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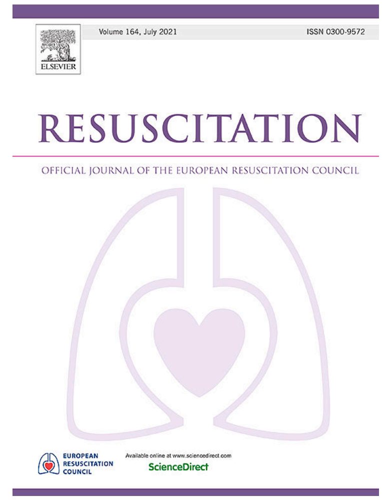

Original paper

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Impact of rhythm changes during CPR on ECPR outcomes: an ELSO Registry Study

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Highlights:

1. Both initial and cannulation rhythms were associated with survival after ECPR.
2. Conversion to ventricular fibrillation improves, while asystole worsens outcomes.
3. Survival decline with longer CPR differs by rhythm, supporting rhythm-based ECPR triage.

Abstract

Background: Cardiac rhythm is a well-established prognostic factor in patients undergoing extracorporeal cardiopulmonary resuscitation (ECPR); however, existing evidence is primarily limited to small, single-center studies. This study aimed to evaluate the prognostic value of both initial rhythm and rhythm at the time of cannulation using data from the international Extracorporeal Life Support Organization (ELSO) Registry.

Methods: We analyzed adult ECPR cases (≥18 years) recorded in the ELSO Registry between 2020 and 2025. The primary outcome was survival to hospital discharge. Multivariable logistic regression was used to assess associations between survival and cardiac rhythm (initial and at cannulation), adjusting for age, sex, witnessed arrest, arrest location, and CPR duration.

Results: Among 5,489 adult ECPR cases, 3,382 were included in the complete case analysis. Median age was 57.1 years (IQR 45.7–65.5), 29.1% were female, and median CPR duration was 44 minutes (IQR 28–61). Survival proportions were highest in patients with persistent ventricular fibrillation (VF) or conversion from an initial non-shockable rhythm to VF, and lowest in those who either converted to or remained in non-shockable rhythm. In multivariable analysis, initial pulseless electrical activity (PEA) (OR 0.59, 95% CI 0.48–0.71) and asystole (OR 0.64, 95% CI 0.47–0.86) were associated with lower odds of survival compared to initial VF. Asystole at the time of cannulation was associated with worse outcomes (OR 0.61, 95% CI 0.38–0.99). The survival decline with prolonged CPR was steepest in those with asystole at cannulation (OR for 60 vs 40 minutes of CPR = 0.64; CI 0.54–0.76; $p<0.001$) and most gradual in patients with VF at cannulation (OR for 60 vs 40 minutes of CPR = 0.84; CI 0.76–0.93; $p=0.001$).

Conclusions: In this large, multicenter analysis, both initial and cannulation rhythms were independently associated with survival among ECPR recipients. Survival showed time-dependent variation across rhythm conversions. These specific survival patterns underscore the need for individualized, rhythm-informed ECPR decision-making algorithms to optimize patient outcomes.

Key words: Extracorporeal cardiopulmonary resuscitation, ECPR, Cardiac arrest rhythm, Extracorporeal membrane oxygenation, ECMO, ELSO Registry.

Main text

Background

Extracorporeal cardiopulmonary resuscitation (ECPR), defined as the rapid initiation of venoarterial extracorporeal membrane oxygenation (VA ECMO) in patients without sustained return of spontaneous circulation (ROSC) despite conventional cardiopulmonary resuscitation (CPR), offers a potentially life-saving option for selected individuals.[1-3] However, identifying suitable candidates during ongoing CPR remains challenging due to limited time and the absence of reliable real-time predictors.[3-4]

Patient selection for ECPR varies widely across institutions and guidelines, reflecting ongoing uncertainty and limited evidence to support uniform inclusion criteria.[5-8] Among established prognostic indicators, initial cardiac rhythm, particularly the presence of a shockable rhythm, is consistently associated with improved survival in both conventional CPR and ECPR settings.[4,9] Moreover, emerging observational data suggest that rhythm conversion during CPR, especially from shockable to non-shockable rhythms, is associated with worse outcomes.[10-11]

Despite this, few studies have systematically evaluated cardiac rhythm at the time of ECPR cannulation, a clinically relevant and potentially modifiable factor during decision-making. Most available data are derived from small, single-center cohorts, which are limited by small to modest sample sizes and potential residual confounding.[12-16] Furthermore, most existing studies focus on out-of-hospital cardiac arrest (OHCA), with limited evidence addressing in-hospital cardiac arrest (IHCA) populations, who may differ substantially in baseline characteristics, response time, and outcomes.

To address these gaps, we analyzed data from the Extracorporeal Life Support Organization (ELSO) Registry, the largest international, multicenter database of ECMO-treated patients, including those who received ECPR.[17] This study aimed to assess the prognostic relevance of both initial rhythm and rhythm at the time of cannulation, drawing on the registry's global coverage, substantial statistical power, and inclusion of both OHCA and IHCA populations. By analyzing rhythm evolution, its prognostic implications, and its time-dependent relationship with survival, we sought to generate evidence that may support progress toward more standardized approaches in ECPR patient selection and management.

Methods

Study design

Data were extracted from the ELSO Registry, an international, multicenter database.[17] Registry entries are submitted voluntarily by participating centers and include standardized data on patient demographics, clinical characteristics, ECMO management, and outcomes. All data are recorded using a uniform electronic case report form by trained and certified site personnel. This study was approved by the ELSO Scientific Oversight Committee following external peer review (ELSO request #2917). It was also approved by the local Ethics Committee of the General University Hospital in Prague (0078/25). Informed consent was waived, as the ELSO dataset contains only de-identified information.

