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Clinical paper

Validation of Utstein-Based score to predict return of spontaneous circulation (UB-ROSC) in patients with out-of-hospital cardiac arrest

Maria Luce Caputo[a,b,*], *Enrico Baldi*[c,d], *Roman Burkart*[e], *André Wilmes*[e], *Ruggero Cresta*[b,f], *Claudio Benvenuti*[b], *Tardu Oezkartal*[a], *Roberto Cianella*[f], *Roberto Primi*[c,d], *Alessia Currao*[c,d], *Sara Bendotti*[c,d], *Sara Compagnoni*[c,d,g], *Francesca Romana Gentile*[c,d,g], *Luciano Anselmi*[f], *Simone Savastano*[c,d], *Catherine Klersy*[h], *Angelo Auricchio*[a,b]

Abstract

Background and aims: The Utstein Based-ROSC (UB-ROSC) score has been developed to predict ROSC in OHCA victims. Aim of the study was to validate the UB-ROSC score using two Utstein-based OHCA registries: the SWiss REgistry of Cardiac Arrest (SWISSRECA) and the Lombardia Cardiac Arrest Registry (Lombardia CARe), northern Italy.

Methods: Consecutive patients with OHCA of any etiology occurring between January 1st, 2019 and December 31st 2021 were included in this retrospective validation study. UB-ROSC score was computed for each patient and categorized in one of three subgroups: low, medium or high likelihood of ROSC according to the UB-ROSC cut-offs (≤ -19; -18 to 12; ≥ 13). To assess the performance of the UB-ROSC score in this new cohort, we assessed both discrimination and calibration. The score was plotted against the survival to hospital admission.

Results: A total of 12.577 patients were included in the study. A sustained ROSC was obtained in 2.719 patients (22%). The UB-ROSC model resulted well calibrated and showed a good discrimination (AUC 0.71, 95% CI 0.70–0.72). In the low likelihood subgroup of UB-ROSC, only 10% of patients achieved ROSC, whereas the proportion raised to 36% for a score between -18 and 12 (OR 5.0, 95% CI 2.9–8.6, $p < 0.001$) and to 85% for a score ≥ 13 (OR 49.4, 95% CI 14.3–170.6, $p < 0.001$).

Conclusions: UB-ROSC score represents a reliable tool to predict ROSC probability in OHCA patients. Its application may help the medical decision-making process, providing a realistic stratification of the probability for ROSC.

Keywords: Out of hospital cardiac arrest, Utstein, Return of spontaneous circulation, Prediction, Score

Introduction

Out-of-hospital cardiac arrest (OHCA) incidence and outcome varies greatly around the globe.[1,2] Outcome is influenced by several independent variables related to patients' characteristics, e.g. age, comorbidity, and event circumstances (etiology, witness status, public or private location).[3] Moreover, several modifiable factors, including intervention time (from call to emergency medical services (EMS) arrival on scene), impact survival.[4,5] Similar to survival at discharge, the probability for return of spontaneous circulation (ROSC) significantly varies across geographical regions.[3,6]

Prediction of sustained ROSC (defined as ROSC at hospital admission) is an important goal in resuscitation science and of great interest for EMS staff, since it provides immediate estimation of outcome. Moreover, its prediction may provide a guidance for termination-of resuscitation.[7–10] Among other scores, the Utstein Based-ROSC (UB-ROSC) score was recently proposed as a multiparametric operative model developed using independent pre-hospital variables, collected according the Utstein

* Corresponding author at: Department of Cardiology, Cardiocentro Ticino Institute-EOC, Via Tesserete 48, 6900 Lugano, Switzerland.
E-mail address: marialuce.caputo@eoc.ch (M.L. Caputo).

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recommendations.[11] It predicts, with good sensitivity and specificity, the probability of sustained ROSC leading to hospital admission.[11] The score was developed and validated in two large regional registries, the TIRECA (TIcino REgstry of Cardiac Arrest) in the Swiss Canton Ticino and the Pavia CARe (Pavia Cardiac Arrest Registry) in the Italian province of Pavia. The score can be calculated using a mobile application (https://www.sanmatteo.org/site/home/ub-rosc-score.html) To date, the UB-ROSC score has never been validated in a larger external cohort of OHCAs.

The aim of our study was to validate the UB-ROSC score in an external cohort of OHCA patients from two large Utstein-based registries of two different countries: the SWISSRECA (Swiss Registry of Cardiac Arrest) and the Lombardia CARe (Lombardia Cardiac Arrest Registry).

