Effect of Intravenous or Intraosseous Calcium vs Saline on Return of Spontaneous Circulation in Adults With Out-of-Hospital Cardiac Arrest: A Randomized Clinical Trial

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**IMPORTANCE** It is unclear whether administration of calcium has a beneficial effect in patients with cardiac arrest.

**OBJECTIVE** To determine whether administration of calcium during out-of-hospital cardiac arrest improves return of spontaneous circulation in adults.

**DESIGN, SETTING, AND PARTICIPANTS** This double-blind, placebo-controlled randomized clinical trial included 397 adult patients with out-of-hospital cardiac arrest and was conducted in the Central Denmark Region between January 20, 2020, and April 15, 2021. The last 90-day follow-up was on July 15, 2021.

**INTERVENTIONS** The intervention consisted of up to 2 intravenous or intraosseous doses with 5 mmol of calcium chloride (n = 197) or saline (n = 200). The first dose was administered immediately after the first dose of epinephrine.

**MAIN OUTCOMES AND MEASURES** The primary outcome was sustained return of spontaneous circulation. The secondary outcomes included survival and a favorable neurological outcome (modified Rankin Scale score of 0-3) at 30 days and 90 days.

**RESULTS** Based on a planned interim analysis of 383 patients, the steering committee stopped the trial early due to concerns about harm in the calcium group. Of 397 adult patients randomized, 391 were included in the analyses (193 in the calcium group and 198 in the saline group; mean age, 68 [SD, 14] years; 114 [29%] were female). There was no loss to follow-up. There were 37 patients (19%) in the calcium group who had sustained return of spontaneous circulation compared with 53 patients (27%) in the saline group (risk ratio, 0.72 [95% CI, 0.49 to 1.03]; risk difference, −7.6% [95% CI, −16% to 0.8%]; P = .09). At 30 days, 10 patients (5.2%) in the calcium group and 18 patients (9.1%) in the saline group were alive (risk ratio, 0.57 [95% CI, 0.27 to 1.18]; risk difference, −3.9% [95% CI, −9.4% to 1.3%]; P = .17). A favorable neurological outcome at 30 days was observed in 7 patients (3.6%) in the calcium group and in 18 patients (9.1%) in the saline group were alive (risk ratio, 0.57 [95% CI, 0.27 to 1.18]; risk difference, −3.9% [95% CI, −9.4% to 1.3%]; P = .17). Among the patients with calcium values measured who had return of spontaneous circulation, 26 (74%) in the calcium group and 1 (2%) in the saline group had hypercalcemia.

**CONCLUSIONS AND RELEVANCE** Among adults with out-of-hospital cardiac arrest, treatment with intravenous or intraosseous calcium compared with saline did not significantly improve sustained return of spontaneous circulation. These results do not support the administration of calcium during out-of-hospital cardiac arrest in adults.

**TRIAL REGISTRATION** ClinicalTrials.gov Identifier: NCT04153435

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n 2018, more than 5000 out-of-hospital cardiac arrests oc-
curred in Denmark.1 Survival following out-of-hospital car-
diac arrest is poor; only 16% of patients were still alive af-
after 30 days based on data from 2018 for Denmark.1 Of those
with a nonshockable rhythm, which accounts for approxi-
mately 80% of all cardiac arrests, less than 10% are alive after
30 days and, compared with those who had a shockable
rhythm, survival has not improved substantially over the last
decade.3 Pharmacological interventions for patients with
cardiac arrest are limited and there is a need for evidence-based
interventions to improve outcomes.2-4

Calcium plays an important role in cardiac muscle con-
traction and is generally acknowledged for its inotropic and
vasopressor effects.5,6 These effects could be beneficial in the
setting of cardiac arrest. Two small, randomized trials7,8 from
1985, including a total of 163 patients, found that administra-
tion of calcium did not result in a significant increase in return
of spontaneous circulation for patients with out-of-hospital car-
diac arrest and asystole or pulseless electrical activity. How-
ever, both trials7,8 had point estimates that favored calcium.
Since then, to our knowledge, there have been no random-
ized clinical trials assessing the effect of administration of cal-
cium during cardiac arrest. Observational studies with high risk
of bias9,10 have found conflicting results.11-14 Although there
are limited data to support the use of calcium during cardiac
arrest, calcium is commonly administered during cardiac ar-
est in some settings.15,16

The Calcium for Out-of-Hospital Cardiac Arrest trial was
designed to address the hypothesis that administration of cal-
cium during out-of-hospital cardiac arrest would result in im-
proved return of spontaneous circulation.