Study population and data acquisition

This study included adult patients (≥18 years) who received ECPR between 2020 and 2025. The study period was restricted to 2020 onward to ensure inclusion of cases documented using the updated "ECPR 2020 Addendum" data form (publicly available at https://www.elso.org/registry/datadefinitions,forms,instructions.aspx), which includes detailed information on cardiac rhythm at the time of ECMO cannulation. ECPR was defined as the rapid deployment of VA ECMO to provide circulatory support in patients for whom conventional cardiopulmonary resuscitation (CPR) failed to achieve sustained return of spontaneous circulation (ROSC). Sustained ROSC is deemed to have occurred when chest compressions are not required for 20 consecutive minutes and signs of circulation persist.[18] Data were extracted for all eligible patients including baseline demographics, resuscitation characteristics, ECPR-specific clinical data, and outcomes. Patients with multiple ECMO runs and patients supported with VP, VV ECMO as their initial mode of support were excluded. Most included cases underwent femoral–femoral VA-ECMO cannulation but alternative arterial cannulation approaches (aortic, subclavian, or axillary access) were retained in the analysis. Additionally, patients with unknown total CPR duration, unknown initial rhythm, or unknown rhythm at cannulation were excluded from the complete case analysis because these variables were essential for the multivariable analysis. Finally, we excluded all patients with an organized rhythm at cannulation to avoid including cases with possible ROSC who may have been cannulated for hemodynamic instability rather than refractory cardiac arrest

Outcomes

The primary outcome was survival to hospital discharge.

Statistical Analysis

Continuous variables were summarized using medians and interquartile ranges (IQR, 25th–75th percentiles), while categorical variables were reported as counts and percentages. Comparisons of continuous variables across groups and subgroups were performed using Welch's t-test, or Mann–Whitney U-test, as appropriate. Categorical variables were compared using the chi-squared test. The primary analysis was conducted as a complete-case analysis, excluding patients with missing data on essential covariates. To address potential bias due to missing data, a secondary analysis with a multiple imputation approach was performed using Multivariate Imputation by Chained Equations (MICE) in R for key variables (initial rhythm, sex, and total CPR duration).[19] We did not impute rhythm at cannulation despite its missingness because patients with organized rhythm at cannulation were excluded a priori from the analytic cohort. Imputing this variable would have required generating organized rhythms for patients who, by design, should not be included, thereby introducing misclassification. A multivariable logistic regression model was used to evaluate associations between variables (including age (per year), sex (male vs. female), witnessed status (yes vs. no), place of cardiac arrest (IHCA, OHCA-home, OHCA-public, OHCA-other), total CPR time (per minute), initial rhythm (VF/pVT, PEA, asystole), and rhythm at cannulation (VF/pVT, PEA, asystole) and the primary outcome, defined as survival to hospital discharge. Detailed definitions of variables of ELSO ECPR addendum are publicly available at https://www.elso.org/registry/datadefinitions,forms,instructions.aspx. Primary complete case model robustness and temporal consistency were evaluated via cross-validation, treating each calendar year from 2020 to 2025 as a separate fold. The significance of individual coefficients was assessed using Wald tests. In addition, the overall contribution of total CPR time was evaluated using a likelihood ratio test. Moreover, to visualize time-dependent associations between total CPR duration and survival across different rhythm at the time of cannulation, we plotted mean survival probabilities with 95% pointwise confidence intervals (Figure 2A-C).

CPR duration was modelled using a quadratic term to account for non-linearity, and an interaction term between CPR duration and rhythm at cannulation was included to evaluate rhythm-specific time-dependent effects. This parametrisation was selected based on cross-validated model performance and the observed non-linear associations. Additional subgroup analyses were performed for out-of-hospital cardiac arrest (OHCA) and in-hospital cardiac arrest (IHCA) cohorts. All statistical analyses were performed using R statistical software (version 4.2.3).[20]

Results

Baseline and resuscitation characteristics

Between 2020 and 2025, a total of 5,489 adult (≥18 years) ECPR cases with ECPR addendum were recorded in the ELSO Registry, of which 3,382 (61.6%) were included in the complete case analysis (Figure 1A). Although most cannulations were femoral–femoral, the final dataset also contained 232 patients (6.9%) who underwent alternative cannulation approaches, including aortic, subclavian, or axillary artery access. Details of exclusions are shown in Figure 1A.

Baseline characteristics stratified by initial rhythm are presented in Table 1. Patients with an initial rhythm of ventricular fibrillation/pulseless ventricular tachycardia (VF/pVT) or pulseless electrical activity (PEA) were older compared to those with asystole. Male sex was more common among patients with initial VF/pVT than among those with PEA or asystole. In 50.1% of VF/pVT cases cardiac arrest occurred in-hospital (IHCA), whereas higher proportions of IHCA were observed among patients with non-shockable rhythms PEA (79.9%) and asystole (69.7%) (Table 1). Total CPR duration differed substantially between IHCA and OHCA subgroups, with shorter durations in IHCA (median 35 minutes) compared with OHCA (60 minutes), consistent with findings from prior ECPR trials (Supplementary Table 2).[1-2]

Conversion between initial rhythm and rhythm at cannulation

Rhythm conversion patterns for all patients are illustrated in Figure 1A. Among patients with initial VF/pVT, 56.4% remained in VF/pVT, 30.4% converted to PEA, and 13.2% to asystole. Among those with initial PEA, 73.1% remained in PEA, while 15.7% converted to VF/pVT and 11.2% to asystole. In the initial asystole group, 62.2% remained in asystole, 21.9% converted to PEA, and 15.8% to VF/pVT.

Survival to hospital discharge

Among patients with initial VF/pVT, overall survival to discharge was 32.9%, highest in those with sustained VF/pVT (40.1%), followed by those who converted to PEA (28.1%) and lowest in those who converted to asystole (13.6%) (Figure 1A). In the PEA group, overall survival was 23.8%, with highest rates in those who converted to VF/pVT (32.7%), followed by those with sustained PEA (23.7%) and conversion to asystole (12.1%). Among patients with initial asystole, the overall survival rate was 19.5%, with survival of 28.6% for those who converted to VF/pVT, 17.5% for conversion to PEA, and 17.8% for sustained asystole (Figure 1A).

Multivariable logistic regression of survival to discharge

Multivariable logistic regression results for all patients are summarized in Table 2. Compared to initial VF/pVT, both initial PEA (OR 0.59, 95% CI 0.48–0.71, $p<0.001$) and initial asystole

(OR 0.64, 95% CI 0.47–0.86, p=0.003) were associated with significantly lower odds of survival. Asystole at the time of cannulation was similarly associated with significantly worse outcomes compared to VF/pVT (OR 0.61, 95% CI 0.38–0.99, p=0.044), while we did not detect an association between PEA at cannulation and survival (OR 0.76, 95% CI 0.54–1.07, p=0.112).

