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CASE REPORT
Other

Recovery from respiratory failure after 49-day extracorporeal membrane oxygenation support in a critically ill patient with COVID-19: case report

Fengwei Guo, Chao Deng, Tao Shi*, and Yang Yan *

Department of Cardiovascular surgery, First Affiliated Hospital of Xi'an Jiaotong University, No. 277 Yanta West Road, Xi'an, 710061, P.R. China

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Background Respiratory failure is a life-threatening complication of coronavirus disease 2019 (COVID-19)-related acute respiratory distress syndrome. Extracorporeal membrane oxygenation (ECMO) in COVID-19 might offer promise based on our clinical experience. However, few critically ill cases with COVID-19 have been weaned off ECMO.

Case summary A 66-year-old Chinese woman presented with fever (38.9°C), cough, dyspnoea, and headache. She had lymphopenia (0.72×10^9/L) and computed tomography findings of ground-glass opacities. Subsequently, she was confirmed to have respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. She was intubated after transfer to the intensive care unit due to respiratory failure and heart failure. However, her condition continued to deteriorate rapidly. Veno-veno ECMO was undertaken for respiratory and cardiac support due to refractory hypoxemic respiratory failure and bradyarrhythmia (45 b.p.m.). During hospitalization, she was also administered anti-viral treatment, convalescent plasma therapy, and continuous renal replacement therapy. She was maintained on ECMO before she had fully recovered from the condition that necessitated ECMO use and had a negative test for the nucleic acids of SARS-CoV-2 twice. Forty-nine days later, this patient was weaned from ECMO. At the most recent follow-up visit (3 months after weaning from ECMO), she received respiratory and cardiac rehabilitation and did not complain of any discomfort.

Discussion As far as we know, the longest duration of ECMO treatment in this critical case with COVID-19 is supportive of ECMO as the most aggressive form of life support and the last line of defence during the COVID-19 epidemic.

Keywords Coronavirus disease 2019 • Acute respiratory distress syndrome • Extracorporeal membrane oxygenation • Case report

Learning points

- The early application of ECMO for patients with respiratory failure and heart failure can dramatically promote recovery and outcomes.
- The complexity of ECMO requires a high professional multidisciplinary team (MDT) to care for critically ill patients, including experts in respiratory, critical medicine, blood purification and cardiovascular surgeons. An integral MDT regularly discusses therapeutic regimen, including ECMO rotation, is recommended.

* Corresponding author. Tel: 0086 29 85323869, Email: shitao068@xjtu.edu.cn (T.S.); Email: yangyan3@xjtu.edu.cn (Y.Y.)
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Introduction

Coronavirus disease 2019 (COVID-19) was declared a pandemic by the World Health Organization on 11 April 2020.[1] Acute respiratory distress syndrome (ARDS)-related respiratory failure and heart failure are common in severe and critically ill cases of COVID-19.[2] Early application of extracorporeal membrane oxygenation (ECMO) in patients with respiratory failure or heart failure can promote recovery and outcomes dramatically.[3] Based on previous experience, ECMO is recommended for treatment of severe and critically ill patients with ARDS due to COVID-19.[4] However, the website of the Extracorporeal Life Support Organization (ELSO) and the literature[5] suggest that few critically ill patients with COVID-19 can be weaned off ECMO.

Here, we describe the recovery from respiratory failure of a critically ill patient with COVID-19 after 49 days of veno-venous extracorporeal membrane oxygenation (VV-ECMO) support.

Timeline

Time	Event
1 day	Chief complaint of fever (38.9°C) and dyspnoea. The lab testing of the blood test showed leukopaenia (3.97×10^9/L) and lymphopenia (0.72×10^9/L), other blood biochemical examination: C-reactive protein 54.86 mg/L, procalcitonin 1.41 ng/mL. Blood gas analysis showed pondus hydrogenii (pH) 7.41, oxygen partial pressure (PO_2) 8.91 KPa, the partial pressure of carbon dioxide (PCO_2) 5.19 KPa with a fraction of inspired oxygen (FiO_2) 40%. Chest computer tomography (CT) scan showed an impressive finding of ground-glass opacities and chronic inflammation of the bilateral lung. The SARS-CoV-2 testing of the throat swab was positive.
3 days	Treated with anti-viral and anti-bacterial medicine in the isolated wards and subsequently supplied with non-invasive and invasive ventilation. However, her condition was rapidly deteriorating as she presented with dropped blood oxygen saturation, severe bradycardia, and hemodynamic instability.
5 days	Cannulated for veno-venous extracorporeal membrane oxygenation (ECMO) and the rotation speed was regulated to 2500–3000 rpm according to the blood oxygen saturation and blood pressure, blood flow was controlled to about 3.0–4.0 L/min. Blood gas analysis was performed every 4 h and partial pressure of carbon dioxide was maintained at about 5.32 KPa and pulse oxygen saturation at about 95%; ECMO oxygen concentration stayed at 100%.
40 days	Re-examination of the chest CT scan showed that Inflammatory infiltrates were significantly reduced.
53 days	Weaned from ECMO.
144 days	Received respiratory and cardiac rehabilitation and did not complain of any discomfort.

