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ORIGINAL RESEARCH

Using Sodium Bicarbonate During Prolonged Cardiopulmonary Resuscitation in Prehospital Setting; a Retrospective Cross-sectional Study

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Abstract: Introduction: Although the 2020 American Heart Association (AHA) guidelines recommend that sodium bicarbonate (SB) be avoided during routine cardiopulmonary resuscitation (CPR) a limited number of studies have examined the effects of SB injection during prolonged CPR (>15 min) in prehospital setting. The present study aimed to examine the effects of prehospital SB use during prolonged CPR on patients' outcome. **Methods:** In this retrospective cross-sectional study adult patients aged >18 years who experienced a non-traumatic, out-of-hospital cardiac arrest (OHCA) were compared regarding three outcomes, namely return of spontaneous circulation (ROSC), ROSC > 20 minute, and survival to discharge, based on receiving or not-receiving SB during CPR. **Results:** 330 patients were divided into two equal groups of 165. The two groups had similar conditions regarding gender distribution (p = 0.729); mean age (p = 0.741); underlying diseases (p = 0.027); etiology of arrest (p = 0.135); the initial rhythm (p = 0.324); receiving normal saline solution (p = 1.000), epinephrine (p = 0.848), and atropine during CPR (p = 0.054); and using defibrillation (p = 0.324). Those who received SB had 0.80 times greater likelihood for sustained ROSC (adjusted odds ratio (OR) = 0.80, 95% CI: 0.47–1.37, p = 0.415), 0.93 times greater likelihood for ROSC at the scene (adjusted OR = 0.93, 95% CI: 0.55–1.59, p = 0.798), and 0.34 times greater likelihood for survival to discharge (adjusted OR = 0.34, 95% CI: 0.10–1.17, p = 0.087). **Conclusion:** The present study demonstrated that prehospital SB use by EMS during prolonged CPR did not improve ROSC rate at the scene, sustained ROSC, and survival to discharge.

Keywords: Cardiopulmonary resuscitation; emergency medical services; treatment outcome; out-of-hospital cardiac arrest; sodium bicarbonate

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1. Introduction

Sodium bicarbonate (SB) is the primary medication used as buffer therapy during cardiac arrest. Previous researchers hypothesized that SB therapy corrected metabolic acidosis and could improve outcomes in cardiac arrest (1). During cardiac arrest, an imbalance in oxygen exchange occurs in the body, resulting in acidosis (2). Observational studies on intensive care units reported that over 95% of cardiac arrest patients exhibited acidosis after return of spontaneous circulation (ROSC), especially those receiving prolonged cardiopulmonary resuscitation (CPR) (3). Moreover, available evidence suggests that low blood pH or acidosis after ROSC significantly increased mortality rates in hospitals. Similarly, one study showed that every 0.1-unit increase in pH from pH <7.2 promoted an increase in the likelihood of survival to discharge (4). SB has been widely used not only in context of in-hospital medical services but also in prehospital emergency medical services (EMS).

A study found that SB use during CPR by EMS significantly

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improved the outcomes of ROSC (5). But, one study found that SB use was not associated with improved outcomes of ROSC or increased rates of survival to discharge in cardiac arrest patients. In fact, mortality increased significantly, with several side effects of SB use having been noted during CPR, which included hypernatremia, alkalosis, and excess carbon dioxide production (6). A prospective randomized controlled trial (RCT) comparing out-of-hospital cardiac arrest (OHCA) patients treated with and without SB found that SB administration was not associated with the likelihood of favorable functional 30-day outcomes (7). Therefore, the 2010, 2015, and 2020 American Heart Association guidelines for advanced cardiac life support do not recommend routine use of SB during CPR in cardiac arrest patients except in the presence of certain indications, namely pre-existing metabolic acidosis, hyperkalemia, and tricyclic antidepressant intoxication (8-10). Previously studies had vigorously attempted to prove the efficacy of SB. One RCT demonstrating the benefit of SB use in cardiac arrest patients requiring prolonged CPR (>15 min) found that SB use was significantly associated with increased ROSC rates (11). Present knowledge has suggested that prolonged CPR results in just a <1% or no chance for ROSC, survival to discharge, and favorable outcomes (12). As such, prolonged resuscitation can trigger anxiety among health care personnel, including prehospital emergency medical staff, and has been associated with many factors. One previous study found that bystander CPR and initial shockable rhythm might be important factors causing prolonged CPR in cardiac arrest patients, particularly prehospitally (13).

