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CASE REPORT

Paraplegia after successful extracorporeal cardiopulmonary resuscitation: a case report

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Abstract

Background: We reported a patient who had paralysis of both lower limbs after successful ECPR, yet recovered after implementing clinical management timely. **Case**: A 16-year-old student who experienced a 40-min episode of unconsciousness. Upon the patient's collapse, immediate cardiac compression and electrical defibrillation were performed. Emergency medical services transferred the patient to the emergency room for continuous cardiopulmonary resuscitation. Traditional cardiopulmonary resuscitation (CPR) and anti-arrhythmic drugs were ineffective in reversing ventricular fibrillation or pulseless ventricular tachycardia. Subsequently, venous-arterial extracorporeal membrane oxygenation (VA-ECMO) was successfully performed. The patient's sinus rhythm was recovered 93 min after running the machine. Vital signs remained stable on the fifth day, and ECMO was removed. On day 7, the patient had paralysis of both lower limbs, with the disappearance of deep and shallow sensations. Complete spinal magnetic resonance imaging (MRI) revealed swelling in the conus medullaris segment, leading to a diagnosis of spinal cord ischemia and hypoxia injury. Management was performed, including anti-inflammation, nerve nutrition, microcirculation improvement, and rehabilitation training of both lower limbs. One year later, the patient had grade IV muscle strength in both lower limbs and could stand and walk for a short distance with the assistance of a walking aid. **Conclusions**: ECPR represents the final choice for patients with CPR refractoriness, potentially improving survival rates.

Keywords

Out-of-hospital cardiac arrest; Hypertrophic cardiomyopathy; Sympathetic electrical storm; Extracorporeal cardiopulmonary resuscitation; Paralysis; Spinal cord ischemia

1. Introduction

Sudden cardiac death is a common cause of out-of-hospital cardiac arrest (OHCA), with malignant arrhythmia being the leading cause of sudden cardiac death [1, 2]. The key to successful rescue from sudden cardiac death is high-quality cardiopulmonary resuscitation and early electrical defibrillation at the scene of the first witness. Extracorporeal cardiopulmonary resuscitation (ECPR) is the last resort for patients with reversible causes and failed conventional cardiopulmonary resuscitation. Timely initiation of ECPR can improve the survival rate, neurological function score and prognosis [3–5]. Some common complications [6], including infection, hemorrhage, thrombosis and lower-limb ischemic necrosis, may occur during ECPR implementation and management. The related literature at home and abroad has been reviewed, and there are no reports of paraplegia after successful ECPR treatment. Nevertheless, we reported a patient who had paralysis of both lower limbs after successful ECPR, yet recovered after implementing clinical management timely.

2. Case report

On 01 June 2022, at 9:49, a 16-year-old male patient suddenly became unconscious while on campus. Upon collapsing, the bystander immediately received CPR and electrical defibrillation. Continuous CPR was performed as the patient was transferred to the emergency department of Changsha Central Hospital at 10:29 on the same day. Upon admission, the patient exhibited the following vital signs: heart rate, 0 beats/min; respiratory rate, 6 beats/min; blood pressure, 0/0 mmHg. He remained unconscious, with pupils dilated to 3 mm, showing a slow light reflex. Notably, he had skin abrasions on his right cheek and outside his right eye, and his carotid pulse was impalpable. Breath and heart sounds were also absent. After 30 min in the rescue room, continuous chest compressions, electrical defibrillation, and anti-arrhythmic drugs still cannot stop the sympathetic storm. The patient indicated that ECMO and its turnaround were successful at 12:27. After the VA-ECMO transition, the sympathetic storm persisted. Sinus rhythm was restored at 14:00 but subsequently turned to a pulsed ventricular rhythm and was transferred to the Emergency Intensive Care Unit (EICU) for further treatment.

