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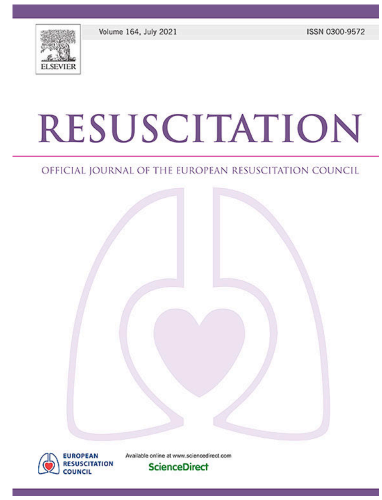

Original paper

Defibrillation in patients with accidental hypothermia and core temperatures ≤30°C – a retrospective observational study

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Defibrillation in patients with accidental hypothermia and core temperatures ≤30°C – a retrospective observational study

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Abstract

Background: Defibrillation often fails in patients in hypothermic cardiac arrest with shockable rhythms. In patients with core temperatures (Tc) ≤30°C the success rate, optimal number, timing of defibrillations, and factors including rewarming associated with successful defibrillation are not well known.

Aims: To determine the success rate of defibrillation in patients in hypothermic cardiac arrest with shockable rhythms. We studied Tc at defibrillation attempt, number of shocks, and factors facilitating defibrillation.

Methods: This was a retrospective observational study from the International Hypothermia Registry of patients with hypothermic cardiac arrest (Tc ≤30°C) and shockable rhythms undergoing defibrillation attempts before and during rewarming with or without extracorporeal life support. We performed multivariate binomial logistic regression to analyse the probability of defibrillation success according to the defibrillation temperature and ECLS rewarming.

Results: Thirty-seven patients with cardiac arrest, shockable rhythm, and Tc ≤30°C were included. Defibrillation was attempted in 20 patients before rewarming and in 17 during rewarming. The overall success rate was 22/37 (59%). Both the success rate of defibrillation (100% [17/17] vs. 25% [5/20]; P<0.001) and Tc at the time of the defibrillation attempt (29.0°C [28.0-30.0°C] vs 25.8°C [24.0-26.2°C]; P<0.001) were higher if defibrillation was performed during rewarming. No defibrillation attempt was successful at Tc <24.8°C.

Conclusions: Defibrillation attempts can be successful before rewarming at Tc ≤30°C. The success rate is higher during rewarming and at a higher Tc. Tc is a strong and independent predictor of defibrillation success. Defibrillation at Tc <25°C is unlikely. These findings require confirmation in larger studies.

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Introduction

Accidental hypothermia (core temperature (Tc) <35°C) is a life-threatening condition that may occur in urban and nonurban environments (1, 2). Hypothermia can provoke arrhythmias and cardiac arrest (CA) (3-6). A hypothermic heart with a Tc <30°C may be resistant to defibrillation. At Tc <30°C, ventricular fibrillation (VF) often recurs despite initial successful defibrillation (7, 8). Repeated defibrillations can cause myocardial injury (9). If VF persists after three shocks, the 2021 and 2025 guidelines of the European Resuscitation Council (ERC) recommend delaying further defibrillation attempts until Tc is >30°C (10, 11). In contrast to the ERC guidelines, the 2025 Special Circumstances guidelines of the American Heart Association (AHA) state that it may be reasonable to perform one defibrillation attempts according to the standard algorithm and to withhold administration of epinephrine until the core Tc is >30°C (12). Similarly to the AHA 2025 special circumstances guidelines, the 2019 guidelines of the Wilderness Medical Society (WMS) recommend that a single shock at a maximum power be given for patients with a temperature <30°C (13). This discrepancy in guidelines can be explained by the different interpretation of poor-quality data from animal studies, case reports and case series in humans (7, 14-16).

We aimed to determine the incidence of successful defibrillation in patients in cardiac arrest with shockable rhythms with Tc ≤30°C. We evaluated Tc at the time of successful defibrillation, number of shocks necessary for successful defibrillation, and factors associated with successful defibrillation. We hypothesised that rewarming patients in hypothermic cardiac arrest on Extracorporeal Life Support (ECLS) would be associated with higher defibrillation success, because of improved myocardial oxygen support, making the heart more responsive to defibrillation.

Methods

This study was approved by the ethical committee of Geneva, Switzerland (2023-01087). We extracted the data on September 1, 2023. The study was registered in clinicaltrials.gov (number NCT06131892). This research adhered to the STROBE guidelines (17).

We performed a retrospective observational study using data from the International Hypothermia Registry (IHR). The IHR collects data of adults and children with accidental hypothermia (Tc <35°C) (18). The registry was created in 2008 (protocol N° 08-040R, Geneva, 23 September 2008). On August 31, 2023, 28 centres in 10 countries (Austria, Denmark, Germany, Italy, Japan, Poland, Spain, Switzerland, the UK, and the USA) were participating in the registry. We included all patients entered into the registry by August 31, 2023, with attempted defibrillation at Tc ≤30°C. We studied two groups: those with attempted defibrillation before rewarming and those with attempted defibrillation during rewarming. Rewarming with extracorporeal life support (ECLS) refers to rewarming using cardiopulmonary bypass (CPB) or extracorporeal membrane oxygenation (ECMO) (venoarterial or venovenous). Non-ECLS rewarming included all other invasive and noninvasive rewarming techniques. The non-ECLS rewarming techniques that can be selected in the International Hypothermia Registry are haemodialysis, continuous venovenous haemofiltration, intravenous catheter rewarming, continuous arteriovenous rewarming, thoracic lavage (thoracotomy), thoracic lavage (thoracoscopy), mediastinal lavage sternotomy, peritoneal lavage, peritoneal dialysis, bladder lavage, gastric lavage, warm IV fluids, and other.

