Blood-based versus crystalloid cardiopulmonary bypass priming in left ventricular assist device surgery: impact on end-organ function and survival

Sophie Bonni [1], Rashad Zayat [1], Natasja W. M. Ramnath [1], Nima Hatam [1], Lachmandath Tewarie [1], Ajay Moza [1], Marjolijn C. Sales [1]

[1]Department of Cardiac Surgery, University Hospital RWTH Aachen, Aachen, Germany

Corresponding author: Sophie Bonni, Department of Cardiac Surgery, University Hospital RWTH Aachen, Pauwelsstraße 30, 52074 Aachen, Germany, +492418036780, sbonni@ukaachen.de.

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ABSTRACT

Objectives

Cardiopulmonary bypass (CPB) priming may influence hemodilution, bleeding and end-organ injury during HeartMate 3 (HM3) implantation, but evidence in contemporary left ventricular assist device (LVAD) surgery is limited.

Methods

We retrospectively analysed 92 HM3 implantations (2015–2025) by priming strategy (blood-based [FFP+RBC], n=36; crystalloid, n=56). Primary endpoint was postoperative right heart failure (RHF; INTERMACS). Multivariable regression and propensity score-based inverse probability of treatment weighting (IPTW) sensitivity analyses were performed.

Results

Baseline characteristics were balanced between groups, with comparable age (blood-based: 58 [49.5–66.0]; crystalloid: 62 [55.8–68.2]; p=0,069) and female sex (blood-based: n=3/36 [8.3%]; crystalloid: n=8/56 [14,3%]; p=0.518). RHF was lower with blood-based priming (blood-based: n=3/36 [8.3%]; crystalloid: n=17/56 [30.4%]; p=0.012; adjusted OR 0.23 [95% CI 0.06–0.86]; p=0.030). Dialysis was lower unadjusted (blood-based: n=4/36 [11.1%]; crystalloid: n=18/56 [32.1%]; p=0,021), with a directionally lower adjusted estimate (OR 0.30 [95% CI 0.09–1.01]; p=0.053). Delirium was lower with blood-based priming (blood-based: n=3/36 [8.3%]; crystalloid: n=16/56 [28.6%]; p=0,019; adjusted OR 0.22 [95% CI 0.06–0.84]; p=0.027). Survival did not differ significantly (log-rank p=0.055; adjusted HR 0.59 [95% CI 0.27–1.32]; p=0.201). IPTW analyses showed lower delirium (OR 0.23; [95% CI 0.06-0.84]) and attenuated RHF association (OR 0.35; [95% CI 0.10-1.23]).

Conclusions

Blood-based CPB priming was associated with lower RHF and delirium, and directionally lower dialysis rates, after HM3 implantation. Survival estimates were not statistically significant. Findings require prospective validation.

Keywords blood-based priming; fresh frozen plasma; red blood cells; cardiopulmonary bypass; HeartMate 3; left ventricular assist device.

INTRODUCTION

Left ventricular assist device (LVAD) implantation is an established therapy in end-stage heart failure (1, 2). Despite improved technologies and perioperative management, complications, including bleeding, thromboembolic events, infections, and end-organ injury, remain high (3-5).

Acute right heart failure (RHF) affects 20–40% of patients after LVAD implantation (6, 7). RHF post-LVAD surgery involves multifactorial mechanisms (8), with right ventricular function being highly sensitive to loading changes (9).

Cardiopulmonary bypass (CPB) priming affects physicochemical and homeostasis balance (10, 11). While crystalloids cause dilution, blood-based priming with fresh frozen plasma (FFP) and red blood cells (RBC) aims to preserve oncotic pressure, reduce hemodilution and may decrease bleeding and postoperative organ dysfunction. However, evidence supporting blood-based priming in contemporary LVAD surgery remains limited (12, 13).

We hypothesized that blood-based CPB priming [FFP+RBC] is associated with lower rates of clinically significant postoperative RHF and end-organ dysfunction compared with crystalloid priming. Early postoperative outcomes were defined as in-hospital complications and early mortality including 30-day mortality.

