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ORIGINAL RESEARCH

Predictive Factors of Outcome in Cases of Out-of-hospital Cardiac Arrest Due to Traffic Accident Injuries in Thailand; a National Database Study

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Abstract: **Introduction:** Traffic accident injury is one of the global leading causes of death and an important public health problem. This study aimed to evaluate the predictive factors of return of spontaneous circulation (ROSC) at the scene in out-of-hospital cardiac arrest (OHCA) due to traffic accidents. **Methods:** This retrospective cross-sectional study was conducted on cases of OHCA due to traffic accident, who were resuscitated at the scene by emergency medical services (EMS) in Bankok, Thiland, from January 1, 2020, to December 31, 2020 (1 year). Patients were divided into two groups of with and without ROSC and independent predictive factors of outcome were evaluated. **Results:** 2400 OHCA cases met the inclusion criteria, among them, 1728 (72.0%) achieved ROSC at the scene. Facial injury (adjusted OR = 2.17, 95%CI: 1.37–3.44, p = 0.001); prehospital airway management using bag valve mask (adjusted OR = 1.69, 95%CI: 1.21–2.34, p = 0.002), and endotracheal tube (adjusted OR = 3.88, 95%CI: 1.84–8.18, p <0.001); and prehospital fluid therapy using normal saline (adjusted OR = 4.24, 95%CI: 3.12–5.77, p <0.001), ringer lactate (adjusted OR = 5.13, 95%CI: 3.47–7.61, p <0.001), and other solutions (adjusted OR = 5.25, 95%CI: 2.16–12.8, p <0.001) were independent predictive factors of ROSC at the scene in OHCA due to traffic accidents. **Conclusion:** Based on the findings, the rate of ROSC at the scene for cases with OHCA due to traffic accidents, serviced by EMS was high, i.e., 72%, and three independent predictive factors of ROSC at the scene were facial injury, prehospital airway management, and prehospital fluid management.

Keywords: Prognosis; emergency medical services; heart arrest; patient outcome assessment; mortality; accidents, traffic

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1. Introduction

The World Health Organization reported the annual average number of deaths due to traffic accidents as 1.35 million. The majority of deaths occurred in vulnerable populations, including pedestrians and motorcyclists. About 93% of deaths occurred in low-to-middle income countries, Traffic accident injury was the leading cause of death in those aged 5–29 years (1). Thai road safety collaboration reported the cumulative number of injuries to be 417,935 in 2021 from January to May, and the number of deaths from traffic accidents was 6,513. Every hour, two died due to traffic accidents in Thailand (2). Two-thirds of road accident victims in Thailand were male (80%) and aged <40 years. About 80% of the injured and deceased were motorcyclists.

Traffic accidents were an important public health problem leading to injuries, disabilities, and mortalities in Thailand, a developing country, causing vast effects on individuals, families, societies, and the nation as a whole (3). Thailand had the highest rate of road accident mortality in South East Asia, i.e.,

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32.7 per 100,000 population (4). Emergency medical services (EMS) were used as a tool to address this issue and focused on prehospital management of injured patients, appending two important concepts, the golden period or golden hour and the platinum 10 minutes. Regarding the golden period, the first 60 minutes for injured patients, starting from accident, is a period with significantly increased morbidity and mortality. The platinum 10 minutes within the golden hour means that paramedics have at most 10 minutes at the scene to manage severely injured patients for survival rate improvement (5).

Bystander cardiopulmonary resuscitation (CPR) increased the survival rate of injured patients with cardiac arrest from an accident, as indicated in previous studies (6, 7). For initial cardiac rhythm, shockable rhythm resulted in survival improvement (8-10). Pediatric patients had a higher survival rate by receiving CPR for out-of-hospital cardiopulmonary arrest (OHCA) due to accidents, as compared to adult patients with a survival rate of approximately 17.8% (95% CI; 15.1–20.8%).