His blood routine showed a white blood cell count of 20.58 $\times$ 10^9/L, a neuter cell rate of 51.20%, and a platelet count of 120 $\times$ 10^9/L. Rapid blood sugar tend was 14.4 mmol/L. Routine coagulation inspection demonstrated that the prothrombin time (PT) was 16.6 s, and the activated partial thromboplastin time (APTT) was 35.6 s. His alanine aminotransferase was 489 μL, and glutamate aminotransferase was 446 μL. Routine renal inspection showed a urea nitrogen of 7.72 mmol/L and a creatinine level of 133 μmol/L. Electrolytes were normal on testing. Brain natriuretic peptide was 243 pg/mL, and myoglobin was elevated (309 ug/L). Blood gas analysis indicated a pH of 6.94, a partial pressure of oxygen of 188.6 mmHg, a partial pressure of carbon dioxide of 33.0 mmHg, and a lactic acid concentration of 19.77 mmol/L. Laboratory results are shown in Table 1. The electrocardiogram displayed ventricular tachycardia, while cardiac ultrasound suggested hypertrophic cardiomyopathy (symmetrical and nonobstructive), left atrial enlargement, mitral regurgitation (mild), and decreased left heart function.

According to the blood pressure situation, norepinephrine gradually decreased during ECMO support (blood flow 2.5~3.0 L/min; gas flow, 3.0 L/min; oxygen concentration, 100%), and the sympathetic application of beta-blockers stopped the electrical storm. Target temperature management (36 °C, maintained for 48 h) was conducted for brain protection. A lung-protection strategy was implemented, and continuous renal replacement therapy (CRRT) was performed due to the absence of urine. The members observed the blood supply to the lower extremities daily to prevent lower-limb ischemia. According to the changes in the patient's body temperature and infection indicators, the etiological examination should be improved, and anti-infection treatment should be adjusted in time.

The patient might have obeyed the instructions at 20:00 on 03 June. Vasoactive drugs were stopped at 23:00, the patient's blood pressure stabilized, and there were no arrhythmias. ECMO was successfully weaned at 11:00 on 05 June. However, on 07 June, ward rounds found that the patient could not move both lower limbs. Physical examination revealed that the muscle strength of both lower limbs was 0. The abdominal wall reflex, cremasteric reflex, and reflex were not elicited. Superficial sensory symmetry and deep sensation in both lower limbs disappeared. We promptly completed a spinal MRI, showing swelling of the conus medullaris segment of the spinal cord, which was considered a spinal cord injury (Figs. 1,2,3,4,5,6). Accordingly, we conducted a multidisciplinary consultation. Management strategies, including anti-inflammation, nerve nutrition, microcirculation improvement and rehabilitation training of both lower limbs, were performed. On 08 June, the ventilator was discontinued, and the endotracheal tube was removed using Spontaneous breathing test (SBT) and an air leak test. The patient's urine output resumed, and CRRT was reinitiated on 11 June. He was transferred to the Department of Cardiology on 16 June and

TABLE 1. Laboratory results.

Investigation	Normal range	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
WBC ($\times 10^9$/L)	4.1~11	20.58	13.74	10.88	8.00	11.17	15.57	14.25	12.76
Neutrophils (%)	37~77	51.2	85.5	85.0	86.8	89.3	86.6	75.9	71.2
Haemoglobin (g/L)	129~172	111	110	91	85	91	111	102	103
Platelets ($\times 10^9$/L)	150~407	120	65	59	70	114	58	57	85
APTT (s)	14~21	35.6	55.2	54.6	46.7	45.1	39.6	34.0	32.7
Albumin (g/L)	42~56	35	33	34	34	32	26	26	30
ALT (U/L)	7~43	489	980	600	307	223	136	187	164
AST (U/L)	12~37	446	2720	1143	553	390	186	256	106
LDH (U/L)	120~250	248	5680	2127	1810	1109	1269	952	864
CK (U/L)	50~310	225	43,090	18,903	14,180	6340	3771	2214	817
CK-MB (U/L)	<25	10	2230	660	460	222	125	77	38
Myoglobin (µg/L)	<90	309	36,460	32,700	10,080	4261	1599	1594	678
Troponin I (ng/mL)	<0.026	0.86	>50	>50	>50	>50	>50	>50	>50
Urea nitrogen (mmol/L)	2.7~7	7.72	8.73	9.61	8.07	7.61	9.90	12.34	14.41
Creatinine (µmol/L)	52~101	133	166	194	204	191	229	265	268
K^+ (mmol/L)	3.5~4.9	3.8	4.3	4.7	5.1	4.6	4.5	4.1	4.5
Procalcitonin (ng/mL)	<0.05		70.47	139.37	62.11	35.99	29.38	16.53	14.00
pH	7.35~7.45	6.94	7.43	7.45	7.34	7.40	7.35	7.42	7.41
Lactate (mmol/L)	0.4~2.2	19.77	8.00	4.80	2.85	−1.40	1.30	1.20	1.00