CPR duration showed a strong and independent association with survival (p<0.001), with a rhythm-specific, time-dependent effect (Figure 2A–C). The decline in survival with increasing CPR duration was steepest in patients converting to asystole (OR between 40min vs 20min CPR = 0.58; CI 0.48-0.70; p<0.001; OR between 60min vs 40min CPR = 0.64; CI 0.54-0.76; p<0.001), followed by those with PEA (OR 40 vs 20 min CPR = 0.72, CI 0.64-0.80; p<0.001, OR between 60min vs 40min CPR = 0.79; CI 0.71-0.86, p<0.001). The decline was most gradual in those with pVT/VF (OR between 40 vs 20 min CPR = 0.77; CI 0.68-0.86, p<0.001; OR between 60 vs 40 min CPR = 0.84; CI 0.76- 0.93, p=0.001).

Other variables independently associated with lower survival were increasing age (OR per year = 0.99, 95% CI 0.98–0.99, p<0.001) and cardiac arrest occurring at home (OR 0.48, 95% CI 0.36–0.63, p<0.001), Table 2. Neither sex nor witnessed status was significantly associated with survival.

Multiple imputation model

The imputed model produced results that were consistent with the complete-case analysis (Supplementary Table 1), supporting the robustness of the identified variables. The negative association of initial and cannulation rhythms, prolonged CPR duration, and cardiac arrest occurring at home with survival remained significant after imputation. The only notable difference was a more pronounced effect of public location of OHCA in the imputed model (Supplementary Table 1).

OHCA and IHCA subgroup analyses

Baseline characteristics for OHCA and IHCA subgroups are provided in Supplementary Table 2. Compared with OHCA, the IHCA cohort was older, had a lower proportion of males, shorter CPR durations, more frequent witnessed arrests, and fewer defibrillation attempts.

Rhythm conversion patterns are shown in Figures 1B (IHCA) and 1C (OHCA). Initial PEA was more common in IHCA, while VF/pVT predominated in OHCA. Among patients with initial VF/pVT, IHCA cases were more likely to sustain VF/pVT (65% vs. 47.5%) and had lower rates of conversion to PEA (23.7% vs. 37.2%) or asystole (11.3% vs. 15.3%), (p<0.001). Across all rhythm transitions, survival rates were higher in IHCA than OHCA. Notably, OHCA patients with a non-shockable rhythm conversion had worse outcomes, especially in the subgroup PEA to asystole (Figure 1C).

Discussion

This study represents the largest multicenter analysis to date examining the association between cardiac rhythm, rhythm conversion, and survival in patients treated with ECPR. It incorporates both OHCA and IHCA populations and yields several clinically relevant insights.

Initial rhythm and rhythm at cannulation are strongly associated with outcomes

Our findings demonstrate that initial VF/pVT is associated with the highest survival, and that conversion from a non-shockable rhythm to VF/pVT is associated with higher survival compared to continued non-shockable rhythm. In contrast, persistence in or conversion to asystole is associated with the lowest survival, particularly among OHCA patients. These results highlight the prognostic importance of pre-cannulation rhythm evolution, which likely reflects the underlying pathophysiology and quality of resuscitation efforts. By including large cohorts of both non-shockable rhythms and IHCA patients, our study provides robust, multicenter validation of the prognostic relevance of rhythm conversion, confirming and extending prior observations from smaller studies.[9-16]

Our findings may offer several rhythm-specific implications for ECPR candidacy. First, patients presenting with initial VF/pVT demonstrated the highest survival across the cohort. Therefore, initial VF/pVT should remain a strong consideration for ECPR, even when subsequent rhythm deterioration occurs.

Second, patients with initial PEA who converted to VF/pVT had unexpectedly favorable survival (32.7% overall; 21.9% in OHCA). These results support considering ECPR for PEA → VF/pVT conversions, particularly when conversion occurs early and aligns with other favorable arrest characteristics.

Third, among patients with sustained non-shockable rhythms, survival varied markedly by pattern. PEA → sustained PEA showed 23.7% overall survival, indicating that selected patients with persistent PEA may still have reasonable outcomes, especially when cannulation occurs early. In contrast, the prognosis of PEA → asystole appeared strongly context-dependent: survival reached 15.8% in IHCA but was 0% in OHCA, suggesting that this conversion pattern may remain reasonable for consideration in controlled in-hospital settings but less so in the prehospital environment.

Finally, although asystole at presentation was generally associated with poor prognosis, a subset of patients (asystole → VF/pVT) demonstrated appreciable survival especially in IHCA.

Together, these findings underscore that dynamic rhythm trajectories offer more prognostic information than static rhythm assessment alone. Incorporating rhythm-conversion patterns may help refine ECPR decision-making beyond the current shockable/non-shockable paradigm, although these observations should be interpreted cautiously as hypothesis-generating given the observational design and absence of a non-cannulated comparator group.

Multivariable modeling demonstrated associations between initial PEA, asystole, cannulation asystole, and lower survival.

After adjusting for key confounders, both initial asystole and initial PEA were independently associated with significantly lower odds of survival compared to initial VF. Similarly, asystole at the time of ECPR cannulation was associated with worse outcomes, while we did not detect an association for PEA at cannulation, suggesting greater prognostic heterogeneity within this group. These findings validate previous studies and support incorporating real-time rhythm data into ECPR selection algorithms.[12,13]

A time-dependent effect of CPR duration on survival varies substantially by rhythm at cannulation.

A time-dependent effect of CPR duration on survival varies substantially by rhythm at cannulation. Our data provide the first evidence in an ECPR cohort of a rhythm-specific association between increasing CPR duration and declining survival. Patients with VF at cannulation exhibited the most gradual decline in survival with prolonged CPR, whereas outcomes for conversions to PEA and especially to asystole deteriorated sharply over time. This pattern supports the hypothesis that each rhythm interacts differently with low-flow duration, likely reflecting variations in perfusion quality, metabolic status, and reversibility of the underlying cause.[12,13] These observations parallel findings in conventional CPR, where time-sensitive and rhythm-dependent survival patterns have been described, although such interactions have not previously been evaluated in ECPR.[21]

The relevance of low-flow duration is further supported by prior OHCA ECPR studies and emerging IHCA ECPR data from Minnesota, all demonstrating steep survival declines with increasing time to cannulation.[22–24] Our results suggest that the optimal time window for ECPR candidacy may differ by rhythm: patients with non-shockable rhythms may require particularly rapid cannulation to achieve meaningful survival, whereas those with persistent VF or conversion to VF may preserve viability over a longer period. If confirmed in prospective studies, this concept could inform real-time decision algorithms and rhythm-adapted ECPR inclusion criteria.

