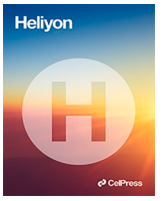
Heliyon 10 (2024) e24565

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Research article

Venoarterial extracorporeal membrane oxygenation for cardiopulmonary resuscitation: A retrospective study comparing the outcomes of fluoroscopy

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ARTICLE INFO

Keywords:
Cardiopulmonary resuscitation
Out-of-hospital cardiac arrest
Venoarterial extracorporeal membrane oxygenation
Fluoroscopy

ABSTRACT

Background: Extracorporeal cardiopulmonary resuscitation (ECPR) using venoarterial extracorporeal membrane oxygenation is performed for out-of-hospital cardiac arrest; however, it is associated with a risk of several complications.
Objective: To investigate whether the fluoroscopy equipment was removed from the emergency department (ED) and whether it would be beneficial to transport the patient to the fluoroscopy room to reduce vascular complications without affecting the induction time.
Methods: This single-center, retrospective, before-and-after analysis was conducted at a tertiary emergency medical center and included 59 patients who underwent ECPR for out-of-hospital cardiac arrest between May 2017 and March 2022. The patients were divided into two groups: those who underwent cannulation in the ED without fluoroscopy (ED-ECPR group) and those who were transferred directly from the ED to the cardiac angiography room (ECPR call group).
Results: The rate of vascular complications associated with ECPR was significantly lower in the ECPR group than in the ED-ECPR group (40.6 % [14/32] vs. 10 % [2/20], respectively; $p = 0.014$). The duration from ED arrival to venoarterial extracorporeal membrane oxygenation initiation was similar in the two groups (median: 23.0 min in the ED-ECPR group vs. 25.5 min in the ECPR call group, $p = 0.71$). Results adjusted for confounding factors showed that performing ECPR under fluoroscopy was a consistent and independent element of vascular complication rates (adjusted odds ratio: 9.92, 95 % confidence interval: 2.04 to 81.2, $p = 0.011$).
Conclusions: Fluoroscopy-guided ECPR can significantly reduce the incidence of vascular complications even if the ED and fluoroscopy room are far apart. However, no significant difference was observed in the time required to establish ECPR in the cardiac catheterization laboratories.

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https://doi.org/10.1016/j.heliyon.2024.e24565
Received 6 November 2023; Received in revised form 21 December 2023; Accepted 10 January 2024
Available online 17 January 2024

1. Introduction

Out-of-hospital cardiac arrest (OHCA) is a significant public health challenge, with approximately 120,000 OHCA events occurring in Japan [1]. Recently, extracorporeal cardiopulmonary resuscitation (ECPR) with venoarterial extracorporeal membrane oxygenation (VA-ECMO) has been used to treat refractory OHCA. While ECPR has shown promise in improving the rate of return of spontaneous circulation compared with that of conventional cardiopulmonary resuscitation (CPR), its impact on neurological prognosis remains a topic of debate [2–5].

The objective of ECPR is to enhance the blood flow and oxygen supply during cardiac arrest, thereby preventing irreversible organ damage and hypoxic brain injury. The femoral vein drainage cannula and femoral artery return cannula for VA-ECMO insertion are the most commonly used cannulas for cardiac arrest. However, this approach carries the risk of various complications, including vascular injury, incorrect insertion, bleeding, subsequent infection, and limb ischemia [6,7]. Vascular complications, including bleeding, hematoma, vascular injury, and cannulation failure, are the most common complications of ECPR implementation [8–11]. Previous studies have shown that the survival-to-discharge rates for patients on ECMO are 18 % and 49 % with and without vascular complications, respectively [12].

Efforts to achieve safer and more efficient introduction of VA-ECMO for cardiopulmonary arrest have led to the exploration of fluoroscopic facilities in emergency rooms (hybrid ER) for ECPR [13–15]. Nevertheless, not all facilities have immediate access to fluoroscopic equipment, which may necessitate catheterization under non-fluoroscopic conditions during ECPR [16].

The importance of conducting ECPR in the fluoroscopy room rather than in the emergency department (ED) for improving safety and efficiency is poorly understood. Moreover, few studies have investigated whether the time spent in the fluoroscopy room affects the overall duration of ECPR and patient outcomes.