Geographical areas where accidents happened between the city and countryside were associated with inpatient survival and hospital discharge (9, 10). Thailand is 513,120 square kilometers (198,120 square miles), divided into 77 provinces. Its mean population was 66.19 million in December 2020. In the 2021 statistical report, 854,118 traffic accidents and 13,235 traffic accident mortalities occurred, which showed that the country had the highest number of injured and deceased patients due to traffic accidents worldwide (11). Every traffic accident led to loss, including deaths, disabilities, and inevitable traffic congestion, an obstacle for ambulances and EMS teams to access the scene. A traffic accident was one of the three most common events managed by the Thai emergency medical units. Out-of-hospital EMS was initiated when Emergency Medical Act B.E.2551 was declared. The National Institute for Emergency Medicine was the backbone supporting emergency medical missions in Thailand. In Thailand, the emergency hotline is 1669. The provincial dispatch center manages each province, except for Bangkok where the Erawan Center and Bangkok EMS center are located. The present study aimed to evaluate prognostic factors associated with the return of spontaneous circulation (ROSC) at the scene and determine the rate of ROSC at the scene for those injured with OHCA due to traffic accidents, serviced by EMS.

2. Methods

2.1. Study design and setting

This retrospective cross-sectional study was conducted on cases of OHCA due to traffic accident, who were resuscitated at the scene by EMS in Bankok, Thiland, from January 1, 2020, to December 31, 2020 (1 year). Patients were divided into two groups of with and without ROSC and independent predictive factors of outcome were evaluated. The ethical approval of the study protocol was granted by The Committee on Human Rights Related to Research Involving Human Subjects, Faculty of Medicine, Vajira Hospital, Navamindradhiraj University (COA. 168/2564). The requirement for informed consent was waived due to the retrospective design. The study data were kept confidential to ensure the privacy of the studied participants. This study was conducted in accordance with the Declaration of Helsinki.

2.2. Participants

Traffic accident patients aged >18 years, coded as 25 Red 1 symptom group based on emergency medical triage protocol and criteria-based dispatch (CBD) of Thailand, defined as a traffic accident with cardiac arrest, who received advanced cardiovascular life support from the Advanced Life Support (ALS) team were eligible for study.

Traffic accident patients serviced by EMS in Bangkok who died at the scene (death on arrival), those who were evaluated as deceased when EMS arrived, those who were deemed unsuitable for CPR by the ALS team leader, patients whose relatives denied treatment and transportation, those receiving CPR during transfer, patients with discordant CBD coding to the actual incident, and those with incomplete data were excluded. ROSC at the scene was defined as the presence of palpable pulse after CPR at the scene of trauma.

2.3. Data gathering

Data were collected from the National Institute for Emergency Medicine database, Thailand, which gathered data on traffic accidents with symptom group 25 based on the Thailand emergency medical triage protocol and criteria-based dispatch (CBD), from the database of Information Technology for Emergency Medical System (ITEMS). Only symptom group 25 Red 1, i.e., traffic accident patients with cardiac arrest, was selected for this study. The ITEMS database of the National Institute for Emergency Medicine is the national database recording Thai EMS operation data including patient management at the scene and during transportation. The EMS team recorded data in the patient record form and then transferred them into the ITEMS database within that day or month. Only authorized people could record and go over the data, including paramedics, emergency nurse practitioners (ENPs), or advanced emergency medical technicians (AEMTs).

The study included the injured and emergency operation unit's data, such as sex, age, operation time, type of wounds, type of orthopedic injuries, type of hemorrhage, type of body part injured, the response time (minute), duration of transfer to the hospital (minute), duration from hospital to the base station (minute), distance from the base station to scene (kilometer), distance from the scene to the hospital (kilometer), distance from hospital to the base station (kilometer), prehospital airway management, prehospital hemorrhage control, prehospital airway management, prehospital fluid management, prehospital immobilization, and prehospital automated external defibrillator (AED) /defibrillation, medication during CPR, and ROSC on the scene.

The concept of emergency medicine in Thailand appends the Anglo-American and Franco-German models. In Thailand, the out-of-hospital emergency staff includes emergency physicians (EPs), paramedics, ENPs, AEMTs, emergency medical technicians (EMTs), and emergency medical responders, which operate under an emergency medical director, which can be divided into off-line and online medical directions. In general, the staff operates under a predetermined off-line medical direction, as a protocol created by the emergency medical director, which is different in each operation unit or hospital, depending on administrative potential and existent resources.

