

## Child with Fulminant Myocarditis Survived by ECMO Support — Report of a Child Case —

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**A 6-year-old girl had cold-like symptoms. Administration of antibiotics did not improve the symptoms, and the patient had chronic chest pain. Electrocardiogram (ECG) demonstrated ventricular tachycardia (VT) and cardiac enzyme levels were increased. Mexiletine and olprinone were continuously administered, but slow VT and III° A-V block repeatedly occurred. Pulse therapy using methyl prednisolone was performed, but hemodynamics did not improve. Ejection fraction (EF) decreased to 20%, and metabolic acidosis occurred. Extra corporeal membrane oxygenation (ECMO) was applied 24 hours after admission to the intensive care unit (ICU). To apply ECMO, a median sternotomy was performed. An in-flow cannula (15 Fr) was inserted into the ascending aorta and an out-flow cannula (19 Fr) was inserted into the right atrium. After returning to the ICU, blood pressure (BP) were stable, and urine volume was maintained at about 100 ml/h. Methyl prednisolone and  $\gamma$ -globulin were administered during circulatory assisted period. About 24 hours later, sinus rhythm was obtained, and weaning was started after improvement of the EF. BP was maintained at 100 mmHg with low dose catecholamin, which was weaned off 42 hours after commencement. Hemodynamics after this remained stable. EF improved to 54.2%. An ECG demonstrated right bundle branch block (RBBB) at the sinus rhythm. Severe inflammatory changes were pathologically observed, and we diagnosed myocarditis. The patient was discharged from the hospital on 43 days post admission, and currently attends school. (*Ann Thorac Cardiovasc Surg* 2007; 13: 60–4)**

**Key words:** extra corporeal membrane oxygenation, fulminant myocarditis

### Introduction

The clinical course of fulminant myocarditis is rapid. Chemotherapy or intraaortic balloon pumping (IABP) application is not always useful for the treatment of cardiogenic shock, and the survival rate was 55.7% in the 52 patients reported in Japan.<sup>1)</sup> Recently, adult patients with fulminant myocarditis who survived by percutaneous cardiopulmonary bypass (PCPS) formation have been re-

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ported. In this study, we applied extra-corporeal membrane oxygenation (ECMO) to a child with fulminant myocarditis under thoracotomy, and the patient survived.

### Case Report

A 6-year-old girl had cold-like symptoms, and consulted a local physician on October 5, 2004. Administration of antibiotics did not improve the symptoms, and the patient had developed chronic chest pain, and reconsulted the physician on October 7, 2004. Since electrocardiogram (ECG) demonstrated ventricular tachycardia (VT), the patient was referred to our hospital the same day.

There was nothing of note in the family history. Normal parturition. Exanthem subitum at the age of 1 year.

**Table 1. Hematological data on admission**

WBC	5,600/mm <sup>2</sup>	Cr	0.55 mg/dl
RBC	539×10 <sup>4</sup> /mm <sup>2</sup>	BUN	17.7 mg/dl
Hb	14.5 mg/dl	Na	135 mmol/l
PLT	29.8×10 <sup>4</sup> /mm <sup>2</sup>	K	4.8 mmol/l
GOT	252 IU/l	Cl	103 mmol/l
GPT	34 IU/l	CRP	1.97 mg/dl
LDH	682 IU/l	Trop I	50 ng/ml
CK	1,937 IU/l	Mb	158 ng/ml
CK-MB	117 IU/l		

WBC, white blood cell count; RBC, red blood cell count; Hb, hemoglobin; PLT, platelet count; GOT, glutamic oxaloacetic transaminase; GPT, glutamic pyruvic transaminase; LDH, lactate dehydrogenase; CK, creatine kinase; MB, myoglobin; Cr, creatinine; BUN, blood urea nitrogen; Na, natrium; K, potassium; Cl, chloride; CRP, C-reactive protein; Trop, troponin; Mb, myoglobin.