Methods

Trial Design and Oversight
This trial was an investigator-initiated, placebo-controlled, par-
allel group, double-blind, superiority, randomized clinical trial
assessing administration of intravenous or intraosseous cal-
cium during out-of-hospital cardiac arrest in adults. The trial
protocol (Supplement 1) was written by the steering commit-
tee and was approved by the regional ethics committee and
the Danish Medicines Agency. Discrepancies between the trial
protocol and what is reported in this article appear in the
eMethods in Supplement 2. Consent was temporarily ob-
tained from a physician not involved in the trial. Oral and writ-
ten consent were later obtained for all patients who survived.
In accordance with Danish legislation, the patient consents
were obtained after the patient regained capacity or when a
surrogate became available (additional details appear in
Supplement 1). An independent data and safety monitoring
committee reviewed the trial data after inclusion of approxi-
mately 50, 200, and 400 patients. There were no predefined
stopping criteria for harm, futility, or benefit.

Setting and Patients
The trial was conducted in the Central Denmark Region, which
has approximately 1.3 million inhabitants. The 2-tiered emer-
gency medical services system responds to all cardiac arrests
with an ambulance and a physician-manned mobile emer-
gency care unit.17 Almost all patients with return of sponta-
neous circulation or ongoing cardiopulmonary resuscitation
during transfer are transported to a single university hospital
capable of coronary catheterization and percutaneous coro-
ary intervention, extracorporeal cardiopulmonary resuscita-
tion, and care after cardiac arrest, including targeted tem-
perature management. Treatment both during and after cardiac
arrest generally adheres to European guidelines.18

Adult patients (aged ≥18 years) were eligible for the trial if
they had an out-of-hospital cardiac arrest and received at least
1 dose of epinephrine during the cardiac arrest. The exclusion
criteria were traumatic cardiac arrest (including strangulation
and foreign body asphyxia), known or strongly suspected preg-
nancy, prior enrollment in the trial, receipt of epinephrine out-
side the trial (from a unit not participating in the trial), or a clin-
ical indication (eg, suspected hypocalcemia or hyperkalemia) for
calcium administration during the cardiac arrest.

Randomization
Patients were randomized in a 1:1 ratio to either calcium or sa-
line in block sizes of 2, 4, or 6 (Figure 1). The randomization
was generated using a random-number generator and stratified
g according to mobile emergency care unit stations.

Intervention
The trial drug consisted of 5 mmol of calcium chloride (cor-
responding to 200 mg of calcium or 735 mg of calcium chloride
dihydrate) or 9 mg/mL of sodium chloride (saline control). The
intravenous or intraosseous administration of the trial drug was
performed immediately after the first dose of epinephrine. A
second dose of the trial drug was administered after the sec-
ond dose of epinephrine if the patient remained in cardiac ar-
rest. The trial drug was administered as a rapid bolus.

The trial was double-blind with patients, investigators, and
the clinical team being unaware of the allocated treatment.

Outcomes
The primary outcome was sustained return of spontaneous cir-
culation, which was defined as spontaneous circulation with no
further need for chest compressions for at least 20 minutes. Data
also were collected on any return of spontaneous circulation and return of spontaneous circulation at hospital arrival.

The key secondary outcomes included survival at 30 days and survival at 30 days with a favorable neurological outcome, which was defined as a score of 0 to 3 on the modified Rankin Scale. Higher scores indicate worse outcomes on the 7-point modified Rankin Scale. Additional outcomes described below were considered tertiary.

At 30 days, health-related quality of life was assessed using the 5-dimensional, 5-level EuroQol score as a numeric value directly assessed by the patient and as an index value (based on Danish data). Outcomes were assessed in person if the patient was still an inpatient at the hospital or by telephone interview if the patient had been discharged. If the patient was not able to participate, relatives of the patient or clinical personnel provided responses for the assessment. Similar outcomes were assessed at 90 days, 180 days, and 1 year. Results for 30-day and 90-day follow-up are provided in this article.

