Experiences With Aggressive Cardiac Rehabilitation in Pediatric Patients Receiving Mechanical Circulatory Supports

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Summary

Although some patients with fulminant myocarditis can be rescued owing to the improvements in mechanical circulatory support therapy, there are few reports providing evidence of cardiac rehabilitation during mechanical circulatory supports, particularly among pediatric patients. We treated two pediatric patients who underwent aggressive cardiac rehabilitation during mechanical support. Five days after the initiation of extracorporeal membrane oxygenation therapy, aggressive cardiac rehabilitation was started in a 10-year-old girl with fulminant myocarditis. After explantation of the device, she was discharged on postoperative day 23. A 6-year-old girl with fulminant myocarditis started receiving cardiac rehabilitation two days after the initiation of an extracorporeal left ventricular assist device, despite having hemiplegia due to a recent broad stroke. She achieved an exercise capacity of supported walking for 280 meters after 127 days of cardiac rehabilitation and then went abroad to undergo heart transplantation when she was in the best physical condition possible. Early initiation of cardiac rehabilitation may be safe and effective for successful pediatric mechanical circulatory support therapy; this acts as a bridge to explantation or heart transplantation. (Int Heart J 2016; 57: 769-772)

Key words: Heart failure, Ventricular assist device, Extracorporeal membrane oxygenation

When patients suffer hemodynamic deterioration because of acute worsening of chronic heart failure (HF), low cardiac output syndrome after open-heart surgery, or fulminant myocarditis, extracorporeal membrane oxygenation (ECMO) therapy is often adopted as a rescue therapy.1,2 In general ECMO therapy for pediatric patients, blood is removed from the right atrium through the internal jugular vein and then returned into the ascending aorta through the internal cervical artery (veno-arterial ECMO).3 ECMO therapy has an advantage in providing strong support for hemodynamics on a short-term basis but has several disadvantages, including bleeding complications because of strong anticoagulation therapy, insufficient unloading of the left ventricle (LV) due to increased afterload, and increased pressure in the left atrium resulting in worsening of congestion.4 Therefore, redundant ECMO support should be avoided to minimize such adverse effects.

Evidence for cardiac rehabilitation has been accumulating with regard to improvement in patient quality of life and prognosis not only among those with chronic HF but also among those with acute HF.5 The current concept of cardiac rehabilitation is comprehensive, and even includes respiratory rehabilitation to prevent atelectasis and exercises to prevent contracture of limbs. However, little has been reported about cardiac rehabilitation during mechanical circulatory support, including ECMO, especially among pediatric patients. Is aggressive rehabilitation recommended in pediatric patients receiving mechanical support? When is the best time to initiate rehabilitation? We report on two pediatric patients receiving mechanical circulatory support who underwent early aggressive cardiac rehabilitation.

Case Report

Case 1: A 10-year-old girl was admitted to our institution because of acute deterioration of hemodynamics due to fulminant myocarditis accompanied by ventricular tachyarrhythmia. Transthoracic echocardiography showed a LV ejection fraction of 18% with diffusely decreased wall motion. The patient underwent emergent implantation of ECMO under mechanical respiratory support on the day of admission.

Early cardiac rehabilitation was started 5 days after initiation of ECMO (day 5, Figure 1). She underwent respiratory rehabilitation to improve atelectasis in addition to range of motion (ROM) exercises on the bed. ROM exercises were performed for all extremities in addition to the rib cage approach exercise for 20 minutes daily. ECMO was explanted on day 7

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owing to normalization of LV systolic function, and mechanical respiration was tapered off on day 13. The ambulation program was begun on day 15, ie, sitting, standing, and walking gradually. Cardiac rehabilitation was continued uneventfully along with a heart rate of approximately 100 bpm at rest and 120 bpm during exercise. Her exercise capacity improved and she could enjoy daily activity comfortably. Myocardial departure enzymes remained within the normal range during the whole postexplantation period. She was discharged ambulatory on day 23.

**Case 2:** A 6-year-old girl underwent ECMO therapy to treat deteriorated hemodynamics due to fulminant myocarditis. An extracorporeal centrifugal type LV assist device (Rota flow) was implanted after 2 weeks of ECMO support because of low recovery of LV contractility. She suffered from left-sided hemiplegia because of a device-related cerebral thrombosis. After 9 months of Rota flow support, she was transferred to our institution to be considered for extracorporeal pulsatile flow LV assist device (EXCOR, Berlin Heart) therapy.

Before transfer to our institution, she remained in bed and received no cardiac rehabilitation due to unstable hemodynamics and concern about bleeding at the cannulation site. She had reduced ROM on the paralyzed side as well as on the healthy side because of spasticity. She could not roll over or sit by herself.