MATERIAL AND METHODS

Study design

We performed a single-center retrospective observational study of 92 adult patients who underwent LVAD implantation (HeartMate 3, Abbott Laboratories, Pleasanton,

CA, USA) from October 2015 to April 2025. Clinical, laboratory, echocardiographic, and hemodynamic data were collected from electronic and paper records into an electronic case report file. Patients were retrospectively categorized according to the CPB priming strategy used at surgery (blood-based [FFP + RBC] versus crystalloid); no assignment to treatment groups occurred. Outcomes and adverse events were defined in accordance with the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) definitions (14).

The primary endpoint was postoperative RHF, defined as elevated central venous pressure >16 mmHg or echocardiographic/clinical equivalents and manifestations of venous congestion. RHF severity was further classified by the need for temporary right ventricular mechanical support or requirement for continuous inotropic support extending beyond 14 days postoperatively. Secondary endpoints included renal failure (new onset dialysis), delirium (clinical diagnosis by positive Confusion Assessment Method for the Intensive Care Unit score), major bleeding (any bleeding event requiring transfusion of ≥ 2 units of RBC involving a critical organ or necessitating surgical re-exploration), transfusions, and survival (time from LVAD implantation to death or last follow-up)

Ethics

Only routinely collected clinical data were used; no biological material, research biobank, or database for indefinite future use was established. Therefore, the WMA Declaration of Taipei did not impose additional requirements. The Ethics Committee of RWTH Aachen University approved the study (EK 25-154, May 15, 2025) and waived informed consent.

CPB, surgery and postoperative management

Priming strategy (blood-based versus crystalloid) was determined by surgeon preference. Crystalloid priming comprised balanced crystalloid (1150 mL), mannitol (100 mL), and 5000 IU unfractionated heparin; blood-based priming comprised four FFP units, two RBC units, and 5000 IU heparin. During CPB, unfractionated heparin (500 IU/kg) targeted ACT >500 seconds and was reversed 1:1 with protamine. CPB discontinuation required absence of relevant surgical bleeding. Cell-saver use was non-mandatory and reserved for high preoperative bleeding risk after interdisciplinary discussion. ROTEM-guided transfusion and vasoactive management followed institutional and guideline-based protocols (15).

Statistical analysis

Analyses were performed in R (v4.2.3). Continuous variables are shown as median (IQR) and compared using Wilcoxon–Mann–Whitney tests; categorical variables as n (%) and compared using χ^2 or Fisher's exact tests. We report RR/OR with 95% CI. Logistic models were unadjusted and adjusted for age, sex, and INTERMACS profile. Survival was assessed by Kaplan–Meier/log-rank and Cox models. We performed propensity score–based inverse probability of treatment weighting (IPTW) sensitivity analysis using stabilized weights truncated at the 1st/99th percentiles and robust standard errors; covariate balance was assessed by standardized mean differences (SMD) (target |SMD|<0.10, acceptable <0.15). Covariates, balance, and weighted estimates are reported in Supplementary Tables S1A–C; the STROBE flow diagram is shown in Supplementary Figure S1.

RESULTS

Baseline preoperative characteristics

Blood-based priming was used in 36 patients [39.1%] and crystalloid priming in 56 [60.9%]. Most baseline characteristics were comparable between both groups (Table 1). Age (blood-based: 58 [49.5–66.0] years; crystalloid: 62 [55.8–68.2] years; p=0.069), female sex (blood-based: n=3/36 [8.3%]; crystalloid: n=8/56 [14.3%]; p=0.518), and INTERMACS profile distribution (blood-based: [25,0%]; crystalloid: [25,0%]; p=0.509) did not differ significantly. Notably, prior PCI was more frequent in the crystalloid group (blood-based: n=8/36 [22.2%]; crystalloid: n=32/56 [57.1%]; p<0.001).

Risk scores, comorbidities, diagnostic findings, and key preoperative laboratory parameters are summarized in Table 1, with extended panels in Supplementary Table S2. Missingness is summarized in Supplementary Table S3.

