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Safety of Interhospital Transport for Patients Receiving Extracorporeal Membranous Oxygenation Support

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ABSTRACT

OBJECTIVES: Patients receiving extracorporeal membranous oxygenation (ECMO) support often have fragile conditions that make them susceptible to physiological deterioration during interhospital transport (IHT). This study aimed to assess the safety of IHT for ECMO-supported patients, utilizing a dedicated critical care transport team.

METHODS: A retrospective analysis was conducted on patients who underwent IHT while receiving ECMO support in a metropolitan city between January 2016 and April 2024. The primary outcome was the occurrence of abnormal physiologic parameters during IHT, including hypotension (mean arterial pressure <65 mmHg), desaturation (pulse oximetry <90%), tachycardia (heart rate >120/min), and bradycardia (heart rate <50/min).

RESULTS: A total of 151 patients were included in the study, with 96 (59.6%) on Veno-arterial (VA)-ECMO and 55 (40.4%) on veno-venous (VV)-ECMO. Of these, 37.1% had experienced cardiac arrest prior to ECMO initiation. The median transport time from departure at the referring hospital to arrival at the receiving hospital was 25 minutes (interquartile range, 19–37 minutes). Several adverse events occurred during transport, including ECMO console shutdown in 8.9% of cases (n=10 spontaneous shutdowns, n=3 due to human error), all of which were appropriately managed by the trained transport team. Physiological parameters remained stable between the start and end of IHT, with a significant reduction in the prevalence of tachycardia ($p<0.01$).

CONCLUSIONS: Interhospital transport for ECMO-supported patients by a dedicated critical care transport team is safe. These findings support the implementation of specialized transport systems to facilitate the safe transfer of critically ill patients receiving ECMO support.

Keywords: Extracorporeal membranous oxygenation; interhospital transfer; Patient safety; Critical care transport

INTRODUCTION

Extracorporeal membrane oxygenation (ECMO) plays a critical role in the treatment of critically ill patients, and its use has been steadily increasing (1, 2). The application of ECMO in critical conditions such as cardiac arrest and acute respiratory distress syndrome has been shown to improve patient survival and neurological outcomes (3, 4). However, due to the high costs and the need for experienced medical staff, regionalization plans and systems have been emphasized for ECMO implementation (5).

Veno-arterial (VA) and veno-venous (VV) ECMO both employ a centrifugal pump and membrane oxygenator for extracorporeal gas exchange in critical care. However, they differ in function and resulting hemodynamics: VA-ECMO delivers combined cardiac and respiratory support by returning oxygenated blood to the arterial system, whereas VV-ECMO provides only respiratory support by routing blood back to the venous circulation, leading to distinct hemodynamic dependencies.

Transporting a patient receiving ECMO support is a highly challenging process within the medical system (6, 7). Previous studies have reported that the ECMO cannulation team can both initiate ECMO and transport the patient. However, they have also noted that complications such as ECMO device malfunctions or patient deterioration may occur during transport (8-11). Despite these findings, research on transport systems managed by an independent critical care transport team—rather than by the dedicated intensivist or ECMO cannulation team from the ECMO center—remains insufficient.

It is well established that inter-hospital transport (IHT) conducted by a dedicated critical care transport team enhances patient safety (12, 13). In particular, a high level of education and training for the transport team helps prevent and appropriately respond to adverse events during IHT (14, 15). A previous study demonstrated that a well-prepared dedicated critical

care transport team can prevent the deterioration of physiological parameters before and after the transport of patients with devices such as targeted temperature management systems (16).

The use of ECMO is a complex procedure, and patients receiving ECMO support often have fragile conditions that make them susceptible to physiological deterioration. We hypothesize that a dedicated critical care transport team for IHT can safely transport patients receiving VA-ECMO or VV-ECMO support. The purpose of this study was to evaluate the safety of IHT for patients receiving ECMO support, with a focus on analyzing the deterioration of physiological parameters during transport.

