

The La Salle Assessment of Return of Spontaneous Circulation in Adult Cardiac Arrest: A Case Control Study (The LASARUS study)

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Abstract

Background: Return of spontaneous circulation (ROSC) is the first crucial phase to be achieved in cardiac arrest resuscitation. To date, there is no valid tool available to prognosticate ROSC in adult, non-traumatic out-of-hospital cardiac arrest (OHCA) patients.

Objective: To develop a model of clinical scoring system predicting ROSC in adult, non-traumatic OHCA patients – the LASARUS score.

Methods: We retrieved complete medical records of adult, non-traumatic OHCA patients between January 2009 and December 2013. Univariate analysis and logistic regression analysis were subsequently performed, providing a value for each variable in the scoring system. Receiver Operating Characteristic (ROC) curve was then done to determine the best cut-off score.

Results: Of the 370 patients, initial ECG rhythm, witnessed

arrest, bystander cardio pulmonary resuscitation (CPR), interval between collapse and CPR initiation were variables associated with ROSC. Logistic regression analysis assigned a value of four (4) for initial ECG rhythm, two (2) for bystander CPR, two (2) for interval between collapse and CPR initiation, and one (1) for witnessed arrest. ROC curve analysis showed three (3) as the best cut-off score (accuracy 0.741, 95% CI: 0.689-0.792, $P < 0.001$). The cumulative score was divided into two groups (0-2 and ≥ 3) with the rate of ROSC in each group was 9.65% and 47.26% respectively ($P < 0.001$).

Conclusion: The LASARUS score demonstrates a preliminary model of clinical scoring system predicting ROSC in adult, non-traumatic OHCA.

Keywords: Non-traumatic out-of-hospital cardiac arrest, return of spontaneous circulation, LASARUS score

Introduction

Out-of-hospital cardiac arrest (OHCA) is one of the major public health problems facing the world today.^{1,2} Although survival with good neurological outcome is the highest goal in every cardiac arrest treatment, return of spontaneous circulation (ROSC) is the first crucial phase to be achieved. Prognostication is an important aspect in managing patients presenting with OHCA at the Emergency Room (ER). A clinical, easy to use scoring system predicting ROSC will enable the physician to predict the outcome of resuscitation in OHCA patients. There are several studies investigating the factors associated with ROSC and survival in non-traumatic OHCA; however, the factors used in these studies were varied with equally variable results.³⁻¹³

To date, there is no valid tool available to aid the physician prognosticate ROSC in adult, non-traumatic

OHCA patients. Review of the local database showed no local publication of predictive scoring in non-traumatic OHCA and factors associated with ROSC in non-traumatic OHCA. We conducted a study to determine the factors associated with ROSC and developed a preliminary model of clinical scoring system (LASARUS score) to predict ROSC in adult, non-traumatic OHCA patients.

Methods

This is a retrospective case control study conducted at a tertiary, university-affiliated teaching hospital in the Philippines (De La Salle University Medical Center). This study was approved by the Independent Ethics Committee and Center for Clinical Epidemiology and Biostatistics De La Salle Health Sciences Institute.

Study population

The study included all adult Filipino patients (age ≥ 18 years old) treated for non-traumatic OHCA at the ER of De La Salle University Medical Center (DLSUMC) between January 1, 2009 and December 31, 2013. All non-traumatic OHCA patients with incomplete medical records or do not resuscitate (DNR) status were excluded.

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Variables and definition of terms

