The Diagnostic Accuracy of the Emergency Department Assessment of Chest Pain (EDACS) Score: A Systematic Review and Meta-analysis

Richard S. J. Boyle, BSc, MPH*; Richard Body, MB ChB, PhD

*Corresponding Author. E-mail: richard.boyle@student.manchester.ac.uk, Twitter: @RichardSJBoyle.

Study objective: We evaluate current evidence for the diagnostic accuracy and safety of the Emergency Department Assessment of Chest Pain Score (EDACS) for patients presenting to the emergency department (ED) with possible acute coronary syndromes.

Methods: MEDLINE, EMBASE, and Cochrane databases were searched for publications reporting data on the EDACS score. No date restrictions were used. Two independent researchers assessed studies for eligibility, bias, and quality. The primary outcome was major adverse cardiac events occurring within 30 days. Heterogeneity was assessed and data were pooled by meta-analysis using a random-effects model.

Results: Eight diagnostic test accuracy studies including 11,578 patients and 1 randomized controlled trial including 558 patients were eligible for inclusion. On meta-analysis, the EDACS score had a pooled sensitivity of 96.1% (95% confidence interval 89.6% to 98.6%) and specificity of 61.1% (95% confidence interval 55.5% to 66.3%). A total of 55.0% of patients (n=6,370/11,578) were identified as low risk and eligible for early discharge. Sixty-two patients (0.54%) identified as low risk had an outcome of major adverse cardiac events within 30 days.

Conclusion: The EDACS score identified greater than 50% of patients with suspected acute coronary syndrome as suitable for discharge after serial troponin sampling during 2 hours. Sensitivity for major adverse cardiac events was relatively high overall and may be acceptable to clinicians. [Ann Emerg Med. 2021;77:433-441.]

Please see page 434 for the Editor''s Capsule Summary of this article.

A **podcast** for this article is available at www.annemergmed.com.

0196-0644/$-see front matter

https://doi.org/10.1016/j.annemergmed.2020.10.020

INTRODUCTION

Background

Chest pain and other symptoms of acute coronary syndromes account for a significant burden on emergency departments (EDs). An effective early rule-out tool for acute coronary syndromes can decrease ED crowding and associated mortality.[1,2] A number of tools have been created for this purpose, one of which is the Emergency Department Assessment of Chest Pain Score (EDACS).[3] It is designed to be used by clinicians aiming to identify patients at low risk of acute myocardial infarction and major adverse cardiac events who are suitable for early discharge after serial cardiac troponin-level testing during 2 hours.

An EDACS score can be calculated for a patient according to his or her cardiovascular risk factors and presenting symptoms, and then combined with ECG and troponin data.[3] The criteria for the calculation of the EDACS score are shown in Table 1. The EDACS score identifies low-risk patients suitable for early discharge and outpatient care. It should not be used for unstable presentations, including patients with crescendo angina or altered vital signs.

Importance

In its design and validation, the EDACS score was able to correctly identify 42.2% and 51.3% of patients presenting with chest pain as safe for early discharge, respectively,[3] performing significantly better than other prediction tools such as ADAPT (A 2 hour Accelerated Diagnostic Protocol to Assess patients with chest Pain symptoms using contemporary Troponins as the only biomarker) (20%),[4] the original form of the History, ECG, Age, Risk factors and Troponin (HEART) score (20.4% to 28.2%),[5,6] and the Vancouver Chest Pain Rule (14.5% to 20.4%).[7] If its accuracy can be consistently demonstrated across studies, then clinical use of the EDACS score could help to rapidly unburden crowded EDs, reduce unnecessary hospital admissions, and enable patients to benefit from

Editor's Capsule Summary

What is already known on this topic

Multiple clinical decision aids are available to risk stratify emergency department (ED) patients with symptoms concerning for acute coronary syndrome.

What question this study addressed

Does the Emergency Department Assessment of Chest Pain Score identify chest pain patients who may be safely discharged?

What this study adds to our knowledge

In this meta-analysis of 11,578 patients, the score was 96% sensitive and 61% specific. There was substantial heterogeneity among studies.

How this is relevant to clinical practice

The Emergency Department Assessment of Chest Pain Score is another tool supporting clinician gestalt in identifying chest pain patients safe for discharge.

early reassurance. The emergence of the coronavirus disease 2019 pandemic shows that this may also be a powerful disaster preparedness intervention.[8,9]

Goals of This Investigation

Our objective was to evaluate the diagnostic accuracy and safety of the EDACS score in patients presenting to the ED with suspected acute coronary syndromes by systematically reviewing the available evidence.

MATERIALS AND METHODS

Study Design

We performed a systematic review of the literature in accordance with the Cochrane protocol and following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[10,11] Two researchers working independently searched EMBASE, MEDLINE, and the Cochrane databases for diagnostic test accuracy studies and randomized controlled trials assessing the efficacy of the EDACS score. No date restrictions were used. This review was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO) database for systematic reviews.