Methods

Participants. All consecutive patients who suffered an OHCA of any etiology between January 1st 2019 and December 31st 2021 in Lombardia, northern Italy, and in Switzerland were included in the study. Patients declared dead before ambulance arrival or at EMS arrival on scene without resuscitation attempts by EMS and patients with a "do not resuscitate" order, were excluded from further analysis. The score was calculated only for those patients with complete dataset. Patients with incomplete UB-ROSC variables were excluded.

Study design and setting. The study is a validation analysis using all OHCAs that occurred between 2019 and 2021 in the Swiss national registry of cardiac arrest (SWISSRECA) and in the Regional registry of Lombardia, northern Italy (Lombardia CARe). All OHCA cases are prospectively entered into the two registries at the time of cardiac arrest. The study was designed to validate the published multiparametric operative score (UB-ROSC score), capable of predicting the probability of survival to hospital admission (sustained ROSC). UB-ROSC score development was described elsewhere.[11] Both the Lombardia region and Switzerland have implemented a prospectively designed registry of cardiac arrest. Both registries follow the Utstein recommendations for data collection,[12,13] were approved by the local ethical committee and are periodically reviewed for quality assessment by an internal commission. The Lombardia CARe enrolls all OHCA cases occurring in the Province of Pavia since January 1st 2015 and additionally in the provinces Lodi, Cremona, and Mantua since January 1st 2019. The registry was approved by the Ethical Committee of the Fondazione IRCSS Policlinico San Matteo (proc. 20140028219). SWISSRECA is a national cardiac arrest registry created by the Interassociation for Rescue Services (IVR-IAS) at the end of 2018, collecting data on every OHCA in Switzerland.. SWISSRECA is approved by the national Ethical committee (Swissethics- ID-2016-01844). Written informed consent was provided by all patients discharged alive. The derivation cohort (Pavia CARe and TIRECA) was excluded from this external validation study.

EMS and resuscitation network in Lombardia Region, Northern Italy. The area covered by the Lombardia CARe registry increased from ca. 7.800 km^2 in 2019 to ca. 15.100 km^2 in 2021, leading to a parallel increase in the population covered by the registry from around 1.5 to 4.3 million inhabitants within the same time period. Details of registry development and changes over time of the included provinces are reported in Table 1 of the supplemental material.

The EMS dispatch center coordinates both ambulances, staffed with basic life support and defibrillation (BLS-D)-trained personnel, and vehicles staffed with advanced life support (ALS)-trained personnel (specialized nurse with or without physician). In the absence of a physician, the specialized nurse applies the same ALS protocol, with the sole difference that supraglottic instead of tracheal tubes are utilized. Furthermore, five helicopters with a physician and specialized nurse on board serve the Lombardy region. If needed, three additional helicopters from neighboring regions are available. In case of suspected OHCA, the EMS dispatcher activates one to three emergency vehicles (which may include a helicopter) with at least one physician and assists the calling bystander during chest compressions (telephone CPR). The decision to attempt resuscitation and its duration is left to the physician, whilst BLS-D and ALS-trained personnel is instructed to start resuscitation unless clear signs of death, such as rigor mortis, hypostasis/lividity, or injuries not compatible with life are present.

EMS and resuscitation network in Switzerland. In Switzerland (8.6 million inhabitants within a territory of 41,300 km^2, divided in 26 Cantons), OHCAs are managed by local EMS with a two-tiered response system, coordinated via a regional dispatch center. The first tier consists of paramedics capable of providing ALS. The second tier consists of teams (ambulance or helicopter) with an emergency physician, alerted if required. Paramedics are instructed to initiate resuscitation unless unequivocal signs of death are present or a Do Not Attempt Resuscitation order is in place. In case of OHCA, at least one ambulance with paramedics and one vehicle with an emergency physician is activated. The decision to stop resuscitation and to declare death is based on the physician's clinical judgment. The Swiss territory encompasses several rural areas (mountains and valleys) and few relatively small urban areas. In all cantons, a network of first responders (FR), comprising off-duty EMS personnel, fire-fighters, police and laypeople trained in CPR, may be alerted through a mobile application. Its members are capable of delivering basic life support and utilizing an automatic external defibrillator (AED).

