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# Early physiological changes and hospital survival after extracorporeal cardiopulmonary resuscitation: a single-center retrospective cohort study

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## Abstract

**Background:** After extracorporeal cardiopulmonary resuscitation (ECPR), physiological measurements must be interpreted in the context of ongoing circulatory support. We examined changes in lactate, blood pressure, vasoactive requirements, and organ dysfunction in one cohort, and assessed how measurement availability affected interpretation of 24-h lactate associations.

**Methods:** This single-center retrospective cohort included 70 consecutive patients treated between January 2025 and August 2026, with follow-up through September 10, 2026. Serial measurements were compared by hospital outcome. The final assessment combined 72-h values with the last measurements before earlier death or decannulation. Separate exploratory logistic models adjusted for low-flow time examined 24-h lactate clearance and absolute lactate, conditional on measurement availability. Sensitivity analyses excluded two patients aged <18 years.

**Results:** Nineteen patients (27.1%) survived to discharge, including 16 with a Cerebral Performance Category score of 1-2. Survivors had lower lactate at 6 h and 24 h and greater 24-h clearance (76.86% vs 49.13%, P=0.002). Among 45 patients with paired measurements and low-flow data, clearance was associated with survival (adjusted odds ratio per 10-percentage-point increase 1.56, 95% confidence interval 1.12-2.18; P=0.008). Absolute 24-h lactate was also associated with survival (adjusted odds ratio per 1 mmol/L increase 0.57, 95% confidence interval 0.36-0.92; P=0.022). Survival was 40% among included patients and 4% among excluded patients. Mean arterial pressure was higher in survivors from the first assessment; vasoactive-inotropic and organ dysfunction scores differed only at the mixed final assessment. Excluding the two minors did not change the direction or nominal significance of serial comparisons; regression samples were unchanged.

**Conclusion:** Survivors had lower lactate and higher arterial pressure at early assessments, while differences in vasoactive requirements and organ dysfunction were detected only at the mixed final assessment. The 24-h lactate associations apply to patients with available measurements and do not establish prognosis at cannulation or a sequence of physiological recovery.

Keywords: extracorporeal cardiopulmonary resuscitation; extracorporeal membrane oxygenation; lactate clearance; hemodynamics; vasoactive-inotropic score; physiological recovery

## Introduction

Extracorporeal cardiopulmonary resuscitation (ECPR) provides circulatory support for selected patients with refractory cardiac arrest while reversible causes are identified and treated. Outcomes depend on patient selection, resuscitation quality, and the time to effective extracorporeal flow [1]. Randomized trials have yielded different results. ARREST found a survival benefit in a highly selected population with refractory ventricular fibrillation, whereas Prague OHCA and INCEPTION did not find significant improvements in their primary neurological outcomes [2-4].

After cannulation, clinicians assess whether circulatory support is accompanied by improving perfusion and organ function. Pre-cannulation factors remain important [5-7], but lactate, blood pressure, and vasoactive requirements also change during treatment. Describing these measurements together may help characterize the course after ECPR, provided that the timing and availability of observations are considered.

We examined early changes in lactate, blood pressure, vasoactive support, and organ dysfunction after ECPR and their associations with survival to hospital discharge.

## Methods

### Study design and reporting

This single-center retrospective cohort study at the Department of Emergency Medicine, Zhongshan Hospital, Fudan University, Shanghai, China included consecutive patients who underwent ECPR between January 2025 and August 2026. Outcome follow-up ended on September 10, 2026. Reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [8]. The Ethics Committee of Zhongshan Hospital, Fudan University approved the study (No. B2025-548R) and waived individual informed consent because the study used retrospective, de-identified clinical data.

## Study population

Patients were eligible if venoarterial extracorporeal membrane oxygenation (VA-ECMO) was initiated during ongoing cardiopulmonary resuscitation (CPR) for cardiac arrest. Patients who received VA-ECMO for other indications were excluded. No age restriction was prespecified. The sample comprised all eligible patients during the study period; no formal sample-size calculation was performed.

## ECPR and post-cannulation management

The treating multidisciplinary team assessed ECPR candidacy according to the arrest circumstances, likelihood of a reversible cause, comorbidities, no-flow and low-flow times, and feasibility of rapid cannulation. Peripheral VA-ECMO was established mainly through femoral venous drainage and femoral arterial return. Distal limb perfusion was used when clinically indicated. ECMO flow, vasoactive therapy, ventilation, anticoagulation, and renal replacement therapy were adjusted to the clinical condition. Coronary or other definitive interventions, intra-aortic balloon pump support, and left ventricular unloading were used as indicated.

## Data collection and time points

Data were extracted from electronic medical records and ECMO records. These included demographic characteristics, arrest circumstances, rhythm immediately before ECMO initiation, presumed cause, no-flow and low-flow times, total CPR duration, cumulative epinephrine dose, time from ECPR activation to effective flow, ECMO duration, adjunctive treatments, and outcomes.