The Sequential Organ Failure Assessment score was collected at 2, 24, 48, and 72 hours after the cardiac arrest. Data were collected on vasopressor-free and ventilator-free days within the first 7 days. Predefined potential adverse events were collected. A full list of adverse events and definitions appears in the trial protocol (Supplement 1).

Sample Size Calculation
The sample size was based on the primary outcome of sustained return of spontaneous circulation. The original sample size (n = 430) was updated based on blinded review of event data after 270 patients were enrolled in the trial (additional details appear in Supplement 1). Based on this, it was assumed that 27% of patients in the calcium group and 18% in the saline group would achieve return of spontaneous circulation. With these estimates, an α level of .05, and the use of the χ² test, a total of 674 patients were required to have 80% power to detect a statistically significant between-group difference.

Statistical Analysis
Patients were analyzed according to their randomized assignment. The analyses only included patients receiving the first dose of the trial drug and meeting all inclusion criteria and no exclusion criteria.

Binary data are presented as counts and percentages and between-group differences are presented as both risk differences and risk ratios with 95% CIs. The 95% CIs were estimated using the method described by Miettinen and Nurminen. Two-sided P values (obtained from the Fisher exact test) are reported for the primary outcome and only for key secondary outcomes. P < .05 was considered statistically significant. As a sensitivity analysis, the risk ratio for the primary outcome was estimated while adjusting for the stratification variable and strong prognostic factors (specifically age, gender, and comorbidities).
The distribution of the data. Between-group differences for the continuous outcomes are presented as mean differences with 95% CIs obtained from a generalized linear model with robust errors.

Five predefined subgroup analyses were performed according to the initial rhythm, the timing of the drug administration, intravenous vs intraosseous administration, whether the cardiac arrest was witnessed, and whether bystander cardiopulmonary resuscitation was performed. Because the trial was not powered to detect subgroup differences, these analyses should be considered as exploratory and hypothesis-generating.

Bayesian analyses were conducted to supplement the primary frequentist analyses. Priors were specified to reflect a range of beliefs (the expected treatment effect expressed as a risk ratio) for the included outcomes. The priors included non-informative, skeptical (no effect), optimistic (beneficial effect), and pessimistic (harmful effect) beliefs. The strength of each informative belief (the variance of the expected treatment effect) was characterized as strong, moderate, or weak, allowing for harm or benefit of 5%, 15%, and 30%, respectively. All priors were prespecified using a standardized approach and assumed a normal distribution on a log-ratio scale.

Posterior probabilities were estimated using Markov chain Monte Carlo methods with 1 chain, 10 000 burn-ins, 1 000 000 iterations, and a thinning rate of 100 to reduce sample autocorrelation. The results are reported graphically and as mean risk ratios with equal-tailed 95% credible intervals and as the posterior probability of significant harm (risk ratio <1.0, <0.8, and <0.5) or benefit (risk ratio >1.0, >1.2, and >1.5).

All analyses were performed using SAS version 9.4 (SAS Institute Inc).

**Results**

**Patient Characteristics**

On April 15, 2021, the independent data and safety monitoring committee recommended that the trial be stopped due to a signal of harm in the calcium group (eTable 1 in Supplement 2). This was based on unblinded data from 383 patients included in the trial between January 20, 2020, and April 6, 2021. Based on this recommendation, the steering committee immediately stopped the trial.

From January 20, 2020, to April 15, 2021, a total of 1221 patients had an out-of-hospital cardiac arrest in the Central Denmark Region (Figure 1). Of these, 397 patients received the trial drug. Six patients with a traumatic cardiac arrest (an exclusion criterion) inadvertently received the trial drug and were excluded from the analyses, leaving 193 patients in the calcium group and 198 patients in the saline group. There was no loss to follow-up. The last 90-day follow-up was on July 15, 2021.

