Long-term outcomes and prognostic factors of extracorporeal cardiopulmonary resuscitation in patients older than 75 years: a single-centre retrospective study

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ABSTRACT

Background Few studies have assessed older adult patients who received extracorporeal cardiopulmonary resuscitation (ECPR) after cardiac arrest, and outcomes and prognostic factors of ECPR in this population remain unclear. This study aimed to assess the long-term outcomes and prognostic factors among patients older than 75 years who received ECPR after experiencing cardiac arrest.

Methods This is a single-centre, retrospective case–control study conducted between August 2010 and July 2019. Consecutive patients older than 75 years who had in-hospital (IHCA) or out-of-hospital cardiac arrest (OHCA) and received ECPR at the Emergency Department in the Hyogo Emergency Medical Center, Hyogo, Japan, were included. The primary outcome was a favourable neurological outcome, defined as a Cerebral Performance Category score of 1–2 at 1 year after the event. Univariate logistic regression was used to determine the association between variables and patient outcomes.

Results Of the 187 patients with cardiac arrest who received ECPR, 30 were older than 75 years and 28 (15% of the cohort receiving ECPR) were examined in this study. The median age of the patients was 79 years (IQR 77–82), and there were 13 (46%) male patients. Neurological outcomes were favourable for seven (25%) patients, five of whom had IHCA and two with out-of-hospital OHCA. On univariate analysis, patients with a favourable outcome had a shorter median total collapse time (TCT) than those with an unfavourable outcome (favourable: 18.0 min (IQR 13.0–33.5) vs unfavourable: 44.0 min (IQR 25.0–53.0); p=0.049).

Conclusion In selected patients older than 75 years, ECPR could be beneficial by providing a shorter TCT, which may contribute to favourable neurological outcomes. Nevertheless, further studies are needed to validate these findings.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Extracorporeal cardiopulmonary resuscitation (ECPR) has improved the outcomes of patients with cardiac arrest; however, outcomes and prognostic factors of this strategy among older adults remain unclear.

⇒ Few studies have assessed the characteristics and complications for older adults who have undergone ECPR, and no study has assessed the long-term outcomes.

WHAT THIS STUDY ADDS

⇒ In this retrospective study conducted in a hospital in Japan, of the 28 patients older than 75 years who underwent ECPR, 25% had favourable neurological outcomes 1 year after the event.

⇒ A shorter total collapse time (TCT), defined as the time interval from collapse to the establishment of full ECPR support, may contribute to favourable neurological outcomes.

⇒ ECPR may have utility in patients older than 75 years.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study could be used as a basis for considering appropriate patients for ECPR for those older than 75 years.

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INTRODUCTION

Extracorporeal cardiopulmonary resuscitation (ECPR) has improved patient outcomes after cardiac arrest.[1–4] However, international resuscitation guidelines state that no evidence exists to define patient selection for ECPR.[5 6] A recent systematic review has shown that a favourable outcome was associated with initial shockable cardiac rhythm and shorter low-flow time.[1] The review found no significant association between prognosis and patient age. Previous prospective studies on ECPR have excluded older patients using the exclusion criteria of age older than 75 years.[7 8]

In out-of-hospital cardiac arrest (OHCA), physicians must occasionally decide the indication for ECPR with little time and without complete patient information, such as age and level of activities of daily living. Although each institution may have rules regarding the indication for ECPR, this resuscitation is ultimately initiated at the discretion of individual clinicians based on known and unknown factors, which occasionally resulted in implementation of extracorporeal membrane oxygenation (ECMO) for patients older than 75 years.

To date, four retrospective studies including patients older than 75 years have investigated the prognosis of ECPR patients, survival at hospital discharge or 1 month ranged from 7.8% to 33.3%; favourable neurological outcome at hospital discharge or 1 month ranged from 0% to 18.2%; however, none of the studies assessed long-term outcomes.[9–12] Therefore, this study aimed to assess the long-term outcomes, characteristics, complications and prognostic factors of patients older than 75 years with cardiac arrest who received ECPR.

METHODS

Participants and setting

This single-centre, retrospective, case–control study evaluated patients treated at the Emergency Department in Hyogo Emergency Medical Center, Hyogo, Japan. Inclusion criteria were consecutive patients older than 75 years with in-hospital cardiac arrest (IHCA) or OHCA who received ECPR between August 2010 and July 2019. The study excluded patients with unsuccessful cannulation for extracorporeal membrane oxygenation (ECMO) that precluded ECPR.