Abbreviations: WBC: white blood cell; APTT: activated partial thromboplastin time; ALT: Alanine transaminase; AST: aspartate aminotransferase; LDH: Lactate dehydrogenase; CK: creatine kinase; CK-MB: creatine kinase-MB; pH: potential of hydrogen.

FIGURE 1. MRI T1 signal of the lumbar spine shows swelling of the conus medullaris segment of the spinal cord.

FIGURE 3. MRI diffusion weighted imaging (DWI) of the lumbar spine shows hyperintensity in the conus medullaris segment of the spinal cord.

FIGURE 2. MRI T2 signal of the lumbar spine shows swelling of the conus medullaris segment of the spinal cord, and the signal is enhanced.

FIGURE 4. MRI enhancement of the lumbar spine showed no enhancement signal of the spinal cone.

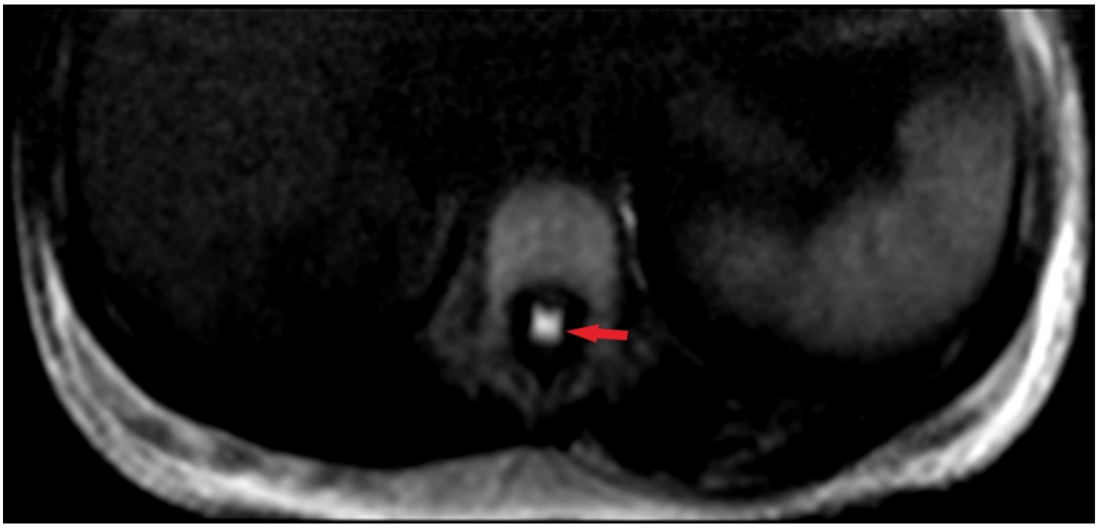

FIGURE 5. MRI cross-sectional DWI of the lumbar spine shows enhanced spinal conus medullaris segment signaling.