There are two tiers of ambulances in Thailand, i.e., advanced life support (ALS) and basic life support. Regarding emergency medical operations for traffic accident patients with cardiac arrest, most EMS teams in the study area consisted of at least three staff members during each operation, including EPs, paramedics, or ENPs as operation leaders and AEMTs and EMTs as members.

2.4. Outcome measures

The primary objective was to evaluate predictive factors of ROSC at the scene in cases with OHCA due to traffic accidents, who were serviced by EMS. The secondary objective was to determine the ROSC rate of the injured with OHCA due to traffic accidents at the scene.

2.5. Statistical analysis

Sample size was calculated using two independent proportions (12). The statistical significance level of 0.05 and test power of 80% were considered. Statistical values for sample size were calculated based on Jun GS et al. (9) study that reported survival rates of male and female patients with both OHCA and ROSC on the scene to be 0.3332% (1988/5966; p1= 0.3332) and 27.08% (615/2271; p2= 0.2708), respectively. The sample size ratio of females to males was 0.38 (2271:5966). Therefore, calculated female and male sample sizes were at least 1,524 and 580, consecutively. Hence, a sample size of 2,104 was determined. However, due to the retrospective design of the study, collecting data from medical records, the sample size was increased to compensate for incomplete data of 10% (13). The final sample size was 2,400.

A descriptive analysis was performed to examine variable distribution. Continuous variables are presented as mean ± standard deviation (SD) or median and interquartile range (IQR), and categorical variables are presented as frequencies and proportions. When comparing the two groups, differences were evaluated using independent t-test or Mann-Whitney U test for numeric variables and chi-square test or Fisher's exact test for categorical variables.

The survival rate of the injured patients with OHCA at the scene who were serviced by EMS was reported as frequency distribution and percentage (incidence) with a 95% confidence interval (CI). Predictive factors associated with ROSC at the scene for the injured with OHCA due to traffic accidents serviced by EMS were reported as frequency distribution and percentage, categorized based on survival, assessed with crude analysis using either the Chi-squared test or Fisher's exact test based on the type of variable. Multivariable analysis using multiple logistic regression analysis was reported as odds ratio (OR) and 95% CI. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY, USA: IBM Corp. was used. All statistical tests were considered statistically significant at a p-value of ≤0.05.

3. Results

3.1. Baseline characteristics of studied cases

2400 cases of OHCA with ROSC at the scene with the mean age of 40.07 ± 18.47 years, who were resuscitated by EMS during the study period were studied. The ROSC rate at the scene was 72.0% (1728 patients). There was no difference between survived and deceased cases regarding sex distribution (78.9% vs. 78% male; p = 0.629) and mean age (40.07 ± 18.47 vs. 40.05 ± 18.85 years, p = 0.985). Table 1 compares the baseline characteristics between patients with and without ROSC.

3.2. Associated factors of ROSC at the scene

Based on univariate analysis, associated factors of ROSC at the scene for cases of OHCA due to traffic accidents were facial injury (OR = 2.08, 95%CI: 1.32–3.26, p = 0.001); prehospital airway management using bag valve mask (BVM) (OR = 2.4–4, 95%CI: 1.80–3.30, p <0.001), endotracheal tube (ETT) (OR = 5.79, 95%CI: 2.80–11.94, p <0.001), or supra-glottic airway devices (OR = 2.17, 95%CI: 1.23–3.81, p = 0.007); prehospital fluid management with normal saline (NSS) (OR = 4.72, 95%CI: 3.51–6.34, p <0.001), lactated Ringer's solution (RLS) (OR = 5.71, 95%CI: 3.89–8.37, p <0.001), and other solutions (OR = 5.71, 95%CI: 2.36–13.79, p <0.001); prehospital immobilization including splint (OR = 2.78, 95%CI: 1.59–4.88, p <0.001) and collar with long spinal board (OR = 2.59, 95%CI: 1.92–3.51, p <0.001); and medication during the CPR process (OR = 1.47, 95%CI: 1.14–1.90, p = 0.003) (Table 2).

