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# Veno-arterial extracorporeal membrane oxygenation uses in trauma: a retrospective analysis of the Japanese nationwide trauma registry

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## Abstract

**Background** Extracorporeal membrane oxygenation (ECMO) can provide temporary circulatory support and vital organ oxygenation and is potentially useful as a bridge therapy in some trauma cases. We aimed to demonstrate the characteristics and outcomes of patients with trauma treated with veno-arterial ECMO (V-A ECMO) using data from a Japanese nationwide trauma registry.

**Methods** This retrospective descriptive study analyzed data from the Japan Trauma Data Bank between January 2019 and December 2021. Patients with severe trauma (injury severity score [ISS] ≥ 9) and treated using V-A ECMO were assessed.

**Results** Among the 72,439 patients with severe trauma, 51 received V-A ECMO. Sixteen patients (31.3%) survived until hospital discharge. On hospital arrival, six (37.5%) survivors and 15 (42.9%) non-survivors experienced cardiac arrest. The median ISS for the survivor and non-survivor group was 25 (range, 25–39) and 25 (range, 17–33), respectively. Thoracic trauma was the most common type of trauma in both groups. In the non-survivor group, open-chest cardiopulmonary resuscitation, aortic cross-clamping, and resuscitative endovascular balloon occlusion of the aorta were performed in 10 (28.6%), 5 (14.3%), and 4 (11.4%) patients, respectively. However, these procedures were not performed in the survivor group. Peripheral oxygen saturation tended to be lower in the survivor group both before and upon arrival at the hospital.

**Conclusions** The results of this study suggest the potential benefit of V-A ECMO in some challenging trauma cases. Further studies are warranted to assess the indications for V-A ECMO in patients with trauma.

**Keywords** Cardiopulmonary resuscitation, Extracorporeal membrane oxygenation, Hemorrhagic shock, Obstructive shock, Trauma

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## Background

The leading cause of death due to trauma is hemorrhage [1]. However, other causes, including severe hypoxia due to lung injury and obstructive shock due to cardiac tamponade, can also cause death from trauma. Although immediate and appropriate management by trauma specialists is ideal for saving patients, trauma specialists are not always available in many countries. Temporal respiratory and circulatory support as a bridge therapy to surgical stabilization by either of DCS or definitive surgery might be effective in such conditions.

Extracorporeal membrane oxygenation (ECMO) is commonly used in non-trauma patients, such as those with cardiogenic shock, pulmonary embolism, or respiratory failure. Although ECMO can potentiate risk of exacerbating trauma coagulopathy and has the potential risk of exacerbating traumatic coagulopathy through heparin-coated circuits, considering the nature of temporary circulatory support as well as oxygenation of vital organs, it can be an option as a bridging therapy to definitive treatment in some trauma cases [2–5]. However, due to the limited number of cases, a consensus for the indication of veno-arterial (V-A) ECMO in trauma cases has not been reached.

Successful management of cases using veno-venous (V-V) ECMO for severe hypoxia related to trauma itself or volume overload has been reported recently [1–3]. Additionally, there have been a few reports of V-A ECMO use for deteriorated circulatory status related to trauma or traumatic injury such as cardiac contusion leading to cardiogenic shock [6–11]. The Extracorporeal Life Support Organization (ELSO) international registry report analyzed 32 trauma cases treated with V-A ECMO [12] and described the setting and management of ECMO; however, detailed patient trauma-related characteristics, including trauma severity, were not clear [12]. Therefore, this study aimed to demonstrate the characteristics and outcomes of patients with trauma treated with V-A ECMO using a Japanese nationwide trauma registry.

## Methods

### Study design and settings

This was a retrospective descriptive study using data from the Japan Trauma Data Bank (JTDB) between January 2019 and December 2021. The JTDB is a nationwide trauma registry established in 2003, and all patients with trauma with an abbreviated injury scale (AIS) [13] score of 3 or higher, regardless of the injured anatomical site, must be registered. Since the registration regulation was revised in 2019, the distinction between V-A ECMO and V-V ECMO has been enabled in the JTDB. During the study period, the JTDB registered records from 303 hospitals. The database contains information on the mechanism of injury, prehospital time course, and baseline characteristics of patients, including vital signs at the scene of injury and upon arrival at the emergency department, procedures performed, and survival status at hospital discharge. The procedures performed in the emergency and operating rooms after admission to the ward are also recorded. The characteristics of these patients, including the injury site, anatomical trauma severity, and physiological status, were assessed.

This study complied with the principles of the 1964 Declaration [14] of Helsinki and its amendments and was approved by the Ethics Committee of Tsuchiura Kyodo General Hospital (approval number: 2023FY119). The requirement for informed consent was waived because of the retrospective nature of the study. The Ethics Committee of Tsuchiura Kyodo General Hospital waived the requirement for informed consent. The opt-out method, which provided opportunities to refuse to participate in the study through online information disclosure at our hospital, was used. All of these details were approved by the Ethics Committee of Tsuchiura Kyodo Hospital.

### Patient selection

Patients who suffered trauma with an injury severity score (ISS) [15] of at least 9 points were transported to a hospital between January 2019 and December 2021 and were treated with peripheral V-A ECMO were included. Patients aged < 15 years were excluded.

