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CASE REPORT

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Simultaneous extracorporeal liver and cardiorespiratory support with double plasma molecular absorption system and extracorporeal membrane oxygenation: A case report

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ABSTRACT:

Introduction: Extracorporeal membrane oxygenation (ECMO) has emerged as a life-saving and bridging therapy for critically ill patients grappling with severe cardiopulmonary failure. However, ECMO is associated with multiple complications, including acute liver failure (ALF), which significantly worsens prognosis and mortality rates. This case report presents a unique instance of simultaneous extracorporeal liver and cardiorespiratory support.

Case presentation: A 43-year-old female with a history of infective endocarditis and prior Bentall's operation, who developed acute decompensated heart failure and cardiogenic shock due to a pseudoaneurysm compressing the left main coronary artery. She required high-dose vasopressors and was initiated on venoarterial ECMO (VA-ECMO) for circulatory and respiratory support. However, her condition worsened with the onset of hepatic encephalopathy and severe hyperbilirubinemia, indicative of acute liver failure, likely due to ischemic hepatitis, congestive hepatopathy, and ECMO-related hemolysis. To address her worsening hepatic dysfunction, we initiated the double plasma molecular absorption system (DPMAS) for three consecutive sessions as a bridge to definitive surgical repair. This intervention led to improvements in hepatic and renal function, allowing for successful ECMO weaning after 10 days. Three days after ECMO discontinuation, she underwent pseudoaneurysm repair and was subsequently discharged in stable condition.

Conclusions: To the best of our knowledge, this simultaneous management of acute liver failure and acute cardiorespiratory failure has never been reported in the literature. Our approach effectively reduced hyperbilirubinemia, improved hepatic encephalopathy, and facilitated successful bridging to cardiac surgery.

Keywords: Extracorporeal membrane oxygenation; Double plasma molecular absorption system; Liver failure; Artificial liver support

INTRODUCTION

Acute liver failure (ALF) is a well-known complication among patients receiving extracorporeal membrane oxygenation (ECMO) and is associated with unfavorable clinical outcomes [1,2]. The reported incidence of ALF in ECMO patients varies across studies; however, it is more prevalent in those receiving venoarterial ECMO (VA-ECMO) compared to venovenous ECMO (VV-ECMO). A study by Lin Lyu et al. reported that 39% of VA-ECMO patients developed hyperbilirubinemia, a surrogate marker for liver dysfunction, whereas Rui Huang et al. found that only 18% of VV-ECMO patients experienced this complication [3,4].

The pathophysiology of ALF differs between VA-ECMO and VV-ECMO. In VA-ECMO, liver dysfunction is primarily attributed to hemolysis from pump head or oxygenator thrombosis, excessive pump speed (>3000 rpm), and hemodynamic instability leading to ischemic liver injury. Additionally, altered hepatic perfusion in VA-ECMO may contribute to ischemic injury of the biliary ducts, further exacerbating liver dysfunction. In contrast, ALF in VV-ECMO is less common and is typically caused by hypoxia-induced liver injury rather than direct hemodynamic compromise [4,5].

While liver transplantation remains the definitive treatment for ALF, it is often not feasible in ECMO patients due to candidacy constraints or other limitations. Consequently, extracorporeal liver support has emerged as an alternative strategy to reduce bilirubin levels and manage liver dysfunction, allowing time for hepatic recovery.

Here, we present a case of a 43-year-old female with cardiopulmonary failure complicated by ALF, successfully treated with simultaneous extracorporeal liver support using the double plasma molecular absorption system (DPMAS) in conjunction with VA-ECMO. To our knowledge, this represents the first reported case of simultaneous extracorporeal liver and cardiorespiratory support in the literature.

KEY MESSAGES:

In this report, we present a successful case of simultaneous extracorporeal liver support utilized by the double plasma molecular absorption system in conjunction with ECMO. Our intervention resulted in a reduction in hyperbilirubinemia, improvement of hepatic encephalopathy, and successful bridging of the patient to cardiac surgery.

CASE PRESENTATION

A 43-year-old female presented with a history of infective endocarditis involving the aortic valve, leading to a perianular abscess and severe aortic insufficiency. She had previously undergone a Bentall's operation with a stentless Freestyle™ aortic root bioprosthesis six months prior, without any complications. She was referred from a private hospital to our hospital with acute decompensated heart failure and concurrent hypoxic respiratory failure.

