BMC Pulmonary Medicine

RESEARCH

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The superiority of veno-arterial over veno-venous extracorporeal membrane oxygenation for operative support of lung transplantation

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Abstract

Background Veno-arterial (V-A) and veno-venous (V-V) extracorporeal membrane oxygenation (ECMO) are crucial support modalities during lung transplantation, yet their comparative effectiveness remains unclear.

Methods We conducted an 8-year retrospective analysis of 62 lung transplant recipients who received intraoperative ECMO (29 V-A, 33 V-V). Baseline characteristics, surgical parameters, and clinical outcomes were compared. To address potential selection bias, we employed entropy weighted inverse probability of treatment weighting (IPTW-EW).

Results After IPTW-EW adjustment, V-A ECMO was associated with superior hemodynamic and respiratory parameters, including lower systolic pulmonary artery pressure (30 vs. 37 mmHg, $p=0.007$), higher arterial oxygen partial pressure (119 vs. 78 mmHg, $p=0.002$), and less severe pulmonary edema (Grade 1: 50% vs. 3%, Grade 2: 45% vs. 38%, Grade 3: 5% vs. 59%, $p<0.001$). Notably, V-A ECMO demonstrated significantly lower 28-day (5% vs. 29%, $p=0.017$) and hospital mortalities (21% vs. 69%, $p=0.035$).

Conclusions V-A ECMO provides superior pulmonary circulation unloading and is associated with improved survival outcomes compared to V-V ECMO in lung transplantation, suggesting its preferential use when clinically appropriate.

Keywords Lung transplantation, Extracorporeal membrane oxygenation, Veno-arterial, Veno-venous, Pulmonary circulation, Mortality

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Introduction

Extracorporeal membrane oxygenation (ECMO) is commonly used not only as a bridging therapy prior to lung transplantation [1] but also as a transitional support in the intra- and post-operative period [2, 3]. Traditionally, veno-venous (V-V) ECMO has been the primary mode of intra- and post-operative support for lung transplant recipients which can provide maintenance of oxygen and carbon dioxide gas exchange [4, 5]. However, lung transplant patients face challenges such as single-lung ventilation, pulmonary hypertension, right ventricular dysfunction, and hemodynamic instability [3]. Consequently, some lung transplant centers have gradually shifted towards choosing veno-arterial (V-A) ECMO [6, 7], which can reduce transpulmonary blood flow, provide sufficient right ventricular unloading, and offer circulatory support [8], potentially providing greater benefits. In recent years, the potential of using V-A ECMO as a routine supportive measure for lung transplantation has been increasingly discussed [9, 10].

Our center has also increasingly been employing V-A ECMO as a transitional support during and after surgery, with a preference for the peripheral approach due to its relative ease of bedside removal post-operatively compared to central V-A ECMO. However, the retrograde blood flow through the femoral artery in peripheral V-A ECMO can increase cardiac afterload, potentially leading to left ventricular distension and pulmonary edema [11]. Over the past eight years, we have accumulated a substantial number of lung transplant cases receiving either post-operative V-V or (peripheral) V-A ECMO support, with comprehensive data collection and follow-up. This study aims to systematically compare the effects of these two ECMO modalities on pulmonary artery pressure, pulmonary edema, oxygenation, and clinical outcomes.

Methods

Study design and participants

We conducted a retrospective cohort study of patients who underwent lung transplantation with intraoperative and postoperative ECMO support at our center from August 2016 to April 2024. The study was approved by the Ethics Committee of Sichuan Provincial People's Hospital (approval number: 2023 – 329), and informed consent for data use was obtained from patients or their immediate family members. According to our center's protocol, patients with preoperative systolic pulmonary artery pressure [SPAP] exceeding 55 mmHg [1] or NYHA class IV heart function were excluded due to their mandatory requirement for V-A ECMO, while the remaining study population had variable candidacy for either V-V or V-A ECMO based on multidisciplinary team assessment. Additionally, patients under 18 years of age, with incomplete records, lost to follow-up, who had previous organ transplantation, or received pre-transplant ECMO bridging were also excluded. It is important to emphasize that, following China's discontinuation of using organs from executed prisoners on January 1, 2015, all lung transplant procedures at our institution during the study period relied exclusively on organs obtained through voluntary donation after death. This study was in accordance with the Declaration of Helsinki.

Clinical trial number: Not applicable as this study employed a retrospective observational design without any interventional component.