Case presentation

A 66-year-old woman presented with the main complaints of fever (38.9°C) and dyspnoea of 1-day duration. She had an 8-year history of hypertension and took candesartan regularly. Her husband was confirmed to have COVID-19 and had been treated in a local hospital.

In the emergency room, laboratory testing of blood revealed leucocyte count of 3.97×10^9/L, lymphopenia (0.72×10^9/L), a C-reactive protein level of 54.86 mg/L, and procalcitonin level of 1.41 ng/mL. Blood–gas analyses revealed pH of 7.41, the partial pressure of oxygen (PO_2) of 8.91 KPa, the partial pressure of carbon dioxide (PCO_2) of 5.19 KPa, with a fraction of inspired oxygen (FiO_2) of 40%. The SARS-CoV-2 testing of the throat swab was positive. Computed tomography (CT) of the chest revealed ground-glass opacities and chronic inflammation of bilateral lungs (*Figure 1A, B*). After a throat swab had confirmed her to be COVID-19-positive, the patient was transferred to an isolated ward.

After the first 3 days of hospitalization, she was treated with the anti-viral agent umifenovir (Arbidol™) in the isolation ward and administered non-invasive and invasive ventilation subsequently. However, her condition was rapidly deteriorating as she presented with a decrease in blood oxygen saturation, severe bradycardia, and became haemodynamic instability.

After consultation between members of the multidisciplinary team (MDT), the patient was cannulated for VV-ECMO (*Figure 2*). The right jugular vein was cannulated with an inflow cannula (17 Fr; Maquet, Rastatt, Germany). The right femoral vein was cannulated with a draining cannula (21 Fr; Maquet). Heparin was pumped continuously for anticoagulation during ECMO cannulation. The rotation speed of the ECMO system was regulated to 2500–3000 rpm according to the blood oxygen saturation and blood pressure. Blood flow was controlled to about 3.0–4.0 L/min. Blood–gas analyses were undertaken every 4 h. PCO_2 was maintained at 5.32 KPa and pulse oxygen saturation at 95%; the oxygen concentration of the ECMO system remained at 100%. The patient also received ultraprotective lung ventilation [positive end-expiratory pressure (PEEP) = 10 cmH_2O; vital volume = 6 mL/kg; respiratory rate = 6–8 b.p.m.], deep sedation, daily awakening, and assessment of consciousness and brain function, and was positioned prone every 6–12 h. Finally, the oxygen flow in the ECMO system declined to 2.0 L/min and the oxygen supply was closed for observation for 24 h at 52 days after CT re-examination of the chest (*Figure 1C, D*) and 35 days after ECMO cannulation. When pressure-control mode (pressure support = 16 cmH_2O; PEEP = 10 cmH_2O; FIO_2 = 50%) was given simultaneously, her oxygen saturation could be maintained at >97%.

During hospitalization, the patient was also administered therapy (hormone, anti-viral, convalescent plasma, continuous renal replacement) and underwent tracheostomy (*Figure 3*). The efficacy of these therapies was observed by measuring various blood parameters (*Figures 4* and *5*). Heart function was assessed by bedside echocardiography (Supplementary material online, *Table S1*).

