Successful Recovery of a Patient with Congenital Heart Disease and ARDS after Drowning with Veno-Venous ECMO Support

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ABSTRACT

This paper presents a rare case of acute respiratory distress syndrome (ARDS) induced by drowning in a 24-year male student with a history of congenital heart disease (CHD), who showed substantial neurological recovery after receiving cardiopulmonary resuscitation (CPR) and veno-venous extracorporeal membrane oxygenation (ECMO). The patient fell into a river on his university campus while playing with friends and received immediate CPR from an emergency medical team, regaining spontaneous circulation after more than 20 minutes. Upon arrival at the emergency department, the patient, suffering from severe type II respiratory failure, was promptly intubated and treated with ECMO alongside continuous renal replacement therapy (CRRT) to address hypoxaemia and provide renal support. Following several days of treatment, his condition improved significantly, and he was discharged on the 12th day after admission.

Key Words: *Acute respiratory distress sydrome, Congenital heart disease, Drowning, Extracorporeal membrane oxygenation*.

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INTRODUCTION

Drowning remains one of the leading causes of death worldwide.[1] As of 2019, it was estimated that drowning led to roughly 236,000 fatalities, excluding deaths from intentional harm, floods, or traffic incidents.[2] The symptoms following a drowning event can range from mild, such as coughing and breathing difficulties, to more severe outcomes such as cardiac and pulmonary failure. In critical situations, the availability of advanced resuscitation techniques is often restricted. The European Resuscitation Council's guidelines recommend considering extracorporeal membrane oxygenation (ECMO) as a potential intervention to manage cardiac arrest directly linked to drowning.[3] Additionally, ECMO is applicable for addressing complications secondary to drowning, such as oedema from inhalational pneumonia or the management of acute respiratory distress syndrome (ARDS).[4]

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We present an uncommon case of ARDS triggered by drowning and cardiopulmonary resuscitation (CPR) in a patient with congenital heart disease (CHD), who experienced favourable neurological outcomes following treatment with veno-venous ECMO.

CASE REPORT

A 24-year male student accidentally fell into a campus river, approximately 3 metres deep, while playing with friends. He had a history of CHD, having undergone ventricular septal defect repair and mitral valve replacement surgery 10 years ago. His companions immediately initiated rescue efforts and called the nearby off-site emergency medical team. About 10 minutes later, he was retrieved from the water, and the emergency medical team, upon arrival and finding no pulse, commenced CPR. Return of spontaneous circulation (ROSC) was restored after more than 20 minutes of on-site resuscitation. The patient arrived at the emergency department (ED) approximately 30 minutes post-incident.

Upon arrival at the ED, his Glasgow Coma Scale (GCS) score was 3 / 15 (E1V1M1), oxygen saturation was 78% while receiving 10 L/min of oxygen, heart rate was 157 beats per minute with occasional supraventricular tachycardia, blood pressure was 83 / 37 mmHg, and body temperature was 35.4°C. The arterial blood gas analysis revealed severe type II respiratory failure, which necessitated urgent intubation. After intubation, his SpO_2 improved to 90% on 100% fraction of inspired oxygen (FiO_2)

with a positive end-expiratory pressure (PEEP) of 15 cm H_2O. The patient was admitted to the intensive care unit (ICU), where bedside bronchoscopy revealed a large amount of pink frothy sputum. After sputum and blood cultures were taken, empirical meropenem was administered to cover gram-negative bacteria, considering the patient drowned in fresh water and had pulmonary oedema with respiratory failure. His temperature was maintained at 36.0°C.

