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E-HEART score: A novel scoring system for undifferentiated chest pain in the emergency department

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Abstract:

OBJECTIVE: Cardiovascular disease is the leading cause of death worldwide. As there is an increase in the global burden of ischemic heart disease, there are multiple scoring systems established in the emergency department (ED) to risk stratify and manage acute coronary syndrome (ACS) in patients with chest pain. The objective of this study was to integrate point-of-care echo into the existing history, electrocardiogram, age, risk factors, and troponin (HEART) score and evaluate a novel scoring system, the echo HEART (E-HEART) score in risk stratification of patients presenting with undifferentiated chest pain to the ED. The E-HEART Score was also compared with existing traditional scoring systems for risk-stratifying acute chest pain.

METHODS: A diagnostic accuracy study involving 250 patients with chest pain at the ED of a single tertiary care teaching hospital in India was conducted. The emergency physicians assessed the E-HEART score after integrating their point-of-care echo/focused echo findings into the conventional HEART score on presentation. The primary endpoint was the occurrence of major adverse cardiovascular events (MACE) within 4 weeks of initial presentation. The accuracy of the E-HEART score was compared with other conventional risk stratification scoring systems such as the thrombolysis in myocardial infarction (TIMI), history, electrocardiogram, age, and risk factors, Troponin Only Manchester ACS (T-MACS), and HEART scores.

RESULTS: A total of 250 patients with a median age of 53 years (42.25–63.00) were part of the study. Low E-HEART scores (values 0–3) were calculated in 121 patients with no occurrence of MACE in this category. Eighty-one patients with moderate E-HEART scores (4–6) were found to have 30.9% MACE. In 48 patients with high E-HEART scores (values 7–11), MACE occurred in 97.9%. The area under receiver operating characteristics (AUROC) of E-HEART score is 0.992 (95% confidence interval: 0.98–0.99), which is significantly higher than AUROC values for HEART (0.978), TIMI (0.889), T-MACS (0.959), and HEAR (0.861), respectively ($P < 0.0001$). At a cutoff of E-HEART score >6, it accurately predicted ACS with a sensitivity of 92% and a specificity of 99% with a diagnostic accuracy of 97%.

CONCLUSION: The E-HEART score gives the clinician a quick and accurate forecast of outcomes in undifferentiated chest pain presenting to the ED. Low E-HEART scores (0–3) have an extremely low probability for short-term MACE and may aid in faster disposition from the ED. The elevated risk of MACE in patients with high E-HEART scores (7–11) may facilitate more aggressive workup measures and avoid disposition errors. E-HEART is an easily adaptable scoring system with improved accuracy compared to conventional scoring systems.

Keywords:

Acute coronary syndrome, echo-history, electrocardiogram, age, risk factors, and troponin score, emergency department, focused echo, point-of-care ultrasound, risk stratification

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Box-ED Section

What is already known on the study topic?

- "HEART" score is a risk stratification scoring system for undifferentiated chest pain in the emergency department (ED).

What is the conflict on the issue? Has its importance for readers?

- Integration of point-of-care ultrasound/focused echo (FECHO) to the "HEART" score can impact the accuracy of the risk stratification.

How is this study structured?

- This was a single-center, diagnostic accuracy design study involving 250 participants presenting to the ED with undifferentiated chest pain.

What does this study tell us?

- Our study evaluated the utility of integrating point-of-care echo or FECHO done by emergency physicians into the existing "HEART" score and termed it the E-HEART score. We significantly improved the accuracy of risk stratification scoring systems by integrating FECHO in undifferentiated chest pain patients.

Introduction

Ischemic heart disease (IHD) is expected to affect 126 million people worldwide (or 1655/100,000), or 1.72% of the total population, according to Global Burden of Disease data in 2017. Around 9 million people worldwide die from cardiovascular diseases each year, making them the leading cause of death globally. Disability-adjusted life years (DALY) for IHD have risen from fourth place in 1990 to first place by 2017, indicative of the rapid rise in the disease burden. There are 1197 prevalence cases in India and 2679 DALYs for every 100,000 people. By 2030, the prevalence of IHD might reach 1845/100,000 people, according to this predicted model.[1] For risk stratification of patients presenting with nonspecific chest pain to the Emergency Department (ED), numerous chest pain scoring systems are available that objectively classify patients and produce standardized patient disposition plans.