In general, patients at our institution were considered for ECPR if they met the following inclusion criteria: (1) aged 16–75 years; (2) presence of initial shockable rhythm or witnessed pulseless electrical activity rhythm with or without bystander cardiopulmonary resuscitation (CPR); and (3) hospital arrival within 45 min of the initial call to emergency medical services or the time of initial cardiac arrest. The exclusion criteria included (1) do-not-attempt resuscitation (DNAR) directive, and (2) poor level of activities of daily living before cardiac arrest. This is subjective information obtained by the physician by interviewing family members or persons concerned. The implementation of ECPR was finally decided by the emergency physician, even if the patient age was older than 75 years in patients with OHCA/IHCA.

Patient management

The ECPR team comprised emergency physicians, cardiovascular specialists, clinical engineering technologists and emergency nurses. An eligible patient was directly transferred to the angiography room, where 17-Fr arterial and 21-Fr venous catheters were inserted into the femoral artery and vein percutaneously using the Seldinger technique, with or without ultrasound guidance by emergency physicians or cardiologists. After starting ECPR, coronary angiography was performed immediately in patients with suspected acute coronary syndrome. Target temperature management (TTM) was used to achieve a body temperature of 33°C for 24 hours and to rewarm to 36.5°C in the next 24 hours. The initial target temperature was modified to 36°C if the patient sustained haemorrhagic complications. For early rehabilitation, passive range of motion exercises were started during ECMO.

Data collection and definitions

The following patient data were collected from the medical and ECPR records: patient characteristics (age, sex, underlying disease, Charlson Comorbidity Index score)[13]; presence of a witness to cardiac arrest; bystander CPR; initial rhythm; cause, location and time course of cardiac arrest; use of TTM; ECMO, ventilator, and intensive care unit (ICU)-free days; survival to hospital discharge; and neurological outcomes at hospital discharge and 1 year after the event. The indication for ECPR, complications and DNAR directive information before cardiac arrest were also collected. The indication for ECPR specifically