Lactate, mean arterial pressure (MAP), and vasoactive-inotropic score (VIS) were recorded at the first available assessment after effective extracorporeal flow was established (T0), at 6 h (±1 h), at 24 h (±4 h), and at the final assessment. These were shared nominal assessment times; exact synchronization of individual measurements could not be verified. VIS was calculated using the infusion rates recorded at each assessment time point [9]. A VIS of 0 indicated no administration of the vasoactive or inotropic agents included in the score.

Sequential Organ Failure Assessment (SOFA) scores were calculated using contemporaneous values at T0, 24 h, and the final assessment. During sedation, the Glasgow Coma Scale (GCS) was assigned a value of 3 for SOFA calculation. The final assessment used the 72-h measurement or, for patients who died or were decannulated earlier, the last measurement before death or decannulation. It is therefore described as 72 h/last available. SOFA scores were treated as supportive measures because of missing data and sedation-related GCS assignment.

**Definitions and outcomes**

Lactate clearance was calculated as [(T0 lactate - follow-up lactate)/T0 lactate] x 100%. Values reported as >20 mmol/L were entered as 20 mmol/L and values reported as <1 mmol/L as 1 mmol/L. No-flow time was defined as the interval from cardiac arrest to the initiation of chest compressions. Low-flow time was defined as the interval from the initiation of chest compressions to establishment of effective ECMO flow, excluding intervals of return of spontaneous circulation (ROSC). Chest compressions were discontinued once effective ECMO flow was established. Total CPR duration therefore corresponded to low-flow time; both excluded no-flow time and intervals of ROSC.

ECMO duration was measured from initiation to discontinuation. For patients transferred while receiving ECMO, duration was censored at departure from the study hospital; transfer was not counted as successful weaning. Successful weaning was defined as decannulation without immediate reinstitution of extracorporeal support.

The primary outcome was survival to hospital discharge. Analyses were restricted to hospital outcomes; 28-day and 90-day outcomes were not analyzed. In-hospital mortality included confirmed deaths before discharge, whether at the study hospital or after interhospital transfer. Hospital outcomes after interhospital transfer were ascertained by telephone follow-up. Final hospital outcomes were available for all 70 patients by the follow-up cutoff. Favorable neurological outcome was defined as a Cerebral Performance Category (CPC) score of 1 or 2 at discharge [10].

## Statistical analysis

Continuous variables are reported as median (interquartile range [IQR]) and categorical variables as number (%). All 70 patients were included in outcome-group comparisons. We used the Mann-Whitney U test with asymptotic, tie-corrected variance and continuity correction for continuous variables and Fisher's exact test for categorical variables. Serial measurements were analyzed using available observations at each time point, without imputation. Lactate-clearance analyses required paired T0 and follow-up measurements. Comparisons at individual time points were exploratory, with no adjustment for multiple testing. Quartiles were calculated by linear interpolation. Rhythm immediately before ECMO initiation was classified as ventricular fibrillation or pulseless ventricular tachycardia (VF/VT), pulseless electrical activity (PEA), or asystole. For the binary comparison, VF/VT was compared with PEA or asystole. These records did not represent the initial arrest rhythm.

Exploratory logistic regression examined the association between 24-h lactate clearance and hospital survival, adjusting for low-flow time because of its clinical relevance to ECPR outcome [7]. Clearance was scaled per 10-percentage-point increase and low-flow time per 10-min increase. These analyses were conditional on availability of T0 and nominal 24-h lactate measurements, low-flow time, and the outcome. They did not estimate prognosis at cannulation. Exact sampling and event timestamps were insufficient to verify a fixed 24-h risk set; consequently, this was not a formal landmark analysis, and measurement availability was not equated with confirmed survival to exactly 24 h. The small number of survivors limited adjustment to one covariate at a time. No prediction model or clinical cut-off was developed.

We repeated final-assessment comparisons in patients with recorded ECMO support of at least 72 h, using final values assigned under the data-collection protocol. Exact sampling timestamps were unavailable. We also replaced low-flow time with out-of-hospital cardiac arrest (OHCA), age, or pre-ECMO shockable rhythm in separate two-variable models. The rhythm-adjusted analysis was added after rhythm data were completed and was exploratory. In an additional exploratory

comparison, we fitted a model containing absolute 24-h lactate and low-flow time in the same 45 patients as the clearance model. Akaike information criterion (AIC; lower values indicate better relative fit) was compared descriptively; these models were not externally validated.

Characteristics of patients included in and excluded from the clearance model were summarized without hypothesis testing. In a post hoc sensitivity analysis, we excluded the two patients aged <18 years, repeated serial outcome-group comparisons, and checked whether regression and 72-h subgroup membership changed.

Analyses used Python 3.12, NumPy 2.3.5, and SciPy 1.17.0. Logistic regression used maximum likelihood estimation with Wald confidence intervals and tests. All tests were two-sided, with $P<0.05$ considered statistically significant.

