

## ORIGINAL RESEARCH

# The Effects of Using Prehospital Calcium Gluconate During Cardiopulmonary Resuscitation: A Retrospective Study

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**Abstract:** **Introduction:** Calcium gluconate (CG) administration during cardiopulmonary resuscitation (CPR) has not been recommended in routine clinical practice. This study examined the impact of prehospital CG administration on outcomes of out-of-hospital cardiac arrest (OHCA) cases. **Methods:** This retrospective cohort study collected data on adult patients aged >18 years who experienced non-traumatic OHCA and were transported by the emergency medical service (EMS) to the emergency department. Data on return of spontaneous circulation (ROSC) at the scene, survival to hospital admission, and survival to hospital discharge were obtained from EMS reports and electronic medical records and compared between OHCA cases who received or didn't receive CG. **Results:** In total, 215 adult patients with non-traumatic OHCA were enrolled in this study. Among them, 107 received CG and 108 didn't receive. In particular, CG administration was associated with a lower rate of ROSC at the scene compared with cases without its administration (8.6% lower). The likelihood of ROSC at the scene was 0.75 times that of those who did not receive CG. CG administration was associated with a lower survival to hospital admission (16.48% lower). The likelihood of survival to hospital admission was 0.42 times that of patients who did not receive CG. In addition, survival to hospital discharge was 7.37% lower in patients who received CG, and the likelihood of survival to hospital discharge was 0.21 times that of those who did not receive CG. **Conclusion:** Prehospital CG administration by the EMS team did not improve ROSC in the scene, survival to hospital admission, or survival to hospital discharge. The findings highlight the need for selective use of calcium based on guideline-recommended indications rather than empirical administration.

**Keywords:** Calcium gluconate; Out-of-hospital cardiac arrest; Out-of-hospital heart arrest; Cardiopulmonary resuscitation; Prehospital emergency care

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## 1. Introduction

Out-of-hospital cardiac arrest (OHCA) is an important public health issue across all nations worldwide. OHCA has high severity and mortality rates at the global population level (1), even in countries with advanced public health systems and medicine in all dimensions, such as the United States of America (2). In 1974, the American Heart Association (AHA) guidelines recommended the use of calcium chloride or calcium gluconate (CG) in patients with cardiac arrest based on cardiac physiology without the consideration of clinical evidence (3). In 2000, the cardiopulmonary resuscitation (CPR) guidelines withdrew its recommendation for calcium administration. This is because other studies have shown that calcium administration was not associated with return of spontaneous circulation (ROSC) in patients with cardiac

arrest (4). It has long been known that CG can treat cardiotoxicity attributed to severe hyperkalemia, which is common in patients with cardiac arrest in emergency departments, particularly those with renal failure or other risk factors (5). However, a systematic review and meta-analysis reported that the incidence of hyperkalemia among adults transported to emergency departments was 2.8 per 100 patients, with a prevalence of 1.3% (6).

Over the years, there has been a significantly limited number of studies investigating the efficacy of CG administration in the emergency medical service (EMS) during CPR in patients with OHCA. A study conducted in Japan assessed patients with OHCA who had a mean blood potassium level of 7.8 mEq/L during CPR. This research revealed that CG or calcium chloride administration at an optimal level helped significantly increase the likelihood of ROSC, particularly in those with a potassium level of < 9.4 mEq/L. However, this group still had an extremely low rate of survival to hospital discharge (3.7%) (7); thereby, indicating the severity of hyperkalemia in the context of OHCA, which requires prompt diagnosis and immediate treatment within the limited time

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frame of CPR (8).

As a developing country, Thailand's emergency medical system, especially its prehospital emergency medical system, allows prehospital emergency medical operators to treat patients with OHCA with CG in prehospital settings. This condition has limitations. In particular, an electrolyte analyzer, which is a point-of-care (POC) device, is not available in EMS ambulances or during prehospital management at the scene. Therefore, paramedics or emergency nurse practitioners (ENPs) cannot identify hyperkalemia during resuscitation. Some studies have recommended CG or sodium bicarbonate administration in patients suspected with the condition (8). Nevertheless, this requires assumptions regarding the clinical context such as underlying diseases (particularly chronic kidney disease), medication history, or suspected hyperkalemia based on electrocardiography findings when administering medications without the support of laboratory data. This may decrease treatment efficiency or increase the risk of adverse drug effects (9). This study examined the effect of prehospital CG administration during CPR on the outcomes of patients with OHCA.

## 2. Methods

### 2.1. Study design and setting

This retrospective, single-center cohort study was conducted at the Vajira Emergency Medical Service (V-EMS), Bangkok, Thailand, from January 1, 2018, to October 31, 2023. Patients with OHCA were divided into two groups of received or not received CG and their outcomes regarding ROSC at the scene, survival to hospital admission, and survival to hospital discharge were compared.