IHCA versus OHCA differences

This is the first study to directly compare IHCA and OHCA populations in terms of rhythm conversions and associated survival outcomes in ECPR. IHCA patients were more likely to present with PEA, sustain VF/pVT, and had generally higher survival across all rhythm categories. These differences likely reflect more controlled environments, faster response times, including shorter time to ECPR among IHCA. In contrast, OHCA patients with non-shockable rhythms and delayed cannulation exhibited worse outcomes, highlighting the need for rapid decision-making and rhythm-based triage in prehospital ECPR systems and confirming results of previous studies showing worse outcomes in OHCA patients with persistent non-shockable rhythms.[12-13]

Limitations

This study is observational and registry-based, which inherently introduces potential limitations, including residual confounding, selection bias, and incomplete data capture. Although we applied robust multivariable modeling and multiple imputation to address missingness and confounding, the absence of variables (such as no-flow time and time to EMS arrival) may have influenced outcomes and limits external validity. Although time to cannulation was available, the registry does not capture no-flow duration as a separate variable, precluding assessment of these intervals independently. In addition, physiologic parameters (PaO_2, lactate etc.) were not included in the multivariable model as there is no pre-defined pre-ECPR measurement in ELSO registry. Further, the dataset did not include information on center case volume, which is a potentially important determinant of ECPR outcomes. Given the pragmatic, observational nature of the ELSO Registry, this study cannot establish causal relationships between rhythm patterns and survival; therefore, the findings should be interpreted as associations rather than evidence of causation. Prospective, standardized clinical studies including randomized and time-targeted ECPR trials are needed to validate these rhythm-specific differences and clarify their implications for clinical decision-making.

A major limitation is the lack of neurological outcome data, which prevents direct assessment of functional recovery as clinically the most important and meaningful endpoint. Survival with good neurological outcome will be lower than crude survival reported in this analysis. However, prior studies indicate a correlation between survival and favorable neurological outcomes in ECPR patients, and non-shockable rhythms have been associated with poorer neurological prognosis.[12–13] Based on these data, we hypothesize that rhythm-based differences in outcomes may extend to neurological prognosis as well, but this requires confirmation in future studies. Another important limitation is that we assessed only survival to hospital discharge. We did not have access to long-term follow-up data, which may reveal a substantial decrease in survival, particularly among patients with non-shockable rhythms who are at higher risk for delayed mortality due to severe neurological injury or multiorgan dysfunction.

Finally, this study focused on initial and cannulation rhythms without information about the timing of rhythm conversions or the occurrence of multiple rhythm transitions during CPR. The lack of detailed rhythm transition dynamics may limit the granularity of patient stratification.

Conclusions

In this large, multicenter analysis, both initial and cannulation rhythms were independently associated with survival among ECPR recipients. Conversion to a shockable rhythm showed higher survival proportions than persistence in non-shockable rhythms, whereas persistence in or conversion to asystole showed the lowest survival proportions. Survival declined in a rhythm-specific, time-dependent manner with increasing CPR duration, underscoring the need for rhythm- and time-adapted ECPR decision pathways.

List of abbreviations

CI Confidence Interval

CPC Cerebral Performance Category

CPR Cardiopulmonary Resuscitation

ECLS Extracorporeal Life Support

ECPR Extracorporeal Cardiopulmonary Resuscitation

ELSO Extracorporeal Life Support Organization

IHCA In-Hospital Cardiac Arrest

IQR Interquartile Range

OHCA Out-of-Hospital Cardiac Arrest

OR Odds Ratio

PEA Pulseless Electrical Activity

ROSC Return of Spontaneous Circulation

VF Ventricular Fibrillation

pVT Pulseless Ventricular Tachycardia

VA ECMO Veno-Arterial Extracorporeal Membrane Oxygenation

Declarations

Ethics approval and consent to participate

Informed consent was waived, as the ELSO dataset contains only de-identified information. The study was approved by the local Ethics Committee of the General University Hospital in Prague (0078/25).

Consent for publication

This study was approved by the ELSO Scientific Oversight Committee following external peer review (ELSO request #2917).

Availability of data and materials

The data that support the findings of this study are available from ELSO, upon request, to ELSO members.

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Figure Legends

Figure 1 A, B, C. Patient flow chart and rhythm conversion patterns for all patients (A), the IHCA subgroup (B), and the OHCA subgroup (C) in the complete-case analysis. Unadjusted differences in survival proportions were evaluated across rhythm-conversion categories (initial VF conversions, initial PEA conversions, and initial asystole conversions), and the results (p-values) are presented at the bottom of the figure.

Abbreviations: CPR cardiopulmonary resuscitation, ECPR extracorporeal cardiopulmonary resuscitation, IHCA in-hospital cardiac arrest, OHCA out-of-hospital cardiac arrest, PEA pulseless electrical activity, VF ventricular fibrillation, pVT pulseless ventricular tachycardia.

Figure 2 A-C. Mean survival probabilities over the total CPR duration (for a patient with a mean age of 55 years) are shown with 95% pointwise confidence intervals for: A) initial VF/pVT, B) initial PEA, and C) initial asystole with subsequent rhythm conversion (to VF/pVT, PEA, or asystole). All panels (A–C) demonstrate a time-dependent effect that varied by rhythm. The steepest decline in survival was observed in patients who converted to asystole, followed by those with PEA, while the slowest decline was seen in patients with VF.

Abbreviations: CPR cardiopulmonary resuscitation, ECPR extracorporeal cardiopulmonary resuscitation, PEA pulseless electrical activity, VF ventricular fibrillation.

Tables Legends

Table 1. Baseline demographics and resuscitation characteristics by initial rhythm for complete case analysis.

Table 2. Multivariable logistic regression analysis of survival to hospital discharge for complete case analysis.

Supplementary Table 1. Multivariable logistic regression analysis of survival to hospital discharge for imputed analysis and mean survival probabilities across total CPR duration for imputed analysis.

Supplementary Table 2. Baseline demographics and resuscitation characteristics for IHCA and OHCA subgroups for complete case analysis.

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Table 1. Baseline demographics and resuscitation characteristics by initial rhythm for complete case analysis.

