

Mechanical Circulatory Support for Low Cardiac Output Syndrome Due to Tachyarrhythmia after Cardiac Surgery in a Newborn

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ABSTRACT

The case of a newborn with malignant tachyarrhythmia after heart surgery treated with cardiac extracorporeal membrane oxygenation (ECMO) is presented. After emergency surgery for a large right atrial tumor, the newborn developed supraventricular and ventricular arrhythmias. Despite antiarrhythmic medication, tachyarrhythmia remained, and low cardiac output syndrome developed progressively. Mechanical circulatory support was started, and soon thereafter sinus rhythm recovered. Four days after implantation, mechanical circulatory support was terminated, and the ECMO device was explanted. At discharge from the hospital, the baby had had stable sinus rhythm without any antiarrhythmic medication.

INTRODUCTION

Effective ventilation, stable metabolism, and especially hemodynamic stability are essential after pediatric cardiac surgery. It is not uncommon that neonates after open-heart surgery need mechanical circulatory support due to low cardiac output syndrome, which is mostly related to ventricular myocardial damage or ischemia. Venoarterial extracorporeal membrane oxygenation (ECMO) is the most potent form of mechanical circulatory support.

The unusual case of a newborn with malignant tachyarrhythmias after heart surgery resulting in hemodynamic instability is presented.

CASE REPORT

A male newborn with a large right atrial tumor underwent emergency surgery with resection of the tumor and reconstruction of the free right atrial wall. After surgery, the newborn developed supraventricular tachyarrhythmia just

before discharge from the operating theater. Administration of adenosine IV (0.1 mg/kg) converted arrhythmia in sinus rhythm.

After admission to the intensive care unit, supraventricular tachyarrhythmia reappeared with a heart rate of 270 bpm. Cardioversion could not establish stable sinus rhythm, nor could repeat application of adenosine IV (starting with 0.1 mg/kg and increasing to 0.4 mg/kg). The next step was application of propafenone IV (1 mg/kg), but sinus rhythm could not be restored. Despite the persistence of tachyarrhythmia, elongation of electrocardiographic wave (QRS) duration resulted; additionally, ventricular arrhythmias appeared. Further antiarrhythmic treatment with continuous administration of amiodarone (loading dose 5 mg/kg IV and continuous dosage 1 mg/kg per hour), lidocaine IV (1 mg/kg), and even repeat electric cardioversion were not successful (Figure 1).

The newborn developed progressively low cardiac output syndrome. At this time, under optimized ventilation, volume treatment and increasing need for inotropic support analysis of blood gases revealed a pH of 7.296, partial pressure of carbon dioxide (pCO₂) of 46.1 mmHg, partial pressure of oxygen (pO₂) of 138 mmHg, and base excess of -3.6 mmol/L. Lactate value was 5.3 mg/dL.

Indication for mechanical circulatory support was given. After (single) cannulation of the right atrium and distal ascending aorta, the newborn was connected on cardiac ECMO

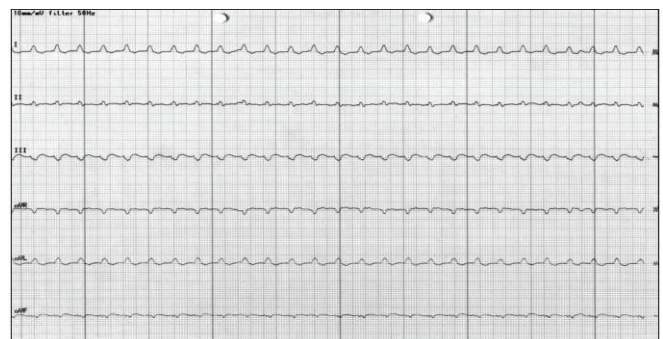


Figure 1. Electrocardiogram of the newborn before implantation of extracorporeal membrane oxygenation (ECMO) support. Heart rate was 270 bpm.

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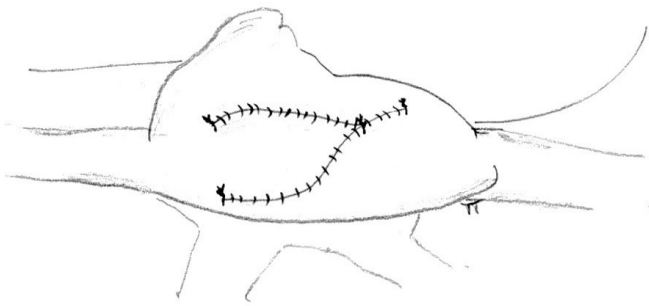


Figure 2. Drawing showing suture lines on the right atrial wall after tumor resection and reconstruction of the free right atrial wall.