Baseline characteristics were similar in the 2 groups (Table 1 and eTable 2 in Supplement 2). The mean age was 68 years (SD, 14 years) and 114 (29%) were female. Most patients had the cardiac arrest at home (82%) and had an initial nonshockable rhythm (75%). There were data on fraction and frequency of

![Table 1. Baseline Characteristics of Patients](https://jamanetwork.com/)

<table>
<thead>
<tr>
<th>Calcium (n = 193)</th>
<th>Saline (n = 198)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age, mean (SD), y</strong></td>
<td>67 (14)</td>
</tr>
<tr>
<td><strong>Sex, No. (%)</strong></td>
<td>Male 131 (68)</td>
</tr>
<tr>
<td><strong>Female</strong></td>
<td>62 (32)</td>
</tr>
<tr>
<td><strong>Medical history, No. (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Arterial hypertension</td>
<td>76 (39)</td>
</tr>
<tr>
<td>Pulmonary disease</td>
<td>49 (25)</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>46 (24)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>38 (20)</td>
</tr>
<tr>
<td>Kidney disease</td>
<td>35 (18)</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>33 (17)</td>
</tr>
<tr>
<td>Chronic heart failure</td>
<td>32 (17)</td>
</tr>
<tr>
<td>Stroke</td>
<td>20 (10)</td>
</tr>
<tr>
<td>Venous thromboembolism</td>
<td>9 (5)</td>
</tr>
<tr>
<td>Dementia</td>
<td>7 (4)</td>
</tr>
<tr>
<td>Cancer</td>
<td>5 (3)</td>
</tr>
<tr>
<td>Liver disease</td>
<td>3 (2)</td>
</tr>
<tr>
<td><strong>Cardiac arrest characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>Location, No. (%)</td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>160 (83)</td>
</tr>
<tr>
<td>Public area</td>
<td>33 (17)</td>
</tr>
<tr>
<td>Witnessed status, No. (%)</td>
<td></td>
</tr>
<tr>
<td>Bystander</td>
<td>101 (52)</td>
</tr>
<tr>
<td>Emergency medical services</td>
<td>16 (8)</td>
</tr>
<tr>
<td>Not witnessed</td>
<td>76 (39)</td>
</tr>
<tr>
<td>Bystander response, No./total (%)</td>
<td></td>
</tr>
<tr>
<td>Cardiopulmonary resuscitation</td>
<td>146/177 (82)</td>
</tr>
<tr>
<td>Automated external defibrillator shock</td>
<td>14/177 (8)</td>
</tr>
<tr>
<td>Initial manual rhythm analysis by emergency medical services, No. (%)</td>
<td></td>
</tr>
<tr>
<td>Asystole</td>
<td>103 (53)</td>
</tr>
<tr>
<td>Pulseless electrical activity</td>
<td>47 (24)</td>
</tr>
<tr>
<td>Ventricular fibrillation</td>
<td>39 (20)</td>
</tr>
<tr>
<td>Ventricular tachycardia</td>
<td>4 (2)</td>
</tr>
<tr>
<td><strong>Administration and drug characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>Intravenous administration, No. (%)</td>
<td>78 (40)</td>
</tr>
<tr>
<td>Intraosseous administration, No. (%)</td>
<td>115 (60)</td>
</tr>
<tr>
<td>Tibial</td>
<td>103 (90)</td>
</tr>
<tr>
<td>Humeral</td>
<td>12 (10)</td>
</tr>
<tr>
<td>Time to administration, median (IQR), min</td>
<td>17 (12-22)</td>
</tr>
<tr>
<td>Epinephrine</td>
<td>17 (13-23)</td>
</tr>
<tr>
<td>No. of trial drug doses</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>53 (27)</td>
</tr>
<tr>
<td>2</td>
<td>140 (73)</td>
</tr>
</tbody>
</table>

*Not witnessed by emergency medical services (n = 362).
Primary Outcome
The primary outcome of sustained return of spontaneous circulation occurred in 37 patients (19%) in the calcium group and 53 patients (27%) in the saline group (risk ratio, 0.72 [95% CI, 0.49-1.03], \( P = .09 \); Table 2). The results for any return of spontaneous circulation and return of spontaneous circulation at hospital arrival were similar (eTable 5 in Supplement 2). The results were attenuated in the adjusted analysis (risk ratio, 0.81 [95% CI, 0.56-1.17]). The results were generally consistent across predefined subgroups (Figure 2).

Secondary Outcomes
Survival at 30 days occurred in 10 patients (5.2%) in the calcium group and 18 patients (9.1%) in the saline group (risk ratio, 0.57 [95% CI, 0.27-1.18], \( P = .17 \); Table 2). Survival at 30 days with a favorable neurological outcome occurred in 7 patients (3.6%) in the calcium group and 15 patients (7.6%) in the saline group (risk ratio, 0.48 [95% CI, 0.20-1.12], \( P = .12 \); Table 2). The results were generally consistent across predefined subgroups (eFigures 3-4 in Supplement 2).

