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ORIGINAL RESEARCH

Predictive Factors of CPR Failure After 20 Minutes of Advanced Cardiac Life Support for Non-Traumatic Out-of-Hospital Arrest Cases; a Cross-sectional Study

Thongpitak Huabbangyang[1,2], Paskorn Sritipsukho[3,4]*

1. Department of Clinical Epidemiology, Faculty of Medicine, Thammasat University, Pathum Thani, Thailand

2. Department of Disaster and Emergency Medical Operation, Faculty of Science and Health Technology, Navamindradhiraj University, Bangkok, Thailand

3. Department of Pediatrics, Faculty of Medicine, Thammasat University, Pathum Thani, Thailand

4. Center of Excellence in Applied Epidemiology, Thammasat University, Pathum Thani, Thailand

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Abstract: Introduction: In patients with out-of-hospital cardiac arrest (OHCA) who receive advanced cardiac life support (ACLS) for 20 minutes, the decision of whether to continue or terminate resuscitation at the scene is difficult and complicated. This study aimed to develop and validate a simple and reliable clinical scoring system for identifying cardiopulmonary resuscitation (CPR) failure at the scene after 20 minutes of ACLS. **Methods:** In this cross-sectional study we evaluated the adults with nontraumatic OHCA who received ACLS for 20 minutes. The independent predictors of CPR failure were identified using multivariate regression analysis and trying to develop a clinical decision rule. Receiver operating characteristic (ROC) curve was used for evaluating the performance of the developed model. **Results:** 455 patients with the mean age of 63.85 ± 19.21 years were included (65.1% male). In most cases of OHCA, the cause of cardiac arrest was respiratory (54.9%). The first cardiac rhythm recorded in 68.1% was asystole. 313 (68.79%) cases were affiliated to the failed CPR group. The independent predictive factors of CPR failure based on multivariate analysis were the first cardiac rhythm recorded ($p < 0.001$), unwitnessed cardiac arrest ($p < 0.001$), lack of pupillary response ($p < 0.001$), advanced airway management at the scene ($p < 0.001$), and administration of drugs at the scene during CPR, including amiodarone ($p = 0.020$) and atropine ($p = 0.002$). The area under the ROC curve of the model was 0.832 (95% confidence interval (CI): 0.793–0.870) with 70.0% sensitivity, 82.4% specificity, 89.8% positive predictive value, 55.5% negative predictive value, 3.97 positive likelihood ratio, and 0.36 negative likelihood ratio. **Conclusion:** Using data from routine care practices by EMS personnel, we devised a simple clinical scoring system for predicting CPR failure at the scene of OHCA after 20 minutes of complete ACLS.

Keywords: Out-of-hospital emergency care; Out-of-hospital cardiac arrest; Out-of-hospital heart arrest; Return of spontaneous circulation; Emergency medical services

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1. Introduction

Out-of-hospital cardiac arrest (OHCA) is an emergency that necessitates immediate management to resuscitate patients. It is an important health issue and a global cause of mortality (1); the worldwide incidence is 50–60 per 100,000 population (2). In the U.S., over 350,000 OHCA cases occur annually, mostly in adults and older adults (3). In Central America, the incidence was reported to be 17–128 per 100,000, and in Asia 21–29 cases per 100,000 (4). The return of spontaneous circulation (ROSC) rate in patients with OHCA at the Vajira Emergency Medical Service was 25.6% (5). According to the standard data reporting system of the Pan Asian Resuscitation Outcomes Study, the rate of survival to discharge of patients with OHCA who were resuscitated by emergency medical services (EMS) in Asian countries was 6% in Thailand (6). Outcome differences after OHCA may stem from variations in study settings, sample sizes, demographics, EMS management, and potential hospital selection bias (7-8).

Cardiopulmonary resuscitation (CPR) has been applied since 1960 for resuscitating patients with acute cardiac arrest (6); as a result of improvements in the technique, CPR has become the standard global guideline for resuscitation by the American Heart Association (AHA) (9). According to one system-

* **Corresponding Author:** Paskorn Sritipsukho; Department of Pediatrics, Faculty of Medicine, Thammasat University, Pathum Thani, Thailand. Center of Excellence in Applied Epidemiology, Thammasat University, Pathum Thani, Thailand. Tel: +66 2-926-9514, Email: paskorn100@gmail.com, ORCID: https://orcid.org/0000-0002-9886-0812.

atic review and meta-analysis, prognostic factors for ROSC after OHCA were the witnessing of OHCA by a bystander and a shockable cardiac rhythm (10).

Predictors of favorable neurological outcomes in OHCA include younger age, male sex, shockable rhythm, witnessed arrest, bystander CPR, and shorter time to cannulation (11). In contrast, non-shockable rhythms (e.g., asystole), sepsis, septic shock, and acidosis were linked to CPR failure and higher mortality (12). Another study found that physicians overestimated in-hospital cardiac arrest survival by up to 300% and ROSC rates by more than double the actual outcomes (13). Most physicians avoided reporting ROSC predictions or CPR failure due to insufficient data for accurate outcome prediction (14).

In the past, several tools developed to assist physicians in predicting CPR failure in hospitals have been used and accepted. The pre-arrest morbidity (PAM) score, developed by George et al. (15), includes 15 variables, and the total possible score is 25. Each variable is scored as 0, 1, and 3. In patients with scores of ≥8, CPR is likely to fail, which reduces the chance of survival to discharge; the area under the receiver operating characteristic (ROC) curve (AuROC) is 0.519 (16). A second tool, the prognosis after resuscitation (PAR) score, developed by Ebell on the basis of a meta-analysis (16), includes 7 variables, each scored from -2 to 10. The higher the score, the higher the chance that the patient will not survive to discharge, especially after cardiac arrest in patients with scores of >8; the AuROC was 0.564 (16). A third tool, the modified PAM index (MPI), was an update of the PAM score (17) according to a retrospective observational study of survival after cardiac arrest; it includes 32 variables.

All three CPR failure prediction tools were developed for in-hospital cardiac arrest (IHCA) and are not suited for the distinct context of OHCA (18). The 2020 American Heart Association (AHA) guidelines recommend termination of resuscitation (TOR) based on two levels: In basic life support, TOR is allowed if the arrest wasn't witnessed by EMS, no ROSC occurred, and no shocks were given. In advanced life support, TOR applies if the arrest wasn't witnessed, no bystander CPR was provided, no ROSC followed 20 minutes of ACLS, and no automated external defibrillator (AED) shocks were delivered. If these criteria aren't met, the patient must be resuscitated and transported (9). One meta-analysis demonstrated that the TOR decision had high specificity (96%) for predicting death within 30 days (19) and another study showed its 99%–100% positive predictive value in this regard (20). In developing countries like Thailand, where emergency physicians are often absent at OHCA scenes, TOR is debatable (21).

This study developed and validated a clinical scoring system to help EMS personnel decide on TOR after 20 minutes of complete ACLS in adult nontraumatic OHCA cases in developing countries.

2. Methods

2.1. Study design and setting

This retrospective, cross-sectional study was conducted in Vajira Emergency Medical Service (V-EMS), a division of Vajira Hospital, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok, Thailand. The independent predictors of CPR failure after 20 minutes of ACLS in adult non-traumatic patients were identified using multivariate regression analysis, and an attempt was made to develop a clinical decision rule for OHCA cases.