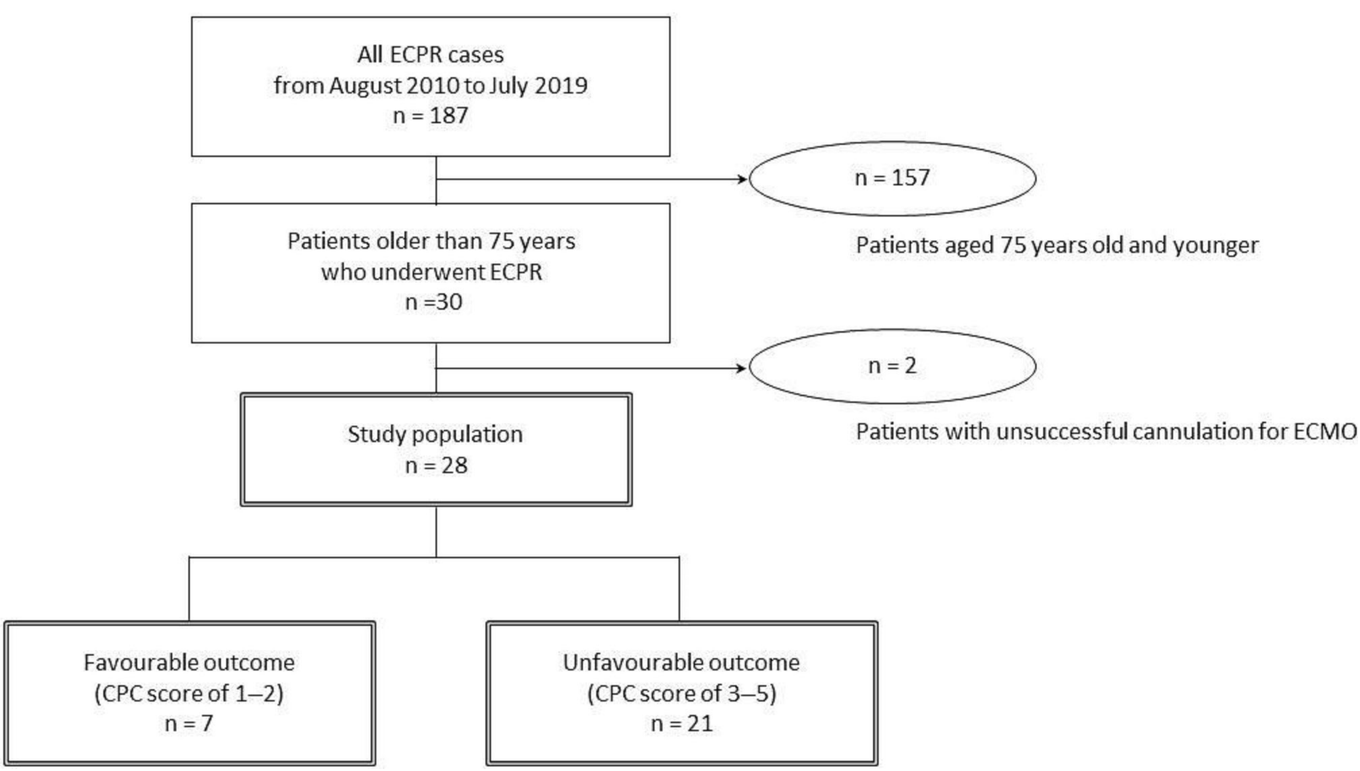

Figure 1 Enrolment algorithm for the favourable and unfavourable outcome groups. The CPC scores were 1–2 for the favourable outcome group, and 3–5 for the unfavourable outcome group. CPC, Cerebral Performance Category; ECPR, extracorporeal cardiopulmonary resuscitation; ECMO, extracorporeal membrane oxygenation.

Table 1 Baseline characteristics of patients older than 75 years with cardiac arrest who received ECPR according to neurological outcome 1 year after the event

Variables	Patients (n=28)	Favourable outcome group (n=7)	Unfavourable outcome group (n=21)	P value
Age (years), median (IQR)	79 (77–82)	81 (81–86)	79 (76–81)	0.025
Male, n (%)	13 (46)	3 (43)	10 (48)	1.000
Height (cm), median (IQR)	154 (150–168)	153 (150–155)	161 (147–171)	0.168
Body weight (kg), median (IQR)	58.2 (48.3–59.7)	55.9 (46.9–59.5)	60.5 (58.0–71.5)	0.160
Body mass index, median (IQR)	23.1 (21.4–26.1)	23.6 (21.5–26.1)	22.0 (20.6–26.3)	0.916
Underlying disease				0.825
Cerebral vascular disease, n (%)	5 (18)	1 (14)	4 (19)	
Dementia, n (%)	1 (4)	0 (0)	1 (5)	
Chronic heart failure, n (%)	3 (11)	1 (14)	2 (10)	
Chronic respiratory failure, n (%)	1 (4)	1 (14)	0 (0)	
Chronic liver failure, n (%)	1 (4)	1 (14)	0 (0)	
Chronic kidney disease, n (%)	3 (11)	2 (29)	1 (5)	
Peripheral vascular disease, n (%)	2 (7)	1 (14)	1 (5)	
Malignancy, n (%)	4 (14)	1 (14)	3 (14)	
Charlson Comorbidity Index score, median (IQR)	0 (0–2)	0 (0–3)	0 (0–1)	0.556
0, n (%)	18 (64)	4 (57)	14 (67)	
1–2, n (%)	7 (25)	1 (14)	6 (29)	
3–4, n (%)	2 (7)	1 (14)	1 (5)	
≥5, n (%)	1 (4)	1 (14)	0 (0)	

Missing data: height, body weight and body mass index=12, others=0.
ECPR, extracorporeal cardiopulmonary resuscitation.

inquired about why this intervention had been undertaken in those older than 75 years. In our ECPR dataset, 1-year outcome of the patient with ECPR who survived until hospital discharge were routinely collected based on a review of medical records and telephone interviews of the patients or their families.

