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Effect of the Emergency Department Assessment of Chest Pain Score on the Triage Performance in Patients With Chest Pain

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The sensitivity of triage systems in identifying acute cardiovascular events in patients presented to the emergency department with chest pain is not optimal. Recently, a clinical score, the Emergency Department Assessment of Chest Pain Score (EDACS), has been proposed for a rapid assessment without additional instruments. To evaluate whether the integration of EDACS into triage evaluation of patients with chest pain can improve the triage's predictive validity for an acute cardiovascular event, a single-center prospective observational study was conducted. This study involved all patients who needed a triage admission for chest pain between January 1, 2020, and December 31, 2020. All enrolled patients first underwent a standard triage assessment and then the EDACS was calculated. The primary outcome of the study was the presence of an acute cardiovascular event. The discriminatory ability of EDACS in triage compared with standard triage assessment was evaluated by comparing the areas under the receiver operating characteristic curve, decision curve analysis, and net reclassification improvement. The study involved 1,596 patients, of that 7.3% presented the study outcome. The discriminatory ability of triage presented an area under the receiver operating characteristic curve of 0.688 that increased to 0.818 after the application of EDACS in the triage assessment. EDACS improved the baseline assessment of priority assigned in triage, with a net reclassification improvement of 33.6% (p <0.001), and the decision curve analyses demonstrated that EDACS in triage resulted in a clear net clinical benefit. In conclusion, the results of the study suggest that EDACS has a good discriminatory capacity for acute cardiovascular events and that its implementation in routine triage may improve triage performance in patients with chest pain. **(Am J Cardiol 2021;161:12−18)**

Chest pain is responsible for 5% to 10% of admissions to emergency departments (EDs) and can be the presenting symptom for benign diseases (e.g., musculoskeletal) or serious time-dependent pathologies (e.g., acute myocardial infarction [AMI] and pulmonary thromboembolism).[1−4] The correct stratification in the triage of patients who need rapid medical treatment from those who can safely wait is crucial but it remains a significant challenge.[5−8] Despite good levels of specificity, the available triage systems appear to have suboptimal sensitivities that cannot adequately prioritize patients with acute cardiovascular diseases.[9] In contrast to triage, several clinical tools have been implemented in the medical assessment of chest pain to support decision-making, but these require the use of electrocardiogram (ECG) and troponin (e.g., HEART score).[7,10,11] Recently, the Emergency Department Assessment of Chest Pain Score (EDACS), through a standardized assessment of the patient's history and presenting symptoms only, provides good levels of sensitivity in stratifying time-dependent acute cardiovascular diseases.[12] The good discriminatory ability of EDACS, combined with its easy clinical applicability, could be used to overcome some of the limitations of triage systems in assessing chest pain. This study aims to evaluate whether EDACS performed during nurse triage to assess patients with chest pain could improve the predictive validity of triage for an acute cardiovascular event.

This is a single-center prospective observational study that consecutively considered all patients who underwent a triage assessment at the ED of the General Hospital of Merano (Italy, 70,000 accesses per year) for chest pain between January 1, 2020, and December 31, 2020. Since 2014, triage procedures at the ED of the Merano Hospital have been a standardized process based on the Manchester Triage System (MTS). MTS is the most used triage system in Europe and is widely studied and validated in different settings. MTS is composed of 52 flowcharts based on the specific symptoms; each symptom gives access to a specific

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flowchart consisting of specific questions of decreasing severity (indicators) that guide the triage nurse in the assignment of the correct level of urgency. The priority codes are divided into 5 levels, each representing a maximum waiting time until medical evaluation: blue (nonurgent, 240 minutes), green (normal, 120 minutes), yellow (urgent, 60 minutes), orange (very urgent, 10 minutes) and red (immediate, 0 minutes). Each triage nurse completed a dedicated training course, worked in the ED for 2 years, and worked with an experienced triage nurse. Audits of individual triage assessments are performed daily in the ED to maintain triage quality and to improve the skills of triage nurses.

