Received: 8 September 2022 | Accepted: 3 October 2022

DOI: 10.1002/rcr2.1053

CASE REPORT

Official Case Reports Journal of the Asian Pacific Society of Respirology
Respirology Case Reports OPEN ACCESS APSR WILEY

# Drowning case complicated with a cardiopulmonary arrest and severe ARDS saved with a good neurological outcome by ECMO: A case report

Songhyon Cho[1] | Toshiki Furukawa[2] | Osamu Ogawa[3]

[1]Department of Radiology, St. Marianna University School of Medicine, Kawasaki, Japan

[2]Department of Respiratory Medicine, Niigata Prefectural Central Hospital, Niigata, Japan

[3]Department of Emergency Medicine, Niigata Prefectural Central Hospital, Niigata, Japan

**Correspondence**
Songhyon Cho, Department of Radiology, St. Marianna University School of Medicine, 2-16-1, Sugao, Miyamae, Kawasaki, Kanagawa 216-8511, Japan.
Email: songhyon.cho.1105@gmail.com

**Associate Editor:** Trevor Williams

**Abstract**

Cardiopulmonary arrest (CPA) due to drowning has an extremely high mortality rate, and very few cases have good neurological outcomes. Severe respiratory failure can occur even after resuscitation. A 66 year old woman with a history of refractory epilepsy had a CPA due to drowning. Approximately 20 min after drowning, she was resuscitated and transported to the hospital, and extracorporeal membrane oxygenation (ECMO) was introduced on day two due to continued severe respiratory failure caused by acute respiratory distress syndrome (ARDS). After the introduction of ECMO, her respiratory status gradually improved and ECMO was discontinued on day 12. Approximately 6 months after drowning, she visited our hospital for a follow-up with a cerebral performance category of 1. Since cases of CPA due to drowning with a short drowning time or hypothermia are expected to have good neurological outcomes, the introduction of ECMO should be considered as a treatment for ARDS after resuscitation.

**KEYWORDS**

acute respiratory distress syndrome, critical care, drowning, extracorporeal membrane oxygenation, radiology

## INTRODUCTION

Drowning is a common cause of accidental deaths worldwide.[1] It is reported that 93% of drowning cases that lead to cardiopulmonary arrest (CPA) result in death.[2] Even in successfully resuscitated cases, the washing out of the surfactant results in acute respiratory distress syndrome (ARDS).[3] We report a rare case of ARDS after CPA due to drowning, with a good neurological outcome by veno-venous extracorporeal membrane oxygenation (ECMO).

## CASE REPORT

A 66 year old woman watched a summer festival by the river. She had a medical history of refractory epilepsy, and a history of drowning while bathing. The festival participants heard something falling into the river, and found her submerged in it. Unfortunately, none of the participants witnessed a fall. However, they were almost simultaneous, when the participants heard the sound, and when they found her submerged. The patient was rescued by the participants approximately 5 min after discovery, and cardiopulmonary resuscitation was immediately initiated as her pulse was not felt. When emergency medical services arrived approximately 10 min after discovery, the ECG showed pulseless electrical activity. The patient was transported to the hospital with advanced cardiac support. Approximately 20 min after discovery, the return of spontaneous circulation (ROSC) was achieved in the ambulance. The patient arrived at the emergency department (ED) approximately 35 min after discovery.

At the ED, her Glasgow Coma Scale (GCS) score was E1V1M1, SpO2 was 72% (10 L/min oxygen), heart rate was 88/min, blood pressure was 151/93 mmHg, and body temperature was 35.2°C. The arterial blood gas analysis showed: pH: 7.335, $PaO_2$: 40.3 mmHg, $PaCO_2$: 53.9 mmHg, $HCO_3^-$: 28.0 mmol/L, base excess: 1.4 mmol/L, lactate: 54.0 mg/dL, blood glucose: 253 mg/dL, indicating severe type II respiratory failure, therefore, an emergency tracheal intubation was performed. After intubation, the patient showed improvement with $SpO_2$: 92% with $FiO_2$ of 100% and positive end-expiratory pressure (PEEP) of 10 $cmH_2O$; however, the chest radiography and whole-body CT images showed extensive consolidation in both the lungs (Figure 1). No CT findings which suggest hypoxic–ischemic brain injury (e.g., brain swelling and inversion of the grey-white densities) were observed. A 12-lead electrocardiogram showed no abnormal findings of note. The patient was admitted to the ICU. Since the patient had drowned in freshwater with severe respiratory failure, legionella and gram-negative rods, such as aeromonas spp. were suspected to be infecting pathogens. Meropenem (MEPM) and levofloxacin (LVFX) were initiated after obtaining sputum and blood cultures. Body temperature was controlled at 36.0°C using water-circulating gel-coated pads.