Indications for lung transplantation

In our center, lung transplantation is performed for two main indications:

1. **Chronic Obstructive Pulmonary Disease** (COPD): (1) progressive disease despite maximal treatment, including pharmacotherapy, pulmonary rehabilitation, and oxygen therapy; (2) unsuitability for lung volume reduction surgery; (3) a body mass index (BMI), airflow obstruction, dyspnea, and exercise capacity (BODE) index of 5 to 6; (4) partial pressure of arterial carbon dioxide ($PaCO_2$) > 50 mmHg and/or partial pressure of arterial oxygen (PaO_2) < 60 mmHg; and (5) forced expiratory volume in 1 s < 25%.
2. **Pulmonary Fibrosis**: (1) a decline in forced vital capacity > 10% within 6 months; (2) a decrease in diffusion capacity for carbon monoxide > 15% within 6 months; (3) peripheral oxygen saturation (SpO_2) < 88% during a 6-minute walk test, a walking distance < 250 m, or a decrease > 50 m over 6 months; (4) evidence of pulmonary hypertension on pulmonary artery catheter (PAC) or echocardiography; or (5) hospitalization due to dyspnea, pneumothorax, or acute exacerbation.

Initiation of intraoperative ECMO support

Intraoperative ECMO implementation was determined by a multidisciplinary team consisting of surgeons, intensivists, and pulmonologists. Mode selection was primarily based on preoperative cardiac function, post-anesthetic pulmonary artery pressure during one-lung ventilation, oxygenation status, $PaCO_2$ levels, and hemodynamic stability. V-V ECMO was preferred for patients with cardiac function below Grade II and stable post-anesthetic hemodynamics, while V-A ECMO was selected for those with post-anesthetic hemodynamic instability or right ventricular dysfunction. V-A configuration utilized femoral vein-to-artery cannulation with a distal perfusion catheter, while V-V ECMO was established via femoral-to-jugular approach. Cannulation (arterial: 15-17Fr; venous: 21-23Fr) was performed percutaneously under

ultrasound guidance by qualified intensivists. Anticoagulation targeted an APTT of 40–60 s, and hemodynamic parameters were continuously monitored via pulmonary artery catheter.

Ventilation strategies

Our center does not utilize cardiopulmonary bypass (CPB) support during lung transplantation procedures. Lung transplant recipients were managed with lung-protective ventilation, implementing a low tidal volume strategy of 6 ml/kg ideal body weight [12]. In cases of lung size mismatch, tidal volume calculations were based on the donor's ideal body weight, which was obtained preoperatively. Moderate levels of positive end-expiratory pressure (5–10 cmH_2O) were employed to minimize ventilator-induced lung injury while maintaining airway plateau pressure < 30 cmH_2O and respiratory driving pressure < 15 cmH_2O [13]. Oxygenation targets were set at PaO_2 > 70 mmHg and oxygen saturation ≥ 92% [14].

Protocol for ECMO weaning during postoperative period

All patients on intraoperative ECMO underwent daily weaning assessments starting from the day following ICU admission. In our center, ECMO withdrawal was based on a comprehensive evaluation of several key aspects: primary disease remission, neurological recovery, and hemodynamic stability. Once these conditions were satisfied, cardiac function was assessed via ultrasound to determine readiness for weaning. Prior to ECMO removal, pulmonary function evaluation was essential, ensuring an oxygenation index (PaO_2/FiO_2) exceeding 200 mmHg and ventilator inspiratory pressure below 30 cmH_2O. ECMO withdrawal was considered when the flow rate was reduced to < 1.5 L/min with good patient tolerance.

Data collection

This study collected baseline characteristics, including age, gender, BMI, underlying diseases, and blood type, and identified indications for lung transplantation. Preoperative data, such as echocardiographic assessment (left ventricular ejection fraction [LVEF], right ventricular [RV] enlargement, severity of tricuspid regurgitation, and SPAP), preoperative use of invasive ventilation, and arterial blood gas analysis (pH, PaO_2, and $PaCO_2$), were gathered. Intraoperative details, including surgical approach (single or bilateral), surgery time, donor lung ischemic time, fluid intake and output, blood transfusion volume, fluid balance, and ECMO modalities, were reviewed. On postoperative day 1, Acute Physiology and Chronic Health Evaluation (APACHE) II score, SPAP, lactate, PaO_2, and pulmonary edema grade on chest X-ray were recorded. Postoperative complications, such as re-exploration for bleeding, primary graft dysfunction (PGD), thrombotic complications (by daily ultrasound assessment of limb arteries and veins), bloodstream infections (BSI), tracheal anastomotic leakage, and acute kidney injury (AKI), were documented. Clinical outcomes and specific postoperative support measures, including ECMO duration, red blood cell (RBC) transfusion within 7 days, continuous renal replacement therapy (CRRT), length of mechanical ventilation (LOMV), tracheostomy, length of intensive care unit stay (LOICU), length of hospital stay (LOHS), 28-day mortality, and hospital mortality, were collected.