V-EMS is the zone leader for EMS area 1, which is one of 11 zones within Bangkok's EMS system. It operates under the Erawan Center and coordinates with six public and private hospitals, within its 50-square-kilometer area, serving a population of approximately 500,000 residents (10, 11). For patients with OHCA in the V-EMS service area, one EMS team is dispatched for each case. The team comprised at least three staff, which included paramedics or ENPs, an operation team leader, and emergency medical technicians. During each operation, paramedics or ENPs would operate under offline and online medical protocols under the emergency physicians' orders. In case of cardiac arrest, the paramedics or ENPs managed the patients based on the 2020 AHA guidelines. All staff have passed the advanced cardiovascular life support provider training.

This study follows the standard data reporting format in accordance with the Standards for the Reporting of Observational Studies in Epidemiology statement (12) and conducted in accordance with the 1975 Declaration of Helsinki and its revised version in 2000. It was approved by the Institutional Review Board of the Faculty of Medicine, Vajira Hospital, Navamindradhiraj University (COA no. 079/2567). The need for informed consent was waived due to the retrospective na-

ture of the study and the anonymity of all patient data.

### 2.2. Participants

Data on adult patients with OHCA were collected from the EMS patient care report. Cardiac arrest was coded with Thailand Emergency Medical Triage Protocol and Criteria-Based Dispatch (TEMTP-CBD) symptom group 6.

The eligibility criteria were adult patients aged > 18 years who had non-traumatic OHCA, were visited by the V-EMS unit, were coded with TEMTP-CBD symptom group 6, and those who had cardiac arrest and needed to be transported to the Emergency Department.

The exclusion criteria were as follows: patients who died before ambulance arrival at the scene, those with signs of irreversible death who could not be resuscitated based on the judgment of team leaders, those who had CPR during transfer, and those with do not attempt to resuscitate order, metastatic malignancy, incomplete data, or no record of related resuscitation.

### 2.3. Data gathering

Data on patients with OHCA were collected from EMS patient care reports, which recorded advanced EMS operation. These reports followed a standardized format used by the Bangkok EMS Center (Erawan Center) and the Bangkok Advanced Emergency Operation Unit. This form comprised data on EMS operation units, patients, and all treatments provided by the EMS teams, which were recorded by dispatchers, paramedics, or ENPs operating at the scene. These data were part of the remuneration package for EMS operation units. Survival data from admission to discharge were extracted from the electronic medical records of Vajira Hospital. All data were entered and recorded in Microsoft Excel. The data comprised the following: 1) general characteristics of patients with OHCA, including gender, age, underlying disease, type of location, cause of cardiac arrest, witnessed collapse, performance of bystander CPR, initial rhythm, defibrillation, advanced airway management, prehospital fluid access, total CPR time, use of medication during CPR, time from CPR to CG administration, and dosage of CG; and 2) study outcomes, including ROSC at the scene, survival to admission, and survival to discharge. The treatment outcomes were monitored every 30 days by the principal investigator (TH). The outcomes of in-patient status were monitored via a review of EMRs.

### 2.4. Definitions were as follows

1) ROSC at the scene was defined as return of spontaneous circulation, ability of the heart to pump blood throughout the body, and palpable pulse and measurable blood pressure at the scene.

2) Survival to hospital admission was defined as the survival of patients with OHCA until hospital admission in in-patient departments, including the intensive care unit, cardiac intensive care unit, or general in-patient department. The data

were obtained via a review of the hospital's EMR.

3) 30-day survival was defined as being alive on the 30th day after the index OHCA event (counted as day 1), as documented in the hospital's EMR. Patients who were transferred to another facility or discharged to hospice care were followed through EMR linkage and considered alive if documented as such on day 30.

### 2.5. Determination of sample size

Sample size estimation was performed using a test for two independent proportions (13), with a significance level of 0.05 ( $\alpha = 0.05$ ) and a power of 90%. The statistical values from the study of Wongtanarasrin W et al. (5) were used in the calculation. The previous study showed that the ROSC rates of the groups with and without prehospital CG administration during CPR were 43.06% ( $p = 0.4306$ ; 31/42) and 69.45% ( $p = 0.6945$ ; 366/527), respectively. Based on the retrospective population distribution, the sample size ratio of 2.71 between the comparison and study groups was applied. Using the sample size calculation formula, the calculated sample size of the study group (which included patients who received CG) was at least 49. Meanwhile, the calculated sample size of the comparison group (which comprised patients who did not receive CG) was 133. Thus, the total number of participants was 182. An additional 15% was added to prevent incomplete data. The sample size calculated using the formula ( $n_{new} = 182 / (1 - 0.15)$ ) was 215. Therefore, this study determined a sample size of 215. Simple random sampling was performed on patients with prehospital cardiac arrest dispatched to the V-EMS unit.