### Use of artificial intelligence

During preparation of this work, the authors used ChatGPT (OpenAI) to assist with language editing, manuscript organization, and generation of code for statistical recalculation and figure preparation. The authors are responsible for verifying the data, code, results, and final manuscript and take full responsibility for the content.

## Results

### Study population and outcomes

The cohort included 70 patients aged 11-92 years, including two patients younger than 18 years. By September 10, 2026, 19 patients (27.1%) had survived to discharge and 51 (72.9%) had died before hospital discharge. Sixteen patients had a favorable neurological outcome at discharge (Cerebral Performance Category 1-2; 22.9%). Twenty-six patients (37.1%) were successfully weaned from ECMO (Figure 1).

## Figure legends

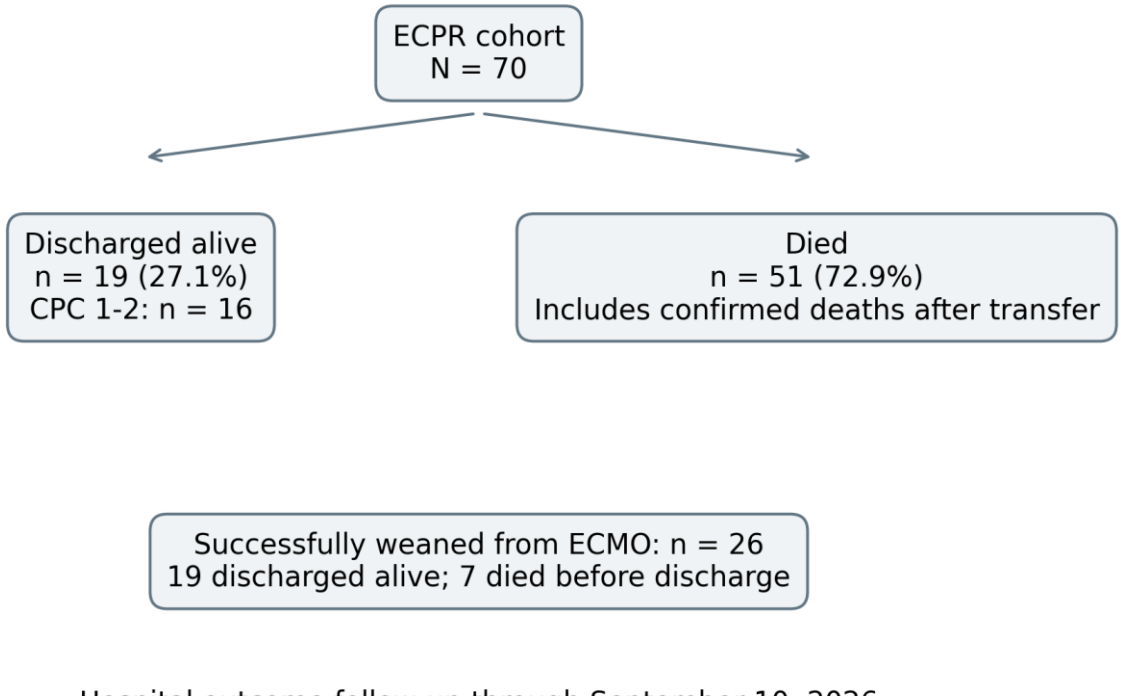



Figure 1. Study cohort and hospital outcomes. All 70 patients had final hospital outcomes: 19 survived to discharge and 51 died, including confirmed deaths after transfer. Sixteen patients had a discharge CPC score of 1-2. Of 26 patients successfully weaned from ECMO, 19 survived to discharge and seven died before discharge. ECPR, extracorporeal cardiopulmonary resuscitation; ECMO, extracorporeal membrane oxygenation; CPC, Cerebral Performance Category.

## Patient characteristics and ECMO support duration

Baseline characteristics are shown in Table 1. Survivors were older, had shorter low-flow times, received less epinephrine, and were less likely to have had out-of-hospital cardiac arrest. Rhythm immediately before ECMO initiation was available for all 70 patients. ECMO support lasted longer among survivors; this measure was considered descriptive because early death can shorten support duration.