According to earlier studies, the time points of cardiac arrest were defined as follows: total collapse time (TCT) was the time interval from collapse to the establishment of ECMO, which comprised no-flow time (NFT) and low-flow time (LFT); NFT was the time interval between collapse and the start of CPR; and LFT was the interval between the start of CPR and establishment of ECMO.[14] To eliminate intentional influence on the time course, the start of LFT or NFT in patients without a witness was set as the time of discovery. We also collected the indication for ECPR based on the review of medical records. Among these, the indication of 'early initiation of ECPR' was defined as a shorter time to ECMO initiation, which the responsible physicians considered they could achieve early initiation of ECPR as the location of the cardiac arrest was close to the location of care, such as an IHCA, or in the case of OHCA where the collapse to arrival time was expected to be much shorter, that is, <30 min. Aetiology of cardiac arrest was clinically determined by emergency physician based on physical examination, history, blood test and radiological findings. Life signs refer to agonal breathing and/or pupillary light reflexes during resuscitation.

Outcome measures

The primary outcome was a favourable neurological outcome, defined as a Cerebral Performance Category (CPC) score of 1–2, based on a 5-category scale at 1 year after the event.[15] Secondary outcomes included favourable neurological outcome at hospital discharge, survival to hospital discharge and complications, which were defined as (1) cannulation site bleeding that required external compression or surgical repair; (2) retroperitoneal haematoma or intracranial haemorrhage, diagnosed with CT; (3) clinically diagnosed gastrointestinal haemorrhage, epistaxis and lower leg ischaemia; and (4) cerebral infarction confirmed on radiological and physical examinations.

Patient and public involvement

No patients were involved in the design of this research.

Statistical analysis

Patients older than 75 years who met the inclusion criteria were categorised into two groups based on the primary outcome. Univariate analysis was used to compare patient characteristics between the favourable and unfavourable outcome groups. To compare the relationship between TCT and outcome, TCT was divided into three groups according to tertiles. Next, we evaluated complications among patients with favourable outcomes. Additionally, the indications for ECPR were compared between the two groups. Continuous variables were analysed using the Mann-Whitney U test, and categorical variables were analysed using the χ^2 test or Fisher's exact test. Categorical variables were counted and presented as proportions. Continuous variables were expressed as medians and IQRs. A p value of <0.05 was considered statistically significant. Statistical analysis was performed using EZR V.1.40 (Kanda, 2014, Saitama, Japan). Missing data were not replaced or estimated.

RESULTS

Patient characteristics

During the study period, 187 patients of all ages underwent ECPR for the treatment of cardiac arrest, among whom 30 were older than 75 years. Of the 30 patients, 2 were excluded because of unsuccessful cannulation. Of the remaining 28 (15%) patients (figure 1), 11 (39%) had an IHCA and 17 (61%) were OHCA. The median age was 79 years (IQR 77–82), and the oldest patient was 88 years. The median body mass index

Table 2 Characteristics regarding cardiac arrest and outcomes of patients older than 75 years with cardiac arrest who received ECPR according to neurological outcome 1 year after the event

Variables	Patients (n=28)	Favourable outcome group (n=7)	Unfavourable outcome group (n=21)	P value
Witnessed CA, n (%)	26 (93)	7 (100)	19 (90)	1.000
Bystander CPR, n (%)	22 (79)	6 (86)	16 (76)	1.000
Initial rhythm				0.207
VF/VT, n (%)	10 (36)	4 (57)	6 (29)	
PEA, n (%)	16 (57)	2 (29)	14 (67)	
Asystole, n (%)	2 (7)	1 (14)	1 (5)	
Cause of CA				0.396
Cardiogenic, n (%)	15 (54)	5 (71)	10 (48)	
Pulmonary embolism, n (%)	2 (7)	0 (0)	2 (10)	
Aortic disease, n (%)	8 (29)	0 (0)	8 (38)	
Accidental hypothermia, n (%)	3 (11)	2 (29)	1 (5)	
Location of CA				0.076
In-hospital, n (%)	11 (39)	5 (71)	6 (29)	
Out-of-hospital, n (%)	17 (61)	2 (29)	15 (71)	
Time courses of CA				
TCT (min), median (IQR)	35.5 (19.5–54.5)	18 (13–33.5)	44 (25–53)	0.049
LFT (min), median (IQR)	33.5 (17.8–46.3)	18 (13–33.5)	38 (24–46)	0.130
NFT (min), median (IQR)	0 (0–5.3)	0 (0–0)	1 (0–16)	0.113
TTM				0.241
Hypothermia, n (%)	4 (14)	1 (14)	3 (14)	
Normothermia, n (%)	12 (43)	6 (86)	6 (29)	
None, n (%)	12 (43)	0 (0)	12 (57)	
ECMO-free days (days), median (IQR)	0 (0–21)	25 (23–25)	0 (0–0)	<0.001
Ventilator-free days (days), median (IQR)	0 (0–2)	21 (13–22)	0 (0–0)	<0.001
ICU-free days (days), median (IQR)	0 (0–9)	17 (10–18)	0 (0–0)	<0.001
CPC score at hospital discharge, n (%)				<0.001
1, n (%)	4 (14)	4 (57)	0 (0%)	
2, n (%)	2 (7)	2 (29)	0 (0%)	
3, n (%)	2 (7)	1 (14)	1 (5%)	
4, n (%)	1 (4)	0 (0%)	1 (5%)	
5, n (%)	19 (68)	0 (0%)	19 (90%)	
CPC score at 1 year after the event, n (%)				<0.001
1, n (%)	7 (25%)	7 (100%)	0 (0%)	
2, n (%)	0 (0%)	0 (0%)	0 (0%)	
3, n (%)	0 (0%)	0 (0%)	0 (0%)	
4, n (%)	0 (0%)	0 (0%)	0 (0%)	
5, n (%)	21 (75)	0 (0%)	21 (100%)	