	Initial VF (n=1611)	**Initial PEA (n=1329)**	**Initial Asystole (n=442)**	**P value**
Age, median (IQR), years	57 (47-65)	58 (45-67)	54 (42-65)	0.001
Sex (men)	1261 (78.3%)	842 (63.4%)	295 (66.7%)	<0.001
Location of cardiac arrest				
IHCA	818 (50.8%)	1063 (79.9%)	308 (69.7%)	<0.001
OHCA - Home	359 (22.3%)	100 (7.5%)	60 (13.6%)	
OHCA - Public	345 (21.4%)	84 (6.3%)	52 (11.8%)	
OHCA - Other	89 (5.5%)	82 (6.2%)	22 (4.9%)	
Rhythm at time of cannulation				
VF	909 (56.4%)	208 (15.7%)	70 (15.8%)	<0.001
PEA	489 (30.4%)	972 (73.1%)	97 (21.9%)	

Asystole	213 (13.2%)	149 (11.2%)	275 (62.2%)	
Witnessed arrest	1458 (90.5%)	1269 (95.5%)	392 (88.7%)	<0.001
Total CPR time (median, IQR, min)	47 (30-65)	38 (25-55)	40 (26-59)	<0.001
Adrenaline (mg), median (IQR)	5 (3-9)	6 (4-10)	7 (4-10)	< 0.001
Number of defibrillations prehospitally, median (IQR)	4 (3-8)	0 (0-2)	0 (0-2)	< 0.001

Abbreviations: CPR: cardiopulmonary resuscitation, IHCA: in-hospital cardiac arrest, IQR: interquartile range, OHCA: out-of-hospital cardiac arrest, PEA: pulseless electrical activity, VF: ventricle fibrillation, VT: ventricle tachycardia.

Table 2. Multivariable logistic regression analysis of survival to hospital discharge for complete case analysis.

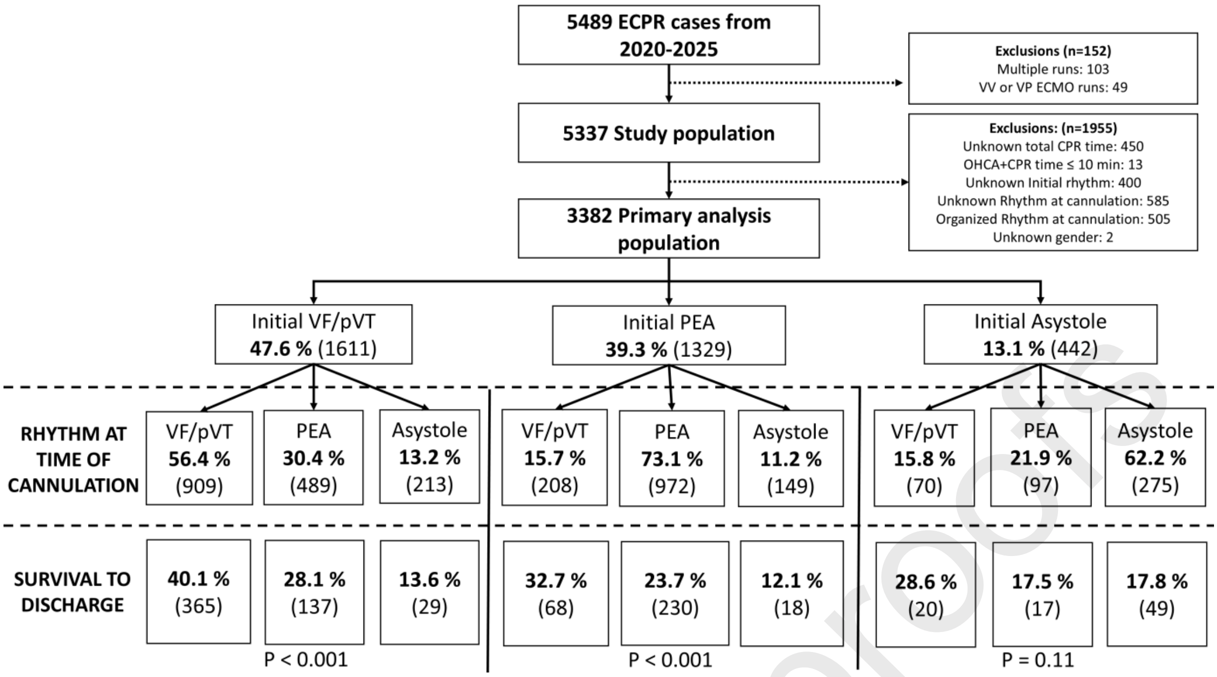
Factor	Odds Ratio	95 Confidence interval	P value
Age (+ 1 year)	0.99	(0.98; 0.99)	<0.001
Gender (male)	0.94	(0.79; 1.12)	0.479
Witnessed status (yes)	1.24	(0.89; 1.75)	0.221
Place of arrest (vs. IHCA)			
- OHCA-home	0.48	(0.36; 0.63)	<0.001

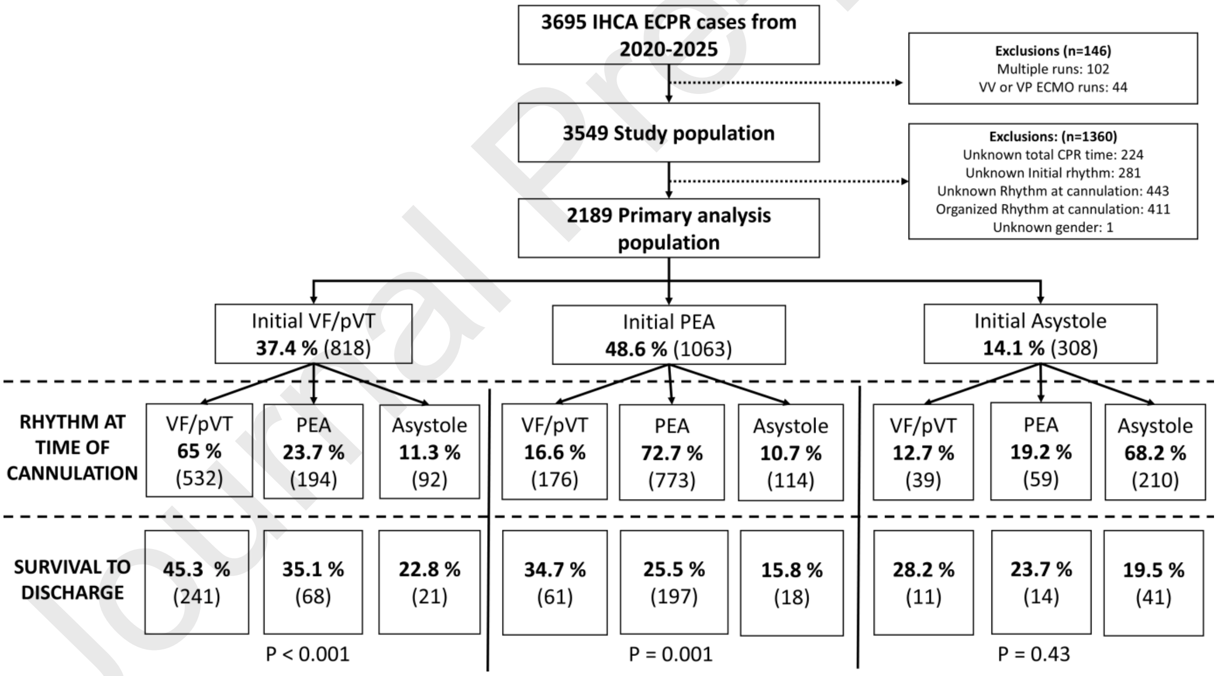
- OHCA-public	0.77	(0.59; 1.00)	0.052
- OHCA other *	1.07	(0.75; 1.51)	0.707
Initial Rhythm (vs. VF/VT)			
- PEA	0.59	(0.48; 0.71)	<0.001
- Asystole	0.64	(0.47; 0.86)	0.003
Rhythm at cannulation (vs. VF/VT)			
- PEA	0.76	(0.54; 1.07)	0.112
- Asystole	0.61	(0.38; 0.99)	0.044
Total CPR time	Figure 2**	Figure 2**	<0.001