METHODS

Study design and setting

This retrospective observational study utilized data from a dedicated IHT system. The study was conducted in Seoul, the capital of Korea, which has a population of approximately 10 million and covers an area of 605.2 km^2. In 2023, approximately 1.7 million patients visited the city's 66 emergency departments (EDs). In Korea, IHT is predominantly managed by private emergency medical services (EMS) agencies, which respond to transfer requests initiated by the referring hospital. According to the Emergency Medical Services Act, each IHT must be staffed by at least one emergency medical technician (EMT) in addition to the ambulance driver. These EMTs in Korea are designated as level 1 or level 2, which correspond to EMT-intermediate and EMT-basic in the United States. In private EMS agencies, ambulance drivers are required to complete only basic emergency care training and do not have an independent medical role beyond vehicle operation. Physicians or nurses do not routinely accompany these transfers, which poses challenges for the effective management of critically ill patients during transport by private EMS agencies.

To address these challenges, the Seoul Mobile Intensive Care Unit (SMICU) was established in 2016 as a dedicated public critical care transport system for IHT within Seoul. Funded by the Seoul Metropolitan Government and operated by Seoul National University Hospital, SMICU operates 24/7 to facilitate IHT for critically ill patients. Each SMICU team comprises three healthcare professionals, including one on-duty emergency physician and two transport team members (nurse or level 1 EMT), ensuring comprehensive care during transport. The SMICU system operates four specialized ambulances equipped with critical care medical devices, each driven by a trained transport team member. Approximately 10 physicians and 25 transport team members are participating in the SMICU program as of 2025. Approximately 1,000 critically ill patients are transported annually, including those with post-cardiac arrest, major trauma, cardiovascular or neurovascular emergencies, and sepsis. Once the referring and receiving hospitals are determined, transport requests are submitted to the SMICU physician. Decisions regarding transport acceptance or refusal are subject to rigorous quality control and are reviewed weekly. Detailed information on SMICU operations is available in a previous study (12). A standardized IHT protocol for patients receiving ECMO support has been developed and implemented (See Supplemental File).

This study complied with the Declaration of Helsinki, and its protocol was approved by the Institutional Review Board of the study site with a waiver of informed consent (IRB No. H-2001-015-1090). All methods were performed in accordance with relevant guidelines and regulations.

Data source

This study utilized the SMICU IHT database, an independently developed system designed for quality control. The database contains a wide range of variables encompassing multiple aspects of the transport process, including patient demographics, time-related variables,

reasons for IHT, chief complaints and diagnoses at the referring hospital, mental status and physiological parameters monitored during transport, medical procedures performed during IHT, and adverse events occurring during ambulance transport. Data entry was conducted by physicians, nurses, and EMTs involved in the transport process. To ensure accuracy and reliability, regular data quality reviews were performed by an administrative nurse assigned as the data manager, under the supervision of the attending physician.

Study population

The study population consisted of patients receiving VA-ECMO or VV-ECMO support who underwent IHT via SMICU between January 2016 and April 2024. Patients younger than 10 years of age or with missing physiological parameters were excluded from the analysis.

Outcomes

To evaluate the safety of IHT for patients receiving ECMO support, the primary outcome of this study was the occurrence of abnormal physiologic parameter events during transport, including hypotension (mean arterial pressure <65 mmHg), desaturation (pulse oximetry <90%), tachycardia (heart rate >120 beats per minute), and bradycardia (heart rate <50 beats per minute). The secondary outcomes included transport-related adverse events and interventions during IHT, such as medication administration, ECMO shutdown, unmeasurable monitoring values, increased vasopressor requirements, mechanical ventilator adjustments, and endotracheal tube management.

Electrocardiography, pulse oximetry, and arterial blood pressure were continuously monitored during transport. If arterial blood pressure monitoring was unavailable, noninvasive blood pressure was measured at least every five minutes. The start of IHT was defined as the time the patient was transferred onto the ambulance stretcher brought by the transport team at the referring hospital, and the end of IHT was defined as the time the

patient was unloaded from the stretcher at the receiving hospital. Episodes of physiologic parameter changes were recorded when clinically significant alterations were observed. Clinically significant changes were defined as values outside predetermined normal ranges that prompted, or were judged by the transport team to require, a medical intervention.