We extracted the following data: age, sex, country, cause of hypothermia (mountain accidents, including avalanche, outdoor exposure, and crevasse accidents; water-related accidents (drowning and immersion); and rural or urban accidents (outdoor exposure in patients experiencing homelessness and other vulnerable populations), presence of asphyxia (submersion in water or avalanche with burial of the head under the snow), lowest measured Tc, first rhythm (prehospital or inhospital), Tc at the time of successful defibrillation or the time of the last shock if attempted defibrillation was unsuccessful, initial cardiac rhythm, and whether CA was witnessed. We extracted the type of defibrillation (i.e. electrical or spontaneous) and recurrence of VF after successful defibrillation.

The primary outcome was the incidence of successful defibrillation with persistent return of spontaneous circulation (ROSC) in patients in hypothermic cardiac arrest with shockable rhythms and Tc ≤30°C (19). We defined persistent ROSC as sustained spontaneous circulation for ≥30 seconds. We defined successful defibrillation as either spontaneous or electrically successful defibrillation with persistent ROSC. Secondary outcomes were the influence of Tc on defibrillation success, the number of shocks necessary to obtain successful defibrillation, the influence of ECLS rewarming, the use of epinephrine and other factors associated with defibrillation success. Although the registered trial protocol included recurrent ventricular fibrillation and cardiac dysfunction as secondary outcomes, these measures were not consistently collected throughout the study.

Statistical analysis

We report general characteristics of the study population using descriptive statistics. We expressed normally distributed data as mean ± standard deviation (SD) and non-normally distributed data as median ± interquartile range (IQR). We assessed normal distribution using the Shapiro-Wilk test and Q-Q plots. We tested homogeneity of variances using Levene's test. We compared defibrillation characteristics of patients (defibrillation during or before rewarming) and those with or without successful defibrillation using Fisher's exact test for categorical characteristics and Student's t-test or Welch's t-test for continuous variables if normality was satisfied, or the Mann-Whitney U test for non-normal distributions. We set the level of significance at <0.05. Analyses were performed as complete-case analyses (**Supplementary table 1** for missing data by variable); defibrillation success was available for all patients, while variables with missing values (lactate, potassium, CPC) were handled using complete-case approach in respective analyses. We assessed univariate associations with defibrillation success using binomial logistic regression. We performed multivariate binomial logistic regression to analyse the probability of defibrillation success according to the defibrillation Tc and ECLS rewarming. Because of quasi-complete separation in the ECLS rewarming variable and the sample size, we complemented the analysis with Firth's penalised logistic regression to obtain more stable estimates. We used a bootstrap with 5,000 replicates to assess the robustness and stability of the penalised regression results. To assess temporal confounding over the 40-year study period, we stratified analyses by pre-2010 vs post-2010, comparing ECLS utilisation, success rates, and temperatures across periods. We included period as a binary variable in our multivariable model using Firth's penalised regression to control for temporal changes in ECLS availability.

Statistical analysis was performed using R version 4.4.3 (2025-02-28).

Results

Of the 37 patients, 20 had attempted defibrillation before rewarming and 17 during rewarming (**Figure 1**). Twenty- six patients were excluded: 9 patients because the temperature at defibrillation was >30°C, 11 patients because temperature at defibrillation was not known. Six patients had defibrillation attempts both before and during rewarming (**Supplementary table 2** compares the main characteristics of included and excluded patients).

Patients came from Switzerland (15), Poland (9), France (4), Austria (5), Italy (2), Spain (1), and the United Kingdom (1). The cases occurred between August 5, 1982 and December 6, 2022.

Patients were mostly male (25/37, 68%), with a mean age of 43±18 years (Table 1). Accidents were more likely to be water-related in patients with defibrillation before rewarming (10/20 (50%) versus 1/17 (6%)). The initial prehospital median core temperature was lower in patients who underwent defibrillation during rewarming compared to those who were defibrillated before rewarming (22.5°C [20.7°–24.7°] vs. 25.8°C [24.0°–26.4°], P = 0.006). Patients with successful defibrillation before rewarming required ECLS to be rewarmed less often than patients who were not defibrillated in the prehospital phase (53% vs 94%, p=0.017) (**Table 1**).

Primary outcome

The overall success rate of electrical and spontaneous defibrillation was 22 of 37 (59%) (**Table 1**). Three of the 22 patients had spontaneous defibrillation and ROSC before rewarming. Defibrillation was more successful when done during, rather than before, rewarming (17/17 (100%) vs 5/20 (25%), p<0.001) (**Table 1**).