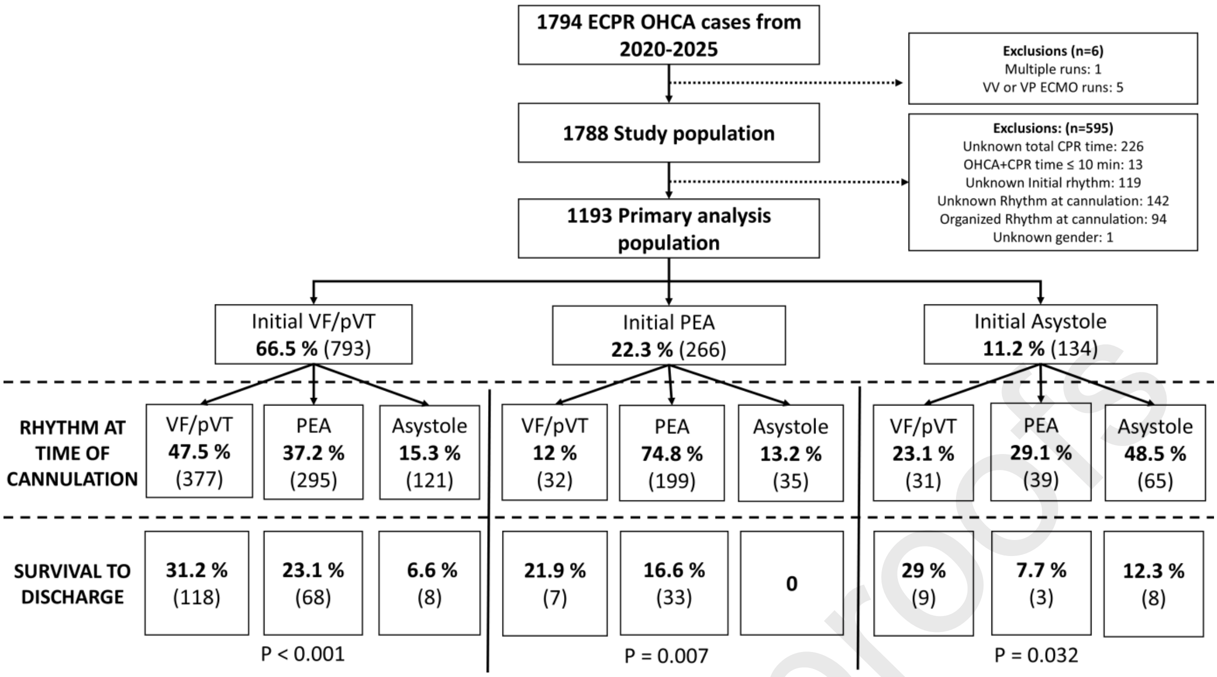
* Ambulance transport/Ambulatory Medical Care/Other unspecified.

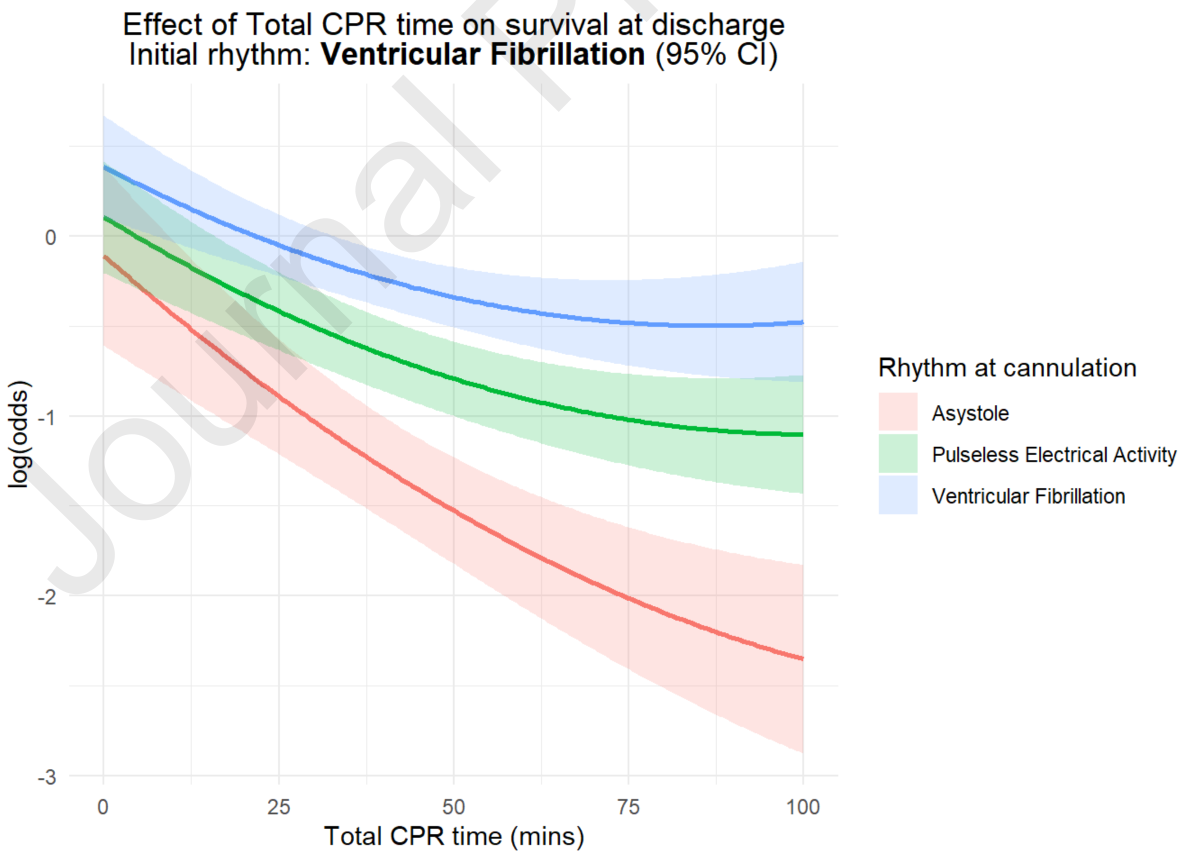
** The influence of CPR time on survival of discharge is presented in Figure 2 and is different for each time period and rhythm at time of cannulation.