Notably, several complications occurred during ECMO cannulation. Pneumothorax was the first and occurred on Day 19 of hospitalization. Pneumothorax disappeared after carrying out 14-day closed thoracic drainage (Supplementary material online, *Figure S1*). Then,

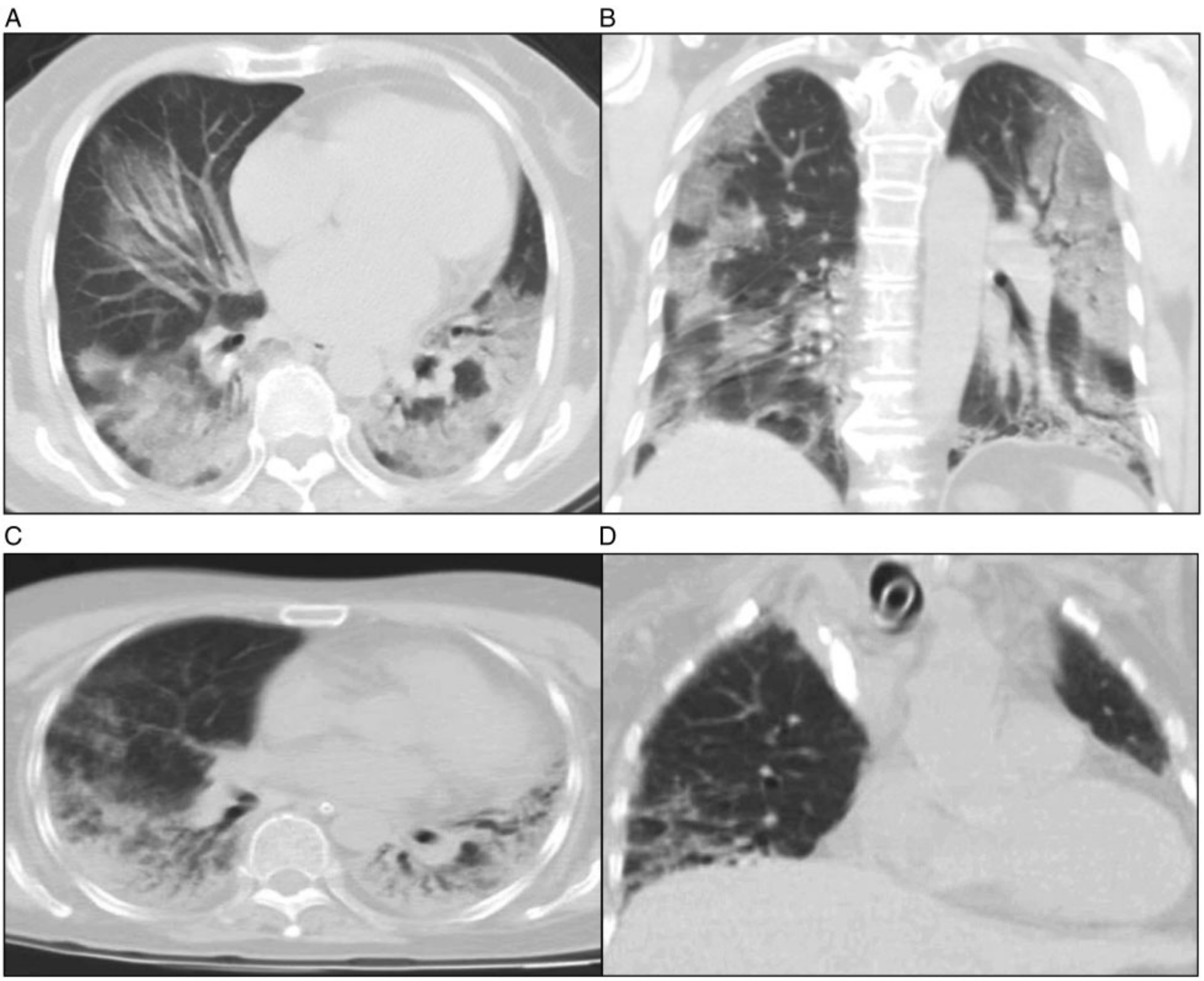

Figure 1 Computed tomography of the chest upon hospital admission showing ground-glass opacities and chronic inflammation of bilateral lungs (*A* and *B*). Computed tomography at 35 days after extracorporeal membrane oxygenation cannulation: the number of inflammatory infiltrates is reduced significantly (*C* and *D*).

nasal haemorrhage and haemoglobinuria (indicating haemolysis) occurred successively; long-term anticoagulation and mechanical destruction of red blood cells were thought to be the main causes. Therefore, the heparin dose was reduced appropriately through the dynamic monitoring of the activated clotting time of whole blood to ensure that neither bleeding nor clotting affected ECMO efficacy. Also, we replaced the centrifugal pump and oxygenator twice during ECMO cannulation to reduce mechanical destruction of red blood cells.