Selection of Participants

The search methodology used was ""(EDACS.mp. OR ED-ACS.mp. OR ""Emergency Department Assessment of Chest Pain Score"".mp.)."" This was conducted on May 7, 2020. Eligible studies required a group of adult patients presenting with 5 minutes of chest pain or other symptoms of acute coronary syndromes in the ED. If data were not reported in a way that permitted extraction for inclusion in 2-by-2 tables, authors were contacted and asked for this information. Conference abstracts were hand searched and included if they gave sufficient methodological detail to demonstrate they met the inclusion criteria. The full list of conference proceedings hand searched is given in Appendix E1 (available online at http://www.annemergmed.com). References were hand searched, with no unindexed studies found. The abstracts and titles of the search results were screened by both researchers (R.S.J.B. and R.B.) according to the review inclusion criteria, followed by full-text review of those ruled eligible. In the event of discrepancies between the 2 researchers, resolution was reached by discussion.

Outcome Measures

The index tests were EDACS and high-sensitivity troponin assay conducted on arrival at the ED and repeated a maximum of 3 hours later. The primary outcome of interest was major adverse cardiac events within 30 days. This reference standard needed to be adjudicated by 2 independent clinicians, with the diagnosis of acute myocardial infarction defined according to the Third Universal Definition of Acute Myocardial Infarction.[12] Major adverse cardiac events in this meta-analysis were defined according to the initial EDACS publication: ST-segment elevation or non–ST-segment elevation myocardial infarction, emergency revascularization, cardiovascular death, ventricular arrhythmia, cardiac arrest, cardiogenic shock, or a high atrioventricular block within 30 days of patients' ED presentation.[3] The secondary outcomes were these individual components of major adverse cardiac events, with data gathered where available.

Methods of Measurement

We assessed study quality with a modified version of the Quality Assessment for Diagnostic Accuracy Studies–2 tool (QUADAS-2), provided as item 2 of Appendix E1 (available online at http://www.annemergmed.com).[13] Both researchers worked together to tailor the QUADAS-2 questionnaire to the research question to assess the eligible studies for bias and applicability. The modified QUADAS-2 tool was then used independently by both researchers to evaluate each study, with discrepancies solved by discussion. The outcome of this assessment was used to

Table 1. EDACS score calculation and EDACS-ADP.[3]

Clinical Characteristics	Score, Points
Age, y	
18–45	+2
46–50	+4
51–55	+6
56–60	+8
61–65	+10
66–70	+12
71–75	+14
76–80	+16
81–85	+18
≥86	+20
Male sex	+6
18–50 y and either	+4
Known coronary artery disease or ≥3 risk factors, including dyslipidemia, diabetes, hypertension, current smoker, or family history of premature coronary artery disease	
Symptoms and signs	
Diaphoresis	+3
Radiates to arm or shoulder	+5
Pain occurred or worsened with inspiration	−4
Pain is reproduced by palpation	−6
Criteria for low risk	Total score <16 points
	No new ischemia on ECG
	0- and 2-h troponin levels below 99th percentile upper reference limit of the assay

Low-risk patients were deemed safe for discharge to early outpatient follow-up investigation (or to proceed to earlier inpatient testing).

make a qualitative decision on whether to include each study according to the significance of any bias identified, with exclusions made if bias could affect the validity of the statistical analysis. Data extraction was then also performed by 2 independent investigators. Two-by-two tables were created for each study according to the number of patients classified by the EDACS score as low risk or not and their corresponding outcomes of major adverse cardiac events or no major adverse cardiac events.

Primary Data Analysis

Statistical analysis was performed on the diagnostic test accuracy studies with Stata/IC (version 14; StataCorp, College Station, TX)[14] with the midas[15] and metandi[16] commands. Randomized controlled trials were reported separately. Midas and metandi are tools designed to meta-analyze diagnostic test accuracy studies using bivariate mixed-effects logistic regression and hierarchic logistic regression, respectively.[17] Midas creates forest plots and summary receiver operating characteristic (ROC) curves by plotting computed empirical Bayes estimates against observed sensitivities and specificities.[17] Statistical analyses were performed by one investigator and their validity was confirmed by the other.

Interstudy heterogeneity and existence of threshold effects were evaluated by visual inspection of the summary ROC curve and by the I^2 and χ^2 statistics for the pooled study data. Additional analyses were then performed to identify the sources of heterogeneity, and subgroups of high- and low-risk studies were identified. These subgroups were further meta-analyzed in sensitivity analyses. The area under the summary ROC curve was calculated as a global measure of the effectiveness of the EDACS score. Publication bias was assessed with a Deeks's funnel plot asymmetry test, whereby asymmetry may suggest that "small study effects" have introduced bias.[18]

RESULTS

The literature search yielded 120 results, 23 of which passed initial screening of abstracts and titles. Fifteen studies passed full-text analysis, with 8 exclusions. Eight studies passed QUADAS-2 analysis, with 7 exclusions. The flow of the literature search is outlined in Figure 1 according to PRISMA 2009 standards.[11]

The 8 diagnostic test accuracy studies provided 9 data sets, totaling 11,578 patients for statistical analysis. Two data sets were published by Than et al,[3] the original derivation study of the EDACS score. These were derivation and validation data sets. The validation data set was expanded and used again by Sanders et al.[19] For the purposes of this meta-analysis, the study populations from these 2 studies were reorganized into and analyzed as derivation, original validation, and extended validation cohorts.