Intraoperative course

CPB duration, transfusions, catecholamines, and inhaled pulmonary vasodilator use were similar between the groups (Table 2). Hemoglobin (g/dL) at ICU admission was higher in the blood-based priming group (blood-based: 10.3 [9.2–10.8]; crystalloid: 9.2 [8.9–10.0]; p=0.002), whereas hemoglobin at 24 hours (blood-based: 9.5 [9.1–10.1]; crystalloid: 9.3 [8.8–9.8]; p=0.070) was similar between groups (Table 2). Fibrinogen administration was comparable; however, prothrombin complex concentrate (IU) use was higher in the crystalloid priming group (blood-based: 1500 [0–2000]; crystalloid: 2000 [0–3000]; p=0.049) (Table 2).

Postoperative outcomes

Postoperative outcomes are summarized in Table 3. The incidences of RHF (blood-based: n=3/36 [8.3%]; crystalloid: n=17/56 [30.4%]; p=0.012), dialysis (blood-based: n=4/36 [11.1%]; crystalloid: n=18/56 [32.1%]; p=0.021), and delirium (blood-based:

n=3/36 [8.3%]; crystalloid: n=16/56 [28.6%]; p=0.019) were lower after blood-based priming.

Major bleeding was numerically lower after blood-based priming (blood-based: n=10/36 [27.8%]; crystalloid: n=26/56 [46.4%]; p=0.074). Chest drain output at 24 hours and postoperative transfusion requirements within 24 hours (excluding fixed priming units) were comparable between groups (Table 3). Need for liver replacement therapy was numerically lower after blood-based priming (blood-based: n=2/36 [5.6%]; crystalloid: n=11/56 [19.6%]; p=0.058).

Duration of mechanical ventilation (h) was similar between both groups (blood-based: 18 [2–40]; crystalloid: 20 [1–39]; p=0.953).

In multivariable logistic regression adjusted for age, sex, and INTERMACS profile (Table 4), blood-based priming was associated with lower odds of RHF (OR 0.23 [95% CI 0.06–0.86]; p=0.030) and delirium (OR 0.22 [95% CI 0.06–0.84]; p=0.027). Dialysis was directionally lower but imprecise (OR 0.30 [95% CI 0.09–1.01]; p=0.053). For major bleeding, the results showed (OR 0,47 ([95% CI 0.19–1.18]; p=0.109).

Survival

Survival analysis (median follow-up 24 months) showed no statistically significant difference between groups (Figure 1) with a log-rank p=0.055. In multivariable Cox regression adjusted for age, sex, and INTERMACS profile (Table 5), blood-based priming was associated with a non-significant lower hazard of mortality during follow-up (HR 0.59 [95% CI 0.27–1.32]; p=0.201). Age remained associated with mortality (HR 1.05 per year [95% CI 1.01–1.10]; p=0.007), and a higher INTERMACS profile was protective (HR 0.52 per 1-level increase [95% CI 0.38–0.70]; p<0.001). In

propensity-weighted sensitivity analyses, effect estimates were directionally consistent for postoperative endpoints (Supplementary Table S1B) and survival (Supplementary Table S1C), although precision remained limited.

DISCUSSION

In this study, blood-based CPB priming during LVAD implantation was associated with lower incidence of postoperative RHF and delirium, and with directionally lower dialysis rates, compared with crystalloid priming. Baseline characteristics were mostly balanced between the groups, although the non-randomized priming strategy precluded exclusion of residual confounding.

The main finding was the association between blood-based CPB priming and lower postoperative RHF. RHF is a major post-LVAD complication (16). In our cohort, RHF was threefold higher with crystalloid priming (blood-based: n=3/36 [8.3%]; crystalloid: n=17/56 [30.4%]; p=0.012; adjusted OR 0.23 [95% CI 0.06–0.86]; p=0.030). In IPTW analysis, this association attenuated (OR 0.35 [95% CI 0.10–1.23]), consistent with limited precision and potential residual confounding, while the direction remained concordant. The right ventricle is load-dependent and vulnerable to postoperative geometric changes (8, 9, 17, 18). Crystalloid priming and transfusions may cause hemodilution and edema, impairing RV contractility and increasing RHF risk (19, 20). By preserving oncotic pressure, FFP may limit interstitial fluid accumulation and help explain lower RHF rates (21, 22).