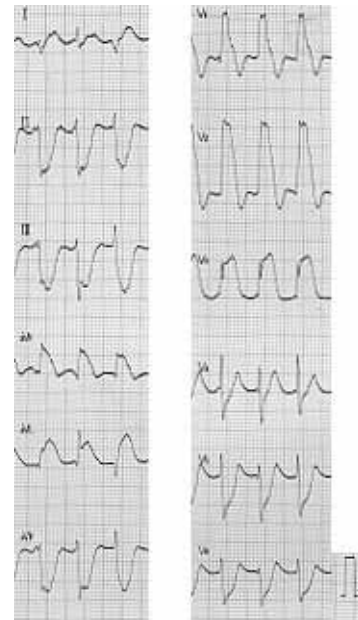
The body weight was 20 kg, height 120 cm, conscious level clear, body temperature (BT) 38.1°C, blood pressure (BP) 130/52, heart rate (HR) 148, respiratory rate 36/min, cardiac murmur (–) and gallop rhythm (+) by thoracic auscultation, radiolucency in the lung field, flat and soft abdominal region, no cervical lymph nodes detected by palpation, and coldness of the upper and lower extremities (+).

Hematologically, a slight increase in the C-reactive protein (CRP) level and marked increases in cardiac enzyme levels were observed (Table 1). On the plain chest X-P (Fig. 1), the cardiothoracic ratio (CTR) was 52.1%, and the lung field was radiolucent without congestion or retention of pleural effusion. ECG demonstrated non-specific ST changes (Fig. 2). Ultrasound cardiogram (UCG) demonstrated that the diameter of the left ventricle (LV) was 32.8 mm at the end of diastole, and the ejection fraction (EF) was 62.3%.

The VT wave pattern monitored by ECG remained unchanged after admission to the intensive care unit (ICU). Although mexiletine (0.6 mg/kg/h) and olprinone (0.1 µg/kg/h) were continuously administered, slow VT and III° A-V block repeatedly occurred, and the systolic BP was slightly low (80–90 mmHg), sometimes decreasing to 60–70 mmHg. Under such conditions, the amount of urine decreased to 10 ml/h, and responses to furosemide, which was occasionally administered, were hardly observed. Pulse therapy using methyl prednisolone (30 mg/kg/d) was performed. Back-up by insertion of ventricle-ventricle-inhibit (VVI) pacing was performed under fluoroscopic guidance 16 hours after admission to the ICU, but hemo-



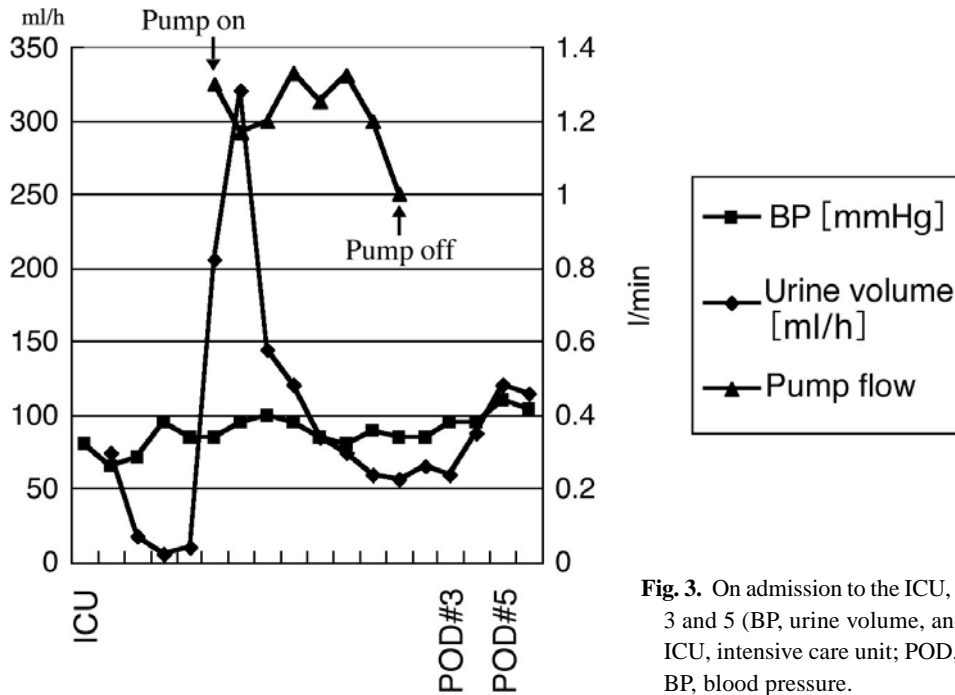
**Fig. 1.** Chest X-P on admission.