UB-ROSC score variables and model outcome. The UB-ROSC score model development was described before.[11] Briefly, variables that may determine survival at hospital admission were identified among Utstein variables immediately available at EMS arrival on-scene. Age, sex, etiology of OHCA, location, witness status, bystander CPR, time to EMS arrival and shockable initial rhythm were included in the model.[11] The coefficients estimated from the model, multiplied by 10 and rounded to the closest integer were used to compute a prediction score. All variables included in the model and corresponding scores for UB-ROSC calculation were reported in Table 1. Survival to hospital admission was defined as patient with ROSC sustained until arrival at the emergency department and transfer of care to medical staff at the receiving hospital. This definition corresponds to the Utstein recommendations' core outcome of "Survived event".[13] Probability of survival at hospital admission corresponding to different values of UB-ROSC score were reported in Table 2 of Supplemental Material.

Statistical analysis. All analyses were performed using the Stata software (release 17, College Station, TX, USA). A 2-sided $p < 0.05$ was considered statistically significant. Continuous data are reported as mean and standard deviation or median and quartiles if skewed. Categorical data are reported as counts and percent. Data were compared between groups of patients (by national territory and by ROSC groups) with the Mann Whitney U test and the

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Table 1 – Variables and corresponding scores for UB-ROSC calculation.

UB-ROSC variables	SCORE COMPONENT
Sex	
Female	0
Male	−3
Age	
<80	0
≧80	−9
Aetiology	
Cardiac	0
Trauma	−3
Drowning	1
Respiratory	19
Other non-cardiac	0
Location	
At home	0
Nursing home	−7
Workplace	6
School	0
Street	4
Public building	5
Sport	7
Bystander and CPR	
No witnessed, no CPR	0
No witnessed, yes CPR	−5
Yes Witnessed, no CPR	2
Yes Witnessed, yes CPR	4
EMS witnessed	13
Rhythm	
Not shockable	0
Shockable	21
Time to EMS arrival	
≦ 10 min	0
11–15 min	−4
≧15 min	−7
Constant	−16

Witness status and cardiopulmonary resuscitation (CPR) before ambulance arrival were combined as follows: no wit/no CPR in cases, in which the OHCA was not witnessed and no CPR before ambulance arrival took place; no wit/yes CPR in cases, in which the OHCA was not witnessed, but CPR before ambulance arrival took place; yes wit/no CPR: in cases witnessed by bystander but without CPR before ambulance arrival; yes wit/yes CPR: in cases witnessed by bystander and with CPR performed before ambulance arrival; EMS: emergency medical service.

Fisher exact test, respectively. The UB-ROSC score was computed for each patient according to the original paper[7] and categorized in the three subgroups of low, medium and high likelihood of ROSC according to the published cut-offs of UB-ROSC. (≤−19; −18 to 12; ≥13). The latter variable was included in a logistic model for ROSC as the independent variable; Huber-White robust standard errors were computed to account for intra-region correlation. We derived the odds ratios (OR) and 95% confidence intervals (95% CI). To assess the performance of the UB-ROSC score in this new cohort, we assessed bot discrimination and calibration. For discrimination we computed the cross-validated model area under the Receiver Operating Characteristic-ROC curve and 95%CI. Sensitivity and specificity of the model were also computed. For this purpose, patients were classified as ROSC if the predicted probability was equal to or above 0.5. To assess calibration, we plotted the observed and predicted probabilities of ROSC as a calibration belt. Model goodness of fit was assessed with the Pearson test and was always satisfied.

Results

Overall, 22,794 OHCA cases were included in the two registries. 8.079 (35%) were declared dead before ambulance arrival or had a “do not resuscitate” order and were excluded. Moreover, 2.138 patients came from the two regional registries of the initial validation of the score and, thus, were excluded, leaving a total of 12.577 OHCA patients for further analysis. UB-ROSC was calculated in 11.904 patients. Demographic and clinical characteristics of OHCAs included in the two national registries are reported in Table 2. Swiss patients were in median 8-year younger than Italian ones (70 years old, IQR 58–79 versus 78 years old, IQR 66–86, respectively, $p < 0.001$, Table 2). Moreover, Swiss OHCAs occurred more often in public location (37% versus 17%, $p < 0.001$, Table 2.) and had a first shockable rhythm (31% versus 14%, $p < 0.001$).