The lower unadjusted rate of postoperative dialysis in the blood-based priming group may suggest renal protection. Acute kidney injury requiring dialysis after LVAD implantation worsens outcomes (23). In our cohort, dialysis occurred more frequently

in the crystalloid group (blood-based: n=4/36 [11.1%]; crystalloid: n=18/56 [32.1%]; p=0.021), although the adjusted estimate was imprecise (OR 0.30 [95% CI 0.09–1.01]; p=0.053). Blood-based priming may maintain intravascular volume better, supporting renal perfusion during CPB (24). In addition, FFP provides coagulation factors and other plasma proteins that may attenuate inflammatory and coagulopathic cascades, potentially limiting kidney injury (25, 26).

Furthermore, our data showed that despite similar overall transfusion rates and comparable 24-hour hemoglobin levels, blood-based priming maintained higher hemoglobin levels at ICU admission. This suggests that prevention of marked intraoperative hemodilution may contribute to lower volume-overload complications such as RHF and dialysis.

Delirium was also lower with blood-based priming (blood-based: n=3/36 [8.3%]; crystalloid: n=16/56 [28.6%]; p=0,019; adjusted OR 0.22 [95% CI 0.06–0.84]; p=0.027). Post-cardiac surgery delirium reflects cerebral hypoperfusion, inflammation, microemboli, and metabolic disturbances; risk factors include prolonged CPB, transfusion, age, and cognitive impairment (27, 28). The association may reflect improved hemodynamic stability, microcirculatory flow, and less systemic inflammation (29, 30). Without neurologic monitoring or biomarker data, causality cannot be inferred, but concordant signals across RHF, renal dysfunction, and delirium support a potential end-organ perfusion benefit (26, 28, 29).

Major bleeding commonly complicates complex cardiac surgery (15). FFP has been proposed as prophylactic priming to reduce bleeding. Bianchi et al. showed that FFP priming in pediatric cardiac surgery reduces bleeding and increases fibrinogen levels (31). Other studies showed improved thromboelastometric parameters and reduced

transfusions (12). However, some randomized studies and meta-analyses reported inconsistent effects of blood-based priming on postoperative bleeding and transfusions (13, 32). In our cohort, bleeding events were numerically fewer in the blood-based priming group (blood-based: n=10/36 [27.8%]; crystalloid: n=26/56 [46.4%]; p=0.074; adjusted OR 0.47 [95% CI 0.19–1.18]; p=0.109).

Survival estimates favored blood-based priming but were not statistically significant (log-rank p=0.055; adjusted HR 0.59 [95% CI 0.27–1.32]; p=0.201). Given the wide CI and few deaths, these data should not be interpreted as evidence of survival benefit.

This study is among the first evaluating the association between blood-based priming and early postoperative outcomes in HM3 implantation, extending evidence from pediatric and non-LVAD cardiac surgery. Multicenter and randomized studies are needed to validate results.

Limitations

The retrospective single-centre design precludes causal inference, and clinician-selected priming introduces potential residual confounding. The small sample size, especially in the blood-based group, limited power for infrequent outcomes such as major bleeding and mortality. Few deaths and wide confidence intervals further limit mortality inference; survival findings should be considered exploratory. Laboratory markers of hemodilution, endothelial injury, and inflammation were not systematically analyzed. Findings may not generalize to centers with different perfusion or perioperative protocols.

CONCLUSION

Our study suggests that blood-based CPB priming is associated with lower rates of postoperative RHF and delirium, and with directionally lower dialysis rates, in HM3 implantation. Survival estimates favored blood-based priming but were not statistically significant. These findings are hypothesis-generating and should be confirmed in prospective multicentre studies, ideally a randomized controlled trial.

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CONFLICTS OF INTEREST

No conflicts of interest.

DATA AVAILABILITY

The data underlying this article will be shared on reasonable request to the corresponding author.

AUTHOR CONTRIBUTIONS

S.B. conceived the study, collected data, performed analyses and drafted the manuscript. R.Z. contributed to analyses and interpretation. N.R., N.H., L.T., A.M. and M.S. contributed to study design/interpretation and critically revised the manuscript.