Upon admission, she developed cardiogenic shock, requiring high doses of vasopressors. Her initial vital signs were a temperature of 37.2°C, blood pressure of 90/65 mmHg (on norepinephrine 0.3 μg/kg/min and dopamine 15 μg/kg/min), heart rate of 128 bpm, respiratory rate of 24 breaths per minute, and oxygen saturation of 100% on full ventilator support. On examination, she appeared drowsy but arousable. Cardiovascular examination revealed a systolic murmur at the right upper sternal border, while pulmonary examination noted bilateral fine crepitations. Hemodynamic parameters showed a central venous pressure (CVP) of 18 mmHg, a cardiac index of 1.7 L/min/m^2, and a lactate level of 6.2 mmol/L.

She was in cardiogenic shock for approximately 12 hours before being promptly supported with extracorporeal membrane oxygenation (ECMO) and an intra-aortic balloon pump (IABP) to address her hemodynamic status and provide essential cardiorespiratory assistance. She was initiated on VA-ECMO using the Maquet ECMO system for circulatory support. The procedure was performed by a cardiovascular and thoracic surgeon under local anesthesia with ultrasound guidance. Cannulation sites included the right femoral artery (arterial access) with a 17 Fr cannula and the right internal jugular vein (venous drainage) with a 21 Fr cannula.

Initial laboratory results indicated acute kidney injury and ischemic hepatitis, consistent with her shock status. Liver function tests revealed elevated levels of aspartate aminotransferase (AST) at 4548 U/L, alanine aminotransferase (ALT) at 2968 U/L, total bilirubin at 7.8 mg/dL, and direct bilirubin at 3.3 mg/dL with normal levels of alkaline phosphatase (ALP) at 75 U/L. Renal function tests revealed a blood urea nitrogen (BUN) of 46.8 mg/dL and serum creatinine of 1.98 mg/dL (compared to her previous baseline serum creatinine of 0.63 mg/dL, measured two months prior to admission).

Further investigation into the etiology of acute decompensated heart failure (ADHF) and cardiogenic shock was undertaken. Echocardiography revealed left ventricular dilation with an ejection fraction of 30%, akinesia at the anterior and septal wall of the left ventricle, and grade III diastolic dysfunction. After ECMO and IABP were established, coronary angiography was performed to exclude coronary artery disease, and it identified significant ostial stenosis of the left main coronary artery attributed to external compression. To address this left main coronary artery stenosis, a percutaneous coronary intervention was conducted, and a drug-eluting stent was also inserted at the left coronary ostium.

A contrast-enhanced CT angiography (CTA) of the heart revealed two small contrast-filled outpouching lesions at the right and left coronary cusps, suggesting pseudoaneurysms (Figures 1A and 1B). The right coronary cusp pseudoaneurysm measured 0.7 × 0.3 × 1.0 cm, while the left coronary cusp pseudoaneurysm measured 4.1 × 3.0 × 2.4 cm, protruding into the left ventricular outflow tract (LVOT). Notably, no active contrast extravasation was observed.