We used a standard data reporting format in accordance with the Standards for the Reporting of Observational Studies in Epidemiology (STROBE) statement (22). This study was conducted in accordance with the tenets of the 1975 Declaration of Helsinki and its revisions in 2000. The study protocol was approved by the Institutional Review Board of the Faculty of Medicine Vajira Hospital, Navamindradhiraj University (COA no. 036/2568) and The Human Research Ethics Committee of the Faculty of Medicine, Thammasat University, Bangkok (COA no. 054/2568). The requirement for informed consent was waived because of the retrospective nature of the study and the anonymization of all patient data.

V-EMS serves zone area 1 in Bangkok, dispatching EMS personnel from Erawan Center and networking with a total of six public and private hospitals in this area, which covers 50 km2 and serves a population of 500,000 (21). For patients with OHCA in this area, one team is dispatched for each emergency; the team includes at least three staff members who are paramedics or emergency nurse practitioners, one of whom serves as an operation team leader, and others serve as emergency medical technicians. In each emergency, paramedics or emergency nurse practitioners follow offline and online medical protocols, under emergency physicians' orders. In cases of cardiac arrest in our area, the 2020 AHA guidelines are applied by the paramedics or emergency nurse practitioners. Everyone in the V-EMS has passed ACLS training and is certified as an ACLS provider. Patients with nontraumatic OHCA are managed with the "stay and play" method of comprehensive life support according to V-EMS; in cases of traumatic OHCA, the "scoop and run" method, which is the standard method for V-EMS operation, is used.

2.2. Participants

The data of OHCA in non-traumatic adults (> 18 years) cases, who received ACLS for 20 minutes according to CPR guidelines (9), were collected from EMS patient care reports that were coded according to Thailand's emergency medical triage protocol and criteria-based dispatch (code 6, which represents cardiac arrest). The patients were managed by V-EMS, Vajira Hospital, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok, Thailand, between January 1, 2017, and December 31, 2024.

Patients in whom ROSC occurred within 20 minutes; patients who were considered dead by a team leader according to the presence of livor mortis, rigor mortis, or other signs; patients who refused CPR; those with do-not-resuscitate orders; those who received CPR for an unknown duration from the EMS team or a bystander; those with repeated cardiac arrest; those who received CPR during transport to a hospital; and those for whom resuscitation data were incomplete or missing were excluded.

2.3. Data gathering

Each patient's data was collected from the EMS patient care report, a standard form for data recording by dispatchers and paramedics or emergency nurse practitioners at the scene. These data included identities of EMS operation units and patients and all treatments administered by the EMS teams. All data were recorded in Microsoft Excel by the principal investigator (TH). The data comprised sex, age, comorbidity, location type (divided into public, which was cardiac arrest at a public place, such as park, temple, or school, and non-public, including house or condominium, etc.), the cause of cardiac arrest, the first cardiac rhythm recorded, whether the cardiac arrest was witnessed, the patient's pupillary response, whether a bystander performed CPR or used an AED, how soon the EMS team responded, defibrillation by EMS personnel at the scene, advanced airway management at the scene, drugs administered at the scene during CPR, and CPR failure. TH was responsible for data gathering.

2.4. Statistical analysis

To determine sample size in this study, we utilized the "pmsampsize" command of Stata, release 17.0 (StataCorp LLC, College Station, TX, USA), which calculates the minimum sample size required for developing a multivariable prediction model. We determined the C-statistic of 0.8 for an equation created to predict CPR failure. The R2 calculated from the equation was 0.2611. The calculated sample size was at least 409. To prevent data incompleteness, we added 10% to this number, using the formula n = 409/(1-0.10); the resulting sample size was 455. We used simple random sampling to select patients.

We performed a descriptive analysis to examine variable distribution. Data for continuous variables were calculated as means ± standard deviations or as medians and interquartile ranges (IQRs), and data for categorical variables were calculated as frequencies and proportions. When we compared patients in whom CPR failed with those in whom it was successful, we evaluated differences by using the independent-samples t-test or the Mann–Whitney U test for numeric variables and the chi-square test or Fisher's exact test for categorical variables. To evaluate factors predictive of CPR failure at the scene after 20 minutes of complete ACLS for OHCA, we performed univariable and multivariable analyses with multiple logistic regression analysis, determining regression coefficients, odds ratios (ORs), and 95% confidence intervals (CIs), through backward elimination. The relevant factors identified in univariable analysis as statistically significant ($p < 0.2$) were used in the multivariable analysis. Then we used the Wald test to eliminate non-associated independent variables one by one. We calculated R2, performed the Hosmer–Lemeshow goodness-of-fit test, and determined the AuROC and the 95% CI. After that, we used the regression coefficient to create the equation to predict CPR failure.

For internal validation of this equation, we used ROC analysis, reported with AuROC, and we chose the cutoff score by using the Youden index, with sensitivity, specificity, the positive predictive value, the negative predictive value, the positive likelihood ratio, the negative likelihood ratio, and the 95% CI. We used bootstrap methods to calibrate the risk score to predict CPR failure at the scene after 20 minutes of complete ACLS for OHCA. Results of all statistical tests were considered statistically significant when the p value was ≤0.05. Stata release 17.0 was used for all analyses.

3. Results

3.1. Baseline characteristics of studied patients

455 patients with the mean age of 63.85 ± 19.21 years met the inclusion criteria (65.1% male; Figure 1). 313 (68.79%) cases were affiliated to the failed CPR group. Most patients had at least 65 years of age (52.1%) and had comorbidities (56.9%), which included hypertension, diabetes, coronary heart disease heart disease, dyslipidemia, renal disease, cancer, respiratory disease, and stroke (Table 1). Cardiac arrest occurred mostly in nonpublic sites (69.7%). In most cases of OHCA, the cause of cardiac arrest was respiratory (54.9%). The first cardiac rhythm recorded in 68.1% was asystole. The cardiac arrest was witnessed in 40.9% of the patients, and pupillary responses were detected in 11.6%. CPR was performed by bystanders in 47% of cases, and bystanders used an AED in 9.5%, as the rhythm found to be non-shockable in most cases. The mean time for EMS to respond to emergency calls was 12.69 ± 6.55 minutes; most such response times were at least 8 minutes. Defibrillation was performed at the scene in 19.3% of the cases, but most patients underwent advanced airway management at the scene with an endotracheal tube (85.3%). The drugs used during CPR at the scene included adrenaline (89.7%), sodium bicarbonate, amiodarone, calcium gluconate, glucose, and atropine (Table 1).

3.2. Associated factors of CPR failure (Univariate analysis)

To evaluate factors associated with CPR failure at the scene after 20 minutes of complete ACLS, we performed univariable analysis with simple logistic regression analysis. The following factors were significantly associated with CPR failure in the aforementioned scenario (Table 1): age ≥65 years ($p = 0.009$), presence of respiratory disease ($p = 0.043$), a respiratory cause of cardiac arrest ($p = 0.015$), asystole as the first cardiac rhythm recorded ($p < 0.001$), unwitnessed cardiac arrest ($p < 0.001$), lack of pupillary response ($p < 0.001$), CPR performed by a bystander ($p < 0.001$), AED application by a bystander ($p < 0.001$), defibrillation by EMS personnel at the scene ($p < 0.001$), advanced airway management at the scene ($p < 0.001$), and administration of drugs at the scene during CPR, such as adrenaline ($p = 0.001$), amiodarone ($p < 0.001$), and atropine ($p = 0.001$).

3.3. Associated factors of CPR failure (Multivariate analysis)

According to the multivariable analysis, the independent predictive factors of CPR failure for non-traumatic OHCA cases were asystole as the first cardiac rhythm recorded ($p < 0.001$), unwitnessed cardiac arrest ($p < 0.001$), lack of pupillary response ($p < 0.001$), advanced airway management at the scene ($p < 0.001$), and administration of drugs at the scene during CPR, including amiodarone ($p = 0.020$) and atropine ($p = 0.002$; Table 2).