Secondary outcomes

The median temperature at the time of the first defibrillation attempt, successful or unsuccessful, was higher in the group with defibrillation during rewarming than in the group with defibrillation before rewarming (29.0°C (28.0-30°C) vs 25.8°C (24.0-26.2°C), P<0.001). No defibrillation with Tc <24.8°C was successful. A higher median core temperature was associated with higher defibrillation success (28°C (26.8-29.9) vs 25°C (23.6-26); P<0.001) (**Table 2**). Each additional 1°C in core temperature at the time of shock was associated with greater odds of successful defibrillation (OR 2.68; P=0.003) (**Table 3**). The Tc at defibrillation was positively associated with defibrillation success, with adjusted odds ratios increasing from 2.68 (95% CI: 1.39–5.14, P=0.003) in univariate analysis to 4.03 (95% CI: 1.3–12.3, P=0.015) in multivariate analysis, adjusting for ECLS rewarming (**Table 4, Figure 2**). At the median cohort temperature of 26.8°C, the difference in the probability of success between patients managed with or without extracorporeal life support (ECLS) was 31% (78% vs. 47%) (**Figure 2**). The discriminative ability of this model was high (AUC 0.94). The application of Firth's penalized regression produced more stable estimates than the standard model, with defibrillation temperature remaining a stable predictor of success (OR 2.83; CI 95% 1.54–9.56, P<0.001). Analyses using bootstrapping confirmed the robustness of the temperature effect.

The number of shocks was reported in 31 patients (**Figure 3, supplementary figure 2**). Seventeen of the 31 patients (55%) were successfully defibrillated. Of the 17 patients successfully defibrillated, 5 (29%) were successfully defibrillated with 1 shock, 7 (41%) with 2 shocks, 3 (1%) with 3 shocks and 2 (12%) with 4 to 5 shocks (**Figure 3, supplementary figure 2**).

Patients who received rewarming with ECLS had greater than 5 times higher odds of successful defibrillation than those who did not receive ECLS rewarming (OR 5.4; P=0.05) (**Table 3**). The absolute number of ECLS-treated patients increased from pre-2010 (n=3) to post-2010 (n=22), reflecting likely changes in ECLS availability. The proportion of patients receiving ECLS was similar between periods (75% pre-2010 vs 73.3% post-2010), suggesting consistent selection criteria. Pre-2010 patients had higher median core temperatures at defibrillation (27.5°C vs 26.9°C) yet lower success rates (50% vs 63.3%), supporting the hypothesis that improved outcomes were driven by temperature effects rather than increased ECLS availability. In the multivariable model adjusted for period (pre-2010 vs post-2010), temperature retained strong significance (OR 2.45, 95% CI 1.47-7.82, p<0.001), while the period variable was not significant (OR 0.15, 95% CI 0-12.39, p=0.53), indicating that the association between temperature and success is consistent across eras and confirming the absence of temporal confounding (**Supplementary figure S1**).

More epinephrine was used in the patients defibrillated before than during rewarming (16/20 (80%) versus 6/17 (35%), P=0.008) (**Table 1**). Epinephrine administration was associated with a lower success rate (10/22 (45%) vs 12/15 (80%); P=0.05).

Higher mean lactate levels were associated with a lower probability of success (21.4 ±8.9 mmol/L vs 12.2 ±5.9mmol/L) vs; p=0.006). Patients with witnessed cardiac arrest had a trend to higher chance of a successful defibrillation that was not statistically significant. (OR 1.7, 95%CI 0.5-8.1, p=0.5). Each 1 mEq/L of higher potassium was associated with a 41% decrease in the odds of successful defibrillation (OR 0.58; P=0.046) (**Table 3**).

Discussion

We assessed the incidence of successful defibrillation in 37 patients in hypothermic cardiac arrest with shockable rhythms. In 25%, defibrillation was successful before rewarming compared to 100% during rewarming. Three of 20 patients (15%) experienced spontaneous defibrillation with ROSC at core temperatures below 30°C prior to rewarming.

In patients in hypothermic cardiac arrest, the likelihood of successful defibrillation is strongly dependent on Tc. Our findings suggest that achieving a Tc of ≥25°C prior to a shock is key to successful defibrillation. This observation should be treated as hypothesis-generating and should be corroborated by further studies providing additional data. Successful defibrillation is possible in patients with Tc ≤30°C (14, 15, 20, 21) but it is unlikely at a Tc <25°C despite a few reported cases with successful defibrillation with lower Tc (14, 16).

Our data suggest that most patients can be successfully defibrillated at Tc under 30ºC during ECLS rewarming (**Figure 2**). This finding has significant implications for clinical practice. Based on our data, defibrillation during ECLS rewarming should be attempted with a Tc >25°C and should not be withheld until Tc reaches 30ºC. Other factors for successful defibrillation in hypothermic cardiac arrest are immediate high-quality cardiopulmonary resuscitation (CPR), and a higher core temperature. These results reinforce the importance of achieving a Tc of ≥25°C before attempting defibrillation in hypothermic cardiac arrest patients. Although achieving a temperature of at least 25°C may improve the chances of success, attempts at defibrillation should not be deterred in patients with lower temperatures. These findings inform expectations of defibrillation success and could help to refine resuscitation protocols. Based on the accident sites, all the patients analysed had access to an ECLS center in less than 6 hours.