Cohort sizes ranged from 4,404 patients (Stopyra et al[20]) to 231 (Yang et al[21]), with a median size of 763 (Flaws et al[22]). No discrepancies occurred between investigators. The basic details of studies selected for inclusion are described in Table 2, whereas further information is provided in Table E1 (available online at http://www.annemergmed.com). The results of the QUADAS-2 analysis for the included and excluded studies are shown in Figures E1 and E2, respectively (available online at http://www.annemergmed.com). Among the significant exclusions was the study by Than et al.[26] This was a

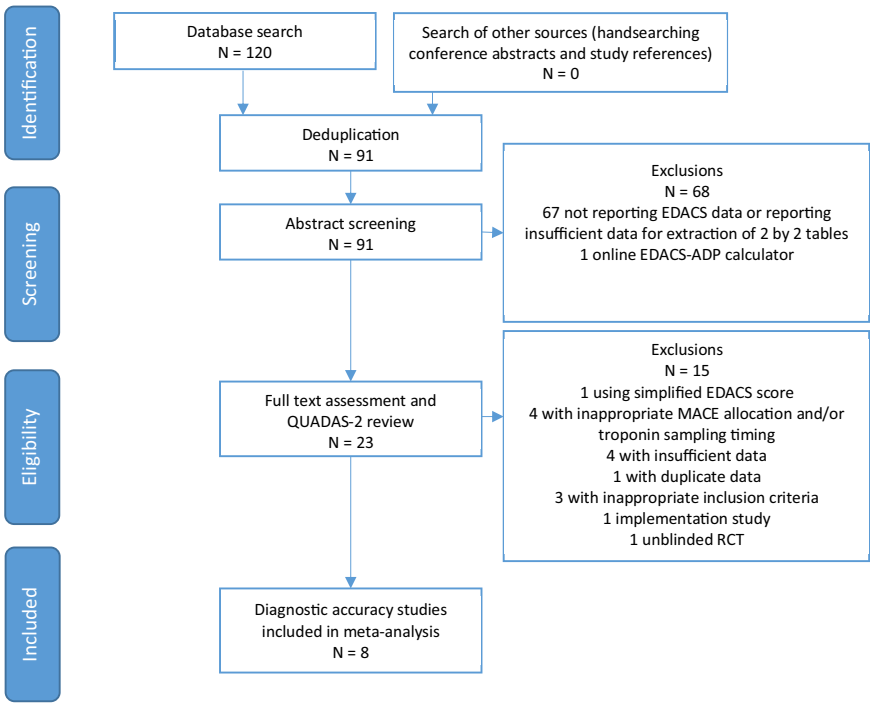

Figure 1. Flow of study selection reported according to PRISMA 2009 standards.[9] *RCT*, Randomized controlled trial; *MACE*, major adverse cardiovascular events.

randomized controlled trial evaluating the clinical implementation of the EDACS score. Methodological differences, including practical limitations on blinding, meant its data were not directly comparable to those from the diagnostic accuracy studies. The details of studies excluded during full-text and QUADAS-2 analysis are provided in Table E2 (available online at http://www.annemergmed.com).

Details of the troponin assay that was used to determine the EDACS score were obtained for 7 of the included studies, as shown in Table E1 (available online at http://www.annemergmed.com). Those studies used 6 troponin

Table 2. Basic details of included studies.

Cohort No.	First Author	Year	Country/Region	Enrollment	Average Age (Years)	Sex Ratio (M/F)	Study Design	No. of Sites	Study Period
1	Shih[23]	2013	United States	1,204	60.1	49/51	DTA	1	November 2008–January 2010
2	Than[3]	2014	Australia and New Zealand	1,974 (derivation)	60.5	60/40	DTA	2	June 2007–February 2010
3	Than[3]	2014	Australia and New Zealand	608 (original validation)	60.1	59/41	DTA	2	June 2007–February 2010
4	Stopyra[24]	2015	United States	282	53.3	43/57	DTA	1	September 2012–February 2014
5	Flaws[22]	2016	Canada	763	58.2	62/38	DTA	1	June 2000–January 2003
6	Sanders[19]	2016	Australia and New Zealand	301 (extended validation)	Unknown	Unknown	DTA	2	June 2007–February 2010
7	Greenslade[25]	2018	Australia	1,121	52.9	60/40	DTA	1	November 2008–February 2011; February 2011–March 2014
8	Yang[21]	2018	Hong Kong	231	57.6	49/51	DTA	1	June 1, 2016, to May 31, 2017
9	Stopyra[20]	2018	United States	4,404	Not reported	Not reported	DTA	Not reported	Not reported

M, Men; *F*, women; *DTA*, diagnostic test accuracy study.
The values for sex ratio and average age in study 6, Sanders et al,[19] are unknown because they cannot be calculated for the extended validation data set from available data.