### 2.6. Statistical analysis

Descriptive analysis was performed to determine the distribution of variables. Continuous variables are presented as mean  $\pm$  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.

The effect of prehospital CG administration during CPR on the outcomes of ROSC at the scene, survival to hospital admission, and survival to hospital discharge were assessed via propensity score matching using inverse probability weighting (IPW). Data were expressed as standardized difference (STD) to assess potential confounding factors associated with the indication for CG application. Factors with  $STD > 0.1$  were analyzed in the multivariate analysis to further control the influence. Covariate balance was assessed using STD for each variable, presented in Table 1, both before and after IPW.

Poisson regression with robust variance was conducted to estimate the primary effect measure, the risk ratio (RR), with corresponding 95% confidence intervals (CIs). Risk differences (RDs) with 95% CIs were additionally estimated using

generalized linear models with an identity link as complementary measures. A  $p$ -value  $< 0.05$  was considered statistically significant. All analyses were performed using Stata version 17.0 (StataCorp College Station, TX, USA).

## 3. Results

### 3.1. Baseline characteristics of studied patients

215 patients met the eligibility criteria and were enrolled in this study. Among them, 107 (49.76%) received CG and 108 (50.23%) didn't (Figure 1). The mean time from CPR to CG administration was  $20.74 \pm 11.19$  minutes and median dosage of CG was 20 (IQR: 20 – 30) mEq/mL. Table 1 compares the baseline characteristics of studied patients.

The two groups were similar regarding mean age ( $p = 0.454$ ); gender ( $p = 0.509$ ); bystander CPR ( $p = 0.541$ ); asystole as an initial rhythm ( $p = 0.277$ ); need for defibrillation ( $p = 0.102$ ); need for advanced airway management with endotracheal tube ( $p = 0.143$ ); prehospital fluid access ( $p = 0.621$ ); epinephrine ( $p = 0.498$ ), glucose ( $p = 0.436$ ), and atropine ( $p = 1.000$ ) used during CPR; and underlying diseases ( $p = 0.445$ ). The patients who received CG commonly had cardiac arrest symptoms at nonpublic places (82.4% vs. 67.3%, respectively;  $p = 0.011$ ), respiratory failure was the most common cause of their cardiac arrest (64.8% vs. 48.6%, respectively;  $p = 0.034$ ), had more witnessed collapse (84.1% vs. 66.7%, respectively;  $p = 0.003$ ), had longer mean total CPR times ( $39.71 \pm 14.89$  vs.  $29.40 \pm 12.77$  minutes;  $p < 0.001$ ), and used more bicarbonate (86.9% and 44.4%, respectively;  $p < 0.001$ ) and amiodarone (17.8% and 8.3%, respectively;  $p = 0.040$ ) during CPR.

### 3.2. Effects of CG on outcomes (univariate analysis)

#### 3.2.1 ROSC

Patients receiving CG had a lower ROSC rate at the scene (unadjusted risk difference (RD) =  $-9.99$ , 95% CI:  $-18.82$  to  $-1.15$ ,  $p = 0.027$  and unadjusted risk ratio (RR) = 0.72, 95% CI: 0.42–1.24,  $p = 0.236$ ) compared with those who did not receive CG. Controlling the influence of confounding factors via propensity score matching with IPW (figure 2), patients with all types of rhythms who were receiving CG had a lower frequency of ROSC at the scene (adjusted RD =  $-8.60$ , 95% CI:  $-17.63$  to 0.43,  $p$ -value = 0.062 and adjusted RR = 0.75, 95% CI: 0.44–1.28,  $p$ -value = 0.285).

#### 3.2.2 Survival to hospital admission

Patients receiving CG had a lower survival to hospital admission than those who did not (unadjusted RD =  $-16.95$ , 95% CI:  $-24.53$  to  $-9.37$ ,  $p < 0.001$  and unadjusted RR = 0.41, 95% CI: 0.17–1.00,  $p$ -value = 0.050). To control the influence of confounding factors via propensity score matching using IPW (figure 2), in patients with all types of rhythms, those receiving CG had a lower survival to hospital admission rate than those who did not (adjusted RD =  $-16.48$ , 95% CI:  $-24.64$  to  $-8.33$ ,  $p < 0.001$  and adjusted RR = 0.42, 95% CI: 0.18–1.03,  $p$ -

value = 0.058)

### 3.2.3 Survival to hospital discharge

Patients receiving CG had a lower survival to hospital discharge rate than those who did not (unadjusted RD = -3.32, 95% CI: -6.30 to -0.33,  $p = 0.029$  and unadjusted RR = 0.19, 95% CI: 0.02-1.63,  $p$ -value = 0.131). To control the influence of confounding factors using propensity score matching with IPW (figure 2), in patients with all types of rhythms, those receiving CG had a lower survival to hospital discharge than those who did not (unadjusted RD = -7.37, 95% CI: -16.48, to 1.74,  $p = 0.113$  and adjusted RR = 0.21, 95% CI: 0.02-1.92,  $p$ -value = 0.167).