### Data collection

The following patient information was collected from the JTDB: age, sex, year of injury, prehospital vital signs (systolic blood pressure, heart rate, and respiratory rate), time from emergency medical service (EMS) dispatch to arrival at the emergency department, prehospital care, vital signs on arrival at the emergency department (systolic blood pressure, heart rate, and respiratory rate), Glasgow coma scale scores, lactate, AIS, ISS, resuscitative procedures, surgery, endovascular treatment, survival status at hospital discharge, and time to death or discharge. Because the JTDB is a general trauma registry and not an ECMO-specific database, information on the time, indication, procedure, management, and duration of V-A ECMO was not available.

### Statistical analysis

Statistical analyses were performed using R 4.3.1 (R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics were used to display categorical variables as counts and percentages and numerical or ordinal variables as medians and 25th to 75th percentiles. Survival curves were generated using Kaplan–Meier estimation and compared using log-rank tests. As the exploratory analysis, a multivariate Cox hazards regression analysis adjusted by Trauma and Injury Severity

Score(TRISS) - Probability of survival (Ps) [16] was performed. The level of significance was defined as two-sided $p<0.05$ for all statistical analyses.

## Results

Of the 72,439 patients with trauma with an ISS of 9 or higher, V-A ECMO was used in 51 patients, of whom 16 (31.3%) were discharged alive (Fig. 1). Regarding patient backgrounds, the median ages of the survivor and non-survivor groups were 50 (range, 20–73) and 52 (range, 40–70) years, respectively. Regarding sex, 11 (68.8%) and 29 (82.9%) patients were male in the survivor and non-survivor groups, respectively. Blunt trauma accounted for 11 (68.8%) and 26 (74.3%) patients in the survivor and non-survivor groups, respectively; the times from EMS dispatch to hospital arrival were 41 (range, 33–60) and 37 (range, 26–48) minutes, respectively (Table 1).

The JTDB data from 2019 to 2021 enrolled 88,817 patients. Of these, minor trauma patients with an ISS of 8 points or less were excluded, resulting in 72,439 patients. Among them, 51 patients used V-A ECMO. V-A ECMO and V-V ECMO were clearly distinguished in this database, and 51 patients were included in the current study. Of these, 16 patients were discharged alive, and 31 were discharged deceased. ECMO, Extracorporeal Membrane Oxygenation; ISS, Injury Severity Score; JTDB, Japan Trauma Data Bank; V-A ECMO, Veno-Arterial Extracorporeal Membrane Oxygenation.

Prehospital interventions and vital signs are shown in Table 2. The median prehospital systolic blood pressure was 103 (range, 82–109) mmHg in the survivor group and 94 (range, 78–120) mmHg in the non-survivor group. Vital signs upon hospital arrival are summarized in Table 3. Six (37.5%) survivors and 15 (42.9%) non-survivors experienced cardiac arrest. Systolic blood pressure was 69 (range, 0–102) mmHg in the survivor group and 40 (range, 0–90) mmHg in the non-survivor group, both of which were lower than the prehospital systolic blood pressure.

Regarding anatomical severity, thoracic trauma was the most common in the survivor and non-survivor groups. The median ISS for the survivor and non-survivor groups was 25 (range, 25–39) and 25 (range, 17–33), respectively, while the revised trauma score (RTS) showed a difference of 3.79 (range, 0.00–6.90) and 1.90 (range, 0.00–3.90) for the survivor and non-survivor groups,