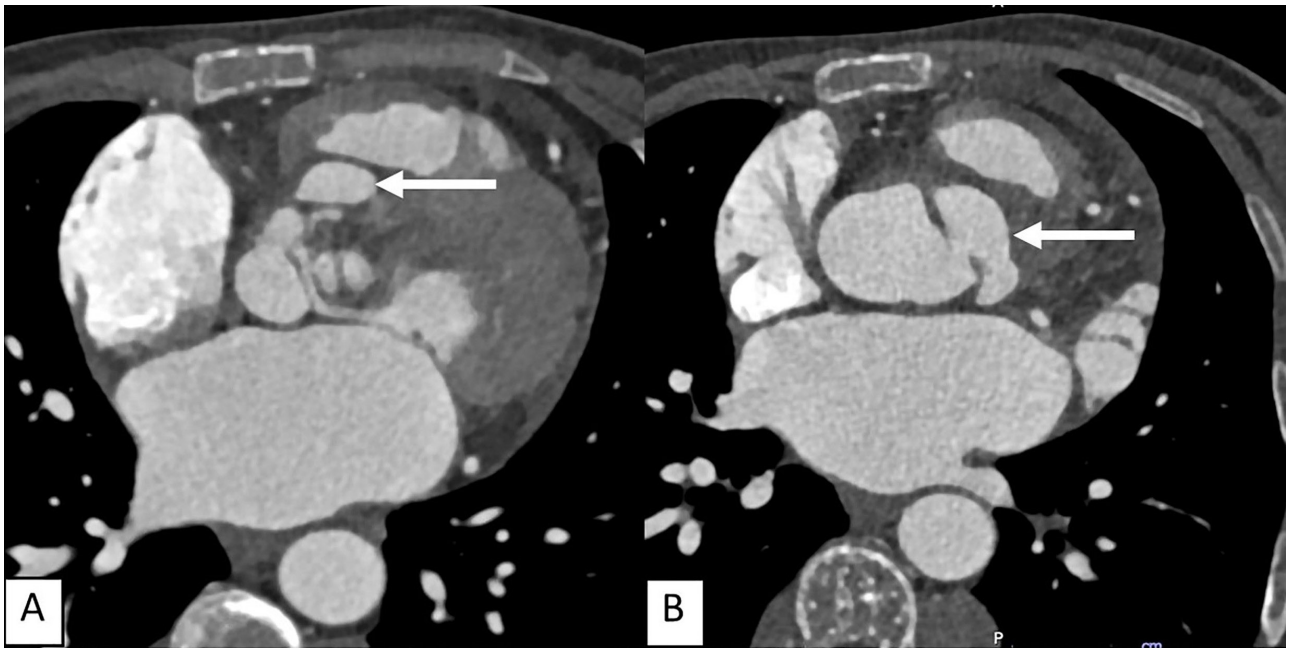

Figure 1. Axial view contrast-enhanced computed tomography angiography (CTA) of the heart show two small contrast-filled outpouching lesions at the right **(A)** and left coronary cusps **(B)**, suggesting pseudoaneurysms.

As a result, the patient's clinical presentation and diagnostic findings raised concerns about a potential pseudoaneurysm located between the left ventricular outflow tract and aortic root bioprosthetic, exerting compression on the left main coronary artery and contributing to cardiogenic shock. Given the complexity of the vascular pathology, the cardiovascular surgical team proposed mechanical hemodynamic supports as a bridge to reoperation, which was destination therapy.

On day 3 after admission, her clinical conditions had deteriorated further, characterized by hepatic encephalopathy and worsening hyperbilirubinemia, indicative of acute liver failure suspected by multifactorial causes, including ischemic hepatitis, congestive hepatopathy, and hemolysis. Laboratory assessments revealed total bilirubin levels at 35.2 mg/dL, direct bilirubin levels at 20.5 mg/dL, aspartate aminotransferase (AST) levels at 1933 U/L, alanine aminotransferase (ALT) levels at 1801 U/L, alkaline phosphatase levels at 80 U/L, serum creatinine levels at 3.27 mg/dL, prothrombin time (PT) at 23.8 s, international normalized ratio (INR) at 2.2, and elevated lactate dehydrogenase (LDH) levels at 902. Additionally, a serum ammonia level at 125 μmol/L was observed (reference range, 18–72 μmol/L).

With regard to acute liver failure, the surgical procedure was postponed due to the instability of the patient's condition. A multidisciplinary team comprised of cardiologists, cardiovascular surgeons, intensivists, and nephrologists deliberated on the potential role of artificial liver support in enhancing hepatic function and reducing hyperbilirubinemia. Subsequently, the decision was made to initiate the DPMAS as a therapeutic intervention.

The DPMAS was applied via a double-lumen catheter inserted in the left femoral vein, separate from the ECMO system, by a nephrologist on day 3 after admission, approximately 72 hours after ECMO insertion, utilizing a hemoperfusion machine (JF—800A, Zhuhai Health Sails Biotechnology Co., Ltd., Zhuhai, China). Heparin anticoagulation was not discontinued during the catheter insertion procedure. A schematic of the simultaneous DPMAS and ECMO system is illustrated in Figure 2. The volume of plasma adsorption used for DPMAS treatment was 5000–6000 mL, with a blood flow of 100–120 mL/min and a plasma adsorption rate of 25–30 mL/min. Each DPMAS session lasted for 3.5-4 hours, and the treatment was administered consecutively for 3 days.

