Heliyon 10 (2024) e35084

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Case report

Successful treatment of sepsis-induced cardiomyopathy with 36 hours refractory ventricular fibrillation: A case report

Songtao Liu [a], Zhixin Wu [a,b], Yi Su [a,b,*], Fucheng Qiu [a,b]

[a] The Eighth Clinical Medical College, Guangzhou University of Chinese Medicine, China
[b] Department of Neurological Intensive Care Unit, Foshan Hospital of Traditional Chinese Medicine, China

ARTICLE INFO

Keywords:
Sepsis-induced cardiomyopathy
Mechanical circulatory support
Refractory ventricular fibrillation
Defibrillation

ABSTRACT

Sepsis-induced cardiomyopathy (SIC) is generally characterized by decreased cardiac ejection fraction (EF) reversibility, less cardiac response to fluid resuscitation and catecholamine, and rarely complicated with refractory ventricular fibrillation (RVF). Once RVF is induced, the mortality rate of sepsis patients will be greatly increased. In this case, we reported a 26-year-old female patient who was diagnosed sepsis-induced cardiomyopathy (SIC), presented with RVF for 36 hours. The patient was maintained by the mechanical circulatory support (MCS) devices and experienced twice defibrillation. Finally, the patient was discharged without intracardial thrombosis and severe craniocerebral complications. This case suggested that early application of MCS and appropriate frequency of defibrillation may help the prognosis of SIC with RVF.

1. Introduction

Sepsis-induced cardiomyopathy (SIC) is generally characterized by decreased cardiac ejection fraction (EF) reversibility, and less cardiac response to fluid resuscitation and catecholamines [1]. The general course of the disease can be recovered in 7–10 days, and rarely complicated with refractory ventricular fibrillation (RVF). RVF is a severe threat to life ventricular arrhythmia, which is a fundamental cause of sudden cardiac death and has a high mortality. Therefore, clinically effective medical decision-making is particularly important for the prognosis of SIC with RVF.

2. Case presentation

On July 5, 2022, a 26-year-old lady came to the emergency department due to a fever and tachypnoea for 10 days. During the period, she had gone to the pharmacy and bought antipyretic painkillers for treatment, but worsened with chest distress for 3 days before coming to the hospital. There was no special medical, family, and psycho-social history and relevant genetic information for her. Upon arrival at the emergency department, the patient felt chest tightness and vomited stomach contents several times with the vital signs as follows: T: 37.6 °C P: 128 times/min R: 21 times/min BP: 76/50 mmHg. The emergency physician hospitalized the patient and administered norepinephrine (0.06 μg/kg/min) to maintain blood pressure. The patient's arterial blood gas analysis (High flow oxygen therapy humidification, FiO_2 70 %): PH 7.456, PCO2 16.7 mmHg, PO2 136.1 mmHg, cHCO3- 11.8mmol/L, K+:3.5mmol/l, NA+

* Corresponding author. Department of Neurological Intensive Care Unit, Foshan Hospital of Traditional Chinese Medicine, The Eighth Clinical College of Guangzhou University of Chinese Medicine, NO. 6 Qinren Road, Chancheng District, Foshan 528000, China.
E-mail address: ayumisure94@163.com (Y. Su).

https://doi.org/10.1016/j.heliyon.2024.e35084
Received 25 January 2024; Received in revised form 2 June 2024; Accepted 22 July 2024
Available online 25 July 2024