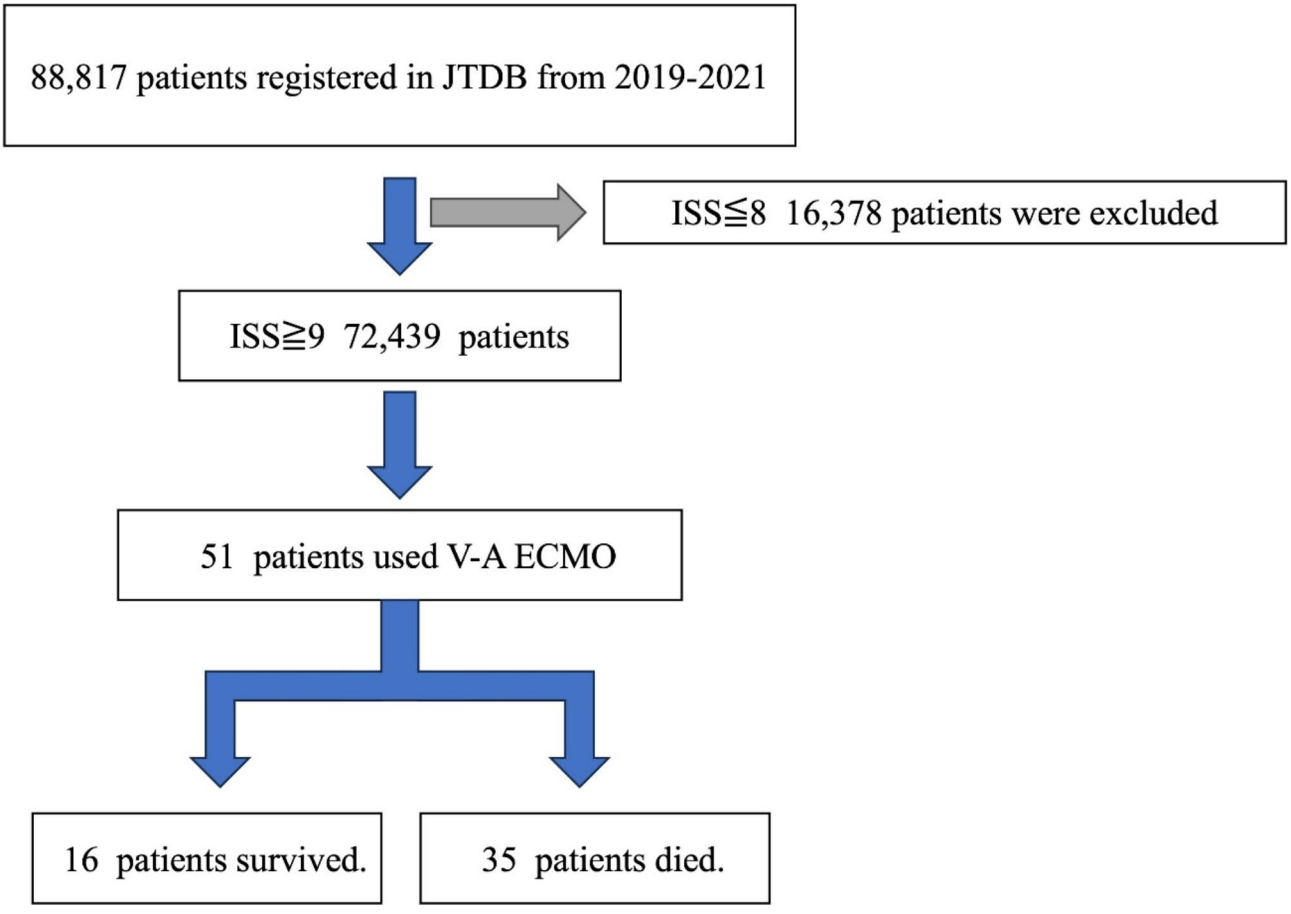


**Fig. 1** Case selection procedures

**Table 1** Patient background and trauma details

| | Survivors (*n* = 16) | Non-survivors (*n* = 35) | *p* value |
|---|---|---|---|
| **Age** (median [IQR]) | 50 [23–73] | 52 [40–70] | 0.590 |
| **sex** (%), male | 11 (68.8) | 29 (82.9) | 0.288 |
| **Type of trauma (%)** | | | |
| Blunt | 11 (68.8) | 26 (74.3) | 0.213 |
| Penetrate | 0 (0.0) | 4 (11.4) | |
| Other | 5 (31.2) | 5 (14.2) | |
| **Mechanism of injury** (%) | | | |
| Traffic accident | 8 (50.0) | 10 (28.6) | 0.141 |
| Railroad accident | 1 (6.2) | 0 (0.0) | 0.314 |
| Falling | 2 (12.5) | 12 (34.3) | 0.390 |
| External forces from objects or people | 3 (18.8) | 4 (11.4) | 0.076 |
| Clamping | 0 (0.0) | 2 (5.7) | 1 |
| Other | 1 (6.2) | 3 (8.5) | 1 |
| **Transport method** | | | |
| Ambulance (%) | 13 (81.2) | 25 (71.4) | 0.730 |
| Physician-staffed ambulance (%) | 2 (12.5) | 5 (14.3) | 1 |
| Physician-staffed helicopter (%) | 2 (12.5) | 7 (20.0) | 0.701 |
| **Time**; From EMS dispatch to hospital arrival (min) (median [IQR]) | 41 [33–60] | 37 [26–48] | 0.211 |
| **Time**; From onsite departure to hospital arrival (min) (median [IQR]) | 14 [9–17] | 12 [9–16] | 0.476 |
| **Past medical history (%)** | | | |
| Cerebrovascular disease | 1 (6.2) | 3 (8.6) | 1 |
| Dementia | 1 (6.2) | 0 (0.0) | 0.314 |
| Chronic lung disease | 0 (0.0) | 2 (5.7) | 1 |
| Peptic ulcer | 1 (6.2) | 0 (0.0) | 0.314 |
| Mild liver disease | 0 (0.0) | 2 (5.7) | 1 |
| Diabetes mellitus | 1 (6.2) | 4 (11.4) | 1 |
| None | 12 (75.0) | 27 (77.1) | 1 |
| **Charlson comorbidity index** (median [IQR]) | 0 [0–0] | 0 [0–0] | 1 |

IQR, interquartile range

**Table 2** Prehospital treatments and vital signs

| | Survivor (*n* = 16) | Non-survivor (*n* = 35) | *p* value |
|---|---|---|---|
| **Prehospital treatment (%)** | | | |
| Oxygen administration | 14 (87.5) | 25 (71.4) | 0.296 |
| Neck collar | 9 (56.2) | 11 (31.4) | 0.126 |
| Spinal motion restriction | 10 (62.5) | 16 (45.7) | 0.368 |
| Artificial respiration | 4 (25.0) | 9 (25.7) | 1 |
| Chest compressions | 4 (25.0) | 10 (28.6) | 1 |
| Intubation | 3 (18.8) | 5 (14.3) | 0.694 |
| Airway management | 6 (37.5) | 9 (25.7) | 0.510 |
| Intravenous drip | 5 (31.2) | 10 (28.6) | 1 |
| Thoracic drainage | 3 (18.8) | 0 (0.0) | 0.027 |
| Blood transfusion | 1 (6.2) | 0 (0.0) | 0.314 |
| **Prehospital vital signs** (median [IQR]) | | | |
| Systolic blood pressure | 103 [82–109] | 94 [78–120] | 0.979 |
| Diastolic blood pressure | 62 [42–77] | 50 [44–57] | 0.721 |
| Heart rate | 85 [47–125] | 88 [51–107] | 0.683 |
| Respiratory rate | 24 [14–28] | 24 [10–30] | 0.744 |
| $SpO_2$ | 91 [78–98] | 95 [90–98] | 0.326 |

IQR, interquartile range

respectively. Therefore, the probability of survival calculated by the trauma and injury severity score was 0.22 (range, 0.09–0.81) for the survivor group and 0.11 (range, 0.03–0.37) for the non-survivor group. There were three (18.8%) focused assessment with sonography for trauma-positive cases in the survivor group and 19 (26.5%) in the non-survivor group (Table 3).

