimester)	494	Low risk

studies, followed by full-text assessment using predefined inclusion and exclusion criteria. The search was finalized on 31 August 2025, and the selection process is illustrated in Figure 1.

Inclusion and Exclusion Criteria

This review included studies that evaluated pregnant women with suspected PE using the pregnancy-adapted YEARS algorithm. The algorithm integrates D-dimer testing with three clinical items: the presence of DVT signs, hemoptysis, and the physician's judgment that PE was the most likely diagnosis. A diagnosis of PE was ruled out when D-dimer values were <1000 ng/mL in the absence of all criteria, or <500 ng/mL when at least one criterion was present. Patients who did not meet these criteria were referred for CTPA or V/Q scanning, which served as the diagnostic reference standard. To be eligible, studies had to apply thoracic imaging as the comparator and report diagnostic accuracy outcomes. Exclusion applied to studies enrolling patients already receiving anticoagulants, those limited only to postpartum women, or those lacking thoracic imaging as a reference. Methodological quality was judged using QUADAS-2, and pooled analyses were performed with a random-effects model in Meta-Disc.

Data Extraction

From each eligible study, data were extracted on study characteristics (author, year, design, sample size, and population features) and details of the index test, including application of the pregnancy-adapted YEARS algorithm, clinical items, and D-dimer thresholds. CTPA or V/Q scanning was considered the reference standard. Outcomes of interest included sensitivity, specificity, and predictive values, with follow-up information noted when available. Extraction was performed independently by two reviewers, with a third author consulted in cases of disagreement.

Statistical Analysis

The statistical analyses were performed using MetaDiSc version 1.4 (Hospital Ramón y Cajal, Madrid, Spain). Sensitivity, specificity, positive and negative likelihood ratios (LR+ and LR–), and Diagnostic Odds Ratios (DOR) were pooled with a random-effects model. To display overall diagnostic performance, a Summary Receiver Operating Characteristic (SROC) curve was generated, and the corresponding Area Under the Curve (AUC) was reported. Heterogeneity across studies was examined using the I^2 statistic and Cochran's Q test, where I^2 values above 50% or p-values less than 0.05 were interpreted as significant. Publication bias was not formally evaluated because only a small number of studies were available. All tests were conducted as two-tailed, with $p < 0.05$ considered statistically significant.

Results

Study Selection

The initial search identified 75 records from PubMed, Scopus, and Cochrane databases. After removing eight duplicates, 67 articles were screened based on title and abstract. Of these, 60 were considered irrelevant to the research question and were excluded. Seven full-text articles were retrieved for eligibility assessment. Two were excluded: one for not using thoracic imaging as the reference standard and another for including patients on anticoagulant therapy. Ultimately, five studies were included in the review (Figure 1).

Study Characteristics

A total of five studies, published between 2019 and 2024, were included. The research was conducted across Europe, the Middle East, and Africa. Study designs comprised one prospective cohort, two retrospective cohorts, and two cross-sectional investigations. All included studies assessed pregnant or postpartum women with suspected PE using the pregnancy-adapted YEARS algorithm as the index test, with CTPA or V/Q scanning as the reference standard. Sample sizes ranged from 35 to 494, giving a total of 1,036 participants. The key characteristics of these studies are summarized in Table 1.

Table 2. Risk of bias assessment.

Study	Risk of bias			
	Patient selection	Index test	Reference standard	Flow and timing
Langlois E, 2019[5]	✓	✓	?	✓
Mileto A, 2024[6]	✓	✓	?	✓
Oweidat KA, 2020[4]	✓	✓	✓	✓
Potgieter R, 2022[3]	✓	✓	✓	✓
van der Pol, 2019[7]	✓	✓	?	✓

Risk of Bias

Risk of bias was assessed using the QUADAS-2 tool. Overall, a low risk of bias was observed across all domains (Table 2).