This patient was maintained on ECMO before she had fully recovered from the condition that necessitated ECMO use (Supplementary Material online, *Videos S1* and *S2*) and had a negative test for the nucleic acids of SARS-CoV-2 twice. After 49 days, this patient was weaned from ECMO. At the most recent follow-up (3 months after ECMO decannulation), she received respiratory and cardiac rehabilitation and did not complain of any discomfort.

Discussion

Extracorporeal membrane oxygenation can take over (transiently) respiratory or cardiac function, thereby providing time to treat the primary disease.[6] Although COVID-19 can result in respiratory diseases and most of them can be cured, some patients unexpectedly develop severe ARDS. The prevalence of the morbidity and mortality of ARDS is 26–58%.[7] Observational studies have suggested that ECMO can ameliorate survival and outcomes in patients with ARDS,[8] but its effect on COVID-19 is not known. Experts in Wuhan (China) used ECMO to treat critically ill patients with COVID-19 and cured in some cases. Currently, the ELSO recommend that ECMO should be considered as salvage treatment for COVID-19 patients with ARDS.[9,10]

Several factors can influence the outcomes of ECMO treatment, such as the: severity of the underlying disease; duration of mechanical ventilation; experience of medical staff; ECMO equipment.[11]

The time when ECMO therapy is started is a vital factor. For ARDS treatment, Steimer *et al.*[12] consider that early ECMO treatment can ensure the oxygen supply and reduce damage to organs and, finally, increase the survival chance of patients with ARDS. Our patient had mild disease initially but her condition deteriorated rapidly. On the basis of previous experience, we started ECMO at Day 3 of hospitalization when she experienced low blood oxygen saturation, severe bradycardia, and became haemodynamically unstable.

The complexity of ECMO requires a highly experienced MDT to care for critically ill patients, including experts in respiratory, critical medicine, blood purification and cardiovascular surgeons.[13] Our MDT discusses the therapeutic regimen twice daily, including ECMO rotation, use of anti-viral agents and antibiotics, and fluid management.

Another key element of the successful outcome of our patient was adjuvant therapy. For example, continuous renal replacement therapy cleared inflammation, and switching to the prone position improved her lung function. Ghelichkhani *et al.*[14] discussed how the prone position can improve ARDS: increase in the end-expiratory lung volume, increase in chest-wall elasticity, decrease in the alveolar shunt, and improvement in the tidal volume. The time that patients are placed in the prone position should be 4–6 h.

Our COVID-19 patient had the longest duration of ECMO treatment ever reported. Our management regimen supports the concept of ECMO being the most aggressive form of life support and the last line of defence during the COVID-19 epidemic.

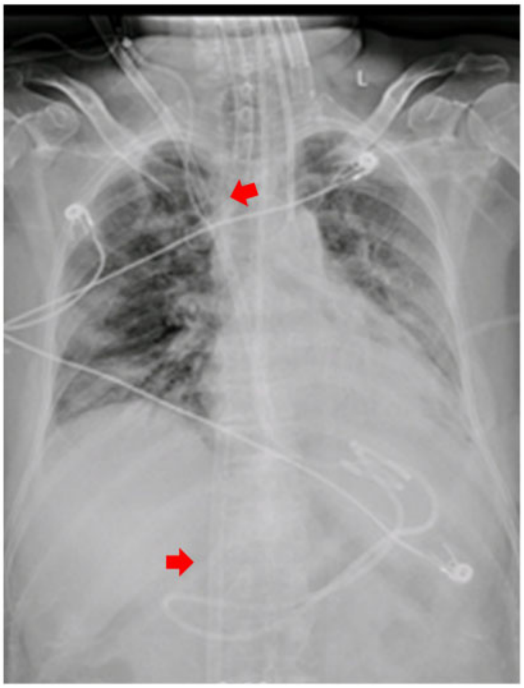

Figure 2 After consultation between the multidisciplinary team, the patient was cannulated for veno-venous extracorporeal membrane oxygenation. VV-ECMO (indicated by the red arrows).

Limitations

Our study had two main limitations. First was the lack of detailed echocardiographic and electrocardiographic data, which was due to the conditions in the isolation ward. Second, we were unsure whether our patient had COVID-19-induced myocarditis because an endomyocardial biopsy was not carried out.