Multivariable analysis using multiple logistic regression analysis and backward stepwise selection method, showed that

Table 1: Comparing the baseline characteristics between patients with and without return of spontaneous circulation (ROSC)

Variables	ROSC on scene (n = 2400)		P value
	Yes (n=1728)	No (n = 672)	
Sex			
Male	1363 (78.9)	524 (78.0)	0.629
Female	365 (21.1)	148 (22.0)	
Age (year)			
0–19	260 (15.0)	101 (15.0)	
20–39	624 (36.1)	243 (36.2)	0.999
40–59	536 (31.0)	207 (30.8)	
>60	308 (17.8)	121 (18.0)	
Shift			
Morning (8.00–15.59)	501 (29.0)	188 (28.0)	
Evening (16.00–23.59)	910 (52.7)	353 (52.5)	0.772
Night (0.00–7.59)	317 (18.3)	131 (19.5)	
Type of wounds			
None	73 (4.2)	29 (4.3)	
Cut/laceration	1213 (70.2)	473 (70.4)	
Abrasion	271 (15.7)	93 (13.8)	0.690
Other	70 (4.1)	32 (4.8)	
Unknown	101 (5.8)	45 (6.7)	
Type of orthopedic injuries			
None	501 (29.0)	174 (25.9)	
Closed fracture	542 (31.4)	217 (32.3)	
Open fracture	446 (25.8)	184 (27.4)	0.668
Dislocation	40 (2.3)	16 (2.4)	
Unknown	199 (11.5)	81 (12.1)	
Hemorrhage status			
None	200 (11.6)	75 (11.2)	
Stopped external bleeding	608 (35.2)	182 (27.1)	
Active external bleeding	489 (28.3)	233 (34.7)	0.002
Internal hemorrhage	230 (13.3)	101 (15.0)	
Unknown	201 (11.6)	81 (12.1)	
Location of trauma			
Head/neck	1199 (69.4)	490 (72.9)	
Face	122 (7.1)	24 (3.6)	
Extremity	56 (3.2)	19 (2.8)	0.035
Other	144 (8.3)	56 (8.3)	
Multiple injuries	38 (2.2)	11 (1.6)	
Unknown	169 (9.8)	72 (10.7)	
Response time (minute)			
Median (IQR)	10 (7–14)	10 (7–15)	0.430
≤8	697 (40.3)	257 (38.2)	0.347
>8	1031 (59.7)	415 (61.8)	
Scene to hospital time (minute)			
Median (IQR)	7 (4–10)	7 (5–12)	0.475
≤8	1041 (60.2)	388 (57.7)	0.262
>8	687 (39.8)	284 (42.3)	
Time from hospital to EMS station (minute)			
Median (IQR)	0 (0.01–0.01)	0.01 (0.01–0.01)	0.004
≤1	1589 (92.0)	583 (86.8)	<0.001
>1	139 (8.0)	89 (13.2)	
Distance from EMS station to scene (km)			
Median (IQR)	7 (4–11)	7 (4–11)	0.249
≤10	1254 (72.6)	481 (71.6)	
>10	448 (25.9)	182 (27.1)	0.817
Unknown	26 (1.5)	9 (1.3)	
Distance from scene to hospital (km)			
Median (IQR)	7 (4–11)	7 (4–11)	0.194
≤10	1257 (72.7)	449 (66.8)	
>10	445 (25.8)	179 (26.6)	<0.001
Unknown	26 (1.5)	44 (6.5)	

Table 1: Comparing the baseline characteristics between patients with and without return of spontaneous circulation (ROSC)