Exposure and variables

Demographic variables included patient age, sex, chief complaint at the time of transfer—such as cardiac arrest, coronary symptoms, dyspnea, or a history of heart disease—and past medical history. Data related to IHT included the reason for transfer and the monitoring devices and life-support equipment applied at the referring hospital.

Time variables were collected, including the time of the initial call; the team's arrival and departure times at both the referring and receiving hospitals; and, when applicable, the time of any adverse events or clinical interventions during IHT. Time intervals were calculated as follows: from the initial call to the team's arrival at the referring hospital; from arrival at the referring hospital to departure; and from departure to arrival at the receiving hospital.

Statistical analysis

Demographic and clinical characteristics were described and compared between patients receiving VA-ECMO and those receiving VV-ECMO support. Categorical variables were presented as frequencies and proportions, while continuous variables were expressed as medians with interquartile ranges (IQR). Comparisons of categorical variables were performed using the chi-square test or Fisher's exact test, while the Wilcoxon rank-sum test was used for continuous variables.

Deterioration of physiological parameters was analyzed and compared before and after IHT to evaluate the safety of IHT for patients receiving ECMO support. Adverse events and

interventions occurring during IHT were reported, and detailed information on critical events was subsequently described.

A p-value of less than 0.05 was considered statistically significant. All statistical analyses were performed using R version 3.5 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Among a total of 7,407 IHT cases during the study period, 156 patients received ECMO support; after excluding five patients younger than 10 years of age, 151 were included in the study population. Of these patients, 96 (59.6%) were supported with VA-ECMO (or VVA-ECMO), while 55 (40.4%) were supported with VV-ECMO. A total of 37.1% of the study population experienced cardiac arrest before ECMO initiation, with a significantly higher prevalence in the VA-ECMO group (54.2%) compared to the VV-ECMO group (7.3%) ($p < 0.01$) (Table 1).

Detailed clinical status during IHT and time-related variables are summarized in Table 2. More than half of the patients underwent IHT to receive or be evaluated for transplantation. The median time from arrival at the referring hospital to departure was 55 minutes (IQR, 46–65), and the median transport time from the referring hospital to the receiving hospital was 25 minutes (IQR, 19–37).

Table 3 presents the physiological parameters at the start and end of IHT, as well as the adverse events that occurred during transport. At the start of IHT, the VA-ECMO group had a lower mean arterial pressure (83 mmHg vs. 96 mmHg, $p < 0.01$) and higher oxygen saturation (99% vs. 96%, $p < 0.01$) compared to the VV-ECMO group. However, at the end

of IHT, there was no significant difference in mean arterial pressure (86 mmHg vs. 93 mmHg, p = 0.18) or oxygen saturation (99% vs. 98%, p = 0.07) between the two groups. Regarding adverse events, ECMO device shutdown occurred spontaneously in 6.8% of cases (n=10) and due to human error in 2.1% (n=3). Among the 13 cases of ECMO shutdown, two required immediate hand crank application. In one VV-ECMO case, the hand crank was used for five minutes, after which the ECMO console was successfully restarted. In the other case, involving a patient on VA-ECMO, the console failed to restart despite manual efforts, necessitating continuous hand crank operation throughout the 80-minute transport. In the remaining 11 cases, the ECMO console was successfully restarted within a few minutes without the need for hand crank support. In one of these 11 cases—a VA-ECMO patient—cardiopulmonary resuscitation was performed for less than one minute. The most common adverse event was the inability to obtain stable readings from patient monitoring devices (n=18, 11.9%), including arterial blood pressure and pulse oximetry. This often necessitated interventions such as arterial line management or switching to alternative monitoring devices.

There was no significant deterioration in physiological parameters between the start and end of IHT. Hypotension was observed in 18 patients (11.9%) at the start of IHT and in 15 patients (9.9%) at the end (p=0.55). Desaturation occurred in 5 patients (3.3%) at the start and in 7 patients (4.6%) at the end (p=0.68). Tachycardia was noted in 29 patients (19.2%) at the start and decreased to 18 patients (11.9%) at the end (p < 0.01) (Table 4).