All patients admitted to the ED with a complete triage assessment for chest pain were considered eligible for the study. Chest pain is considered to be an acute chest pain, described as pain, pressure, tightness, or burning as outlined in the guidelines.[13] Chest pain equivalent symptoms may include dyspnea, epigastric pain, and pain in the left arm.[13] Only patients complaining about chest pain as the main symptom were considered eligible for the study. Patients under 18 years, with posttraumatic chest pain or chest pain present for more than 7 days, were directly admitted to the shock room without performing nurse triage. Patients not residing in the district (tourists), who did not give consent to participate and were not able to reconstruct follow-up were excluded from the study. For each enrolled patient, the study protocol initially included the assessment of the patient according to the MTS method and the priority code assignment. Subsequently, the EDACS score was calculated for each patient, without the application of the additional protocol proposed by the authors, "accelerated diagnostic protocol" including the performance of troponin and ECG.[12] Baseline characteristics, associated symptoms, triage assessments (including priority code and nursing history), cardiovascular comorbidities, vital parameters, and the EDACS were recorded. The EDACS calculation is based on 7 rapid questions, each of which has a specified score; the maximum obtainable score is 34 and the minimum score is −10 (Supplementary Table 1). EDACS defines 2 levels: low risk (<16 points) and high risk (≥16 points).[12]

The main outcome of the study was the presence of acute cardiovascular events, defined by the presence of one of the following events: (1) death within 72 hours from any cardiovascular cause, (2) diagnosis of myocardial infarction according to the fourth universal definition of myocardial infarction, (3) the need for coronarography within 48 hours of the ED visit, (4) cardiac arrest during the ED stay, (5) a ventricular arrhythmia during the ED stay, (6) diagnosis of cardiogenic shock or (7) atrioventricular block. Patients experiencing at least one of the previously mentioned adverse events were considered positive for "acute cardiovascular events."[12,13] Outcome reconstruction was performed by a cardiologist (R.P.) and an emergency physician (G.T.) through evaluating all available medical material following the triage assessments (ED records, inpatient medical records with the final medical diagnosis given using the International Classification of Diseases ninth revision, and any diagnostic procedures performed). In direct discharge from the ED, patients were contacted by telephone after 30 days to assess the possible presence of an adverse outcome.

Categorical variables were described as percentage and number of events whereas continuous variables were described as mean and SD or median and interquartile range depending on the distribution presented. Univariate comparisons among variables and the study outcome were conducted with Fisher's exact test, chi-square, Student's *t* test, and the Mann-Whitney test as appropriate. The possible usefulness of EDACS in nurse triage was investigated through a sequential process, using some well-known analyses specifically designed for this purpose (net reclassification improvement [NRI], and decision curve analysis [DCA]). The discriminatory ability of EDACS alone was assessed to confirm the validity of the tool, then its ability to reclassify the baseline risk provided by MTS was evaluated and finally, the clinical impact of a merged strategy on the overall triage was assessed. The discriminatory abilities of the triage system and EDACS were studied by analyzing the area under the curve of the receiver operating characteristic (ROC) curves. Differences in discriminatory abilities among the 3 different stratification models (triage system only, EDACS only, and triage system and EDACS in combination) and the study of pathological outcome were analyzed by comparing the respective areas under the ROC curve (AUROC). AUROC values are reported with 95% confidence intervals (95% CIs). The possible improvement in risk stratification of patients with chest pain by implementing EDACS in triage was investigated using NRI. Based on the stratification by the percentage of the absolute risk predicted by the priority codes assigned during MTS stratification, patients were classified into 4 a priori risk groups: <5%, between 5% and 15%, between 15% and 30%, and ≥30%. The NRI tested how the presence of EDACS in triage can optimize patient classification, moving patients up or down in risk categories, in both patient outcome and controls. The unweighted sum of these improvements expresses the NRI. DCA is a new, simple method to assess the clinical benefit of predictive models and formulate better clinical strategies. On the basis of DCA, the net clinical benefit of implementing EDACS in triage over standard clinical management provides for a range of threshold probabilities for patient risk outcomes. Statistical tests with p values of <0.05 were considered significant for all analyses. Statistical analysis was conducted using the statistical software STATA 16.0 (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, Texas: StataCorp LLC.).