N.H. additionally collected the missing clinical data, performed the updated statistical analysis, and generated the new supplementary tables. All authors approved the final version.

FIGURE LEGENDS

Graphical Abstract. The scheme outlines the impact on end-organ function and survival of blood-based priming (fresh frozen plasma and red blood cells, n=36) versus crystalloid priming (n=56) in a retrospective study of 92 patients who underwent LVAD surgery. Blood-based priming was associated with lower rates of postoperative right heart failure and delirium, and with directionally lower dialysis rates. Survival estimates favored blood-based priming but were not statistically significant.

Alt-text: Graphical abstract comparing blood-based versus crystalloid CPB priming in 92 LVAD patients, highlighting lower right heart failure, delirium and directionally lower dialysis rates after blood-based priming, with a non-significant survival estimate.

Figure 1. Kaplan–Meier curves showing postoperative survival in HM3 patients with blood-based or crystalloid priming.

Alt-text: Kaplan–Meier survival curves comparing blood-based and crystalloid CPB priming after HM3 implantation, showing numerically higher survival in the blood-based group without statistical significance.

TABLES

Table 1. Baseline preoperative characteristics.

Variable	Crystalloid priming (n=56)	Blood-based priming (n=36)	P-value
Demographics			
Age, years	62.0 (55.8–68.2)	58.0 (49.5–66.0)	0.069
Female sex, n (%)	8 (14.3%)	3 (8.3%)	0.518
Body mass index, kg/m²	26.8 (24.1–29.7)	27.1 (24.7–30.0)	0.640
Body surface area, m²	2.02 (1.93–2.16)	2.04 (1.97–2.17)	0.614
Heart failure severity and operative risk			
Left ventricular ejection fraction, %	20 (15–25)	20 (15–25)	0.700
NYHA class III, n (%)	24 (42.9%)	14 (38.9%)	0.706
NYHA class IV, n (%)	30 (53.6%)	19 (52.8%)	0.941
LVAD implantation strategy, n (%)			0.052
Bridge to transplant	18 (32.1%)	16 (44.4%)	
Destination therapy	21 (37.5%)	12 (33.3%)	
Bridge to candidacy	16 (28.6%)	3 (8.3%)	
Bridge to recovery	1 (1.8%)	2 (5.6%)	
Bridge to destination	0 (0.0%)	2 (5.6%)	
Unknown	0 (0.0%)	1 (2.8%)	
INTERMACS profile, n (%)			0.509
1	10 (17.9%)	5 (13.9%)	
2	8 (14.3%)	2 (5.6%)	
3	17 (30.4%)	14 (38.9%)	
4	21 (37.5%)	15 (41.7%)	
EuroSCORE II, %	5.16 (3.01–15.29)	4.12 (3.34–8.49)	0.592
EUROMACS score	2.0 (0.0–4.8)	2.0 (0.0–2.0)	0.200
Comorbidities and preoperative support			
Coronary artery disease, n (%)	7 (12.5%)	4 (11.1%)	1
Peripheral arterial disease, n (%)	4 (7.1%)	3 (8.3%)	1
Insulin dependent diabetes mellitus, n (%)	6 (10.7%)	4 (11.1%)	1
Non-insulin dependent diabetes mellitus, n (%)	16 (28.6%)	7 (19.4%)	0.324
Chronic obstructive pulmonary disease, n (%)	21 (37.5%)	11 (30.6%)	0.495
Restrictive lung disease, n (%)	26 (46.4%)	17 (47.2%)	0.941
Pulmonary hypertension, n (%)	30 (53.6%)	23 (63.9%)	0.328
Chronic kidney disease, n (%)	21 (37.5%)	12 (33.3%)	0.684
Prior cardiac surgery, n (%)	10 (17.9%)	6 (16.7%)	0.883
Prior percutaneous coronary intervention, n (%)	32 (57.1%)	8 (22.2%)	<0.001
Dialysis, n (%)	5 (8.9%)	2 (5.6%)	0.701
Mechanical ventilation, n (%)	14 (25.0%)	4 (11.1%)	0.101
Intra-aortic balloon pump, n (%)	0 (0.0%)	0 (0.0%)	1
Percutaneous microaxial pump, n (%)	10 (17.9%)	4 (11.1%)	0.379
Extracorporeal membrane oxygenation, n (%)	10 (17.9%)	2 (5.6%)	0.117
Right ventricular function			
Tricuspid annular plane systolic excursion, mm	16.0 (12.0–19.0)	15.0 (12.5–17.5)	0.808
Pulmonary artery systolic pressure, mmHg	44 (33–55)	37 (30–40)	0.527
Right atrial to pulmonary capillary wedge pressure ratio	0.42 (0.23–0.62)	0.37 (0.14–0.50)	0.425
Preoperative laboratory values			