## Tables

### Table 1. Patient characteristics and ECMO support duration by hospital outcome

| Variable | Overall (N=70) | Survivors (N=19) | Non-survivors (N=51) | P value |
|---|---|---|---|---|
| Age, years | 52.0 (43.0-62.0) | 62.0 (50.0-68.0) | 51.0 (40.0-61.0) | 0.0467 |
| BMI, kg/m² | 24.5 (22.8-26.2) | 24.2 (21.9-26.3) | 24.5 (23.5-26.2) | 0.373 |
| No-flow time, min | 0.0 (0.0-0.0) | 0.0 (0.0-0.0) | 0.0 (0.0-1.0) | 0.354 |
| Low-flow time, min | 60.0 (40.0-77.0) | 48.0 (27.5-60.0) | 63.0 (50.0-79.8) | 0.016 |
| Epinephrine dose, mg | 10.0 (5.0-13.0) | 5.0 (2.0-10.0) | 10.0 (5.0-14.0) | 0.012 |
| ECPR activation-to-flow, min | 20.0 (15.0-30.8) | 20.0 (15.0-30.0) | 22.0 (15.5-32.0) | 0.508 |
| ECMO support duration, h | 68.1 (15.9-114.3) | 90.0 (76.4-117.4) | 30.4 (11.7-106.4) | 0.009 |
| Male sex | 59/70 (84.3%) | 15/19 (78.9%) | 44/51 (86.3%) | 0.474 |
| Out-of-hospital cardiac arrest | 37/70 (52.9%) | 5/19 (26.3%) | 32/51 (62.7%) | 0.008 |
| Witnessed cardiac arrest | 66/70 (94.3%) | 19/19 (100.0%) | 47/51 (92.2%) | 0.568 |
| Bystander CPR | 56/70 (80.0%) | 17/19 (89.5%) | 39/51 (76.5%) | 0.322 |
| Pre-ECMO VF/VT | 41/70 (58.6%) | 15/19 (78.9%) | 26/51 (51.0%) | 0.055 |
| Pre-ECMO PEA | 3/70 (4.3%) | 1/19 (5.3%) | 2/51 (3.9%) | — |
| Pre-ECMO asystole | 26/70 (37.1%) | 3/19 (15.8%) | 23/51 (45.1%) | — |
| Acute coronary syndrome etiology | 41/70 (58.6%) | 12/19 (63.2%) | 29/51 (56.9%) | 0.786 |
| Mechanical CPR | 58/70 (82.9%) | 15/19 (78.9%) | 43/51 (84.3%) | 0.723 |

Data are median (IQR) or n/N (%). Comparisons include 19 survivors and 51 non-survivors, including confirmed deaths after transfer. Continuous variables were compared using the two-sided Mann-Whitney U test and categorical variables using Fisher's exact test. Available N (survivors/non-survivors): BMI 19/49; no-flow 19/47; low-flow 19/48; epinephrine 16/44; ECMO duration 19/49; other continuous variables 19/51. Rhythm was recorded immediately before ECMO initiation, not at the onset of arrest. The P value compares VF/VT with PEA or asystole using Fisher's exact test; the three rhythm categories are described without separate tests. VF, ventricular

fibrillation; VT, pulseless ventricular tachycardia; PEA, pulseless electrical activity. ECMO duration is a post-baseline descriptive measure. BMI, body mass index; CPR, cardiopulmonary resuscitation; ECPR, extracorporeal cardiopulmonary resuscitation; ECMO, extracorporeal membrane oxygenation; IQR, interquartile range. Total CPR duration and low-flow time were equivalent under the study definition.

**Lactate and lactate clearance**

Lactate at T0 did not differ significantly between outcome groups. Survivors had lower lactate at 6 h and 24 h and at the mixed final assessment (Table 2, Figure 2). Six-hour clearance did not differ significantly. Twenty-four-hour clearance was higher among survivors [76.86% (63.71-83.26) vs 49.13% (24.30-70.54), P=0.002]. The adjusted analysis included 45 patients (18 survivors and 27 non-survivors). Each 10-percentage-point increase in clearance was associated with higher odds of hospital survival after adjustment for low-flow time (odds ratio [OR] 1.56, 95% confidence interval [CI] 1.12-2.18; P=0.008). Of the 25 excluded patients, 24 lacked 24-h lactate and one lacked T0 lactate; three also lacked low-flow time. Included patients had shorter median low-flow time (58 vs 71 min), less frequent OHCA (42.2% vs 72.0%), and higher hospital survival (40.0% vs 4.0%) than excluded patients (Additional file 1: Table S4).

**Table 2. Serial physiological changes after ECPR according to in-hospital outcome**

| Variable and assessment | Overall | Survivors | Non-survivors | P value |
|---|---|---|---|---|
| Lactate, mmol/L<br>T0 | 12.00 (7.04-15.41)<br>(n=62) | 10.32 (5.30-13.73)<br>(n=18) | 12.71 (8.12-15.50)<br>(n=44) | 0.107 |
| Lactate, mmol/L<br>6 h | 6.37 (3.47-11.10)<br>(n=55) | 4.90 (2.66-7.47)<br>(n=19) | 7.10 (4.38-11.29)<br>(n=36) | 0.038 |
| Lactate, mmol/L<br>24 h | 2.84 (1.72-5.52)<br>(n=46) | 1.72 (1.45-2.22)<br>(n=19) | 4.42 (2.84-8.41)<br>(n=27) | <0.001 |
| Lactate, mmol/L<br>72 h/last | 2.58 (1.27-6.61)<br>(n=54) | 1.27 (1.13-1.70)<br>(n=18) | 4.33 (2.52-10.98)<br>(n=36) | <0.001 |