### 3.3. Multivariable analysis

Multivariable analysis of the effects of prehospital CG administration during cardiopulmonary resuscitation based on a subgroup analysis according to initial rhythm is presented in table 3. After adjustment using propensity score matching with IPW, patients receiving CG showed lower survival to hospital discharge than those who did not (unadjusted RD = -7.37, 95% CI -16.48 to 1.74,  $p = 0.113$ ; adjusted RR = 0.21, 95% CI 0.02-1.92,  $p = 0.167$ ). In the ventricular fibrillation (VF) subgroup, survival was also lower among those receiving CG (unadjusted RD = -10.36, 95% CI -33.79 to 13.06,  $p = 0.386$ ; adjusted RR = 0.70, 95% CI 0.06-8.13,  $p = 0.775$ ). Analysis for asystole, pulseless electrical activity (PEA), and pulseless ventricular tachycardia (pVT) was not performed due to limited sample sizes.

## 4. Discussion

This study found that prehospital CG administration in adults with non-traumatic OHCA was associated with poorer outcomes. Patients receiving CG had lower rates of ROSC at the scene, survival to hospital admission, and survival to discharge compared with those who did not receive it.

Our findings were consistent with prior systematic reviews, which reported that calcium administration during CPR did not improve short-term survival (immediate ROSC), mid-term survival (30- and 90-day survival), or long-term survival (6- and 12-month survival), and did not increase favorable neurological outcomes (14). Similarly, our rhythm-based analysis did not demonstrate benefit of calcium administration among OHCA patients, consistent with previous evidence from both adult and pediatric populations (15, 16). Importantly, these results should be interpreted with caution. Calcium administration is more likely in prolonged or refractory resuscitation, where CPR duration is longer and adjunctive drugs such as bicarbonate and amiodarone are often used. Thus, calcium may represent a marker of refractory arrest rather than an isolated harmful exposure. Although we adjusted for CPR duration and time to calcium administration, residual time-dependent confounding cannot be excluded.

From a pathophysiologic perspective, patients with VF generally have higher survival probability than those with asy-

tole or PEA (17). The less favorable outcomes observed in the VF subgroup of calcium-treated patients may reflect underlying confounding rather than a direct causal effect. As calcium plays an essential role in myocardial excitation-contraction coupling through  $Ca^{2+}$  influx and sarcoplasmic reticulum release (18), excess administration without validated indication could theoretically disrupt this balance. However, this study cannot determine harm versus confounding due to its observational design and lack of electrolyte data. Therefore, causal interpretations should be avoided.

In EMS systems without point-of-care devices for rapid electrolyte testing, empiric calcium is often administered under the assumption of conditions such as hyperkalemia or hypocalcemia. Our findings, consistent with the 2020 AHA Guidelines (19) and the 2021 European Resuscitation Council (ERC) Guidelines (20), suggest that calcium should not be used empirically in undifferentiated OHCA. Instead, its use should be restricted to cases with a clear diagnosis of hyperkalemia, hypocalcemia, or other reversible causes of cardiac arrest where calcium is specifically indicated.

Prehospital CG administration during CPR was one of the treatment strategies used by EMS personnel; however, our findings showed that it did not improve short-term outcomes, including ROSC at the scene, survival to hospital admission, or survival to hospital discharge. These results are consistent with previous studies conducted in limited EMS settings and further confirm that empirical calcium use without specific indications provides no clinical benefit. Therefore, calcium administration should be reserved only for patients with clear indications according to standardized resuscitation guidelines, emphasizing the importance of high-quality CPR and identification of reversible causes of cardiac arrest. Finally, although our results add to the growing body of literature, the limitations of retrospective observational design remain. Future studies, ideally randomized controlled trials in EMS settings or advanced analytic approaches such as marginal structural models, are needed to more definitively assess the role of calcium in resuscitation. In the meantime, emphasis should remain on delivering high-quality CPR and using calcium only when clinically indicated.

