Chinese Medical Journal®

Veno-arterial extracorporeal membrane oxygenation as a bridge in patients with advanced heart failure: Initial experience in China

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To the Editor: Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) has been used as a bridge in patients with advanced heart failure (AdHF) while waiting for heart transplantation (HTx). Many studies reported by developed countries have confirmed the advantages of VA-ECMO in terms of bridge to left ventricular assist device (LVAD) or HTx, with stabilizing the condition and improving the possibility of further treatment of patients.[1–3] Recent data from the Extracorporeal Life Support Organization (ELSO)[4] indicated that ECMO used as a bridge has increased by 20.5% over a decade. However, to date, there are few studies on the bridge experience of VA-ECMO in the mainland of China.

This study reviewed patients with AdHF from 2015 to 2022, and selected those who received VA-ECMO as a bridge while waiting for HTx. We aimed to examine the clinical course and outcomes of patients with AdHF, and to describe our initial experience utilizing VA-ECMO as a bridge for these patients.

The single-center, retrospective, observational study was approved by the Institutional Ethic Review Board of Fuwai Hospital (No.2022-1777), and the need for informed consent was waived.

The VA-ECMO circuit comprised of an arterial cannula (Edwards Lifesciences, Irvine, CA, USA), a venous cannula (Edwards Lifesciences), an oxygenator kit (BE-PLS 2050, Maquet, Rastatt, Germany), and a centrifugal pump drive and console (Jostra Medizintechnik AG, Hirrlingen, Germany). All patients underwent VA-ECMO by femo-femoral cannulation. A 5–7 French (Fr) cannula was placed in the distal end of femoral artery to provide sufficient perfusion and thus prevent limb ischemia. Indications for VA-ECMO initiation should be based on following indexes: (1) systemic systolic arterial blood pressure <90 mmHg, or continuous inotropic therapy is required to maintain systemic systolic arterial blood pressure at a level of 90 mmHg; (2) urine output <0.5 $mL \cdot kg^{-1} \cdot h^{-1}$; (3) cardiac index <1.8 $L \cdot min^{-1} \cdot m^{-2}$; (4) left atrial pressure or capillary wedge pressure >20 mmHg; and (5) uncorrectable/continuous metabolic acidosis. Intravenous unfractionated heparin was used for anticoagulation to maintain an activated partial thromboplastin time (aPTT) of 160–180 s or an activated clotting time (ACT) of 50–70 s.

Upon VA-ECMO support, patients were anticipated to bridge to HTx or LVAD [Figure 1]. LVAD implantation was performed in the operating room by surgeons. Left heart support has been achieved by cannulating the apex of the left ventricle and the ascending aorta. Two types of domestic LVAD were used for patients with AdHF: CH-VAD (CH Biomedical, Inc., Suzhou, China) and EVAHEART (Chongqing EVAHEART Medical Device Co., LTD., Chongqing, China). CH-VAD has fully magnetically levitated centrifugal pumps and provides a continuous flow. EVAHEART has a distinctive hydraulic circulation system and a unique impeller design, which can ensure to maintain a high end-systolic peak flow and arterial pulsatility.

Cardiopulmonary bypass (CPB) was conducted during cardiac surgery. During the HTx operation, the nasopharyngeal temperature was targeted to reduce to 28–30°C. During the LVAD implantation operation, the nasopharyngeal temperature was targeted to maintain at 34–35°C. Right ventricular assist was performed in patients who developed early right ventricular failure after surgery. The right ventricular assist was cannulated from right atrium to pulmonary artery with centrifugal pump drive and console (Jostra Medizintechnik AG, Hirrlingen, Germany).

Access this article online

Quick Response Code:

Website: www.cmj.org

DOI: 10.1097/CM9.0000000000002822

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Chinese Medical Journal 2024;137(10)
Received: 27-02-2023; **Online:** 23-08-2023 **Edited by:** Jing Ni

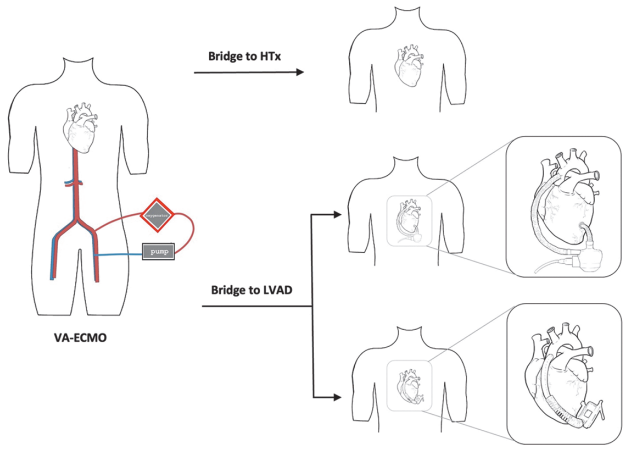

Figure 1: The bridge strategy of VA-ECMO. HTx: Heart transplantation; LVAD: Left ventricular assist device; VA-ECMO: Veno-arterial extracorporeal membrane oxygenation.

Continuous data were expressed as mean ± standard deviation or median (Q1, Q3), where appropriate. Categorical data were presented as the proportion of numbers (*n*/*N*). Paired student *t*-tests were used to test the laboratory variables (pre-ECMO *vs*. 96th hour post-ECMO initiation). A Kaplan–Meier estimate was performed to plot the survival curves between patients bridged to HTx and LVAD. *P* values <0.05 were considered significant difference. All analyses were performed with using IBM SPSS Statistics for Windows, version 21.0 (IBM Corporation, Armonk, NY, USA).