Observed ROSC and UB-ROSC validation. Sustained ROSC was obtained in 2.719 patients (22%). The overall observed ROSC rate was higher in SWISSRECA than in Lombardia CARe (31% versus 14%, $p < 0.001$, Table 2.). UB-ROSC model had a similar discrimination power with an area under the ROC curve (AUC) of 0.67 (95%CI 0.65–0.68) in SWISSRECA and of 0.71 (95% CI 0.69–0.73) in Lombardia CARe. Model validation of UB-ROSC likelihood groups and calibration in the entire population is reported in Fig. 1. Overall, UB-ROSC model showed a good discrimination (AUC 0.71, 95% CI 0.70–0.72, Fig. 1, panel A). Model had 10% sensitivity and 99% specificity to predict ROSC, with a positive predictive value of 85% and a negative predictive value of 78%. Events correctly classified by the model were 78%. Model calibration showed a 10-fold cross validation AUC of ROC of 0.70, 95%CI 0.70–0–72, $p = 1.0$ (Fig. 1 panel B). The probability to obtain ROSC, according to the 3 likelihood groups and corresponding ORs are reported in Fig. 2. For UB-ROSC score values of less than or equal to −19, only in 10% of patients a ROSC was achieved, increasing to 36% for UB-ROSC score between −18 and 12 (OR 5.0, 95% CI 2.9–8.6, $p < 0.001$). Finally, in 85% of patients with UB-ROSC values of more than or equal to 13 a ROSC was obtained (OR 49.4, 95%CI 14.3–170.6, $p < 0.001$). Characteristics of OHCA presentation according to UB-ROSC score subgroups are reported in Table 3. Patients with the lowest UB-ROSC values (≦−19) were significantly older (median age 80 years old, IQR 68–87), 52% unwitnessed, 83% occurred in private location and 99% of them had a no-shockable rhythm. In contrast, patients in the high likelihood subgroup of UB-ROSC (UB-ROSC score ≧ 13) were younger (median age 62 years old, IQR 53–71), 58% occurred in public location, and 99% of them were witnessed and with a first shockable rhythm.

Discussion

UB-ROSC is an operational score for prediction of ROSC probability after OHCA. It was designed using Utstein variables and categories, thus, allowing a very easy calculation of the score and of the corresponding probability of ROSC. For the first time, we showed in a

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Table 2 – Comparison between out-of-hospital cardiac arrest presentation and outcome in the two registries.

	Lombardia Care N = 5980	SWISSRECA N = 6597	p value	Missing data, n (%) N = 12.577
Sex, n (%)			<0.001	34 (0.3)
Female	2411 (40)	1894 (29)		
Male	3534 (60)	4703 (71)		
Age, median (IQR)	78 (66–86)	70 (58–79)	<0.001	32 (0.2)
Medical etiology, n (%)			<0.001	5 (0.04)
Yes	5536 (92)	5899 (89)		
No	439 (8)	698 (11)		
Location, n (%)				0 (0)
Public	984 (17)	2470 (37)	<0.001	
Private	4996 (83)	4127 (63)		
Shockable rhythm, n (%)			<0.001	89 (0.7)
Yes	818 (14)	2064 (31)		
No	5073 (86)	4533 (69)		
Combined Witness/CPR before EMS arrival, n (%)			<0.001	191 (1.5)
No wit/no CPR	1511 (25)	691 (10)		
No wit/yes CPR	648 (11)	1587 (24)		
Yes wit/no CPR	1362 (24)	932 (14)		
Yes wit/ yes CPR	1611 (28)	2468 (38)		
EMS witnessed	657 (12)	919 (14)		
Time to EMS arrival, min, median (IQR)	13 (10–16)	10 (8–13)	<0.001	925 (7.3)
Total resuscitation time, min, median (IQR)	25 (16–39)	23 (15–33)	<0.001	984 (7.8)
Sustained ROSC, n (%)	834 (14)	1885 (31)	<0.001	623 (4.9)

Witness status and cardiopulmonary resuscitation (CPR) before ambulance arrival were combined as follows: no wit/no CPR in cases, in which the OHCA was not witnessed and no CPR before ambulance arrival took place; no wit/yes CPR in cases, in which the OHCA was not witnessed, but CPR before ambulance arrival took place; yes wit/no CPR: in cases witnessed by bystander but without CPR before ambulance arrival; yes wit/yes CPR: in cases witnessed by bystander and with CPR performed before ambulance arrival; EMS: emergency medical service.
ROSC: return of spontaneous circulation.

large OHCA cohort that the UB-ROSC score had excellent discrimination capability and may be used in-field to possibly support resuscitation-related decisions and to provide realistic expectations about the likelihood of achieving sustained ROSC during resuscitation maneuvers. This knowledge is important for paramedics, rescue teams and even more so, for family members.