Missing data: TCT and NFT=2 (VF/VT patients without witness).
CA, cardiac arrest; CPC, Cerebral Performance Category; CPR, cardiopulmonary resuscitation; ECMO, extracorporeal membrane oxygenation; ECPR, extracorporeal cardiopulmonary resuscitation; ICU, intensive care unit; LFT, low-flow time; NFT, no-flow time; PEA, pulseless electrical activity; TCT, total collapse time; TTM, targeted temperature management; VF/VT, ventricular fibrillation/ventricular tachycardia.

(BMI) was 23.1 (IQR 21.4–26.1). The underlying diseases were cerebral vascular disease in five (18%), and malignancy in four (14%) patients. The median Charlson Comorbidity Index score was 0 (IQR 0–2) (table 1). Witnessed cardiac arrest occurred in 26 (93%) patients, and 22 (79%) received bystander CPR. The initial rhythm was ventricular fibrillation/ventricular tachycardia in 10 (36%), pulseless electrical activity in 16 (57%) and asystole in 2 (7%) patients. The cardiogenic aetiology was confirmed in 15 (54%) patients. The median TCT was 35.5 min (IQR 19.5–54.5) (table 2).

Outcomes and complications of ECPR

Nine (32%) patients survived to hospital discharge and seven (25%) survived to 1 year after the event. Regarding the primary outcome, all seven patients who survived to 1 year had favourable neurological outcomes at 1 year after the event. Five of the patients who survived with favourable neurological outcome had IHCA and two had OHCA (table 2). The CPC scores of 3 for one patient and 2 for two patients at hospital discharge improved to a CPC score of 1 at 1 year. The most common adverse event was bleeding, which most often occurred at the cannulation site (six patients (21%)), followed by retroperitoneal haematoma extending from cannulation site in five patients (18%) and gastrointestinal bleeding in two patients (7%) (table 3).

Comparison of patients in the favourable and unfavourable outcome groups

Among the patients older than 75 years who received ECPR, patients with favourable outcomes were older than those with unfavourable outcomes (81 years (IQR 81–86) vs 79 years (IQR 76–81); OR 1.36; 95% CI 1.06 to 1.89; p=0.025). Patients with favourable outcomes had a shorter TCT than those with unfavourable outcomes (18.0 min (IQR 13.0–33.5) vs 44.0 min (IQR 25.0–53.0); OR 0.96; 95% CI 0.90 to 0.99; p=0.049). The TCT tertiles of patients with favourable outcomes showed that the TCT was <24 min in five (56%) patients (first tertile), 24–49.5 min in one (11%) patient (second tertile) and >49.5 min

Table 3 Complications in patients who received extracorporeal cardiopulmonary resuscitation