The study was approved by the Local Ethics Committee (Comitato etico per la sperimentazione clinica, Azienda Sanitaria dell'Alto Adige, Bolzano, Italia, approval No. 94-2019) and was conducted according to the Declaration of Helsinki, adhering to the Ethical Principles for Medical Research Involving Human Subjects.

The number of patients admitted in the ED for chest pain in the study period was 1,958. There were 1,596 patients enrolled in the study (Figure 1). The baseline characteristics of the study cohort are listed in Table 1. The application of the 5-level emergency triage divided the patients into blue 1.1% (17/1,596), green 44.3% (707/1,596), yellow 37.2%

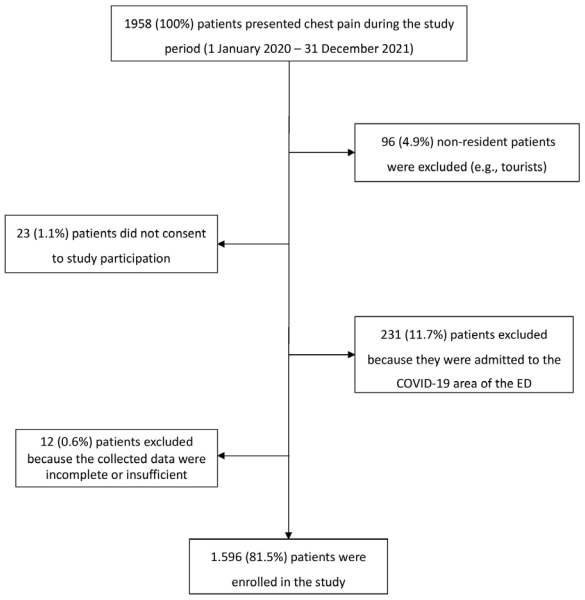

Figure 1. Flow chart of patients enrolled in the study.

(594/1,596), orange 17.1% (273/1,596) and red 0.3% (5/1,596). A total of 82.6% (1,318/1,596) were prioritized as nonurgent patients (blue, green, and yellow) and 17.4% (278/1,596) with an urgent code (orange and red).

In total, 7.3% (116/1,596) of patients presented an acute cardiovascular event. The baseline characteristics of patients who did and did not present the study outcome are listed in Table 2. Of the 116 patients with a positive outcome, 45.7% (53/116) were classified as urgent in the triage whereas 54.3% (63/116) were coded as nonurgent, p <0.001. The triage system, therefore, presented a sensitivity of 45.7% (96% CI 45.2 to 46.1), a specificity of 84.8% (95% CI 83.8 to 85.7), and an accuracy of 81.9% (95% CI 81.8 to 81.9). The discriminatory ability of the triage for the outcome in patients with chest pain had an AUROC of 0.688 (0.635 to 0.740).

The mean EDACS value in the study sample was 11 (SD 8). Patients who presented the study outcome had a mean EDACS value of 19 (SD 6), whereas patients who did not present the outcome had a mean value of 10 (SD 9) (p <0.001). Only 2.7% (29/1,069) of patients with an EDACS <16 presented the study outcome compared with 16.5% (87/527) who presented the value ≥16, p <0.001. The sensitivity, specificity and accuracy of EDACS were 75.0% (95% CI 67.2 to 82.8), 70.3% (95% CI 62.0 to 78.6) and 70.1% (95% CI 67.9 to 72.3), respectively. AUROC of EDACS had a discriminatory capacity for the outcome of 0.805 (0.770 to 0.839).