Pooled Diagnostic Accuracy

The pooled analysis showed that the pregnancy-adapted YEARS algorithm had a sensitivity of 1.00 (95% CI: 0.94–1.00), confirming its strong ability to rule out PE. However, specificity was much lower at 0.12 (95% CI: 0.10–0.14), indicating that the tool provides limited confirmation of the disease. The likelihood ratios were 1.13 (95% CI: 1.02–1.25) for LR+ and 0.35 (95% CI: 0.10–1.16) for LR–, while the diagnostic odds ratio reached 3.47 (95% CI: 0.95–12.75). Overall diagnostic performance, illustrated by the SROC curve, yielded an AUC of 0.72, consistent with moderate discriminative capacity (Figures 2–7).

Sensitivity

Sensitivity was consistently high across all included studies, with a pooled estimate of 1.00 (95% CI: 0.94–1.00). No heterogeneity was observed (I^2 = 0.0%, p = 1.000), supporting the robustness of this finding.

Specificity

Specificity was low at 0.12 (95% CI: 0.10–0.14), with marked heterogeneity (I^2 = 95.1%, p < 0.0001). This indicates a tendency to misclassify patients without PE, resulting in a high false-positive rate.

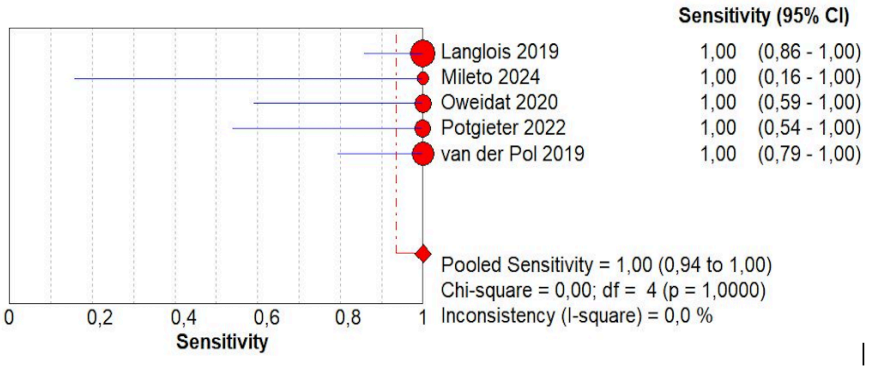

Figure 2. The pooled sensitivity of the pregnancy-adapted YEARS algorithm.

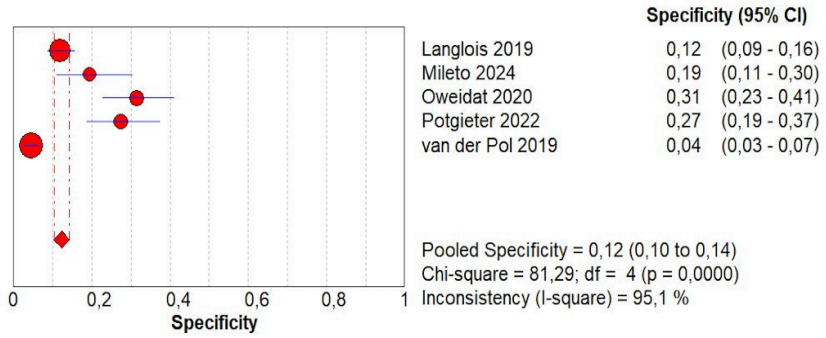

Figure 3. The pooled specificity of the pregnancy-adapted YEARS algorithm.

Likelihood Ratios

The pooled LR+ was 1.13 (95% CI: 1.02–1.25), offering little value in confirming PE. In contrast, the LR– was 0.35 (95% CI: 0.10–1.16), supporting its utility as a rule-out tool.

DOR and SROC

The DOR was modest at 3.47 (95% CI: 0.95–12.75), with no significant heterogeneity (I^2 = 0.0%, p = 0.8675). The SROC analysis yielded an AUC of 0.72, indicating moderate overall discriminative ability of the algorithm.