| Variable and assessment | Overall | Survivors | Non-survivors | P value |
|---|---|---|---|---|
| VIS<br>T0 | 0.33 (0.00-33.00)<br>(n=69) | 6.00 (0.00-35.22)<br>(n=19) | 0.00 (0.00-30.25)<br>(n=50) | 0.632 |
| VIS<br>6 h | 15.00 (0.00-50.00)<br>(n=57) | 16.00 (3.00-35.34)<br>(n=19) | 14.00 (0.00-65.00)<br>(n=38) | 0.972 |
| VIS<br>24 h | 14.00 (0.00-32.00)<br>(n=47) | 14.00 (0.00-21.84)<br>(n=19) | 19.00 (0.00-54.75)<br>(n=28) | 0.272 |
| VIS<br>72 h/last | 7.00 (0.00-39.50)<br>(n=59) | 0.00 (0.00-5.50)<br>(n=19) | 27.30 (0.00-77.00)<br>(n=40) | <0.001 |
| MAP, mmHg<br>T0 | 63.00 (50.00-74.00)<br>(n=57) | 71.00 (62.50-74.00)<br>(n=19) | 55.50 (45.25-67.50)<br>(n=38) | 0.027 |
| MAP, mmHg<br>6 h | 67.00 (55.00-78.00)<br>(n=51) | 76.00 (69.00-82.50)<br>(n=19) | 60.50 (51.50-74.50)<br>(n=32) | 0.004 |
| MAP, mmHg<br>24 h | 72.00 (64.25-85.75)<br>(n=46) | 83.00 (73.50-94.00)<br>(n=19) | 69.00 (56.50-85.00)<br>(n=27) | 0.005 |
| MAP, mmHg<br>72 h/last | 71.00 (54.00-82.00)<br>(n=53) | 79.00 (74.50-88.50)<br>(n=19) | 62.00 (46.25-76.00)<br>(n=34) | <0.001 |
| Lactate clearance, %<br>6 h | 32.91 (11.87-57.97)<br>(n=53) | 43.09 (15.20-57.65)<br>(n=18) | 27.17 (11.80-58.12)<br>(n=35) | 0.393 |
| Lactate clearance, %<br>24 h | 66.17 (36.19-80.99)<br>(n=45) | 76.86 (63.71-83.26)<br>(n=18) | 49.13 (24.30-70.54)<br>(n=27) | 0.002 |
| SOFA<br>T0 | 9.00 (8.00-11.00)<br>(n=59) | 8.50 (7.00-9.75)<br>(n=18) | 9.00 (8.00-11.00)<br>(n=41) | 0.217 |
| SOFA<br>24 h | 11.00 (9.00-14.00)<br>(n=44) | 9.00 (8.00-13.00)<br>(n=17) | 12.00 (9.50-14.00)<br>(n=27) | 0.177 |
| SOFA<br>72 h/last | 12.00 (8.00-14.00)<br>(n=45) | 9.00 (7.00-12.75)<br>(n=18) | 13.00 (9.50-15.00)<br>(n=27) | 0.042 |

213 Values are median (IQR). Overall values summarize available observations from the 70-patient
214 cohort; n in each cell indicates the number of available observations. VIS = 0 indicates no
215 administration of agents included in the score at the assessment time. SOFA scores were calculated

using values at each assessment time; GCS was assigned as 3 during sedation. The final assessment is 72 h/last available: the 72-h measurement or the last measurement before earlier death or decannulation. P values are exploratory two-sided Mann-Whitney U tests without adjustment for multiple testing. ECPR, extracorporeal cardiopulmonary resuscitation; MAP, mean arterial pressure; VIS, vasoactive-inotropic score; SOFA, Sequential Organ Failure Assessment.

