Critical Care

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Impact of ECPR initiation time and age on survival in out-of-hospital cardiac arrest patients: a nationwide observational study

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Introduction

Extracorporeal cardiopulmonary resuscitation (ECPR) is a critical rescue strategy for refractory out-of-hospital cardiac arrest (OHCA), but its success is highly dependent on patient selection and timely initiation [1]. Older age and prolonged extracorporeal membrane oxygenation (ECMO) initiation time are known to negatively affect outcomes [2, 3]. Guidelines recommend initiating ECMO within 60 min of cardiac arrest, and experts advocate for early consideration of ECPR [1]. Despite these recommendations, the upper time limit for ECPR effectiveness remains uncertain, particularly in older OHCA patients. This study aims to define the upper limit for ECPR initiation time and investigate how advanced age influences this threshold.

Methods

We conducted a retrospective cohort study using data from the nationwide Korean OHCA database from 2016 to 2021. The database systematically records consecutive adult OHCA cases attended by emergency medical services (EMS) following standardized Utstein guidelines. The study included 483 adult (≥ 18 years) patients who received ECPR for non-traumatic OHCA. ECPR initiation time was defined as the time from hospital arrival to ECMO pump-on time. The primary outcome was a survival-to-discharge rate. The Institutional Review Board of Asan Medical Center granted ethical approval with a waiver for informed consent (IRB No. 2023–0438).

Patients were stratified into two groups: elderly (age > 65 years, n = 104) and non-elderly (age ≤ 65 years, n = 379). We used multivariable logistic regression to assess the effects of age, ECPR initiation time, and their interaction on survival. Variables included in the multivariable model were selected based on clinical relevance and variance inflation factor < 10. Dynamic and cumulative survival proportions were used to identify time thresholds [4].

Results

Age distribution for elderly (> 65 years) and non-elderly (≤ 65 years) patients is presented in Supplementary Fig. 1. The median (interquartile range) age was 70.0 (68.0–74.0) years in the elderly group and 52.0 (44.0–60.0) years in the non-elderly group.

The overall survival-to-discharge rate was 18.2% (88 of 483 patients). After adjusting for confounding variables, both increasing age (adjusted OR: 0.97, 95% CI: 0.95–0.99, $P < 0.001$) and longer ECPR initiation time (adjusted OR: 0.97, 95% CI: 0.95–0.98, $P = 0.003$) were independently associated with decreased survival. A significant interaction was found between age and initiation time (adjusted OR: 0.999, 95% CI: 0.998–1.000, $P = 0.021$), indicating that treatment delays have a more pronounced negative effect on older patients (Supplemental eTable1).

Age-stratified analysis revealed significantly different time windows for effective treatment (Fig. 1). In elderly patients, the probability of survival dropped below 10% when ECPR initiation was delayed beyond 21 (0–33 min) minutes, and it fell below 1% after 40 min (33–42 min). In

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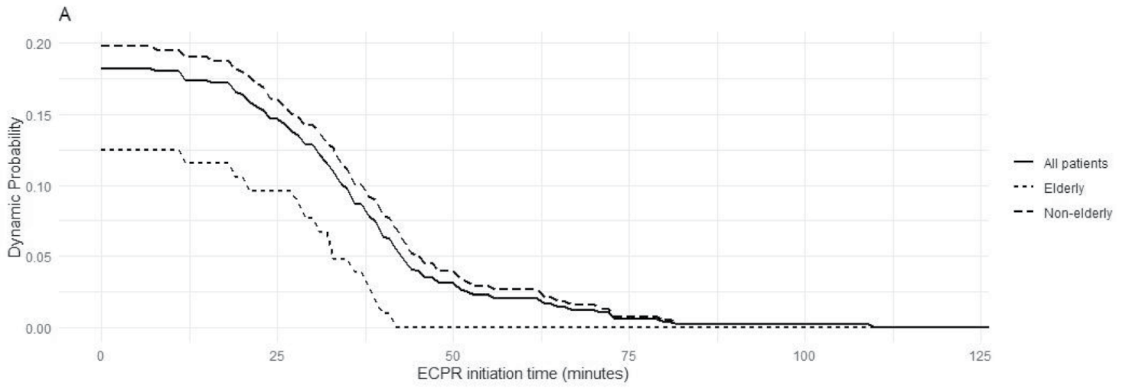

B.