Adverse Events
Among patients with calcium values measured who had return of spontaneous circulation, 26 patients (74%) in the calcium group and 1 patient (2%) in the saline group had hypercalcemia. Additional adverse events appear in eTable 10 in Supplement 2.

Tertiary Outcomes
Survival at 90 days was identical to 30-day survival (Table 2). The Kaplan-Meier curve for 90-day survival appears in eFigure 5 in Supplement 2. Survival at 90 days with a favorable neurological outcome occurred in 7 patients (3.6%) in the calcium group and 18 patients (9.1%) in the saline group (risk ratio, 0.40 [95% CI, 0.17-0.91]. Quality-of-life scores in survivors were lower in the calcium group, although the 95% CIs were wide (Table 2).

The first ionized calcium level after return of spontaneous circulation was higher in the calcium group (1.41 mmol/L [SD, 0.15 mmol/L]) compared with the saline group (1.17 mmol/L [SD, 0.07 mmol/L]) and the mean between-group difference was 0.23 mmol/L (95% CI, 0.18-0.28 mmol/L), and remained higher for approximately 12 hours (eFigure 6 in Supplement 2). The first collected potassium level, pH level, and lactate level after return of spontaneous circulation appear in eTable 6 in Supplement 2. In addition, data on organ dysfunction after return of spontaneous circulation (assessed by the Sequential Organ Failure Assessment score and vasopressor-free and ventilator-free days) appear in eTable 6 in Supplement 2. Additional details on outcomes appear in eTables 7 through 9 in Supplement 2.
Results are presented for the 5 predefined subgroups. The time from cardiac arrest to trial drug administration was dichotomized at the median. Only cardiac arrests not witnessed by emergency medical services (EMS) were included in the bystander cardiopulmonary resuscitation (CPR) subgroup. The vertical dashed lines represent the estimated effect in the primary outcome analysis. The vertical dotted lines represent no difference between the calcium and saline groups.
Bayesian Analysis

The posterior probability distribution for return of spontaneous circulation, survival at 30 days, and survival at 30 days with a favorable neurological outcome based on noninformative priors appear in Figure 3. The probability that calcium has a beneficial effect (ie, a risk ratio >1.0) based on the data is 4% for return of spontaneous circulation, 6% for survival at 30 days, and 4% for survival with a favorable neurological outcome at 30 days. The corresponding probabilities for a risk ratio greater than 1.2 were 0%, 2%, and 1%. Additional results, including for all the informative priors, appear in eTables 11 through 13 and eFigures 7 through 9 in Supplement 2.

Discussion

In this randomized clinical trial, the administration of calcium, compared with saline, did not result in a statistically significant difference in sustained return of spontaneous circulation for patients with out-of-hospital cardiac arrest. In addition, there were no statistically significant differences in 30-day survival or 30-day survival with a favorable neurological outcome. Although not reaching statistical significance, patients receiving calcium had worse outcomes, including worse 30-day survival with a favorable neurological outcome. At 90 days, fewer patients in the calcium group had a favorable neurological outcome and quality of life was lower in survivors.

Given that the trial was stopped early, the results should be interpreted carefully. Trials that are stopped early based on knowledge of the accruing results tend to overestimate the effects. Furthermore, given the widths of the 95% CIs, it is possible that the point estimates suggesting harm are chance findings. In the adjusted analysis for the primary outcome, the effect estimate still suggested harm, but the size of the effect was attenuated. Supporting a true harmful effect of calcium administration during cardiac arrest is the consistent signal across multiple outcomes and time points.

The rationale for the current trial was the well-established inotropic effect of administered calcium, calcium's role in maintaining vascular tone, and a nonsignificant increase in return of spontaneous circulation found in 2 previous small trials. Although contrary to the original hypothesis, there are theoretical mechanisms that could potentially explain a harmful effect of calcium during cardiac arrest. Due to adenosine triphosphate depletion during ischemia, sodium accumulates intracellularly, reducing the transmembrane sodium gradient and causing the sodium-calcium exchanger to operate in reverse mode. High levels of calcium immediately after administration of calcium may have caused cytosolic and mitochondrial calcium overload during the cardiac arrest. This may have caused cardiac hypercontraction, a phenomenon termed stone heart. In addition, because calcium is involved in multiple intracellular signaling pathways, cytosolic and mitochondrial calcium overload could have promoted oxidative stress, release of proapoptotic factors, and activation of calcium-dependent lipases, proteases, and nucleases.