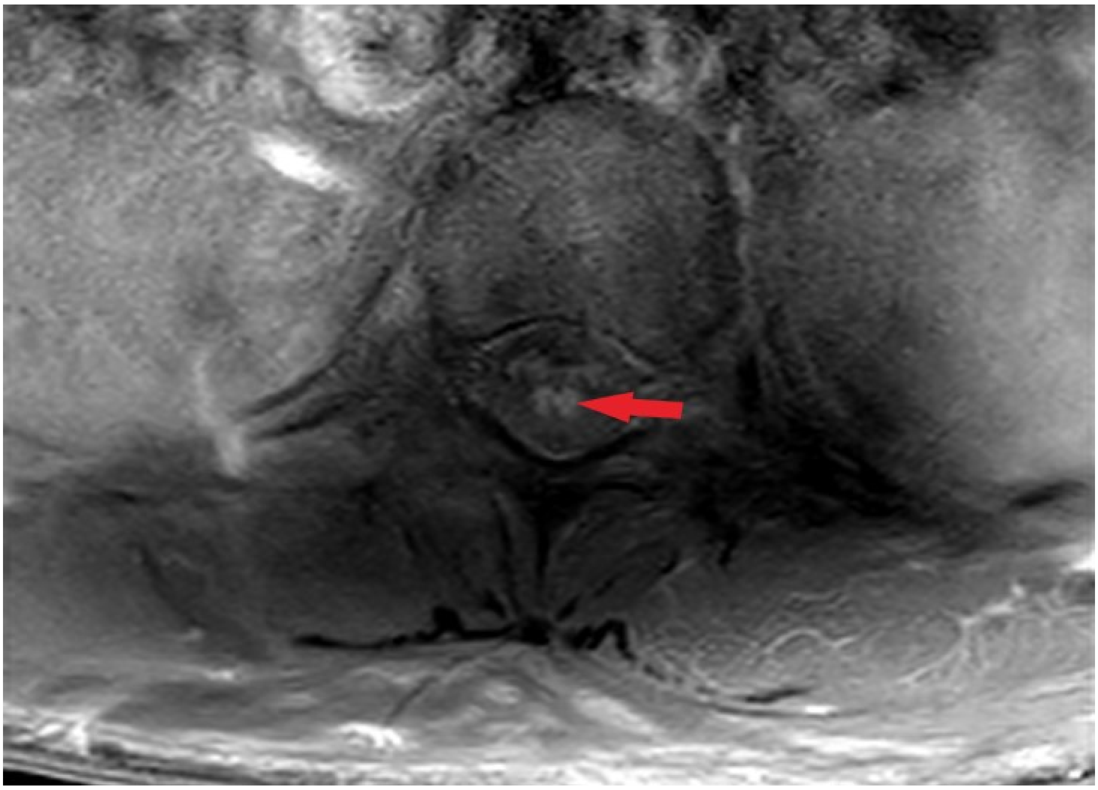

FIGURE 6. MRI transection of the lumbar spine showed no enhanced signal of the spinal cord cone.

discharged from the hospital on 22 June, continuing with physical rehabilitation.

After one year of follow-up, the patient's stool and urine function returned to normal, his lower limb muscle strength level was at an IV level, and both depth and shallow sensation recovered. He was able to stand and walk short distances with the assistance of a walker.

3. Discussion

Annually, 550,000 individuals in China are diagnosed with OHCA, with a rescue success rate of less than 1% [7]. While coronary heart disease is the primary cause of OHCA in adults, hypertrophic cardiomyopathy (HCM) is the leading cause of sudden death among adolescents and athletes [8, 9]. The key to managing OHCA lies in on-site identification and immediate provision of high-quality CPR [10]. The patient's successful treatment and cerebral resuscitation benefited from correct treatment on-site and before the hospital. After admission, high-quality cardiopulmonary resuscitation failed to reverse the sympathetic electrical storm. Our team initiated ECPR and successfully weaned after four days of ECMO assistance.

Registry studies conducted in Europe reveal that ECPR was used in approximately 4% of patients with suspected cardiogenic OHCA between May 2011 and January 2018 [3]. As of October 2022, 12,125 adult ECPR cases were registered in extracorporeal life support organizations, with 42% successfully removed from VA-ECMO, and 30% could be discharged or waiting for organ transplantation [11]. Regional ECPR centers have been built in some parts of China, and good treatment results have been obtained. From 2015 to 2022, the survival rate of OHCA patients in the Emergency Center of the First Affiliated Hospital of Nanjing Medical University was 22.5%, with 77.8% of surviving patients exhibiting a good neurological prognosis [12].