It is not clear whether the higher likelihood of successful defibrillation during ECLS rewarming can be attributed solely to the higher Tc observed during ECLS rewarming or whether improved myocardial perfusion, oxygenation and metabolic state also play a role (22). Our data support continuing CPR even if ECLS is not available, e.g. in case of bad weather, long distances, low-resource settings, because there is a 25% chance of successful defibrillation and ROSC using standard CPR and non-ECLS rewarming with a Tc >25°C. When transfer to an ECLS centre is not possible, active rewarming should be started as early as possible. With a Tc <25°C cerebral metabolism is reduced by >70%, allowing CPR to be intermittent during a difficult evacuation (23), but with a Tc between 28 to 30°C, even short interruptions of CPR are associated with a high risk of hypoxic cerebral injury. Above a Tc of 28, successful defibrillation may be life-saving (23). In the defibrillation before rewarming group, 8 patients were first transferred to a non-ECLS hospital. Only one patient wasn’t transferred to an ECLS center. Eight of the patients of the ECLS group were first admitted in a non-ECLS hospital, before arriving in an ECLS center.

Our data support the ERC 2021 and 2025 guidelines to deliver more than one shock to patients in cardiac arrest with Tc ≤30°C and shockable rhythms (10, 11). Using the WMS 2019 and the AHA 2025 guidelines that recommend only one defibrillation attempt, would have reduced the chances of achieving a successful defibrillation in 67% of patients in the present study (12, 13). No patient in our study had a successful defibrillation after more than 5 shocks. All patients requiring 6 or more shocks (n=4) failed to achieve defibrillation success despite continued resuscitation efforts.

Higher lactate and potassium levels were associated with a lower probability of successful defibrillation, suggesting that poor tissue perfusion and a worse metabolic state reduce the efficacy of defibrillation. These associations likely reflect the severity and duration of cardiac arrest rather than being causal. Epinephrine administration was also associated with a lower success rate but, we were unable to determine if this was a causal effect. It is still unclear whether epinephrine improves outcome in hypothermic cardiac arrest. Because of potential detrimental effects of epinephrine and the risk of accumulation in hypothermic cardiac arrest (24-26) the 2021 European Resuscitation guidelines did not recommend its use (10) and the 2025 European Resuscitation guidelines (11) recommend only 1 mg during hypothermic cardiac arrest. The WMS 2019 and the AHA 2025 do not recommend any epinephrine use at all (12, 13). Some experimental studies have suggested that the rate of successful defibrillation is higher after administration of epinephrine but, so far, no clinical studies have confirmed this (24, 25). The discrepancy in the AHA, ERC and WMS guidelines may be explained with a different interpretation of data and their clinical applicability and efficiency. Certainly, the differences in these guidelines are decreasing over time.

The HOPE score was lower in the unsuccessful defibrillation group (35±21%) vs 65±25%) but was far above the 10% cut-off below which patients should not be rewarmed with ECLS. The prehospital HOPE score should be interpreted as being associated with the hospital-based HOPE score, rather than as a predictor of prehospital outcomes.

Limitations

Of 251 patients in the IHR, few patients (n=37) were included in this study (15% of inclusion rate). The geographic representation is biased, which limits generalisability and information about severity of trauma was not reported. The largest human series on defibrillation in hypothermic cardiac arret includes four patients (16). The data were collected retrospectively with a significant rate of missing data (17%). A selection bias may have led to preferential inclusion of patents with better outcomes, such as higher rates of defibrillation success or survival. Differences in baseline characteristics between patients defibrillated before and during ECLS rewarming may have confounded the defibrillation success variable. We do not have access to injury severity scores (ISS) or other detailed injury characteristics that would enable us to adjust for injury severity as a confounding factor. Furthermore, we lack documented criteria for ECLS selection decisions made by clinical teams during the study period. We are not aware of any study, which has included a similarly large number of patients to assess this study question.

Conclusion

Defibrillation attempts can be successful before rewarming at Tc ≤30°C. The success rate is higher during rewarming and at a higher Tc. Tc is a strong and independent predictor of defibrillation success. Defibrillation at Tc <25°C is unlikely. These findings require confirmation in larger studies.

Conflicts of Interest: None

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Conceptualization: EC, BW, PP; Data curation: EC, RB, DC; Formal analysis; EC, RB, DC; Investigation; EC, MP, PP, Methodology; EC, PP, HB, TD, DC, Project administration: EC; Resources: EC, BW; Software: RB, DC; Supervision: BW, PP; Validation; HB, PP, RB, TD, KZ, SR, Visualization; EC, RB, PP, Roles/Writing –

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Figures

Figure 1. Flowchart of the study population.