Low risk scores can expedite the disposition rate of patients from the hospital and are used for an accelerated diagnostic pathway for the patient. Due to its simplicity and accuracy, EDs have used the history, electrocardiogram (ECG), age, risk factors, and troponin (HEART) score to predict major adverse cardiac events (MACE). The HEART score is considered superior to thrombolysis in myocardial infarction (TIMI) and GRACE scores regarding risk classification for patients with nonspecific chest pain who visit the emergency room.[2]

Point-of-care cardiac ultrasonography or focused echo (FECHO) may be helpful in patients who present to the ED with nonspecific chest pain in several ways. A 2016 American College of Emergency Physicians (ACEP) statement states that a student must finish at least 25–50 cases in point-of-care USG to be proficient in that application.[3] The most frequent use is to recognize regional wall motion abnormalities (RWMA) in undifferentiated chest pain to identify the possibility of an acute coronary syndrome (ACS) and select the best pharmacotherapies and treatments.[4] The Moore *et al*.'s study shows that emergency physicians with focused training in echocardiography can accurately determine left ventricular dysfunction in hypotensive patients as proficient as cardiologists and other echocardiography technicians.[5,6] ED physicians have used visual estimations to assess overall left ventricle (LV) function. A few studies have also found that visual estimations by emergency physicians coincide with quantitative and semiquantitative techniques of measuring global heart function.[7]

In this study, we used point-of-care ultrasound in the ED to do a FECHO to evaluate for RWMA and consider that parameter as an additional variable to the existing "HEART" score and review its impact on accuracy. We also wanted to compare how it fares with conventional scoring systems. It is vital to remember that the FECHO examination's purpose is to help clinicians make quick decisions for patients with chest pain and can benefit from pharmacologic or other modes of intervention.[8]

The study aims to determine the accuracy of the echo-HEART (E-HEART) score (i.e. adding FECHO as an additional parameter in existing HEART score) in undifferentiated chest pain patients presenting to the ED and also to compare the accuracy of different scoring systems, including TIMI, HEART, history, ECG, age, and risk factors (HEAR), and Troponin Only Manchester ACS (T-MACS) with E-HEART scores in undifferentiated chest pain patients presenting to the ED.

Methods

Study setting

Department of emergency medicine (ED) at a tertiary care teaching hospital in India.

Study design

This was a diagnostic accuracy study approved by IEC – 155/2021 and the Clinical Trials Registry of India (CTRI). The study was carried out in the ED from June 2021 to October 2022 on patients presenting with a history of chest pain, satisfying the inclusion and exclusion criteria.

Study population

Inclusion criteria: Patients who are >18 years of age presenting with chest pain.

Exclusion criteria:

- Diagnosed acute ST-segment elevation myocardial infarction
- Pregnant women
- Rapid antigen test for COVID-19 – Positive
- Patients who are not willing to participate in the study.

Sampling method: Consecutive

Sample size estimation:

$$n = \frac{\left(Z_{1-\alpha/2}\right)^2 \widehat{se}\left(1-\widehat{se}\right)}{d^2\ P}$$

n = required sample size

$Z_{1-\alpha/2}$ = 1.96 at 95% confidence level

$\widehat{se}$ = anticipated sensitivity = 0.95 and above

P = anticipated prevalence of the disease = 0.9

d = margin of error = 0.03

$$n = \frac{(1.96)^2 \times 0.95 \times (1-0.95)}{(0.03)^2 \times 0.9} \cong 225$$

Accounting for a dropout rate of 10% $n = \frac{225}{1-0.1} \cong 250$

Methods and measurements

We ruled out COVID-19 infection in the enrolled patients with rapid antigen testing (institutional protocol). The risk stratification was done by emergency medicine (EM) consultants on duty. The ED protocol currently uses the HEART score for primary risk stratification. The study observed the impact of integrating FECHO by the emergency physician to the current risk stratification scores and how it fares with existing scoring systems. The components of the E-HEART score include FECHO, HEART levels. High-sensitivity Troponin-T (ROCHE) was used for all chest pain patients as part of the institutional protocol in our study. Point-of-care echo/FECHO was performed by a single EM resident who has completed training and achieved competency to perform bedside screening echo (performed at least 50 scans and were reviewed by a supervisor) as suggested by the institutional guidelines and ACEP guidelines, utilizing a single ultrasound machine (Philips CX 50) available in the ED. The images/videos procured were reviewed by an independent EM consultant who is a faculty for point-of-care ultrasound, blinded and not part of the study group. Four views were obtained and recorded: the parasternal long axis, parasternal short axis, apical four-chamber, and subxiphoid views. Echo findings noted in the parasternal short axis view by observing individual sections or part of the LV (interventricular septum, apex, anterior wall, lateral wall, inferior, and posterior wall) as the presence of regional wall motion abnormality (RWMA) was given a score of 1, and its absence a score 0. The cardiology team did a formal two-dimensional echo before disposition.