At our hospital, without a fluoroscopy system in the ED and with the cardiac catheterization laboratory located at a distance from the ED, we initially introduced VA-ECMO without fluoroscopy in the ED. However, this approach can result in serious complications and unsuccessful VA-ECMO procedures. To address these challenges, we developed an "ECPR call" protocol in May 2020. This protocol clarifies the criteria for ECPR indication, allowing patients with OHCA to be promptly transferred to a distant cardiac angiography room for VA-ECMO insertion under fluoroscopic guidance. Our hypothesis was that transporting patients to the fluoroscopy room, regardless of the distance, would lead to reduced cannulation-related vascular complications without affecting the induction time. In this study, we retrospectively compared the effectiveness of the new CPR protocol to that of conventional CPR.

2. Materials and methods

2.1. Design, setting, and population

This single-center retrospective study was conducted at the Tertiary Emergency Medical Center, Kushiro City General Hospital, Kushiro, Hokkaido, Japan. We enrolled 75 patients who underwent ECPR at our hospital between May 2017 and March 2022, and finally included 59 patients. The following patients were excluded: patients with insufficient data because chronological details were not recorded in the electronic medical record, and patients with return of spontaneous circulation before the introduction of VA-ECMO, regardless of whether they were out-of-hospital or in-hospital.

The ED-ECPR group was defined as those who underwent ECPR between May 2017 and April 2020; the ED-ECPR group had no obvious ECPR criteria. The emergency physician determined the indications for ECPR based on age, situation, and initial rhythm and consulted a cardiologist to implement ECPR in the ED. Eventually, the decision to perform ECPR was made by an emergency physician or a cardiologist.

The ECPR call group was defined as the group that received ECPR from May 2020 to March 2022 after adapting the ECPR call protocol. ECPR indication criteria and implementation protocols for the ECPR call group were clarified. We defined the criteria for ECPR calls as follows: (1) witnessed onset, (2) received bystander CPR, (3) performance status 0–1 (no cognitive decline), (4) no malignant or chronic disease with poor prognosis, and (5) no refusal of resuscitation or active treatment. As this was a pilot study, there were no age or transport-time restrictions. At the time of the hotline call, these criteria were checked and an ECPR call was issued. Emergency physicians, cardiologists, nurses, and radiologists were contacted before the patients were transported to the hospital. If a patient had a shockable rhythm (ventricular fibrillation or ventricular tachycardia) during transport, emergency services could perform up to three electrical defibrillations to avoid transport delays. If a patient met any of these criteria during treatment, ECPR was discontinued.

2.2. Data collection

Patient characteristics, such as age, diagnosis, sex, bystander CPR, witness, initial rhythm, medical history, incidence of vascular complications associated with ECPR, history of anticoagulant or antiplatelet medication, implementation of targeted temperature management, blood lactate level, pH, and years of experience were collected from electronic medical records. Vascular complications associated with ECPR include abnormalities in cannula placement, hemothorax, retroperitoneal hemorrhage due to vascular injury, iatrogenic aortic dissection, and bleeding at the cannula puncture site. Cannular-puncture bleeding was defined as bleeding requiring surgical repair or making it difficult to continue VA-ECMO. The VA-ECMO withdrawal rate, ventilator days, length of intensive care unit (ICU) stay, mortality, time from call to ED arrival, and ED arrival to VA-ECMO initiation were calculated upon ICU admission. We considered anticoagulant or antiplatelet medication use, arterial disease, and operator's years of experience as confounding factors.

These factors were selected based on the findings of a previous study [17]. The time from call to ED arrival was defined as the period between the emergency command center receiving the patient's emergency call and arrival at the ED. The time from ED arrival to VA-ECMO initiation was defined as the period between the arrival of the ambulance at the emergency delivery entrance and the start of VA-ECMO. The location where the ambulance was parked and the emergency delivery entrance were immediately adjacent to each other, so the patient transfer time was substantially short. Medication and medical history were obtained from the medical records and interviews with the patients' family members.