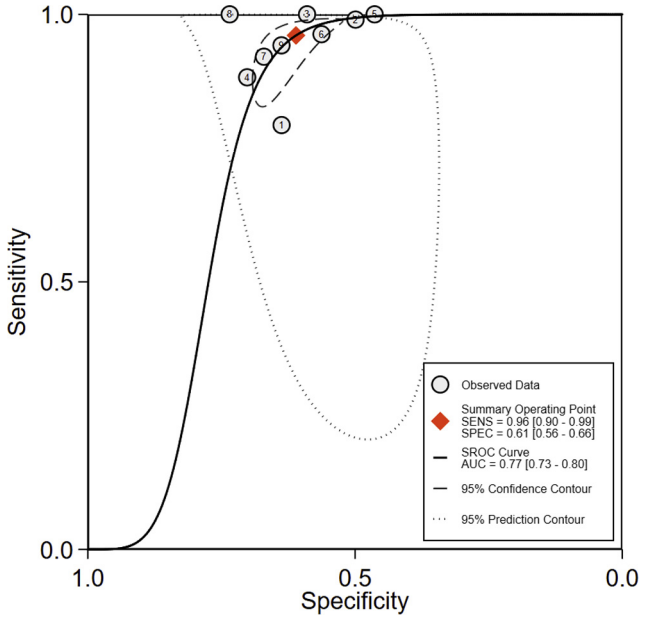

Figure 2. Summary ROC curve. This provides a visual representation of the between-study heterogeneity, with low risk of heterogeneity shown if most studies are within the 95% confidence contour or on the regression line. The prediction contour shows the area within which there is a 95% probability a new study will fall. Numbers refer to study cohorts listed in Table 2.

assays, as follows: Than et al[3] and Sanders et al[19] used both the Abbott Architect cardiac troponin I (cTnI) (Abbott Laboratories, Abbott Park, IL) and Beckman Coulter DxI Access AccuTnI assays (Beckman Coulter, Brea, CA) but did not report diagnostic accuracy for each individually. Greenslade et al[25] used the Beckman Coulter Access high sensitivity-cTnI assay. Flaws et al[22] used the Roche Elecsys third-generation troponin T assay (Roche Diagnostics, Rotkreuz, Switzerland). Stopyra et al[20,24] used the Siemens ADVIA Centaur TnI-Ultra (Siemens Healthineers, Erlangen, Bavaria, Germany). Than et al[26] used the Abbott Architect high sensitivity-cTnI assay. All studies using troponin I assays used the 99th percentile cutoff. Because of the wide range of assays used, it was not possible to proceed to a formal analysis of between-assay heterogeneity.

Heterogeneity between the included studies was shown to be significant, as indicated by the χ^2 statistic of 67.6 and I^2 statistic of 97 (95% confidence interval [CI] 95 to 99). Seventy-nine percent of heterogeneity was calculated to be due to threshold effects. Figure 2 shows the summary ROC curve for the combined data. The area under the summary ROC curve for the combined data was 0.78 (95% CI 0.74 to 0.81), consistent with a valid diagnostic test. Two studies lay outside the 95% confidence contour, confirming some degree of heterogeneity between studies.

The 9 diagnostic test accuracy data sets included 11,578 patients. The prevalence and pretest probability of major adverse cardiac events was 10.5%, with an outcome of major adverse cardiac events reported for n=1,214/11,578 patients (10.5%) within 30 days of presentation to the ED. A total of 6,370 patients were classified as low risk and safe for early discharge by the EDACS score, 55.0% of the pooled patient group. Sixty-two patients in the low-risk group were among those with a 30-day outcome of major adverse cardiac events, resulting in a missed major adverse cardiac events rate of 0.5%. The combined sensitivity was 96.1% (95% CI 89.6% to 98.6%) and specificity was 61.1% (95% CI 55.5% to 66.3%), shown in Figure 3. The positive likelihood ratio was 2.47 (95% CI 2.21 to 2.76) and negative likelihood ratio was 0.06 (95% CI 0.03 to 0.16), with a diagnostic odds ratio of 38 (95% CI 16 to 91). Individual study performance of the EDACS score as measured by sensitivity, specificity, negative predictive value, and positive predictive value is shown in Table E1 (available online at http://www.annemergmed.com). A total of 41 of 4,686 patients died within 30 days of initial admission, with 565 of 7,260 experiencing acute myocardial infarction.

All studies in the analysis reported data on the primary outcome, major adverse cardiac events, and 4 studies reported data on the secondary outcomes. Only 2 studies reported a full breakdown of the components of major adverse cardiac events.[20,24] Two other studies provided data for 30-day acute myocardial infarction.[22,26]

The risk of publication bias was evaluated as low, indicated by a highly symmetrical Deeks's funnel plot with a near-vertical regression line (P=.99) (Figure E3, available online at http://www.annemergmed.com).

Lower sensitivity values were observed for the EDACS score in a subgroup of studies conducted in North America (United States and Canada) than a subgroup in Australasia (Australia and New Zealand). To investigate the contribution of this discrepancy to heterogeneity, the data were separated by geographic region and statistical analysis was repeated. The separated North American and Australasian data are presented as forest plots in Figure E4*A* and *B* (available online at http://www.annemergmed.com). The sensitivity and specificity of the North American data were 95.2% (95% CI 71.7% to 99.4%) and 60.1% (95% CI 52.5% to 68.8%), respectively, compared with values of 97.6% (95% CI 94.7% to 99.1%) and 58.3% (95% CI 51.7% to 64.5%) for the Australasian data. These differences were not statistically significant; there is considerable overlap in