The comparison among the discriminatory ability of the 5-level triage, EDACS alone, and the combination of triage and EDACS is illustrated in Figure 2. The ROC curve of the introduction of EDACS in triage is higher than the other 2 curves (0.688 vs 0.808 vs 0.818, p <0.001). The NRI that resulted from the implementation of EDACS during the triage assessment is reported in Table 3. In patients with an acute cardiovascular event, EDACS allowed 46 patients to be reclassified into higher-risk categories, whereas 22 patients were inappropriately reclassified as lower risk. Regarding the category of patients without acute cardiovascular events, EDACS allowed the reclassification of 420 patients into a lower risk category, whereas 229 patients were classified into a higher risk category (Table 3). Thus, the predictive performance obtained using EDACS in triage and expressed in terms of the NRI index was 33.6% (p <0.001). Better reclassification was especially evident in the intermediate-risk groups (5% to 15% and 15% to 30%), where 35.6% (31/87) of patients with a diagnosis of an acute cardiovascular event, and 53.5% (418/780) of patients without a diagnosis of the acute cardiovascular event, were more accurately reclassified, whereas 24.1% (21/87) and 12.5% (98/780), respectively, were less accurately classified.

The possible net clinical benefit of implementing EDACS in the triage was assessed using DCAs (Figure 3). The inclusion of EDACS in triage had a net clinical benefit superior to triage alone over a wide range of threshold probabilities. In threshold probability of 5% to 15%, the use of EDACS resulted in a net clinical benefit of 2% to 6%, suggesting the possibility of detecting up to 6 additional true positives per 100 patients assessed for chest pain in the ED, that were not previously correctly identified by triage alone.

Table 1
Baseline characteristics and medical history recorded in triage of the cohort of patients enrolled in the study (n = 1,596)

Variable	Total
Age in years, mean (SD)	57 (19)
Gender	
Male	816 (51.1%)
Female	780 (48.9%)
Arrival mode	
Autonomous	1,027 (64.3%)
Ambulance	442 (27.7%)
Emergency medical service	127 (8.0%)
Vital parameters, median (IQR)	
Systolic blood pressure (mm Hg)	143 (129−160)
Diastolic blood pressure (mm Hg)	82 (75−90)
Oxygen saturation (%)	98 (97−99)
Hearth rate (bpm)	80 (70−90)
Respiratory rate (breath per minute)	16 (14−18)
Medical history	
Ischemic heart disease	198 (12.4%)
Hypertension	317 (19.9%)
Atrial fibrillation	104 (6.5%)
Chronic kidney failure	37 (2.3%)
Diabetes mellitus	88 (5.5%)
Chronic heart failure	48 (3.0%)
Dyslipidemia	170 (10.7%)
Stroke	22 (1.4%)
Pulmonary embolism	14 (0.9%)
Associated symptoms	
Palpitation	19 (1.2%)
Syncope	4 (0.3%)
Dyspnea	76 (4.8%)
Triage priority code	
Blue	17 (1.1%)
Green	715 (44.3%)
Yellow	601 (37.2%)
Orange	276 (17.1%)
Red	5 (0.3%)

Table 2
Univariate analysis of baseline characteristics and medical history recorded in triage, divided between patients who reported the outcome and those who did not

Variable	No Acute Cardiovascular Event	Acute Cardiovascular Event	p Value
Patients	1,480 (92.7%)	116 (7.3%)	
Age in years, mean (SD)	56 (19)	68 (14)	<0.001
Gender			<0.001
Female	745 (50.3%)	35 (30.2%)	
Male	735 (48.7%)	81 (69.8%)	
Medical history			
Ischemic heart disease	162 (10.9%)	36 (31.0%)	<0.001
Hypertension	272 (18.4%)	45 (38.8%)	<0.001
Atrial fibrillation	95 (6.5%)	9 (8.6%)	0.337
Chronic kidney disease	33 (2.3%)	4 (3.4%)	0.353
Diabetes mellitus	74 (5.0%)	14 (12.1%)	0.004
Chronic heart failure	45 (3.1%)	3 (2.6%)	1.000
Dyslipidemia	143 (9.7%)	27 (23.3%)	<0.001
Stroke	19 (1.3%)	3 (3.4%)	0.087
Pulmonary embolism	13 (0.9%)	1 (0.9%)	1.000
Vital parameters, median (IQR)			
Systolic blood pressure (mm Hg)	141 (128−160)	150 (132−169)	0.013
Diastolic blood pressure (mm Hg)	82 (75−90)	81 (75−96)	0.463
Oxygen saturation (%)	98 (97−99)	98 (96−98)	0.024
Heart rate (bpm)	80 (70−90)	77 (64−87)	0.035
Respiratory rate (breaths per minute)	16 (14−18)	16 (14−18)	0.642
Triage priority			<0.001
Non-urgent	1,255 (84.8%)	63 (54.3%)	
Urgent	225 (15.2%)	53 (45.7%)	