2.3. ECPR protocol

VA-ECMO was administered in the ED in the ED-ECPR cohort, whereas a cardiovascular fluoroscopy room was used for the initiation of VA-ECMO in the ECPR-call group. The inflow and outflow cannulas were inserted into the femoral vessels by a cardiologist using the percutaneous Seldinger technique. An inflow cannula was inserted into the femoral artery and an outflow cannula was implanted into the femoral vein. The target perfusion volume was 60 mL/kg based on the approximate patient weight. For achieving a flow rate of 4 L/min, a 16.5 Fr cannula was selected for the inflow, paired with a 21 Fr cannula for the outflow; whereas for a flow rate of 3 L/min, a 15 Fr cannula was selected for the inflow along with a 19.5 Fr cannula for the outflow. Cannula size was determined according to the surgeon's instructions. The ECMO centrifugal pumps, circuits, and cannulation were of the same type (Capiox EBS; Terumo Corp., Tokyo, Japan).

2.3.1. ED-ECPR group

Conventionally, we performed non-fluoroscopic cannulation in the ED until April 2020. An ambulance arrived at the emergency entrance, and the patient was transferred to the ED. The VA-ECMO circuit was primed after the final decision to perform ECPR was made. In the ED, the cardiologist started puncturing the femoral vessels under non-fluoroscopic guidance and without ultrasound guidance. After inserting the guidewire and cannula, the location was confirmed using transesophageal echocardiography, fluoroscopy, or computed tomography (CT). Endotracheal intubation and defibrillation for shockable rhythm were performed at the surgeon's discretion.

2.3.2. ECPR call group

In the ECPR call group, cardiopulmonary resuscitation was performed using the mechanical CPR device, LUCAS™2 (JOLIFE AB, Sweden). If the device was not attached before the patient entered the hospital, it was installed at the ED entrance. Echocardiography confirmed no clinical findings suggestive of aortic dissection, such as pericardial effusion or intra-arterial flaps. Otherwise, the patient bypassed the ED and went straight to the cardiac catheterization laboratory. The patients were transported directly to the cardiac catheterization laboratory with mechanical CPR and ongoing cardiac life support. Intubation and intravenous catheterization were performed after the patient was transferred to a cardiac catheterization laboratory. Before hospital arrival, emergency personnel administered defibrillation in accordance with the American Heart Association/American College of Cardiolog (AHA/ACC) guidelines to identify shockable rhythms during patient transportation [18]. After hospital arrival, if a shockable rhythm manifested during ECPR induction, defibrillation was performed according to the operator's directives. However, to minimize the impact on cannulation time, defibrillation was abstained during percutaneous vascular puncture with a primary focus on ECPR induction. The ED and cardiac catheterization laboratory were located on the same floor, almost in a straight line with no obstruction, and approximately 80 m apart. Puncture was initiated from the femoral vein and artery, and guidewire insertion and cannula placement were performed under fluoroscopic guidance using real-time imaging (Trinias F8 Unity edition; Shimadzu Corp., Kyoto, Japan).

In both groups, percutaneous coronary intervention was performed if coronary angiography revealed significant stenotic lesions. Prior to ICU admission, contrast-enhanced CT was performed on all patients. Following the successful completion of ECPR, patients were admitted to the ICU, and therapeutic targeted temperature management was initiated, ensuring that the temperatures did not exceed 36 °C within the 24 h post-ICU admission.

2.4. Statistical analysis

Normally distributed data are presented as the mean ± standard deviation, and non-normally distributed data are presented as the median and interquartile range. Categorical data are presented as percentages (%). Statistical software (GraphPad Prism 9.0) was used for statistical analysis. Fisher's exact test was used for categorical variables, and the Mann–Whitney *U* test was used for continuous variables. Multivariate logistic regression analysis was performed to evaluate confounding factors for each ECPR introduction method and vascular complications. The level of statistical significance was set at $p < 0.05$.

2.5. Outcomes

The primary outcome assessed was the incidence of ECPR-associated vascular complications. Secondary outcomes were the duration from call to ED arrival, time from ED arrival to VA-ECMO initiation, VA-ECMO and ventilator withdrawal rates, 28-day survival rate, survival to discharge rate, and discharge rate with favorable neurological outcomes. Neurologically favorable survival was defined as a Cerebral Performance Category score of 1–2.

3. Result

We excluded six patients with insufficient data and one patient who returned to spontaneous circulation before the introduction of VA-ECMO. Finally, the study included 52 patients (20 in the ECPR call group and 32 in the ED-ECPR group) (Fig. 1); no patients underwent fluoroscopic ECPR before April 2020 and no patients followed the ECPR call protocol after that date. The patient characteristics are shown in Table 1.