Prevailing knowledge suggests that buffer therapy with SB by EMS can be an option for treating OHCA patients requiring prolonged CPR. However, such circumstances have some limitations, that is, blood gas testing cannot be performed and there is a current paucity in human studies examining the effects of SB in cases requiring prolonged CPR. No clear and concrete guidelines on rational SB use in OHCA patients have been established, and empirical evidence supporting the prehospital use of SB has been lacking and there are limited resources and emergency medical staff.

Hence, the present study aimed to examine the effects of prehospital SB use during prolonged CPR (for >15 min) on sustained ROSC (>20 min), ROSC at the scene, and survival to discharge.

2. Methods

2.1. Study design and setting

This retrospective cross-sectional study was conducted at Vajira Emergency Medical Service (V-EMS), Vajira Hospital, Navamindradhiraj University, Bangkok, Thailand. Patients with OHCA, who underwent CPR were compared regarding ROSC, ROSC > 20 minute, and survival to discharge, based on receiving or not-receiving SB during CPR.

V-EMS is primarily responsible for providing EMS to zone area one among a total of nine zone areas within Bangkok and is dispatched by Erawan Center, Bangkok, which maintains a network of six public and private hospitals within the 50 km2 area of responsibility with a population of 500,000 (14, 15). When responding to OHCA patients in need of EMS, V-EMS dispatches one team at a time, which includes at least three staff comprising paramedics or emergency nurse practitioners (ENPs) as the operation team leader and emergency medical technicians. During each operation, paramedics or ENPs would follow off-line and on-line medical protocols under the emergency physicians' orders. In cases involving cardiac arrest patients within the area, the 2020 American Heart Association (AHA) guidelines were applied by paramedics or ENPs. Everyone passed advanced cardiovascular life support training (10).

This study was conducted in accordance with the tenets of the Declaration of Helsinki 1975 and its later revisions. Our study protocol was approved by the Institutional Review Board of the Faculty of Medicine, Vajira Hospital, Navamindradhiraj University (COA no. 216/2565). The requirement for informed consent was waived due to the retrospective nature of our study and anonymity of all patient data.

2.2. Participants

Data of adult OHCA patients aged >18 years were collected from EMS patient care reports coded as symptom group 6 (cardiac arrest) based on the Thailand Emergency Medical Triage Protocol and Criteria-Based Dispatch (CBD) from 1 January 2019 to 31 December 2020 (2 years). OHCA patients to whom the V-EMS unit was dispatched were selected using simple random sampling. These reports were completed by the V-EMS unit.

Patients who had ROSC within 15 min, had incomplete or missing data, were evaluated as dead by a team leader and required no resuscitation, had a do-not-resuscitate order, had a cardiac arrest outdoors, had suffered an OHCA during transfer, in which CPR was started at the scene and continued during transfer to the hospital, and had termination of resuscitation at the scene were excluded from the study.