Using a large prospective cohort of patients assessed in the ED for chest pain, this study investigated the predictive ability of EDACS recorded during triage nursing assessment and its possible role in improving triage risk prediction. The results of the study confirmed the good performance of EDACS in assessing patients with chest pain and suggest that its implementation during triage may improve the prediction of the risk of acute cardiovascular events.

Recently, triage has assumed a central role in the organization of Western EDs. The continuous increase in ED admissions combined with a limitation of available resources indicate that the correct determination of the real risk of patients presenting at the ED is crucial for patient outcome and the good performance of the overall ED system.[6,14] Chest pain is one of the main causes of ED access and remains an insidious symptom to assess[8,12,13] Because the medical assessment of a patient with chest pain has been facilitated by various predictive tools in recent years, the triage performed by nurses has shown less success.[5,7] The suboptimal predictive capabilities of triage systems have not been improved by introducing triage tools as has happened in the medical assessment in the ED.[8,9] To the best of our current knowledge, this is the first study to evaluate the impact of EDACS obtained during nurse triage assessment in standard clinical practice. The study presents some important findings that can be applied in clinical practice.

First, the study seems to confirm that triage systems have difficulties in stratifying patients with chest pain with possible acute cardiovascular disease. Confirmation of good specificity is, however, associated with a sensitivity of <50%, meaning that an adequate safety profile cannot be provided.[9,15] Nishi et al[8], in their study on MTS and chest pain, reported a sensitivity of 44.6% and a specificity of

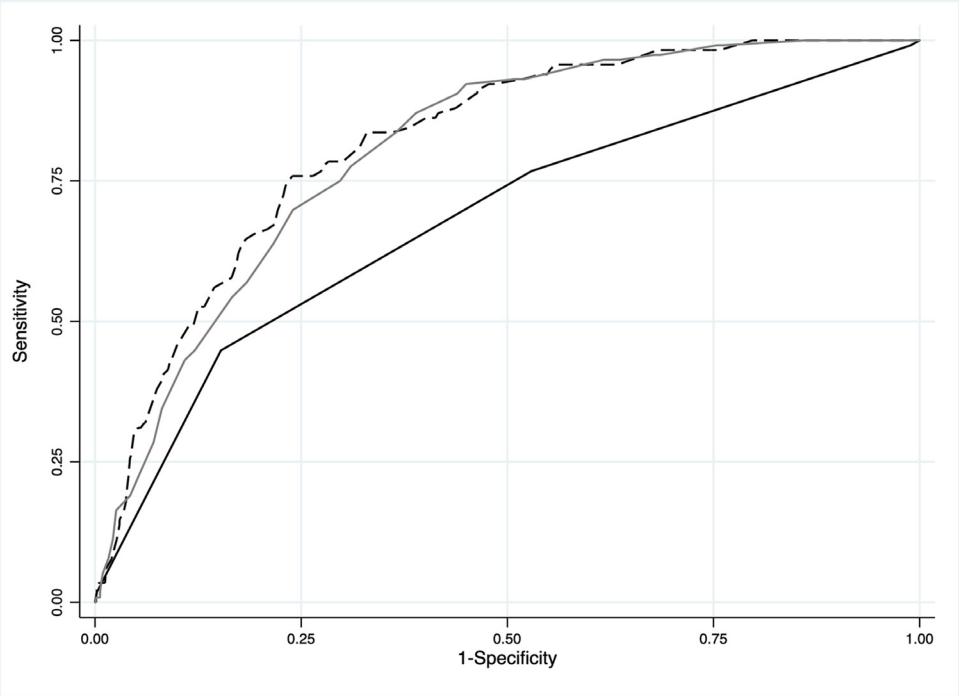

Figure 2. Representation of the 3 different priority classifications compared using receiver operating characteristic (ROC) curves. The black line represents triage performance, the gray line represents EDACS performance and the black dashed line represents the performance of EDACS and triage combined.