The primary and secondary outcomes are presented in Table 2. The rate of vascular complications associated with ECPR was significantly lower in the ECPR group than in the ED-ECPR group (40.6 % [14/32] vs. 10 % [2/20], respectively; $p = 0.014$). The duration from ED arrival to VA-ECMO initiation was similar between the two groups (median, 23.0 min in the ED-ECPR group vs 25.5 min in the ECPR call group, $p = 0.71$). The 28-day survival rates were 21.9 % and 30.0 % in the ECPR call group ($p = 0.53$).

Table 3 shows vascular complications associated with cannulation. In the ED-ECPR group, the vascular complication rate was 40.6 %, and the following vascular complications had occurred: arterioartery cannulation, 3.1 %; venovenous cannulation, 6.3 %; hemothorax, 3.1 %; iatrogenic aortic dissection, 6.3 %; retroperitoneal hemorrhage, 12.5 %; and cannula puncture site bleeding, 12.5 %. In the ECPR-call group, the vascular complication rate was 10.0 %, with cannula puncture site bleeding being the only vascular complications (Table 3).

Table 4 shows the results of multivariate logistic regression analysis to estimate the effect of differences in ECPR enforcement methods and eliminate the effects of possible confounders. Performing ECPR under fluoroscopy was consistently an independent element of vascular complication rates (adjusted odds ratio: 9.92, 95 % confidence interval: 2.04 to 81.2, $p = 0.011$), while each confounding factor was not independent of the incidence of vascular complications. (Table 4).

4. Discussion

In this retrospective study, we investigated the efficacy of a newly developed method of introducing ECPR at our facility. Our institution's ED does not use fluoroscopic equipment; therefore, patients indicated for ECPR were directly transported to a distant cardiac angiography room, bypassing the ED. To minimize time loss, we implemented a well-prepared manpower protocol prior to patient transport. This approach resulted in a reduction in vascular complications during VA-ECMO intervention compared to that during the conventional method, with no significant difference in the time to ECPR completion or patient prognosis, even after adjusting for several confounders.

Studies have reported that 10%–20 % of patients undergoing ECMO for heart or respiratory failure experience complications related to cannulation, mainly bleeding and vascular injury [17]. The failure rate of VA-ECMO cannulation under non-transilluminated conditions was reported to be 7%–10 % [19,20]. A previous study comparing the rates of vascular complications between fluoroscopically and non-fluoroscopically guided ECPR demonstrated significantly higher complication rates in the non-fluoroscopy group (36 % vs. 8.7 %), which is consistent with our findings and suggests that fluoroscopically guided ECPR is associated with fewer complications [21].

Facilities lacking fluoroscopic equipment must transfer patients to a cardiac angiography room or any other location with a

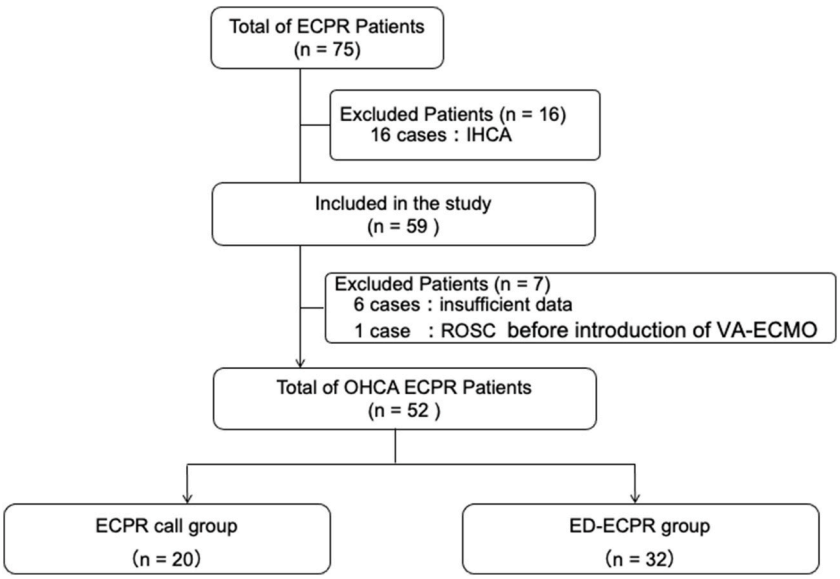

Fig. 1. Flowchart showing the enrollment of patients, including those who underwent ECPR at our hospital, from May 2017 to March 2022. ECPR: Extra-corporeal cardiopulmonary resuscitation, IHCA: In-hospital cardiac arrest, OHCA: Out-of-hospital cardiac arrest, ROSC: Return of spontaneous circulation, ED: Emergency department.