## 5. Limitations

The current study has several limitations. First, this retrospective single-center cross-sectional study collected data exclusively from the V-EMS, a medical operational unit providing care at the comprehensive life support level. Therefore, its results may not be generalizable. Second, the subgroup analysis stratified according to cardiac rhythm had substantial limitations due to sample size. In particular, the number of patients with pVT was not sufficient to perform an analysis of ROSC at the scene. Further, survival to hospital admission could not be assessed in patients with PEA and pVT, and survival to hospital discharge could not be examined in patients with asystole, PEA, and pVT. Third, even

though therapeutic research was imitated by performing a propensity score analysis, the study design had multiple biases and confounders that could not clearly identify the reasons for calcium use during CPR. Therefore, identifying the reasons for calcium administration may help improve our understanding of the impacts of CG on clinical outcomes. Fourth, in this study, data on calcium administration during CPR were not collected. Thus, the association between CG administration and the outcomes of OHCA could not be directly confirmed. Fifth, the study area did not have available devices for POC electrolyte and blood gas tests at the scene for patients with cardiac arrest, which was different from studies conducted in emergency departments that have devices for the diagnosis of reversible causes of cardiac arrest. Sixth, data on prehospital care at the scene from EMS patient care reports and prehospital CPR records were used, and outcomes, including survival to admission and survival to hospital discharge, were examined. The time intervals used to measure outcomes might have been influenced by unmeasured confounding factors, such as differences in hospital management or care provided in the emergency department or intensive care unit. These factors should be considered when interpreting our data. Seventh, although we adjusted for CPR duration and time to calcium administration, we did not perform a sensitivity analysis stratified by CPR duration because the sample size was insufficient to provide robust subgroup estimates. Therefore, residual time-dependent confounding cannot be excluded. Finally, in the assessment of survival to discharge, the neurological status of patients with OHCA were not assessed because the data from the EMS did not identify patient status after discharge.

## 6. Conclusions

This study demonstrated that prehospital CG administration during CPR was not associated with improved outcomes in adult patients with non-traumatic OHCA. The findings highlight the need for selective use of calcium based on guideline-recommended indications rather than empirical administration.

## 7. Declarations

### 7.1. Acknowledgments

We would like to thank the V-EMS, Faculty of Medicine, Vajira Hospital, Navamindradhiraj University, for facilitating data collection and providing access for this study.

### 7.2. Author contributions

Conceptualization: Thongpitak Huabbangyang, Agasak Silakoon, Suchanaree Soimongkolchai, Punyawee Dang-sawasd, Siravit Phankhot, Piyada Yomklang and Chunlanee Sangketchon; Methodology: Thongpitak Huabbangyang; Validation: Thongpitak Huabbangyang; Formal analysis: Thongpitak Huabbangyang; Investigation: Thongpitak Huabbangyang, Suchanaree Soimongkolchai, Punyawee

Dangsawasd, Siravit Phankhot and Piyada Yomklang; Resources: Thongpitak Huabbangyang; Data Curation: Thongpitak Huabbangyang; Writing – Original Draft: Thongpitak Huabbangyang; Writing - Review & Editing: Thongpitak Huabbangyang; Visualization: Thongpitak Huabbangyang; Supervision: Thongpitak Huabbangyang; Project administration: Thongpitak Huabbangyang; Funding acquisition: Thongpitak Huabbangyang.

All authors read and approved final version.

### 7.3. Conflict of Interest

The authors have no conflicting interests to declare.

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This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

### 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 intelligence and chatbots

None.

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**Table 1:** Comparing the baseline characteristics of out of hospital cardiac arrest (OHCA) patients between cases with and without calcium gluconate administration at prehospital setting