120.9mmol/L, CI - 91.6mmol/L, BE (ECF) −12.1 mmol/L, Lac 4.86 mmol/L, indicating respiratory alkalosis with metabolic acidosis. PCT 1.84 ng/mL (< 0.5), and the chest CT revealed pneumonia (Fig. 1). The emergency physician applied Peracillin tazobactam sodium (4.5g q8h) to cure the infection. After treatment, the patient still had recurrent fever, the echocardiography indicated LVEF decreased to 29.01 % (Fig. 2A), and the electrocardiogram indicated second degree atrioventricular block (Fig. 3A). After a general consultation in the hospital, the patient was transferred to the ICU at 18:05 on 6th July. The endotracheal intubation with MV (model: SIMV + PS, f:15, PC 12 mmHg, PS 12 mmHg, FiO_2 100 %, PEEP 8 mmHg) and nor-epinephrine (0.1 μg/kg/min) was given to maintain vital signs. The next-generation-sequencing (NGS) of alveolar lavage fluid indicated Enterococcus faecium, Stenotrophomonas maltophilia, and *Pseudomonas aeruginosa* (Fig. 4A). The NGS of blood showed Enterococcus faecium, Akkermansia muciniphila and Klebsiella pneumonia (Fig. 4B). The patient's SOFA score was 12 (TBIL 31.90 μmol/L, Cr 211.9 μmol/L, PLT 45 × 109/L, nor-epinephrine 0.1 μg/kg/min, oxygenation index 194 mmHg). The patient was diagnosed sepsis according to the sepsis 3.0 criteria from the Surviving Sepsis Campaign Guideline. NT-proBNP 22639 pg/ml (0–900), c-TnI 20.00 ng/ml (0–0.1), suggested that the patient's myocardium was damaged. Suffering from sepsis, the patient's myocardial damage and cardiac dysfunction occurred. As for a young female being excluded from other heart disease, the patient was finally diagnosed with SIC. Considering that the patient has been unresponsive to multiple antibiotics since onset, combined with mNGS results and the risk of nosocomial infection, Imipenem-Cilastatin sodium hydrate (0.5g q8h) and Vancomycin (0.5g q6h) were used for anti-bacterial infection. At 3 hours after admitting to ICU, the patient's ECG showed a conduction block and the echocardiography showed the cardiac function was worse with EF 26.32 % (Fig. 2B). Then ICU attending physician immediately performed venous-arterial extracorporeal membrane oxygenation (VA-ECMO) (the rotate speed 2800 rpm and blood flow velocity 2.5 L/min) interconnecting with the continuous renal replacement therapy (CRRT) (model: CVVH) on the patient. On 7th July, the patient developed the complications such as low distal extremity skin temperature, cyanosis, and Lac 3.9mmol/L (0.5–1.7), which indicated microcirculation disturbance, the anisodamine (5 μg/h) and papaverine (30mg q8h) were administered to improve patient's microcirculation.

At 09:37 on 8th July, the patient's ECG developed RVF (Fig. 3B), and we tried to take various antiarrhythmic drugs, such as lidocaine (1 mg/kg, intravenous injection, qd) for ventricular tachycardia at the beginning and then amiodarone (1mg/kg/h, intravenous pump) for VF, but it did not work. Because the patient's blood vessels were fragile and the low blood flow by bedside ultrasound, the intra-aortic balloon pump (IABP) was failed to performed. After cardiac defibrillation with a biphasic shock of 200 J, the patient's ECG signal changed from ventricular fibrillation to no electrical activity (Fig. 3C). At 02:00 on 9th July, the ECG of the patient reappeared VF (Fig. 3D). IABP was successfully inserted at 13:00 (counterpulsation ratio 1:2). At 37th hour from the VF had begun, the rhythm restored to third-degree conduction block (HR 50–60 times/min) (Fig. 3E and F) after the second defibrillation with a biphasic shock of 200 J (supplementary materials 1) at 21:50. The echocardiography on 9th July also presented that the patient's left ventricular wall motion improved than before (Fig. 2C).

Finally, CRRT, ECMO and IABP were evacuated from the patient on 15th July. The patient was successfully transferred to the department of Cardiology on 25th July. The entire process of this episode was summarized in a timeline (Fig. 5). 41 days later, the patient's echocardiography showed an estimated ejection fraction of 53 % (Fig. 2D), and she was discharged from the hospital with normal cardiac function without cognitive impairment, but remained limb nerve damage.