Initiating ECPR can improve coronary perfusion pressure, return of spontaneous circulation (ROSC) rate, and defibrillation success rate. It improves hemodynamic status, provides adequate organ perfusion, and reduces the risk of ischemic hypoxic encephalopathy. However, attention must be directed towards potential implications for each ECMO patient, as timely detection and correct treatment of these complications determine the patient's prognosis [13]. The common complications include infection (10%~23.3%), hemorrhage (3%~70%), lower limb ischemia (8.6%~50%) [14], and hemolysis (5%~18%) [15]. Accordingly, ECPR patients have a strong time limit for rescue, limited site and time, and a greater incidence of complications. This patient experienced gastrointestinal bleeding, bleeding at the puncture site and infection. We must prevent and treat them early to control these common complications. Since the complications of paraplegia after ECPR have not been previously reported, the examination of muscle strength was ignored due to the focus on lower limb hemorrhage and ischemia before and after the machine. The patient had paralysis of both lower limbs during ward rounds on the second day after weaning from the machine, and an MRI of the spinal cord was completed promptly, suggesting possible injury to the conus medullaris. After consulting with the multidisciplinary treatment (MDT) team of the hospital, considering the high possibility of spinal cord ischemia and hypoxia injury, the patient was given comprehensive treatment such as anti-inflammatory, neurotrophic, and rehabilitation physiotherapy, resulting in a good recovery.

Spinal cord ischemic injury represents a rare disease with a poor prognosis [16]. It is commonly seen in trauma, spinal cord space occupation, infection, aortic vascular surgery, interventional therapy complications, drugs and severe shock [17]. Rinaldi *et al.* [18] (2022) mentioned that spinal cord ischemia is a significant potential complication after thoracic and thoracoabdominal aortic treatment, whether open or endovascular. Bax *et al.* [19] (2021) reported a case of quadriplegia caused by spontaneous spinal cord ischemia caused by COVID-19. Literature [20] reported a case of acute spinal cord ischemia after transcatheter arterial chemoembolization for liver cancer. Akella *et al.* [21] (2022) reported a case of quadriplegia due to spinal cord ischemia caused by cocaine use. However, no cases of lower extremity paralysis have been reported due to spinal cord injury after ECPR.

MRI is the preferred diagnostic method for spinal cord ischemic injury [22]. We improved the whole spine MRI for the first time, revealing lesions that suggested a conus medullaris injury, consistent with the clinical manifestations and signs of the patient. The patient lacked any history of spinal cord injury, spinal cord occupation, hemorrhage on imaging, aorta-related surgery, or drugs reported in the literature that caused spinal cord ischemia. Given the patient's youth, prolonged cardiopulmonary resuscitation, and extended period of low blood perfusion, lower limb paraplegia was considered to be caused by spinal cord ischemia and hypoxic injury.

Treatment for hypoxic-ischemic injury of the spinal cord is different based on its different etiology [23, 24]. Patients with spinal cord infarction can be treated with anti-platelet aggregation and thrombolytic therapy. The primary infection focus should be actively controlled in patients with infection. The surgical plan and operation should be carefully improved during the operation [25]. People with drug-induced ischemia should avoid using these drugs. In this patient, considering the ischemic and hypoxic damage, target temperature control was used in the early stage to protect nerve cells and maintain mean arterial pressure, thereby beneficial to the blood supply of the spinal cord. Early hormone anti-inflammation reduces spinal cord edema, while vitamin B1 and mecobalamin nourish the nerves. Traditional Chinese medicine, such as Shuxuetong, improves the local microcirculation, and the rehabilitation treatment promotes the recovery of limb function [26]. Although hyperbaric oxygen therapy was feasible, it was not performed due to the patient's sudden cardiac death caused by malignant arrhythmia, which posed a high risk. After the treatment, the patient cooperated with functional exercises and achieved a favorable recovery.

4. Limitations

First, if the patient can undergo lumbar puncture, electromyography, and spinal artery angiography, the cause of paraplegia may become clearer; second, for patients with hypertrophic cardiomyopathy, a family gene profile test can be conducted to understand family genetic information, which can provide further health guidance and recommendations.