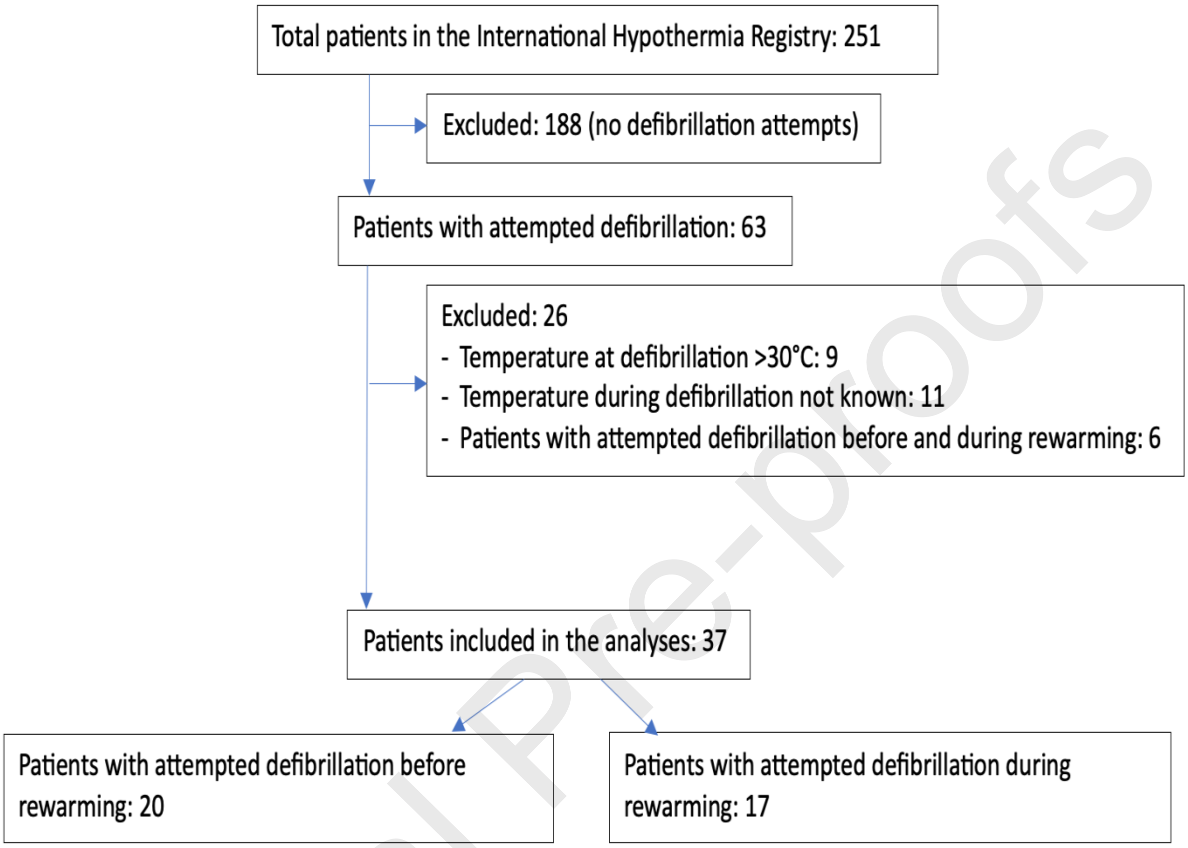


Figure 2. Probability of successful defibrillation among patients rewarmed or not using ECLS and the temperature at the first defibrillation. ECLS = extracorporeal life support.