2.3. Data gathering

Data of OHCA patients were collected from EMS patient reports, a standard form recording advanced EMS procedures performed by Bangkok EMS (Erawan Center), with the Bangkok Advanced Emergency Operation Unit utilizing a similar form. In particular, this form contained data on EMS operation units, patients, and all treatments performed by EMS teams, including dispatchers and paramedics or ENPs operating at the scene. These data were required to determine the remuneration of EMS operation units. Data on survival to discharge were extracted from the electronic medical records (EMR) at Vajira Hospital. All data were collected and entered into a Microsoft Excel spreadsheet. Data obtained from the electronic medical records comprised: 1) the general characteristics of OHCA patients including gender, age, underlying disease, location type, cause of cardiac arrest, witnessed collapse, bystander CPR, initial rhythm, defibrillation, advanced airway, prehospital intravenous (IV) fluids, medication during CPR, total CPR time (min), time from CPR to SB (min), and SB amount (mEq/mL), and 2) study outcomes including sustained ROSC (>20 min), ROSC, and survival to discharge. Patients were followed up every 30 days by a principal investigator (TH) to determine the survival to discharge outcomes. In-hospital outcomes were determined from the EMR of Vajira Hospital.

2.4. Definitions

- ROSC indicates a return of circulation wherein the heart is able to sufficiently pump blood throughout the body, which can be characterized by a palpable pulse and measurable blood pressure at the scene (1, 15).

- Sustained ROSC (>20 min) indicates a return of circulation wherein the heart is able to sufficiently pump blood throughout the body, which can be characterized by a palpable pulse and measurable blood pressure at the scene that continued for 20 min (1).

- Survival to discharge indicates the patient's status after 30 days starting from the first day the patient suffered an OHCA (1).

- Symptom group 6 indicates OHCA according to the emergency level screening system, which can be classified as CBD 6, severity level–critical (Red) 6 critical 1 or 6 Red 1, indicating cardiac arrest including unconsciousness, apnea, or pulselessness (15).

- Total CPR time (min) indicates the duration from the first medical contact (FMC) to the end of CPR determined from the EMS patient care report.

- Time from CPR to SB (min) indicates the duration from the FMC to SB injection among OHCA patients determined from the EMS patient care report.

- Witnessed collapse or witnessed arrest means cardiac arrest with witness, which probably is layperson or medical personnel witnessing the event during a patient having sudden cardiac collapse (10).

2.5. Outcomes measurement

The primary outcome was effects of prehospital SB use during prolonged CPR on sustained return of spontaneous circulation (ROSC) (>20 min) at the scene, and the secondary outcome was survival to discharge.

2.6. Statistical analysis

We estimated the sample size needed to test two independent proportions (16). Sample size calculation was based on statistical data presented in a previous study by Weng et al. (1), who reported sustained ROSC (>20 min) rates of 6.7% (p1 = 0.067) and 19.4% (p2 = 0.194) for those with and without prehospital SB administration during CPR, respectively. Assuming a 1:1 ratio in the sample size of the compared groups, our sample size calculation determined that at least 147 patients per group were needed. After adding 10% of the sample size using the formula nnew = 147/(1–0.1), we determined that at least 163 patients per group were required. Therefore, the final sample size consisted of 165 patients per group or a total of 330 patients.

Descriptive analysis was performed to determine the distribution of variables. Continuous variables are presented as mean ± standard deviation (SD), whereas categorical variables are presented as frequencies and proportions. Differences between the two studied groups were evaluated using the independent t-test or Mann–Whitney U test for numeric variables and the chi-square test or Fisher's exact test for categorical variables.

To compare the groups with and without prehospital SB administration during CPR, the chi-squared test or Fisher's exact test were used depending on the appropriateness of data. Multivariate analysis using multiple logistic regression was used to determine the effects of prehospital SB use during prolonged CPR on sustained ROSC, ROSC at the scene, and survival to discharge, reporting the odds ratios (OR) and 95% confidence intervals for the same.

IBM SPSS Statistics for Windows version 28.0 (Armonk, NY, USA: IBM Corp.) was used for all statistical analyses, with a P value of ≤.05 indicating statistical significance.

3. Results

3.1. Baseline characteristics of studied cases

330 patients with OHCA were divided into two groups based on prehospital SB use (165 patients each). The mean time from CPR to SB was 18.92 ± 7.51 minutes and the mean amount of SB was 54.48 ± 18.72 meq/ml.