Table 1
Characteristics of subjects by group.

	ED-ECPR (n = 32)	ECPR call (n = 20)	P-value
Age, median (IQR), y	62.5 (48.5, 75.8)	72 (52, 81)	0.13
Male sex, No. (%)	28 (87.5)	13 (65)	0.053
Witness, No. (%)	25 (78.1)	19 (95)	0.13
BS-CPR, No. (%)	23 (71.9)	20 (100)	0.0088
TTM, No. (%)	25 (78.1)	20 (100)	0.025
Time from call to ED arrival, median (IQR), min	31.5 (22.0, 45.0)	33.0 (28.3, 60.3)	0.20
Anticoagulant/antiplatelet medication No. (%)	5 (15.6)	7 (35.0)	0.18
Initial cardiac rhythm, No.(%)			
Asystole	7 (21.9)	0 (0)	0.035
Pulseless electrical activity	6 (18.8)	5 (25.0)	0.73
Pulseless ventricular tachycardia	1 (3.1)	0 (0)	>0.99
Ventricular fibrillation	18 (56.3)	15 (75.0)	0.24
Diagnosis, No. (%)			
Acute coronary syndrome	20 (62.5)	8 (40.0)	0.16
Idiopathic ventricular fibrillation	3 (9.4)	7 (35.0)	0.033
Acute aortic dissection	1 (3.1)	3 (15.0)	0.29
Hypothermia	4 (12.5)	3 (15.0)	>0.99
Necrotizing fasciitis	1 (3.1)	0 (0)	>0.99
Fulminant cardiomyopathy	1 (3.1)	0 (0)	>0.99
Drowning	1 (3.1)	0 (0)	>0.99
Sepsis	1 (3.1)	0 (0)	>0.99
Medical history, No. (%)			
HT	8 (25.0)	11 (55.0)	0.04
DM	5 (15.6)	3 (15.0)	>0.99
Coronary artery disease	6 (18.8)	8 (40.0)	0.12
Chronic heart Failure	4 (12.5)	9 (45.0)	0.019
COPD	0 (0)	1 (5.00)	0.38
Chronic kidney disease	1 (3.1)	3 (15.0)	0.29
Implanted ICD	0 (0)	1 (5.00)	0.38
Artery disease	1 (3.1)	1 (5.00)	>0.99
Stroke	6 (18.8)	1 (5.00)	0.23
Dementia	0 (0)	2 (10.0)	0.14
Smoking	13 (40.6)	9 (45.0)	0.78
Place, No. (%)			
Public place	9 (28.1)	2 (10.0)	0.17
Home	17 (53.1)	11 (55.0)	>0.99
EMS	2 (6.3)	0 (0.00)	0.52
Car	0 (0)	1 (5.00)	0.38
Workplace	2 (6.3)	3 (15.0)	0.36
Hotel	1 (3.1)	0 (0.00)	>0.99
Health facility	1 (3.1)	3 (15.0)	0.29
pH, median (IQR)	6.99 (6.86, 7.14)	7.03 (6.83, 7.13)	0.88
Lactate, median (IQR), mg/dL	91.3 (60.3, 122)	93.1 (66.2, 107)	0.68
Operators' years of experience, median (IQR), y	4.50 (4.00, 6.50)	8.5 (5.00, 9.00)	0.070

Non-normally distributed data are presented as medians and interquartile ranges (IQR). Categorical data are presented as percentages (%). ED: Emergency department, ECPR: Extracorporeal cardiopulmonary resuscitation, BS-CPR: Bystander cardiopulmonary resuscitation, TTM: Targeted temperature management, HT: Hypertension, DM: Diabetes mellitus, COPD: Chronic obstructive pulmonary disease, ICD: Implantable cardioverter defibrillator, EMS: Emergency medical services.

fluoroscopic capability. During ECPR, the time between illness onset and VA-ECMO establishment affects survival and neurological prognosis [22]. Studies have indicated that a shorter time to VA-ECMO induction, especially within 60 min of the call, is associated with improved neurological outcomes [2,3]. In our study, we found no significant differences in patient prognosis, and the time to complete ECPR was not significantly different between the ECPR call and ED-ECPR groups at 23 and 25 min, respectively. This suggests that moving the patients to the fluoroscopy room did not affect the time to VA-ECMO establishment or patient survival.