Similarly, ACLS score has been proposed as an operative score,[14] helping to stratify the probability of survival during ongoing resuscitation. Although both models use similar variables, their performance is not comparable, since the ACLS score indicates survival at discharge from hospital, whereas the UB-ROSC model predicts persistent ROSC at hospital admission. Among various models that predict ROSC likelihood, the RACA (ROSC after Cardiac Arrest) score developed using the German Resuscitation Registry,[15] is one of the most frequently validated scores in external populations. Unlike UB-ROSC, the RACA score was not designed as a prediction tool on the spot to facilitate resuscitation decisions. Instead, by providing a predicted ROSC rate, the score enables comparison of studies conducted in different communities and cohorts, serving as'quality indicator' of different EMS systems. External validation of RACA score yielded mixed results.[16–20] These discrepancies, while partially attributable to variations in resuscitation practices over time, often require additional model adjustments to ensure its relevance and applicability across diverse communities.[18]

By using Utstein based variables, the UB-ROSC score overcomes two major limitations of the RACA score: first, the need to re-classify variables included in Utstein registries before calculating the score, and second, the potential bias resulting from ROSC overestimation by including patients with transient ROSC. Furthermore, the validation of the RACA score in an external population[17] resulted in a suboptimal calibration at the two extremes, i.e. in patients with the lowest or highest probability of ROSC. In contrast, the UB-ROSC score showed a good discrimination power with an AUC of ROC curve of 0.72, confirmed at 10-fold cross validation, and an excellent calibration of the model even at the two extremes.

Swiss and Italian OHCA populations were significantly different in characteristics of presentation and in some aspects of the out-of-hospital management.[21,22] As compared with the Italian population, Swiss patients were younger, more often had OHCA in public places and up to 50% received CPR before ambulance arrival.[23] Despite these significant differences, the UB-ROSC score confirmed a good power in prediction of ROSC probability with an excellent calibration of the model.

The increasing demand for enhanced survival prediction models, like including surrogates for CPR quality, end-tidal CO_2,[24] or artificial intelligence software,[25] stems from the growing requirement to maximize available resources for pre-hospital and in-patient management. Prolonged resuscitation and transportation of patients with little possibility of survival to the hospital, has several negative consequences in terms of public health costs and represents an additional distress for family members. Hence, algorithms have been proposed to help identifying OHCA patients with low probability of survival at discharge, in whom it could be reasonable to terminate resuscitation prior to hospital admission. UB-ROSC score cut-offs