Leukocyte count, /nL	7.3 (6.3–10.0)	9.2 (7.8–11.1)	0.013
Hemoglobin, g/dL	11.9 (9.4–13.4)	12.8 (10.3–14.1)	0.117
Platelet count, /nL	209 (141–250)	217 (174–298)	0.151
International Normalized Ratio	1.10 (1.03–1.26)	1.07 (1.02–1.19)	0.537
Fibrinogen, g/L	386.00 (298.00–494.00)	469.00 (409.00–640.50)	0.180
Creatinine, mg/dL	1.18 (0.91–1.60)	1.08 (0.91–1.44)	0.697
Glomerular filtration rate, mL/min/1.73 m²	72.1 (49.4–86.2)	75.9 (49.3–96.0)	0.453
Bilirubin, mg/dL	0.54 (0.35–0.83)	0.62 (0.42–0.90)	0.590
Lactate, mmol/L	0.85 (0.70–1.27)	0.90 (0.62–1.40)	0.857
N-terminal-pro- B-type natriuretic peptide, ng/L	2046 (1355–4150)	3128 (1866–6588)	0.253
Euroscore II, European System for Cardiac Operative Risk Evaluation; INTERMACS, Interagency Registry for Mechanically Assisted Circulatory Support; LVAD, left ventricular assist device; NYHA, New York Heart Association.			

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Table 2. Intraoperative course.			
Variable	**Crystalloid priming (n=56)**	**Blood-based priming (n=36)**	**P-value**
Sternotomy, n (%)	46 (85.2%)	29 (80.6%)	0.775
Left lateral thoracotomy, n (%)	8 (14.8%)	7 (19.4%)	0.775
Cytokine adsorption, n (%)	3 (5.4%)	1 (2.8%)	1
Hemofiltration, n (%)	6 (10.7%)	1 (2.8%)	0.240
Cell saver use, n (%)	22 (39.3%)	19 (52.8%)	0.204
Total heparin dose, IU	40000 (35000–50000)	45000 (40000–50000)	0.281
Tranexamic acid, g	2.0 (2.0–2.0)	2.0 (2.0–4.0)	<0.001
Bypass time, min	104 (80–136)	98 (82–135)	0.839
Last intraoperative lactate, mmol/L	3.30 (2.25–5.07)	2.50 (1.90–5.15)	0.338
Hemoglobin at ICU admission, g/dL	9.2 (8.9–10.0)	10.3 (9.2–10.8)	0.002
Hemoglobin 24h postoperative, g/dL	9.3 (8.8–9.8)	9.5 (9.1–10.1)	0.070
Protamine, IU	35000 (30000–42750)	40000 (35000–45000)	0.213
Prothrombin complex concentrate, IU	2000 (0–3000)	1500 (0–2000)	0.049
Fibrinogen, g	4.0 (0.0–4.0)	2.0 (0.0–4.0)	0.456
Red blood cells, units	4 (1–7)	3 (2–5)	0.168
Fresh frozen plasma, units	4 (0–7)	4 (4–6)	0.575
Platelets, units	2 (2–4)	2 (2–3)	0.511
Inhaled pulmonary vasodilators, n (%)	35 (62.5%)	18 (50.0%)	0.236
All products listed above were administered as adjuncts to the priming solution and were not included in the prime itself.			

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Table 3. Postoperative outcomes.