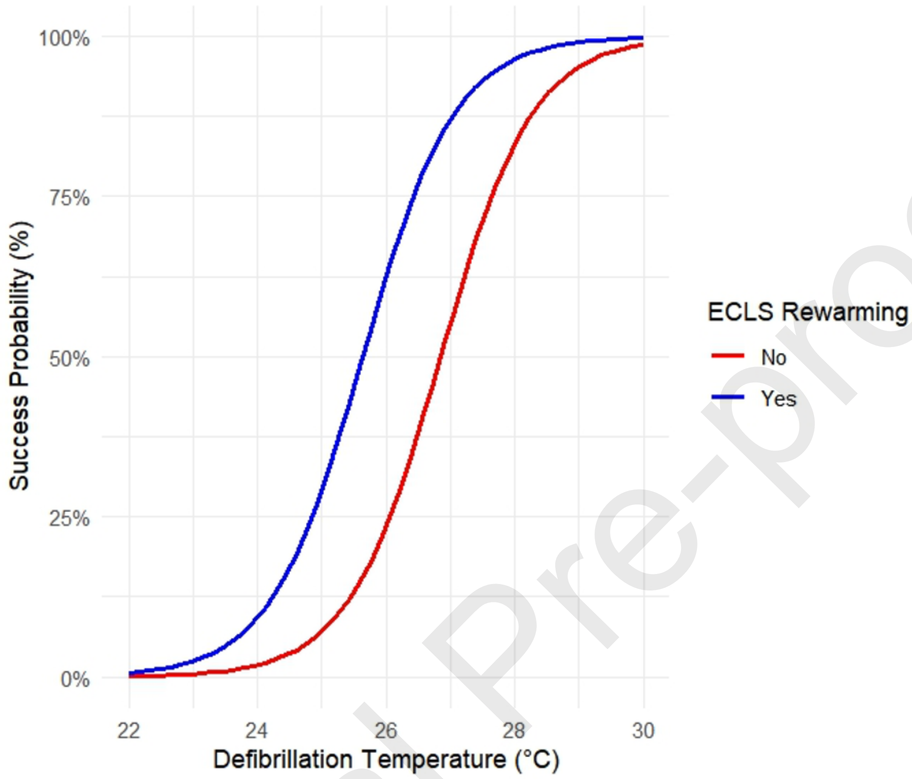
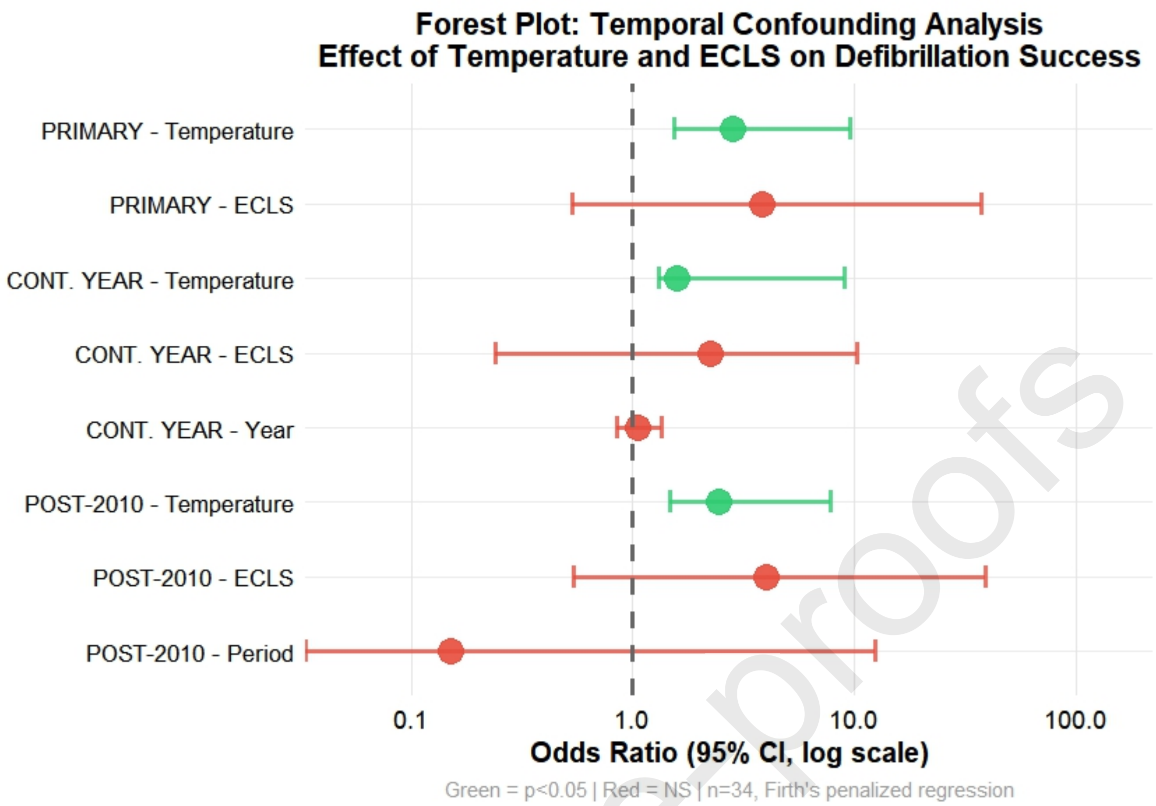


Figure 3. Number of Shocks versus Core Temperature at Defibrillation



Supplemnetary Figure S1: Temporal confounding analysis of temperature and ECLS on defibrillation success across study periods.

Variable	Overall	Defibrillation Before Rewarming	Defibrillation During Rewarming	p-value
Number of patients	N=37	N=20	N=17	
PATIENT CHARACTERISTICS				
Sex male (n, %)	25 (68%)	14 (70%)	11 (65%)	0.99
Age (mean, ±SD)	43±18	42±20	44±17	0.78
CARDIAC ARREST CHARACTERISTICS				
Shockable rhythm prehospitally (n, %)	15 (58%)	10 (67%) Missing=5	5 (45%) Missing=6	0.43
Lowest prehospital temp. (median, IQR)	24.6°C (22.3-26)	25.8°C (24–26.4)	22.5°C (20.7–24.7)	**0.006**
Core temp. at first defibrillation (median, IQR)	26.8°C (25–29)	25.8°C (24–26.2)	29°C (28–30)	**<0.001**
Accident site (n, %)				**0.009**

- Mountain	13 (35%)	5 (25%)	8 (47%)	
- Water	11 (30%)	10 (50%)	1 (6%)	
- Rural/Urban	13 (35%)	5 (25%)	8 (47%)	
Rescue collapse (n, %)	11 (48%)	6 (43%), Missing=6	5 (56%), Missing=8	0.68
Asphyxia (n, %)	15 (43%)	7 (39%), Missing=2	8 (47%)	0.73
Witnessed CA (n, %)	19 (66%)	12 (71%), Missing=3	7 (58%), Missing=5	0.69
pH (mean, ±SD)	6.9±0.2	6.9±0.2, Missing=8	6.9±0.2, Missing=3	0.47
Lactate (mean, ±SD)	14.7±7.8	17.4±9, Missing=9	12.7±6.5, Missing=2	0.13
Potassium (median, IQR)	3.9 (3.1–4.57)	3.7 (2.80–6.29), Missing=6	4 (3.32–4.43), Missing=1	0.98
TREATMENT PROVIDED				
Epinephrine (n, %)	22 (59%)	16 (80%)	6 (35%)	0.008