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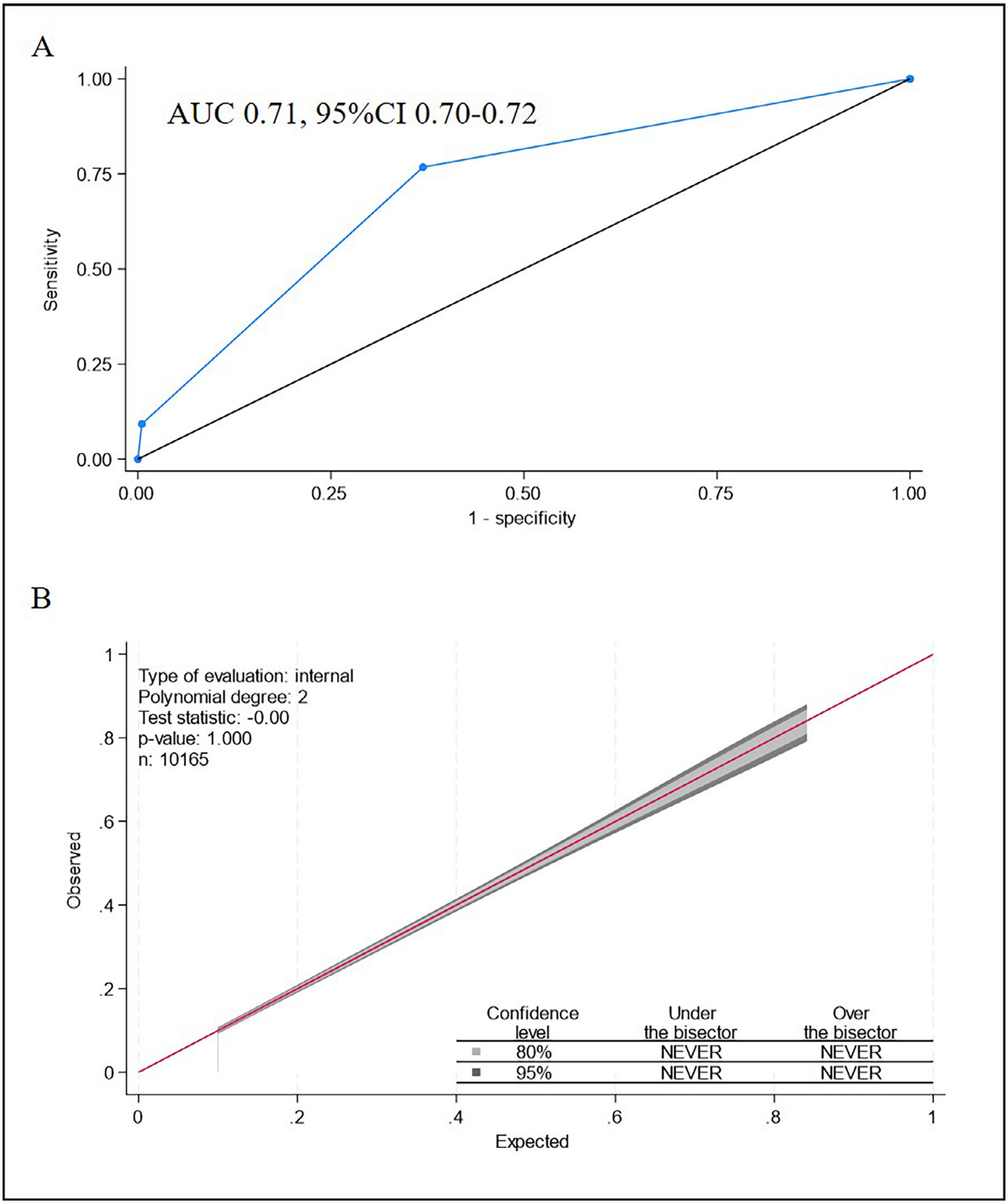

Fig. 1 – UB-ROSC model discrimination and calibration. Panel A: Receiver Operating Characteristic (ROC) curve of UB-ROSC likelihood groups. Panel B: Calibration curve of the model. The bisecting line corresponds to perfect calibration of the model (perfect agreement between observed ROSC and predicted ROSC. The line is entirely included in the shaded area corresponding to the 80% and 95% confidence intervals for the observed-predicted relationship, denoting that the model is well calibrated (there is neither over nor underestimation of mortality).

were very accurate in identifying patients with low survival probability. Only 10% of patients in the low subgroup of UB ROSC score (≦−19) achieved a ROSC. Almost all patients had an unwitnessed OHCA with a non-shockable rhythm, who did not receive CPR before ambulance arrival.

As in UB-ROSC, some similar variables have been included in several termination-of-resuscitation protocols and their accuracy in predicting in-hospital mortality was assessed in large registries in Western countries and in the PAROS (Pan-Asian Resuscitation Outcomes Study) registry.[26,27] They identified a large proportion of patients, who were candidates for termination of resuscitation for OHCA with very low rate of misclassifying eventual survivors (<0.1%). Although all these algorithms use similar pre-hospital characteristics for survival prediction, the evaluated outcome is substan-

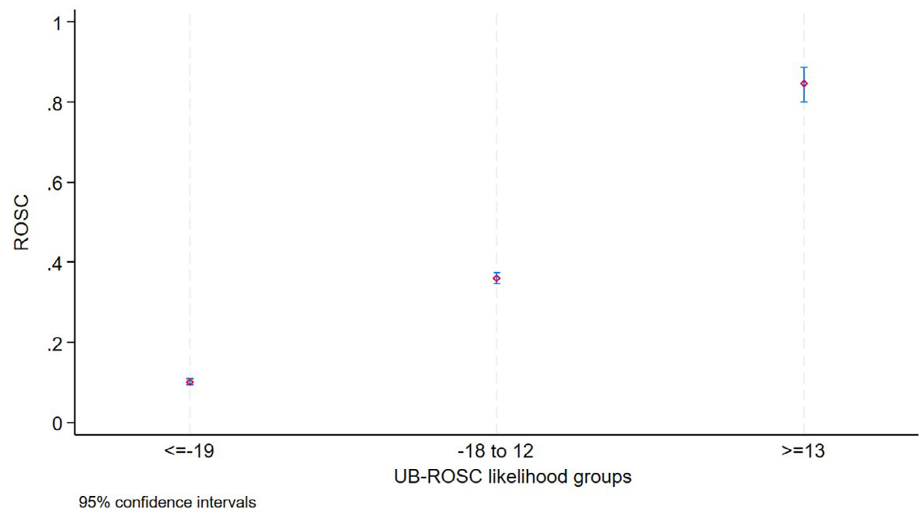

Fig. 2 – UB-ROSC likelihood groups and corresponding probability of ROSC.