Table 1 compares the baseline characteristics of studied cases between the two groups. The two groups had similar conditions regarding gender distribution (p = 0.729); mean age (p = 0.741); underlying diseases (p = 0.027); etiology of arrest (p = 0.135); the initial rhythm (p = 0.324); receiving normal saline solution (p = 1.000), epinephrine (p = 0.848), and atropine during CPR (p = 0.054); and using defibrillation (p = 0.324).

53.3% and 41.8% had witnesses arrest (p = 0.036), and 55.2% and 35.2% obtained bystander CPR, in the SB and non-SB

Table 1: Comparing the baseline characteristics of patients with out of hospital cardia arrest (OHCA) based on receiving or not receiving sodium bicarbonate (SB)

Characteristic	Total (n = 330)		P value
	SB (n = 165)	Non-SB(n=165)	
Gender			
Male	106 (64.2)	109 (66.1)	0.729
Female	59 (35.8)	56 (33.9)	
Age (year)			
Mean ± SD	64.44 ± 17.88	65.08 ± 17.68	0.741
Underlying disease			
No	65 (39.4)	85 (51.5)	0.027
Yes	100 (60.6)	80 (48.5)	
Location of cardiac arrest			
Non-public	131 (79.4)	133 (80.6)	0.783
Public	34 (20.6)	32 (19.4)	
Cause of cardiac arrest			
Presumed cardiac etiology	128 (77.6)	134 (81.2)	
Respiratory	33 (20.0)	21 (12.7)	
AOC	1 (0.6)	5 (3.0)	
Hypoglycemia	3 (1.8)	2 (1.2)	0.135
Seizure	0 (0.0)	1 (0.6)	
UGIB	0 (0.0)	1 (0.6)	
Unknown	0 (0.0)	1 (0.6)	
Witnessed arrest			
No	77 (46.7)	96 (58.2)	0.036
Yes	88 (53.3)	69 (41.8)	
Bystander CPR			
No	74 (44.8)	107 (64.8)	<0.001
Yes	91 (55.2)	58 (35.2)	
Initial rhythm			
Asystole	111 (67.3)	122 (73.9)	
Ventricular fibrillation	27 (16.4)	25 (15.2)	0.324
PEA	25 (15.2)	18 (10.9)	
Pulseless VT	2 (1.2)	0 (0.0)	
Defibrillation			
No	121 (73.3)	139 (84.2)	0.015
Yes	44 (26.7)	26 (15.8)	
Advanced airway management			
ETT	144 (87.3)	107 (64.8)	<0.001
BVM	11 (6.7)	54 (32.7)	
LMA	10 (6.1)	4 (2.4)	
Prehospital IV fluid			
NSS	161 (97.6)	161 (97.6)	1.000
RLS	3 (1.8)	3 (1.8)	
Acetar	1 (0.6)	1 (0.6)	
Medication during CPR			
Epinephrine	165 (100)	165 (100.0)	NA
Amiodarone	16 (9.7)	14 (8.5)	0.848
Atropine	8 (4.8)	2 (1.2)	0.054
Calcium gluconate	63 (38.2)	9 (5.5)	<0.001
Glucose	23 (13.9)	8 (4.8)	0.005
Total CPR time (minute)			
Mean ±SD	33.81 ± 13.25	25.08 ± 12.40	<0.001

Data are presented as mean ± standard deviation (SD) or frequency (%). NA: data not applicable; PEA: pulseless electrical activity; VT: ventricular tachycardia; ETT: endotracheal tube; BVM: bag valve mask; LMA: laryngeal mask airway; AOC: alteration of consciousness; CPR: cardiopulmonary resuscitation; UGIB: upper gastrointestinal bleeding; IV: intravenous; NSS: normal saline solution; RLS: Ringer's lactated solution.