**Fig. 2.** Electrocardiogram on admission.

dynamics were not improved. Hematologically, glutamic oxaloacetic transaminase (GOT) increased to 2,507 IU/l, glutamic pyruvic transaminase (GPT) 1,870 IU/l, creatine kinase (CK) 2,738 IU/l, CK-myoglobin (MB) 163 IU/l, and creatinine (Cr) 1.42 mg/dl. The EF decreased to 20%, and metabolic acidosis occurred by aggravation of congestive heart failure based on blood gas data. ECMO was applied 24 hours after admission to the ICU.

To apply ECMO, a median sternotomy was performed, about 50 ml serous pericardial fluid was observed after



**Fig. 3.** On admission to the ICU, postoperative days 3 and 5 (BP, urine volume, and pump flow). ICU, intensive care unit; POD, preoperative day; BP, blood pressure.

pericardiectomy.

A pump (Biomedicus BP50, Medtronic Inc., Minneapolis, MN, USA) and an artificial lung (Minimax, Medtronic Inc., Minneapolis, MN, USA) were used. Blood circulation was performed from a 15-Fr tube (OUKN-LC-6.0, TOYOBO Co., Ltd., Tokyo, Japan) inserted into the ascending aorta to a 19-Fr tube inserted into the right atrium. All devices were heparin-coated. The priming volume was 380 ml, and anti-coagulation therapy with heparin was performed at an activated clotting time (ACT) of 150–200 sec. The initial rate of assisted circulation was 1.5 l/min, which elevated BP to 100 mmHg.

After returning to the ICU, the BP was stable at 90–100 mmHg, and the urine volume was maintained at about 100 ml/h (Fig. 3). Pulse therapy using prednisolone (30 mg/kg/d) and administration of  $\gamma$ -globulin (200 mg/kg/d) was performed during the circulatory assisted period. About 24 hours after the start of assisted circulation, sinus rhythm was obtained, and weaning was started by improvement of the EF. Since BP was reduced to 60 mmHg by the on-off test during surgery,  $3\gamma$  dopamine,  $3\gamma$  dobutamine, and  $0.02\gamma$  noradrenaline were administered. BP was maintained at 100 mmHg, facilitating the removal of assisted circulation 42 hours after commencing it. Hemodynamics after the removal of assisted circulation remained stable, and the CK-MB improved from 163 IU/l at the peak immediately before the start of VVI pac-

ing. GOT, GPT, and Cr also improved to 25 IU/l, 43 IU/l, and 0.52 mg/dl, respectively. No significant lesion was detected in the coronary artery by left ventriculography performed on disease day 35, and the left ventricular function was maintained. UCG demonstrated that the EF improved to 54.2%, and the left ventricle at the end of diastole was slightly larger (diameter, 3.62 cm) than normal.

ECG demonstrated right bundle branch block (RBBB) at the sinus rhythm. Since severe inflammatory changes were pathologically observed in the sample collected from the right atrium wall at the time of ECMO fixation, the disease was definitely diagnosed as myocarditis. No causal viruses were detected in the right atrium wall sampled during surgery. The patient was discharged from the hospital on disease day 43, and currently attends school.

## Discussion

Myocarditis is defined as infiltration of inflammatory cells into the myocardial interstitium and disorder of the surrounding myocardial cells. Fulminant myocarditis rapidly occurs, and causes pump failure or lethal arrhythmia, sometimes leading to death by cardiogenic shock.<sup>2)</sup> In our patient, since rapid changes in hemodynamics and ventricular arrhythmia were observed after admission, we suspected that the disease was fulminant myocarditis, and started chemotherapy in the early stage. Pathological ex-