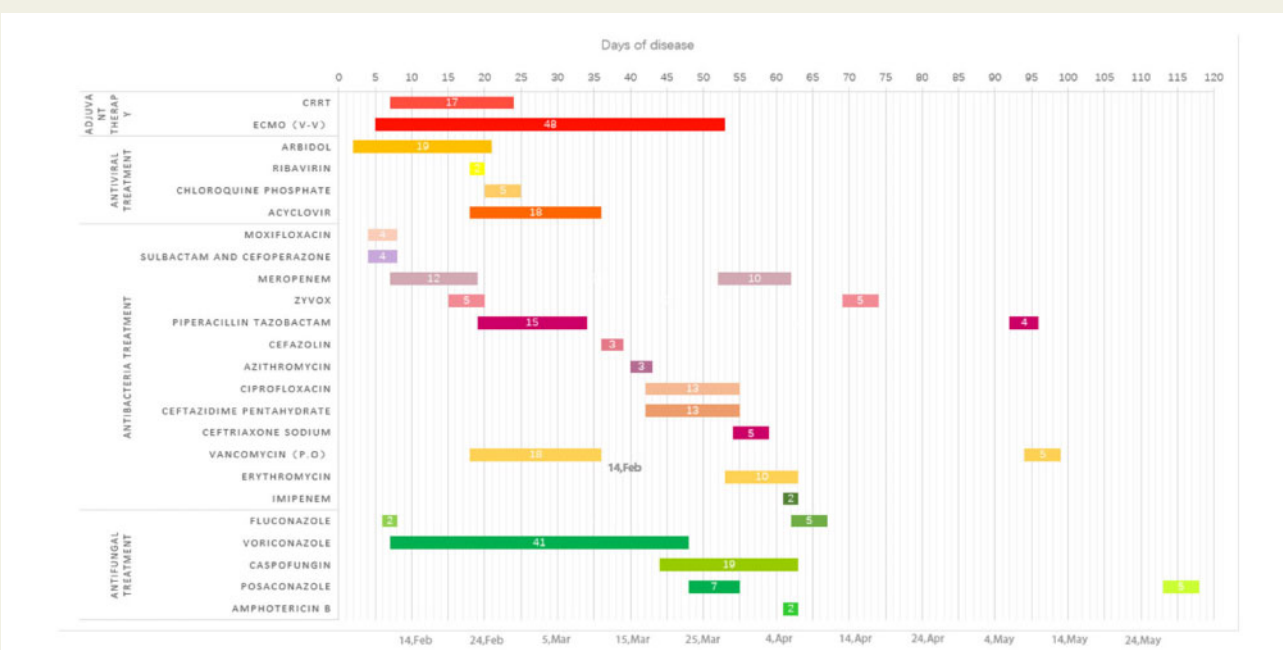

Figure 3 Main drug therapy and adjuvant therapy from 5 February to 6 April 2020.