![Figure 3. Posterior Probability Distributions Based on Noninformative Priors](https://jamanetwork.com/)

- **A**. Return of spontaneous circulation
- **B**. Survival at 30 d
- **C**. Favorable neurological outcome at 30 d

The results from the bayesian analyses are presented as posterior probability distributions based on noninformative priors. The x-axis is logarithmic. The vertical dotted lines represent no effect (ie, a risk ratio of 1). The dark blue shaded areas represent values below 1 (ie, a beneficial effect of calcium) and the light blue shaded areas represent values above 1 (ie, a harmful effect of calcium). CrI indicates credible interval. Additional results from the bayesian analysis appear in Supplement 2.
European and US cardiac arrest guidelines suggest that calcium should only be administered during cardiac arrest in special circumstances, such as during cardiac arrest caused by hyperkalemia or hypocalcemia or during an overdose of calcium channel blockers.\textsuperscript{2,3,5} Although limited data have been published on the actual use of calcium in the out-of-hospital cardiac arrest setting, calcium is often administered during in-hospital cardiac arrest.\textsuperscript{15,16} In a large, multicenter, US registry of in-hospital cardiac arrest, calcium was administered in approximately 25\% to 30\% of adult patients and 30\% to 50\% of pediatric patients, corresponding to approximately 90,000 patients receiving calcium during in-hospital cardiac arrest each year in the US alone.\textsuperscript{15,16,36} The rationale for administration of calcium in this setting is unclear but could reflect either a perceived etiology of the cardiac arrest in which calcium is currently recommended (eg, hyperkalemia) or based on a hypothesis that calcium would be beneficial in unselected patients with cardiac arrest. The findings from this trial suggest that the administration of calcium to an unselected cardiac arrest population is unlikely to result in improved outcomes and may in fact result in worse outcomes.

This trial has several strengths. Administration of the trial drug was blinded, delivered quickly after the administration of epinephrine, and there were few protocol deviations or use of calcium outside the protocol. The administration of calcium resulted in a clinically relevant increase in ionized calcium values at hospital arrival. The trial included patient-relevant outcomes, including quality of life, and there was no loss to follow-up.

Limitations
The trial also has several limitations. First, the trial was stopped early and did not reach its preplanned sample size. Even though continuing the trial would have resulted in more precise estimates of the treatment effect, it was not considered ethically justified to continue after the results of the interim analysis were evident. This decision was consistent with the recommendations from the independent data and safety monitoring committee.

Second, the trial only tested 1 dosing regime and timing and the trial results cannot necessarily be extrapolated to other doses or a different timing interval.

Third, the current trial was conducted in the out-of-hospital setting with a relatively long time to drug delivery. The generalizability to the in-hospital setting is therefore unclear.

Conclusions
Among adults with out-of-hospital cardiac arrest, treatment with intravenous or intraoesophageal calcium compared with saline did not significantly improve sustained return of spontaneous circulation. These results do not support the administration of calcium during out-of-hospital cardiac arrest in adults.

Disclosure: Dr. Andersen is a statistical reviewer of JAMA but was not involved in any of the decisions regarding review of the manuscript or its acceptance.


Data Sharing Statement: See Supplement 3.

Additional Contributions: We thank the clinical teams that facilitated inclusion of patients as well as the members of the independent data and safety monitoring committee: Jesper Kjærgaard, MD, PhD (Rigshospitalet, University of Copenhagen, Copenhagen, Denmark), Jerry Nolan, MD (Royal United Hospital, Bath, England), and Theresa Olasveengen, MD, PhD (University of Oslo, Oslo, Norway). We also thank Michael W. Dominio, MD (Beth Israel Deaconess Medical Center, Boston, Massachusetts), Clifton Callaway, MD, PhD (University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania), and Markus Skrifvars, MD, PhD (Helsinki University, Helsinki, Finland), who provided valuable feedback on the trial protocol during the early stages of planning the trial. None of the above were compensated for their work.

REFERENCES
Intravenous or Intraosseous Calcium vs Saline on Return of Spontaneous Circulation in Adults

Original Investigation Research