Variables	ROSC on scene (n = 2400)		P value
	Yes (n=1728)	No (n = 672)	
Distance from hospital to EMS station (km)			
Median (IQR)	5 (2–11)	7 (3–15)	0.176
<10	103 (6.0)	54 (8.0)	<0.001
≥10	36 (2.1)	30 (4.5)	
Unknown	1589 (92)	588 (87.5)	
Prehospital airway management			
No	100 (5.8)	89 (13.2)	<0.001
BVM	1507 (87.2)	550 (81.8)	
ETT	65 (3.8)	10 (1.5)	
Supra-glottic airway devices	56 (3.2)	23 (3.4)	
Prehospital hemorrhage control			
No	342 (19.8)	148 (22)	0.444
Pressure dressing	1127 (65.2)	430 (64)	
Dressing	259 (15.0)	94 (14)	
Prehospital fluid management			
No	82 (4.7)	131 (19.5)	<0.001
NSS	1371 (79.3)	464 (69.0)	
RLS	250 (14.5)	70 (10.4)	
Other	25 (1.4)	7 (1.1)	
Prehospital immobilization			
No	97 (5.6)	90 (13.4)	<0.001
Splint	66 (3.8)	22 (3.3)	
Collar with long spinal board	1565 (90.6)	560 (83.3)	
Prehospital AED/defibrillation			
No	1640 (94.9)	630 (93.8)	0.261
Yes	88 (5.1)	42 (6.3)	
Medication during CPR			
No	266 (15.4)	118 (17.6)	<0.001
Yes	897 (51.9)	270 (40.2)	
Unknown	565 (32.7)	284 (42.3)	

Data are presented as number (%) or mean ± standard deviation or median (interquartile range). P-value corresponds to independent samples t-test, Mann-Whitney U test, Chi-square test, or Fisher's exact test. ROSC, return of spontaneous circulation; EMS, emergency medical services; IQR, interquartile range; BVM, bag valve mask; ETT, endotracheal tube; NSS, normal saline; RLS, ringer lactate; AED, automated external defibrillator; CPR, cardiopulmonary resuscitation.

facial injury (adjusted OR = 2.17, 95%CI: 1.37–3.44, p = 0.001); prehospital airway management using BVM (adjusted OR = 1.69, 95%CI: 1.21–2.34, p = 0.002) and ETT (adjusted OR = 3.88, 95%CI: 1.84–8.18, p <0.001); and prehospital fluid therapy using normal saline (adjusted OR = 4.24, 95%CI: 3.12–5.77, p <0.001), ringer lactate (adjusted OR = 5.13, 95%CI: 3.47–7.61, p <0.001), and other solutions (adjusted OR = 5.25, 95%CI: 2.16–12.8, p <0.001) were the independent predictive factors of ROSC at the scene in OHCA due to traffic accidents (Table 2).

4. Discussion

In the present study, the rate of ROSC at the scene for cases of OHCA due to traffic accidents, serviced by EMS was high, i.e., 72%, and three predictive factors of ROSC at the scene were facial injury, prehospital airway management, and prehospital fluid management.

The high rate of ROSC at the scene among traffic accident patients probably means that the traffic accident patients with cardiac arrest usually had a high survival rate, consistent with the results of a study in Thailand, reporting that the survival rate of those injured due to traffic accidents, managed by EMS, and admitted to tertiary hospitals was 97.9% at the scene (14). Moreover, the result was comparable to the authors' previous study, which showed that the ROSC rate among traffic accident patients was higher than non-traumatic patients at the scene (15). The results of the present study were consistent with those of a previous study reporting short and quite good survival and recovery time for traffic accident patients (16). Most traffic accident patients with OHCA survived with a mortality rate of only 7.4% in the emergency department in Addis Ababa, Ethiopia (17).

A facial injury could predict ROSC at the scene for traffic accident patients with OHCA, managed by EMS in the present study, a finding consistent with that of a previous study

Table 2: Multivariate analysis of factors associated with on-the-scene return of spontaneous circulation in patients with out-of-hospital cardiopulmonary arrest due to traffic accident

Factors	Multivariate analysis		
	OR adjusted	95%CI	P value
Location of trauma			
Head/Neck	1.00	Reference	
Face	2.17	(1.37–3.44)	0.001
Extremity	1.17	(0.68–2.01)	0.570
Other	1.01	(0.72–1.42)	0.948
Multiple injuries	1.55	(0.77–3.12)	0.220
Unknown	1.03	(0.76–1.41)	0.833
Prehospital airway management			
No	1.00	Reference	
Bag valve mask	1.69	(1.21–2.34)	0.002
Endotracheal tube	3.88	(1.84–8.18)	<0.001
Supraglottic airway devices	1.41	(0.78–2.54)	0.253
Prehospital fluid management			
No	1.00	Reference	
Normal saline	4.24	(3.12–5.77)	<0.001
Ringer lactate	5.13	(3.47–7.61)	<0.001
Other	5.25	(2.16–12.8)	<0.001