Resuscitative procedures are summarized in Table 4. Concurrent use of V-V ECMO was performed in three (18.8%) survivors and three (8.6%) non-survivors. In the non-survivor group, open-chest cardiopulmonary resuscitation was performed in 10 patients (28.6%), aortic clamping in five patients (14.3%), and resuscitative endovascular balloon occlusion of the aorta in four patients (11.4%). However, these procedures were not performed on the survivors. Thoracic drainage was performed in seven (43.8%) survivors and 14 (40%) non-survivors. Regarding the type of surgery or interventional radiology, thoracotomy was performed more frequently in both groups: three (18.8%) cases in the survivor group and 11 (31.4%) in the non-survivor group. Laparotomy was performed in four (11.4%) of the non-survivors but only in one (6.2%) of the survivors. Figure 2 shows the survival curves of the 51 patients treated with V-A ECMO. The 28-day survival rate of all patients was 32.7%. A table ranking the most frequently injured trauma disease names in all patients by AIS code is shown in Online Resource 1. The exploratory multivariate analysis of V-A ECMO use, adjusted for TRISS Ps, revealed a hazard ratio of 0.411 (95% C.I. 0.13–1.29) (Online Resource 2).

This shows the survival curve for all 51 V-A ECMO patients, with a 28-day survival rate of 32.7% and a median survival time of 2 days.

## Discussion

We examined the characteristics of 51 patients with trauma treated with V-A ECMO. Of these, 16 (31.3%) were discharged alive. Our results suggest the potential benefit of V-A ECMO in some challenging trauma cases.

Reports on the use of V-A ECMO for the treatment of trauma are limited [6–8, 17]. This study analyzed a Japanese nationwide trauma database that provided more detailed trauma-related information than did a previous study using the ELSO registry [12] by Swol et al. We demonstrated the types of traumas, anatomical severity according to AIS and ISS, and other resuscitative treatments. Additionally, contrary to the ELSO registry analysis, which included both V-A ECMO and V-V ECMO, this study was completely dedicated to V-A ECMO. To the best of our knowledge, this study included the largest

**Table 3** Patient status upon hospital arrival and anatomical severity

| | Survivor ($n=16$) | Non-survivor ($n=35$) | $p$ value |
|---|---|---|---|
| **Cardiac arrest on hospital arrival (%)** | 6 (37.5) | 15 (42.9) | 0.768 |
| **Vital signs at the Emergency department** (median [IQR]) | | | |
| Systolic blood pressure | 69 [0–102] | 40 [0–90] | 0.474 |
| Diastolic blood pressure | 50 [0–75] | 0 [0–59] | 0.244 |
| Heart rate | 101 [45–124] | 50 [0–106] | 0.139 |
| Respiratory rate | 11 [0–25] | 0 [0–19.50] | 0.467 |
| $SpO_2$ | 93 [77–97] | 98 [95–100] | 0.065 |
| Body temperature | 34.9 [31.0–36.4] | 35.8 [32.7–36.5] | 0.700 |
| Glasgow Come Scale | 5 [3–9] | 3 [3–5] | 0.164 |
| **Lactate_(mmol/L)** (median [IQR]) | 4.7 [2.0–10.1] | 10.7 [6.2–16.3] | 0.041 |
| **FAST-Positive** (%) | 3 (18.8) | 19 (26.5) | 0.933 |
| **AIS** (median [IQR]) | | | |
| Head | 0 [0–4] | 0 [0–2] | 0.408 |
| Face | 0 [0–0] | 0 [0–0] | 0.952 |
| Neck | 0 [0–0] | 0 [0–0] | 0.143 |
| Thorax | 4 [0–5] | 3 [0–4] | 0.642 |
| Abdomen | 0 [0–1] | 0 [0 – 0] | 0.713 |
| Spinal or Spine | 0 [0–0] | 0 [0–0] | 0.759 |
| Upper limbs | 0 [0–0] | 0 [0–0] | 0.251 |
| Lower limbs | 0 [0–2] | 0 [0–2] | 0.904 |
| Surface | 0 [0–2] | 0 [0–0] | 0.449 |
| **ISS** (median [IQR]) | 25 [25–39] | 25 [17–33] | 0.429 |
| **RTS** (median [IQR]) | 3.79 [0.00–6.90] | 1.90 [0.00–3.90] | 0.224 |
| **TRISS Ps** (median [IQR]) | 0.22 [0.09–0.81] | 0.11 [0.03–0.37] | 0.158 |

FAST, Focused Assessment with Sonography in Trauma; AIS, Abbreviated Injury Scale; ISS, Injury Severity Score; IQR, interquartile range; RTS, Revised Trauma Score; TRISS, Trauma and Injury Severity Score; Ps, Probability of survival

number of cases in which V-A -ECMO was used to treat trauma.