Following three sessions of DPMAS, the patient's condition gradually improved. She regained consciousness and alertness while under light sedation for comfort. Serum ammonia levels decreased to 33 μmol/L. Total bilirubin and direct bilirubin levels were maintained. The trends of liver function tests and serum ammonia levels during DPMAS are presented in Figure 3.

On the 10th day after admission, successful weaning and decannulation from ECMO with stable hemodynamics was achieved. Bedside transthoracic echocardiography has shown better left ventricular systolic function without any regional wall abnormality. Three days later, a reoperation procedure was performed to address a pseudoaneurysm. Under standard cardiopulmonary bypass (CPB) and arrested heart, the origin of the pseudoaneurysm was found at LVOT under the non-coronary cusp area, as observed from preoperative imaging. Eight stitches of 4-0 polypropylene reinforced with bovine pericardium were applied to the closed origin of the pseudoaneurysm. After the pseudoaneurysm was closed, followed by the removal of the aortic cross clamp, CPB was weaned off smoothly. Intraoperative transesophageal echocardiography showed no more flow around the previous pseudoaneurysm area. Post-surgery, the patient was weaned off the ventilator five days after the procedure. She was referred to a private hospital on hospital day 20. The total bilirubin and direct

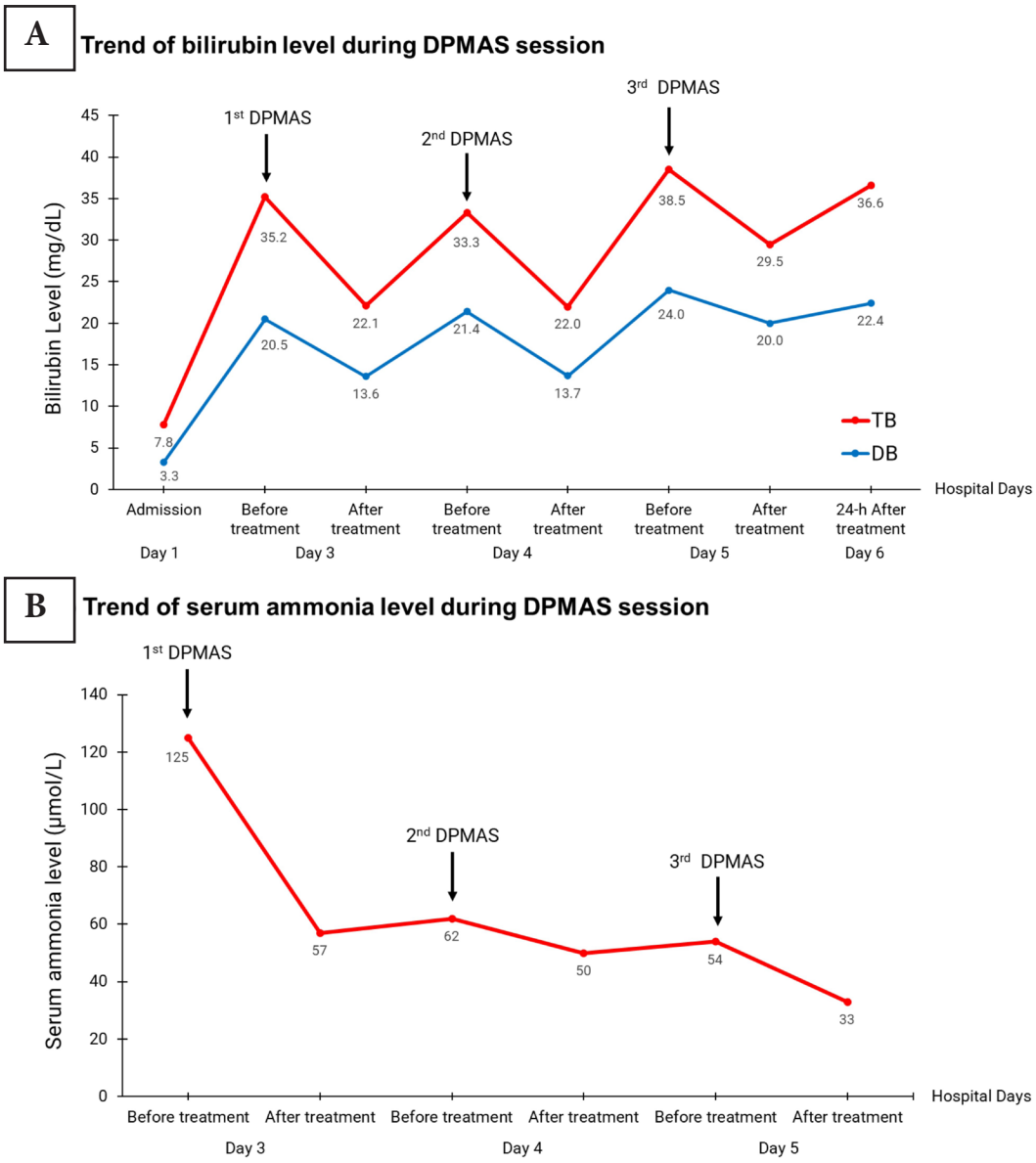

Figure 2. Trend of bilirubin level **(A)** and serum ammonia level **(B)** during DPMAS session.
Abbreviations: TB: Total bilirubin; DB: Direct bilirubin; DPMAS: double plasma molecular absorption system

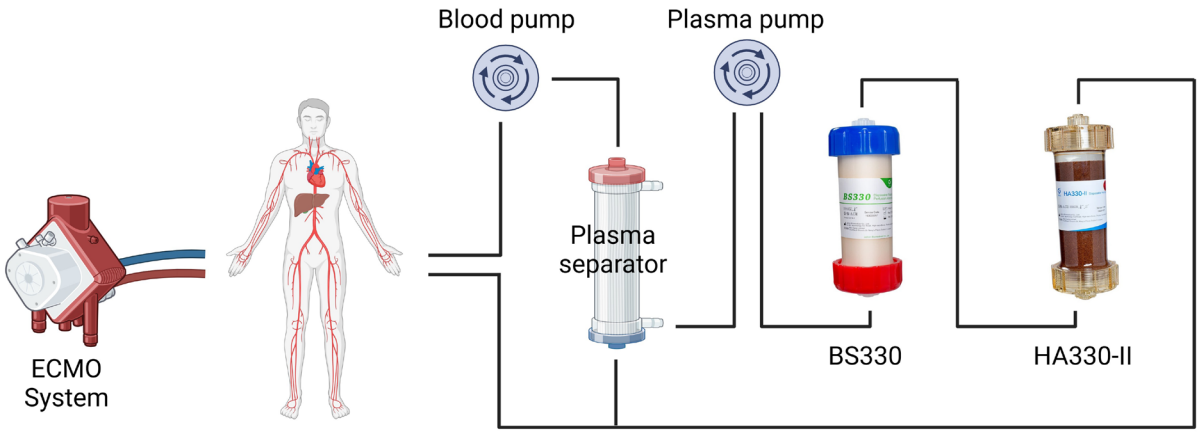