Discussion

This review analyzed five studies involving 1,036 pregnant and postpartum women suspected of having pulmonary embolism to evaluate the diagnostic performance of the pregnancy-adapted YEARS algorithm. This review found that the pooled analysis demonstrated excellent sensitivity (100%) but low specificity (12%), with an AUC of 0.72. These findings confirm that the algorithm is highly effective for ruling out PE but has limited value for confirming the diagnosis.

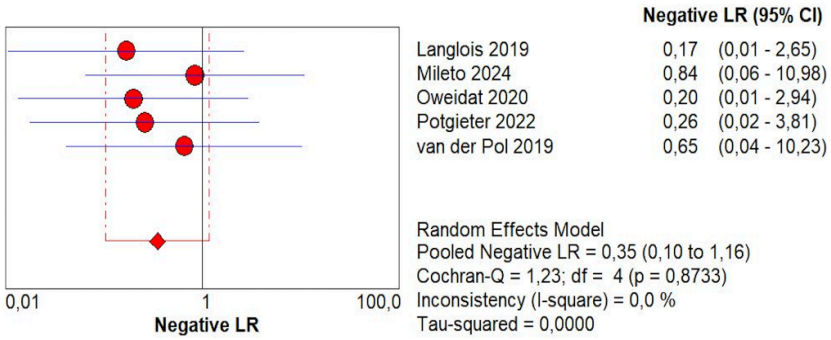

Figure 4. Pooled LR- of the studies.

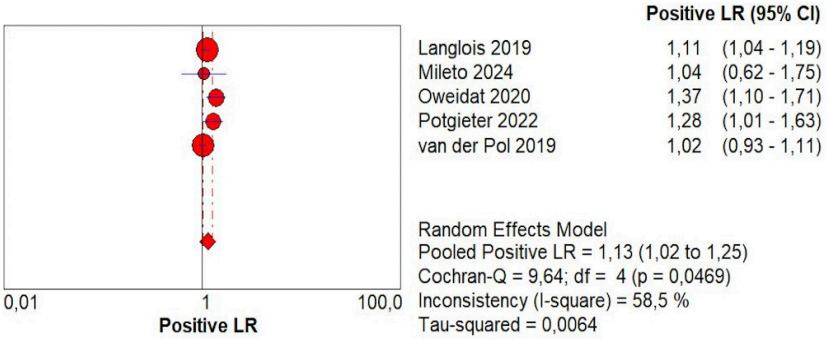

Figure 5. Pooled LR+ of the studies.

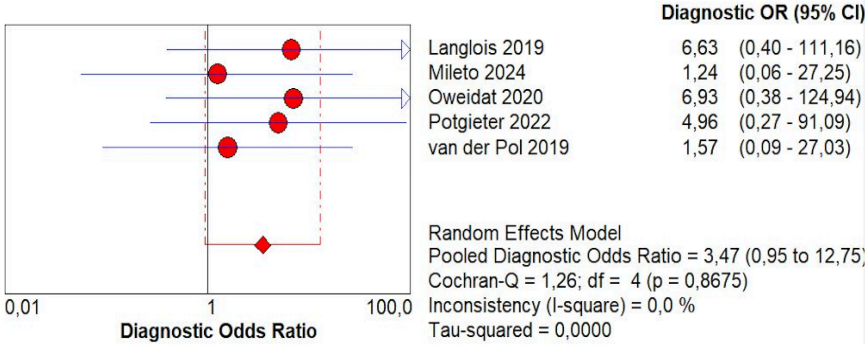

Figure 6. The diasnotic odds ratio of the studies.