amination of the right atrium wall sampled during surgery revealed infiltration of inflammatory cells, such as lymph cells and monocytes, diffuse destruction of myocardium, and hypertrophy of the endocardium, and the disease was diagnosed as fulminant myocarditis. The incidence of myocarditis caused by coxsackie A, coxsackie B, echo, influenza A, or influenza B infection is considered high, but separation of such viruses and identification of antigens are difficult, and the positive rate was 28.2%.<sup>3)</sup> In the present study, no viruses were detected in the pericardial fluid or serum collected during surgery. The initial symptoms reported are fever (61.5%), general fatigue (23.1%), and cough (21.2%), which are similar to those of cold, and symptoms in the digestive tract, such as vomiting (15.4%), diarrhea (5.8%), and constipation (3.8%).<sup>4)</sup> The mean period between occurrence and admission was reported to be 4.7 days.<sup>5)</sup> The present patient was admitted to our hospital 3 days after the occurrence of cold-like symptoms and fever. The relatively early admission may have resulted in the successful treatment and discharge from the hospital. It has been reported that the mortality rate in the acute stage within 1 month after occurrence was 5%, the mortality rate including that in the chronic stage was 14%, and about 40% of survivals had sequelae.<sup>6)</sup> In our patient, no dilation in the left ventricle was detected by UCG, and the left ventricular systolic function improved to 54.2%, but myocardial scintigraphy demonstrated ischemic changes in the septum, anterior wall, and cardiac apex regions. A disease course similar to that of dilative cardiomyopathy is observed in some patients during a long-term follow-up observation period, and heart transplantation is sometimes required following the acute stage. Therefore, it is necessary to perform regular follow-up observations.

Methyl prednisolone pulse therapy,  $\gamma$ -globulin therapy, and immuno-suppressive and modulating therapy for the treatment of myocarditis have been reported, but the usefulness of these methods has not been established. Methyl prednisolone pulse therapy is considered effective in suppressing inflammation, but sometimes aggravates infection. When human immuno-globulin preparations are administered to children, there are risks of unknown infection. Immuno-suppressants induce suppression of cytokine production, which is enhanced by simultaneous administration of steroids, but such administration can enhance the induction of side-effects. Since some steroids reduce ovarian function, administration of steroids to girls as in this patient must be carefully performed. The administration of 30 mg/kg/d prednisolone and 200 mg/kg/d

$\gamma$ -globulin between before ECMO application and the time of its removal could suppress inflammatory reactions during the period of ECMO-supported hemodynamics.

There have been a number of studies showing that patients with fulminant myocarditis survived by application of ECMO or PCPS.<sup>7-9)</sup> These treatment methods are applied to patients under such conditions as refractory cardiac rest or lethal arrhythmia, and peripheral circulatory failure by low output syndrome. The severity of peripheral circulatory failure is evaluated using the blood gas analysis, oxygen saturation in mixed venous blood, lactate level, bilirubin/ketone body ratio, hemobiochemical parameters, and amount of urine. In our patient, refractory arrhythmia and a markedly reduced EF were observed. The blood gas data showed acidosis, and increases in cardiac enzyme levels and a decrease in the amount of urine were observed. Therefore, ECMO was applied. The optimal timing of ECMO application has not been established, but it is important to clarify this because rapid aggravation of hemodynamics could occur.

Cannulation is performed in the ascending aorta, internal carotid artery, and femoral artery. In children who are physically small, constriction of the common carotid artery and complications in the central nervous system were reported to occur after removal of ECMO by cannulation in the internal carotid artery.<sup>10)</sup> There has been a report showing that circulatory disorder in the lower limb was caused by cannulation in the femoral artery, and Achilles tendon lengthening was required after prolonged immobility.<sup>11)</sup> In our patient, blood circulation was performed from the ascending aorta to the right atrium by a median sternotomy, taking these risks in physically small children into consideration. The assisted circulation using a 15-Fr tube for the blood in-flow and a 19-Fr tube for the blood out-flow was sufficient for securing the flow volume. Major problems of median sternotomy are hemorrhage and infection. Such problems did not occur in our patient because the assisted circulation could be terminated in a relatively short time (42 hours). In our literature search, the mean duration of assisted circulation by application of ECMO or PCPS was 126 hours (20–216 hours) in patients with fulminant myocarditis who had survived, suggesting that the prognosis strongly depends on the early termination of assisted circulation.

## Conclusion

We encountered a child with fulminant myocarditis who survived by ECMO treatment. Application of ECMO at

an appropriate time is considered useful for assisted circulation in conservative treatment-resistant fulminant myocarditis, and will be an effective treatment method in the future.

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