Characteristics	Total (n = 215)	Calcium gluconate use		p-value	Standardized differences	
<b>Age (years)</b>						
Mean ± SD	65.30 ± 16.75	66.16 ± 16.37	64.44 ± 17.15	0.454	0.102	0.080
<60	68 (31.6)	29 (27.1)	39 (36.1)	0.156	0.195	0.022
≥ 60	147 (68.4)	78 (72.9)	69 (63.9)			
<b>Gender</b>						
Male	138 (64.2)	71 (66.4)	67 (62.0)	0.509	0.090	0.023
Female	77 (35.8)	36 (33.6)	41 (38.0)			
<b>Underlying disease</b>						
Yes	164 (76.3)	84 (78.5)	80 (74.1)	0.445	0.104	0.091
<b>Location type</b>						
Non-public	161 (74.9)	72 (67.3)	89 (82.4)	0.011	0.354	0.032
Public	54 (25.1)	35 (32.7)	19 (17.6)			
<b>Cause of cardiac arrest</b>						
Respiratory	122 (56.7)	52 (48.6)	70 (64.8)	0.034	0.334	0.040
Presumed cardiac etiology	90 (41.9)	53 (49.5)	37 (34.3)			
Hypoglycemia	3 (1.4)	2 (1.9)	1 (0.9)			
<b>Witnessed collapse</b>						
Yes	162 (75.3)	90 (84.1)	72 (66.7)	0.003	0.414	0.063
<b>Performance of bystander CPR</b>						
Yes	113 (52.6)	54 (50.5)	59 (54.6)	0.541	0.083	0.126
<b>Initial rhythm</b>						
Asystole	137 (63.7)	62 (57.9)	75 (69.4)	0.277	0.255	0.014
Ventricular fibrillation	47 (21.9)	26 (24.3)	21 (19.4)			
Pulseless electrical activity	29 (13.5)	18 (16.8)	11 (10.2)			
Pulseless ventricular tachycardia	2 (0.9)	1 (0.9)	1 (0.9)			
<b>Need for defibrillation</b>						
Yes	73 (34)	42 (39.3)	31 (28.7)	0.102	0.224	0.113
<b>Advanced airway management</b>						
Endotracheal tube	198 (92.1)	102 (95.3)	96 (88.9)	0.143	0.264	0.124
Laryngeal mask airway	11 (5.1)	4 (3.7)	7 (6.5)			
Bag valve mask	6 (2.8)	1 (0.9)	5 (4.6)			
<b>Prehospital fluid access</b>						
NSS	211 (98.1)	106 (99.1)	105 (97.2)	0.621	0.137	0.045
RLS	4 (1.9)	1 (0.9)	3 (2.8)			
<b>Total duration of CPR (min)</b>						
Mean ± SD	34.53 ± 14.77	39.71 ± 14.89	29.40 ± 12.77	<0.001	0.744	0.122
<b>Type of medication used during CPR</b>						
Epinephrine	214 (99.5)	106 (99.1)	108 (100)	0.498	0.137	0.102
Bicarbonate	141 (65.6)	93 (86.9)	48 (44.4)	<0.001	1.000	0.023
Amiodarone	28 (13.0)	19 (17.8)	9 (8.3)	0.040	0.283	0.017
Glucose	17 (7.9)	10 (9.3)	7 (6.5)	0.436	0.106	0.023
Atropine	8 (3.7)	4 (3.7)	4 (3.7)	1.000	0.002	0.012

Data are presented as mean ± standard deviation (SD) or frequency (%). CPR: cardiopulmonary resuscitation; NSS: Normal Saline Solution; RLS: Ringer's Lactate Solution.

**Table 2:** Effects of prehospital calcium gluconate administration during cardiopulmonary resuscitation based on initial rhythm (univariate analysis)