In a follow-up 3 months later, the patient was still in good condition. She said that she had not been impressed with the period of mechanical circulation assistance, and had no significant memories until after the withdrawal of the devices. She felt gradually recovering after discharge, but could not tolerate strenuous exercise. The toe problem did not affect daily walking. For the medical research, she was willing to a make her medical records a case report for public awareness.

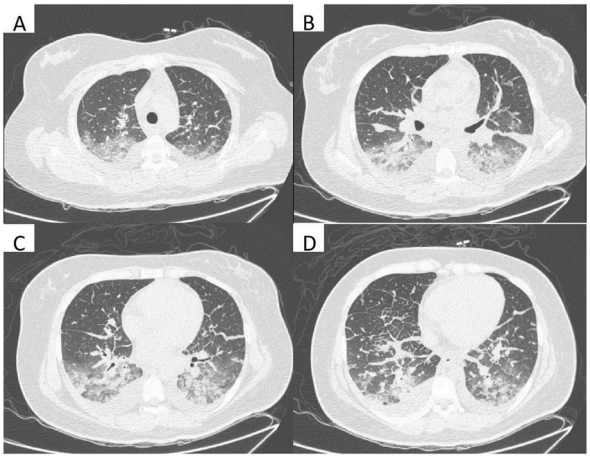

Fig. 1. Chest CT scans at different levels showed exudative lesions.

Fig. 2. (A) mNGS results of alveolar lavage fluid, indicated the sequence number of Enterococcus faecium was 42, Stenotrophomonas maltophilia was 9, and Pseudomonas aeruginosa was 4; (B) mNGS result of bood, indicated the sequence number of Enterococcus faecium was 49, Akkermansia muciniphila was 103, and Klebsiella pneumonia was 23.

3. Discussion and literature review

The current VF management guidelines emphasize early cardiopulmonary resuscitation, defibrillation, and drug treatment. In addition, early effective mechanical circulatory support (MCS) interventions such as (ECMO) and (IABP), can effectively adjust the stability of hemodynamic, avoid systemic perfusion insufficiency and vital damage to organs, and improve short-term survival [2]. However, there is a lack of evidence on how many times of defibrillation before cardioversion, and how long MCS could maintain for the RVF without serious cranial complications.

A retrospective study showed that only 42.8 % patients were successfully discharged with the average 5.4 times of defibrillation [3]. The frequent defibrillation may aggravate myocardial damage. Doherty et al. [4] found that when the energy of defibrillation was more than 30 J, the injury of cardiomyocytes increased and the blood flow in cardiomyocytes decreased. It was observed under electron microscope that the gaps between myocardial intercalated discs increased after defibrillation, thus affecting the myocardial contractile function. Several potential mechanisms involved in shock related cardiac tissue injury include extreme physical conditions, regulated cell death, metabolic remodelling, oxidative stress, calcium dysregulation, inflammation and fibrosis [5].

The choice of a MCS device depends on the characteristics of the patient, the level of support required, local expertise and logistics. The role of MCS in SIC has not been extensively studied. The clinical consensus statement of the European Heart Rhythm Association of the European Society of Cardiology (ESC) recommends that MCS may be helpful in acute haemodynamic decompensation because of refractory, haemodynamically intolerant ventricular arrhythmia as a rescue therapy [6]. According to previous researches, ECMO can ensure hemodynamic stability and tissue perfusion, can receive adequate levels of antiarrhythmic drugs during electrical storm (ES) and rapidly wean catecholamines those may contribute to ES. In addition, ECMO's reduction in myocardial oxygen consumption may also contribute to the end of ES [7]. The ARREST study has proved that early ECMO-facilitated resuscitation for patients with RVF significantly improved survival to hospital discharge compared with standard ACLS treatment [8]. MCS can maintain the stable circulation in VF patients, but how long it maintained without severe complication, was still lack of evidence. There are few literatures on the timing and frequency of re-defibrillation. In 7 case reports which had clearly stated the duration of VF and frequency of defibrillation, the longest duration of VF was 30 hours, and the frequency of defibrillation was over 10 times. The shortest duration was 26 minutes, and the defibrillation frequency was up to 7 times. Among all the reports, the frequency of defibrillation was at least 4 times (Table 1). In this case, with the support of MCS, the patient totally experienced two times of defibrillations.