Compared with broader populations, our findings are consistent with prior evidence from non-pregnant populations. In the largest meta-analysis to date, Te Haara et al.[5] pooled nearly 14,000 participants. They reported a sensitivity of 96% (95% CI 93–98%) and specificity of 50% (33–67%), alongside a 22% reduction in advanced imaging (RR 0.78, 95% CI 0.67–0.90). These results similarly support the YEARS algorithm as a safe rule-out tool while highlighting its modest rule-in utility. The lower specificity observed in our pregnancy-focused review (12% vs ~50% in the general population) likely reflects pregnancy-specific factors, including physiologically elevated D-dimer levels, the use of lower D-dimer thresholds in adapted protocols, and variations in PE prevalence.[7]

The consistently high sensitivity across both pregnant and non-pregnant cohorts is clinically reassuring, as underdiagnosis of PE in pregnancy can lead to severe maternal and fetal outcomes.[7-8] This aligns with earlier multicentre studies, which showed that combining YEARS criteria with D-dimer testing maintains patient safety while reducing unnecessary imaging.[2,9] However, the very low specificity in pregnancy means that many women without PE will still require confirmatory

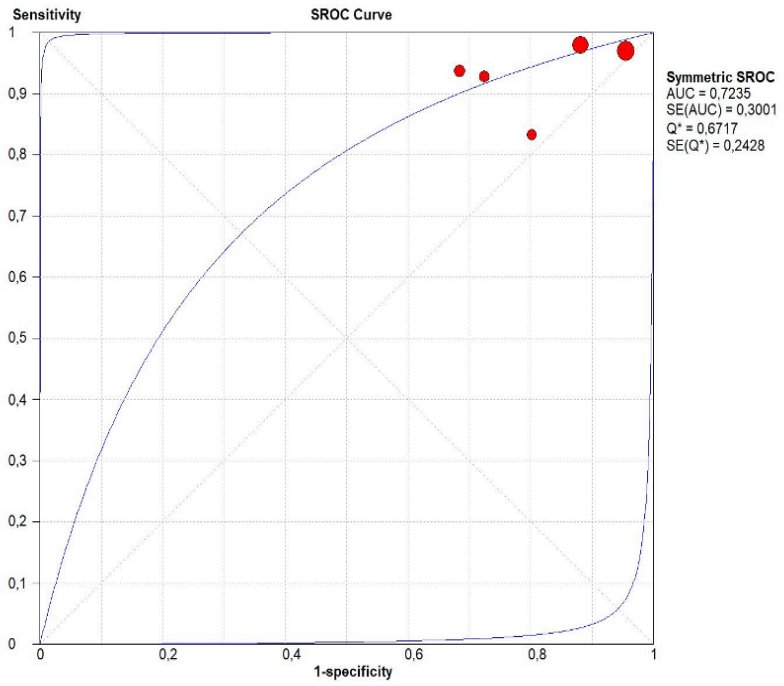

Figure 7. The ROC of the pregnancy-adapted YEARS algorithm.

thoracic imaging. Thus, while the algorithm safely excludes PE, it cannot substitute for imaging when results are positive. [3-4,8]

From a clinical perspective, our findings indicate that the pregnancy-adapted YEARS algorithm can safely defer imaging in women with low pre-test probability, thereby reducing unnecessary radiation exposure. This is particularly important because the breast receives the highest organ dose from CTPA, with an estimated 94 future cancer cases per million CTPA procedures.[10] In settings with limited access to CTPA or V/Q scans, such as Indonesia, the algorithm can help protect low-risk women while conserving scarce resources. Positive cases, however, still require confirmatory imaging, and decisions must balance their excellent sensitivity with low specificity and the constraints of healthcare infrastructure.

Compared with other clinical prediction rules, such as the Wells score for DVT or the revised Geneva score for PE, the pregnancy-adapted YEARS algorithm offers a simpler, more pragmatic approach. Traditional scores were not explicitly designed for pregnancy and have demonstrated limited validation in this population, often leading to poor specificity and higher imaging rates.[10-11] By contrast, the YEARS algorithm, while still limited in specificity, maintains nearly perfect sensitivity and a streamlined diagnostic pathway that is more practical for use in pregnant and postpartum women.