Statistical analysis

Continuous variables were presented as median with interquartile range (IQR) or mean ± standard deviation, while categorical variables were reported as frequencies and percentages. Statistical comparisons were performed using the Wilcoxon rank-sum test, t-test, and chi-square test for non-normally distributed continuous, normally distributed continuous, and categorical variables, respectively. To account for potential propensity in selecting different ECMO modes, which typically manifests in preoperative characteristics such as transplant indications, surgical approaches, and underlying diseases, we employed inverse probability of treatment weighting (IPTW) to adjust for these differences. Among the five available weighting methods for IPTW, we specifically chose entropy weights (EW) for its advantages in avoiding extreme weights and reducing variance inflation due to such weights, making it particularly suitable for studies with relatively small sample sizes while maintaining optimal balance and providing more precise treatment effect estimates [15]. For the primary outcomes of interest, scatter plots, box plots, and pie charts were generated using IPTW-EW-adjusted data for visualization, and survival curves were also plotted and compared. All statistical tests were two-tailed, with a significance level set at $P < 0.05$. Statistical analyses were conducted using R version 4.2.3 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Patients

Over the past eight years, a total of 62 lung transplant patients in our center had ECMO initiated intraoperatively, with 29 cases on V-A and 33 cases on V-V (Fig. 1). Notably, none of the V-V ECMO patients were converted to V-A mode postoperatively. Among V-A and V-V ECMO patients, COPD as the surgical indication accounted for 72% and 45% ($p = 0.059$), respectively, while single-lung transplantation accounted for 86% and 58% ($p = 0.028$), with operative times of 390 (IQR: 330–440) and 360 (IQR: 300–400) min ($p = 0.043$), and donor lung ischemia times of 600 (IQR: 520–630) and 490 (IQR:

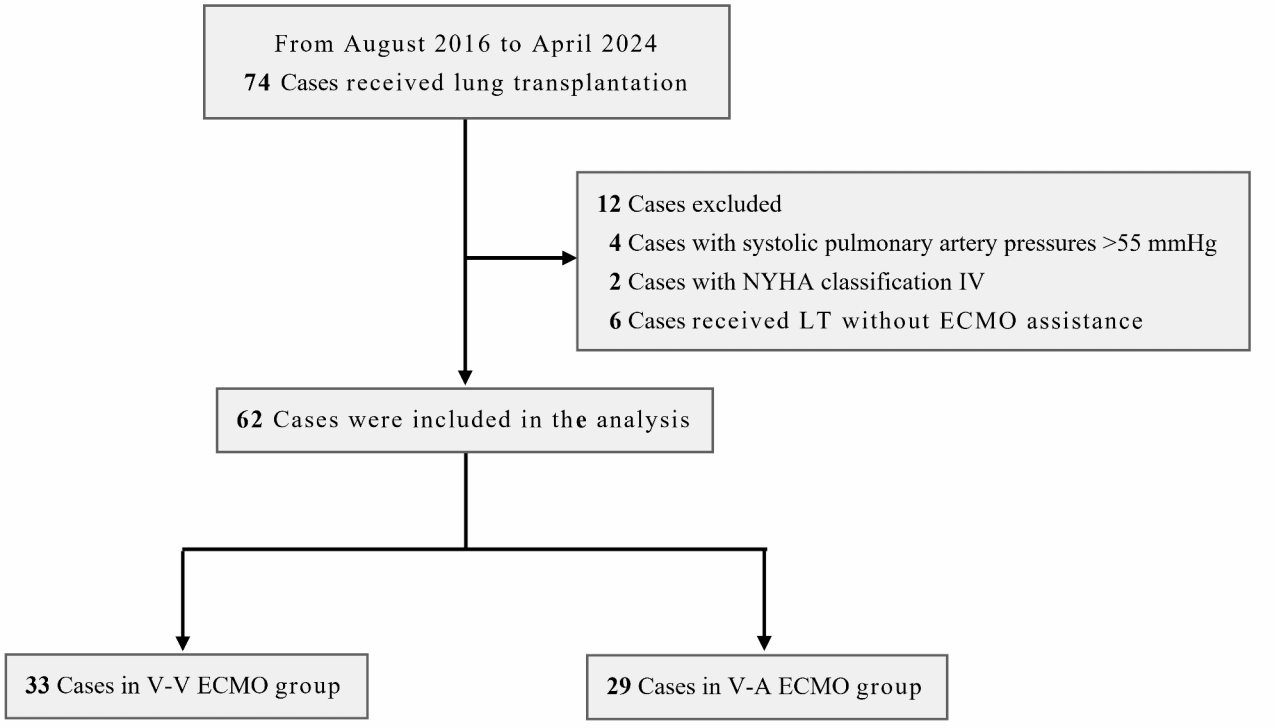

Fig. 1 Study Flowchart. NYHA: New York Heart Association; LT: Lung Transplantation; ECMO: Extracorporeal Membrane Oxygenation; V-V: Veno-Venous; V-A: Veno-Arterial