Figure 3. Schematic representation of simultaneous extracorporeal membrane oxygenator (ECMO) and double plasma molecular adsorption system (DPMAS) to the patient through a separate catheter independent of the ECMO circuit.

bilirubin levels on the date of discharge were 4.3 mg/dL and 2.1 mg/dL, respectively. She was admitted to the private hospital for 7 days before being discharged. Her liver function normalized within 30 days after discharge (total bilirubin was 3.1 mg/dL and direct bilirubin was 2.0 mg/dL), along with the restoration of renal and cardiac functions. Remarkably, no readmissions occurred during the 3-month follow-up period.

DISCUSSION

Extracorporeal membrane oxygenation has emerged as a life-saving and bridging therapy for critically ill patients grappling with severe cardiopulmonary failure. In the context of ECMO therapy, ALF can manifest due to a multitude of factors, including ischemic hepatitis, congestive hepatopathy, and hemolysis [6]. Regardless of the etiology of liver failure, its occurrence represents a medical emergency necessitating immediate supportive care, with treatment extending until the recovery of liver function or consideration of liver transplantation.

Recently, extracorporeal liver-assisted devices have been employed as a bridge therapy aimed at facilitating hepatic recovery. These systems play a pivotal role in detoxification and metabolic function support for the liver. Presently, various techniques have been used in ALF patients including high-volume plasma exchange, hemoperfusion, plasma bilirubin absorbance, and DPMAS, each demonstrating the potential for mitigating bilirubin levels and cytokine clearance within the context of acute liver failure [7,8].