The equation for predicting CPR failure was suitable according to the Hosmer–Lemeshow test (X2 = 5.83; df = 6; $p = 0.442$). In addition, the variables used in the analysis had no multicollinearity, and R2 = 0.2725; thus, six independent variables in the model—the first cardiac rhythm recorded, witnessed cardiac arrest, pupillary response, advanced airway management at the scene, and two drugs (amiodarone and atropine) administered at the scene during CPR—could explain the 27.25% variation in the prediction of CPR failure. In the format of logit transformation, in which logit P(X) = b0 + b1X1 + b2X2 + b3X3 + … + bnXn, the predictive equation could be written as follows:

Logit P(CPR failure at the scene after 20 minutes of complete ACLS) = -5.319 + 1.544X1 + 0.710X2 + 1.255X3 + 1.439X4 + 1.994X5 + 0.878X6 + 2.221X7

in which -5.319 is the constant; X1 represents asystole as the first cardiac rhythm recorded; X2 represents ventricular fibrillation as the first cardiac rhythm recorded; X3 represents no witnessed arrest; X4 represents no pupillary response; X5 represents no advanced airway management at the scene; X6 represents no amiodarone; and X7 represents no atropine.

3.4. Model performance

To analyze the predictability of CPR failure at the scene, we performed ROC analysis and calculated the AuROC. The regression equation could predict CPR failure statistically significantly with an AuROC of 0.834 (95% CI: 0.795–0.872; Figure 2a.). In addition, to simplify the equation for application, the authors conducted score transformation, utilizing the logistic regression coefficient. The scoring criteria for each variable were determined (Table 2). The score from the calculation of this equation was designated the clinical score in the prediction of CPR failure. The study population had a mean risk score of 8.69 ± 2.24 (range: 1–13), and this score was classified according to CPR failure. Patients with and without CPR failure had average clinical scores of 9.51 ± 1.82 and 6.89 ± 1.99, respectively, which differed significantly ($p < 0.001$).

In validating the clinical score in predicting CPR failure, we found that this score had an AuROC of 0.832 (95% CI: 0.793–0.870; Figure 2a). Postestimation ROC analysis revealed that the AuROC was 0.847 (95% CI: 0.850–0.916; Figure 2b).

To classify patients in terms of CPR failure, we used the Youden index to choose a score cutoff point. A clinical score of at least 9 indicated high risk for CPR failure at the scene after 20 minutes of complete ACLS for OHCA; it has 70.0% sensitivity, 82.4% specificity, a positive predictive value of 89.8%, a negative predictive value of 55.5%, a positive likelihood ratio of 3.97, and a negative likelihood ratio of 0.36 (Table 3). We constructed a calibration plot between the score-predicted probability of CPR failure and the CPR failure observed in the aforementioned scenario (Figure 3a). The distribution of the clinical prediction score of CPR failure is illustrated in Figure 3b. Results of risk curve analysis—observed risk and predicted risk of CPR failure at the scene after 20 minutes of complete ACLS—are depicted in Figure 4.

4. Discussion

The developed prediction score in this study showed an area under the ROC curve of 0.832, with 70.0% sensitivity and 82.4% specificity, indicating high accuracy in predicting CPR failure at the scene after 20 minutes of complete ACLS. In Thailand, which is a middle-income country, 68.79% of the patients were resuscitated by the EMS team. In 2000, the National Association of EMS Physicians recommended that CPR be performed for at least 20 minutes, which would be considered a sufficient attempt at ACLS (23). A previous report revealed that of the patients with IHCA and non-shockable rhythm, especially asystole, after CPR for more than 20 minutes, fewer than 1% survived, and none had favorable neurological outcomes at discharge (24). Since then, 20 minutes has remained the recommended criterion when CPR termination is considered (9,25) and is compatible with recommendations by the European Resuscitation Council in 2015 (26) and 2021 (27).

Ethical recommendations are that CPR duration not exceed 20 minutes in cases of non-shockable rhythm and absence of ROSC after ACLS by the EMS team. However, prolonged CPR might be beneficial in cases of refractory cardiac arrest. Although the amount of empirical evidence for 20 minutes is limited, the appropriate duration for CPR termination is debatable. In addition, maximal CPR duration cannot be clearly determined because in the clinical context, many factors should be considered; however, CPR duration that is shorter (because the patient responded) probably leads to better results in terms of both ROSC and favorable neurological outcomes than does a longer CPR duration (9).

Second, we found five factors that were predictive of CPR failure at the scene after 20 minutes of complete CPR:

1. Asystole as the first cardiac rhythm recorded at the scene. Asystole is a non-shockable heart rhythm without the role of AED application. We found that in patients with asystole, the chance of CPR failure was 4.68 times that for patients in

whom the first cardiac rhythm recorded was pulseless electrical activity. This finding was consistent with those of previous studies, in which the chances of CPR failure in patients with asystole were 1.63 (28), 7.83 (12), and 10.31 (29) times higher than in those with other cardiac rhythms. Therefore, patients who's first recorded cardiac rhythm was asystole had a low survival rate, and the chance of CPR failure was significantly high (29). AHA recommendations regarding basic life support, ALS, and TOR are that no AED shocks be delivered in cases of asystole, which can influence the decision to terminate CPR without transport to a hospital (9).

2. No witnesses for cardiac arrest. We found that in patients with OHCA who received CPR for 20 minutes, CPR failure was 3.51 times more likely when cardiac arrest was unwitnessed than when it was witnessed. This finding was consistent with those of a retrospective single-center cohort study, in which ROSC was 4.91 times more likely to occur in patients with witnessed OHCA than in those with unwitnessed OHCA. Furthermore, in patients with unwitnessed cardiac arrest, the chances of unfavorable neurological outcomes were significantly higher (29) and, according to a large systematic review and meta-analysis, rates of survival with favorable functional outcomes were lower than in those with witnessed cardiac arrest (11). Consequently, unwitnessed cardiac arrest was one of the variables in the AHA's recommendations for CPR termination without transport to a hospital (9).

3. No pupillary response. We found that among patients with OHCA, CPR for 20 minutes was 4.22 times more likely to fail in those who exhibited no pupillary response than in those with a pupillary response. We found that nonreactive pupils were one of the clinical indicators that could be used in the assessment of central nervous system function in patients resuscitated from cardiac arrest. Many previous studies about the association between nonreactive pupils and CPR outcomes have shown that nonreactive pupils during CPR were associated with CPR failure and reduced rates of survival to discharge (30,31). According to the 2021 guidelines of the European Resuscitation Council and the European Society of Intensive Care Medicine, continuously nonreactive pupils during CPR and after resuscitation might be associated with significantly increased rates of mortality (32).

4. No advanced airway management at the scene. We found that in patients with OHCA who received only bag-valve-mask ventilation but not advanced airway management at the scene, CPR was 7.34 times more likely to fail after 20 minutes than in those who received endotracheal intubation. This finding was consistent with those of a systematic review and meta-analysis in which the application of bag-valve-mask ventilation yielded worse outcomes than did endotracheal intubation in terms of ROSC (24% vs. 48%, respectively; relative risk [RR] = 0.86), the rate of survival to hospital admission (21% vs. 27%; RR = 1.037), and the rate of survival to discharge (6% vs. 12%; RR = 1.476) (33). This finding, however, conflicted with that of a retrospective study involving a large Thailand database (Information Technology of EMS [ITEMS]) in which the National Institute for Emergency Medicine reported no significant difference between application of bag-valve-mask ventilation and endotracheal intubation in terms of ROSC and minimally higher rates of ROSC with the former than with the latter (19.63% vs. 15.56%; p = 0.148). According to that study, patients who received bag-valve-mask ventilation had less severe symptoms, and most were immediately transported to hospitals for faster treatment, than did those who received endotracheal intubation (34). However, bag-valve-mask ventilation in the case of OHCA might not prevent aspiration and may have a higher risk of inadequate ventilation (35).