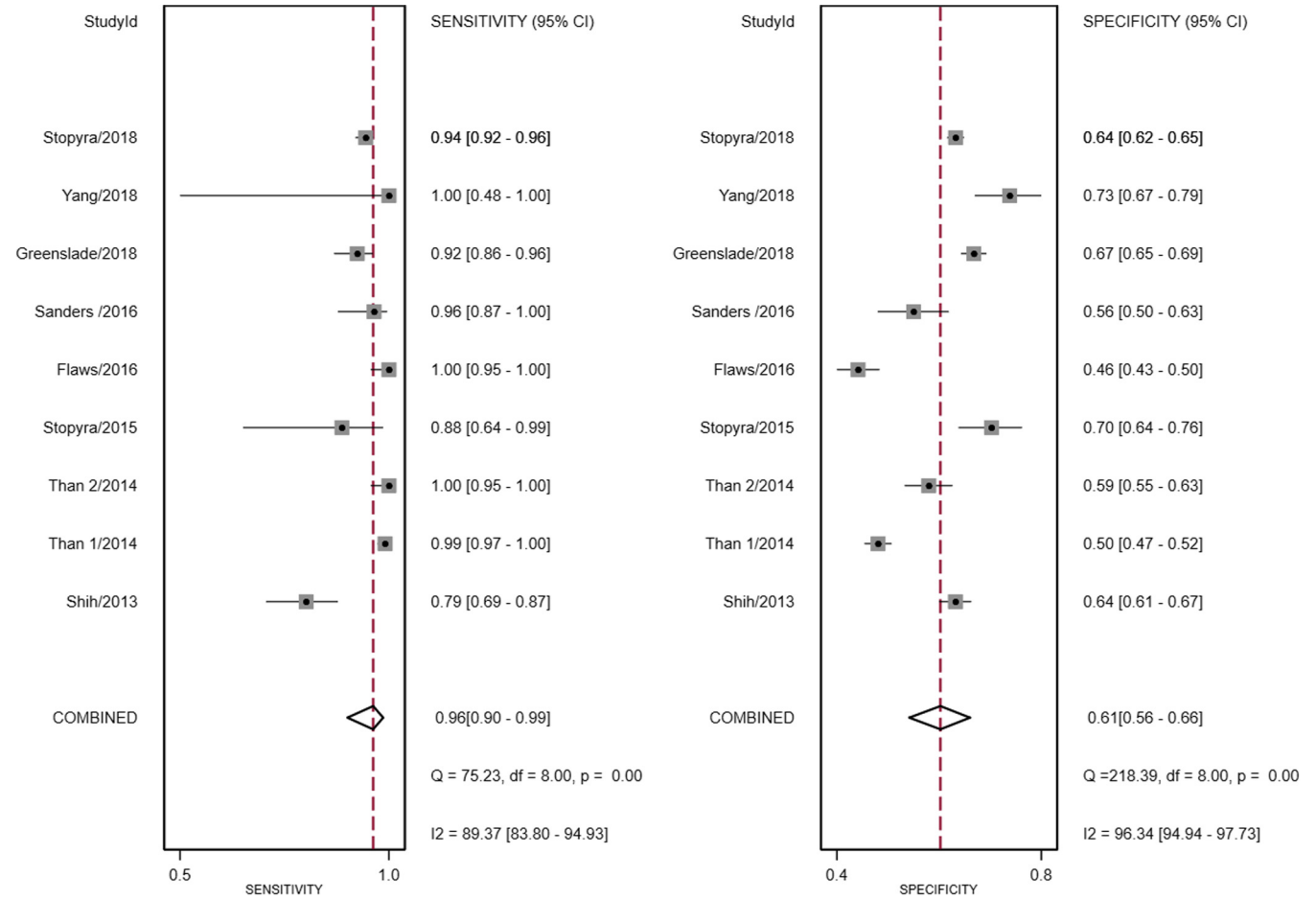

Figure 3. Forest plot of combined data sets. This displays the sensitivity and specificity for individual studies alongside the combined effect estimate, with 95% CIs. Than 1/2014 refers to the EDACS derivation data set; Than 2/2014, to the original validation data set; and Sanders/2016, to the extended validation data set.

their CIs and the CI of their mean difference crossed zero. There was again evidence of significant heterogeneity, with $P<.05$ for both sensitivity analyses.

A Fagan's nomogram, such as shown in Figure 4, can use the pretest probability of the outcome and the negative likelihood ratio to calculate the posttest probability of diagnosis. Applying the negative likelihood ratio of 0.06 to our combined population pretest probability of major adverse cardiac events of 11.4% resulted in a posttest probability of 0.7%. Figure 4 therefore shows that if the EDACS score were to have been used in our combined patient population, 0.7% of patients classified as low risk and discharged would have experienced major adverse cardiac events within 30 days. The pretest prevalence of major adverse cardiac events in the North American and Australasian populations was 9.5% and 12.3%, respectively, with negative likelihood ratio 0.08 and 0.04, respectively. This results in the posttest probabilities of 0.8% and 0.5% for these regions shown in Figure E5*A* and *B* (available online at http://www.annemergmed.com).