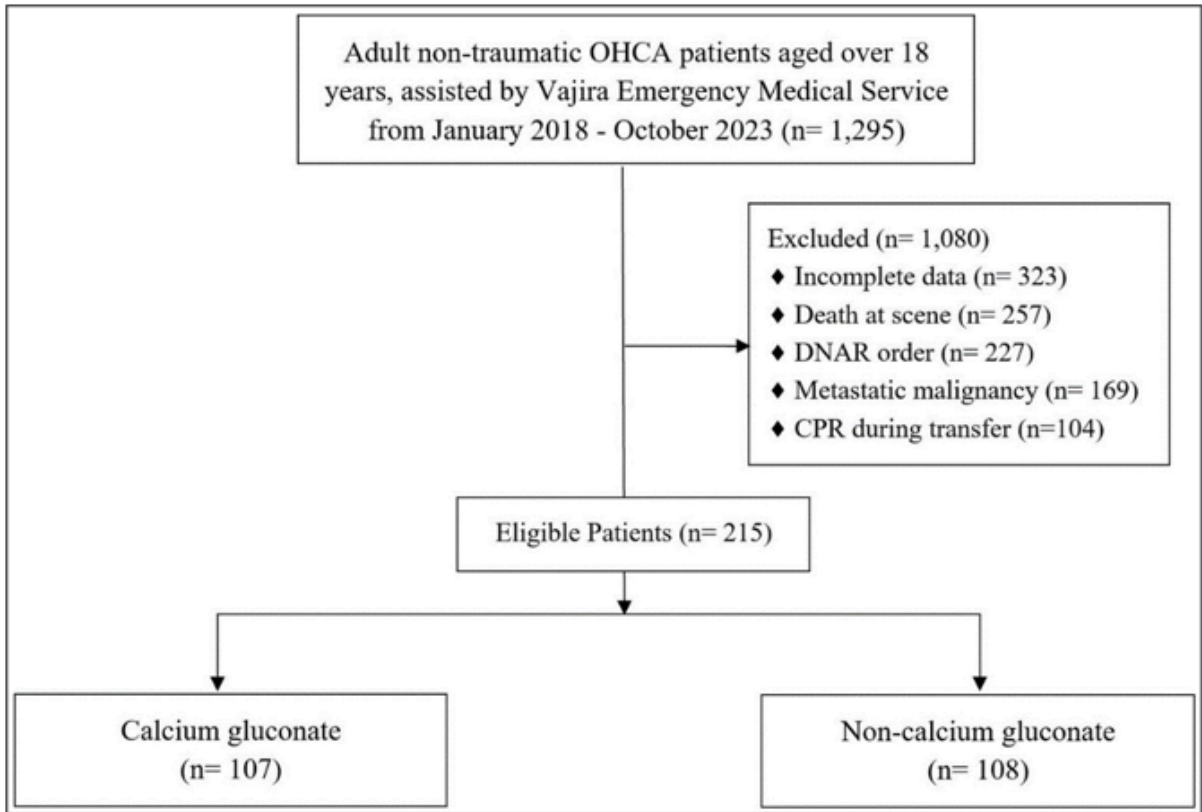
Outcomes	Calcium gluconate		RD (95% CI)	p-value	RR (95% CI)	p-value
	Yes (n = 107)	No (n = 108)				
<b>All rhythms (N = 215)</b>						
ROSC on the scene	28 (26.2)	40 (37.0)	-9.99 (-18.82 to -1.15)	0.027	0.72 (0.42-1.24)	0.236
Survival to hospital admission	10 (9.4)	31 (28.7)	-16.95 (-24.53 to -9.37)	<0.001	0.41 (0.17-1.00)	0.050
Survival to hospital discharge	1 (0.9)	6 (5.6)	-3.32 (-6.30 to -0.33)	0.029	0.19 (0.02-1.63)	0.131
<b>Asystole (n = 137)</b>						
ROSC on the scene	17 (27.4)	23 (30.7)	-2.12 (-12.78 to 8.54)	0.697	0.92 (0.44-1.92)	0.833
Survival to hospital admission	7 (11.3)	15 (20.0)	-4.53 (-13.45 to 4.39)	0.319	0.76 (0.25-2.30)	0.625
Survival to hospital discharge	0 (0.0)	4 (5.3)	-	IERME	-	IERME
<b>Ventricular fibrillation (n = 47)</b>						
ROSC on the scene	6 (23.1)	12 (57.1)	-24.38 (-42.30 to -6.46)	0.008	0.46 (0.17-1.24)	0.125
Survival to hospital admission	3 (11.5)	12 (57.1)	-34.37 (-50.55 to -18.19)	<0.001	0.24 (0.07-0.86)	0.028
Survival to hospital discharge	1 (3.9)	2 (9.5)	-0.91 (-8.92 to 7.11)	0.825	0.81 (0.07-9.24)	0.864
<b>Pulseless electrical activity (n = 29)</b>						
ROSC on the scene	5 (27.8)	5 (45.5)	-26.15 (-53.91 to 1.61)	0.065	0.56 (0.21-1.47)	0.237
Survival to hospital admission	0 (0.0)	4 (36.4)	-	IERME	-	IERME
Survival to hospital discharge	0 (0.0)	0 (0.0)	-	IERME	-	IERME
<b>Pulseless ventricular tachycardia (n = 2)</b>						
ROSC on the scene	0 (0.0)	0 (0.0)	-	IERME	-	IERME
Survival to hospital admission	0 (0.0)	0 (0.0)	-	IERME	-	IERME
Survival to hospital discharge	0 (0.0)	0 (0.0)	-	IERME	-	IERME

Data are presented as mean ± standard deviation or frequency (%). CI: confidence interval; RD: risk difference; RR: risk ratio; ROSC: return of spontaneous circulation; IERME: insufficient events for reliable model estimation. Risk differences (RDs) were estimated using generalized linear models with an identity link. Risk ratios (RRs) were estimated using Poisson regression with robust variance. RRs were the primary estimates.

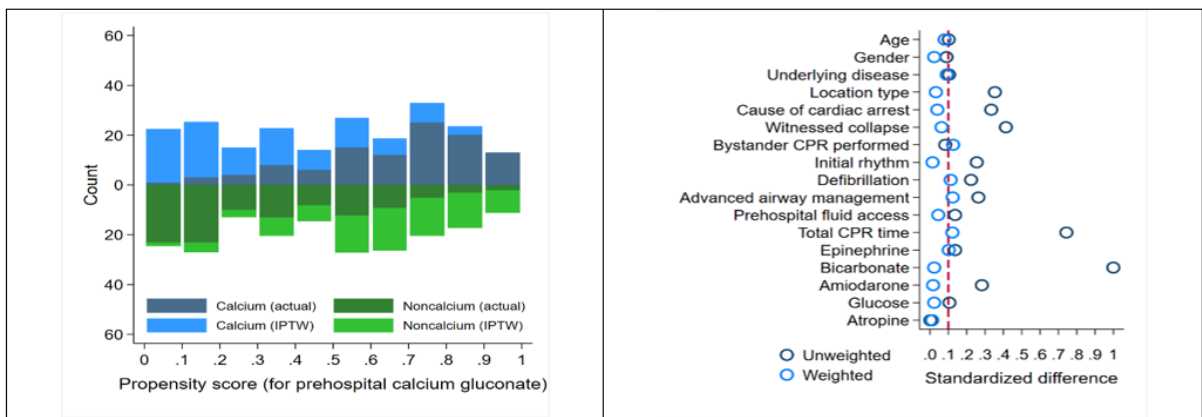
**Table 3:** Multivariable analysis of the effects of prehospital calcium gluconate administration during cardiopulmonary resuscitation based on initial rhythm