Table 3 – OHCA presentation characteristics according to UB-ROSC score likelihood groups. For categorical variables, Post-hoc comparisons p for significance was 0.017. * Significant p value between low and intermediate groups; $ significant p value between intermediate and high groups; £ significant p value between high and low groups. For continuous variables, p-value resulting from one-way analysis of variance by ranks (Kruskall-Wallis test) was reported.

	Low likelihood ≤ −19	Intermediate likelihood −18 to 12	High likelihood ≥ 13	p value between groups
Sex, n (%)				
	*			
Female	2218 (36)	1746 (33)	107 (34)	
Male	4003 (64)	3616 (67)	214 (66)	
Age, median (IQR)	80 (67–86)	68 (57–77)	62 (53–70)	<0.001
Medical etiology, n (%)				
	*		£	
Yes	5808 (94)	4717 (88)	300 (93)	
No	413 (6)	645 (12)	21 (7)	
Location, n (%)				
	*	$	£	
Public	1041 (17)	2050 (38)	191 (60)	
Private	5180 (83)	3312 (62)	130 (40)	
Shockable rhythm, n (%)				
	*	$	£	
Yes	5 (1)	2483 (46)	318 (99)	
No	6216 (99)	2879 (54)	3 (1)	
Combined Witness/CPR, n (%)				
	*	$	£	
No wit/no CPR	1679 (27)	407 (8)	0	
No wit/yes CPR	1612 (25)	539 (10)	3 (1)	
Yes wit/no CPR	1298 (21)	917 (17)	2 (1)	
Yes wit/ yes CPR	1409 (23)	2440 (45)	85 (26)	
EMS witnessed	223 (4)	1059 (20)	231 (72)	
EMS arrival time, min (IQR)	13 (10–17)	10 (8–13)	9 (7–10)	<0.001
Total resuscitation time, min (IQR)	23 (15–32)	27 (16–40)	21 (11–32)	<0.001
ROSC, n (%)	611 (10)*	1776 (36)$	243 (85)£	<0.001

Witness status and cardiopulmonary resuscitation (CPR) before ambulance arrival were combined as follows: no wit/no CPR in cases, in which the OHCA was not witnessed and no CPR before ambulance arrival took place; no wit/yes CPR in cases, in which the OHCA was not witnessed, but CPR before ambulance arrival took place; yes wit/no CPR: in cases witnessed by bystander but without CPR before ambulance arrival; yes wit/yes CPR: in cases witnessed by bystander and with CPR performed before ambulance arrival; EMS: emergency medical service. ROSC: return of spontaneous circulation.

tially different (survival at discharge vs. sustained ROSC). In a pre-hospital setting evaluating ROSC probability, as opposed to survival at discharge, is more reasonable, since the latter is also affected by in-hospital management. With this purpose, UB-ROSC score was designed to be calculated even before EMS team arrival on scene in order to provide an estimation of ROSC likelihood before approaching the patient. Therefore, it is important to emphasize that UB-ROSC is not a score to withhold resuscitation. UB-ROSC helps in setting realistic expectations about sustained ROSC achievement during resuscitation manoeuvres. Other studies mostly refer to termination of resuscitation rules (TORR) that are designed for prediction of in-hospital death.[26,27] By applying TORR medical futility is defined as medical managements that provide ≤1% chance of survival. Similarly, one should consider that an UB-ROSC of −45 corresponds to a probability of sustained ROSC of 1%, thus, it may be used as a decision aid whether to withhold resuscitation".

Tools like UB-ROSC may be also useful in individuating patients with the highest chance of survival, i.e. an UB-ROSC score ≥13. They usually have a favourable OHCA presentation, i.e. shockable rhythm, public place, bystander or EMS witnessed. UB-ROSC highest likelihood category might be use as a cut-off for prompt recognition of patients who may require specific resources, for example early in-hospital hemodynamic support and thus, for a customization of the resuscitation approach.