5. No administration of drugs (e.g., amiodarone and atropine) at the scene during CPR. A possible explanation for these findings was that standard AHA guidelines recommended that antiarrhythmic drugs, including amiodarone or lidocaine, be used for sustained ventricular fibrillation and pulseless ventricular tachycardia that were refractory to CPR and defibrillation; such drugs help improve ROSC outcomes in patients with cardiac arrest (9,36). In patients with OHCA who did not receive amiodarone, cardiac rhythms may have been considered viable through CPR and defibrillation; as a result, rates of CPR failure at the scene may have been higher in those patients than in patients whose cardiac rhythms were refractory to CPR and defibrillation (37). A systematic review and meta-analysis revealed that in comparison with placebo, amiodarone usage increased the chances of ROSC at the scene (ORs = 1.402, p = 0.015) but did not increase survival to discharge (relative risk = 0.850, p = 0.284) or improve neurological outcomes (ORs = 1.114, p = 0.475) (38). In patients who did not receive atropine, CPR failed after 20 minutes 9.22 times more often than in those who received atropine, which could be explained by the review of EMS patient care reports. Of the patients with OHCA, 3.1% received atropine before and during CPR for unstable bradycardia, and some received atropine for organophosphate poisoning. Administering atropine during CPR used to be an ACLS guideline in the treatment of cardiac arrest with asystole and pulseless electrical activity (39). However, the AHA has removed atropine from the standard guidelines because of no clear evidence that atropine application helps improve ROSC outcomes and survival to discharge in patients with cardiac arrest, except for those who had symptomatic bradycardia earlier or had suffered organophosphate or carbamate poisoning (9,39).

Last, we developed a simple clinical scoring system for predicting CPR failure. This system can enable EMS personnel, such as emergency physicians, paramedics, and emergency nurse practitioners, to identify such predictors in patients with OHCA, as well as to inform the patients' relatives of the prognosis in the emergency situation. The total score ranges from 0 to 14, the scoring system is easy and convenient to remember, and it can be applied at the scene in real clinical situations. A score of at least 9 can identify patients at high risk for CPR failure; it has an AuROC of 0.832, which is excellent and is supported by clinical research (40,41) with 70.0% sensitivity, 82.4% specificity, a positive predictive value of 89.8%, a negative predictive value of 55.5%, a positive likelihood ratio of 3.97, and a negative likelihood ratio of 0.36. To our knowledge, three other tools for predicting immediate CPR failure—PAM (15), PAR (16), and MPI (17)—are available, but they are designed for patients with IHCA and not OHCA; therefore, they are not useful after intervention and complete ACLS by EMS teams, as in our study. These tools are thus not suitable for predicting CPR failure at the scene in patients with OHCA, and they cannot be applied to predict survival to discharge failure. Data for variables such as malignancy stage and the diagnosis of S-T elevation myocardial infarction cannot be collected from at the scene because they can be diagnosed only in hospitals. In addition, in the original studies, PAM scores of >8 and PAR scores of >7 had AuROCs of 0.52 (15) and 0.56 (16), respectively, which have not been classified in clinical research (40,41). The MPI was developed from the PAM score (17), and it was used in two studies to predict CPR failure in cases of IHCA; however, MPI scores of ≥5 had a mean AuROC of 0.63 (range: 0.52–0.73) (42), and MPI scores of >6 had a mean AuROC of 0.61 (range: 0.59–0.64) (43), which were poor and not useful alone for classification in clinical research (40,41).

In a previous study, the ALS–TOR rule recommended by the AHA, used to predict long-term outcomes such as survival to discharge, had 27.2% sensitivity, 100.0% specificity, a negative predictive value of 7.9%, and a positive predictive value of 100.0% (44); the predictability of unfavorable neurological outcomes had 27.3% sensitivity, 100.0% specificity, a negative predictive value of 2.7%, and a positive predictive value of 100.0% (45). We believe that even if the ALS–TOR rule is easy to apply, much important data (e.g., for advanced intervention) would be missing in the context of management by the EMS team in specific situations, including management of patients with OHCA. Adherence to the ALS–TOR rule will increase the efficiency and accuracy of predicting CPR failure at the scene in patients with OHCA. We believe the newly developed clinical prediction score will substantially increase advantages in the situation where completed ACLS is performed for 20 minutes by EMS team. This clinical prediction score will help enhance additional decisions from the rule of ALS-TOR.

5. Limitations

This study had several important limitations. First, it was a retrospective cross-sectional study involving data from a single center that provides comprehensive life support in the Bangkok area of Thailand. Therefore, the study results may not be generalizable to other areas; the external validity of the clinical scoring system needs to be further investigated. Second, the data were collected retrospectively from 2017 to 2024. During this period, one new treatment guideline was developed in 2015 and another was changed by the AHA in 2020. The nature of the data may have been influenced by these differences in the recommendations of the AHA. Third, we studied only the short-term outcomes (CPR success or failure at the scene). The score's ability to predict the long-term outcomes, such as survival to hospital discharge and neurological function, must be assessed. Fourth, the studied outcomes may have been confounded by other unknown, unmeasured factors. All data were from the retrospective review of EMS patient care reports. Although we tried to maintain neutrality, selection bias may have occurred. Fifth, the EMS patient care report used for recording the data of patients with OHCA in the studied areas did not reflect the standard record and collection of the Utstein OHCA template. Lastly, only one system of EMS in Bangkok, Thailand was included in this study. Although the internal validation of the score will be adequately efficient, the external validation of the clinical prediction score is substantially required for the generalizability to the EMS of other regions.

6. Conclusions

Using data from routine care practices by EMS personnel, we devised a simple clinical scoring system for predicting CPR failure at the scene of OHCA after 20 minutes of CPR. A score of ≥9 has an acceptable AuROC of 0.832 with 70.0% sensitivity and 82.4% specificity. This scoring system might help emergency medical personnel at the scene in predicting the usefulness of CPR for OHCA.

7. Declarations

7.1. Acknowledgments

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7.2. Author contributions

Conceptualization: Thongpitak Huabbangyang, Paskorn Sritipsukho; Methodology: Thongpitak Huabbangyang; Software: Thongpitak Huabbangyang; Validation: Thongpitak Huabbangyang; Formal analysis: Thongpitak Huabbangyang; Investigation: Thongpitak Huabbangyang; Resources: Thongpitak Huabbangyang; Data Curation: Thongpitak Huabbangyang; Writing—Original Draft: Thongpitak Huabbangyang; Writing—Review & Editing: Thongpitak Huabbangyang, Paskorn Sritipsukho; Visualization: Thongpitak Huabbangyang, Paskorn Sritipsukho; Supervision: Paskorn Sritipsukho; Project administration: Thongpitak Huabbangyang; Funding acquisition: Thongpitak Huabbangyang. All authors read and approved the final version.

7.3. Funding

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7.4. Conflict of interest

The authors have no conflicting interests to declare.

7.5. Data availability

The datasets generated and analyzed during this study are available from the corresponding author on reasonable request.

7.6. Use of artificial intelligence chatbots

None.