	All (n=483)	Elderly (age>65) (n=104)	Non-elderly (age≤65) (n=379)	*P* value
Dynamic probability of survival at discharge				
<1%	73 (63 - 82) min	40 (33 - 42) min	73 (63 – 82) min	0.018
<10%	35 (29 - 39) min	21 (0 - 33) min	38 (32 - 42) min	0.013
Cumulative proportion of survival at discharge				
>90%	63 (48 - 73) min	40 (36 – 42) min	65 (51 -73) min	0.047
>99%	110 (73 -110) min	42 (38 - 42) min	110 (73-110) min	0.003

Fig. 1 Survival Probability and Discharge Outcomes in Relation to ECPR Initiation Time, Stratified by Age. **A** Dynamic survival probability curve by ECPR initiation time. **B** Dynamic probability and cumulative proportion of survival at discharge by ECPR initiation time, stratified by age group. Values are present as minutes (95% confidence interval)

contrast, non-elderly patients maintained a 10% survival probability for up to 38 min (32–42 min) and a 1% probability for up to 73 min (63–82 min) of initiation time. The ECPR time threshold difference between groups was statistically significant. The cumulative survival rate reached 90% after 40 min of CPR in elderly patients and 65 min in non-elderly patients.

Discussion

This study demonstrates that both ECPR initiation time and age are independent predictors of survival to discharge in OHCA patients. Elderly patients showed a markedly reduced survival probability when ECMO initiation was delayed beyond 21 min, whereas non-elderly patients maintained higher survival potential until much later time points. These findings emphasize the need for more rapid ECPR initiation in elderly individuals.

Consistent with previous literature, our results confirm the inverse relationship between ECPR initiation time and survival outcomes. While current guidelines recommend ECMO initiation within 60 min [1], our data suggest that this threshold may be too long for elderly patients. Notably, survival remained possible up to 110 min of CPR in non-elderly patients, but the effective therapeutic window was significantly shorter in the elderly. This age-dependent benefit underscores the importance of timely decision-making tailored to patient age.

ECPR initiation time may serve as a practical surrogate for low-flow duration, which is often difficult to quantify during resuscitation [3, 5]. As such, ECPR timing could represent a more feasible quality metric for clinical decision-making, reflecting team readiness and system efficiency. Given the sharp decline in survival beyond 20 min in the elderly, early ECPR activation—ideally within 20 min—should be considered in carefully selected candidates.

This study has limitations inherent to its retrospective design, including potential selection bias, limited information on CPR quality, and differences in post-resuscitation care. Additionally, generalizability may be restricted to other healthcare systems. Nonetheless, the large-scale, standardized registry data provide meaningful insights into age-specific timing strategies for ECPR implementation in OHCA.

In conclusion, the effective time window for ECPR is significantly shorter in elderly patients. To maximize the potential for survival in this group, clinical teams must make rapid decisions and mobilize for ECPR initiation almost immediately upon patient arrival, ideally within 20 min.

Abbreviations

ECPR	Extracorporeal cardiopulmonary resuscitation
ROSC	Return of spontaneous circulation
CPR	Cardiopulmonary resuscitation
ELSO	Extracorporeal Life Support Organization
ECMO	Extracorporeal membrane oxygenation
OHCA	Out-of-Hospital Cardiac Arrest
EMS	Emergency medical services

Supplementary Information

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Additional file 1.

Additional file 2.

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Not applicable.

Author contributions
D.K. conceived the study, developed the methodology, curated the data, performed formal analyses, led the investigation, and prepared the visualizations. H.L. curated the data and performed validation. H.P. contributed to data curation and investigation. Y.-J.K. contributed to investigation and provided resources. W.Y.K. contributed to conceptualization and methodology and supervised the study. D.K. drafted the manuscript, and H.L., H.P., Y.-J.K., and W.Y.K. reviewed and edited the manuscript. All authors approved the final manuscript.

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Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The KDCA approved the use of the data, and the Institutional Review Board of Asan Medical Center granted ethical approval with a waiver for informed consent (IRB No. 2023–0438).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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