The generalizability of these findings also requires cautious interpretation. The included studies were mainly conducted in Europe, the Middle East, and Africa, across diverse healthcare systems and diagnostic capacities. Because most of the data rely on CTPA as the reference standard, their applicability to low-resource settings where such imaging is less available may be limited. In countries like Indonesia, where diagnostic infrastructure is variable, large-scale prospective studies are needed to validate the relevance of the YEARS algorithm in these environments.

It is also important to note discrepancies across the included studies. Reported PE prevalence varied considerably, from as low as 2.7% in the U.S. study by Mileto et al.[9] to 6.5% in the French–Swiss cohort by Langlois et al., eight while the ARTEMIS trial reported 4.0%.[7] Study populations differed, with Al-Oweidat et al.[4] including predominantly third-trimester patients and Potgieter et al.[3] reporting all PE cases during the puerperium, in contrast to van der Pol et al.,[7] who enrolled women across all trimesters. Differences in design (prospective vs retrospective), D-dimer assays, and reference standards (CTPA, V/Q) also contributed to heterogeneity in findings, particularly specificity estimates. These variations highlight the need for harmonized diagnostic protocols and large-scale multicentre validation.

By focusing exclusively on pregnant and postpartum cohorts, this review builds on earlier

analyses by confirming the safety of the YEARS algorithm for ruling out PE while highlighting its limitations as a confirmatory tool. Future studies should directly compare the YEARS algorithm with other clinical prediction models to refine diagnostic strategies for this high-risk population.

Limitations

This review is subject to several limitations. The number of available studies was small (n = 5), and sample sizes were modest, which may reduce statistical power and the precision of pooled estimates. Considerable heterogeneity was observed, particularly in specificity, likely due to differences in study design, patient selection, and reference standards. Most trials relied on CTPA as the reference test, with limited use of V/Q scans, which restricts generalizability to settings where nuclear medicine is more commonly used. This limitation is especially relevant in low-resource environments, including Indonesia, where access to advanced thoracic imaging is limited and confirmation of positive YEARS results may be challenging. Variation in D-dimer assays and threshold values across studies may also have influenced diagnostic accuracy. Publication bias could not be formally assessed because of the small number of included studies; more minor negative or inconclusive studies may remain unpublished, potentially inflating estimates of diagnostic safety. Although the literature search covered PubMed, Scopus, and Cochrane, it remains possible that some studies were missed, particularly unpublished or non-English reports. Finally, as all included studies were observational, residual confounding and selection bias cannot be excluded. To strengthen the evidence base, future large-scale, prospective, multicenter studies are needed to validate the diagnostic accuracy of the pregnancy-adapted YEARS algorithm across diverse healthcare settings, including those with limited resources.

Conclusion

The pregnancy-adapted YEARS algorithm showed excellent sensitivity (100%) for ruling out PE in pregnant and postpartum women, yet its specificity remained low (12%), limiting its usefulness for diagnostic confirmation. It may be safely applied to reduce unnecessary imaging and radiation exposure in low-risk patients, although imaging remains essential for positive cases. Validation through large-scale, prospective studies is needed to strengthen these findings and guide optimal management strategies in this high-risk population.

List of Abbreviations

AUC	Area Under the Curve
CI	Confidence Interval
CTPA	Computed Tomography Pulmonary Angiography
DOR	Diagnostic Odds Ratio
DVT	Deep Vein Thrombosis
LR+	Positive Likelihood Ratio
LR-	Negative Likelihood Ratio
PE	Pulmonary Embolism
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QUADAS-2	Quality Assessment of Diagnostic Accuracy Studies-2
ROC	Receiver Operating Characteristic
SROC	Summary Receiver Operating Characteristic
V/Q	Ventilation-Perfusion (scan)

Ethical Clearance

Not required. This work is a systematic review and meta-analysis of previously published studies; no new human participants were recruited and no individual level, identifiable data were collected.