395–540) ($p = 0.001$), indicating a certain selection propensity (Table 1). After IPTW-EW adjustment, these differences were well balanced (Table 1).

Pulmonary circulatory unloading

On postoperative day 1, APACHE II scores and lactate levels showed no significant differences between two modalities (Table 1). V-A ECMO patients had lower SPAP (30 ± 9 vs. 40 ± 10 mmHg, $p < 0.001$), higher PaO_2 (119 [IQR: 104–146] vs. 97 [IQR: 74–123] mmHg, $p = 0.003$), and milder pulmonary edema (Grade 1: 31% vs. 9%, Grade 2: 62% vs. 49%, Grade 3: 7% vs. 42%, $p = 0.003$). These differences remained significant after IPTW-EW adjustment. Among the adjusted population, V-A ECMO group had lower SPAP (30 ± 8 vs. 37 ± 9 mmHg, $p = 0.007$), greater PaO_2 difference (119 [IQR: 102–135] vs. 78 [IQR: 72–103] mmHg, $p = 0.002$), and a lower proportion of moderate-to-severe pulmonary edema (Grade 1: 50% vs. 3%, Grade 2: 45% vs. 38%, Grade 3: 5% vs. 59%, $p < 0.001$) (Table 2**&** Fig. 2**ABC**).

Post-operative complications

The incidence of postoperative complications, including re-exploration for bleeding (7% vs. 6%, $p = 1.000$), PGD (7% vs. 9%, $p = 1.000$), thrombotic complications (31% vs. 49%, $p = 0.255$), bloodstream infection (14% vs. 36%, $p = 0.083$), tracheal anastomotic leakage (3% vs. 12%, $p = 0.433$), and AKI (41% vs. 64%, $p = 0.134$), did not differ significantly between V-A and V-V ECMO patients (Table 1). After IPTW-EW adjustment, all aforementioned postoperative complications remained statistically comparable between the two groups (Table 2).

Supportive therapy and clinical outcomes

There were no significant differences between the two groups in terms of major support parameters, such as RBC transfused within 7 days, ECMO duration, use of CRRT, LOMV, and tracheostomy rate (Table 1). The LOICU and LOHS were also very similar between the two groups (Table 1). The hospital mortality rates for V-A and V-V ECMO patients were 21% vs. 42% ($p = 0.120$) and 7% vs. 30% ($p = 0.045$), respectively, with the latter reaching statistical significance. After IPTW-EW adjustment, the differences in the aforementioned support parameters remained non-significant (Table 2). However, both the 28-day mortality (5% vs. 29%, $p = 0.017$) and hospital mortality (21% vs. 69%, $p = 0.035$) were lower in V-A ECMO patients. Furthermore, in the adjusted cohort, the survival curves of the two groups showed a significant difference, with V-A ECMO patients exhibiting better survival outcomes (Fig. 2. **D**).

Table 1 Baseline and perioperative characteristics before and after IPTW-EW adjustment