Outcomes

The primary outcome was to check for RWMA using FECHO and the addition of this variable to the traditional HEART score to devise a new scoring system called E-HEART score and evaluate if it improves the predictive accuracy of ACS and also compares the E-HEART score with the HEART score in patients who present with undifferentiated chest pain. The secondary outcome entails telephonic follow-up with patients enrolled after 30 days to check for any major adverse cardiovascular events (MACE). Data were gathered using an approved and validated pro forma. The scores were computed using the online calculator MDCalc, which was tabulated and compared.[9] Patients with acute myocardial ınfarction (AMI) (non-ST elevation myocardial infarction) on presentation or recurrent MI within 30 days of an ED visit or patients undergoing percutaneous trans coronary angiography/coronary artery bypass graft (CABG) or mortality within 30 days of an ED visit were referred to as MACE.

Data (or statistical) analysis

Wilcoxon rank sum test is a nonparametric test used for data that is not distributed normally. For categorical data group comparisons, the Chi-squared test was employed. Wilcoxon rank sum test (Mann–Whitney *U*-test) compares the median association between age with other variables such as diabetes, cerebrovascular accident, chronic kidney disease, CABG, thrombolysis, and death.

Fisher's exact test was used in place of the contingency tables if the anticipated frequency was discovered to be 5 for more than 20% of the cells. The best cutoff for a continuous predictor predicting a binary outcome was expected using ROC analysis. By creating a 2 × 2 cross-table using the result, the diagnostic performance of the predictors was evaluated by calculating the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy. The data analysis was performed using statistical tools, including SPSS version 23 (IBM Corp)

IBM Corp. Released 2015. IBM SPSS Statistics for windows, Version 23.0. Armonk, New York: IBM Corp. Microsoft Word and Excel spreadsheet programs were used to create the graphs, tables, and other outputs.

Consent to participate in the study was taken from all participants.

The study was initiated after approval from the institutional ethical committee/institutional review board with IEC – 155/2021. CTRI approval was also established before beginning the study.

The study conforms to the STARD checklist for diagnostic accuracy study design.

Results

After getting consent, two hundred sixty patients who presented with nonspecific chest pain to the ED who were treated according to institutional protocol and met the inclusion criteria were included in the study. Ten patients were excluded; 8 were excluded due to poor echo window, and two were excluded as they later withdrew consent to participate in the study. Ultimately, 250 patients were included in the statistical analysis.

The primary outcome was to check the impact of adding FECHO as a variable to the existing HEART score. In our study, the E-HEART score had a diagnostic accuracy of (97%) for ACS compared to the HEART score (93%) in patients who present with undifferentiated chest pain. The summary of multiple variables with the outcome and the accuracy of the scores in diagnosing MACE are provided in Table 1.

The median age of patients in the study was 53.00 years (interquartile range: 42.25–63.00) and was significantly male predominant (65%). Among 250 patients, 53 patients (21%) were between 18 and 40 years of age, 112 patients (45%) were between the age group of 41 and 60 years, and 85 patients (34%) were >60 years of age group category. The youngest patient enrolled in the study was 18, and the oldest was 83. The study population has a male predominance, with 162 (65%) male and 88 (35%) female patients. The distribution of comorbid illnesses is provided in Table 2. The summary of the various scoring systems and their comparison with the E-HEART score are presented in Table 3. In our study, the distribution of MACE is provided in Table 4. Among 250 enrolled participants, 72 patients (28%) had MACE, including nine deaths; ten patients underwent CABG, and 178 (70%) did not have any MACE. In our study, we had 2 cases each of ventricular septal rupture and pericardial tamponade, which were also added as a major adverse cardiovascular

Table 1: Comparison of the diagnostic performance of various scores in predicting major adverse cardiovascular event