While there have been no reports of using DPMAS in conjunction with ECMO, the simultaneous use of other extracorporeal support modalities has been documented. Mitchell Dyer et al. reported on 76 patients who underwent both ECMO and therapeutic plasma exchange for multisystem organ failure and coagulopathy, demonstrating that simultaneous extracorporeal support is tolerable and can be performed in critically ill children and adults [9].

To the best of our knowledge, this is the first case report documenting the use of DPMAS in ECMO patients with acute liver failure. Previously, Sparks et al. demonstrated the efficacy of the molecular adsorbent recirculating system (MARS), a form of liver dialysis, in accelerating liver function recovery, reducing plasma bilirubin levels, and improving survival in ECMO patients suffering from acute shock liver failure [10]. Our findings similarly suggest that DPMAS, one of the latest advanced techniques, promotes the rapid recovery of liver function, reduces plasma bilirubin levels, and improves survival without introducing additional complications.

The Double Plasma Molecular Adsorption System (DPMAS) introduces a novel paradigm in the realm of artificial liver support. Utilizing plasma separation, DPMAS employs neutral macroporous adsorption resin (HA330-II) and ion exchange resin (BS330) columns for continuous plasma adsorption and return [11,12]. DPMAS offers effective clearance of medium- and macro-molecules, along with protein-bound toxins, with a specific focus on bilirubin, all without necessitating plasma supplementation or replacement solutions during treatment [13]. This unique attribute positions DPMAS as an optimal solution for conditions characterized by hypercytokinemia and hyperbilirubinemia, which are frequently encountered by ECMO patients with ALF.

There are two techniques for combining DPMAS with ECMO: the separation technique and the integration technique. The separation technique involves the independent operation of DPMAS alongside ECMO, simplifying the process and eliminating the need for perfusionist involvement. Conversely, the integration technique involves incorporating DPMAS into the ECMO circuit, necessitating perfusionist support while eliminating the requirement for additional vascular access. Vigilant attention is crucial regarding pressure limits, especially concerning the hemoperfusion machine. It is recommended the access line be positioned post-pump to prevent air entrainment, and the return line should be connected before the oxygenator, typically located post-pump, to mitigate the risk of air embolism [14]. In our case, we opted for the separation technique to streamline the process.

The decision to implement DPMAS in our patient was driven by the presence of acute liver failure accompanied by hepatic encephalopathy and progressive hyperbilirubinemia, stemming from ischemic hepatitis caused by delayed ischemic myocardium and low cardiac output with hypoperfusion syndrome, and hemolysis exacerbated by ECMO support. Her laboratory profile exhibited a rapid surge in serum bilirubin levels, alongside a gradual amelioration in liver enzyme levels consistent with a typical shock liver pattern. Notably, elevated levels of lactate dehydrogenase (LDH) also indicated potential hemolysis compounded by ECMO. The significance of heightened bilirubin concentrations in ECMO patients cannot be overstated; such elevations have been linked to inflammatory responses, cellular apoptosis within cerebral and pulmonary tissues, as well as thrombocytopenia arising from oxidative stress and platelet apoptosis [15,16]. From our perspective, artificial liver support should help to improve the patient's clinical conditions.

Following three sessions of DPMAS, the patient's bilirubin levels did not fully return to baseline due to liver failure not being fully resolved (Figure 1). Noteworthy improvements in hepatic encephalopathy, coagulopathy, and hemodynamic stability collectively enabled her to safely undergo cardiac surgery. This underscores the role of DPMAS as a supportive measure for liver care, facilitating recovery rather than serving as a definitive treatment.

CONCLUSION

In conclusion, we reported on a case of simultaneous cardiorespiratory and liver support by the ECMO and DPMAS. The results included decreased hyperbilirubinemia, decreased hypercytokinemia, and improvement of hepatic encephalopathy as well as bridging the patient to undergo cardiac surgery. Further research is warranted to establish precise patient selection criteria and optimal initiation timing for this combined therapeutic approach.

STATEMENT OF ETHICS

This case report was conducted according to the Declaration of Helsinki and Good Clinical Practice guidelines. This study protocol was reviewed and approved by the institutional review board at Central Chest Institute of Thailand, approval number 090/2566. Written informed consent was obtained from the patient for publication of the details of their medical case and any accompanying images.