Table 3
Results of net reclassification improvement obtained by combining the EDACS by the nurse and the triage priority level. Cells with the number bolded and underlined indicate patients whose risk prediction improved due to EDACS, and cells with the number in bold indicate patients whose risk prediction worsened due to EDACS

Patients Who Presented the Study Outcome					
	Basic Triage Priority Level	Basic Triage Priority Level+Emergency Department Assessment of Chest Pain Score			
Positive Outcome	Total	<5%	5%−15%	15%−30%	≥30%
<5%	27	12	**13**	**2**	0
5%−15%	37	**2**	13	**16**	**6**
15%−30%	50	**2**	**17**	22	**9**
≥30%	2	0	0	**1**	1
Total	116	16	43	41	16
Patients who did not present the study outcome					
	basic triage priority level	basic triage priority level+Emergency Department Assessment of Chest Pain Score			
Negative outcome	total	<5%	5%−15%	15%−30%	≥30%
<5%	697	566	**118**	**13**	0
5%−15%	557	**287**	201	**55**	**14**
15%−30%	223	**32**	**99**	63	**29**
≥30%	3	**1**	0	**1**	1
Total	1.480	886	418	132	44

91.3% in the identification of AMI, these results are comparable to those of this study. Sanders et al[16] considered patients diagnosed with AMI and found that only 54.1% of patients were correctly prioritized with an emergency severity index level 2 or 1, indicating an unsatisfactory performance of the triage system. In a detailed systematic review, Hinson et al[9] analyzed the most widely used triage systems (Canadian Triage Acuity Scale, Emergency Severity Index, MTS, Australasian Triage Scale, South African Triage Scale) and reported that triage fails to be adequately accurate, especially with complex symptoms or diagnosis (sensitivity of 56% to 79% for ST-segment elevation myocardial