Variables	Patients (n=28)	Favourable outcome group (n=7)	Unfavourable outcome group (n=21)
Cannulation site bleeding, n (%)	6 (21)	0 (0)	6 (29)
Retroperitoneal haematoma, n (%)	5 (18)	3 (43)	2 (10)
Gastrointestinal haemorrhage, n (%)	2 (7)	1 (14)	1 (5)
Epistaxis, n (%)	1 (4)	0 (0)	1 (5)
Intracranial haemorrhage, n (%)	1 (4)	0 (0)	1 (5)
Cerebral infarction, n (%)	1 (4)	0 (0)	1 (5)
Subcutaneous haematoma, n (%)	1 (4)	0 (0)	1 (5)
Extremity ischaemia, n (%)	1 (4)	0 (0)	1 (5)
Compartment syndrome of the lower extremity, n (%)	1 (4)	0 (0)	1 (5)

in one (10%) patient (third tertile) (figure 2). The favourable outcome group had a median 25 ECMO-free days, 21 ventilator-free days and 17 ICU-free days (table 2). Favourable neurological outcomes were observed in 5 (45%) of 11 patients with IHCA (OR 2.50; 95% CI 1.10 to 5.69) and 2 (12%) of 17 patients with OHCA (OR 0.4; 95% CI 0.12 to 1.33).

Indication for ECPR

Of the 28 patients studied, 26 (93%) had witnessed cardiac arrest and 22 (79%) had bystander CPR as stated indications for ECPR implementation. Four patients (14%) received ECPR because age was unknown and they appeared to be less than 75 years old before ECPR implementation. In the univariate analysis, the favourable outcome group had a higher number of individual indications for early initiation of ECPR compared with the unfavourable outcome group (100% vs 43%; OR 2.33; 95% CI 1.42 to 3.82; p=0.010) (table 4).

DISCUSSION

In this study, at 1 year after the event, 25% of patients had survived and had favourable neurological outcomes. A shorter TCT was a prognostic factor for favourable neurological outcomes.

In a prospective observational study of ECPR in patients aged 20–75 years with OHCA with shockable rhythm in Japan, the favourable neurological outcome at 6 months after the event, was defined as a CPC scores of 1–2, and the 6-month survival rate was 12.4% and 21.5%.[7] According to a previous national observational study of patients with OHCA underwent conventional CPR in Japan, only 1.1% of patients aged 75–84 years and 0.5% of those aged 85 years and older showed favourable neurological outcomes.[16] Our findings suggest that ECPR is effective for favourable outcomes in selected patients, even in those older than 75 years.

Regarding ECPR inclusion criteria, previous studies have excluded patients older than 75 years.[7 8] Therefore, it is difficult to identify those older patients who may benefit from ECPR. To the best of our knowledge, the longest time of follow-up in this age group is 1 month after the event or at hospital discharge.[9–12] The American Heart Association has reported that the timing for outcome measurement in neurological prognostication in all age groups after cardiac arrest should be 1, 3 and 6 months after the event, with 1 year observation if resources permit.[17] However, the optimal time to assess the neurological outcomes is unclear, particularly in older patients with ECPR. It may be necessary to investigate the improvement in neurological status as well as whether the patients actually continue to survive afterward while overcoming the effects of acquired complications and original comorbidities. Therefore, to avoid unnecessary resuscitation and to save medical costs for ECPR among older adults, we assessed the long-term outcome at 1 year after the event and prognostic factors in patients with favourable neurological