Outcome	Crystalloid priming (n=56)	Blood-based priming (n=36)	RR (95% CI)	P-value
Right heart failure, n (%)	17 (30.4%)	3 (8.3%)	0.27 (0.09–0.87)	0.012
Dialysis, n (%)	18 (32.1%)	4 (11.1%)	0.35 (0.13–0.94)	0.021
Delirium, n (%)	16 (28.6%)	3 (8.3%)	0.29 (0.09–0.93)	0.019
Acute kidney injury, n (%)	3 (5.4%)	2 (5.6%)	1.04 (0.18–5.91)	1
Need for liver replacement therapy, n (%)	11 (19.6%)	2 (5.6%)	0.28 (0.07–1.20)	0.058
Any major bleeding, n (%)	26 (46.4%)	10 (27.8%)	0.60 (0.33–1.09)	0.074
Re-thoracotomy, n (%)	24 (42.9%)	9 (25.0%)	0.58 (0.31–1.11)	0.081
Ischemic stroke, n (%)	5 (8.9%)	3 (8.3%)	0.93 (0.24–3.67)	1
Hemorrhagic stroke, n (%)	2 (3.6%)	0 (0.0%)	0.31 (0.02–6.24)	0.518
Pneumonia, n (%)	24 (42.9%)	19 (52.8%)	1.23 (0.80–1.90)	0.352
Sepsis, n (%)	24 (42.9%)	15 (41.7%)	0.97 (0.60–1.59)	0.910
30-day mortality, n (%)	9 (16.1%)	1 (2.8%)	0.17 (0.02–1.31)	0.082
Right ventricular assist device, n (%)	4 (7.1%)	2 (5.6%)	0.78 (0.15–4.03)	1
Extracorporeal membrane oxygenation, n (%)	4 (7.1%)	3 (8.3%)	1.17 (0.28–4.91)	1
Inotropes >14 days, n (%)	16 (28.6%)	6 (16.7%)	0.58 (0.25–1.35)	0.191
Vasopressors >14 days, n (%)	20 (35.7%)	8 (22.2%)	0.62 (0.31–1.26)	0.170
Inhaled pulmonary vasodilators >14 days, n (%)	21 (37.5%)	14 (38.9%)	1.04 (0.61–1.76)	0.893
Total duration of inhaled nitric oxide, hours	12 (0–40)	0 (0–28)		0.272
Chest drain output 24 h, mL	820 (578–1152)	840 (485–1080)		0.451
Postoperative transfusions within 24 h (excluding priming), units				
Red blood cell units (24 h)	1 (0–2)	1 (0–2)		0.849
Fresh frozen plasma units (24 h)	0 (0–2)	0 (0–0)		0.459
Platelets (24 h)	0 (0–0)	0 (0–0)		0.548
Mechanical ventilation, hours	20 (1–39)	18 (2–40)		0.953
Intensive care unit stay, days	39.0 (20.8–49.8)	30.5 (19.0–51.0)		0.565

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Table 4. Adjusted association between blood-based priming and key postoperative outcomes.		
Outcome	**Adjusted OR (95% CI)**	**P-value**
Right heart failure	0.23 (0.06–0.86)	0.030
Dialysis	0.30 (0.09–1.01)	0.053
Delirium	0.22 (0.06–0.84)	0.027
Any major bleeding	0.47 (0.19–1.18)	0.109
Models adjusted for age, sex, and INTERMACS profile.		

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Table 5. Multivariable Cox regression for all-cause mortality.

Predictor	Adjusted HR (95% CI)	P-value
Blood-based priming vs. crystalloid	0.59 (0.27–1.32)	0.201
Age, years	1.05 (1.01–1.10)	0.007
Female sex	1.47 (0.55–3.96)	0.445
INTERMACS profile (per 1-level increase)	0.52 (0.38–0.70)	<0.001
Models adjusted for age, sex, and INTERMACS profile.		