Although assessing the association between V-A ECMO use and patient survival was impossible because of the limited number of cases and lack of detailed time-course information, we were able to compare the characteristics of the survivor and non-survivor groups. The anatomical severity defined by the ISS was similar in both groups. Although the vital signs at the scene of injury were similar, those upon hospital arrival were different. The non-survivor group had lower blood pressure, worse consciousness levels, and elevated lactate levels compared to the survivor group, indicating that their circulatory status worsened during transport. The deteriorated circulatory status resulted in a lower RTS and probability of survival in the non-survivor group. Notably, the $SpO_2$ value was lower in the survivor group than in the non-survivor group. While V-V ECMO is the first choice for poor oxygenation, the oxygenation circulatory support of V-A ECMO may have had a positive influence in case circulatory failure coexisted. Regarding the injured region, V-A ECMO was likely introduced for severe chest injury in both groups.

As this was a retrospective registry-based analysis, the introduction of VA-ECMO did not follow a specific protocol. Some patients may have survived without V-A ECMO. However, it is noteworthy that six patients (37.5%) in the survivor group and 15 (42.9%) in the non-survivor group had cardiac arrest on hospital arrival, which indicated that some of the most severe patients could survive using V-A-ECMO. Notably, none of the survivors underwent open-chest cardiopulmonary resuscitation, aortic cross-clamp, or resuscitative endovascular occlusion of the aorta. This suggests that patients with massive hemorrhage requiring aortic cross-clamping or aortic occlusion below the diaphragm are not good candidates for V-A ECMO.

The first touch in the emergency department for trauma cases is performed by an emergency physician in many Japanese hospitals other than limited resourceful hospitals. A trauma surgeon is uncommon in Japan, and a surgeon who can provide hemostatic surgery is not always available in many emergency hospitals [18, 19]. In addition, because immediate hemostatic surgery is often difficult, the use of bridging measures, such as V-A ECMO or REBOA, is more common in Japan than in the USA [20–23]. This describes the current characteristics of trauma care in Japan and how they differ from the global standard.

In light of these considerations, several possibilities exist for using V-A ECMO in trauma patients. First, V-A ECMO may prevent cardiac arrest when the heart

**Table 4** Treatment at the hospital

| | Survivor (*n* = 16) | Non-survivor (*n* = 35) | *p* value |
|---|---|---|---|
| **Blood Transfusion (within 24 h)** (median [IQR]) | | | |
| Red Blood Cell | 5 [1–18] | 21 [3–44] | 0.052 |
| Fresh Frozen Plasma | 11 [0–28] | 26 [2–51] | 0.116 |
| Platelet Cell | 0 [0–12] | 20 [0–30] | 0.140 |
| **Circulatory and respiratory care** | | | |
| Tracheal intubation (%) | 13 (81.2) | 30 (85.7) | 1 |
| Assisted breathing or Artificial respiration (%) | 9 (56.2) | 28 (80.0) | 0.099 |
| V-V ECMO (%) | 3 (18.8) | 3 (8.6) | 0.363 |
| Open-chest cardiopulmonary resuscitation (%) | 0 (0.0) | 10 (28.6) | 0.021 |
| Aortic cross clamp (%) | 0 (0.0) | 5 (14.3) | 0.167 |
| Resuscitative endovascular balloon occlusion of the aorta (%) | 0 (0.0) | 4 (11.4) | 0.295 |
| Thoracic drainage (%) | 7 (43.8) | 14 (40) | 0.547 |
| Pericardiocentesis (%) | 0 (0.0) | 5 (14.3) | 0.167 |
| **Operation/interventional radiology** | | | |
| Head, craniotomy | 1 (6.2) | 0 (0.0) | 0.314 |
| Face, operation | 1 (6.2) | 0 (0.0) | 0.314 |
| Neck, operation | 1 (6.2) | 2 (5.7) | 1 |
| **Thorax** | | | |
| Thoracotomy | 3 (18.8) | 11 (31.4) | 0.508 |
| Interventional radiology | 0 (0.0) | 2 (2.9) | |
| Other | 1 (6.2) | 1 (2.9) | |
| **Abdomen** | | | |
| Laparotomy | 1 (6.2) | 4 (11.4) | 0.295 |
| Interventional radiology | 0 (0.0) | 1 (2.9) | |
| **Extremities/Pelvis/Spine** | | | |
| Operation | 4 (25.0) | 1(2.9) | 0.027 |
| Interventional radiology | 0 (0.0) | 2 (5.7) | |
| Other | 1 (6.2) | 1 (2.9) | |