Outcomes	Multivariate analysis			
	RD (95% CI)	p-value	RR (95% CI)	p-value
<b>All rhythms (N = 215)</b>				
ROSC on the scene	-8.60 (-17.63 to 0.43)	0.062	0.75 (0.44-1.28)	0.285
Survival to hospital admission	-16.48 (-24.64 to -8.33)	<0.001	0.42 (0.18-1.03)	0.058
Survival to hospital discharge	-7.37 (-16.48 to 1.74)	0.113	0.21 (0.02-1.92)	0.167
<b>Asystole (n = 137)</b>				
ROSC on the scene	-0.67 (-11.85 to 10.5)	0.906	0.99 (0.49-2.02)	0.979
Survival to hospital admission	-3.96 (-14.17 to 6.26)	0.448	0.77 (0.26-2.30)	0.639
Survival to hospital discharge	-	IERME	-	IERME
<b>Ventricular fibrillation (n = 47)</b>				
ROSC on the scene	-27.91 (-47.18 to -8.65)	0.005	0.47 (0.18-1.23)	0.122
Survival to hospital admission	-45.10 (-66.8 to -23.40)	<0.001	0.24 (0.07-0.78)	0.018
Survival to hospital discharge	-10.36 (-33.79 to 13.06)	0.386	0.70 (0.06-8.13)	0.775
<b>Pulseless electrical activity (n = 29)</b>				
ROSC on the scene	-18.39 (-51.54 to 14.77)	0.277	0.67 (0.31-1.45)	0.309
Survival to hospital admission	-	IERME	-	IERME
Survival to hospital discharge	-	IERME	-	IERME
<b>Pulseless ventricular tachycardia (n = 2)</b>				
ROSC on the scene	-	IERME	-	IERME
Survival to hospital admission	-	IERME	-	IERME
Survival to hospital discharge	-	IERME	-	IERME

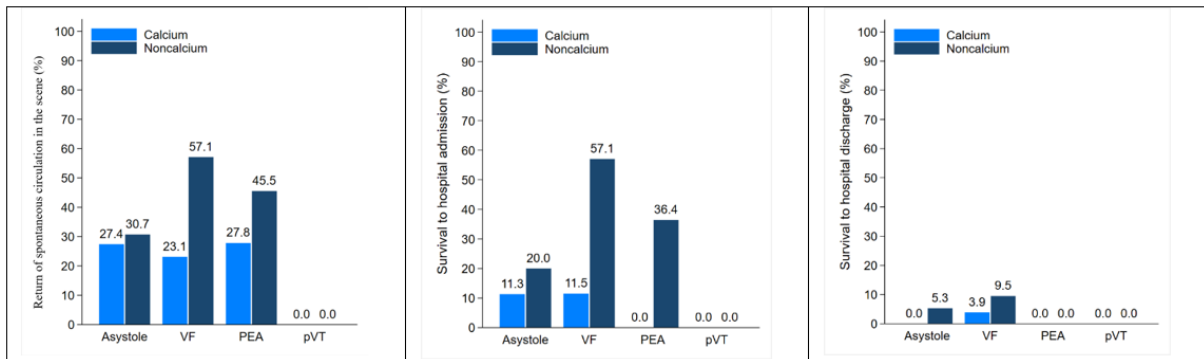
CI: confidence interval; RD: risk difference; RR: risk ratio; ROSC: return of spontaneous circulation; IERME, insufficient events for reliable model estimation. Risk differences (RDs) estimated using generalized linear models with an identity link. Risk ratios (RRs) estimated using Poisson regression with robust variance. RRs were the primary estimates.



**Figure 1:** Flow diagram of the study. OHCA: out-of-hospital cardiac arrest; DNAR: do not attempt to resuscitate; CPR: cardiopulmonary resuscitation.



**Figure 2:** Distribution of propensity scores between the unweighted and weighted samples (a) and balance of prognostic factors at baseline based on standardized differences in the unweighted and weighted samples (b). CPR: cardiopulmonary resuscitation; IPTW: inverse probability of treatment weights.



**Figure 3:** Comparison of outcomes between the calcium gluconate and non-calcium gluconate groups based on initial CPR rhythm of patients with out of hospital cardiac arrest (OHCA): return of spontaneous circulation on the scene(a), survival to hospital admission (b) and survival to hospital discharge (c). VF: Ventricular fibrillation; PEA: Pulseless electrical activity; pVT: Pulseless ventricular tachycardia; CPR: cardiopulmonary resuscitation.