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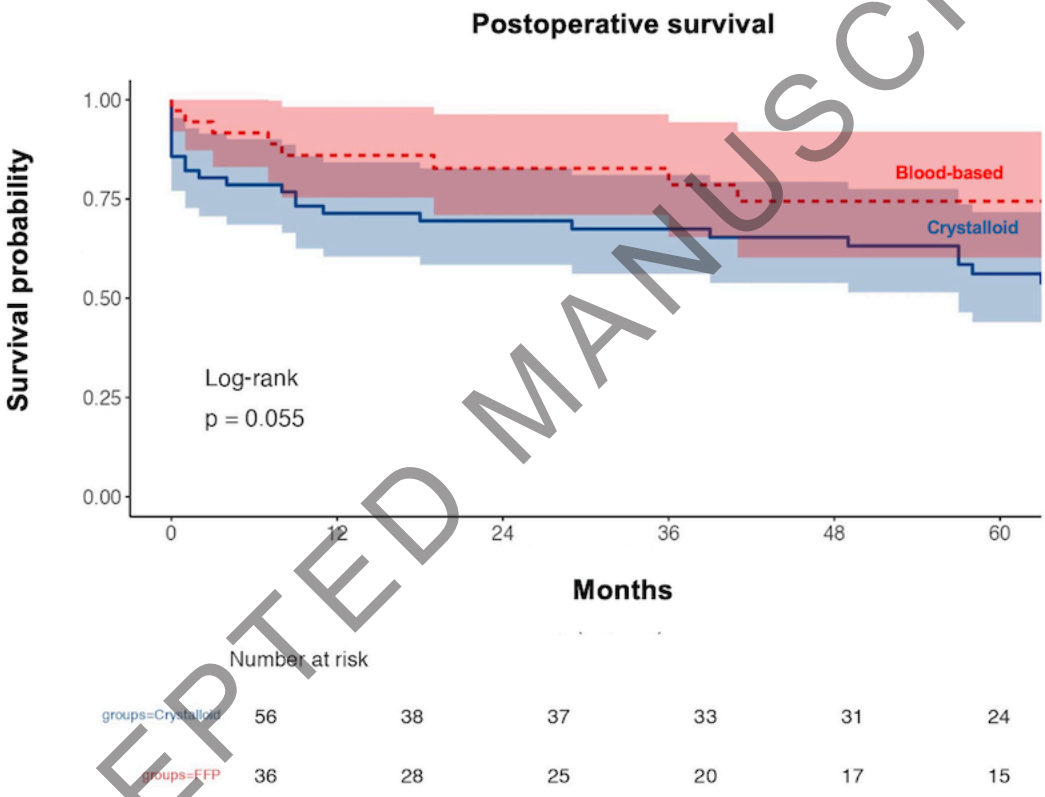
Figure

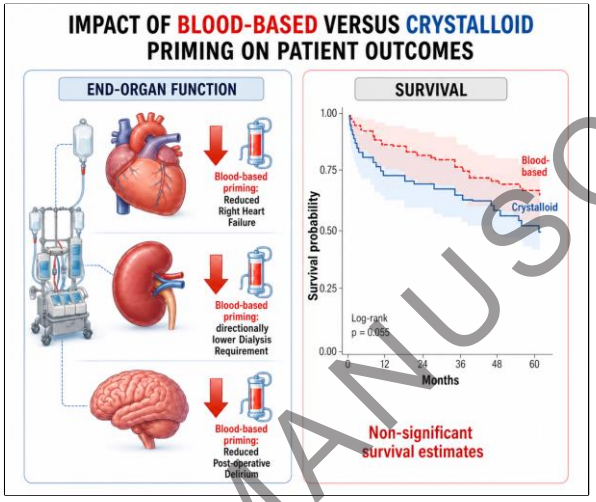


Blood-based versus crystalloid cardiopulmonary bypass priming in left ventricular assist device surgery: impact on end-organ function and survival

Summary

Retrospective, single-centre study of 92 patients with LVAD implantation.
CPB priming: blood-based (FFP/RBC, n=36) versus crystalloid (n=56).

Endpoints: right heart failure, dialysis, delirium, major bleeding, transfusions, and survival.
Blood-based priming showed:
→ lower right heart failure and delirium
→ directionally lower dialysis requirement
→ non-significant survival estimates



Abbreviations: CPB, cardiopulmonary bypass; FFP, fresh frozen plasma; RBC, red blood cells; LVAD, left ventricular assist device.