References

1. Gräsner JT, Herlitz J, Tjelmeland IBM, Wnent J, Masterson S, Lilja G, et al. European Resuscitation Council Guidelines 2021: Epidemiology of cardiac arrest in Europe. Resuscitation. 2021;161:61-79.
2. Yeeheng U. Factors associated with successful resuscitation of out-of-hospital cardiac arrest at Rajavithi Hospital's Narenthorn Emergency Medical Service Center, Thailand. Asia Pac J Public Health. 2011;23(4):601-7.
3. Ait Hssain A, Chalkias A, Vahedian-Azimi A, Elmelliti H, Alamami A, Tawel R, et al. Survival rates with favorable neurological outcomes after in-hospital and out-of-hospital cardiac arrest: A prospective cohort study. Intensive Crit Care Nurs. 2025;87:103889.
4. Berdowski J, Berg RA, Tijssen JG, Koster RW. Global incidences of out-of-hospital cardiac arrest and survival rates: Systematic review of 67 prospective studies. Resuscitation. 2010;81(11):1479-87.
5. Thongpitak Huabbangyang P, Tavachai Soion R, Acharee Promdee R, Kasemchai Nguanjinda R, Assanai Chamchan R, Ratree Chaisorn P, et al. Factors associated withsuccessful resuscitation during out-of-hospital cardiacarrest performed by Surgico Medical Ambulance andRescue Team (SMART), Division of Emergency MedicalService and Disaster, Faculty of Medicine Vajira Hospital, Navamindradhiraj University. J Med Assoc Thai 2021;104(9):1-9.
6. Hsu SH, Sun JT, Huang EP, Nishiuchi T, Song KJ, Leong B, et al. The predictive performance of current termination-of-resuscitation rules in patients following out-of-hospital cardiac arrest in Asian countries: A cross-sectional multicentre study. PLoS One. 2022;17(8):e0270986.
7. Lee SCL, Mao DR, Ng YY, Leong BS, Supasaovapak J, Gaerlan FJ, et al. Emergency medical dispatch services across Pan-Asian countries: a web-based survey. BMC Emerg Med. 2020;20(1):1.
8. Kouwenhoven WB, Jude JR, Knickerbocker GG. Closed-chest cardiac massage. Jama. 1960;173(10):1064–7.
9. Panchal AR, Bartos JA, Cabañas JG, Donnino MW, Drennan IR, Hirsch KG, et al. Part 3: Adult Basic and Advanced Life Support: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2020;142(16_suppl_2):S366-s468.
10. Sasson C, Rogers MA, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. Circ Cardiovasc Qual Outcomes. 2010;3(1):63-81.
11. Tran A, Rochwerg B, Fan E, Belohlavek J, Suverein MM, Poll M, et al. Prognostic factors associated with favourable functional outcome among adult patients requiring extracorporeal cardiopulmonary resuscitation for out-of-hospital cardiac arrest: A systematic review and meta-analysis. Resuscitation. 2023;193:110004.
12. Pramono A, Widyastuti Y, Soenarto Y, Rochmawati E, Sudadi. Predictive Factors for Cardiopulmonary Resuscitation Failure. Indian J Palliat Care. 2021;27(3):426-30.
13. Miller DL, Gorbien MJ, Simbartl LA, Jahnigen DW. Factors influencing physicians in recommending in-hospital cardiopulmonary resuscitation. Arch Intern Med. 1993;153(17):1999-2003.
14. Christakis NA, Iwashyna TJ. Attitude and self-reported practice regarding prognostication in a national sample of internists. Arch Intern Med. 1998;158(21):2389-95.
15. George AL, Jr., Folk BP, 3rd, Crecelius PL, Campbell WB. Pre-arrest morbidity and other correlates of survival after in-hospital cardiopulmonary arrest. Am J Med. 1989;87(1):28-34.
16. Ebell MH. Prearrest predictors of survival following in-hospital cardiopulmonary resuscitation: a meta-analysis. J Fam Pract. 1992;34(5):551-8.
17. Godinjak A, Iglica A, Rama A, Tančica I, Jusufović S, Ajanović A, et al. Predictive value of SAPS II and APACHE II scoring systems for patient outcome in a medical intensive care unit. Acta Med Acad. 2016;45(2):97-103.
18. Høybye M, Stankovic N, Holmberg M, Christensen HC, Granfeldt A, Andersen LW. In-Hospital vs. Out-of-Hospital Cardiac Arrest: Patient Characteristics and Survival. Resuscitation. 2021;158:157-65.
19. Goodarzi A, Sadeghian E, Babaei K, Khodaveisi M. Knowledge, Attitude and Decision-making of Nurses in the Resuscitation Team towards Terminating Resuscitation and Do-not-Resuscitate Order. Ethiop J Health Sci. 2022;32(2):413-2.
20. Nas J, Kleinnibbelink G, Hannink G, Navarese EP, van Royen N, de Boer MJ, et al. Diagnostic performance of the basic and advanced life support termination of resuscitation rules: A systematic review and diagnostic meta-analysis. Resuscitation. 2020;148:3-13.
21. Huabbangyang T, Sangketchon C, Ittiphisit S, Uoun K, Saumok C. Predictive Factors of Outcome in Cases of Out-of-hospital Cardiac Arrest Due to Traffic Accident Injuries in Thailand; a National Database Study. Arch Acad

Emerg Med. 2022; 10(1): e63.

22. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet. 2007;370(9596):1453-7.
23. Bailey ED, Wydro GC, Cone DC. Termination of resuscitation in the prehospital setting for adult patients suffering nontraumatic cardiac arrest. National Association of EMS Physicians Standards and Clinical Practice Committee. Prehosp Emerg Care. 2000;4(2):190-5.
24. Okubo M, Komukai S, Andersen LW, Berg RA, Kurz MC, Morrison LJ, et al. Duration of cardiopulmonary resuscitation and outcomes for adults with in-hospital cardiac arrest: retrospective cohort study. Bmj. 2024;384:e076019.
25. Millin MG, Khandker SR, Malki A. Termination of resuscitation of nontraumatic cardiopulmonary arrest: resource document for the National Association of EMS Physicians position statement. Prehosp Emerg Care. 2011;15(4):547-54.
26. Hunyadi-Antičević S, Protić A, Patrk J, Filipović-Grčić B, Puljević D, Majhen-Ujević R, et al. [european resuscitation council guidelines for resuscitation 2015]. Lijec Vjesn. 2016;138(11-12):305-21.
27. Lott C, Truhlář A, Alfonzo A, Barelli A, González-Salvado V, Hinkelbein J, et al. European Resuscitation Council Guidelines 2021: Cardiac arrest in special circumstances. Resuscitation. 2021;161:152-219.
28. Ayyıldız A, Ayyıldız FA, Yıldırım Ö T, Yıldız G. Investigation of mortality rates and the factors affecting survival in out-of-hospital cardiac arrest patients. Aging Male. 2023;26(1):2255013.
29. Reynolds JC, Frisch A, Rittenberger JC, Callaway CW. Duration of resuscitation efforts and functional outcome after out-of-hospital cardiac arrest: when should we change to novel therapies? Circulation. 2013;128(23):2488-94.
30. Sandroni C, Cariou A, Cavallaro F, Cronberg T, Friberg H, Hoedemaekers C, et al. Prognostication in comatose survivors of cardiac arrest: an advisory statement from the European Resuscitation Council and the European Society of Intensive Care Medicine. Resuscitation. 2014;85(12):1779–1789.
31. Tamura T, Namiki J, Sugawara Y, Sekine K, Yo K, Kanaya T, et al. Quantitative assessment of pupillary light reflex for early prediction of outcomes after out-of-hospital cardiac arrest: A multicentre prospective observational study. Resuscitation. 2018;131:108-13.
32. Nolan JP, Sandroni C, Böttiger BW, Cariou A, Cronberg T, Friberg H, et al. European Resuscitation Council and European Society of Intensive Care Medicine guidelines 2021: post-resuscitation care. Intensive Care Med. 2021;47(4):369-421.
33. Yang Z, Liang H, Li J, Qiu S, He Z, Li J, et al. Comparing the efficacy of bag-valve mask, endotracheal intubation, and laryngeal mask airway for subjects with out-of-hospital cardiac arrest: an indirect meta-analysis. Ann Transl Med. 2019;7(12):257.
34. Yuksen C, Phattharapornjaroen P, Kreethep W, Suwanmano C, Jenpanitpong C, Nonnongku R, et al. Bag-Valve Mask versus Endotracheal Intubation in Out-of-Hospital Cardiac Arrest on Return of Spontaneous Circulation: A National Database Study. Open Access Emerg Med. 2020;12:43-6.
35. Yang Z, Liu J, Zhu Y, Liu L, Qi W. Comparison of Bag-Valve-Mask Ventilation, Endotracheal Intubation, and Supraglottic Airway Devices for Out-of-Hospital Cardiac Arrest: A Meta-analysis. Am J Emerg Med. 2019;37(3):435–441.
36. Sugiyama K, Kashiura M, Hamabe Y. Amiodarone and lidocaine for shock refractory ventricular fibrillation or ventricular tachycardia in out-of-hospital cardiac arrest: are they really effective? J Thorac Dis. 2016;8(8):E791-3.
37. Alhenaki A, Alqudah Z, Williams B, Nehme E, Nehme Z. Temporal trends in the incidence and outcomes of shock-refractory ventricular fibrillation out-of-hospital cardiac arrest. Resusc Plus. 2024;18:100597.
38. Huang Y, He Q, Yang M, Zhan L. Antiarrhythmia drugs for cardiac arrest: a systemic review and meta-analysis. Crit Care. 2013;17(4):R173.
39. Neumar RW, Otto CW, Link MS, Kronick SL, Shuster M, Callaway CW, et al. Part 8: Adult Advanced Cardiovascular Life Support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2010;122(18 Suppl 3):S729–S767.
40. Hosmer DW, Lemeshow S, Sturdivant RX. Applied Logistic Regression. 3rd ed. Hoboken (NJ): Wiley; 2013. p. 177–80.
41. Hajian-Tilaki K. Receiver Operating Characteristic (ROC) Curve Analysis for Medical Diagnostic Test Evaluation. Caspian J Intern Med. 2013;4(2):627–35.
42. Limpawattana P, Suraditnan C, Aungsakul W, et al. A comparison of the ability of morbidity scores to predict unsuccessful cardiopulmonary resuscitation in thailand. J Med Assoc Thai. 2018;101(9): 1231-6.
43. Bowker L, Stewart K. Predicting unsuccessful cardiopulmonary resuscitation (CPR): a comparison of three morbidity scores. Resuscitation. 1999;40(2):89-95.
44. Lin YY, Lai YY, Chang HC, Lu CH, Chiu PW, Kuo YS, et al. Predictive performances of ALS and BLS termination of resuscitation rules in out-of-hospital cardiac arrest for different resuscitation protocols. BMC Emerg Med. 2022;22(1):53.
45. Cheong RW, Li H, Doctor NE, Ng YY, Goh ES, Leong BS, et al. Termination of Resuscitation Rules to Predict Neurological Outcomes in Out-of-Hospital Cardiac Arrest for an Intermediate Life Support Prehospital System. Prehosp Emerg Care. 2016;20(5):623-9.

Table 1: Comparing the baseline characteristics of studied patients between those with and without cardiopulmonary resuscitation (CPR) failure after 20 minutes of complete advanced cardiac life support (N = 455)

Factors	Total	CPR Failure				P
		Yes (n = 313)		No (n = 142)		
Sex						
Male	296	199	(63.6)	97	(68.3)	0.327
Female	159	114	(36.4)	45	(31.7)	
Age (years)						
Mean ± SD	63.85 ± 19.21	65.19 ± 18.41		60.90 ± 20.64		0.027†
<65	218	137	(43.8)	81	(57.0)	0.009
≥65	237	176	(56.2)	61	(43.0)	
Comorbidity	259	170	(54.3)	89	(62.7)	0.095
Hypertension	165	108	(34.5)	57	(40.1)	0.247
Diabetes mellitus	146	102	(32.6)	44	(31.0)	0.734
Coronary heart disease	70	45	(14.4)	25	(17.6)	0.376
Dyslipidemia	42	24	(7.7)	18	(12.7)	0.087
Renal diseases	34	22	(7.0)	12	(8.5)	0.593
Cancer	29	22	(7.0)	7	(4.9)	0.396
Respiratory disease	18	17	(5.4)	1	(0.7)	0.017
Stroke	5	4	(1.3)	1	(0.7)	1.000§
Other	45	26	(8.3)	19	(13.4)	0.093
Total	259	170	(54.3)	89	(62.7)	0.095
Type of scene						
Nonpublic	317	223	(71.2)	94	(66.2)	0.278
Public	138	90	(28.8)	48	(33.8)	
Cause of cardiac arrest						
Respiratory	250	184	(58.8)	66	(46.5)	0.040
Cardiac	118	72	(23.0)	46	(32.4)	
Other	87	57	(18.2)	30	(21.1)	
First cardiac rhythm recorded						
Asystole	310	250	(79.9)	60	(42.3)	<0.001
Ventricular fibrillation	80	35	(11.2)	45	(31.7)	
Pulseless electrical activity	64	28	(8.9)	37	(26.1)	
Witnessed cardiac arrest						
No	269	224	(71.6)	45	(31.7)	<0.001
Yes	186	89	(28.4)	97	(68.3)	
Pupillary response						
No	402	298	(95.2)	104	(73.2)	<0.001
Yes	53	15	(4.8)	38	(26.8)	
CPR performed by bystander						
No	241	186	(59.4)	55	(38.7)	<0.001
Yes	214	127	(40.6)	87	(61.3)	
AED application by bystander						
No	412	294	(93.9)	118	(83.1)	<0.001
Yes	43	19	(6.1)	24	(16.9)	
EMS personnel to respond (minute)						
Mean ± SD	12.69 ± 6.55	13.21 ± 6.85		11.52 ± 5.69		0.006†
<8	97	66	(21.1)	31	(21.8)	0.857
≥8	358	247	(78.9)	111	(78.2)	
Defibrillation at scene						
No	367	275	(87.9)	92	(64.8)	<0.001
Yes	88	38	(12.1)	50	(35.2)	
Advanced airway management at scene						
No	64	59	(18.8)	5	(3.5)	<0.001§
Endotracheal tube	388	252	(80.5)	136	(95.8)	
Laryngeal mask airway	3	2	(0.6)	1	(0.7)	
Drugs administered at scene during CPR						
Adrenaline	408	270	(86.3)	138	(97.2)	<0.001
Sodium bicarbonate	122	79	(25.2)	43	(30.3)	0.261
Amiodarone	56	21	(6.7)	35	(24.6)	<0.001
Calcium gluconate	52	32	(10.2)	20	(14.1)	0.230
Glucose	31	21	(6.7)	10	(7.0)	0.896
Atropine	14	3	(1.0)	11	(7.7)	<0.001§

Data are presented as numbers (percentages) or means ± standard deviations (SD). The p value corresponds to an independent-samples t test except where otherwise noted. †Chi-square test. §Fisher's exact test. AED: automated external defibrillator; EMS: Emergency Medical Services.