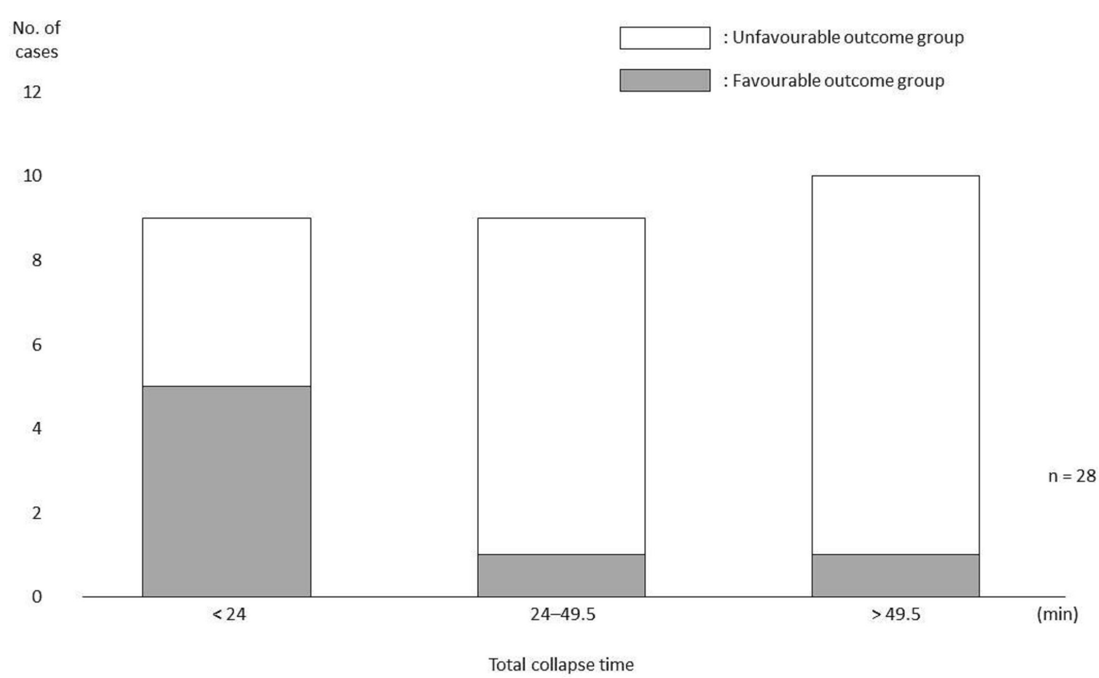

Figure 2 Associations between total collapse time (TCT) and favourable outcome at 1 year after the event. TCT was divided into three groups according to tertiles. Fifty-six per cent (n=5), 11% (n=1) and 10% (n=1) of patients had favourable outcomes in the first (<24 min), second (24–49.5 min) and third (>49.5 min) tertiles, respectively. TCT was defined as the time interval from collapse to the start of extracorporeal cardiopulmonary resuscitation.

Table 4 Indication for ECPR

Variables	Patients (n=28)	Favourable outcome group (n=7)	Unfavourable outcome group (n=21)	P value
Witnessed CA, n (%)	26 (93)	7 (100)	19 (90)	1.000
Bystander CPR, n (%)	22 (79)	6 (86)	16 (76)	1.000
Bystander CPR performed by medical staff after CA, n (%)	15 (54)	6 (86)	9 (43)	0.084
Early initiation of ECPR, n (%)	16 (57)	7 (100)	9 (43)	0.010
Presence of signs of life, n (%)	4 (14)	1 (14)	3 (14)	1.000
Uncertain patient age at hospital admission, n (%)	4 (14)	0 (0)	4 (19)	0.545
Accidental hypothermia, n (%)	3 (11)	2 (29)	1 (5)	0.145

CA, cardiac arrest; CPR, cardiopulmonary resuscitation; ECPR, extracorporeal cardiopulmonary resuscitation.

outcomes. Favourable neurological outcome and survival rate at discharge were 21% (four patients with CPC scores of 1 and two patients with CPC scores of 2) and 32%, respectively. These results are consistent with previous studies.[9–12] Notably, three patients showed improved neurological outcomes at 1 year after the event despite less favourable CPC scores at hospital discharge. On the other hand, nine patients survived at hospital discharge, two of whom died 1 year later.

Using the Extracorporeal Life Support Organisation registry database, Mendiratta *et al*[10] reported that 8 (33.3%) of 24 patients older than 75 years who received ECPR survived to hospital discharge. Yu *et al*[12] reported a greater likelihood of survival among adults older than 75 years in a large prospective Taiwanese study. This research included patients with IHCA (93.9%). Nine (18.4%) of 49 patients older than 75 years who received ECPR had a CPC score of 1–2 at hospital discharge. A systematic review associated IHCA with a good outcome because patients with IHCA were likely to have a shorter LFT and rapid access to a dedicated ECPR response team compared with those with OHCA.[18] In contrast, Goto *et al*[9] revealed that none of the 22 patients with OHCA who underwent ECPR had a CPC score of 1–2 at 1 month after the event. Miyamoto *et al* found that 2 (1.7%) of 115 patients older than 75 years with OHCA presented with shockable or unshockable initial rhythm and underwent ECPR had a CPC score of 1–2 at 1 month after the event.[11] Overall, the results of these studies showed a poor outcome from ECPR in older patients with OHCA compared with studies on older patients with IHCA.