At 24 h after admission, despite ventilator control with $FiO_2$ of 100% and PEEP of 15 $cmH_2O$, the patient was still severely hypoxic with $PaO_2$: 79.5 mmHg. The bilateral lung consolidations on the chest radiograph exacerbated, with a Murray score of 4. Transthoracic echocardiography showed no obvious abnormalities in cardiac function, and we diagnosed the patient with severe ARDS due to drowning. On day 2 we decided that ECMO had to be introduced with reached limit of conventional life support with continued deterioration in radiology and gas exchange, and a 20 French catheter scale (Fr) infusion cannula in the right internal jugular vein and a 22 Fr drainage cannula in the right femoral vein were percutaneously inserted (HLS Cannulae, Getinge, Göteborg, Sweden). The tip of the femoral cannula was placed in the right atrium, while the tip of the internal jugular cannula was placed near the junction of the superior vena cava and right atrium. Just before introducing ECMO,

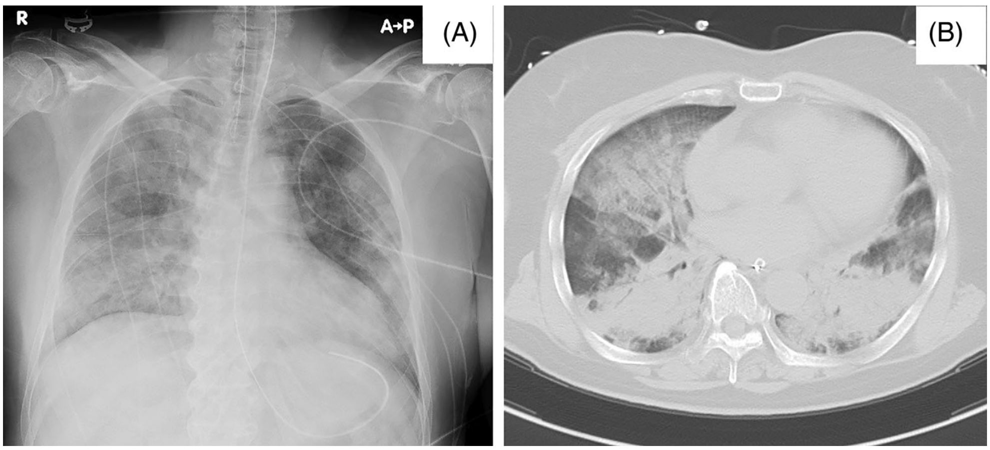


**FIGURE 1** (A) Chest radiographs on admission showing diffuse infiltration in lungs bilaterally and (B) computed tomography on admission shows diffuse consolidations with dorsal predominance and ground-glass opacity