	Original cohort			IPTW-EW cohort		
	V-A ECMO (*n* = 29)	V-V ECMO (*n* = 33)	p value	V-A ECMO	V-V ECMO	p value
Age, years	59 (54, 69)	61 (53, 65)	0.994	59 (53, 69)	61 (56, 66)	0.65
Male, n (%)	27 (93)	30 (91)	1.000	11.0 (95)	12.6 (94)	0.869
BMI, kg/m2	20.3 (4.8)	21.8 (4.1)	0.209	21.1 (5.1)	22.2 (3.3)	0.513
Indication, n (%)						
Pulmonary Fibrosis	8 (28)	18 (55)	0.059	4.4 (38)	4.3 (32)	0.762
COPD	21 (72)	15 (45)		7.2 (62)	9.0 (68)	
Underlying disease, n (%)						
Diabetes	6 (21)	3 (9)	0.351	1.6 (14)	3.3 (25)	0.506
Hypertension	3 (10)	7 (21)	0.415	0.9 (8)	2.8 (21)	0.321
Coronary heart disease	4 (14)	7 (21)	0.667	1.4 (12)	2.4 (18)	0.659
Blood type, n (%)						
A	7 (24)	11 (33)	0.864	2.5 (21)	2.1 (15)	0.919
B	10 (35)	9 (27)		1.7 (14)	1.2 (9)	
AB	3 (10)	3 (9)		3.0 (26)	3.9 (29)	
O	9 (31)	10 (30)		4.4 (38)	6.2 (46)	
NYHA, n (%)						
I	13 (45)	12 (36)	0.785	4.5 (39)	2.9 (21)	0.252
II	14 (48)	18 (55)		6.1 (53)	10.2 (76)	
III	2 (7)	3 (9)		0.9 (8)	0.3 (2)	
Echocardiography						
LVEF, %	67 (5)	66 (5)	0.789	66 (5)	64 (5)	0.319
RV Enlargement, n (%)	7 (24)	10 (30)	0.797	3.7 (32)	1.5 (11)	0.114
Tricuspid regurgitation, n (%)						
mild	24 (83)	29 (88)	0.836	9.0 (78)	10.0 (75)	0.964
moderate	4 (14)	3 (9)		1.7 (15)	1.9 (14)	
severe	1 (3)	1 (3)		0.9 (8)	1.4 (11)	
SPAP, mmHg	35 (9)	35 (8)	0.969	38 (9)	36. (6)	0.416
Ventilation preoperatively, n (%)	6 (21)	7 (21)	1.000	1.7 (15)	2.4 (18)	0.789
Blood gas preoperatively						
pH	7.39 (7.35, 7.43)	7.40 (7.37, 7.44)	0.358	7.41 (7.38, 7.43)	7.40 (7.36, 7.44)	0.717
PaO_2, mmHg	203 (160, 269)	147 (115, 220)	0.124	164 (95, 219)	180 (131, 265)	0.313
$PaCO_2$, mmHg	64 (44, 68)	45 (40, 64)	0.209	45 (37, 62)	45 (37, 63)	0.905
Intraoperative information						
Transplantation method, n (%)						
Single	25 (86)	19 (58)	0.028	8.4 (73)	10.7 (80)	0.661
Bilateral	4 (14)	14 (42)		3.1 (27)	2.6 (20)	0.661
Surgery time, min	390 (330, 440)	360 (300, 400)	0.043	331 (290, 420)	360 (360, 370)	0.612
Donor lung ischemia time, min	600 (520, 630)	490 (395, 540)	0.001	540 (515, 600)	540 (480, 596)	0.96
Fluid intake, ml	2700 (2320, 3000)	2910 (2020, 3520)	0.572	2519 (2271, 2905)	2713 (2000, 3005)	0.669
Fluid output, ml	3000 (2570, 3600)	2700 (2100, 3500)	0.175	2778 (2440, 3337)	2681 (2334, 2886)	0.663
Urine volume, ml	1400 (800, 1600)	1600 (1200, 2000)	0.177	1200 (800, 1591)	1430 (848.39, 1700)	0.734
Blood transfusion, ml	1070 (830, 1440)	1200 (600, 1440)	0.703	993 (800, 1240)	1011 (260, 1320)	0.323

Data are presented as mean (standard deviation), median (interquartile ranges), or number (percentage) as appropriate

APACHE: Acute Physiology and Chronic Health Evaluation; BMI: Body Mass Index; COPD: Chronic Obstructive Pulmonary Disease; ECMO: Extracorporeal Membrane Oxygenation; LVEF: Left Ventricular Ejection Fraction; NYHA: New York Heart Association; $PaCO_2$: Partial pressure of arterial Carbon Dioxide; PaO_2: Partial pressure of arterial Oxygen; RV: Right Ventricular; SPAP: Systolic Pulmonary Artery Pressure; V-A: Veno-Arterial; V-V: Veno-Venous

Discussion

This eight-year retrospective cohort study, using IPTW to adjust for selection propensity and achieve baseline balance, showed that V-A ECMO provided superior pulmonary circulatory unloading and improved survival compared to V-V ECMO in lung transplant patients.