MCS has been widely used in refractory cardiogenic shock and cardiac arrest, especially ECMO [9]. However, there is still a lack of evidence that the application of MCS improves the prognosis in VF patients. Even research indicated that rescue ablation of refractory ventricular electrical storm requiring MCS was associated with higher 30-day mortality [10]. In this case, we regulated the

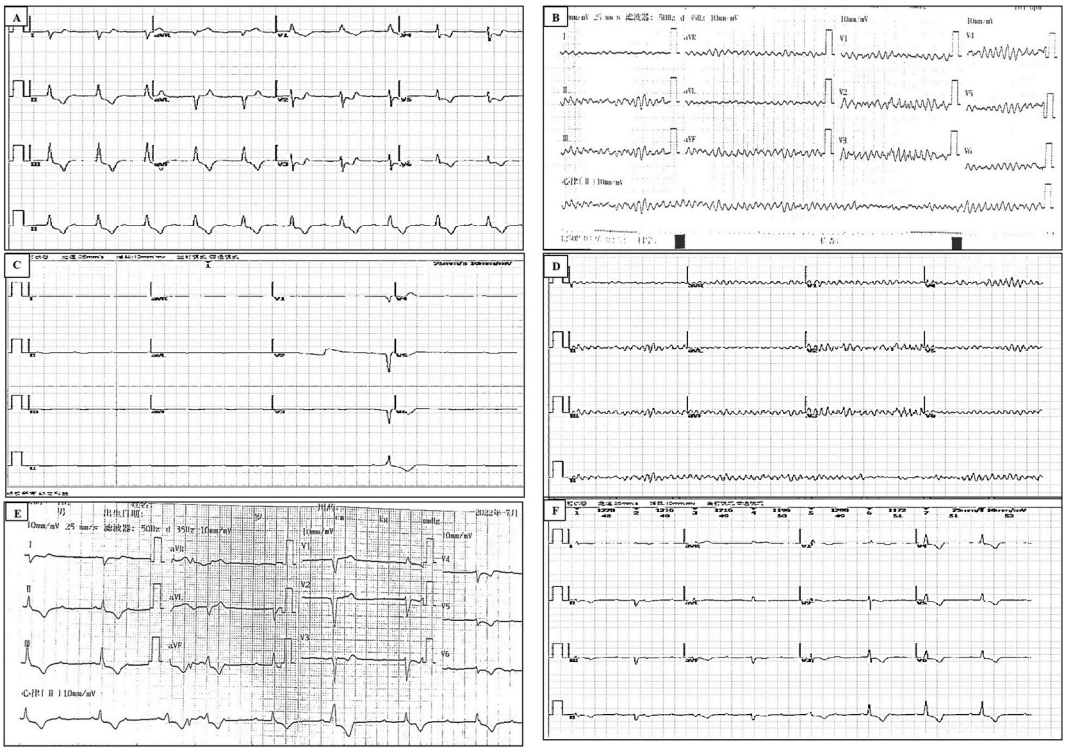

Fig. 3. The evolution of the patient's electrocardiogram. (A) On admission, the electrocardiogram (ECG) revealed ST-segment depression and second-degree atrioventricular block; (B) At 09:37 on 8th July, the ECG developed VF; (C) At 23:12 on 8th July, after cardiac defibrillation, the patient developed cardiac arrest; (D) At 02:00 on 9th July, the ECG of the patient reappeared VF; (E) After the second shock, the rhythm recovered to third-degree conduction block; (F) On 11th July, the ECG of the patient became degree II atrioventricular block.

hemodynamic stability via MCS in the early stage to avoid systemic perfusion insufficiency, tried to minimize the frequency and the adverse events of defibrillation.