Table 2: Independent predictors of cardiopulmonary resuscitation (CPR) failure at the scene after 20 minutes of complete advance cardiac life support (ACLS) in patients with nontraumatic out-of-hospital cardiac arrest based on multivariable analyses (N = 455)

Predictors	AOR (95% CI)		P	RC	Score
First cardiac rhythm recorded					
Asystole	4.68	(2.48–8.86)	<0.001	1.544	2
Ventricular fibrillation	2.03	(0.90–4.61)	0.089	0.710	1
Pulseless electrical activity	1.00	Reference		0.000	0
Witnessed cardiac arrest					
No	3.51 (2.14–5.76)	<0.001		1.255	2
Yes	1.00	Reference		0.000	0
Pupillary response					
No	4.22	(1.95–9.10)	<0.001	1.439	2
Yes	1.00	Reference		0.000	0
Advanced airway management at scene					
No	7.34	2.47–21.82)	<0.001	1.994	3
Yes	1.00	Reference		0.000	0
Drugs administered at scene during CPR					
Amiodarone					
No	2.41	(1.15–5.04)	0.020	0.878	1
Yes	1.00	Reference		0.000	0
Atropine					
No	9.22	(2.22–38.25)	0.002	2.221	3
Yes	1.00	Reference		0.000	0

Model summary: -2 log likelihood = -205.49; pseudo-R2 = 0.2725; according to the Hosmer and Lemeshow test: 2 = 5.83, df = 6, p = 0.442; constant = -5.319. CI: confidence interval; NA: data not applicable; AOR: adjusted odds ratio; RC: regression coefficient.

Table 3: Performance of developed model in predicting the probability of cardiopulmonary resuscitation (CPR) failure at the scene after 20 minutes of advance cardiac life support (ACLS) in patients with nontraumatic out-of-hospital cardiac at different cutoff points

Cutoff	CPR Failure	Sensitivity	Specificity	PPV	NPV	LR+	LR-
≥2	313 (68.9)	100.0 (98.8–100)	0.7 (0–3.9)	68.9 (64.5–73.2)	100.0 (2.5–100)	1.01 (0.99–1.02)	0.00
≥3	313 (69.1)	100.0 (98.8–100)	1.4 (0.2–5)	69.1 (64.6–73.3)	100.0 (15.8–100)	1.01 (1.00–1.03)	0.00
≥4	313 (69.6)	100.0 (98.8–100)	3.5 (1.2–8)	69.6 (65.1–73.8)	100.0 (47.8–100)	1.04 (1.00–1.07)	0.00
≥5	311 (72.0)	99.4 (97.7–99.9)	14.8 (9.4–21.7)	72.0 (67.5–76.2)	91.3 (72–98.9)	1.17 (1.09–1.25)	0.04 (0.01–0.18)
≥6	306 (73.7)	97.8 (95.4–99.1)	23.2 (16.6–31.1)	73.7 (69.2–77.9)	82.5 (67.2–92.7)	1.27 (1.16–1.4)	0.10 (0.04–0.21)
≥7	291 (78.0)	93.0 (89.6–95.5)	42.3 (34–50.8)	78.0 (73.5–82.1)	73.2 (62.2–82.4)	1.61 (1.39–1.86)	0.17 (0.11–0.26)
≥8	278 (81.5)	88.8 (84.8–92.1)	55.6 (47.1–64)	81.5 (77–85.5)	69.3 (60–77.6)	2.00 (1.66–2.42)	0.20 (0.14–0.28)
≥9†	219 (89.8)	70.0 (64.6–75)	82.4 (75.1–88.3)	89.8 (85.2–93.3)	55.5 (48.5–6230)	3.97 (2.76–5.71)	0.36 (0.3–0.44)
≥10	204 (92.3)	65.2 (59.6–70.4)	88.0 (81.5–92.9)	92.3 (88–95.5)	53.4 (46.8–59.9)	5.44 (3.46–8.57)	0.40 (0.34–0.47)
≥11	53 (98.2)	16.9 (12.9–21.6)	99.3 (96.1–100)	98.1 (90.1–100)	35.2 (30.5–40.1)	24.00 (3.36–172)	0.84 (0.79–0.88)
≥12	33 (100.0)	10.5 (7.4–14.5)	100.0 (97.4–100)	100.0 (89.4–100)	33.6 (29.2–38.4)	—	0.90 (0.86–0.93)
≥13	31 (100.0)	9.9 (6.8–13.8)	100.0 (97.4–100)	100.0 (88.8–100)	33.5 (29–38.2)	—	0.90 (0.87–0.94)

Data are presented with 95% confidence interval (CI). CPR failure column reported as number (%). †The best threshold value was determined from the Youden index (Youden index J = sensitivity + specificity 1). PPV: positive predictive value; NPV: negative predictive value; LR+: positive likelihood ratio; LR-: negative likelihood ratio.

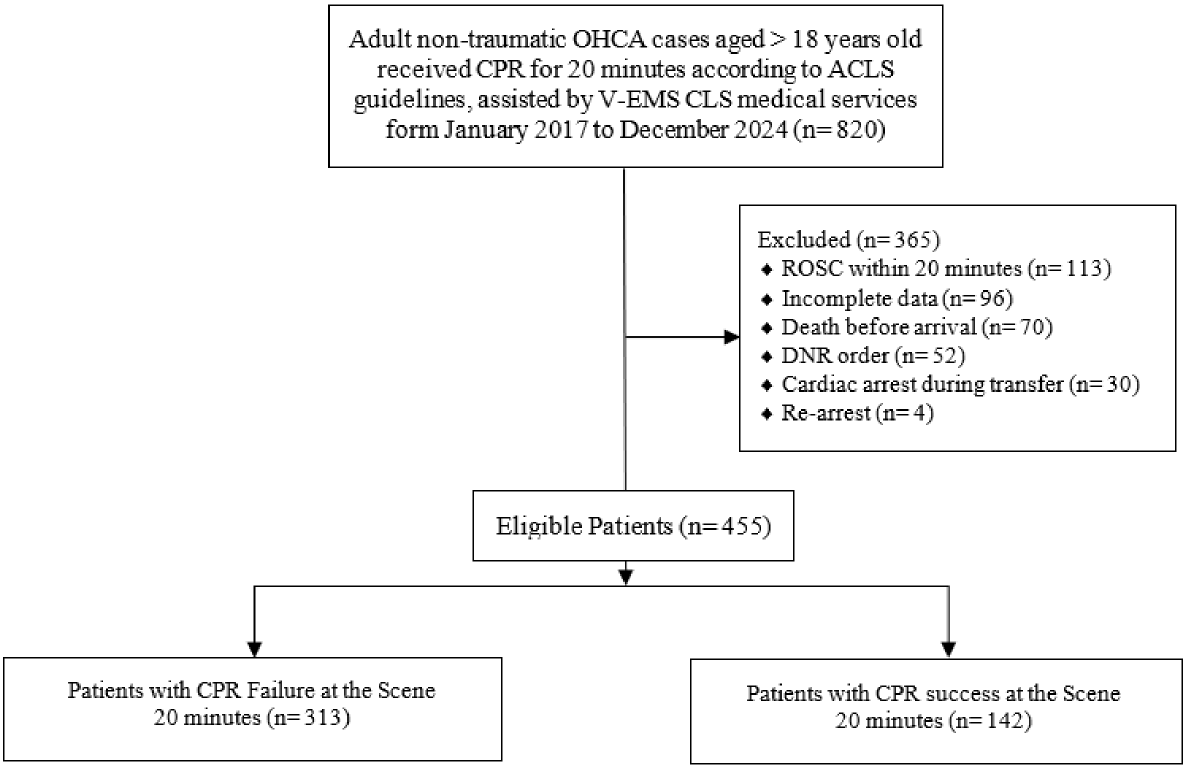

Figure 1: Patient selection flowchart. OHCA: out of hospital cardiac arrest; ACLS: advanced cardiac life support; ROSC: return of spontaneous circulation; DNR: do not resuscitate; CPR: cardiopulmonary resuscitation.