DISCUSSION

We found that IHT conducted by a dedicated critical care transport team safely maintained physiological stability in patients receiving ECMO support. However, several clinically important adverse events occurred, including 13 unintentional ECMO console shutdowns, all of which required prompt intervention. Despite these events, no mortality or ECMO reinsertion occurred during transport, owing to the timely and appropriate responses of the transport team. These findings underscore the importance of a dedicated critical care transport system staffed with highly trained personnel capable of recognizing and managing unexpected complications, thereby supporting the safe transfer of patients requiring ECMO.

This study specifically focused on physiological parameters, including vital signs and their maintenance before and after IHT, in contrast to previous studies that primarily concentrated on critical events occurring during transport (6, 8, 10). Given the complexity of ECMO management, patients on ECMO support are particularly vulnerable to physiological deterioration (17). The role of the IHT team is to maintain the patient's condition as it was at the referring hospital, particularly during ECMO transport. This includes not only managing ECMO settings and troubleshooting device-related issues but also adjusting medications such as vasopressors and sedatives and optimizing ventilator settings. While some patients may still present with abnormal vital signs at the end of transport, our findings suggest an overall decrease in these instances. These results suggest that the transport team plays a crucial role in maintaining key physiological parameters during transit.

A particularly concerning finding was that ECMO shutdowns occurred in approximately 8.9% of all transports in this study. Previous studies have reported varying rates of similar complications (11, 18). Based on our experience, older ECMO equipment appears to be more susceptible to power failures, particularly in the unstable environment of an ambulance. This issue may stem from both equipment instability and potential disruptions in the transport

vehicle's power supply. To mitigate these risks, the IHT team follows established protocols for ECMO shutdowns, including immediate resuscitation measures and manual operation using hand cranks when necessary (19). Additionally, unstable vital sign readings were not uncommon in patients receiving ECMO support, particularly in those with minimal residual cardiac function or unstable tissue perfusion due to hypoxia. In such cases, the use of point-of-care blood testing or ultrasound within the ambulance is recommended per our SMICU protocols.

In our study, patients receiving VA- and VV-ECMO exhibited distinctly different clinical characteristics, underscoring the need for tailored approaches during IHT. Patients on VA-ECMO were more likely to experience hypotension both before and after transport, reflecting a higher degree of hemodynamic instability. In contrast, patients on VV-ECMO showed more frequent desaturation at the start of transport, highlighting the importance of vigilant respiratory monitoring. These findings emphasize that critical care transport teams must recognize these differing physiological and procedural requirements to optimize patient safety and transport outcomes.

A regional critical care transport system is essential for ensuring the safety of critically ill patients during IHT (20, 21). The SMICU team, comprising emergency specialists, nurses, and EMTs with specialized training, follows comprehensive protocols tailored to critically ill patients, including those on ECMO support. These protocols enable intensive monitoring and medical interventions for patients in the ambulance, comparable to those in an intensive care unit, ensuring the safe and effective execution of critical care procedures during transport. The ambulances are equipped with all necessary resuscitation and procedural equipment, and the ongoing provision of structured training programs ensures that transport personnel maintain the highest level of proficiency (22).

There were no cases of mortality during transport, nor any instances requiring new ECMO cannulation at the receiving hospital. All adverse events that occurred during transport were appropriately managed by the transport team, and no clinical deterioration was observed. The overall incidence of adverse events (27.8%) was comparable to that observed in transports conducted by teams consisting of ECMO specialists and intensivists (27.3%) (23). Physical factors such as vibrations caused by ambulance movement, as well as sudden accelerations and decelerations of the vehicle, can affect ongoing treatment and alter intravascular volume distribution, potentially leading to hemodynamic instability (24). However, this study found no significant increase in hypotension, desaturation, or abnormalities in heart rate between the start and end of IHT. A large-scale clinical trial is needed to further investigate the long-term clinical outcomes of ECMO patients transported by dedicated critical care teams. These findings could serve as important evidence for the development and optimization of regional critical care transport systems.