Comparison between predicted and observed ROSC represents a unique opportunity for EMS staff to re-analyse and debrief most difficult cases thus, UB-ROSC use may go beyond its on-site evaluation of OHCA probability to reach a ROSC. With this purpose, UB-ROSC is currently automatically calculated for each OHCA patient enrolled in SWISSRECA and all patients that fail to achieve ROSC, despite a high UB-ROSC score, are analysed for quality assessment purposes. A debriefing of the case is organized in few weeks, to re-analyse key points of the mission and find out potentially strategies of improvement.

Limitations

This study has several limitations. Although EMS personnel are trained to report cardiac arrest cases in the registry, it is possible that a number of patients with OHCA were not included resulting in a potential under- or overestimation of the UB-ROSC model. However, in both systems (Swiss and Italian), there is periodic monitoring of data quality and, therefore, it is conceivable that only a negligible proportion of patients has not been reported correctly. Paediatric population represents a very small part of the OHCA patients reported in our two registries. Wide application of UB-ROSC in paediatric OHCA might require further validation. This validation cohort encompasses the same two regions in whom the score was originally developed. Even if the derivation cohort of the score was excluded from this analysis, and the time-period used for its validation was different, the original cohort and the validation cohort share similarities in geography and EMS organization. Therefore, further validation may be needed to ensure generalizability of the results, and wide application to other EMS systems/geographies. The COVID 19 pandemic took place during the time frame of the study. Potential impact of the pandemic on the performance of model was not assessed. Furthermore, UB-ROSC score is calculated using Utstein variables and categories. Application of the score in non-Utstein registries requires adjustment of variables and its performance in another setting may differ and needs further evaluation. Moreover, apart from patients with a DNR declaration who were excluded from this study, there is a proportion of patients in whom the decision to terminate resuscitation is mostly guided by comorbidities and family's wishes, affecting in an unpredictable way the performance of this model. However, this bias probably affects all models for OHCA outcome prediction. Finally, UB-ROSC score was designed to predict likelihood of sustained ROSC. Further studies are needed to validate this score in survival with good neurological outcome prediction.

Conclusions

UB-ROSC score is a valuable tool to predict ROSC probability after OHCA. Its external validation in a large cohort of patients confirmed the good performance and calibration of the model. Therefore, the application of the score in a pre-hospital setting may be helpful in the stratification of likelihood of a sustained ROSC achievement and in quality assessment of EMS teams' work in order to continuously improve OHCA management.

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CRediT authorship contribution statement

Maria Luce Caputo: Conceptualization, Writing – original draft. **Enrico Baldi:** Methodology, Investigation, Conceptualization. **Roman Burkart:** Resources, Data curation. **André Wilmes:** Resources, Data curation. **Ruggero Cresta:** Methodology, Data curation. **Claudio Benvenuti:** Supervision, Data curation. **Tardu Oezkartal:** Writing – review & editing. **Roberto Cianella:** Project administration, Data curation. **Roberto Primi:** Project administration, Data curation. **Alessia Currao:** Investigation, Data curation. **Sara Bendotti:** Data curation. **Sara Compagnoni:** Data curation. **Francesca Romana Gentile:** Data curation, Methodology. **Luciano Anselmi:** Visualization, Validation. **Simone Savastano:** Writing – review & editing, Conceptualization. **Catherine Klersy:** Writing – review & editing, Methodology, Formal analysis. **Angelo Auricchio:** Writing – review & editing, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary materials

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Author details

[a]Department of Cardiology, Cardiocentro Ticino Institute-EOC, Lugano, Switzerland [b]Fondazione Ticino Cuore, Lugano, Switzerland [c]Division of Cardiology, Fondazione IRCCS Policlinico San Matteo, Pavia, Italy [d]Cardiac Arrest and Resuscitation Science Research Team (RESTART), Fondazione IRCCS Policlinico San Matteo, Pavia, Italy[e]Interassociation for Rescue Services (IVR-IAS), Aarau, Switzerland [f]Federazione Cantonale Ticinese Servizi Autoambulanze, Bellinzona, Switzerland[g]Department of Molecular Medicine, University of Pavia, Pavia, Italy [h]Service of Biostatistics and Clinical Trial Center, Fondazione IRCCS Policlinico San Matteo, Pavia, Italy

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