1. **Cardiac Arrest** - the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation.¹⁴
2. **Return of spontaneous circulation (ROSC)** - Signs of the ROSC include breathing (not just an occasional gasp), coughing, movement, palpable pulse, measureable blood pressure. In this study, the term of ROSC indicates sustained ROSC, defined as 20 consecutive minutes of signs of circulation without chest compression.¹⁴ The term of ROSC (-) indicates non sustained ROSC or unsuccessful resuscitation.
3. **Survival to hospital discharge (after ROSC)** - The patient was being discharged alive regardless of neurological status, outcome, or destination.¹⁴
4. **Initial ECG rhythm** - The first cardiac rhythm present when a monitor or defibrillator was attached to a patient after cardiac arrest.¹⁴ The rhythm may consist of shockable rhythm (e.g. ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT)); or and non shockable rhythm (e.g. pulseless electrical activity (PEA), or asystole).
5. **Bystander cardio pulmonary resuscitation (CPR)** - CPR performed by a person who is not responding as part of an organized emergency response system.¹⁴
6. **Witnessed arrest** - A witnessed cardiac arrest is one that was seen or heard by another person or an arrest that was monitored.
7. **Interval between collapse and CPR initiation** - This data was based on the information from the one who brought the patient to the ER and the unit of time interval was in hour or minute. For patient without bystander CPR prior to arrival at the ER, the time interval will be the duration between collapse and arrival time at the ER. For patient having bystander CPR prior to arrival at the ER, the time interval will be the duration between collapse and first bystander CPR. For uniformity, all data were recorded in minutes.
8. **Presence of comorbidity** - All patients' past medical illness as written in the chart will be recorded and classified based on organ system. For analysis purposes, this variable was grouped into those with or without comorbidity.
9. **Complete medical record** - Medical record was classified as complete medical record if it had complete data of all variables (age, gender, initial ECG rhythm, witnessed arrest, bystander CPR, interval between collapse and CPR initiation, presence of comorbidity), CPR result (ROSC or ROSC (-)), survival to hospital discharge (in ROSC group). Unavailability data

of any variable stated in above will be classified as incomplete medical record.

Outcome

The primary outcome was ROSC. The secondary outcome was discharged alive after ROSC.

Data Analysis

Patients achieving ROSC were first compared with those not achieving ROSC by using the Chi-square test for the following categorical data: gender, initial ECG rhythm, witnessed arrest, bystander CPR, presence of comorbidity. Independent t-test was used for the following: age, interval between collapse and CPR initiation. Crude odds ratio were computed with their 95% confidential intervals. Variables with p-values < 0.20 in the univariate analysis were included in the multivariate analysis. We considered p-values < 0.20 in this study because the use of a more traditional level (such as 0.05) might not be able to identify some important variables. The use of higher level, in contrary, would give a possibility to include variables with questionable importance.¹⁵ Logistic regression techniques were then were used for model development in order to obtain a specific score and an equation. Variables emerging with a possible prognostic value ($P < 0.20$) were entered simultaneously into multiple logistic regression models. Independent prognosis factors emerging from these logistic regression models were used to develop the scoring system predicting ROSC. Probability of having ROSC was then computed for each value of the scoring system to determine the best cut-off score for predicting ROSC. Open Epi was used for the computation of ROC curve and the corresponding sensitivity and specificity at each cut-off point.

Results

There were 489 cases of non-traumatic OHCA at the ER DLSUMC between January 2009 and December 2013, which consisted of 150 cases (30.67%) with ROSC and 339 cases (69.33%) with ROSC (-). From 150 cases of ROSC, 132 cases (88.00%) had complete medical record and from 339 cases of ROSC (-), 238 cases (70.21%) had complete medical record. Of the seven originals candidate variables, four had p-values less than 0.20 (Table I).

No significant statistical differences in age, gender, or presence of comorbidity were observed between ROSC and ROSC (-) group. For the initial ECG rhythm, 21.97% of patients with ROSC and 0.42% of patients with ROSC (-) had shockable rhythm ($P < 0.001$). Patients with ROSC

Table I. Variables analyzed in relation to ROSC

Variables	All Patients (n=370)	ROSC (n=132)	ROSC (-) (n=238)	p-value
Age (years)	58.1 ± 15.42	57.0 ± 17.16	58.7 ± 14.37	0.308
Male	132 (64.86%)	81 (61.36%)	159 (66.81%)	0.293
Initial ECG rhythm				< 0.001
• Shockable rhythm	30 (8.11%)	29 (21.97%)	1 (0.42%)	
• VF	• 25 (6.76%)	• 24(18.18%)	• 1 (0.42%)	
• Pulseless VT	• 5 (1.35%)	• 5 (3.79%)	• 0 (0%)	
• Non-shockable rhythm	340 (91.89%)	103 (78.03%)	237(99.58%)	
• Asystole	• 251(67.84%)	• 67(50.76%)	• 184(77.31%)	
• PEA	• 89 (24.05%)	• 36(27.27%)	• 53(22.27%)	
Witnessed arrest	326 (88.11%)	125 (94.70%)	201 (84.45%)	0.004
Bystander CPR	5 (1.35%)	4 (3.03%)	1 (0.42%)	0.13
Interval between collapse &CPR (minutes)	31.5 ± 23.90	19.2 ± 12.11	38.3 ± 26.03	< 0.001
Presence of comorbidity	307 (82.97%)	113 (85.61%)	194 (81.51%)	0.316