LIMITATIONS

This study has several limitations. First, the study population included only patients transported by the regional critical care transport system. In Seoul Metropolitan City, nearly 30,000 IHTs occur annually through the ED. While it can be assumed that all ECMO patients in Seoul are included in this study, given that only the SMICU system is capable of transporting ECMO patients between hospitals, the possibility of selection bias remains if this assumption does not hold. In addition, the small sample size may have introduced variability and limited the robustness of the findings. Although statistical methods were employed to address these limitations and enhance the reliability of the results, some degree of uncertainty likely remains. We also excluded pediatric cases younger than 10 years of age due to their heterogeneity and deviation from the routine transport protocol, which represents another limitation of this study. Second, the methods for measuring blood pressure and

oxygen saturation were not uniform across all patients. In most cases, blood pressure was obtained using arterial blood pressure monitors, except for 2% of the study population, with insertion sites in either the radial or femoral artery. Oxygen saturation sensors were attached to areas with a high perfusion index and clearly visible plethysmography waveforms. While the IHT team used the most accurate methods available to measure vital signs, this variability remains a limitation. Third, outcomes were defined based on the proportion of abnormal vital signs relative to the normal range. However, in some cases, the targeted vital signs may have been outside the normal range due to the patient's condition. Fourth, as a retrospective observational study based on a registry, unmeasured biases could have influenced the results. Additionally, due to the absence of video recordings, it was not possible to measure the exact duration in seconds. Furthermore, clinical outcomes of the transported patients at the receiving hospitals were not available. Access to such data in future studies would help further justify the value and effectiveness of the transport system. Finally, the study was conducted in a single dedicated critical care transport system in a metropolitan city, which may limit its generalizability to other settings.

CONCLUSIONS

Interhospital transport performed by a dedicated critical care transport team for patients receiving ECMO support appears to be safe. The trained transport team was able to respond appropriately to adverse events during transport. These findings suggest that developing specialized critical care transport systems may further facilitate the safe transfer of patients supported with ECMO.

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DATA SHARING STATEMENT: The data for the study were obtained from the Seoul Mobile Intensive Care Unit (SMICU), but restrictions apply to the availability of these data and so are not publicly available, but are available from the corresponding author on reasonable request. This study complied with the Declaration of Helsinki, and its protocol was approved by the Institutional Review Board of the study site with a waiver of informed consent (IRB No. H-2001-015-1090). All methods were performed in accordance with relevant guidelines and regulations. De-identified data from this study are not available in a public archive. De-identified data from this study will be made available (as allowable according to institutional IRB standards) by emailing the corresponding author. Analytic code used to conduct the analyses presented in this study are not available in a public repository. They may be available by emailing the corresponding author. The authors agree to provide the full content of the manuscript on request by contacting the corresponding author.

AUTHORSHIP STATEMENT: Drs. Ro and Kim (KKH) had full access to all of the data in the study and take responsibility for the integrity of the data as well as the accuracy of the data analysis. Conceptualization: Dr. Kim (KKH), Dr. Ro, and Dr. Shin. Data curation: all authors.

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Table 1: Demographic information and clinical findings of study population

	Total	VA-ECMO	VV-ECMO	p-value
	N (%)	N (%)	N (%)	
Total	151	96 (59.6)	55 (40.4)	
Age, years, median, IQR	58 [50, 64]	60 [49, 64]	57 [50, 63]	0.29
Sex, male	101 (66.9)	71 (74.0)	30 (54.5)	0.02
Cardiac arrest event before ECMO insertion	56 (37.1)	52 (54.2)	4 (7.3)	<0.01
Days from ECMO insertion to IHT, median, IQR	6 [1, 10]	5 [1, 9]	8 [2, 15]	0.01
Chief complaint at the referring hospital				<0.01
Cardiac arrest	23 (15.2)	23 (24.0)	0 (0.0)	
Chest pain/coronary symptom	29 (19.2)	29 (30.2)	0 (0.0)	
Dyspnea	70 (46.4)	22 (22.9)	48 (87.3)	
Known heart disease	3 (2.0)	3 (3.1)	0 (0.0)	
Others	26 (17.2)	19 (19.8)	7 (12.7)	
Main diagnosis at the referring hospital				<0.01
Acute myocardial infarction	50 (33.1)	50 (52.1)	0 (0.0)	
Pneumonia	35 (23.2)	2 (2.1)	33 (60.0)	
Idiopathic pulmonary fibrosis	17 (11.3)	3 (3.1)	14 (25.5)	
Myocarditis	13 (8.6)	12 (12.5)	1 (1.8)	
Pulmonary thromboembolism	7 (4.6)	7 (7.3)	0 (0.0)	
Ischemic or dilated cardiomyopathy	10 (6.6)	10 (10.4)	0 (0.0)	
Others	19 (12.6)	12 (12.5)	7 (12.7)	
Past medical history				
Hypertension	53 (35.1)	35 (36.5)	18 (32.7)	0.72
Diabetes mellitus	44 (29.1)	32 (33.3)	12 (21.8)	0.14
Cancer	10 (6.6)	4 (4.2)	6 (10.9)	0.17
Heart disease	29 (19.2)	27 (28.1)	2 (3.6)	<0.01
Liver disease	4 (2.6)	4 (4.2)	0 (0.0)	0.30