There are certain limitations in this case report. Due to the patient's mechanical circulatory support at that time, MRI examination could not be performed, and the bedside ultrasound instrument was not up to the conditions for spot tracking, so the diagnosis of SIC could only be based on pathogenesis, clinical manifestations, and laboratory findings. However, life-saving cardiogenic shock, regardless of the cause, must be supported by mechanical circulation, and whether to insist on repeated defibrillation in RVF with MCS is still controversial. Therefore, this case report suggests that sepsis can induce severe cardiac dysfunction, and attempts can be made to choose appropriate defibrillation frequency in RVF with early MCS.

4. Conclusion

Cardiac function can be recovered quickly in general SIC, once RVF is induced, it will be a great challenge for clinicians. In this case, we provided a clinical medical experience that if RVF caused by SIC, appropriate frequency of defibrillation with early MCS may be considered, which was helpful for the prognosis.

Ethics statement

This study was approved by the Ethics Committee of Foshan Hospital of TCM (Approval Letter No. 2021245). Informed patient consent was obtained for the case report.

Funding

Medical Research Foundation of Guangdong Province (No. 20241307, No. A2023198); National Natural Science Foundation of China (No. 82374216); Research Project of Traditional Chinese Medicine Bureau of Guangdong Province (No. 20241307); Self-funded scientific and technological innovation projects of Foshan Science and Technology Bureau were put into storage (No. 2220001005576); Foshan Medical Research Project (No. 20210001).