Table II. Significant predictor variables for ROSC

Variables	B	p-value	Odds Ratio	95.0% C.I.
Witnessed arrest	.933	.041	2.541	1.041-6.205
Bystander CPR	2.192	.097	8.957	.672-119.375
Initial ECG rhythm	3.702	< 0.001	41.251	5.510-308.848
Interval between collapse and CPR (≤ 30 min vs. > 30 min)	1.964	< 0.001	7.127	3.112-16.321

more often were witnessed arrest (94.70% vs. 84.45%, $P=0.004$), had bystander CPR (3.03% vs. 0.42%, $P = 0.13$). These ROSC patients had significantly shorter time interval between collapse compared to the ROSC (-) and CPR compared to the ROSC (-) patients (19.2 ± 12.11 min vs. 38.3 ± 26.03 min, $P < 0.001$). The median time interval between collapse and CPR was 30 minutes. The minimum time was five minutes and the maximum was 120 minutes.

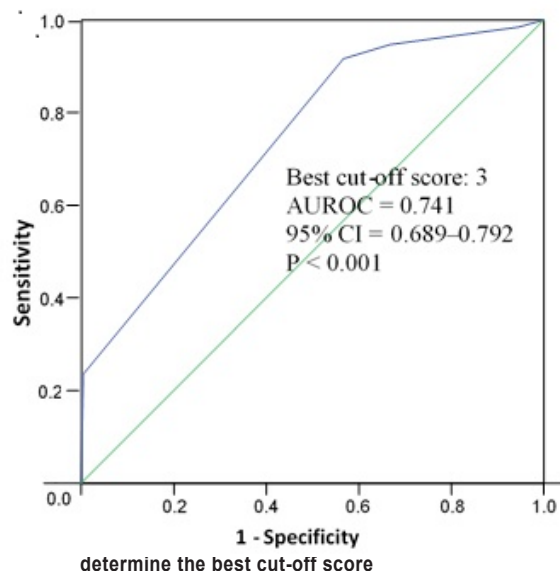
For the scoring system, we used the regression coefficient from the logistic regression model (**Table II**). The LASARUS scoring system was then developed by assigning a value to each variable according to the coefficient as follow:

If witnessed arrest = 1

If there was a bystander CPR = 2

If the initial ECG rhythm was shockable rhythm = 4

If the interval between collapse and CPR was
≤ 30 min =2



Score	Sensitivity	(95% CI)	Specificity	(95% CI)
1	98.48%	(94.64, 99.58)	5.46%	(3.22, 9.12)
2	94.7%	(89.46, 97.41)	33.19%	(27.52, 39.40)
3	91.67%	(85.69, 95.28)	43.28%	(37.14, 49.63)
4	23.48%	(17.07, 30.4)	99.58%	(97.66, 99.93)
5	22.73%	(16.41, 30.59)	99.58%	(97.66, 99.93)
6	21.97%	(15.75, 29.77)	99.58%	(97.66, 99.93)
7	0.76%	(0.1399, 4.166)	100%	(98.41, 100)
8	0.76%	(0.1399, 4.166)	100%	(98.41, 100)