Table 2: Comparing the studied outcomes between patients receiving and not receiving sodium bicarbonate (SB)

Outcomes	SB (n = 165)	Non-SB (n = 165)	Odds (95% CI)	p value
ROSC at the scene				
No	115 (69.7)	110 (66.7)	0.8 7 (0.55–1.38)	0.555
Yes	50 (30.3)	55 (33.3)		
Sustained ROSC (>20 min)				
No	122 (73.9)	124 (75.2)	1.07 (0.65–1.75)	0.800
Yes	43 (26.1)	41 (24.8)		
Survival to discharge				
No	140 (84.8)	132 (80.0)		
Yes	4 (2.4)	9 (5.5)	0.42(0.13–1.39)	0.145
Unknown	21 (12.7)	24 (14.5)		

Data are presented as frequency (%). CI: confidence interval; ROSC: return of spontaneous circulation.

groups, respectively (p < 0.001). Most patients in the SB and non-SB groups were managed using endotracheal tube (ETT) (87.3% and 64.8%, respectively; p < 0.001) and among the same groups, 38.2% and 5.5% received calcium gluconate (p < 0.001), and 13.9% and 4.8% received glucose during CPR, respectively (p = 0.005). The mean total CPR time was 33.81 ± 13.25 and 25.08 ± 12.40 minutes in the SB and non-SB groups, respectively (p < 0.001).

3.2. Comparing the studied outcomes between groups

Table 2 compares the studied outcomes between patients receiving and not receiving SB. Among the patients in the SB and non-SB groups, 30.3% and 33.3% exhibited ROSC at the scene, respectively (p = 0.555). The rate of sustained ROSC was 26.1% and 24.8% (p = 0.800), whereas the rate of survival was 2.4% and 5.5% (p = 0.145) in SB and non-SB cases, respectively).

3.3. Chance of ROSC

Univariate analysis using simple logistic regression analysis showed that the SB group had 0.87 times greater chance for ROSC at the scene (crude OR = 0.87, 95% CI: 0.55–1.38, p = 0.555). Multivariate analysis using multiple logistic regression was performed including confounders that were found to be significantly (p < 0.05) associated with ROSC at the scene in univariate analysis (which included: location of arrest, witness arrest, initial rhythm, defibrillation, atropine, and total CPR time). The analysis showed that the SB group had 0.93 times greater likelihood of ROSC at the scene (adjusted OR = 0.93, 95% CI: 0.55–1.59, p = 0.798).

3.4. Likelihood of sustained ROSC

Similarly, univariate analysis using simple logistic regression showed that the SB group had 1.07 times greater likelihood of sustained ROSC (crude OR = 1.07, 95% CI: 0.65–1.75, p = 0.800). Multivariate analysis using multiple logistic regression, entering confounders that were significantly (p < 0.05) associated with sustained ROSC (which included: witnesses arrest, initial rhythm, and advanced airway) showed that the SB group had 0.80 times greater likelihood of sustained ROSC (adjusted OR = 0.80, 95% CI: 0.47–1.37, p = 0.415).

3.5. Likelihood of survival to discharge

Univariate analysis using simple logistic regression showed that the SB group had 0.42 times greater likelihood of survival to discharge (crude OR = 0.42, 95% CI: 0.13–1.39, p = 0.156). Multivariate analysis using multiple logistic regression, entering confounders that were significantly (p < 0.05) associated with survival to discharge during univariate analysis (which included: initial rhythm and defibrillation) showed that the SB group had 0.34 times greater likelihood of survival to discharge (adjusted OR = 0.34, 95% CI: 0.10–1.17, p = 0.087).

4. Discussion

Our main finding showed that SB use during prolonged CPR did not improve sustained ROSC. Notably, 26.1% of OHCA patients receiving SB had sustained ROSC, whereas 24.8% of those who did not receive SB had the same. Although the group who used SB use showed greater rates of sustained ROSC, the difference was not statistically significant (p = 0.800), suggesting that SB administration by EMS did not increase the rate at which patients achieved ROSC at the scene. Surprisingly, our finding showed that the group with SB use had lower rates of survival to discharge than did those without SB administration (2.4% vs. 5.5%, respectively).