Predictor	AUROC (95% CI)	Sn (95% CI)	Sp (95% CI)	PPV (95% CI)	NPV (95% CI)	DA (95% CI)	PLR (95% CI)	NLR (95% CI)
HEART score	0.978 (0.965–0.991)	97% (90–100)	91% (86–95)	81% (72–89)	99% (96–100)	93% (89–96)	10.82 (6.77–17.29)	0.03 (0.01–0.12)
E-HEART score	0.992 (0.985–0.999)	92% (83–97)	99% (96–100)	97% (90–100)	97% (93–99)	97% (94–99)	81.58 (20.53–324.24)	0.08 (0.04–0.18)
TIMI score	0.889 (0.85–0.927)	94% (86–98)	78% (71–83)	63% (53–72)	97% (93–99)	82% (77–87)	4.2 (3.18–5.55)	0.07 (0.03–0.19)
T-MACS score	0.959 (0.937–0.98)	90% (81–96)	92% (87–96)	82% (72–90)	96% (92–98)	92% (87–95)	11.48 (6.9–19.09)	0.11 (0.05–0.21)
HEAR score	0.861 (0.819–0.904)	92% (83–97)	68% (61–75)	54% (44–63)	95% (90–98)	75% (69–80)	2.86 (2.29–3.59)	0.12 (0.06–0.27)

HEAR: History, electrocardiogram, age, and risk factors, HEART: HEAR and troponin, E-HEART: Echo-HEART, TIMI: Thrombolysis in myocardial infarction, T-MACS: Troponin Only Manchester Acute Coronary Syndrome, AUROC: Area under receiver operating characteristics, Sn: Sensitivity, Sp: Specificity, PPV: Positive predictive value, NPV: Negative predictive value, DA: Diagnostic accuracy, CI: Confidence interval, PLR: Positive likelihood ratio, NLR: Negative likelihood ratio

Table 2: Distribution of comorbidities and outcomes

Comorbidities and outcomes	Yes, *n* (%)	No, *n* (%)
DM	70 (28.0)	180 (72.0)
HTN	91 (36.4)	159 (63.6)
IHD	33 (13.2)	217 (86.8)
CKD	11 (4.4)	239 (95.6)
CVA	2 (0.8)	248 (99.2)
PTCA	50 (20.0)	200 (80.0)
Thrombolysis	5 (2.0)	245 (98.0)
Conservative management	7 (4.0)	243 (96.3)
CABG	10 (4.0)	240 (96.0)
Acute MI	16 (6.4)	234 (93.6)
Death	9 (3.6)	241 (96.4)
MACE	72 (28.8)	178 (71.2)

DM: Diabetes mellitus, HTN: Hypertension, IHD: Ischemic hearth disease, CKC: Chronic kidney disease, CVA: Cerebrovascular accident, PTCA: Percutaneous trans coronary angiography, CABG: Coronary artery bypass graft, MI: Myocardial infarction, MACE: Major adverse cardiovascular event

Table 3: Summary of scores

Scoring	Median (IQR)	Minimum–maximum
HEART score	4.00 (2.00–5.00)	0.0–9.0
E-HEART score	4.00 (2.00–6.00)	0.0–9.0
TIMI score	1.00 (0.00–3.00)	0.0–9.0
T-MACS score	26.00 (5.00–98.00)	1.0–100.0
HEAR score	3.00 (2.00–4.00)	0.0–7.0

HEAR: History, electrocardiogram, age, and risk factors, HEART: HEAR and troponin, E-HEART: Echo-HEART, TIMI: Thrombolysis in myocardial infarction, T-MACS: Troponin Only Manchester Acute Coronary Syndrome, IQR: Interquartile range

Table 4: Summary of major adverse cardiovascular event

Parameters	MACE		*P*
	Yes (*n*=72), *n* (%)	No (*n*=178), *n* (%)	
HEART category			
0–3	0	121 (100.0)	<0.001[a]
4–6	50 (46.7)	57 (53.3)	
≥7	22 (100.0)	0	
E-HEART category			
0–3	0	121 (100.0)	<0.001[a]
4–6	25 (30.9)	56 (69.1)	
≥7	47 (97.9)	1 (2.1)	
HEAR category			
<2	0	38 (100.0)	<0.001[a]
≥2	72 (34.0)	140 (66.0)	
TIMI category			
<2	4 (2.8)	138 (97.2)	<0.001[a]
≥2	68 (63.0)	40 (37.0)	
T-MACS category			
<20	0	101 (100.0)	<0.001[a]
20–50	6 (10.2)	53 (89.8)	
50–95	1 (9.1)	10 (90.9)	
≥95	65 (82.3)	14 (17.7)	

[a]Chi-squared test. HEAR: History, electrocardiogram, age, and risk factors, HEART: HEAR and troponin, E-HEART: Echo-HEART, TIMI: Thrombolysis in myocardial infarction, T-MACS: Troponin Only Manchester Acute Coronary Syndrome, MACE: Major adverse cardiovascular event

event (MACE). Right-sided strain with suspected pulmonary embolism was also noted in 5 cases, but computed tomography pulmonary angiography was negative.