5. Conclusion

ECPR represents the final choice for patients with CPR refractoriness, potentially improving survival rates. It should be immediately employed when clear indications and conditions exist. Lower extremity paraplegia, a rare complication of ECPR with a poor prognosis, has been reported for the first time and warrants careful consideration. We are reminded that besides observing the patient's vital signs, consciousness, organ function, and common complications in clinical work, we should systematically check the body daily, find rare complications in time, perform perfect relevant examinations as soon as possible, make a clear diagnosis, and provide corresponding treatment.

ABBREVIATIONS

ECPR, Extracorporeal Cardiopulmonary Resuscitation; EMS, Emergency Medical Service; CPR, cardiopulmonary resuscitation; VA-ECMO, Venous-Arterial Extracorporeal Membrane Oxygenation; EICU, Emergency Intensive Care Unit; SBT, Spontaneous breathing test; MRI, Magnetic Resonance Imaging; OHCA, Out-of-hospital cardiac arrest; NGS, next-generation sequencing; HCM, hypertrophic cardiomyopathy; ROSC, the return of spontaneous circulation; MDT, Multidisciplinary Treatment; COVID-19, Corona Virus Disease 2019; DWI, Diffusion Weighted Imaging.

AVAILABILITY OF DATA AND MATERIALS

Datasets used and/or analyzed in the present study were availed by the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

SFZ and LDH—wrote the manuscript writing and recorded patient's data. CLL—assisted in information collection. ND—analyzed and interpreted the patients' general indices. All authors read and ratified final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The study was approved by institutional review board of Changsha Central Hospital, Ethics Approval Number: 2023-045 (KTSB). Written informed consent was obtained from the patient for publication of this study and accompanying images.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Myat A, Song KJ, Rea T. Out-of-hospital cardiac arrest: current concepts. The Lancet. 2018; 391: 970–979.

[2] Otani T, Sawano H, Oyama K, Morita M, Natsukawa T, Kai T. Resistance to conventional cardiopulmonary resuscitation in witnessed out-of-hospital cardiac arrest patients with shockable initial cardiac rhythm. Journal of Cardiology. 2016; 68: 161–167.

[3] Bougouin W, Dumas F, Lamhaut L, Marijon E, Carli P, Combes A, *et al*. Extracorporeal cardiopulmonary resuscitation in out-of-hospital cardiac arrest: a registry study. European Heart Journal. 2020; 41: 1961–1971.

[4] Guerguerian A, Sano M, Todd M, Honjo O, Alexander P, Raman L. Pediatric extracorporeal cardiopulmonary resuscitation ELSO guidelines. ASAIO Journal. 2021; 67: 229–237.

[5] Shirasaki K, Hifumi T, Goto M, Shin K, Horie K, Isokawa S, *et al*. Clinical characteristics and outcomes after extracorporeal cardiopulmonary resuscitation in out-of-hospital cardiac arrest patients with an initial asystole rhythm. Resuscitation. 2023; 183: 109694.

[6] Rao P, Khalpey Z, Smith R, Burkhoff D, Kociol RD. Venoarterial extracorporeal membrane oxygenation for cardiogenic shock and cardiac arrest. Circulation: Heart Failure. 2018; 11: e004905.

[7] Xu F, Zhang Y, Chen Y. Cardiopulmonary resuscitation training in China. JAMA Cardiology. 2017; 2: 469–470.

[8] Maron BJ, Mackey-Bojack S, Facile E, Duncanson E, Rowin EJ, Maron MS. Hypertrophic cardiomyopathy and sudden death initially identified at autopsy. The American Journal of Cardiology. 2020; 127: 139–141.

[9] Finocchiaro G, Papadakis M, Sharma S, Sheppard M. Sudden cardiac death. European Heart Journal. 2017; 38: 1280–1282.

[10] Al-Khatib SM, Stevenson WG, Ackerman MJ, Bryant WJ, Callans DJ, Curtis AB, *et al*. 2017 AHA/ACC/HRS guideline for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: a report of the American College of Cardiology/American Heart Association Task Force on clinical practice guidelines and the heart rhythm society. Journal of the American College of Cardiology. 2018; 72: e91–e220.

[11] Tonna JE, Boonstra PS, MacLaren G, Paden M, Brodie D, Anders M, *et al*. Extracorporeal Life Support Organization Registry International Report 2022: 100,000 Survivors. ASAIO Journal. 2024; 70: 131–143.