In total, 17 patients (average age, 36.5 ± 10.9 years) were included and 11 were men [Supplementary Table 1, http://links.lww.com/CM9/B688]. AdHF resulted from various etiologies, but dilated cardiomyopathy was the most represented, accounting for 7/17 in the overall cohort. The median left ventricular ejection fraction (LVEF) was 25% (22%, 34%). The median lactate was 2.4 (1.4, 4.7) mmol/L. Before ECMO deployment, 9 of 17 patients required cardiopulmonary resuscitation (CPR) and 10 of 17 patients underwent invasive mechanical ventilation. In our study cohort, 8/17 patients were bridged to HTx, 4 of 17 were bridged to LVAD, and 5 of 17 were only supported with ECMO [Supplementary Figure 1, http://links.lww.com/CM9/B688].

After 96 h of ECMO support, the creatine, aspartate aminotransferase (AST), and alanine aminotransferase (ALT) levels declined significantly (*P* <0.05) [Supplementary Table 2, http://links.lww.com/CM9/B688]. Lactate, creatine, AST, and ALT levels were higher at all time-points in patients who were only supported with ECMO. No statistically significant difference were seen for the laboratory tests between patients bridged to HTx and patients bridged to LVAD [Supplementary Figure 2, http://links.lww.com/CM9/B688].

The median CPB time was longer in patients who underwent HTx than that in those who underwent LVAD (248 min *vs*. 195 min). There was no distinct difference of the median aortic cross-clamping time in these patients. Patients who underwent HTx had received 5 (1, 8) units red blood cell intraoperatively, and patients who underwent LVAD implantation had received 6 (3, 7) units red blood cell intraoperatively [Supplementary Table 3, http://links.lww.com/CM9/B688].

Ten patients were successfully weaned from VA-ECMO after HTx or LVAD implantation. The median ECMO duration was 141.5 h in patients bridged to HTx, 272.5 h in patients bridged to LAVD, and 249.0 h in patients who were only supported with ECMO. Patients who were only supported with VA-ECMO all suffered from acute kidney injury (AKI) and received continuous renal replacement therapy (CRRT) [Supplementary Table 4, http://links.lww.com/CM9/B688]. During the 1-year follow-up, 7 patients were survived. Patients bridged to HTx had relatively favorable survival compared with those bridged to LVAD (5/8 *vs*. 2/4) [Supplementary Figure 3, http://links.lww.com/CM9/B688].

In this study, we described our experience utilizing VA-ECMO as a bridge to HTx or LVAD in patients with AdHF. Most patients had severe cardiovascular and non-cardiovascular illness. Despite these patients' unfavorable initial risk profile, VA-ECMO could facilitate the systemic function recovery, and allow them to overcome the hemodynamically unstable stage.

Although VA-ECMO could function as a bridge strategy in AdHF patients, several factors may affect the prognosis. First, ealy recognition of high-risk patient for ECMO initiation is very important. The progress of chronic heart failure is gradual and subtle. During the acute onset, these patients often suffer from mutiliple organ dysfuction due to irreversibily of drugs. Not only could VA-ECMO help stabilize the patient's condition and improve end-organ perfusion, but it can provide the possibility of further treatment for these patients. Therefore, for acute exacerbations of chronic heart failure, early adoption of ECMO therapy may be benefit for long-term treatment and survival. Second, a prolonged duration of ECMO may increase the risk of complications, thereby leading to unfavorable outcomes. Patients supported by VA-ECMO should be given priority of HTx or LVAD to increase the survival.[2,5] Given our findings and previous reports, we suggest that decision-making in bridging from VA-ECMO to HTx or LVAD should be made early if no recovery signs occurred. Third, further treatment is an important determinant of survival. We observed that the 1-year survival was non-inferior in patients bridged to LVAD compared with patients bridged to HTx. With the increasing number of candidates for HTx and the shortage of donor hearts in China, many AdHF patients may face a prolonged waiting time, thus miss the optimal timing for recovery. Besides, for HTx patients, the immunotherapies were required to prevent rejection of cardiac allograft, which may be associated with an increased risk of infections. LVAD is a durable mechanical circulatory support, which has improved long-term survival for AdHF patients. When a prolonged waiting time for donor heart is expected, these patients may be benefit from LVAD as a substitute therapy. Forth, right ventricular

dysfunction may occur after ECMO decannulation and cause unfavorable outcomes. In our center, we chose the system of ROTAFLOW centrifugal pump (Jostra Medizintechnik AG, Hirrlingen, Germany) to conduct the short-term right ventricular support. The system could easily regulate the pump speed and flow volume to achieve the right ventricular support.

In conclusion, VA-ECMO can be used as a bridge to HTx or LVAD for patients with AdHF experiencing a hemodynamically unstable stage, which may improve the possibility of further treatment and better prognosis. Domestic LVAD could be a promising alternative therapy to HTx, and further study regarding the potential benefit of domestic LVAD is warranted.

Funding

The research was supported by a grant from CAMS Innovation Fund for Medical Sciences (CIFMS) (No. 2020-I2M-C&T-B-054).

Conflicts of interest

None.

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How to cite this article: Wang J, Wang J, Gao SZ, Liu G, Wang Q, Yan SJ, Zhou BY, Yuan Y, Gao GD, Ji BY. Veno-arterial extracorporeal membrane oxygenation as a bridge in patients with advanced heart failure: Initial experience in China. Chin Med J 2024;137:1228–1230. doi: 10.1097/CM9.0000000000002822