The components of the E-HEART score and risk stratification are provided in Table 5. Among 250 patients, 72 patients (28.8%) had MACE. RWMA was present in 60 patients (95.2%) in the MACE category.

Discussion

In the current study, the emergency physician's point-of-care echo at the patient's bedside has implications for identifying RWMA, determining the likelihood of ACS, and risk-stratifying patients who presented to the ED with nonspecific chest pain. "This is accomplished by scanning the parasternal short axis image for abnormalities in regional wall motion. Patients were categorized into low risk, intermediate risk, and high risk categories based on HEART levels and the presence or absence of RWMA.

We evaluated the E-HEART score's diagnostic accuracy, comparing it to existing risk stratification scoring systems used in undifferentiated chest pain patients presenting to the ED. In addition, we assessed the effectiveness of the E-HEART score in evaluating MACE and compared it with other scoring methods. For comparison, the MACE events for different scores [Figure 1], i.e. E-HEART, HEART, TIMI, and GRACE, have an area under receiver operating characteristics (AUROC) of 0.992, 0.78, 0.65, and 0.62, respectively. In the current study, among 250 patients, 72 (28.8%) patients had a MACE. RWMA was present in 60 (95.2%) patients in the MACE category, and 26 patients were shifted from the intermediate risk group to the high risk group based on FECHO integration to HEART score. Of the 26 patients, 25 were in the MACE category and 1 in the non-MACE category in our study.

The E-HEART score is stratified into low-risk, intermediate-risk, and high-risk categories based on six variables: HEART and FECHO. The scores vary from "0 to 11-point scores." A score of 0–3 indicates a patient is at "low risk" and advises consideration of discharge and further investigations can be planned during out patient department visits. Our study saw a MACE of 0% for low-risk patients. Patients with a score of 4–6 are classified as "intermediate risk," and they require hospitalization and clinical observation, including recurrent troponin levels and treadmill test (TMT) testing. About 31% of intermediate-risk patients had MACE in our study. Patients with a score of 7–11 are deemed "high risk" and require early aggressive care with invasive procedures. Approximately 97% of high-risk

Table 5: Components of E-HEART (Echo History, Electrocardiogram, Age, Risk Factors, and Troponin) score

Parameters	Scores
Echo	
Definite RWMA	0
No definite RWMA	1
History	
Highly suspicious	2
Moderately suspicious	1
Mildly suspicious	0
ECG	
Significant ST-segment	2
Nonspecific repolarisation	1
Normal	0
Age (years)	
>65	2
45–64	1
<45	0
Risk factors	
>3 risk factors/history of atherosclerotic disease	2
1 or 2 risk factors	1
No risk factors	0
Troponin	
≥3 times the normal limit	2
1–3 times the normal limit	1
≤ Normal limit	0

RMWA: Regional wall motion abnormality, ECG: Electrocardiogram

patients had MACE in our study. The possibility to stratify undifferentiated patients into high-risk categories increases tremendously with integrating FECHO at presentation. This highlights the importance of FECHO integration in undifferentiated chest pain patients for their risk stratification. The association between RWMA and ACS has been documented well.[10] Emergency physicians trained in FECHO can identify significant RWMA in the ED setting.[11,12]

The Sakamoto *et al*.'s and Wamala *et al*.'s study used statistical approaches such as sensitivity, specificity, NPV, PPV, and AUROC to compare MACE with other risk stratification scores.[13,14]

The Body *et al*.'s study was carried out in 14 ED in England, enrolling 999 patients who presented within 12 h of suspected ACS symptoms. A comparison of the HEART, TIMI, T-MACS, and EDACS decision aids was made, and the occurrence of MACE after 30 days was measured. Sensitivity, specificity, PPV, and NPV measurements were used to evaluate the accuracy of each scoring system. The current study also uses a similar approach of using the same statistical tools to compare MACE with other risk stratification scores. T-MACS could rule out 46.5% of individuals with AMI in a subset of patients while maintaining a 99.2% sensitivity. The HEART and TIMI scores demonstrated decreased