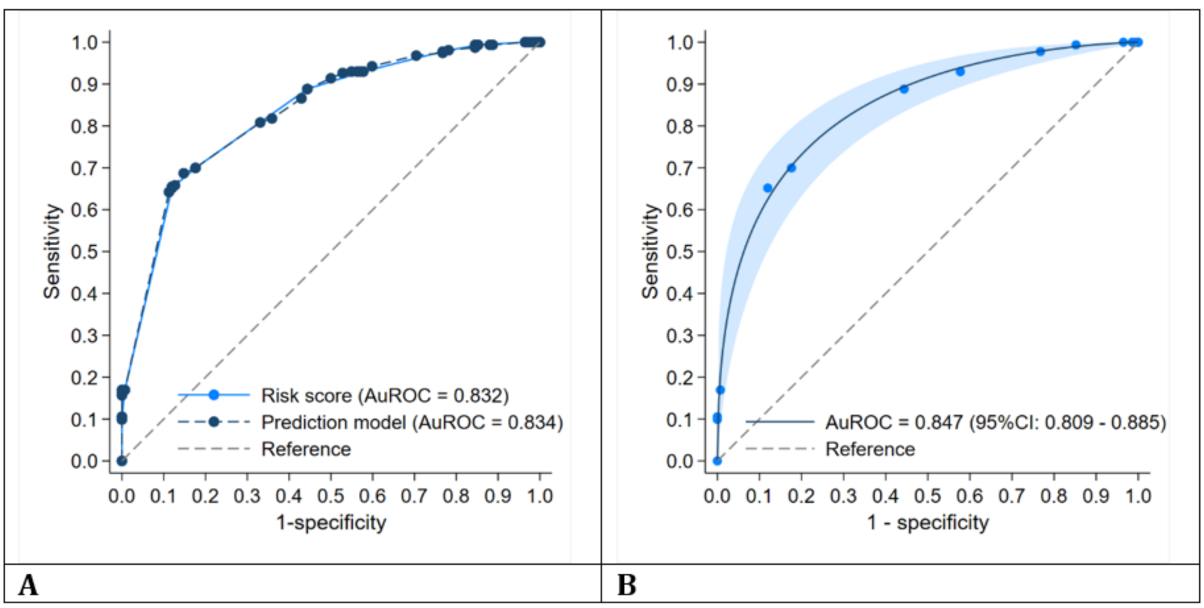

Figure 2: Area under the receiver operating characteristic curve (AuROC) with 95% confidence interval (CI) of the clinical prediction score of cardiopulmonary resuscitation (CPR) failure at the scene after 20 minutes of complete advanced cardiovascular life support (ACLS) in patients with nontraumatic out-of-hospital cardiac arrest. (A) clinical score and (B) postestimation ROC analysis.

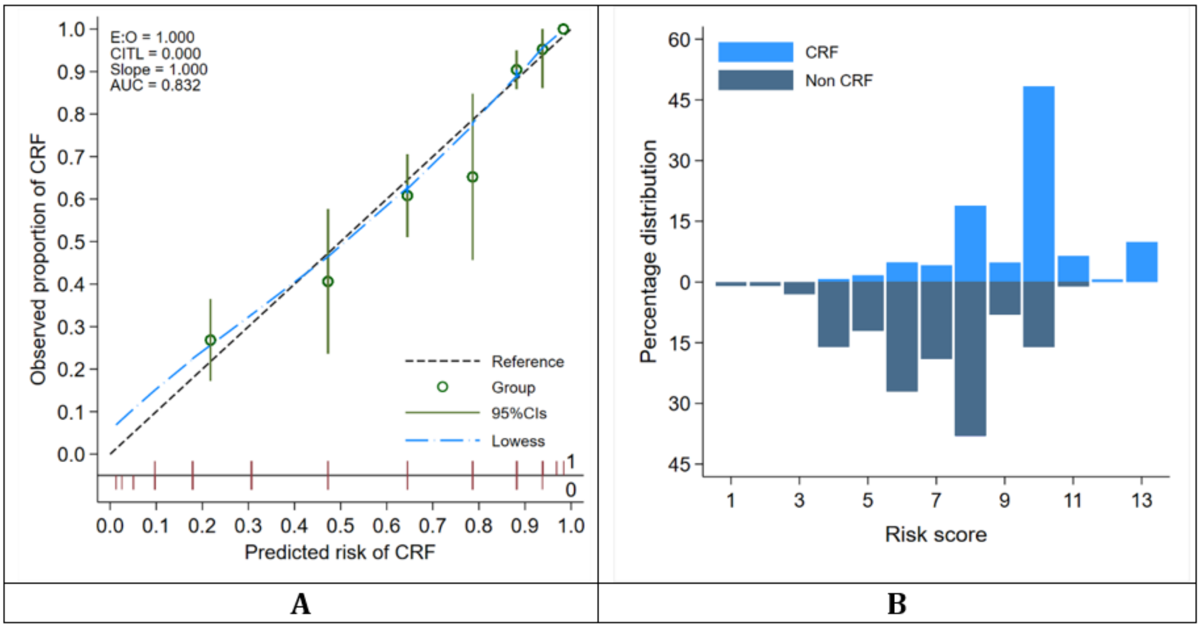

Figure 3: A: Calibration plots of the score-predicted probability of cardiopulmonary resuscitation (CPR) failure and the CPR failure observed at the scene after 20 minutes of complete advanced cardiovascular life support (ACLS) in patients with nontraumatic out-of-hospital cardiac arrest. B: The distribution of the clinical prediction score of cardiopulmonary resuscitation (CPR) failure at the scene after 20 minutes of complete advanced cardiovascular life support (ACLS) in patients with nontraumatic out-of-hospital cardiac arrest. CRF: cardiac resuscitation failure; CI: confidence interval.

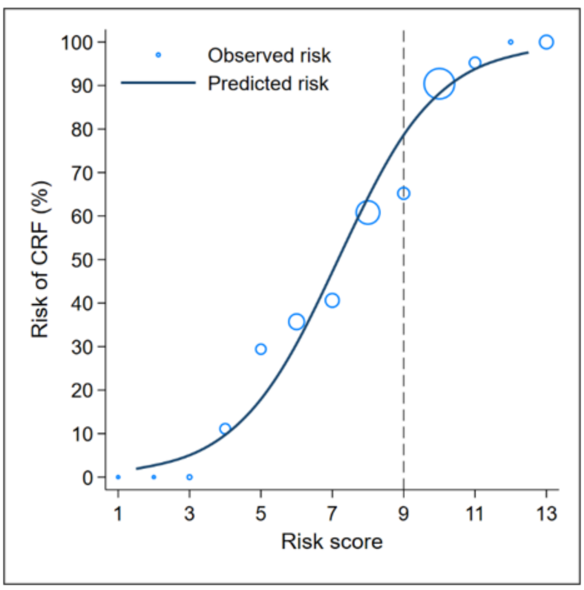

Figure 4: Risk curve analysis: observed risk of cardiopulmonary resuscitation (CPR) failure and predicted risk of CPR failure at the after scene 20 minutes of complete advanced cardiovascular life support (ACLS) by scores (solid line). The size of each circle represents the relative number of patients with each score. CRF: cardiac resuscitation failure.