In the initial cohort comparison, V-A ECMO patients exhibited lower pulmonary arterial pressure, improved oxygenation, reduced pulmonary edema severity, and

Table 2 Postoperative parameters and clinical outcomes before and after IPTW-EW adjustment

	Original cohort			IPTW-EW cohort		
	V-A ECMO (*n* = 29)	**V-V ECMO (*n* = 33)**	**p value**	**V-A ECMO**	**V-V ECMO**	**p value**
Postoperative first ICU day						
APACHE II score	17.6 (5.9)	18.0 (5.5)	0.775	17 (5)	17 (6)	0.926
SPAP, mmHg	30 (9)	40 (10)	< 0.001	30 (8)	37 (9)	0.007
Lactate, mmol/L	3.2 (2.0, 5.2)	3.9 (2.4, 5.5)	0.568	1.9 (1.5, 3.5)	2.2 (1.6, 4.0)	0.933
PaO_2, mmHg	119 (104, 146)	97 (74, 123)	0.003	119 (102, 135)	78 (72, 103)	0.002
Pulmonary edema on CXR, n (%)						
Grade 1	9 (31)	3 (9)	0.003	5.8 (50)	0.4 (3)	< 0.001
Grade 2	18 (62)	16 (49)		5.2 (45)	5.0 (38)	
Grade 3	2 (7)	14 (42)		0.6 (5)	7.9 (59)	
Post-operative complications, n (%)						
Re-exploration for bleeding	2 (7)	2 (6)	1.000	0.5 (4)	0.8 (6)	0.872
PGD	2 (7)	3 (9)	1.000	0.9 (8)	1.3 (10)	0.969
Thrombotic complication	9 (31)	16 (49)	0.255	3.0 (26)	5.7 (43)	0.340
Bloodstream infection	4 (14)	12 (36)	0.083	0.9 (8)	4.4 (33)	0.072
Tracheal anastomotic leakage	1 (3)	4 (12)	0.433	0.8 (7)	0.5 (4)	0.610
AKI	12 (41)	21 (64)	0.134	4.9 (43)	8.7 (65)	0.244
Clinical outcomes						
ECMO duration, day	2 (1, 2)	2 (2, 3)	0.119	2 (1, 2)	2 (2, 4)	0.390
RBC transfused with 7 day, U	4.0 (0, 5.5)	3.5 (1.5, 6.0)	0.954	2 (0, 6)	2 (0, 3)	0.582
CRRT, n (%)	3 (10)	5 (15)	0.854	1.1 (10)	1.8 (13)	0.980
LOMV, hour	161 (40, 665)	62 (35, 480)	0.485	43 (19, 309)	38 (25, 258)	0.417
Tracheostomy, n (%)	11 (38)	12 (36)	1.000	2.6 (22)	5.0 (38)	0.360
LOICU, day	7 (4, 10)	7 (5, 16)	0.343	6 (5, 9)	7 (4, 9)	0.986
LOHS, day	43 (31, 56)	47 (32, 71)	0.568	37 (30, 43)	35 (33, 63)	0.533
28-day mortality, n (%)	2 (7)	10 (30)	0.045	0.5 (5)	3.9 (29)	0.017
Hospital mortality, n (%)	6 (21)	14 (42)	0.120	2.5 (21)	8.0 (69)	0.035

Data are presented as mean (standard deviation), median (interquartile ranges), or number (percentage) as appropriate

AKI (Acute Kidney Injury), CRRT (Continuous Renal Replacement Therapy), CXR (Chest X-Ray), ECMO (Extracorporeal Membrane Oxygenation), ICU (Intensive Care Unit), LOHS (Length of Hospital Stay), LOICU (Length of Intensive Care Unit stay), LOMV (Length of Mechanical Ventilation), PaO_2 (Partial pressure of arterial Oxygen), PGD (Primary Graft Dysfunction), RBC (Red Blood Cell), SPAP (Systolic Pulmonary Artery Pressure), V-A (Veno-Arterial), V-V (Veno-Venous)

better clinical outcomes. However, detailed data analysis revealed a selection propensity: patients with COPD, single-lung procedures, and prolonged surgery and ischemia times were more likely to receive V-A ECMO. Correcting this propensity was crucial for a fair evaluation of both ECMO modes. We attempted propensity score matching but found it led to substantial sample size reduction, prompting our use of IPTW [16, 17] to address intergroup imbalances. After adjustment, V-A ECMO maintained its superiority in pulmonary circulatory unloading and clinical outcomes.

Traditionally, V-V ECMO has been the primary support modality for lung transplantation, offering efficient blood oxygenation and enabling stringent lung-protective ventilation strategies postoperatively, thus markedly reducing driving pressure—a factor strongly correlated with mechanical ventilation duration and mortality in lung transplant recipients [18, 19]. However, this ECMO modality does not reduce pulmonary blood flow, which is particularly concerning in COPD patients with compensatory right ventricular hypertrophy (developed in response to pre-existing pulmonary hypertension) [20]. In these patients, the excessive transpulmonary blood flow may exacerbate the risk of pulmonary edema [21].