CPA, Cardiopulmonary resuscitation; IQR, interquartile range; V-V ECMO, Veno-Venous Extracorporeal membrane oxygenation

is repositioned to secure the surgical field during repair of the left heart system [8, 24]. Additionally, it could serve as a bridge until the obstruction is relieved in the operating room, particularly in patients nearing cardiac arrest due to obstructive shock from conditions such as cardiac tamponade or massive hemothorax. The second application is intraoperative. In cases of aortic injury [25] or cardiac injury, partial extracorporeal circulation with oxygenation from the femoral vein to the femoral artery can be used during aortic or cardiac repair [26], which can minimize ischemia in more peripheral organs than in the injured aorta or cardiac. Third, temporal circulatory stabilization is achieved after hemostatic surgery in patients unable to maintain their circulatory status due to extensive trauma and subsequent surgical interventions [7, 27]. Moreover, in certain instances, it has also served as a bridge to alleviate obstruction in the operating room during near-cardiac arrest scenarios induced by cardiac tamponade or massive hemothorax obstructive shock [28]. If a large number of vasopressors and fluids are required after hemostasis, mechanical support by V-A ECMO would be useful to reduce adverse events related to massive fluid infusion therapies. V-V ECMO is better than V-A ECMO as a temporary adjunct to hypoxia, and V-A ECMO seems to be a very good indication when it is accompanied by shock that is not hemorrhagic, i.e., cardiogenic shock. V-A ECMO is sometimes performed when cardiac function fails to return after cardiac repair post-injury or does not recover following hemostasis due to hemorrhagic shock or other reasons. Considering that 20 patients in this study experienced cardiac arrest upon hospital arrival, the most common reason for using V-A ECMO for trauma in Japan was considered to maintain circulation and oxygenation simultaneously during and after hemostatic surgery. It is difficult to clearly present the potential usefulness of V-A ECMO in trauma because our study is a retrospective observational study using a database with a small number of cases using V-A ECMO. Regarding vital signs, the patient's blood pressure was low but did not demonstrate cardiac arrest. No cases of fatal peripheral circulatory failure were recorded, with lactate levels exceeding 10. Similarly, no survivors were noted following resuscitative thoracotomy or REBOA in the emergency room. While pulmonary contusions generally indicate the use of V-V ECMO, V-A ECMO may

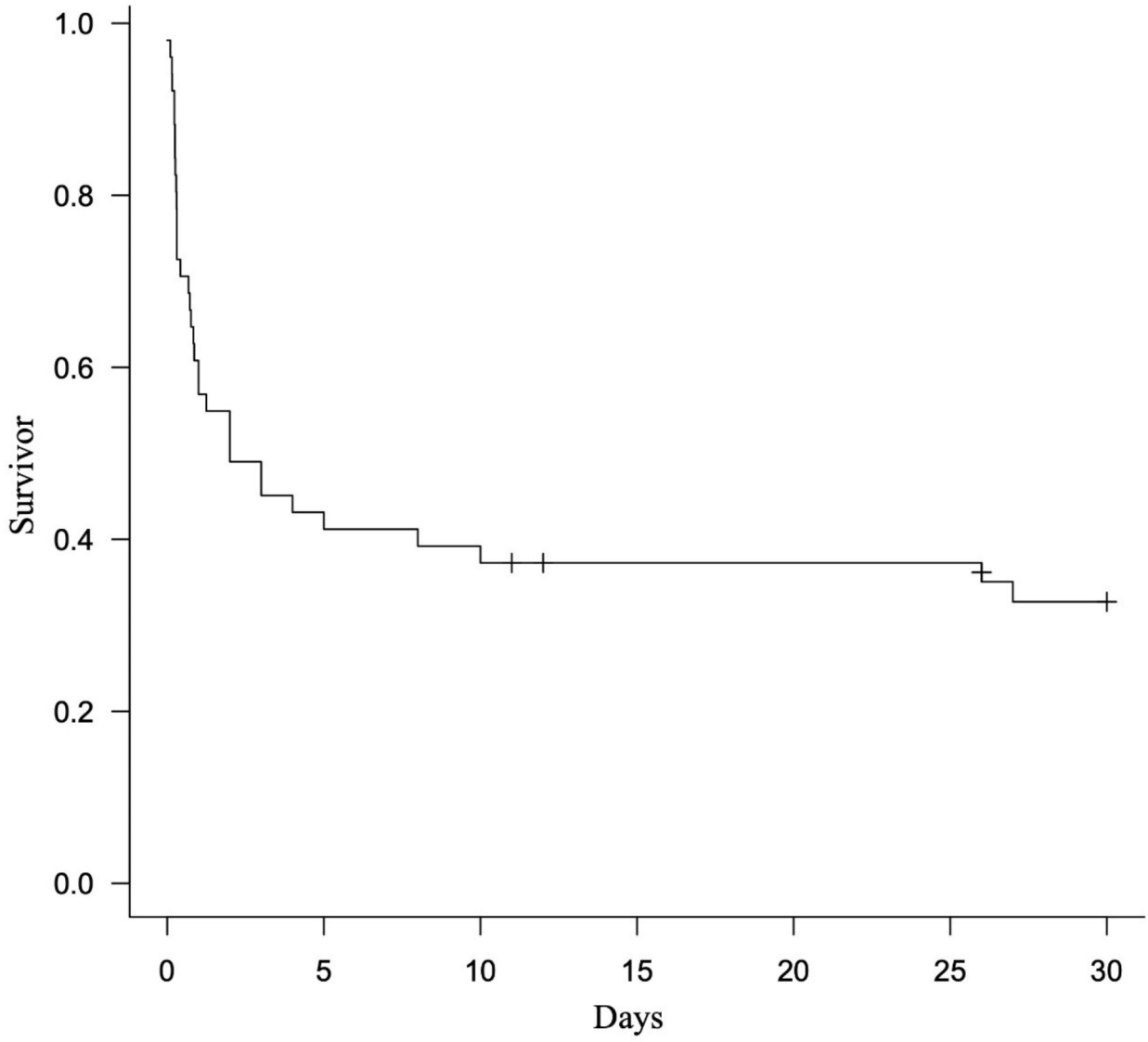


**Fig. 2** Survival curve of all cases

prove beneficial in cases of circulatory failure [4, 9, 27, 28] (Online Resource 1).