Hosmer and Lemeshow Test: Chi-square = 7.060, df = 4, p-value = 0.133, Constant = -0.922. OR: odds ratio; CI: confidence interval.

demonstrating that the injured body part affected the chance of survival, especially in those with a single injury, such as the face and extremity. They also reported that injury to critical body parts, such as the chest, abdomen, pelvis, head, and neck, and multiple injuries negatively affected survival (18). Prehospital airway management, such as BVM and ETT in traffic accident patients with OHCA, can also be used to predict ROSC at the scene, a finding consistent with the authors' previous national database study, comparing ROSC rates between patient groups receiving BVM and ETT. No statistically significant difference in prehospital ROSC rate was detected (19), which conflicted with that of a previous study indicating that traffic accident patients intubated with ETT by EMS had a better outcome than those without ETT intubation and prehospital ETT intubation in indicated patients. Patients with OHCA might have a lower mortality rate and also improved early neurological outcomes (20), a finding comparable to the study indicating that those with ETT intubation in out-of-hospital patients had better outcome than the group without ETT intubation, including decreased mortality rate, and prehospital ETT intubation was not associated with increased morbidities and mortalities (21). However, ETT intubation in our study area depended on the protocols of each area, and only EPs and paramedics were permitted to intubate, which limited its performance. For ALS teams with neither EPs nor paramedics, BVM was used instead of ETT.

Prehospital fluid management was a factor that could predict ROSC at the scene for traffic accident patients with OHCA, managed by EMS. RLS, NSS, and other fluid replacements were well known for prehospital fluid resuscitation in traumatic arrest, as an isotonic crystalloid solution is suggested to be the first choice in the injured with shock due to blood loss and OHCA (22). A previous clinical trial study indicated that RLS was superior to NSS in clinical outcomes, admission duration, and survival (23, 24). However, a decision in fluid replacement selection for traffic accident patients with OHCA in the present study relied on the team leader, and the protocol determined in each area was different.

5. Limitations

The most important limitation of the present study was for ITEMS database, as some of the important factors reported by previous studies to affect survival of the injured patients by were not recorded for OHCA patients, such as bystander CPR and initial cardiac rhythm. The second limitation was the inevitable bias associated with a retrospective study, as some data were lost, leading to exclusion. Third, since data were collected from the database in the ITEMS, treatment results were limited, accessible only to treatment at the scene; thus, no in-hospital treatment and patient outcomes, treatment in the emergency department, surgery, or other treatments were included, resulting in evaluating only the outcomes at the scene by emergency unit or EMS team. Fourth, the severity and mechanism of injury were not considered in the study. Lastly, EMS operation units in the study area were markedly different in operation staff, resources, and protocols for each area, which probably leads to the inability to generalize the present study's results.

6. Conclusion

Based on the findings, the ROSC rate of OHCA cases due to traffic accidents, serviced by EMS was high at the scene, i.e., 72%, and three independent predictive factors of ROSC at the scene were facial injury, prehospital airway management, and prehospital fluid management.

7. Declarations

7.1. Acknowledgments

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7.2. Authors' contributions

Design of the study by Thongpitak Huabbangyang; Data acquisition by Thongpitak Huabbangyang, Chunlanee Sangketchon, Sakditat Ittiphisit and Kanittha Uoun; Data analysis and interpretation by Thongpitak Huabbangyang, Chunlanee Sangketchon and Chomkamol Saumok; drafting the manuscript by Thongpitak Huabbangyang; Revision of the manuscript by Thongpitak Huabbangyang, Chunlanee Sangketchon, Sakditat Ittiphisit, Kanittha Uoun and Chomkamol Saumok; the final version of the manuscript is approved by all the authors.

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7.4. Conflict of interest

The authors report no conflict of interest.

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