LIMITATIONS

Statistical analysis showed significant between-study heterogeneity, which places limitations on the conclusions that can be drawn from the meta-analysis. Sensitivity analyses failed to explain this, with significant heterogeneity still found between studies in the same geographic region. This large degree of heterogeneity appears to be best explained by the existence of threshold effects, supported by statistical analysis showing that threshold effects were responsible for 79% of calculated heterogeneity. These effects can occur when there are systematic differences in interpreting data used to calculate the output of the decision aid. If some sites have a lower threshold for determining that a variable is present, their data may tend toward a higher sensitivity and a lower specificity. For

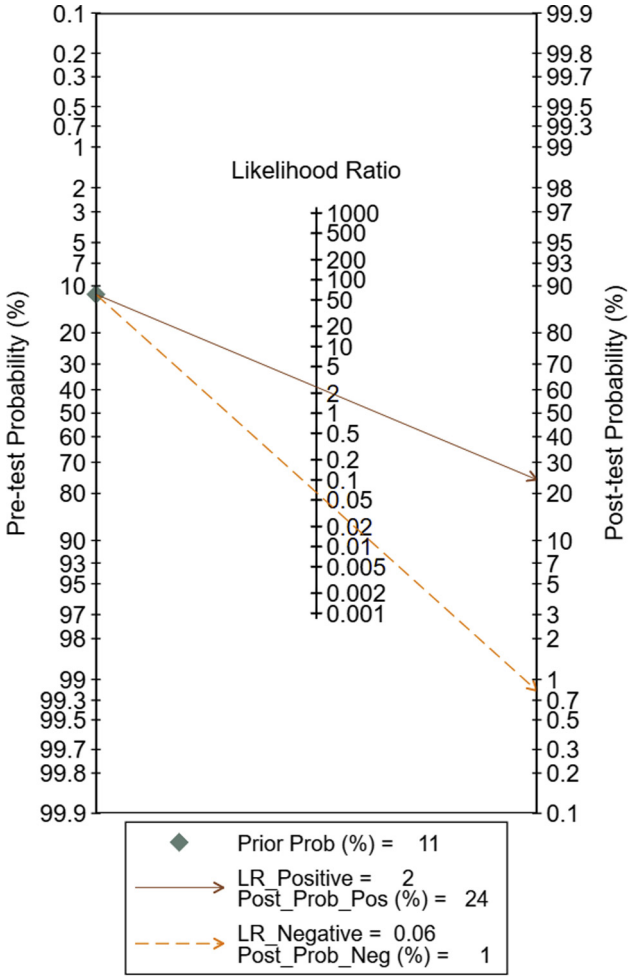

Figure 4. Fagan nomogram for the combined data sets. This allows the calculation of post-test probability based on applying the likelihood ratio to the pretest probability.

example, this may occur if there are systematic differences in the way different sites assessed patients for "chest pain reproducible by palpation." Some sites may routinely perform a thorough chest wall examination, whereas others may not.

It is also possible that variation in the incidence of the different individual components of major adverse cardiac events accounts for some of the between-study heterogeneity. However, our ability to assess this was limited because few studies reported data on the individual components of major adverse cardiac events, and none of the authors we contacted were able to provide these data.

The EDACS score was designed to be used in conjunction with serial troponin sampling, using 2 troponin results taken within 2 hours. Studies that diverged from this protocol were excluded, such as those using a single troponin result or 3-hour testing, because it was thought that this could decrease overall sensitivity. Further analysis was beyond the scope of this review.

DISCUSSION

This systematic review and meta-analysis appraised the EDACS score, demonstrating that it has a relatively high sensitivity and specificity. This means that it could be used in conjunction with serial troponin sampling to identify patients at low risk of major adverse cardiac events who are suitable for early discharge. To our knowledge, this was the first systematic review of the EDACS score.

With a sensitivity of 96.1%, this analysis suggests that the EDACS score could inappropriately label 4% of patients with major adverse cardiac events within 30 days of ED presentation as low risk. This is lower than the EDACS score target sensitivity of 99%, chosen according to the miss rate considered acceptable in a survey of clinicians,[3,27] which could impede the adoption of the EDACS score. However, the authors of the EDACS score did not precisely define the meaning of miss rate in their survey of clinicians. It may be appropriate to define this as the proportion of all patients attending the ED who have chest pain suggestive of acute coronary syndromes categorized as eligible for early discharge with the EDACS score, and who experience major adverse cardiac events within 30 days. In this case, the posttest probability of 0.7%, calculated by applying the negative likelihood ratio of 0.06 to our combined population pretest probability of major adverse cardiac events of 11.4%, meets the miss-rate target of 1% specified by the authors of the EDACS score.[3,27]

Australasian studies investigating the EDACS score reported slightly higher sensitivity, and thus slightly better performance, than North American studies, although this difference was not statistically significant. This may be consistent with an investigation into the ADAPT-ADP that showed poor sensitivity for major adverse cardiac events in a North American population.[28] It is unclear whether this is a random statistical effect or caused by a factor such as an epidemiologic difference between the patient populations, a difference in the way the tool is used, or because of a reporting bias. Although it is speculation, it is possible that this difference is influenced by geographic differences in medicolegal risk perception, which affects clinical judgment and has previously been reported.[29-31] This may include the decision to classify a patient's chest pain as possibly cardiac in origin or the threshold at which a patient is sent for coronary revascularization.