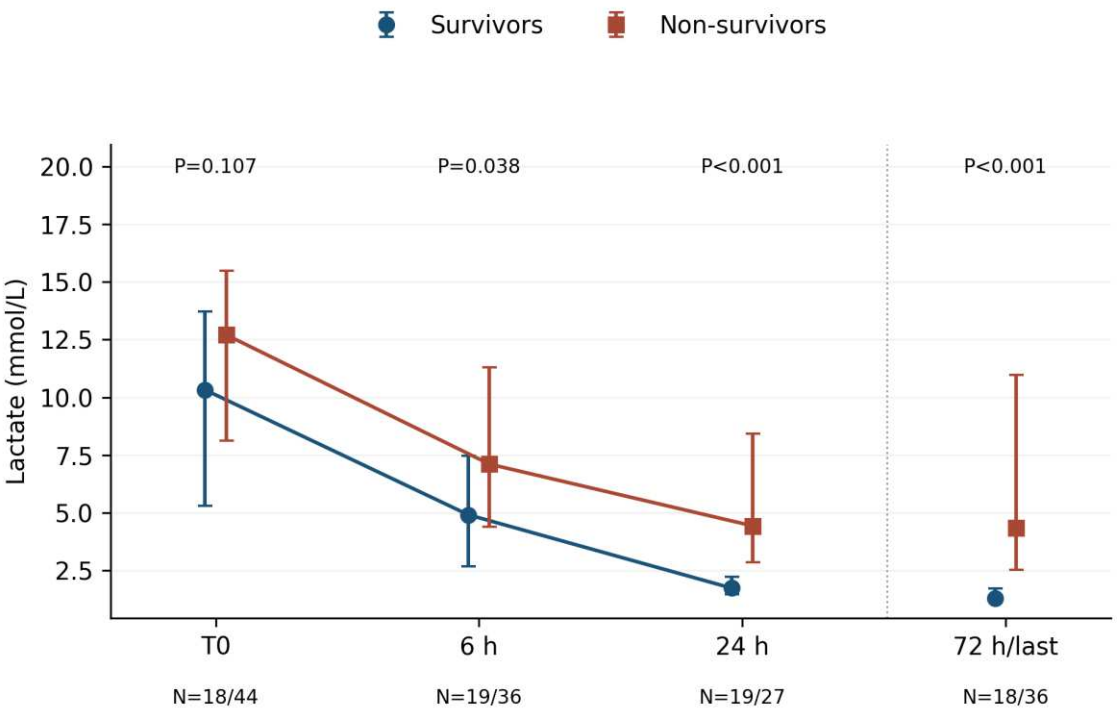



Figure 2. Lactate measurements after ECPR according to hospital outcome. Points show medians and error bars show interquartile ranges. N is reported as survivors/non-survivors. Lines connect group medians at scheduled assessments and do not represent individual patient trajectories. The separate final points combine 72-h measurements with the last measurements before earlier death or decannulation. P values are exploratory two-sided Mann-Whitney U tests without adjustment for multiple testing. ECPR, extracorporeal cardiopulmonary resuscitation.

**Hemodynamic and vasoactive-support changes**

MAP was higher among survivors from the first post-cannulation assessment (Table 2, Figure 3). VIS did not differ significantly during the first 24 h, but was lower among survivors at the mixed final assessment.

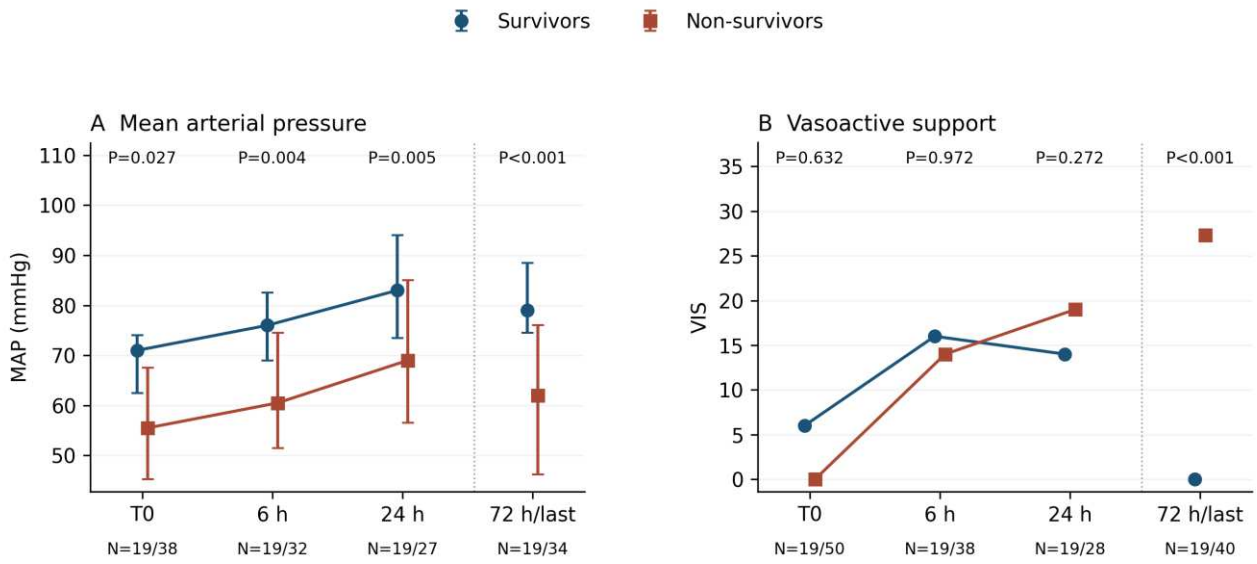



Figure 3. Hemodynamic and vasoactive support measurements after ECPR. (A) Mean arterial pressure (MAP) medians and interquartile ranges. (B) Vasoactive-inotropic score (VIS) medians. N is reported as survivors/non-survivors. Lines connect group medians at scheduled assessments. The separate final points use the 72 h/last available assessment. P values are exploratory two-sided Mann-Whitney U tests without adjustment for multiple testing. ECPR, extracorporeal cardiopulmonary resuscitation.

**Organ dysfunction and ECMO weaning**

SOFA scores did not differ significantly at T0 or 24 h. At the mixed final assessment, scores were lower among survivors, based on 45 available observations (Table 2). Of the 26 patients successfully weaned from ECMO, 19 survived to discharge and seven subsequently died in hospital.