[12] Zhang H, Mei Y, Lu J, Hu D, Sun F, Li W, *et al*. A retrospective analysis of 40 patients with extracorporeal membrane oxygenation-assisted cardiopulmonary resuscitation in adults with out-of-hospital cardiac arrest. Chinese Journal of Emergency Medicine. 2022; 31: 1618–1622.

[13] Rajsic S, Treml B, Jadzic D, Breitkopf R, Oberleitner C, Popovic Krneta M, *et al*. Extracorporeal membrane oxygenation for cardiogenic shock: a meta-analysis of mortality and complications. Annals of Intensive Care. 2022; 12: 93.

[14] Koerner MM, Harper MD, Gordon CK, Horstmanshof D, Long JW, Sasevich MJ, *et al*. Adult cardiac veno-arterial extracorporeal life support (VA-ECMO): prevention and management of acute complications. Annals of Cardiothoracic Surgery. 2019; 8: 66–75.

[15] Appelt H, Philipp A, Mueller T, Foltan M, Lubnow M, Lunz D, *et al*. Factors associated with hemolysis during extracorporeal membrane oxygenation (ECMO)—Comparison of VA-versus VV ECMO. PLOS ONE. 2020; 15: e0227793.

[16] Alektoroff K, Kettner M, Papanagiotou P. Spinal cord ischemia. Radiologe. 2021; 61: 263–266.

[17] Ishikawa T, Suzuki H, Ishikawa K, Yasuda S, Matsui T, Yamamoto M, *et al*. Spinal cord ischemia/injury. Current Pharmaceutical Design. 2014; 20: 5738–5743.

[18] Rinaldi E, Loschi D, Favia N, Santoro A, Chiesa R, Melissano G. Spinal cord ischemia in open and endovascular aortic repair. AORTA: Official Journal of the Aortic Institute at Yale-New Haven Hospital. 2022; 10: 194–200.

[19] Bax F, Gigli GL, Iaiza F, Valente M. Spontaneous spinal cord ischemia during COVID-19 infection. Journal of Neurology. 2021; 268: 4000–4001.

[20] Ruiz Rodríguez AJ, Bravo Aranda AM, Martínez Martínez C, Sáez de Tejada Cervilla ME, Cabrera Peña Á. Acute spinal cord ischemia after transarterial chemoembolization of hepatocarcinoma. Gastroenterology & Hepatology. 2022; 45: 713–714.

[21] Akella R, Raj R, Kannan L, Jacob A, Ganti SS. Acute spinal cord ischemia associated with cocaine use: a case report. Cureus. 2022; 14: e25693.

[22] Stettler S, El-Koussy M, Ritter B, Boltshauser E, Jeannet P, Kolditz P, *et al*. Non-traumatic spinal cord ischaemia in childhood—clinical manifestation, neuroimaging and outcome. European Journal of Paediatric Neurology. 2013; 17: 176–184.

[23] Nardone R, Pikija S, Mutzenbach JS, Seidl M, Leis S, Trinka E, *et al*.

Current and emerging treatment options for spinal cord ischemia. Drug Discovery Today. 2016; 21: 1632–1641.

[24] Ahn JH, Lee TK, Kim DW, Shin MC, Cho JH, Lee JC, *et al*. Therapeutic hypothermia after cardiac arrest attenuates hindlimb paralysis and damage of spinal motor neurons and astrocytes through modulating Nrf2/HO-1 signaling pathway in rats. Cells. 2023; 12: 414.

[25] Chung JC, Lodewyks CL, Forbes TL, Chu MWA, Peterson MD, Arora RC, *et al*. Prevention and management of spinal cord ischemia following aortic surgery: a survey of contemporary practice. The Journal of Thoracic and Cardiovascular Surgery. 2022; 163: 16–23.e7.

[26] Sun W, Zhang L, Fang Z, Han L, Wang Q, Leng Y, *et al*. Shuxuetong injection and its peptides enhance angiogenesis after hindlimb ischemia by activating the MYPT1/LIMK1/Cofilin pathway. Journal of Ethnopharmacology. 2022; 292: 115166.

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