From a physiological standpoint, V-A ECMO directly delivers oxygenated blood to the systemic circulation, effectively reducing pulmonary blood flow [22] and unloading the pulmonary circulation, thereby enabling controlled perfusion of the graft. This controlled reperfusion, recognized as a protective strategy, can significantly mitigate the risk of reperfusion edema in transplanted lungs [23, 24]. Although retrograde blood flow from the femoral artery can increase left ventricular afterload, potentially leading to left ventricular dilation and worsening pulmonary edema in cases of left heart dysfunction [25], this study excluded patients with severe cardiac insufficiency. Thus, in lung transplant recipients, V-A ECMO's reduction of pulmonary blood flow explains the observed physiological benefits, including reduced pulmonary circulatory pressure, less severe pulmonary edema, and better oxygenation.

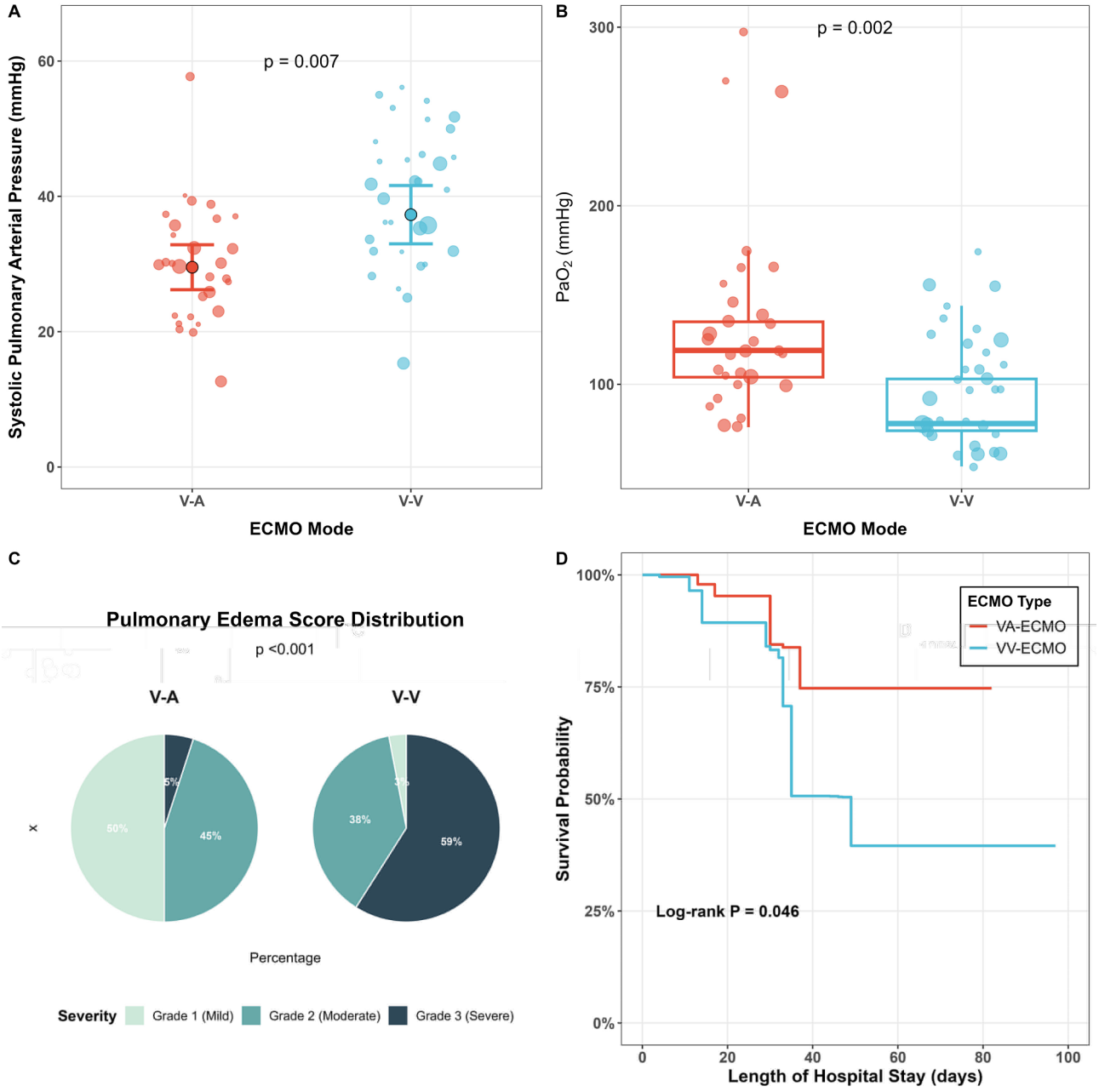

Fig. 2 V-A ECMO's benefits on SPAP (**A**), Oxygen (**B**), pulmonary edema (**C**) and patients' survival (**D**)