**Sensitivity and additional analyses**

The subgroup with at least 72 h of recorded ECMO support included 32 patients (16 survivors and 16 non-survivors). Lactate was lower among survivors. The MAP comparison was close to the nominal significance threshold (P=0.0498); VIS and SOFA did not differ significantly (Additional file 1: Table S1). The primary clearance model is shown in Figure 4. Clearance remained associated with survival in separate models adjusting for OHCA, age, or pre-ECMO shockable rhythm (Additional file 1: Table S2).

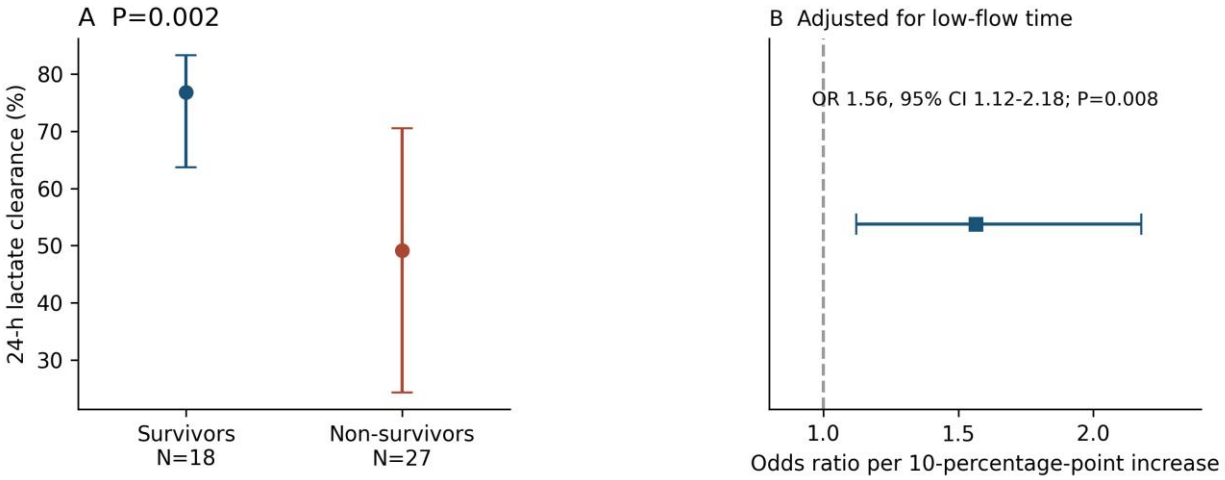



Figure 4. Twenty-four-hour lactate clearance and hospital survival. (A) Medians and interquartile ranges for survivors (N=18) and non-survivors (N=27), compared using a two-sided Mann-Whitney U test. (B) Odds ratio for hospital survival per 10-percentage-point increase in clearance, adjusted for low-flow time. The model included 45 patients (18 survivors and 27 non-survivors): OR 1.56, 95% CI 1.12-2.18; P=0.008. CI, confidence interval; OR, odds ratio.

In the same 45 patients, absolute 24-h lactate was also associated with survival after adjustment for low-flow time (OR per 1 mmol/L increase 0.57, 95% CI 0.36-0.92; P=0.022). AIC was 52.37 for the absolute-lactate model and 54.63 for the clearance model (Additional file 1: Table S3).

After exclusion of the two minors, 19 of 68 adults (27.9%) survived to discharge and 16 (23.5%) had CPC 1-2. The direction and nominal significance of serial comparisons were unchanged (Additional file 1: Table S5). Neither minor entered any regression model or the subgroup with at least 72 h of recorded ECMO support, so those analysis samples and estimates were unchanged.

## Discussion

In this cohort, survivors had lower lactate from 6 h and higher MAP from the first assessment, whereas VIS and SOFA did not differ significantly during the first 24 h. Assessing these routinely collected measurements within one cohort showed that differences in lactate and pressure were not accompanied by detectable differences in vasoactive requirements or organ dysfunction at the early

assessments. This pattern describes the course during support; differences in statistical significance do not establish a sequence of recovery.

Interpretation of the 24-h lactate findings depends on which patients had measurements available. Both clearance and absolute lactate were associated with hospital survival after adjustment for low-flow time, but survival was 40% among the 45 included patients and 4% among the 25 excluded patients. This difference makes selection by measurement availability central to interpretation. The estimates describe associations during ongoing care and do not establish prognosis at cannulation or the incremental predictive value of clearance.

Survivors had shorter low-flow times and received less epinephrine, consistent with earlier evidence relating resuscitation duration to ECPR outcome [7]. The differing results of randomized trials also emphasize the importance of patient selection and systems of care [2-5]. Our lactate findings are consistent with previous ECPR and VA-ECMO studies [11-13]. Absolute 24-h lactate had a modestly lower AIC than clearance, but this descriptive comparison does not establish predictive superiority. Lactate is also affected by catecholamine exposure and hepatic metabolism and is not a direct measure of tissue perfusion [13].