Many studies have explored the relation between the time from cardiopulmonary arrest to VA-ECMO establishment and patient outcomes, considering factors, such as age, initial cardiac rhythm, and predicted time of transport to the ED [2–4,14]. The impact of these factors on patient prognosis remains controversial, and further consideration is needed to include them in the ECPR indication criteria [4,23,24].

Notably, in our study, VA-ECMO cannulation was initiated immediately on site under non-transfluoroscopic conditions in the ED-ECPR group upon deciding to proceed with ECPR. In contrast, the ECPR call group started ECPR after transferring the patient to a distant fluoroscopy room approximately 80 m from the ED. However, the time required to complete ECPR was not significantly different between the ECPR and ED-ECPR groups. The success of the ECPR call group can be attributed to the convening of a team of emergency physicians, cardiologists, emergency nurses, and clinical engineers before patient transport, ensuring comprehensive preparation for ECPR, including VA-ECMO priming. However, the ED-ECPR group may not have decided on the ECPR indications for all patients before transport, potentially leading to inadequate labor and preparation. Although cannulation without transfer to the

Table 2
Primary and secondary outcomes.

	ED-ECPR (n = 32)	ECPR call (n = 20)	P-value
Primary outcome			
Complications during ECPR, No. (%)	14 (40.6)	2 (10.0)	0.014
Secondary outcome			
Time from ED arrival to VA-ECMO start, median (IQR), min	23.0 (15, 38)	25.5 (18.25, 31.50)	0.71
VA-ECMO withdrawal rate, No. (%)	14 (43.8)	12 (60.0)	0.39
Ventilator weaning rate, No. (%)	8 (25.0)	5 (25.0)	>0.99
ICU discharge rate, No. (%)	7 (21.9)	6 (30.0)	0.53
28-day survival rate, No. (%)	7 (21.9)	6 (30.0)	0.53
Prognosis, No. (%)			
CPC score: 1–2	3 (9.4)	3 (15.0)	0.66
Survival to hospital discharge	5 (15.6)	5 (25.0)	0.48
Mortality	27 (84.4)	15 (75.0)	0.48

Non-normally distributed data are presented as medians and interquartile ranges (IQR). Categorical data are presented as percentages (%). ED: Emergency department, ECPR: Extracorporeal cardiopulmonary resuscitation, ICU: Intensive care unit, CPC: Cerebral Performance Category, VA-ECMO: Venoarterial extracorporeal membrane oxygenation.

Table 3
Vascular complications associated with cannulation, No. (%).

	Overall (n = 52)	ED-ECPR (n = 32)	ECPR call (n = 20)
A-A Cannulation	1 (1.92)	1 (3.1)	0 (0)
V–V Cannulation	2 (3.85)	2 (6.3)	0 (0)
Hemothorax	1 (1.92)	1 (3.1)	0 (0)
Iatrogenic aortic dissection	2 (3.85)	2 (6.3)	0 (0)
Retroperitoneal hemorrhage	4 (7.70)	4 (12.5)	0 (0)
Cannula puncture site bleeding	6 (11.5)	4 (12.5)	2 (10.0)

Categorical data are presented as percentages (%). A-A: Arterioartery, V–V: Venovenous.

Table 4
Multiple logistic regression analysis of predictors for vascular complications associated with cannulation.

	Adjusted odds ratio (95 % CI)	P-value
Anticoagulant/antiplatelet medication	0.41 (0.071–2.16)	0.29
Operators' years of experience	0.92 (0.74–1.12)	0.41
Transfer to Fluoroscopy Room	9.92 (2.04–81.2)	0.011

CI: Confidence interval.

cardiographic laboratory can complete ECPR more quickly when everything goes smoothly, it can lead to considerable delays and vascular complications when issues arise. For example, the maximum cannulation time in the ED-ECPR group was 67 min. Therefore, considering transport time and performance location, we believe that ECPR can be performed in a cardiac catheterization laboratory or in the ED without fluoroscopy.