The results of the present study were consistent with those reported in a previous study with a small sample size, which showed that SB administration, as buffer therapy during prolonged CPR, did not improve sustained ROSC and survival to discharge. Unexpectedly, the same study showed that among those who received SB injection, none showed survival to discharge (1). Moreover, a previous pilot study, which was an RCT comparing the administration of SB and placebo in cardiac arrest patients at the emergency department with severe metabolic acidosis during prolonged cardiopulmonary resuscitation, showed that SB use significantly affected pH values and helped modify the acid–base balance of the blood. However, the mentioned study did not find a significant difference in sustained ROSC (4.0% vs. 16.0%, $p = 0.349$) or good neurologic survival at 1 month (0.0% vs. 4.0%, $p = 1.000$) between the SB and placebo groups (17).

Recently, two systematic review and meta-analysis studies evaluating the effects of SB on ROSC and survival-to-discharge rates both concluded that SB use was not associated with improvement in ROSC or survival-to-discharge rate, consistent with our findings. Furthermore, the same studies found that SB administration was associated with decreased rates of sustained ROSC and survival-to-discharge (6, 18). However, some previous studies have shown findings contrary to those presented herein, such as the population-based study using data of OHCA patients at an emergency department in Taiwan that had been retrospectively collected for 16 years. Accordingly, the mentioned study showed that SB administration during resuscitation at the emergency department was positively associated with survival to hospital admission (adjusted OR: 4.47; 95% CI: 3.82–5.22, $p < 0.001$) (19).

Another study on cardiac arrest patients with non-shockable rhythm, including asystole and pulseless electrical activity (PEA), showed that SB use helped improve ROSC and significantly increased rate of survival to discharge from a hospital (20). In addition, one study on SB use during prolonged cardiopulmonary resuscitation at the emergency department found that determining the bicarbonate levels from blood gas tests and administering the appropriate amount of SB that accounted for body weight (1 mEq/kg) could increase the rates of ROSC within 20 min (21).

Several explanations for the present results may be provided. Firstly, the increased rates of sustained ROSC and survival to discharge in the non-SB group might be explained by the shorter total CPR time in the non-SB group than in the SB group (22.66 ± 13.48 vs. 30.24 ± 12.79 min, respectively; $p < 0.001$). This could have been due to the failure of the EMS to identify the cause of the arrest in patients who had no ROSC and needed to receive prolonged CPR, which could have resulted in more SB administration. However, in the present study, SB administration during prolonged CPR did not improve the rates of ROSC at the scene, sustained ROSC, and survival to discharge. Therefore, we do not recommend SB use during prolonged CPR in the prehospital setting. When prolonged CPR is required, the EMS should focus on providing high-quality CPR and identifying the cause of the arrest, which are more important than SB administration. Regarding the context of EMS in the present study area, the decision for prolonged CPR depended on several factors, such as the cause of the arrest, relatives' decision regarding CPR duration, cardiac rhythm, and unwitnessed or witnessed arrest, among others. The 2010, 2015, and 2020 AHA guidelines do not recommend routine use of SB during CPR in cardiac arrest patients, unless there is medical indication (8-10). The 2020 AHA guidelines used in the present study recommend using SB only in patients whose cause of arrest could be determined, those with sodium channel blocker toxicity (e.g., tricyclic antidepressants and diphenhydramine), and those receiving adjunctive therapy for suspected hyperkalemia (10).

