Combined application of extracorporeal membrane oxygenation and an artificial pacemaker in fulminant myocarditis in a child

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Abstract

Fulminant myocarditis is severe and aggressive, but it is self-limited and usually has a favorable prognosis if the patients can survive the acute phase. When drug treatment is not effective, extracorporeal membrane oxygenation technology should be applied to support cardiopulmonary function. Extracorporeal membrane oxygenation can simultaneously support function of the left ventricle, right ventricle, and lungs, and provide stable blood circulation for patients with heart and respiratory failure, which allows sufficient time for the cardiopulmonary system to recover. Fulminant myocarditis affects cardiac systolic function, as well as the function of autorhythmic cells and the conduction system. If severe bradycardia or atrioventricular block appears, a pacemaker needs to be installed. We report a child with fulminant myocarditis who was treated with extracorporeal membrane oxygenation combined with an artificial pacemaker. (Turk Pediatr Ars 2017; 52: 101-4)

Keywords: Child, extracorporeal membrane oxygenation, fulminant myocarditis, pacemaker

Introduction

Fulminant myocarditis (FM) is severe and aggressive, with a high mortality rate under regular treatment procedures. However, FM is self-limited and usually has a favorable prognosis if the patients can survive the acute phase (1, 2). When drug treatment is ineffective, extracorporeal membrane oxygenation (ECMO) should be applied. It can simultaneously support function of heart and lungs, and provide stable blood circulation for patients with heart and respiratory failure. This allows sufficient time for the cardiopulmonary system to recover (3). Fulminant myocarditis affects cardiac systolic function, as well as the function of autorhythmic cells and the conduc-

tion system. If severe bradycardia or atrioventricular (AV) block appears, a pacemaker needs to be installed (4). We report a FM child who developed grade III AV block after the treatment of ECMO, and was put on permanent pacemaker.

Case

A boy aged 11 years and 7 months was admitted to hospital with convulsions, he had also had a 4-day fever and chest congestion for 3 days. The local hospital initially considered acute upper respiratory infection and prescribed cefuroxime. However, the child still had repeated fever, dizziness, vomiting, and abdominal pain. Three days before hospitalization, the child presented

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Figure 1. a-c. ECG on the day of admission (a); ECG on day 3 after admission (b); ECG on day 15 after admission (c)

with chest congestion, palpitation, and fatigue, and viral myocarditis was considered. After hospitalization, the patient was treated with gamma globin, methylprednisolone, vitamin C and fructose diphosphate. On the evening of admission, the patient developed Adams-Stokes syndrome (ASS), atropine, isoprenaline, dopamine and dobutamine were applied. A physical examination at admission showed the following: temperature, 36.8°C; respiratory rate, 22 times/min; heart-beat, 56 beats/min; blood pressure, 73/39 mm Hg; and weight, 34.6 kg. The patient was mentally clear, but weak with a pale face. He had bilateral coarse lung sounds, arrhythmia, and a weak pulse, but without obvious murmur. The liver was 4.5 cm below the costal margin and was soft. There was no splenomegaly. The capillary refilling time was 3 s. Troponin was high of 25.35 ng/mL; creatinine kinase-MB (CKMB) was 288 U/L, N-terminal B-type natriuretic peptide was 3347 pg/mL, glutamic oxaloacetic transaminase was 578 U/L, and lactic acid was 2.6 mmol/L. An electrocardiogram (ECG) showed sinus arrhythmia, paroxysmal supraventricular tachycardia, second-degree AV block, and ST-T changes. Cardiac ultrasound showed left ventricular dysfunction with an ejection fraction (EF) of 0.42, and no pericardial effusion detected. The primary diagnosis was (1) FM, (2) acute cardiac dysfunction, (3) cardiogenic shock, and (4) ASS.

Auxiliary examinations on the day of admission to our hospital showed the following: CKMB, 39.10 ng/mL; troponin 3.540 ng/mL; N-terminal B-type natriuretic peptide, 13 683 pg/mL; and lactic acid, 9.5 mmol/L. An ECG showed third-degree AV block with ventricular escape rhythm, ST-segment elevation of 2–4 mm in leads

Figure 2. Chest X-ray on the day of admission.