IQR, interquartile range; VA-ECMO, veno-arterial extracorporeal membrane oxygenator; VV-ECMO, veno-venous extracorporeal membrane oxygenator

Table 2: Interhospital transport information of study population

	Total	VA-ECMO	VV-ECMO	p-value
	N (%)	N (%)	N (%)	
Total	151	96 (59.6)	55 (40.4)	
Reason for IHT				0.19
Transplantation	90 (59.6)	54 (56.2)	36 (65.5)	
Need for advanced intensive care	32 (21.2)	20 (20.8)	12 (21.8)	
Surgical or radiologic intervention	16 (10.6)	13 (13.5)	3 (5.5)	
Others	13 (8.6)	9 (9.4)	4 (7.3)	
Monitoring and devices at referring hospital				
Arterial blood pressure monitor	148 (98.0)	94 (97.9)	54 (98.2)	1.00
Central venous catheter	130 (86.1)	86 (89.6)	44 (80.0)	0.14
High-flow nasal cannula	4 (2.6)	2 (2.1)	2 (3.6)	0.62
Mechanical ventilator	134 (88.7)	82 (85.4)	52 (94.5)	0.11
Chest tube	25 (16.6)	12 (12.5)	13 (23.6)	0.11
Intra-aortic balloon pump	4 (2.6)	4 (4.2)	0 (0.0)	0.30
Targeted temperature management	1 (0.7)	1 (1.0)	0 (0.0)	1.00
Continuous infusion during IHT				
Norepinephrine	92 (60.9)	68 (70.8)	24 (43.6)	<0.01
Dopamine	38 (25.2)	32 (33.3)	6 (10.9)	<0.01
Remifentanil	92 (60.9)	58 (60.4)	34 (61.8)	1.00
Midazolam	45 (29.8)	25 (26.0)	20 (36.4)	0.20
Vasopressin	10 (6.6)	9 (9.4)	1 (1.8)	0.09
Dobutamine	47 (31.1)	41 (42.7)	6 (10.9)	<0.01
Epinephrine	13 (8.6)	13 (13.5)	0 (0.0)	<0.01
Dexmedetomidine	32 (21.2)	16 (16.7)	16 (29.1)	0.10
Vecuronium	14 (9.3)	7 (7.3)	7 (12.7)	0.38
Nitroglycerin	7 (4.6)	7 (7.3)	0 (0.0)	0.04
Amiodarone	14 (9.3)	14 (14.6)	0 (0.0)	<0.01
Propofol	40 (26.5)	21 (21.9)	19 (34.5)	0.12
Nicardipine	3 (2.0)	2 (2.1)	1 (1.8)	1.00
Time intervals during IHT, minutes, median (IQR)				
From call to arrival at the referring hospital	33 (22, 41)	30 (22, 39)	30 (22, 45)	0.85
From arrival at the referring hospital to departure	55 (46, 65)	56 (46, 66)	53 (47, 62)	0.68
From departure to arrival at the receiving hospital	25 (19, 37)	24 (18, 36)	29 (22, 41)	0.07