(Deltastream, Medos, Stolberg, Germany), and mechanical support started with a flow of 2.5 L/min per m². Activated clotting time was maintained between 160 and 180 seconds. Rhythm was soon after ECMO support mainly sinus rhythm with intermittent supraventricular arrhythmias. After rhythm recovery and hemodynamic stabilization, weaning started with optimized inotropic support, vasodilator treatment, and ventilator support. Four days after implantation, mechanical circulatory support was stopped, and cannulae were explanted following a satisfactory observation period of 1 hour on conventional support.

At discharge from the hospital, the neonate's rhythm was stable sinus rhythm without any antiarrhythmic medication.

DISCUSSION

Arrhythmias after cardiac surgery are common, and most of them were treated well with antiarrhythmic medication. The mechanisms causing arrhythmias are complex and different. For example, Chaturvedi and colleagues found that in patients after surgery for Tetralogy of Fallot, hemodynamic depression necessitating ECMO frequently was precipitated by an arrhythmia; postmortem examination in such cases revealed histological evidence of myocardial infarction [Chaturvedi 2004]. On the other hand, Ündar et al reported on the need for cardiac ECMO because of refractory atrial tachyarrhythmia in hypertrophic cardiomyopathy with pulmonary valve stenosis and atrial septal defect [Ündar 2004]. Probably there was some degree of preexisting structural malformation of myocardium facilitating arrhythmia.

The cause of tachyarrhythmia in the present case remains unclear. There was no ventriculotomy nor clinical evidence of myocardial infarction. Probably alterations on right atrial tissue caused by dense direct contact of the tumor with the atrial wall and direct surgical trauma (suture lines on right atrial wall; Figure 2) resulted in supraventricular arrhythmia. Despite antiarrhythmic medical treatment, hemodynamic depression increased. Two mechanisms seem to be responsible: 1) arrhythmogenic effects of the drugs resulting in persistence of tachyarrhythmia with additional appearance of ventricular arrhythmia and elongation of QRS duration and 2) negative inotropic properties of antiarrhythmic drugs

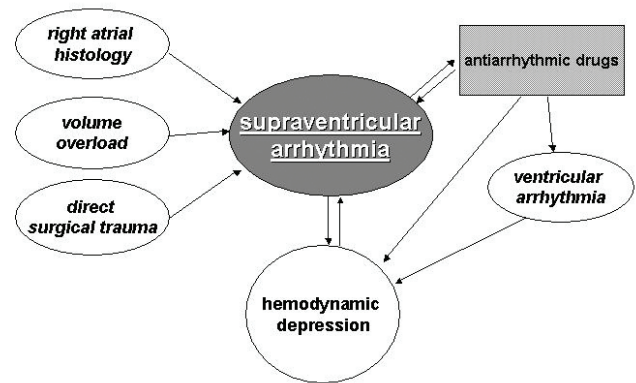


Figure 3. Algorithm of mechanisms responsible for arrhythmia and post-operative low cardiac output syndrome.

themselves. However, tachyarrhythmia resulted in low cardiac output syndrome, and this condition was having a deleterious effect on hemodynamics in the form of a vicious circle (Figure 3).

A breakthrough into the vicious circle was achieved by cardiac ECMO support. The mechanisms of ECMO reversing myocardial dysfunction effectively may be 1) unloading the heart and 2) consecutive decrease of intracardiac pressures, especially in the right atrium and right ventricle.

Although patients were mostly transferred directly from cardiopulmonary bypass to assist device in the operating theater, mechanical circulatory support may also be easily started in the intensive care unit. A reasonable time limit for mechanical circulatory support has not been clearly identified. Weaning from cardiac ECMO is mostly starting after 72 hours of support or at least if it is expected to be successful at this time, but data are still controversial [Chaturvedi 2004; Ündar 2004; Sachweh 2007].

CONCLUSION

In the presented case, cardiac ECMO support was a successful treatment of low cardiac output syndrome after open heart surgery in a newborn. The cause of low cardiac output syndrome by malignant and drug resistant arrhythmias after heart surgery was an unusual indication for ECMO treatment.

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