I and aVF, ST-segment depression of 2–6 mm in leads V1, V2, V3, V4, V5, and V6, and T wave inversion in leads II, III, and aVF (Figure 1a). Cardiac ultrasound showed left ventricular dysfunction with an EF of 0.3. A chest X-ray showed an enlarged cardiac silhouette and mild bilateral pleural effusion (Figure 2). Viral tests were negative. A high dose of methylprednisolone, gamma globulin, and vasoactive drugs were administered. Thirty minutes later, the child presented with ASS again, and immediately ECMO and a ventilator were applied. One hour later, venous-arterial ECMO was successfully established. During ECMO, the activated clotting time (ACT) was monitored and maintained between 140–220 s. The blood flow rate was adjusted

to maintain venous oxygen saturation (SvO_2) $>65\%$, FiO_2 of the mixed air provided to the lungs between 40–60%, and arterial oxygen saturation $>95\%$. Two days after the treatment of ECMO, the patient recovered and the ventilator was withdrawn, and his heart function greatly improved with an EF of 0.65. However, ECG still showed third-degree AV block (Figure 1b); therefore, a temporary pacemaker was placed. On day 5, the patient had a steady heartbeat, blood pressure, and SvO_2 . The ECMO system was then removed. The total duration of ECMO was 88 h. Two weeks after the placement of the temporary pacemaker, his ECG still showed third-degree AV block (Figure 1c), thus a permanent pacemaker was eventually placed. We obtained informed consent from the next of parents on the behalf of the patient involved in our study.

Discussion

Fulminant myocarditis is characterized by acute onset, and might cause left ventricular dysfunction and subsequent cardiogenic shock, with high mortality of 50% without mechanical circulation assistance (MCA) (5). Early MCA can help to improve recovery of cardiac function and the prognosis of patients. Mechanical circulation assistance mainly includes an intra-aortic balloon pump, percutaneous cardiopulmonary support system, ECMO, and a ventricular assistance device. Extracorporeal membrane oxygenation is often used in children because of less severe trauma, convenience, and effectiveness (6). Extracorporeal membrane oxygenation can also be applied during cardiopulmonary resuscitation (3).

Extracorporeal membrane oxygenation can sustainably and effectively assist circulatory and respiratory function until sufficient recovery of the cardiopulmonary system. This procedure has two bypass modes. One mode is the V-V mode, which guides venous blood to the oxygenator to be oxygenized while removing carbon dioxide, and then pumps the blood back to the vein. This mode allows partial air exchange before the blood flows back to the lungs. The V-V mode is suitable in cases with simple lung dysfunction and no risk of cardiac arrest. The other mode, the V-A mode, guides venous blood to the oxygenator while removing carbon dioxide, and then pumps the blood back to the artery. The V-A mode can simultaneously support heart and lung functions, and is suitable in cases of heart failure and severe lung failure where heart arrest may occur. The patient in the present study had combined

heart and lung failure accompanied by severe arrhythmia. Therefore, the V-A mode was applied. Extracorporeal membrane oxygenation was applied to patients with FM who have severe arrhythmia or/and poor heart function. Delayed application of ECMO among children with ASS might affect their ultimate treatment outcomes (4). Therefore, evaluation of the circulation status is required among these children, and physicians need to decide whether ECMO is needed. Application of ECMO is reasonable for children with severe arrhythmia, terminal organ failure, or circulatory system failure because of the rapid progression of FM, poor outcomes associated with routine therapy, and low risk of short-term ECMO (3).

Though the patient had significantly improved cardiac systolic function after 3 days of ECMO support, third-degree AV block was continuously present. A temporary pacemaker was placed because prolonged use of ECMO may cause complications such as bleeding, infection, and kidney damage (7). Further observation of his heart automaticity and conduction recovery was conducted. However, 2 weeks later, the ECG still showed third-degree AV block, which indicated that recovery of the cardiac conduction system was suboptimal. A permanent pacemaker was then placed.

Fulminant myocarditis might affect cardiomyocytes and cardiac autorhythmic cells, causing decreased cardiac systolic function and arrhythmia, followed by cardiac dysfunction, cardiogenic shock, and ASS. In the present case, the pacemaker was easily placed under ECMO support and the outcome was fair. Among children with FM and simultaneous complete AV block, treatment using isoprenaline is suboptimal, and the corresponding drug toxicity may further aggravate cardiac damage and cause severe arrhythmia such as ventricular tachycardia and ventricular fibrillation (8). Therefore, an artificial pacemaker might be safer and more effective.

In summary, FM is severe and aggressive. ECMO can provide effective support for children with reversible cardiopulmonary failure. Evaluation of the timing of ECMO is important for the success of ECMO. After cardiac systolic function recovers, an artificial pacemaker can be used to treat slow arrhythmia.

Informed Consent: Written informed consent was obtained from patients' parents who participated in this study.

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