This study had some limitations. First, the reasons for introducing V-A ECMO were not clearly recorded. As mentioned, a detailed time course, including the chronological context of resuscitative thoracotomy or REBOA use, in the emergency department or operating room was unavailable. As the JTDB is not an ECMO-specific database, detailed ECMO-related information, such as the duration of circulatory support, device settings and use of heparin, was unclear. It is also unclear whether the patient was treated radically for V-A ECMO withdrawal. Second, owing to the lack of a specific protocol to introduce V-A ECMO, there may have been a selection bias. Because JTDB registers treatment actions that were actually performed, cases that were attempted but could not be performed (e.g., due to poor blood drawing) may not be included, which could be a serious bias. Third, due to the nature of registry-based analysis, registration errors may have occurred. However, this study has the strength of presenting rare cases of V-A ECMO use in severe trauma and reporting their detailed characteristics, including survival rates. These data will be useful for future studies to establish the indications for V-A ECMO in patients with severe trauma.

In conclusion, we described the characteristics, treatment interventions, and prognosis of severe trauma patients treated with V-A ECMO using the Japanese national trauma registry. Our results suggest the potential utility of V-A ECMO in some challenging trauma

cases. Therefore, further research is needed to use a common patient identification system for the ECMO and trauma databases; hence, information from both databases can be linked and analyzed if necessary.

**Abbreviations**

| | |
|---|---|
| AIS | Abbreviated injury scale |
| ECMO | Extracorporeal membrane oxygenation |
| ELSO | Extracorporeal Life Support Organization |
| EMS | Emergency medical service |
| FAST | Focused assessment with sonography for trauma |
| ISS | Injury severity score |
| JTDB | Japan Trauma Data Bank |
| TRISS | Trauma and Injury Severity Score |
| Ps | Probability of survival |
| MEWS | Modified Early Warning Score |
| RTS | Revised trauma score |
| VA-ECMO | Veno-arterial ECMO |
| VV-ECMO | Venovenous ECMO |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12873-024-01096-6.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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**Author contributions**
TA drafted and revised the manuscript, prepared the study concept and design, and performed the statistical analysis and data interpretation, as well as study supervision; AE revised the manuscript, prepared the study concept and design, and performed data interpretation; RY, KY, KS, and HH performed data acquisition and revised the manuscript; YO and KM revised the manuscript and performed data interpretation. All authors accept responsibility for the conduct of research and final approval and have read and approved the final manuscript.

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**Data availability**
An overview of the Japan Trauma Data Bank (JTDB) is available at http://www.jtcr-jatec.org/traumabank/index.htm. The detailed data in the JTDB, which support the findings of this study, are available from Japan Trauma Care and Research; however, restrictions apply to the availability of these data, which were used under license for the current study and, hence, are not publicly available. If you would like to use the data, please contact the Corresponding author: Akira Endo (akira.endo.0112@gmail.com).

## Declarations

**Ethics approval and consent to participate**
This study complied with the principles of the 1964 Declaration [12] of Helsinki and its amendments and was approved by the Ethics Committee of Tsuchiura Kyodo General Hospital (approval number: 2023FY119).

**Consent to publish**
Not applicable.

**Competing interests**
The authors declare no competing interests.

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**References**

1. Teeter W, Haase D. Updates in traumatic cardiac arrest. Emerg Med Clin North Am. 2020;38:891–901. https://doi.org/10.1016/j.emc.2020.06.009.
2. Cordell-Smith JA, Roberts N, Peek GJ, Firmin RK. Traumatic lung injury treated by extracorporeal membrane oxygenation (ECMO). Injury. 2006;37:29–32. https://doi.org/10.1016/j.injury.2005.03.027.
3. Cavarocchi NC. Introduction to extracorporeal membrane oxygenation. Crit Care Clin. 2017;33:763–6. https://doi.org/10.1016/j.ccc.2017.06.001.
4. Bosarge PL, Raff LA, McGwin G, Carroll SL, Bellot SC, Diaz-Guzman E, et al. Early initiation of extracorporeal membrane oxygenation improves survival in adult trauma patients with severe adult respiratory distress syndrome. J Trauma Acute Care Surg. 2016;81:236–43. https://doi.org/10.1097/TA.0000000000001068.
5. Bakowitz M, Bruns B, Mccunn M. Acute lung injury and the acute respiratory distress syndrome in the injured patient. Scand J Trauma Resusc Emerg Med. 2012;20:54. https://doi.org/10.1186/1757-7241-20-54.
6. Amos T, Bannon-Murphy H, Yeung M, Gooi J, Marasco S, Udy A, et al. ECMO (extra corporeal membrane oxygenation) in major trauma: a 10 year single centre experience. Injury. 2021;52:2515–21. https://doi.org/10.1016/j.injury.2021.03.058.
7. Lin CY, Tsai FC, Lee HA, Tseng YH. Extracorporeal membrane oxygenation support in post-traumatic cardiopulmonary failure: a 10-year single institutional experience. Medicine. 2017;96:e6067. https://doi.org/10.1097/MD.0000000000006067.
8. Tseng YH, Wu TI, Liu YC, Lin PJ, Wu MY. Venoarterial extracorporeal life support in post-traumatic shock and cardiac arrest: lessons learned. Scand J Trauma Resusc Emerg Med. 2014;22:12. https://doi.org/10.1186/1757-7241-22-12.
9. Strumwasser A, Tobin JM, Henry R, Guidry C, Park C, Inaba K, et al. Extracorporeal membrane oxygenation in trauma: a single institution experience and review of the literature. Int J Artif Organs. 2018;41:845–53. https://doi.org/10.1177/0391398818794111.
10. Arlt M, Philipp A, Voelkel S, Rupprecht L, Mueller T, Hilker M, et al. Extracorporeal membrane oxygenation in severe trauma patients with bleeding shock. Resuscitation. 2010;81:804–9. https://doi.org/10.1016/j.resuscitation.2010.02.020.
11. Misselbrook GP, Hameed SM, Garraway N, Al-Lawati R. VA-ECMO as a salvage strategy for blunt cardiac injury in the context of multisystem trauma. BMJ Case Rep. 2021;14(4):e241034. https://doi.org/10.1136/bcr-2020-241034. Published 2021 Apr 8.
12. Swol J, Brodie D, Napolitano L, Park PK, Thiagarajan R, Barbaro RP, et al. Indications and outcomes of extracorporeal life support in trauma patients. J Trauma Acute Care Surg. 2018;84:831–7. https://doi.org/10.1097/TA.0000000000001895.
13. Rating the Severity of Tissue Damage. JAMA. 1971;215:277.
14. World Medical Association. World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. Bull World Health Organ. 2001;79:373–4.
15. Baker SP, O'Neill B, Haddon W, et al. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. J Trauma. 1974;14:187–96.
16. Boyd CR, Tolson MA, Copes WS. Evaluating trauma care: the TRISS method. Trauma score and the Injury Severity score. J Trauma. 1987;27:370–8.