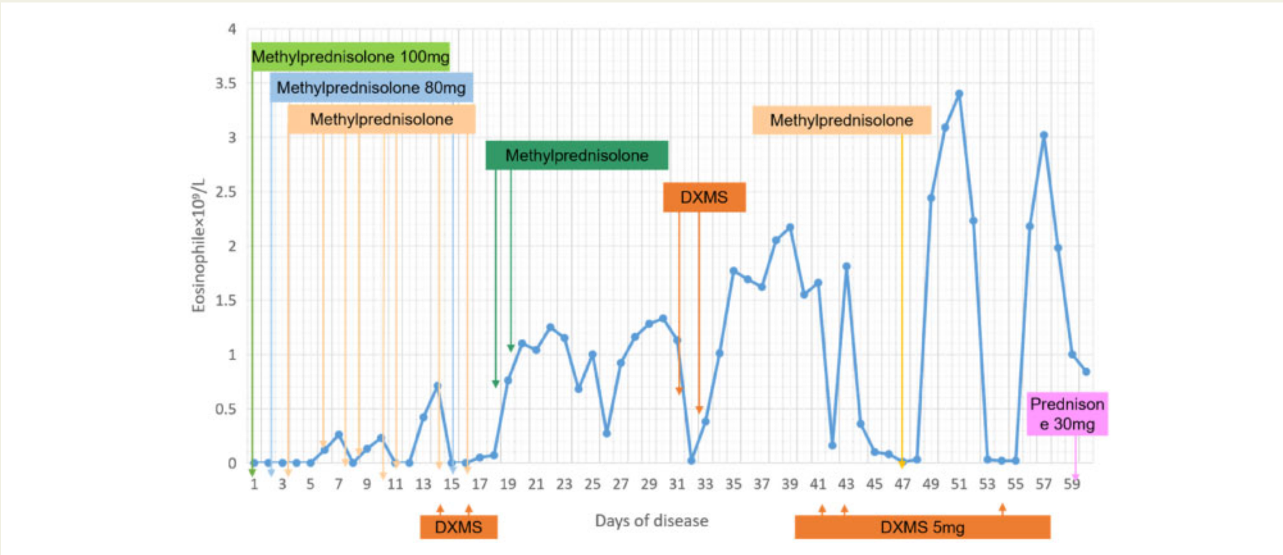

Figure 4 Changes in the eosinophil count during hormone therapy from 5 February to 6 April 2020.

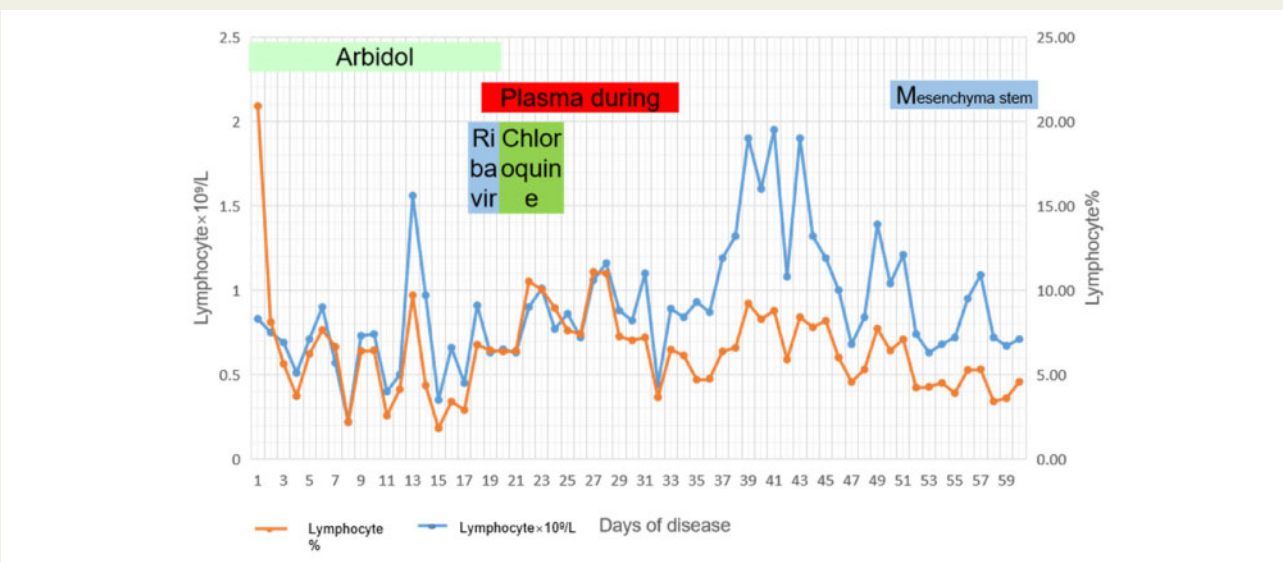

Figure 5 Changes in the lymphocyte count and lymphocyte percentage during anti-viral therapy from 5 February to 6 April 2020.

Lead author biography

Yang Yan, MD, associate professor, chief physician of cardiovascular surgery. Engaged in cardiovascular surgery medical, teaching, and research work. He has carried out a number of complicated congenital heart disease operations for infants and young children, minimally invasive cardiac surgery, and coronary artery bypass grafting under laparoscopy, and successfully implemented cardiac mechanical auxiliary (VAD, ECMO) treatment for critically ill patients.

Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

Acknowledgements

All have to understand, we have to list just four of us here as the co-authors because of the authorship introduction, but its literally hundreds of people that went into this patient being able to survive.

Thanks all who fight against COVID-19 pandemic, we believe there will be more patients to come off ECMO and survive.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that consent for submission and publication of this case report, including images and associated text, has been obtained from the patient in accordance with COPE guidance.

Conflict of interest: none declared.

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