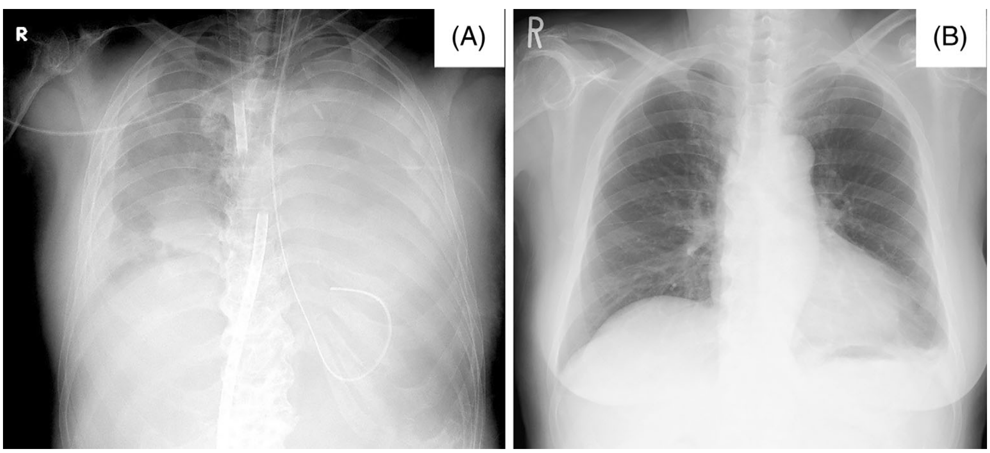


**FIGURE 2** Chest radiographs (A) immediately after the introduction of ECMO showing worsening of the diffuse infiltration than at admission and (B) at discharge showing almost normal appearance

the patient's GCS score was E1VtM1 (when sedated with midazolam). With severe respiratory failure, sedation could not be interrupted for the neurological state check. However, neither myoclonus nor seizures, which are suggestive of severe neurological injury, were observed after ROSC.

After the introduction of ECMO, the lung consolidations on chest radiography showed gradual improvement (Figure 2), and MEPM and LVFX were discontinued on day 8 because the cultures on admission were negative. Tracheostomy was performed on day 9. After tracheotomy, sedation was discontinued and she could successfully return a handshake. On day 12, with the ECMO flow reduced to 1.0 L/min and the oxygen supply from ECMO stopped, the patient was on ventilator control with PACV, $FiO_2$: 40%, pressure support: 8 $cmH_2O$, PEEP: 8 $cmH_2O$, respiratory rate: 14/min, $PaO_2$: 114.4 mmHg, end-tidal $CO_2$: 38 mmHg. Head CT was performed on day 14, which displayed no noteworthy abnormal findings. The hemodynamic status was stable, therefore, ECMO was discontinued. After extubation from the ventilator on day 17, the patient underwent rehabilitation and was discharged on day 75. Approximately 6 months after drowning, the patient visited our hospital for outpatient follow-up with a cerebral performance category of 1.

## DISCUSSION

According to a WHO report, drowning is the third leading cause of accidental deaths worldwide.[1] However, Bierens et al. estimated that this was only the "tip of the iceberg" as it was the only number of reported cases, and the actual number was even higher.[4] Furthermore, epilepsy is also a risk factor for drowning, and the risk of drowning in epilepsy patients is 15–19 times higher than normal individuals.[5] Although no apparent seizure was witnessed in this case, it is quite possible that the seizure was the trigger for drowning because the patient had a history of drowning while bathing.

The mortality rate of drowning is considered extremely high, with Szpilman et al. reporting a mortality rate of up to 93% in drowning cases resulting in CPA.[2] Furthermore, it has been reported that approximately 20% of the drowned victims who are successfully saved have neurological sequelae.[6] Therefore, cases of CPA due to drowning with good neurological outcomes are scarce, as in the present case. Submersion time is recommended by the International Liaison Committee on Resuscitation (ILCOR) as a factor in estimating the neurological prognosis in patients with CPA due to drowning; better results can be expected with submersion times of 10 min or less, while better results are unlikely with submersion times of 25 min or more.[7] Based on this report, it can be inferred that this patient had a good neurological outcome because her submersion time was only 5 min, and her neurological outcome was good. The patient was hypothermic from the time of arrival at the ED, and the target temperature management was performed after arrival in the ED to prevent hyperthermia. This was also considered a factor resulting in a good neurological outcome. Brain injury after cardiac arrest can be classified into primary injury caused by sudden cessation of cerebral blood flow, and secondary injury caused by impaired reperfusion and microcirculatory dysfunction after the cerebral blood flow resumes. Preventing hyperthermia after ROSC has a cerebral protective effect by suppressing secondary brain injury.[8]