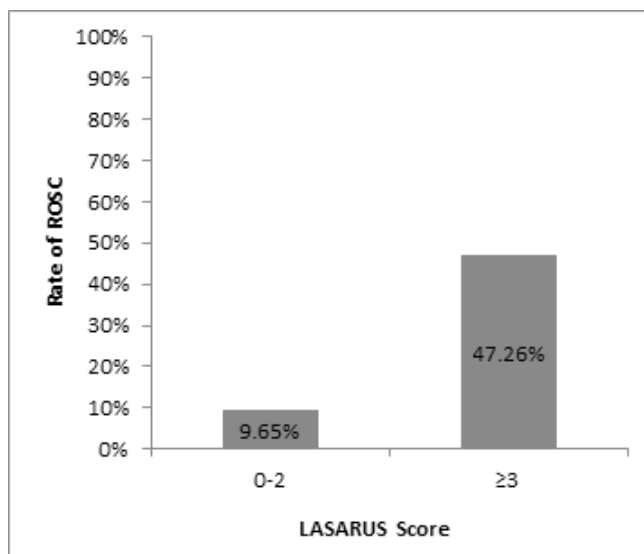


Figure 2. Percentage of ROSC by LASARUS score

ROC curve analysis showed that the best cut-off score was 3 (Figure 1), with accuracy (the area under the curve (AUROC)) for prediction of ROSC was 0.741 (95% CI: 0.689–0.792, $P < 0.001$).

Table III showed the number and percentage of ROSC patients with scores ≥ 3 and 0-2. The rate of ROSC increased in the group with higher score and was statistically significant with $P < 0.001$ (Figure 2).

For the secondary outcome, 58 (43.9%) patients with ROSC were discharged alive.

Discussion

This study showed witnessed arrest, bystander CPR, interval between collapse and CPR, and initial ECG rhythm were the factors associated with ROSC in adult patients treated for non-traumatic OHCA.

As shown in previous studies,^{6,12,13} shorter interval between collapse and CPR was associated with survival and better outcome, but the median time in our study was longer than the previous studies (median time: 30 minutes; minimum time: five minutes, maximum time: 120 minutes) which might be due to recall bias and rough estimation of the time. It was difficult to obtain accurate time interval in our study since majority of our patients were brought to the hospital by their family with no detailed time documentation of each event.

In the initial ECG rhythm factor, better outcome was associated with ventricular fibrillation or shockable rhythm as the initial ECG rhythm.^{6-9,11} Similar result was shown in our study; however, we had no patient with pulseless ventricular tachycardia rhythm in the ROSC (-) group and further study with greater subject population is needed to get more reliable measure of association.

Table III. Observed ROSC by categorical score

Score	ROSC		ROSC (-)		Total	
	N	%	N	%	N	%
0-2	11	9.65%	103	90.35%	114	30.8
≥ 3	121	47.26%	135	52.74%	256	69.2
Total	132	35.67%	238	64.32%	370	100

Chi-square value=48.64, $df=1$,

Witnessed arrest was associated with ROSC, this was similar to findings from previous studies.^{6,8,13} However, in comparison to other studies, there were just five patients (1.35%) getting bystander CPR in our study. A study by Ubon in Thailand had 20 patients (27.4%) with bystander CPR which was associated with sustained ROSC ($P = 0.005$).¹³ A greater percentage of bystander CPR was found in the Arrest study in Amsterdam with 497 patients (54%) got bystander CPR and had 1.3 times the chances to be admitted alive.⁸

Although the p-value of bystander CPR in univariate analysis was 0.13, we considered this factor was significant as we had decided to put the threshold of p-value < 0.2 . Looking to the previous studies and since bystander CPR is the second step of first three chain of survival according 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care,¹⁶ we decided to maintain bystander CPR in our scoring system. The small number of patients having bystander CPR in our study indicated that there's a need to give CPR training to the community, especially to the high-risk patient's family in developing countries. The quality of bystander CPR would also affect the outcome of resuscitation.

For the LASARUS scoring system, an ROC curve was plotted and the best cut off score was 3. Based on the best cut off score and due to only one subject only with cumulative score 4-9 in ROSC (-), we divided the cumulative score into two groups (0-2 and ≥ 3) and noted significant increase in the rate of ROSC between the two groups.

Study limitation and recommendation

As this is a retrospective study, all information relied on the data written in the medical records. Only those with complete medical records were included in this study. Although there was a possibility of missing data bias and or recall bias, this study is important as a basis and model to assess the factors significantly associated with ROSC and demonstrates a preliminary model of clinical scoring system predicting ROSC. Further prospective study is recommended for obtaining better measure of association for some variables and validation of the scoring system.

Conclusion

In this study, 58 (43.9%) patients with ROSC were discharged alive with various neurological status (measured in Glasgow Coma Scale). Patients going home per request and transferred to other hospital were also included in this category.

It is important to understand that this scoring system is intended to assist the physician in evaluating and predicting the rate of ROSC more objectively and not to serve as sole basis for end-of-life decision.

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