17. Grant AA, Hart VJ, Lineen EB, Lai C, Ginzburg E, Houghton D, et al. The impact of an advanced ECMO program on traumatically injured patients. Artif Organs. 2018;42:1043–51. https://doi.org/10.1111/aor.13152.
18. Sakamoto Y, Hakamada K. Current status and future prospects of acute care surgery in Japan. Nihon Rinsho Geka Gakkai Zasshi (J Jpn Surg Assoc). 2022;83:635–43. https://doi.org/10.3919/jjsa.83.635.
19. Morishita K, Coimbra R, Ito K, Otomo Y. The American Association for the surgery of trauma–European society of trauma and emergency surgery emergency surgery course: initial experience in Japan. J Trauma Acute Care Surg. 2023;95:e3–5. https://doi.org/10.1097/TA.0000000000003995.
20. Zhang Y, Zhang L, Huang X, Ma N, Wang P, Li L, et al. ECMO in adult patients with severe trauma: a systematic review and meta-analysis. Eur J Med Res. 2023;28:412. https://doi.org/10.1186/s40001-023-01390-2.
21. O'Connor JV, DuBose JJ, Scalea TM. Damage-control thoracic surgery: management and outcomes. J Trauma Acute Care Surg. 2014;77:660–5. https://doi.org/10.1097/TA.0000000000000451.
22. Lee HK, Kim HS, Ha SO, Park S, Lee HS, Lee SK, et al. Clinical outcomes of extracorporeal membrane oxygenation in acute traumatic lung injury: a retrospective study. Scand J Trauma Resusc Emerg Med. 2020;28:41. https://doi.org/10.1186/s13049-020-00733-w.
23. Broome JM, Ali A, Simpson JT, Tran S, Tatum D, Taghavi S, et al. Impact of time to emergency department resuscitative aortic occlusion after noncompressible torso hemorrhage. Shock. 2022;58:275–9. https://doi.org/10.1097/SHK.0000000000001988.
24. Huh U, Song S, Chung SW, Kim SP, Lee CW, Ahn HY, et al. Is extracorporeal cardiopulmonary resuscitation practical in severe chest trauma? A systematic review in single center of developing country. J Trauma Acute Care Surg. 2017;83:903–7. https://doi.org/10.1097/TA.0000000000001680.
25. Masroor S, Tehrani H, Pham S, Neijman T, Martinez-Ruiz R, McKenney M, et al. Extracorporeal life support in pulmonary failure after traumatic rupture of the thoracic aorta: a case report. J Trauma. 2004;57:389–91. https://doi.org/10.1097/01.ta.0000037285.52097.8c.
26. Lee SK, Gongora E, O'Donnell S, Carrillo EH, Sanchez R, Kiffin C, et al. Intraoperative rescue extracorporeal membrane oxygenation and damage control during repair of a traumatic aortic injury. J Surg Case Rep. 2017;2017:rjx022. https://doi.org/10.1093/jscr/rjx022.
27. Weidemann F, Decker S, Epping J, Örgel M, Krettek C, Kühn C, et al. Analysis of extracorporeal membrane oxygenation in trauma patients with acute respiratory distress syndrome: a case series. Int J Artif Organs. 2022;45:81–8. https://doi.org/10.1177/0391398820980736.
28. Trivedi JR, Alotaibi A, Sweeney JC, Fox MP, van Berkel V, Adkins K, et al. Use of extracorporeal membrane oxygenation in blunt traumatic injury patients with acute respiratory distress syndrome. ASAIO J. 2022;68:e60–1. https://doi.org/10.1097/MAT.0000000000001544.

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