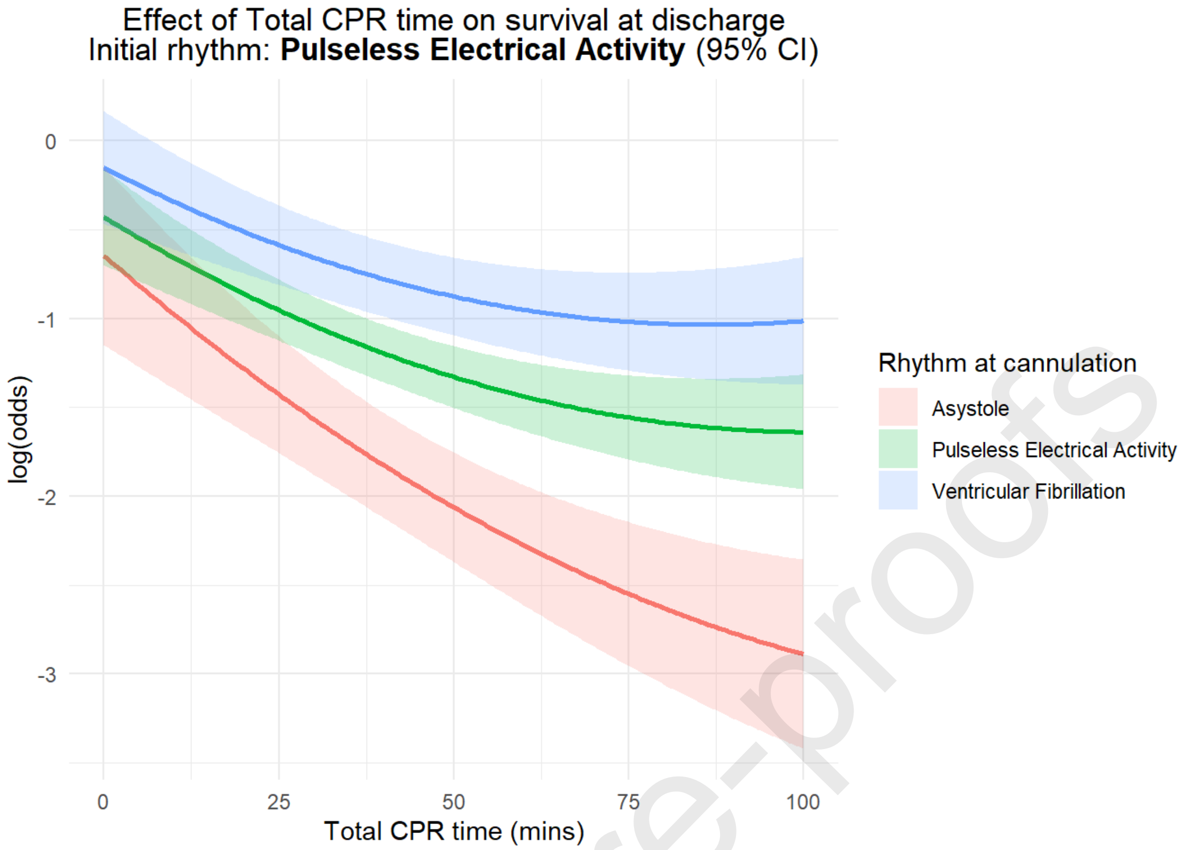
Abbreviations: CPR: cardiopulmonary resuscitation, IHCA: in-hospital cardiac arrest, IQR: interquartile range, OHCA: out-of-hospital cardiac arrest, PEA: pulseless electrical activity, VF: ventricle fibrillation, VT: ventricle tachycardia.