VA-ECMO, veno-arterial extracorporeal membrane oxygenator; VV-ECMO, veno-venous extracorporeal membrane oxygenator; IHT, interhospital transport

Table 3: Physiologic status and adverse events during interhospital transport

	Total	VA-ECMO	VV-ECMO	p-value
	N (%)	N (%)	N (%)	
Total	151	96 (59.6)	55 (40.4)	
Patient status at the start of IHT, median (IQR)				
Mean arterial pressure, mmHg	88 (74, 100)	83 (71, 93)	96 (86, 104)	<0.01
Heart rate, beats per min	100 (80, 112)	100 (78, 112)	100 (86, 114)	0.61
Pulse oximetry, %	98 (96, 100)	99 (97, 100)	96 (94, 100)	<0.01
Body temperature, Celsius	36.7 (36.3, 37.6)	36.7 (36.3, 37.2)	36.8 (36.3, 38.3)	0.08
Patient status at the end of IHT, median (IQR)				
Mean arterial pressure, mmHg	87 (76, 99)	86 (76, 97)	93 (78, 101)	0.18
Heart rate, beats per min	97 (79, 109)	97 (79, 109)	97 (80, 107)	0.75
Pulse oximetry, %	98 (96, 100)	99 (96, 100)	98 (94, 100)	0.07
Body temperature, Celsius	36.8 (36.4, 37.8)	36.8 (36.3, 37.6)	36.8 (36.5, 38.2)	0.43
Adverse events and interventions during IHT				
ECMO spontaneous shutdown	10 (6.8)	9 (9.7)	1 (1.9)	0.09
ECMO shutdown due to human error	3 (2.1)	3 (3.2)	0 (0.0)	0.55
ECMO insertion site bleeding	1 (0.7)	1 (1.1)	0 (0.0)	1.0
Unmeasurable monitoring values	18 (11.9)	13 (13.5)	5 (9.1)	0.60
Increased vasopressor requirement	2 (1.3)	2 (2.1)	0 (0.0)	0.53
Ventilator or airway management	11 (7.3)	5 (5.2)	6 (11.3)	0.21
Endotracheal tube adjustment or suctioning	1 (0.7)	0 (0.0)	1 (1.9)	0.36
Any adverse event	42 (27.8)	30 (31.3)	12 (21.8)	0.86

VA-ECMO, veno-arterial extracorporeal membrane oxygenator; VV-ECMO, veno-venous extracorporeal membrane oxygenator; IHT, interhospital transport; IQR, interquantile range

Table 4: Comparison of physiologic deterioration between the start and end of interhospital transport

	Total	at the start of IHT	at the end of IHT	p-value*
	N (%)	N (%)	N (%)	
Mean arterial pressure <65 mmHg				
All ECMO	33 (21.9)	18 (11.9)	15 (9.9)	0.55
VA-ECMO	26 (27.1)	15 (15.6)	11 (11.5)	0.29
VV-ECMO	7 (12.7)	3 (5.5)	4 (7.3)	1.00
Pulse oximetry <90%				
All ECMO	12 (7.9)	5 (3.3)	7 (4.6)	0.68
VA-ECMO	4 (4.2)	0 (0.0)	4 (4.2)	0.13
VV-ECMO	8 (14.5)	5 (9.1)	3 (5.5)	0.48
Heart rate >120 beats/min				
All ECMO	47 (31.1)	29 (19.2)	18 (11.9)	<0.01
VA-ECMO	27 (28.1)	17 (17.7)	10 (10.4)	0.02
VV-ECMO	20 (36.4)	12 (21.8)	8 (14.5)	0.13
Heart rate <50 beats/min				
All ECMO	1 (0.7)	1 (0.7)	1 (0.7)	NA
VA-ECMO	1 (1.0)	1 (1.0)	1 (1.0)	NA
VV-ECMO	0 (0.0)	0 (0.0)	0 (0.0)	NA

VA-ECMO, veno-arterial extracorporeal membrane oxygenator; VV-ECMO, veno-venous extracorporeal membrane oxygenator; IHT, interhospital transport

* performed using the McNemar test