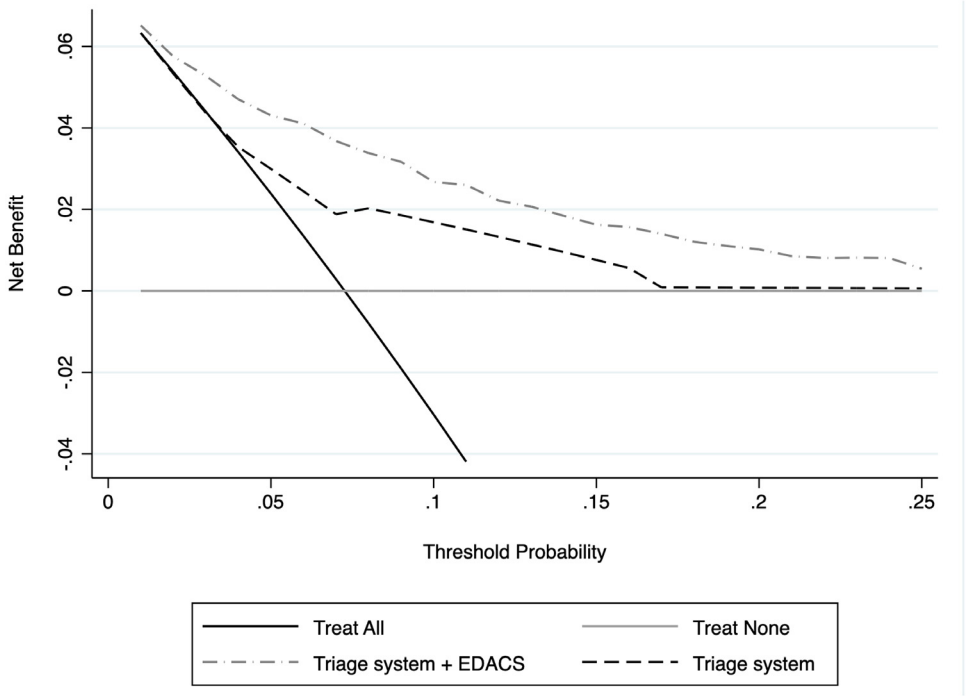

Figure 3. Decision curve analysis for the determination of the net clinical benefit from triage (black dashed line) and the implementation of EDACS in triage (gray dashed and dotted line) evaluation in patients with chest pain. The *x* axis indicates the threshold probability for adverse cardiac events and the *y* axis indicates the net benefit. The black line assumes that all the patients would have the composite outcome, whereas the gray line reflects the assumption that no patients would have the composite outcome. The dashed black line represents the net clinical benefit provided by the triage evaluation and the gray dashed and dotted line represents the net clinical benefit provided by the introduction of EDACS in the triage evaluation. As demonstrated in the graph, EDACS in triage achieved greater clinical utility in the threshold probability, indicating that EDACS may be a valuable tool in defining the priority of patients.

infarction and 44% to 63% for non−ST-segment elevation myocardial infarction).

Secondly, the study confirmed that in a different setting, namely the context of a triage assessment that is rapid and stressful, EDACS is accurate and predictive for the risk of acute cardiovascular events. Previously, Leite et al[17], in a retrospective reconstruction of HEART scores with triage information, described a very high sensitivity of over 90% and a specificity of 63.2%. The authors concluded that the HEART score may be a useful tool for decision-making in triage in patients with chest pain. Compared with HEART performed by Mark et al[18], EDACS combined with the accelerated diagnostic protocol (EDACS-ADP) (ECG and troponin) performed comparably. Despite the excellent performance of the HEART score and EDACS-ADP, their implementation in standard clinical practice in the most widely used triage systems appears not to be possible. The need for ECG interpretation and especially the need for troponin development, that would alter the timing of triage and its fundamental characteristic of speed, are elements that seem to deter the use of HEART scores in triage.[19] By contrast, compared with more complex instruments, the application of a simple and rapid score such as EDACS, even without troponin, may be easier to apply to the clinical practice with better results.[12]

Third, the high specificity of MTS and the high sensitivity of EDACS could complement each other to improve the triage performance. Triage systems are designed to identify time-dependent urgent conditions within a multitude of heterogeneous clinical presentations.[9,20] When tested for a specific symptom, such as chest pain, triage systems appear to have good specificity, ensuring that when a minor code is given there is not a serious condition, however, it struggles to detect the presence of the severe condition, often assigning severe codes to patients without an acute condition.[8,21,22] Conversely, a tool such as EDACS, designed to identify pathology, is unable to support triage operations on its own because it is limited in its ability to safely address the complex symptoms of patients admitted in the ED.

This study has several limitations. First, the length of time required for triage evaluation was not collected. The impact of EDACS on triage times cannot be specified. However, EDACS is an easily applicable and quick-to-use tool and contains information that is already required in the standard triage nursing history, and therefore a hypothetical routine use of EDACS should not increase triage time. Second, there was no investigation of how EDACS may have an impact on the timing of subsequent assessments (time until medical evaluation, duration of medical evaluation, length of stay in ED). Third, owing to the COVID-19 pandemic, patients with chest pain may not respect the previously observed proportions of pathological and nonpathological patients.

The assessment of chest pain is complicated, and the correct classification of the patient at triage appears to be a critical challenge. The introduction of specific clinical tools in recent years has improved the medical prediction of patients with chest pain. The results of this study suggest that EDACS has a good discriminatory capacity for acute cardiovascular events, and its routine implementation may improve triage performance for patients with chest pain. Further evidence is needed to confirm these initial findings, but it seems possible to optimize triage by incorporating symptom-specific clinical tools into nursing decision-making.

Disclosures

The authors have no conflicts of interest to disclose.

Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amjcard.2021.08.058.

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