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AUTHORS' CONTRIBUTIONS

Peerapat Thanapongsatorn was responsible for study concept and design. Peerapat Thanapongsatorn, Massupa Krisem, and Sahaporn Wathanawanichakun were responsible for data collection, acquisition, analysis, and interpretation of data. Peerapat Thanapongsatorn, Massupa Krisem, and Sahaporn Wathanawanichakun were contributed to writing the manuscript, and approved the final version of the manuscript to be published.

REFERENCES

1. Blandino Ortiz A, Lamanna I, Antonucci E, Pozzebon S, Dell'anna AM, Vincent JL, et al. Altered liver function in patients undergoing veno-arterial extracorporeal membrane oxygenation (ECMO) therapy. Minerva Anestesiol. 2017;83:255-65.
2. Chor CYT, Mahmood S, Khan IH, Shirke M, Harky A. Gastrointestinal complications following cardiac surgery. Asian Cardiovasc Thorac Ann. 2020;28(9):621-632.
3. Lyu L, Yao J, Gao G, Long C, Hei F, Ji B, et al. Incidence, risk factors, and outcomes of hyperbilirubinemia in adult cardiac patients supported by Veno-Arterial ECMO. Artif Organs. 2018;42:148-54.
4. Huang R, Shao M, Zhang C, Fang M, Jin M, Han X, et al. Serum total bilirubin with hospital survival in adults during extracorporeal membrane oxygenation. Front Med (Lausanne). 2022;9:914557.
5. Akbar A, Baron TH. Ischemic biliary injury following extra-corporeal membrane oxygenation (ECMO). Dig Liver Dis. 2012;44:705.
6. Roth C, Schrutka L, Binder C, Kriechbaumer L, Heinz G, Lang IM, et al. Liver function predicts survival in patients undergoing extracorporeal membrane oxygenation following cardiovascular surgery. Crit Care. 2016;20:57.
7. Aron J, Agarwal B, Davenport A. Extracorporeal support for patients with acute and acute on chronic liver failure. Expert Rev Med Devices. 2016;13:367-80.
8. Tandon R, Froghi S. Artificial liver support systems. J Gastroenterol Hepatol. 2021;36:1164-79.
9. Dyer M, Neal MD, Rollins-Raval MA, Raval JS. Simultaneous extracorporeal membrane oxygenation and therapeutic plasma exchange procedures are tolerable in both pediatric and adult patients. Transfusion. 2014;54:1158-65.
10. Sparks BE, Cavarocchi NC, Hirose H. Extracorporeal membrane oxygenation with multiple-organ failure: Can molecular adsorbent recirculating system therapy improve survival? J Heart Lung Transplant. 2017;36(1):71-6.
11. Rosa-Diez GJ, Joannes-Boyau O. The use of adsorption in extracorporeal liver support: The Double Plasma Molecular Adsorption System (DPMAS). Contrib Nephrol. 2023;200:210-7.
12. Wan YM, Li YH, Xu ZY, Yang J, Yang LH, Xu Y, et al. Therapeutic plasma exchange versus double plasma molecular absorption system in hepatitis B virus-infected acute-on-chronic liver failure treated by entercavir: A prospective study. J Clin Apher. 2017;32:453-61.
13. Yao J, Li S, Zhou L, Luo L, Yuan L, Duan Z, et al. Therapeutic effect of double plasma molecular adsorption system and sequential half-dose plasma exchange in patients with HBV-related acute-on-chronic liver failure. J Clin Apher. 2019;34:392-8.
14. Ostermann M, Lumlertgul N. Acute kidney injury in ECMO patients. Crit Care. 2021;25:313.
15. D'Ancona G, Baillot R, Poirier B, Dagenais F, de Ibarra JI, Bauset R, et al. Determinants of gastrointestinal complications in cardiac surgery. Tex Heart Inst J. 2003;30:280-5.
16. NaveenKumar SK, Thushara RM, Sundaram MS, Hemshekhar M, Paul M, Thirunavukkarasu C, et al. Unconjugated Bilirubin exerts Pro-Apoptotic Effect on Platelets via p38-MAPK activation. Sci Rep. 2015;5:15045.