The current study findings differed slightly from those of previous studies, in that favourable neurological outcomes were observed in 5 (45%) of 11 patients with IHCA and 2 (12%) of 17 patients with OHCA. The TCT for the two patients with OHCA with a favourable outcome was relatively short (20 and 47 min). Thus, ECPR could be beneficial, particularly for older adults with IHCA and OHCA in urban areas, who may have shorter TCTs. The proportion of favourable outcome was high (56%) in patients with TCT <24 min in this study. In a previous study, the cut-off value of LFT among patients with OHCA who presented with favourable neurological outcomes and underwent ECPR was 58 min.[19] Yu *et al*[12] showed that the median LFT was 44 min among patients older than 75 years who presented with IHCA. Compared with other studies, the TCT in the current study was relatively short (median is 18 min in patients with a favourable neurological outcome and 35.5 min among all patients (n=28)), which may have contributed to the good outcomes in this analysis.

The age of patients with OHCA is often unknown, and patients older than 75 years may appear younger. In this study, older patients with a minimal chance of survival may not have been included because the responsible emergency physicians had collected patient information before initiating ECPR. For example, physical characteristics, such as apparent cirrhosis, anaemia, emaciation, shunt for dialysis and the presence of home oxygen therapy or walkers, were assessed. Therefore, a high percentage of favourable neurological outcomes may be attributable to an effort to reduce unnecessary ECPR. However, physicians commonly initiate ECPR based on positive information. If physicians believe that resuscitation is worth attempting, patients aged older than 75 years or those with an uncertain age with promising information (eg, agonal breathing, pupillary light reflexes) may receive ECPR. Compared with a previous study, the number of patients with witnessed cardiac arrest and those who received bystander CPR was high.[11] Additionally, Japan has one of the most rapidly ageing populations worldwide. The average life expectancy and healthy life expectancy of a Japanese person are 84.3 and 74.1 years, respectively, the highest worldwide.[20] These factors may contribute to the good outcome in this study. Our study showed unexpected result that median ages in favourable and unfavourable outcomes were 81 and 79, respectively. This might be due to the small sample size or aetiology. Favourable outcome including two patients with OHCA who were both over 85 years old with accidental hypothermia could be achieved by reversible aetiology. The rate of complications in this study was not very high compared with those in a previous report that reported bleeding as the most common complication in patients with ECPR for OHCA (8%–70%), most often at the cannulation site (49%).[21]

There are several countries other than Japan that have ageing societies, and future studies are needed on indications for ECPR among older adults. In this study, only one patient had a DNAR directive before cardiac arrest, but the patient had undergone ECPR before the directive was found. Fortunately, the patient survived without neurological sequela.

This study has several limitations. The first limitation is the retrospective design of the case–control study performed at a single institution in Japan. A long study period was required to include patients older than 75 years. Since the first case of COVID-19 infection was confirmed in January 2020 in Japan, the study was limited to cases before 2020. Because of the small sample size, a multivariate analysis could not be performed and the influence of confounders, such as Charlson Comorbidity Index score, which may be useful for the evaluation of older patients, cannot be ruled out. Furthermore, no comparison tests between younger and older patients were performed. Second, the cardiac arrest timing among patients without a witnessed collapse was evaluated based on the information from the family or emergency medical services; thus, TCT and NFT may be inaccurate. Third, selection bias associated with clinician judgement cannot be ignored. The indications for ECPR among patients older than 75 years may be extremely strict compared with those among younger patients and the reasons for ECPR implementation, especially for early initiation, may strongly depend on clinician's judgement. Fragility in older adults is an important consideration, but this study only considered BMI. Further studies are warranted to determine the important characteristics to be considered in determining appropriateness of ECPR in older patients. Finally, cost-effectiveness was not analysed.

In conclusion, in selected patients older than 75 years, ECPR could be beneficial by providing a shorter TCT, which may contribute to favourable neurological outcomes. Nevertheless, further studies are needed to validate these findings.

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Contributors All the authors discussed the idea and design of study. Data analysis and first draft writing were done by SK and AI. SK and AI contributed equally to this work. All authors read the draft and provided insight for the final version. S Ishihara, AI, SM, S Ijuin and SN played an important role in the development of our institute's ECPR protocol. SK contributed to patient data collection. SK and AI the guarantors of the paper, taking responsibility for the integrity of the work as a whole, from inception to published article.

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Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The Ethics Committee of Hyogo Emergency Medical Center approved this study (ID: 2020010) and waived the informed consent requirement due to the retrospective nature of the study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available.

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