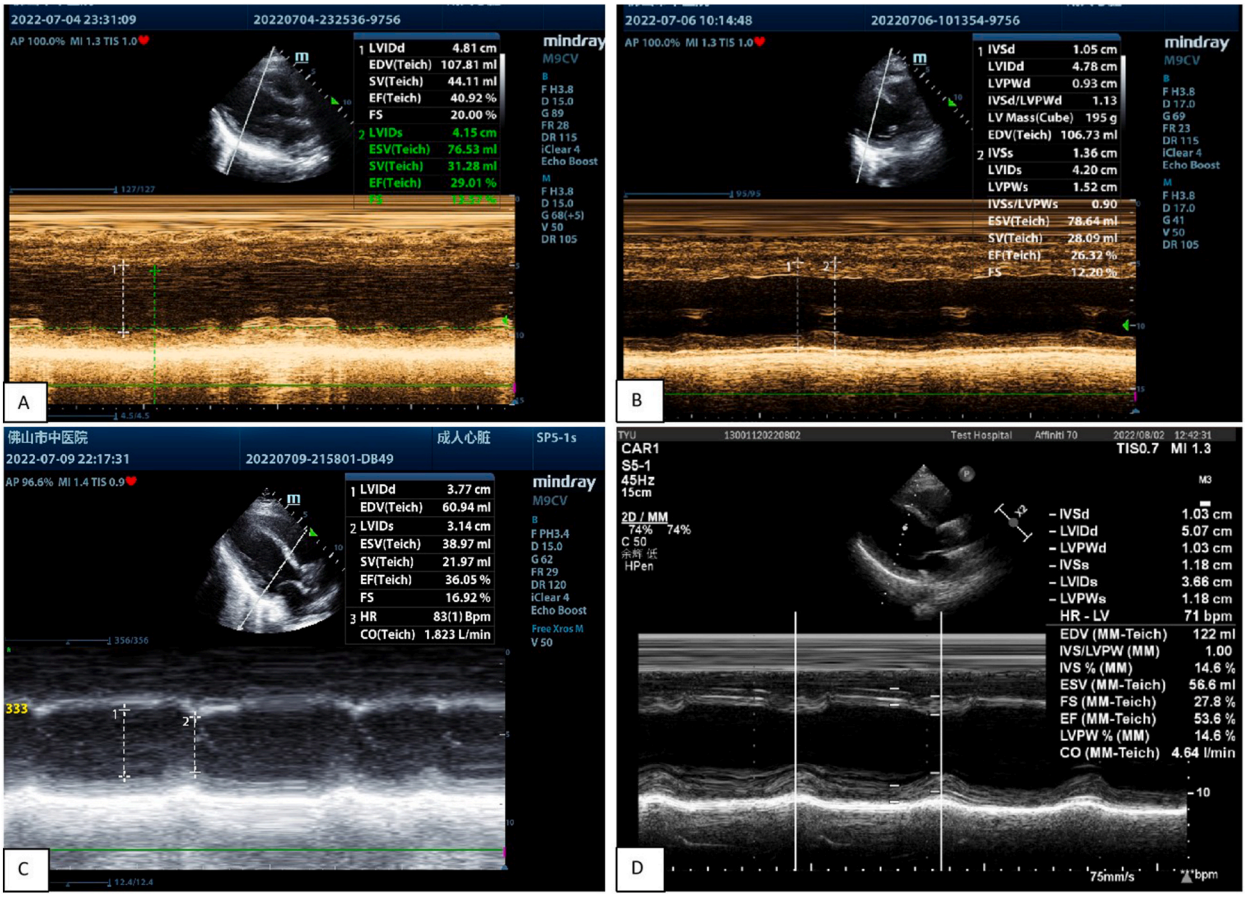

Fig. 4. The evolution of the patient's echocardiography. (A) On admission, the echocardiography revealed that left ventricular wall motion was generally weak, with an estimated ejection fraction (EF) of 29 %; (B) At 21:00 on 6th July, the cardiac function was worse with EF 26.32 %; (C) On 9th July, left ventricular wall motion improved with EF 36.05 %; (D) 41 days after admission, the patient's echocardiography showed an estimated ejection fraction of 53 %.

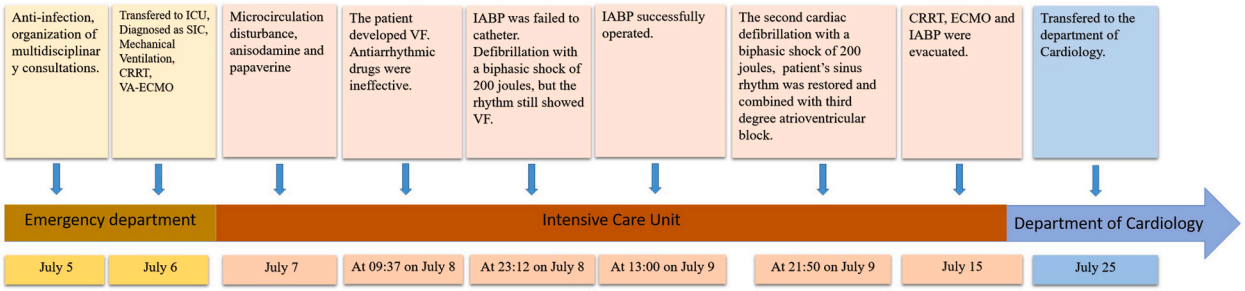

Fig. 5. The entire process of this episode was summarized in a timeline.

Data availability statement

Data included in article/supp. material/referenced in article.

CRediT authorship contribution statement

Songtao Liu: Writing – original draft. **Zhixin Wu:** Investigation, Conceptualization. **Yi Su:** Writing – review & editing, Writing – original draft, Project administration, Investigation, Formal analysis. **Fucheng Qiu:** Data curation.

Table 1
Case reports of RVF with MCS.