MAP and VIS need to be interpreted in the context of ECMO support. MAP was higher among survivors from T0, although VIS did not differ significantly during the first 24 h. Previous studies have linked higher vasoactive requirements to adverse outcomes in VA-ECMO and cardiogenic shock [9,14]. Arterial pressure during ECPR depends on ECMO flow, native cardiac output, vascular tone, and drug treatment. A maintained MAP may therefore coexist with hyperlactatemia or a substantial need for support. Our data do not identify a MAP target or show that a change in vasoactive treatment improves outcome.

SOFA findings were less consistent. The difference at the mixed final assessment was not reproduced in the subgroup with at least 72 h of recorded support. Missing observations, assessment timing, and sedation-related GCS assignment limit interpretation. Seven of the 26 successfully weaned patients died before discharge, illustrating that decannulation and hospital survival are

distinct outcomes. Death after successful VA-ECMO weaning has also been reported elsewhere [15].

Prospective studies with standardized sampling and complete event timestamps could clarify changes during support while accounting for death and decannulation. This question differs from baseline risk estimation with scores such as SAVE, which was developed for refractory cardiogenic shock [16].

In clinical practice, lactate and arterial pressure should be considered alongside the treatment required to maintain circulation. These observational findings do not establish treatment targets, weaning criteria, or thresholds for withdrawing support.

### Limitations

Several limitations affect interpretation. This was a retrospective study at one center, with 19 hospital survivors. The adjusted analysis included 45 patients and 18 survivors, limiting precision and control of confounding. The adult-only sensitivity analysis was consistent with the full-cohort findings, but did not provide independent model validation. Patient selection and care practices may differ across ECPR programs, limiting generalizability.

Measurements were incomplete and obtained during routine care. Availability of paired measurements selected patients with substantially better hospital outcomes. Many excluded patients had early death or transfer recorded, although exact death times relative to ECMO initiation were not consistently verifiable. This selection may distort the estimated association in either direction; its magnitude cannot be determined from these data. The mixed final assessment linked measurement timing to death or decannulation; exact sampling times could not be independently verified in the subgroup with at least 72 h of support. Assigning GCS 3 during sedation may have inflated SOFA scores and confounded changes with sedation practice. Component scores were unavailable for recalculation without the neurological component.

Rhythm was recorded immediately before ECMO initiation; initial arrest rhythm was not reliably available as a separate variable. Each sensitivity model adjusted for only one covariate, leaving residual confounding. Repeated comparisons, the absence of multiplicity adjustment, and evaluation of both lactate models in the same small dataset make these findings exploratory. ECMO duration and weaning are affected by survival time and treatment decisions. Substitution of assay-limit values may also have affected calculated lactate clearance.

## Conclusion

In this single-center ECPR cohort, survivors had lower lactate and higher MAP at early assessments, while VIS and SOFA differed only at the mixed final assessment. Both 24-h lactate clearance and absolute lactate were associated with hospital survival among patients with available measurements. These conditional associations do not establish prognosis at cannulation, and the observed group differences do not define a sequence of physiological recovery.

## List of abbreviations

AIC, Akaike information criterion; BMI, body mass index; CI, confidence interval; CPC, Cerebral Performance Category; CPR, cardiopulmonary resuscitation; ECMO, extracorporeal membrane oxygenation; ECPR, extracorporeal cardiopulmonary resuscitation; GCS, Glasgow Coma Scale; IHCA, in-hospital cardiac arrest; IQR, interquartile range; MAP, mean arterial pressure; OHCA, out-of-hospital cardiac arrest; OR, odds ratio; PEA, pulseless electrical activity; SAVE, Survival After Veno-arterial ECMO; SOFA, Sequential Organ Failure Assessment; STROBE, Strengthening the Reporting of Observational Studies in Epidemiology; T0, first available assessment after effective extracorporeal flow; VA-ECMO, venoarterial extracorporeal membrane oxygenation; VF, ventricular fibrillation; VIS, vasoactive-inotropic score; VT, ventricular tachycardia.

## Declarations

### Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Zhongshan Hospital, Fudan University (No. B2025-548R). The requirement for individual informed consent was waived because this retrospective study used de-identified clinical data.

### Consent for publication

Not applicable. This manuscript reports aggregate results and contains no identifiable individual patient information.

### Availability of data and materials

The de-identified data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to applicable ethical and institutional requirements.

### Competing interests

The authors declare that they have no competing interests.


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### Authors' contributions

HD, ZY, and JH collected the data, performed the statistical analyses, and drafted the manuscript. SL, SW, DC, ZK, and MX contributed to data collection and statistical analysis. CY and GG designed and supervised the study and critically revised the manuscript. All authors read and approved the final manuscript.

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**Additional files**

Additional file 1. Additional_file_1.docx. Supplementary analyses. Table S1: final assessments in patients with at least 72 h of recorded ECMO support. Table S2: exploratory lactate-clearance regression models. Table S3: comparison of absolute 24-h lactate and clearance models in the same 45 patients. Table S4: characteristics of patients included in and excluded from the clearance model. Table S5: adult-only sensitivity analysis excluding two patients aged <18 years.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

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