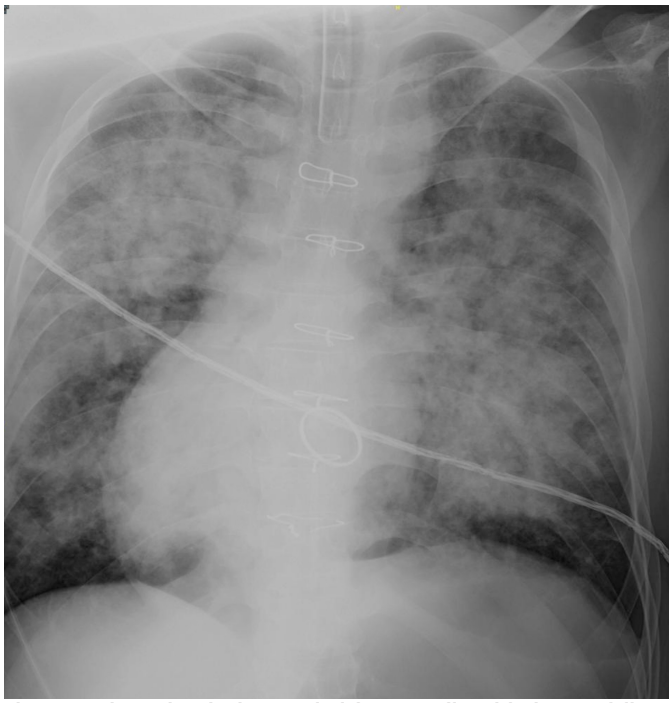

Figure 1: The patient had congenital dextrocardia, with changes following ventricular septal defect repair and mitral valve replacement. Before initiating extracorporeal membrane oxygenation (ECMO), bedside chest radiography showed extensive exudative changes in both lungs.

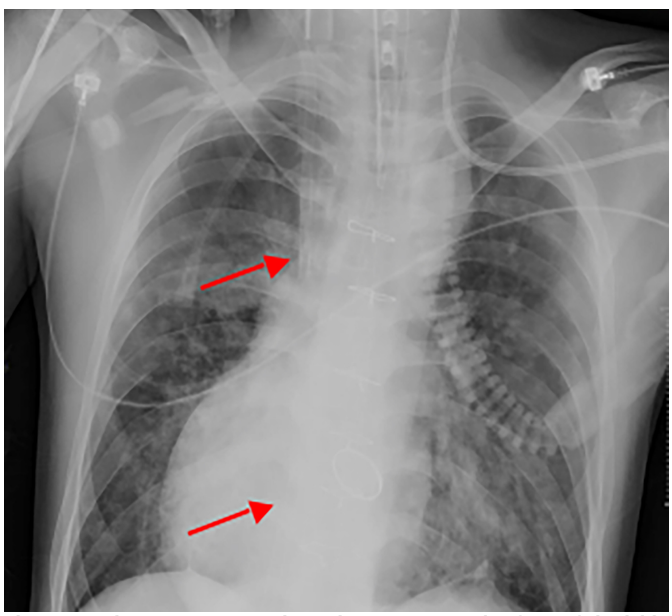

Figure 2: After extracorporeal membrane oxygenation (ECMO), bedside chest radiography showed the positions of the drainage and perfusion tubes (the red arrows), with improvement in the exudative changes in both lungs.

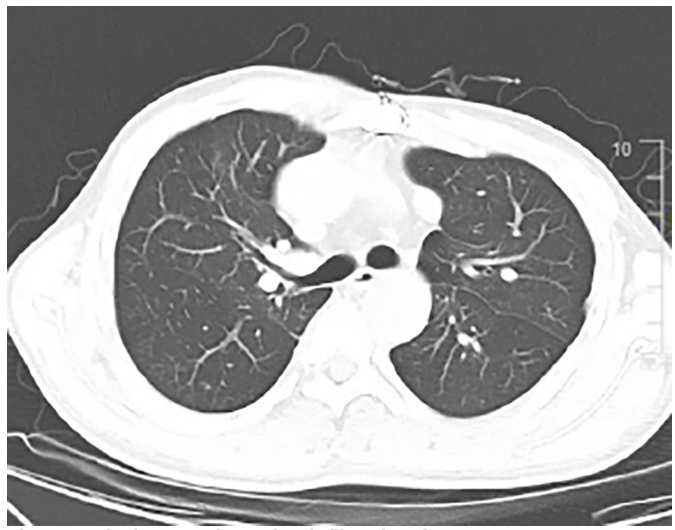

Figure 3: The lung CT showed no infiltrative changes.

Six hours after admission, the patient was still severely hypoxic. He was on mechanical ventilation with 100% FiO_2 and a PEEP of 15 cm H_2O, but his PaO_2 was only 60.0 mmHg. Bedside chest radiography suggested diffuse bilateral infiltrates and post-surgical changes in the heart (Figure 1). Echocardiography confirmed the diagnosis of severe ARDS due to drowning, showing diffuse B-lines in the lungs. The decision was made to initiate veno-venous ECMO in conjunction with continuous renal replacement therapy (CRRT) to improve the patient's hypoxaemic state and provide renal support. ECMO was initiated with a 23 Fr drainage cannula percutaneously inserted into the right femoral vein and a 17 Fr infusion cannula into the right internal jugular vein (ECMO machine model: Cardiohelp, Germany). For CRRT, the Prismaflex system (Baxter, USA) was used. Under ultrasound guidance, a femoral vein cannula was inserted through the femoral vein and advanced into the right atrium, while the internal jugular vein cannula was positioned close to where the superior vena cava meets the right atrium. The patient was sedated with midazolam and morphine before starting ECMO. At that time, the GCS score was 2 / 15 (E1VtM1), indicating eye response 1 (no eye opening), verbal response t (tube), and motor response 1 (no motor response). The pupils were equal, round, 2 mm in size, and exhibited a sluggish light reflex. No severe neurological damage signs, such as myoclonus or seizures, were observed after ROSC. After initiating ECMO, chest radiography showed gradual improvement in pulmonary infiltrates (Figure 2).