ECLS rewarming (n, %)	25 (73.5%)	9 (53%), Missing=3	16 (94%)	**0.017**
CPR duration (median, IQR)	119 (75-159)	122 (64-164), Missing=8	119 (76-157), Missing=3	0.73
Number of shocks given (median, IQR)	2 (1-3.5)	3 (1.25-4.75)	2 (1-2)	0.15
Energy defibrillation (mean, SD)	255 (93)	230 (82)	274 (99)	0.27
Low flow time (median, IQR)	94 (66-145)	82 (39-122), Missing=4	140 (75-155), Missing=4	0.07
OUTCOMES				
Successful defibrillation (n, %)	22 (59%)	5 (25%)	17 (100%)	<0.001
HOPE score (mean, SD)	55 (27)	41 (26), Missing =10	67 (23), Missing=6	**0.026**
CPC ICU discharge (n, %)		Missing=9	Missing=1	0.09
- CPC 1	11 (41%)	2 (18%)	9 (56%)	
- CPC 2	4 (15%)	3 (27%)	1 (6%)	

- CPC 3	1 (4%)	0	1 (6%)	
- CPC 4	0	0	0	
- CPC 5	11 (41%)	6 (54%)	5 (31%)	

TABLE 1. *Baseline characteristics of patients stratified by timing of defibrillation.*

CA denotes cardiac arrest, CPC cerebral performance category, ECLS extracorporeal life support, ICU intensive care unit, IQR interquartile range, SD standard deviation.

Variable	Overall	Successful defibrillation	Not successful defibrillation	p-value
Number of patients	N=37	N=22 (59.5%)	N=15 (40.5%)	
PATIENT CHARACTERISTICS				

Age (mean, ±SD)	43±18.4	45±19.7	39±16.1	0.29
Sex male (n, %)	25 (68%)	14 (64%)	11 (73%)	0.72
CARDIAC ARREST CHARACTERISTICS				
Shockable rhythm prehospitally (n, %)	15 (58%)	8 (53%) Missing=7	7 (64%) Missing=4	0.7
Prehospital lowest temperature (median, IQR)	24.6°C (22.3-26)	23.6°C (21.5–25.5)	25°C (23.6-26)	0.25
Core temperature at first defibrillation (median, IQR)	26.8°C (25–29)	28°C (26.8–29.9)	25°C (23.6-26)	**<0.001**
Accident site (n, %)				0.59
- Mountain	13 (35%)	8 (36%)	5 (33%)	
- Water	11 (30%)	5 (23%)	6 (40%)	
- Rural/Urban	13 (35%)	9 (41%)	4 (27%)	
Rescue collapse (n, %)	11 (48%)	7 (54%), Missing=9	4 (40%), Missing=5	0.68

Asphyxia (n, %)	15 (43%)	10 (45%)	5 (38%), Missing=2	0.73
Witnessed CA (n, %)	19 (66%) Missing=8	12 (71%) Missing=5	7 (58%) Missing=3	0.69
pH (mean, ±SD)	6.9±0.2	6.9±0.18, Missing=5	6.87±0.21, Missing=6	0.48
Lactate (mean, ±SD)	14.7±7.8	12.2±5.9, Missing=3	21.3±8.8, Missing=8	**0.006**
Potassium (median, IQR)	3.9 (3.1–4.57)	3.75 (3–4.4), Missing=2	5 (3.15–7.6), Missing=5	0.08
TREATMENT PROVIDED				
Epinephrine (n, %)	22 (59%)	10 (45%)	12 (80%)	**0.047**
CPR duration (median, IQR)	119 min (75-159)	102 min (69-155) Missing=5	153 min (94-175) Missing=6	0.17
Low flow time (median, IQR)	94 min (66-145)	98.5 min (67-153) Missing=4	94 min (67-125) Missing=4	0.73
Number of shocks given (median, IQR)	2 (1-3.5)	2 (1-3) Missing=5	3 (1.25–5.75) Missing=1	0.16

Energy defibrillation (mean, ±SD)	255±93.1	276±96 Missing=8	222±82.7 Missing=6	0.18
ECLS rewarming (n, %)	25 (73.5%)	18 (85%) Missing=1	7 (53%), Missing=2	**0.05**
- Before rewarming		2 (50%)	7 (54%)	
- During rewarming		16 (94%)	0	
OUTCOMES				
HOPE score (mean, ±SD)	55.0±27.3 Missing=16	65.3±24.6 Missing=8	34.6±21.1 Missing=8	**0.011**
CPC at ICU discharge (n, %)		Missing=3	Missing=7	0.17
- CPC 1	11 (41%)	10 (53%)	1 (12%)	
- CPC 2	4 (15%)	2 (10%)	2 (25%)	
- CPC 3	1 (4%)	1 (5.3%)	0	
- CPC 4	0	0	0	

- CPC 5	11 (41%)	6 (31.6%)	5 (62.5%)	

TABLE 2. Differences between patients with successful or not successful defibrillation.