Author	Publish year	age	gender	Diagnosis	MCS	The time of RVF	Times of defibrillation/ ICD discharges
Thomas Fux et al. [11]	2010	39	male	idiopathic VT	VA-ECMO	30 hours	> 10
Naofumi Bunya et al. [12]	2017	22	female	sibutramine-containing weight loss pills	VA-ECMO	66 minutes	4
Misa Fister et al. [13]	2019	54	male	Hypothermia	VA-ECMO	4 hours and 16 minutes	4
Douglas Darden et al. [14]	2020	67	male	ventricular arrythmias from the moderator band	ECMO	12 hours	> 20
Yumi Kato et al. [15]	2020	43	male	caffeine intoxication	VA-ECMO	26 minutes	7
Tharusan Thevathasan et al. [16]	2022	54	male	ST-segment elevation acute coronary syndrome	VAV ECMO and Impala	32 minutes	10
Boldizsár Kiss et al. [17]	2023	27	male	cardiac arrest	LUCAS, MV, VA-ECMO	58 minutes	8

*PCPS: percutaneous cardiopulmonary support system.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Y. Su, X. Yin, X. Huang, Q. Guo, M. Ma, L. Guo, Astragaloside IV ameliorates sepsis-induced myocardial dysfunction by regulating NOX4/JNK/BAX pathway, Life Sci. 310 (2022), https://doi.org/10.1016/j.lfs.2022.121123.

[2] K. Chen, J. Hou, H. Tang, S. Hu, Concurrent initiation of intra-aortic balloon pumping with extracorporeal membrane oxygenation reduced in-hospital mortality in postcardiotomy cardiogenic shock, Ann. Intensive Care 9 (1) (2019), https://doi.org/10.1186/s13613-019-0496-9.

[3] M.A. Merlin, A. Tagore, R. Bauter, Arshad FH: a case series of double sequence defibrillation, Prehosp. Emerg. Care 20 (4) (2016) 550–553, https://doi.org/10.3109/10903127.2015.1128026.

[4] X. Zhou, Z. Zhang, C. Gong, Y. Fang, The effect of prophylactic intravenous amiodarone administration on reperfusion ventricular fibrillation in patients with left ventricular hypertrophy undergoing cardiopulmonary bypass surgery: protocol for a randomized double-blind clinical trial, JMIR Research Protocols 12 (2023), https://doi.org/10.2196/40115.

[5] A. Bodin, V. Labas, A. Bisson, A.-P. Teixeira-Gomes, H. Blasco, D. Tomas, L. Combes-Soia, P. Marcelo, E. Miquelestorena-Standley, C. Baron, et al., Acute pathophysiological myocardial changes following intra-cardiac electrical shocks using a proteomic approach in a sheep model, Sci. Rep. 10 (1) (2020), https://doi.org/10.1038/s41598-020-77346-x.

[6] R. Lenarczyk, K. Zeppenfeld, J. Tfelt-Hansen, et al., Management of patients with an electrical storm or clustered ventricular arrhythmias: a clinical consensus statement of the European heart rhythm association of the ESC-endorsed by the asia-pacific heart rhythm society, heart rhythm society, and Latin-American heart rhythm society, Europace 26 (4) (2024) euae049, https://doi.org/10.1093/europace/euae049.

[7] G. Baudry, R. Sonneville, X. Waintraub, et al., Extracorporeal membrane oxygenation to support life-threatening drug-refractory electrical storm, Crit. Care Med. 48 (10) (2020) e856–e863, https://doi.org/10.1097/CCM.0000000000004490.

[8] D. Yannopoulos, J. Bartos, G. Raveendran, E. Walser, J. Connett, T.A. Murray, G. Collins, L. Zhang, R. Kalra, M. Kosmopoulos, et al., Advanced reperfusion strategies for patients with out-of-hospital cardiac arrest and refractory ventricular fibrillation (ARREST): a phase 2, single centre, open-label, randomised controlled trial, Lancet 396 (10265) (2020) 1807–1816, https://doi.org/10.1016/s0140-6736(20)32338-2.