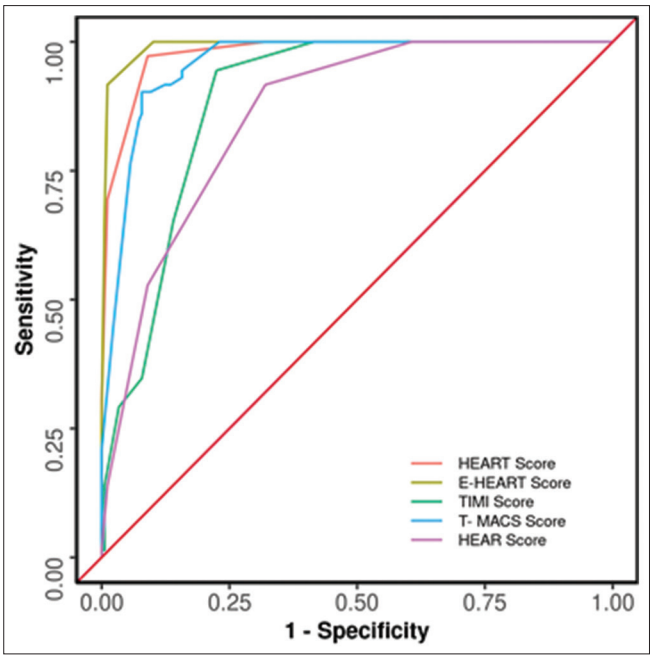

Figure 1: Receiver operating characteristics curve analysis showing diagnostic performance of various scores in predicting major adverse cardiovascular event. TIMI: Thrombolysis in myocardial infarction, T-MACS: Troponin Only Manchester Acute Coronary Syndrome

diagnostic accuracy, and EDACS could exclude 48.3% of individuals with AMI with lower sensitivity.[15] The results of the current study demonstrated a comparison of the HEART, E-HEART, TIMI, HEAR, and T-MACS scores with AUROC values [Figure 1] for HEART (0.978), TIMI (0.889), T MACS (0.959), HEAR (0.861), and E-HEART (0.992) (95% confidence interval: 0.98–0.99). At a cutoff of E-HEART score >6, it accurately predicts ACS with a sensitivity of 92% and a specificity of 99%. On analysis, the E-HEART score was the most accurate regarding AUC compared to the other existing scores.

From this study analysis, it can be inferred that in terms of specificity, diagnostic accuracy and PPV, the E-HEART score is more accurate than other existing scoring systems such as HEART, HEAR, TIMI, and T-MACS in predicting 30 days MACE events."

Limitations

Our study's primary limitations are that it is a single-center study with a sample size of 250. We also noted that in patients with low-risk E-HEART scores, FECHO did not contribute to patient management. The COVID pandemic impacting health-care services during the study period is also a possible confounder.[16,17] It has been documented that treatment strategies have been affected due to the pandemic globally.[18] Large-scale vaccination during the pandemic may also be a confounder.[19,20] However, there is insufficient evidence to conclude the vaccine-induced side effects and the post-COVID thrombotic phenomena manifesting as ACS.[21] Our

study needs external validation in a more comprehensive multicentric sample."

Conclusion

Our study evaluated the utility of point-of-care echo/FECHO done by emergency physicians and found a significant impact in improving the accuracy of risk stratification scoring systems by integrating FECHO into the conventional "HEART" score.

This study can catalyze integrating FECHO into the risk stratification scoring system for undifferentiated chest pain patients presenting to the ED. There is, however, a need to evaluate the newer scoring system in a larger population from different centers before recommending the same.

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Author contributions statement
We confirm that everyone who has contributed to this manuscript is listed as author.

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Writing – review and editing	YV, VK, SNS
Writing – original draft	YV, VK, SNS

YV – Yuvaraj V, SNS – Sachin Nayak Sujir, VK – Vimal Krishnan

Conflicts of interest
None Declared.

Ethical approval
This study was conducted after approval from the Institutional Research Board/Institutional Ethics Committee (Registration No. IEC – 155/2021). The study has also been registered with the Clinical Trials Registry, India (CTRI) (CTRI/2021/06/033981.)

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