CA denotes cardiac arrest, CPR cardiopulmonary resuscitation, ECLS extracorporeal life support, IQR interquartile range, SD standard deviation. HOPE: Hypothermia Outcome Prediction after Extracorporeal life support

	Unit of change	OR	IC	p-value	AUC
Age	per 1 year	1.02	0.98-1.06	0.29	0.61
Witnessed CA	Binary	1.7	0.36-8.1	0.50	0.56
Low flow time	per 1 minute	1	0.99-1.01	0.78	0.54
Lactate	per 1 mmol/L	0.83	0.71-0.98	**0.02**	0.81
pH	per 0.1 units	1.18	0.75-1.86	0.47	0.59
K	per 1 mmol/L	0.58	0.34-0.99	**0.05**	0.63

Epinephrine	Binary	0.21	0.05-0.95	**0.04**	0.67
CPR duration	per 1 minute	0.99	0.98-1	0.31	0.67
Prehospital temperature	per 1°C	0.91	0.72-1.15	0.44	0.61
ECLS	Binary	5.14	1.00-26.5	**0.05**	0.66
Shocks given	per 1 shock	0.68	0.45-1.03	0.07	0.68
Defibrillation energy (per shock)	per 1 Joule	1.007	0.99-1.02	0.18	0.65
Temperature at defibrillation	per 1°C	2.68	1.39-5.14	**0.003**	0.89
HOPE score	per 1%	1.06	1.00-1.14	**0.04**	0.88

TABLE 3. Univariate binomial logistic regression for predictors of success in defibrillation.

AUC denotes area under the curve, CA cardiac arrest, CPR cardiopulmonary resuscitation, ECLS extracorporeal life support, IQR interquartile range, IR information coefficient, OR odds ratio. HOPE: Hypothermia Outcome Prediction after Extracorporeal life support

Model	Variable	*OR*	*CI 95%*	*p-value*
Multivariable classic logistic regression	Defibrillation temperature (°C)	4.03	1.32-12.3	0.015
	ECLS rewarming (Yes/No)	5.42	0.51-57	0.15
Firth's penalised logistic regression	Defibrillation temperature (°C)	2.83	1.54-9.56	<0.001
	ECLS rewarming (Yes/No)	3.85	0.53-37.4	0.18
Bootstrap after Firth	Defibrillation temperature (°C)	3.74	1.98-45	-
	ECLS rewarming (Yes/No)	5.07	0.56-109	-

TABLE 4: Multivariate logistic regression for the probability of defibrillation success according to the defibrillation temperature during defibrillation and the ECLS rewarming and a comparative for outcome predictors using different models.

Classic model: AUC 0.94, Sensibility 0.905, Specificity 0.846. Cox & Snell R square 0.518, Nagelkerke R square 0.704). AUC denotes area under the curve, CA cardiac arrest, CI confidence interval, ECLS extracorporeal life support, OR odds ratio.

Variable	Included (n=37)	Excluded (n=26)	p-value
Age	42.7±18.4	44.6±17.0	0.683
First Initial Rhythm	Asystole: 18 (50%)	Asystole: 7 (29%)	0.158
	Ventricular Fibrillation: 12 (33%)	Ventricular Fibrillation: 9 (38%)	
	Sinus: 4 (11%)	Sinus: 3 (12%)	
	Pulseless Activivty: 2 (6%)	Pulseless Activity: 1 (4%)	

		Junctional: 1 (4%)	
		Atrial Fibrilaltion: 3 (12%)	
	(Missing: 1)	(Missing: 2)	
Mechanism	Mountain=13, Water=11, Urban=13	Mountain=15, Water=5, Urban=6	0.207
Lactate	14.7±7.8 (Missing=11)	9.3±6.4 (Missing=13)	**0.039**
Potassium	3.9 [3.1-4.6] (Missing=7)	4.7 [3.5-6.5] (Missing=12)	0.166
CPC Outcome	CPC 1: 11 (41%)	CPC 1: 4 (17%)	0.185
	CPC 2: 4 (15%)	CPC 2: 2 (9%)	
	CPC 3: 1 (4%)	CPC 3: 2 (9%)	
	CPC 4: 0 (0%)	CPC 4: 2 (9%)	

	CPC 5: 11 (41%)	CPC 5: 13 (57%)	
	(Missing: 10/37)	(Missing: 3/26)	
Defibrillation Success (Pre- and in hospital)	22/37 (59%)	0/26 (0%)	—

Table S1. Comparison of the main characteristics of the included and excluded patients.

Variable	N Available	N Missing	% Missing
Age	37	0	0%
Sex	37	0	0%
Mechanism (Mountain/Water/Urban)	37	0	0%
Lactate (mmol/L)	26	11	29.7%
Potassium (mmol/L)	30	7	18.9%

Initial rhythm	26	11	29.7%
CPC at ICU discharge	27	10	27%
Witnessed CA	29	8	21.6%
Defibrillation success	37	0	0%
Pre-hospital temperature	37	0	0%
Temperature at defibrillation	37	0	0%
Resuscitation Variables			
CPR duration (min)	26	11	29.7%
Shocks given (n)	31	6	16.2%
ECLS rewarming	34	3	8.1%
Epinephrine use	37	0	0%

HOPE score	21	16	43.2%
pH	26	11	29.7%
Asphyxia	35	2	5.4%

Table S2. Numer of missings of the studied variables.

Declaration of interest

None

Conflicts of Interest Statement

All authors declare to have no conflicts of interest.