Authors Contributions

HA, RM, and LKP conceived the study idea and concept. HA and RM contributed to study design and preparation of figures. VR supervised the project. HA and RM drafted the manuscript. All authors reviewed, commented, and approved the final version of the manuscript.

Acknowledgments

The authors would like to express their gratitude to the Department of Cardiology and Vascular Medicine, National Cardiovascular Centre Harapan Kita, Universitas Indonesia, for their unwavering support in completing this work.

Conflict of Interest

None.

Availability of Data and Materials

Not applicable.

Funding

None.

Copyright/Permissions for Figures

Not applicable.

Generative AI and AI-Assisted Technologies in the Writing Process

Authors acknowledge that Artificial Intelligence (AI) tools were only used to assist in language editing and did not generate or alter the scientific content, analyses, or conclusions presented in this manuscript.

References

1. Stals MAM, Moumneh T, Ainle FN, Aujesky D, van Bemmel T, Bertoletti L, et al. Noninvasive diagnostic work-up for suspected acute pulmonary embolism during pregnancy: a systematic review and meta-analysis of individual patient data. J Thromb Haemost. 2023;21:606–15.
2. Righini M, Robert-Ebadi H, Elias A, Sanchez O, Le Moigne E, Schmidt J, et al. Diagnosis of pulmonary embolism during pregnancy a multicenter prospective management outcome study. Ann Intern Med. 2018;169:766–73.
3. Potgieter R, Becker P, Suleman F. The effectiveness of the pregnancy adapted YEARS algorithm to safely identify patients for CT pulmonary angiogram in pregnant and puerperal patients suspected of having pulmonary embolism. South African J Radiol. 2022;26:1–6.
4. Al Oweidat K, AlRyalat SA, Al-Husban N, Alhawari H, Ghareeb R, Ribie M, et al. Additive evidence of the competence of pregnancy-adapted YEARS algorithm in reducing the need for CTPA, Q and/or V/Q scintiscan. Hell J Nucl Med. 2020;23:165–72.
5. Te Haara SR, De Rezende H, Wang C. Diagnostic test accuracy of the YEARS algorithm for pulmonary embolism: a systematic review and meta-analysis. Sultan Qaboos Univ Med J. 2024;24:491–500.
6. Makowska A, Treumann T, Venturini S, Christ M. Pulmonary embolism in pregnancy: a review for clinical practitioners. J Clin Med. 2024;13:2863.
7. van der Pol L, Tromeur C, Bistervels I, Ni Ainle F, van Bemmel T, Bertoletti L, et al. Pregnancy-adapted years algorithm for diagnosis of suspected pulmonary embolism. N Engl J Med. 2019;380:1139.
8. Langlois E, Cusson-Dufour C, Moumneh T, Elias A, Meyer G, Lacut K, et al. Could the YEARS algorithm be used to exclude pulmonary embolism during pregnancy? Data from the CT-PE-pregnancy study. J Thromb Haemost [Internet]. 2019;17:1329–34. Available from: https://doi.org/10.1111/jth.14483
9. Mileto A, Rossi G, Krouse B, Rinaldi R, Ma J, Willner K, et al. Pregnancy-adapted YEARS Algorithm: A Retrospective Analysis. West J Emerg Med. 2024;25:136–43.
10. Harun HH, Abdul Karim MK, Abbas Z, Abdul Rahman MA, Sabarudin A, Ng KH. Association of radiation doses and cancer risks from CT pulmonary angiography examinations in relation to body diameter. Diagnostics (Basel). 2020;10:681.
11. Wiegers HMG, Middeldorp S. Contemporary best practice in the management of pulmonary embolism during pregnancy. Ther Adv Respir Dis. 2020;14:1753466620914222.