Nonetheless, the 2021 European Resuscitation Council Guidelines still recommended SB use in cases requiring prolonged unresponsive resuscitation, together with efficient rescue breathing to decrease acidosis. Guideline recommendations regarding SB use still need to be discussed and prospectively studied, especially SB use in the prehospital context by EMS (22). Secondly, the vicious cycle of metabolic acidosis due to cardiac arrest and prolonged CPR, resulting in delayed cardiac response and delayed ROSC, must be addressed. Limited approaches for prehospital management are available, including buffer therapy with SB, ETT, or laryngeal mask airway (LMA) insertion and proper rescue breathing. The present study found that the rate of ROSC was greater in patients receiving SB with ETT and LMA insertion than in those receiving rescue breathing by BVM. Thirdly, one previous study reported that SB had multiple side effects, which probably increased the severity level of the cardiac arrest. The reason why only a limited number of patients achieved sustained ROSC, ROSC at the scene, and survival to discharge could probably be explained by the side effects of SB use, which include alkalosis, hypernatremia, excess production of carbon dioxide, central venous acidosis with inactivation of epinephrine administration, and compromised coronary flow (23). Available evidence to date suggests that SB needs to be used cautiously and rationally in OHCA patients to reduce disadvantages due to excessive SB use. However, the 2020 AHA guidelines specify the amount of SB to be used based on body weight (mEq/kg) (10). Nonetheless, in the context of actual EMS practice, determining the actual body weight of OHCA patients is considerably challenging and might lead to medication dosage errors.

5. Limitations

Firstly, the present study was a retrospective single-center study with two data sources: 1) from EMS patient care reports and 2) from the electronic medical records. Despite our attempts to maintain neutrality where possible, the risk of selection bias cannot be completely eliminated. Secondly, no blood gas test results were available in the present study given that no equipment for blood gas point-of-care testing were available for the management of cardiac arrest patients at the scene, unlike studies at the emergency department. Thirdly, some confounding factors associated with the target outcomes might have been overlooked. Only data on prehospital management were analyzed in the present study without considering essential data from the emergency department or intensive care unit. Fourthly, data on survival to discharge had several unknown aspects regarding the patients' last status, such as neurological evaluation or Cerebral Performance Category (CPC) score after hospital discharge. Fifthly, For the study area, off-line protocol in management of OHCA patients allowed paramedics or ENPs to be able to administer SB in patients with prolonged CPR. If the study results were applied in other areas, there would probably be limitations regarding generalizability (external validity) of the study results. This might include capacity of the operating team, indications and discretion of clinical decision of CPR commander about decision using SB. Lastly, data for OHCA patients in the area were not recorded and collected using the Utstein OHCA template.

6. Conclusion

The present study demonstrated that prehospital SB use by EMS during prolonged CPR did not improve the likelihood of sustained ROSC, ROSC at the scene, and survival to discharge. It seems that, in cases requiring prolonged CPR, high-quality CPR and determination of the cause of arrest, focusing on the 5 H's and 5 T's that may cause cardiac arrest, should be emphasized over buffer therapy.

7. Declarations

7.1. Acknowledgments

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7.2. Conflict of interest

The authors have no conflicting interests to declare.

7.3. Fundings

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7.4. Authors' contribution

Conceptualization: Thongpitak Huabbangyang, Chunlanee Sangketchon, Chomkamol Saumok, Gotchagorn Noimo, Korawee pinthong, Ketvipa Saungun and Kaiwit Bunta; Methodology: Thongpitak Huabbangyang, Gotchagorn Noimo, Korawee pinthong, Ketvipa Saungun and Kaiwit Bunta; Validation: Thongpitak Huabbangyang and Chunlanee Sangketchon; Formal analysis: Thongpitak Huabbangyang; Investigation: Thongpitak Huabbangyang, Gotchagorn Noimo, Korawee pinthong, Ketvipa Saungun and Kaiwit Bunta; Resources: Thongpitak Huabbangyang and Chunlanee Sangketchon; Data Curation: Thongpitak Huabbangyang; Writing – Original Draft: Thongpitak Huabbangyang; Writing - Review & Editing: Thongpitak Huabbangyang and Chunlanee Sangketchon; Visualization: Thongpitak Huabbangyang; Supervision: Thongpitak Huabbangyang and Chunlanee Sangketchon; Project administration: Thongpitak Huabbangyang; Funding acquisition: Thongpitak Huabbangyang. All authors read and approved final version.

7.5. Data availability

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

7.6. Using artificial intelligent chat bots

None.

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