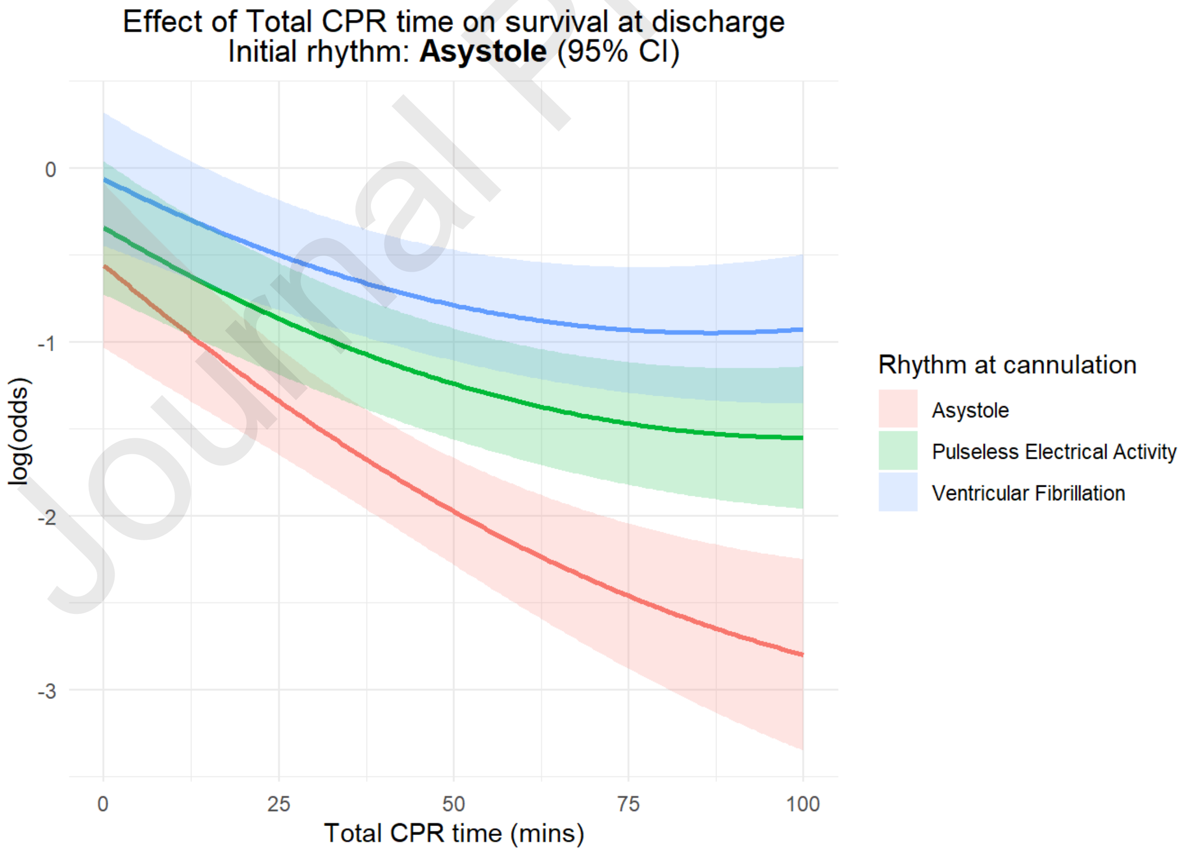

5489 ECPR cases from 2020-2025
Exclusions (n=152)
Multiple runs: 103
VV or VP ECMO runs: 49
5337 Study population
Exclusions: (n=1955)
Unknown total CPR time: 450
OHCA+CPR time ≤ 10 min: 13
Unknown Initial rhythm: 400
Unknown Rhythm at cannulation: 585
Organized Rhythm at cannulation: 505
Unknown gender: 2
3382 Primary analysis population
Initial VF/pVT 47.6 % (1611)
Initial PEA 39.3 % (1329)
Initial Asystole 13.1 % (442)
RHYTHM AT TIME OF CANNULATION
VF/pVT 56.4 % (909)
PEA 30.4 % (489)
Asystole 13.2 % (213)
VF/pVT 15.7 % (208)
PEA 73.1 % (972)
Asystole 11.2 % (149)
VF/pVT 15.8 % (70)
PEA 21.9 % (97)
Asystole 62.2 % (275)
SURVIVAL TO DISCHARGE
40.1 % (365)
28.1 % (137)
13.6 % (29)
32.7 % (68)
23.7 % (230)
12.1 % (18)
28.6 % (20)
17.5 % (17)
17.8 % (49)
P < 0.001
P < 0.001
P = 0.11


3695 IHCA ECPR cases from 2020-2025
Exclusions (n=146)
Multiple runs: 102
VV or VP ECMO runs: 44
3549 Study population
Exclusions: (n=1360)
Unknown total CPR time: 224
Unknown Initial rhythm: 281
Unknown Rhythm at cannulation: 443
Organized Rhythm at cannulation: 411
Unknown gender: 1
2189 Primary analysis population
Initial VF/pVT 37.4 % (818)
Initial PEA 48.6 % (1063)
Initial Asystole 14.1 % (308)
RHYTHM AT TIME OF CANNULATION
VF/pVT 65 % (532)
PEA 23.7 % (194)
Asystole 11.3 % (92)
VF/pVT 16.6 % (176)
PEA 72.7 % (773)
Asystole 10.7 % (114)
VF/pVT 12.7 % (39)
PEA 19.2 % (59)
Asystole 68.2 % (210)
SURVIVAL TO DISCHARGE
45.3 % (241)
35.1 % (68)
22.8 % (21)
34.7 % (61)
25.5 % (197)
15.8 % (18)
28.2 % (11)
23.7 % (14)
19.5 % (41)
P < 0.001
P = 0.001
P = 0.43


1794 ECPR OHCA cases from 2020-2025
Exclusions (n=6)
Multiple runs: 1
VV or VP ECMO runs: 5
1788 Study population
Exclusions: (n=595)
Unknown total CPR time: 226
OHCA+CPR time ≤ 10 min: 13
Unknown Initial rhythm: 119
Unknown Rhythm at cannulation: 142
Organized Rhythm at cannulation: 94
Unknown gender: 1
1193 Primary analysis population
Initial VF/pVT 66.5 % (793)
Initial PEA 22.3 % (266)
Initial Asystole 11.2 % (134)
RHYTHM AT TIME OF CANNULATION
VF/pVT 47.5 % (377)
PEA 37.2 % (295)
Asystole 15.3 % (121)
VF/pVT 12 % (32)
PEA 74.8 % (199)
Asystole 13.2 % (35)
VF/pVT 23.1 % (31)
PEA 29.1 % (39)
Asystole 48.5 % (65)
SURVIVAL TO DISCHARGE
31.2 % (118)
23.1 % (68)
6.6 % (8)
21.9 % (7)
16.6 % (33)
0
29 % (9)
7.7 % (3)
12.3 % (8)
P < 0.001
P = 0.007
P = 0.032


Effect of Total CPR time on survival at discharge
Initial rhythm: Ventricular Fibrillation (95% CI)
log(odds)
0
-1
-2
-3
0
25
50
75
100
Total CPR time (mins)
Rhythm at cannulation
Asystole
Pulseless Electrical Activity
Ventricular Fibrillation


Effect of Total CPR time on survival at discharge
Initial rhythm: **Pulseless Electrical Activity** (95% CI)
0
-1
-2
-3
log(odds)
0
25
50
75
100
Total CPR time (mins)
Rhythm at cannulation
Asystole
Pulseless Electrical Activity
Ventricular Fibrillation


Effect of Total CPR time on survival at discharge
Initial rhythm: **Asystole** (95% CI)
0
-1
-2
-3
log(odds)
0
25
50
75
100
Total CPR time (mins)
Rhythm at cannulation
Asystole
Pulseless Electrical Activity
Ventricular Fibrillation

Competing interests

The first author (DR) has received lecture honoraria from Abiomed. The corresponding author (JB) has received lecture honoraria from the Abiomed, Getinge, Xenios, Resuscitec, Novartis, Astra-Zeneca, Boehringer-Ingelheim. The remaining authors report no conflict of interest.

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