When evaluated according to region in the sensitivity analyses, posttest probability remained at an acceptable 0.8% and 0.5% for the North American and Australasian studies, respectively. This small difference was due to regional variation in pretest probability of major adverse cardiac events within 30 days, the reasons for which are not clear. The lower sensitivity of the tool in the North American studies may thus be compensated for by the lower proportion of cardiac events in this cohort, enabling it to be safely used in North American populations without significantly increasing the rate of missed major adverse cardiac events. The 95% CI crosses the 1% miss-rate target.

Multiple troponin assays were used in the studies evaluated in this review, which increases the generalizability of these findings. However, this may be a source of between-study heterogeneity because the EDACS score may perform differently when used with different assays. Future work could investigate this.

Other decision aids are available for patients with this presentation. The EDACS score was compared with one of these, the ADAPT-Accelerated Diagnostic Protocol (ADP), in a randomized controlled trial.[25] This showed that the rate of discharge within 6 hours for the EDACS score was 2.1% lower than that of the older ADAPT-ADP, despite that the EDACS score identified 11.1% more patients as low risk and safe for early discharge.[25] This is hypothesized to be due to clinician adherence to each ADP, which could be influenced by experience with and trust in the ADP. Alternatives also include the HEART score, which has been extensively studied and shown to improve early discharge rates when used with serial sampling during 2 hours.[32,33] The Troponin-Only Manchester Acute Coronary Syndromes decision aid has also been shown to identify greater than 40% of patients as eligible for immediate discharge after a single blood test.[34] Clinicians implementing a new decision aid should consider the relative merits of these alternatives. This could include factors such as whether the decision aid has been validated in a local population and with the relevant troponin assay.

In summary, in this meta-analysis of 11,578 patients from 8 diagnostic test accuracy studies, the EDACS score had a pooled sensitivity of 96.1% for major adverse cardiac events at 30 days. The posttest probability of 0.7% shows that fewer than 1% of patients classified as suitable for early discharge by the EDACS score would have experienced major adverse cardiac events within 30 days. These data support the use of the EDACS score to rapidly rule out acute coronary syndromes when used alongside serial troponin sampling during 2 hours.

Supervising editor: Tyler W. Barrett, MD, MSCI. Specific detailed information about possible conflict of interest for individual editors is available at https://www.annemergmed.com/editors.

Author affiliations: From the University of Manchester, Manchester, United Kingdom (Boyle, Body); and Manchester University Foundation NHS Trust, Manchester, United Kingdom (Body).

Author contributions: RSJB and RB conceived and designed the analysis. RSJB and RB collected the data. RSJB performed the analysis, which was verified by RB. RSJB drafted the manuscript and RB contributed substantially to its revision.

All authors attest to meeting the four ICMJE.org authorship criteria: (1) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (2) Drafting the work or revising it critically for important intellectual content; AND (3) Final approval of the version to be published; AND (4) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding and support: By *Annals* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). Dr. Body has undertaken research involving donation of reagents without charge by Roche, Abbott, Alere, and Randox; has accepted speaker fees from Singulex, Alere, and Siemens; and has accepted provision of travel and accommodation to present research findings at conferences from Roche and Randox.

Publication dates: Received for publication August 5, 2019. Revisions received January 31, 2020; July 18, 2020; October 5, 2020, and October 23, 2020. Accepted for publication October 28, 2020. Published online January 6, 2021.

Trial registration number: CRD42018097333

REFERENCES

1. Goodacre S, Cross E, Arnold J, et al. The health care burden of acute chest pain. *Heart*. 2005;91:229-230.
2. Sun BC, Hsia RY, Weiss RE, et al. Effect of emergency department crowding on outcomes of admitted patients. *Ann Emerg Med*. 2013;61:605-611.e6.
3. Than M, Flaws D, Sanders S, et al. Development and validation of the Emergency Department Assessment of Chest pain Score and 2 h accelerated diagnostic protocol. *Emerg Med Australas*. 2014;26:34-44.
4. Than M, Cullen L, Aldous S, et al. 2-Hour accelerated diagnostic protocol to assess patients with chest pain symptoms using contemporary troponins as the only biomarker. *J Am Coll Cardiol*. 2012;59:2091-2098.
5. Mahler SA, Miller CD, Hollander JE, et al. Identifying patients for early discharge: performance of decision rules among patients with acute chest pain. *Int J Cardiol*. 2013;168:795-802.
6. Six AJ, Cullen L, Backus BE, et al. The HEART score for the assessment of patients with chest pain in the emergency department: a multinational validation study. *Crit Pathw Cardiol*. 2013;12:121-126.
7. Scheuermeyer FX, Wong H, Yu E, et al. Development and validation of a prediction rule for early discharge of low-risk emergency department patients with potential ischemic chest pain. *CJEM*. 2014;16:106-119.