Recent reports on the effectiveness of fluoroscopy-guided ECPR in hybrid emergency room settings are encouraging [25]; however, these setups may not be available in all general primary hospitals. Some facilities may not have an ED or fluoroscopy room in close proximity; they may even be located far apart. Our study might motivate such facilities, where ECPR is unavoidably performed under nonfluoroscopic conditions owing to the poor flow between the ED and fluoroscopy equipment, to consider direct patient transfer to the fluoroscopy room for ECPR initiation with adequate provision. Moreover, the original group did not undergo ultrasound, which may have been the main reason for the higher number of complications. Several studies have shown that ultrasound-guided ECPR is effective in reducing complications, shortening cannulation time, and improving neurological prognosis [26–28].

Our study has several strengths. First, we meticulously controlled for confounding variables using a multivariate logistic regression analysis. Second, the execution of ECPR adhered scrupulously to the meticulously outlined protocol, thereby endowing the ECPR call group with a precisely defined baseline. The incorporation of transfer to the fluoroscopy room within the protocol is a pivotal strength of our study. Nevertheless, in this investigation, transfer to the fluoroscopy room exhibited no correlation with prolonged cannulation time; rather, it was associated with a notable reduction in complication rates. Consequently, within a facility lacking fluoroscopy devices in the ED, the relocation of patients to the cardiac angiography room, even if time-consuming, proved to be a judicious course of action. Moreover, the mitigation of complications may alleviate escalation in medical costs, rendering this study meaningful even in the absence of discernible distinctions in patient prognosis between the two groups [29–31].

As with any study, this study has several limitations. First, given the small sample size, the results may not be reproducible. However, these results need to be confirmed in prospective randomized controlled trials. Second, some patients had insufficient data and were excluded, which may have introduced a selection bias. Third, we could not completely adjust for confounding factors, such as

vascular structure, platelet count, coagulation function at the puncture site, patient obesity, and ultrasound guidance, which could influence vascular complication rates during VA-ECMO coagulation. Additionally, we did not account for the number of operators performing VA-ECMO insertion or the time of day, which could affect manpower availability, preparation, and ECPR outcomes. Finally, the ECPR call group logically involved more experienced personnel one month later. In addition, a cardiac catheterization lab has access to other specialists and a quiet, streamlined environment and is expected to have better outcomes.

5. Conclusion

Fluoroscopy-guided ECPR can significantly reduce the incidence of vascular complications even if the ED and fluoroscopy room are far apart. However, no significant difference was observed in the time required to establish ECPR in the cardiac catheterization laboratories. The ECPR call system at our facility may be functional, but needs to be more sophisticated.

Ethics statement

This study was conducted in accordance with the Declaration of Helsinki, and the study design and protocol were approved by the Institutional Review Board of Kushiro City General Hospital (approval number: 2022 [R4]-8). The requirement for patient consent was waived due to the retrospective nature of the study. This study was registered in the Japan Registry of Clinical Trials (clinical research number: jRCT1012220035).

Data availability statement

The data that support the findings of this study are available on request from the corresponding author, [ST]. The data are not publicly available due to restrictions on their containing information that could compromise the privacy of research participants.

Funding source

This study did not receive any specific grants from funding agencies in the public, commercial, or non-profit sectors.

CRediT authorship contribution statement

Soichi Tanaka: Writing – original draft, Formal analysis, Data curation, Conceptualization. **Shunsuke Tachibana:** Writing – review & editing, Supervision. **Takashi Toyohara:** Data curation, Conceptualization. **Hajime Sonoda:** Supervision, Conceptualization. **Michiaki Yamakage:** Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Not applicable.

Abbreviations

CPR	Cardiopulmonary resuscitation
CT	Computed tomography
ED	Emergency department
ECPR	Extracorporeal cardiopulmonary resuscitation
ICU	Intensive care unit
OHCA	Out-of-hospital cardiac arrest
VA-ECMO	Venoarterial extracorporeal membrane oxygenation

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