Cardiac rehabilitation was initiated 2 days after EXCOR implantation (day 2, Figure 2). ROM exercise and thermotherapy were initiated at first. ROM exercise was performed for each joint of both lower extremities for 20 minutes daily. Thermotherapy was performed at the left hamstrings for 20 minutes daily. Sitting exercise was started on day 6, and walking exercise was initiated using ankle-foot orthosis on day 27. Estimated blood flow of the device, the degree of pump filling, continuous monitoring of heart rate, and arterial oxygen saturation

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**Figure 1.** Time course of case 1. DOB indicates dobutamine; POD, postoperative day; ECMO, extracorporeal membrane oxygenation; and ROM, range of motion.

**Figure 2.** Time course of case 2. HTx indicates heart transplantation; POD, postoperative day; and ROM, range of motion.
were carefully monitored during exercise, and cardiac rehabilitation was suspended when any unexpected change in these parameters was observed. On day 100, she could walk > 100 meters without resting. She went abroad to undergo heart transplantation on day 129 when her exercise capacity improved up to the level of supported walking for 280 meters.

**Discussion**

**Cannulation procedure during ECMO therapy and cardiac rehabilitation:** Aggressive cardiac rehabilitation is recommended in patients with a ventricular assist device, but few reports have discussed cardiac rehabilitation during ECMO support, particularly in pediatric patients, probably because of unstable hemodynamics and the cannulation system. As for veno-venous ECMO, in which blood is removed from the venous side and pumped back into it, Abrams, et al reported that patients could perform aggressive exercises safely when ECMO was approached from the cervical portion. However, few reports discuss cardiac rehabilitation during veno-arterial ECMO, probably because of anxiety concerning bleeding complication at the cannulation site of the artery during exercise. At our institute, cardiac rehabilitation on the bed can be safely performed even in patients with veno-arterial ECMO, as in case 1, when careful attention is paid to the cannulation site. Estimated blood flow, the degree of pump filling (when we use an extracorporeal pulsatile device), blood pressure, heart rate, and arterial oxygen saturation should be carefully monitored, and the cannulation site should be fixed during cardiac rehabilitation. Changes in these parameters are essential, particularly during aggressive exercise, because device support may not necessarily follow the increasing demand of blood flow during exercise. Exercise should be suspended when unexpected changes in these vital parameters, such as an acute increase in heart rate, are observed. Blinded and excessive rehabilitation must rather result in recurrence of HF. Establishing evidence of cardiac rehabilitation during veno-arterial ECMO should be a future concern.

An adequate cannulation site is essential to facilitate cardiac rehabilitation and improve patient prognosis. When explantation of mechanical support cannot be expected, an immediate switch from a peripheral to a central cannulation system or ventricular assist device would expand the strategy of cardiac rehabilitation. Case 2 consistently enjoyed improved quality of life through aggressive cardiac rehabilitation after switching from ECMO to EXCOR.

**Strategy of cardiac rehabilitation considering therapeutic goal:** A strategy for cardiac rehabilitation should be constructed depending on the therapeutic goal of each patient (Figure 3). When myocardial recovery is expected, aggressive rehabilitation should be considered along with weaning from ECMO, which is a bridge to recovery strategy. Even during respiratory support, ROM exercise and respiratory rehabilitation should be considered soon after initiation of ECMO. Such aggressive rehabilitation would facilitate early ambulation, as shown in case 1. Therefore, early initiation of cardiac rehabilitation soon after the stabilization of hemodynamics should be performed. The concept of early aggressive cardiac rehabilitation we proposed here is different from the conventional one. Conventional rehabilitation targets improvement of exercise capacity by dynamic motion. In contrast, we initiate cardiac rehabilitation from ROM exercise and respiratory rehabilitation at the bed side first targeting improvement of physical function.

After explantation of ECMO, we should pay attention to tachycardia caused by residual HF or hypotension due to up titration of a β-blocker during cardiac rehabilitation. In addition to vital signs such as tachycardia, we should be careful of objective findings, such as the complexion of the patient and the existence of cold extremity, especially in pediatric patients, who are too immature to express their physical condition. When myocardial recovery is unexpected, long-term successive rehabilitation is required along with early switching from ECMO to ventricular assist device support, ie, a bridge to

![Figure 3. Strategy of mechanical support and cardiac rehabilitation in patients with acute HF. HF indicates heart failure; ECMO, extracorporeal membrane oxygenation; VAD, ventricular assist device; and HTx heart transplantation.](image-url)
transplant strategy (Figure 3). Improving physical fitness up to the level of safe heart transplantation is a goal of cardiac rehabilitation during long-term mechanical support. Long-term mechanical supports often are accompanied by device-related complications including bleeding, stroke, and infection, which decrease the quality of life or even survival rate of the patient. Management of these complications also would be another target of long-term cardiac rehabilitation. Consistently, we managed device-related hemiplegia during long-term rehabilitation in case 2. Furthermore, rehabilitation during long-term mechanical support is important, particularly in pediatric patients, because motor problems may persist throughout childhood without sufficient physical training.17

DISCLOSURES

None.

REFERENCES