8. Mareiniss DP. A brewing storm: our overwhelmed emergency departments. *Am J Emerg Med*. 2017;35:368.
9. Mareiniss DP. The impending storm: COVID-19, pandemics and our overwhelmed emergency departments. *Am J Emerg Med*. 2020;38:1293-1294.
10. Leeflang MMG, Deeks JJ, Takwoingi Y. Cochrane diagnostic test accuracy reviews. *Syst Rev*. 2013;2:1-6.
11. Moher D, Liberati A, Tetzlaff J, et al. Preferred Reporting Items for Systematic Reviews and Meta-analyses: the PRISMA statement. *J Clin Epidemiol*. 2009;62:1006-1012.
12. Thygesen K, Alpert JS, Jaffe AS, et al. Third Universal Definition of Myocardial Infarction. *Circulation*. 2012;126:2020-2035.
13. Whiting PF, Rutjes AWS, Westwood ME, et al. QUADAS-2: a revised tool for the Quality Assessment of Diagnostic Accuracy Studies. *Ann Intern Med*. 2011;155:529-536.
14. StataCorp. Stata statistical software: release 14. 2015, Availabel at: https://www.stata.com/stata14/, Accessed December 21, 2020.
15. Dwamena B. MIDAS: Stata module for meta-analytical integration of diagnostic test accuracy studies. Available at: https://econpapers.repec.org/RePEc:boc:bocode:s456880. Accessed December 21, 2020.
16. Harbord RM, Whiting P. metandi: Meta-analysis of diagnostic accuracy using hierarchical logistic regression. *Stata J*. 2009;9:211-229.
17. Dwamena BA, Sylvester R, Carlos RC. Midas: Meta-analysis of Diagnostic Accuracy Studies. Available at: http://fmwww.bc.edu/repec/bocode/m/midas.pdf. Accessed June 2, 2018.
18. van Enst WA, Ochodo E, Scholten RJPM, et al. Investigation of publication bias in meta-analyses of diagnostic test accuracy: a meta-epidemiological study. *BMC Med Res Methodol*. 2014;14:1-11.
19. Sanders S, Flaws D, Than M, et al. Simplification of a scoring system maintained overall accuracy but decreased the proportion classified as low risk. *J Clin Epidemiol*. 2016;69:32-39.
20. Stopyra J, Miller C, Hiestand B, et al. Comparison of accelerated diagnostic pathways for emergency department chest pain risk stratification. In: Society for Academic Emergency Medicine annual meeting; May 15-18, 2018, JW Marriott Indianapolis, Indianapolis, IA.
21. Yang SM, Chan CH, Chan TN. HEART pathway and Emergency Department Assessment of Chest Pain Score–Accelerated Diagnostic Protocol application in a local emergency department of Hong Kong: An external prospective validation study. *Hong Kong J Emerg Med*. 2018;27:30-38.
22. Flaws D, Than M, Scheuermeyer FX, et al. External validation of the Emergency Department Assessment of Chest Pain Score Accelerated Diagnostic Pathway (EDACS-ADP). *Emerg Med J*. 2016;33:618-625.
23. Shih J, Lohse C, Than M, et al. External validation of the Australasian ED Acute Coronary Syndrome Score. In: Society for Academic Emergency Medicine annual meeting; May 14-18, 2013, The Westin Peachtree Plaza, Atlanta, GA.
24. Stopyra JP, Miller CD, Hiestand BC, et al. Performance of the EDACS-Accelerated Diagnostic Pathway in a cohort of US patients with acute chest pain. *Crit Pathw Cardiol*. 2015;14:134-138.
25. Greenslade JH, Carlton EW, Van Hise C, et al. Diagnostic accuracy of a new high-sensitivity troponin I assay and five accelerated diagnostic pathways for ruling out acute myocardial infarction and acute coronary syndrome. *Ann Emerg Med*. 2018;71:439-451.e3.
26. Than MP, Pickering JW, Aldous SJ, et al. Effectiveness of EDACS versus ADAPT accelerated diagnostic pathways for chest pain: a pragmatic randomized controlled trial embedded within practice. *Ann Emerg Med*. 2016;68:93-102.e1.
27. Than M, Herbert M, Flaws D, et al. What is an acceptable risk of major adverse cardiac event in chest pain patients soon after discharge from the emergency department? a clinical survey. *Int J Cardiol*. 2013;166:752-754.
28. Mahler SA, Miller CD, Litt HI, et al. Performance of the 2-hour accelerated diagnostic protocol within the American College of Radiology Imaging Network PA 4005 cohort. *Acad Emerg Med*. 2015;22:452-460.
29. Yan SC, Hulou MM, Cote DJ, et al. International defensive medicine in neurosurgery: comparison of Canada, South Africa, and the United States. *World Neurosurg*. 2016;95:53-61.
30. Nash LM, Walton MM, Daly MG, et al. Perceived practice change in Australian doctors as a result of medicolegal concerns. *Med J Aust*. 2010;193:579-583.
31. Marco CA, Bessman ES, Kelen GD. Ethical issues of cardiopulmonary resuscitation: comparison of emergency physician practices from 1995 to 2007. *Acad Emerg Med*. 2009;16:270-273.
32. Mahler SA, Lenoir KM, Wells BJ, et al. Safely identifying emergency department patients with acute chest pain for early discharge. *Circulation*. 2018;138:2456-2468.
33. Brady W, de Souza K. The HEART score: a guide to its application in the emergency department. *Turk J Emerg Med*. 2018;18:47-51.
34. Body R, Carlton E, Sperrin M, et al. Troponin-only Manchester Acute Coronary Syndromes (T-MACS) decision aid: single biomarker re-derivation and external validation in three cohorts. *Emerg Med J*. 2017;34:349-356.