[9] H. Zhou, Y. Zhu, Z. Zhang, Y. Mei, J. Lv, G. Zhang, W. Li, X. Chen, Ventricular Fibrillation/ventricular Tachycardia within 72 H of VA-ECMO: Incidence, Outcomes, Risk Factors, and Management, ESC Heart Failure, 2023, https://doi.org/10.1002/ehf2.14615.

[10] F.P. Chung, Y.C. Liao, Y.J. Lin, S.L. Chang, L.W. Lo, Y.F. Hu, T.C. Tuan, T.F. Chao, J.N. Liao, C.Y. Lin, et al., Outcome of rescue ablation in patients with refractory ventricular electrical storm requiring mechanical circulation support, J. Cardiovasc. Electrophysiol. 31 (1) (2019) 9–17, https://doi.org/10.1111/jce.14309.

[11] T. Fux, P. Svenarud, K.H. Grinnemo, A. Albåge, F. Bredin, J. van der Linden, I. Hagerman, A. Gabrielsen, L.H. Lund, Extracorporeal membrane oxygenation as a rescue of intractable ventricular fibrillation and bridge to heart transplantation, Eur. J. Heart Fail. 12 (3) (2010) 301–304, https://doi.org/10.1093/eurjhf/hfq012.

[12] N. Bunya, K. Sawamoto, S. Uemura, R. Kyan, H. Inoue, J. Nishida, H. Kouzu, N. Kokubu, T. Miura, E. Narimatsu, Cardiac arrest caused by sibutramine obtained over the Internet: a case of a young woman without pre-existing cardiovascular disease successfully resuscitated using extracorporeal membrane oxygenation, Acute Medicine & Surgery 4 (3) (2017) 334–337, https://doi.org/10.1002/ams2.275.

[13] M. Fister, R. Knafelj, P. Radsel, M. Zlicar, T. Goslar, M. Noc, Cardiopulmonary resuscitation with extracorporeal membrane oxygenation in a patient with profound accidental hypothermia and refractory ventricular fibrillation, Ther. Hypothermia Temp. Manag. 9 (1) (2019) 86–89, https://doi.org/10.1089/ther.2018.0011.

[14] D. Darden, J.C. Hsu, S. Shah, K. Hoffmayer, G.K. Feld, F.T. Han, Ventricular tachycardia storm originating from moderator band requiring extracorporeal membrane oxygenation, JACC (J. Am. Coll. Cardiol.): Case Reports 2 (6) (2020) 946–950, https://doi.org/10.1016/j.jaccas.2020.05.019.

[15] Y. Kato, A. Kuriyama, R. Hata, T. Ikegami, Extracorporeal membrane oxygenation for hypokalemia and refractory ventricular fibrillation associated with caffeine intoxication, J. Emerg. Med. 58 (1) (2020) 59–62, https://doi.org/10.1016/j.jemermed.2019.09.023.

[16] T. Thevathasan, L. Füreder, D.W. Donker, C. Nix, T.H. Wurster, W. Knie, G. Girke, A.S. Al Harbi, U. Landmesser, C. Skurk, Case report: refractory cardiac arrest supported with veno-arterial-venous extracorporeal membrane oxygenation and left-ventricular Impella CP®–Physiological insights and pitfalls of ECMELLA, Frontiers in Cardiovascular Medicine 9 (2022), https://doi.org/10.3389/fcvm.2022.1045601.

[17] B. Kiss, B. Nagy, Á. Pál-Jakab, B. Lakatos, Á. Soltész, I. Osztheimer, K. Heltai, I.F. Édes, E. Németh, B. Merkely, et al., Early application of ECMO after sudden cardiac arrest to prevent further deterioration: a review and case report, J. Clin. Med. 12 (13) (2023), https://doi.org/10.3390/jcm12134249.