Another significant finding in our study was the survival benefit associated with V-A ECMO. This modality provides more comprehensive systemic perfusion, resulting in superior organ function preservation. Notably, we observed a trend towards a lower incidence of AKI in these patients, though this difference approached but did not reach statistical significance. Furthermore, after adjustment, the BSI rate in V-V ECMO patients was nearly triple that of V-A ECMO patients, albeit not statistically significant. A previous study reported a higher prevalence of BSI during V-V ECMO (13.1%) compared to V-A ECMO (5.7%), with associated increases in mortality risk of 1.6-fold and 4.9-fold, respectively [26]. This trend might offer a plausible explanation for the higher mortality observed in the V-V ECMO group in our study.

Emerging technological innovations hold promises for improving ECMO outcomes in lung transplantation. Dual-lumen VV cannulas can minimize cannulation-related trauma while facilitating early awakening, extubation, and mobilization [27]. For patients with preoperative pulmonary hypertension and right ventricular dysfunction, the Protektduo cannula system offers the

additional advantage of right ventricular support [28]. Moreover, hemoadsorption has shown encouraging results in ECMO patients [29, 30], suggesting its potential as an adjunctive therapy to improve outcomes in lung transplant recipients requiring ECMO support. The integration of these emerging technologies represents a promising direction for future investigation in this patient population.

Our study has several limitations that warrant careful consideration. Despite analyzing an eight-year period, the relatively modest sample size may limit statistical power and generalizability. Although we employed robust statistical adjustments, residual confounding from ECMO modality selection bias cannot be completely eliminated. The retrospective design introduces potential unmeasured confounders and missing data that preclude definitive causal inferences. Furthermore, our comparison was limited to conventional femoral-jugular VV ECMO and peripheral VA ECMO, excluding alternative VV cannulation strategies and central ECMO configurations. These limitations highlight the need for larger prospective studies to comprehensively evaluate various ECMO modalities in lung transplantation.

Conclusions

This eight-year retrospective cohort study revealed that V-A ECMO offered superior pulmonary circulatory unloading and improved survival compared to V-V ECMO for lung transplant recipients. These findings suggest V-A ECMO may be the preferred modality for transitional extracorporeal support in this population.

Abbreviations

AKI	Acute kidney injury
APACHE	Acute Physiology and Chronic Health Evaluation
APTT	Activated partial thromboplastin time
BMI	Body mass index
BODE	Body mass index, airflow obstruction, dyspnea, and exercise capacity
BSI	Bloodstream infection
COPD	Chronic Obstructive Pulmonary Disease
CPB	Cardiopulmonary bypass
CRRT	Continuous renal replacement therapy
ECMO	Extracorporeal membrane oxygenation
IPTW	Inverse probability of treatment weighting
IQR	Interquartile range
LOHS	Length of hospital stay
LOICU	Length of intensive care unit stay
LOMV	Length of mechanical ventilation
LVEF	Left ventricular ejection fraction
NYHA	New York Heart Association
PaO_2	Partial pressure of arterial oxygen
$PaCO_2$	Partial pressure of arterial carbon dioxide
PAC	Pulmonary artery catheter
PAP	Pulmonary artery pressure
PGD	Primary graft dysfunction
RBC	Red blood cell
RV	Right ventricular
SPAP	Systolic pulmonary artery pressure
SpO_2	Peripheral oxygen saturation
V-A	Veno-arterial
V-V	Veno-venous

Acknowledgements

None.

Author contributions

SL, XQZ and XBH designed the study; SL and JCL wrote the manuscript; SL, PW, GF and HLH collected and analyzed the data; CP, YC and XBH revised the manuscript. The authors have read and approved the final manuscript.

Funding

This study was supported by the China Foundation for International Medical Exchange (z-2016-23-2101-05), the Medical Science and Technology Project of Sichuan Provincial Health Commission (21PJ080), Key Research and Development Project of Science and Technology of Sichuan Province (2022YFS0605) and Project of Sichuan Provincial Health Commission (21PJ082), Key projects of Jiangsu Provincial Health Commission (ZD2021057).

Data availability

Data are available from the authors upon reasonable request and with permission of Xiao-bo Huang.

Declarations

Ethics approval and consent to participate

Written informed consent for data utilization was obtained from all patients during their hospitalization.

Consent for publication

Not available.

Competing interests

The authors declare no competing interests.

Received: 14 November 2024 / Accepted: 6 January 2025
Published online: 20 January 2025

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