In drowning, hypoxemia occurs by multiple mechanisms. Immediately after drowning, inhalation of a small amount of water causes laryngospasm to prevent further water inhalation, resulting in a negative pressure pulmonary edema, which can produce hypoxemia even with minimal water inhalation. However, if drowning continues, the laryngospasm disappears owing to hypoxemia, and a large volume of water invades the airways. As a result, the surfactant and alveolar-capillary membranes of the lungs are destroyed, resulting in severe hypoxemia due to ARDS.[9]

A study of 251 drowning patients who used ECMO between 1986 and 2015 reported a survival rate of 57.0% for patients who regained ROSC before ECMO, and 23.4% for those who received extracorporeal cardiopulmonary resuscitation.[10] In recent years, several extensive literature reviews have been published on the treatment of drowning, including systematic and scoping reviews.[4,11] Thom et al. reported that the use of ECMO is uncommon for drowning, and that there is a lack of evidence informing its use and efficacy in the management of drowning patients.[11] Therefore, it is crucial to record cases of ECMO for drowning, such as this present case, to build high-quality evidence.

In conclusion, we report a case where veno-venous ECMO allowed recovery of drowning induced CPA and ARDS and a good neurological recovery was evident. As the reported rate of severe neurological injury seems relatively low in those with return of circulation, this case supports consideration of veno-venous ECMO support in similar cases.

### AUTHOR CONTRIBUTIONS

Songhyon Cho, Toshiki Furukawa, and Osamu Ogawa were the attending doctors who treated the patient on admission. Toshiki Furukawa is an outpatient physician. All authors have read and approved the final manuscript.

### ACKNOWLEDGMENT

We would like to thank Editage (www.editage.com) for English language editing.

### CONFLICT OF INTEREST

None declared.

### DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

## ETHICS STATEMENT

The authors declare that appropriate written informed consent was obtained for the publication of this manuscript and accompanying images.

## ORCID

*Songhyon Cho* https://orcid.org/0000-0003-4422-6223

## REFERENCES

1. World Health Organisation. Preventing drowning: an implementation guide. Switzerland: Geneva; 2017. Accessed September 5, 2022. https://www.who.int/publications/i/item/preventing-drowning-an-implementation-guide
2. Szpilman D. Near-drowning and drowning classification: a proposal to stratify mortality based on the analysis of 1831 cases. Chest. 1997; 112:660–5.
3. Bierens JJ, Knape JT, Gelissen HP. Drowning. Curr Opin Crit Care. 2002;8:578–86.
4. Bierens J, Abelairas-Gomez C, Barcala Furelos R, Beerman S, Claesson A, Dunne C, et al. Resuscitation and emergency care in drowning: a scoping review. Resuscitation. 2021;162:205–17.
5. Bell GS, Gaitatzis A, Bell CL, Johnson AL, Sander JW. Drowning in people with epilepsy: how great is the risk? Neurology. 2008;71: 578–82.
6. Gonzalez-Rothi RJ. Near drowning: consensus and controversies in pulmonary and cerebral resuscitation. Heart Lung. 1987;16:474–82.
7. Perkins GD, Travers AH, Berg RA, Castren M, Considine J, Escalante R, et al. Part 3: adult basic life support and automated external defibrillation: 2015 international consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Circulation. 2015;95:e43–69.
8. Sekhon MS, Ainslie PN, Griesdale DE. Clinical pathophysiology of hypoxic-ischemic brain injury after cardiac arrest: a "two-hit" model. Crit Care. 2017;21:90.
9. Glueck T, Capasso P, Schnyder P, Gudinchet F, Schaller M-D, Revelly J-P, et al. Clinical and radiologic features of pulmonary edema. Radiographics. 1999;19:1507–31.
10. Burke CR, Chan T, Brogan TV, Lequier L, Thiagarajan RR, Rycus PT, et al. Extracorporeal life support for victims of drowning. Resuscitation. 2016;104:19–23.
11. Thom O, Roberts K, Devine S, Leggat PA, Franklin RC. Treatment of the lung injury of drowning: a systematic review. Crit Care. 2021;25:253.

**How to cite this article:** Cho S, Furukawa T, Ogawa O. Drowning case complicated with a cardiopulmonary arrest and severe ARDS saved with a good neurological outcome by ECMO: A case report. Respirology Case Reports. 2022;10:e01053. https://doi.org/10.1002/rcr2.1053