On the third day after admission, ECMO flow was reduced to 1.0 L/min, and ECMO oxygenation was ceased, with the patient on mechanical ventilation using pressure assisted / controlled ventilation (PACV) mode, FiO_2: 40%, pressure support: 12 cm H_2O, PEEP: 8 cm H_2O, and respiratory rate: 12 breaths/minute, and SpO_2 98%. The patient's oxygenation improved, pulmonary oedema resolved, and circulation stabilised, leading to the removal of ECMO. CRRT was initiated and stopped after 72 hours when renal functions showed signs of recovery. On the

sixth day after admission, the patient became alert, and the endotracheal tube was removed. Due to negative cultures upon admission, meropenem was discontinued on the seventh day. The patient was discharged on the 12th day without any neurological deficits and was scheduled for regular outpatient follow-up. Meanwhile, the re-examination of the lung CT showed no infiltrative changes (Figure 3).

DISCUSSION

The World Health Organization reports that drowning is the third leading cause of unintentional death worldwide,[5] with arrhythmias being a contributing risk factor.[6] In this case, the patient's pre-existing CHD increased the likelihood of arrhythmias, which may have led to the drowning incident, although this is speculative without direct evidence. Arrhythmias could also be a manifestation of myocardial ischaemia and hypoxia post-cardiac arrest. Mechanistically, drowning victims initially exhibit panic, loss of normal breathing patterns, breath-holding, air hunger, and struggle at the water surface, eventually leading to reflexive inhalation efforts, resulting in water aspiration. Within minutes, hypoxaemia, loss of consciousness, and then respiratory arrest occur. Hypoxaemia can also cause cardiac arrest, affecting all organ systems, with complications and deaths primarily related to cerebral hypoxia. For severe ARDS patients who remain hypoxaemic despite optimal invasive ventilation, veno-venous ECMO is recommended if feasible.[7] Additionally, ECMO can actively rewarm patients with persistent hypothermia. Observational studies report good neurological outcomes in patients who did not experience cardiac arrest and received ECMO for respiratory rather than circulatory support.[8] A 30-year multicentre registry study included 247 drowning victims, with 71% of patients who received extracorporeal life support (ECLS) without experiencing cardiac arrest surviving to discharge, compared to 57% and 23% of patients who experienced cardiac arrest before or during ECLS, respectively.[9] Another study, using data from the German Federal Statistical Office from 2007 - 2020 on drowning patients treated with ECMO, encompassing all age groups, calculated the mortality rates of the general population and ECMO-treated patients, applying a multivariate logistic regression model to analyse ECMO patients, controlling for predefined patient characteristics and complications. The results showed that among 12,354 patients admitted for drowning, 237 patients (1.9%) received ECMO treatment, with a hospital mortality rate of 74.7% (177 people) for ECMO-treated patients.[10] While the mortality rate among drowning patients treated with ECMO has increased compared to previous reports, this increase may reflect the identification and inclusion of more patients, including those with more severe conditions or previously underreported cases. Moreover, with improved diagnostic techniques and heightened awareness of drowning incidents, more patients in critical conditions are being identified and treated, potentially facing higher baseline risks, leading to an overall increase in mortality rates.

Through the reporting of this case, we emphasise the importance of addressing ARDS in patients with CHD. The timely implementation of interventions such as CPR, ECMO, and CRRT played a crucial role in the patient's recovery. This experience offers valuable insights for the diagnosis and treatment of similar situations, highlighting the importance of teamwork and comprehensive therapeutic approaches.

PATIENT'S CONSENT:
Informed consent was obtained from the patient.

COMPETING INTEREST:
The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:
RY: Literature search, and supervised and revised the final manuscript.
ZF: Data extraction, manuscript preparation, and data analysis, as well as retrieving relevant literature.
Both authors approved the final version of the manuscript to be published.

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