Monitoring Cardiac Output and Transesophageal Echocardiography during Removal of a Ventricular Assist Device

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A ventricular assist device (VAD) is a mechanical pump used to support heart function and blood flow in patients with poor heart functions. For selected patients who are too ill to wait for a heart transplant or are not eligible for a heart transplant because of age or other medical problems, ventricular assist devices offer life-saving therapy. This device has also become a life-saving approach for patients with acute viral myocarditis. Following the acute illness phase, when heart function has improved, the VAD is carefully removed. It is very important to continuously monitor myocardial functions during this period. In this paper, we present a patient who underwent cardiac output and transesophageal echocardiography monitoring during VAD removal.

Key Words: Anaesthesia, cardiac output, mechanical circulatory support, ventricular assist device

Introduction

Recently the use of mechanical circulatory support systems has gradually gained importance, in the surgical treatment of end-stage heart failure for the purposes of providing a bridge to transplantation, for recovery or permanent support. The use of ventricular assist devices (VADs) for short-term support is aimed to control heart failure in acute cardiogenic shock. VADs can also be used in patients who cannot be weaned off cardiopulmonary bypass after open heart surgery, or in those after severe acute myocardial infarction, and in conditions like acute myocarditis, deteriorated heart function after heart transplantation and overdose of some drugs (blockers, agonists). VAD may be used for temporary support, for several days to weeks, to achieve recovery from cardiac failure in acute myocarditis following inflammatory viral infections. The VAD is then carefully removed when the heart recovers from acute injury and regains normal functions. The use of transesophageal echocardiography (TEE) is valuable during the perioperative management of both implantation and removal of the VAD. TEE is important in terms of providing vital information regarding the diagnosis, allowing early detection of problems associated with implantation, and assessment of functions following the implantation of VAD; it also helps in maintenance during the perioperative period (1, 2). Continuous monitoring of the cardiac output during VAD removal is quite useful (3). In this paper, we presented our experiences regarding the anaesthetic management of a case in whom VAD removal was performed under the guidance of cardiac output and TEE monitoring.

Case Report

A 28-year-old male patient, with a body weight of 70 kg, was admitted to our hospital with chest pain, fatigue and shortness of breath after an upper respiratory tract infection he had 10 days ago. He had significantly impaired myocardial function, decreased global myocardial wall motion and an ejection fraction (EF) of 15% on echocardiography. His blood pressure was 80/50 mmHg and heart rate was 100 beats per minute. As the patient's hemodynamic status worsened during the course of initial evaluation (systolic BP <80mmHg, urine output <30 mL per hour, somnolence), a decision to perform urgent VAD implantation was taken by the Hospital Clinical Council, and patient consent was obtained. The patient who was classified as ASA IV-E, was taken to the operating room without receiving any pre-medication. Following electrocardiogram and pulse-oximetry monitoring, two intravenous lines were established, and an arterial cannula was inserted through the right radial artery. After preoxygenation with 100% oxygen, a slow induction with 75 µg kg⁻¹ of fentanyl, 0.1 mg kg⁻¹ midazolam and 0.6 mg kg⁻¹ rocuronium was performed and then endotracheal intubation was performed. Maintenance of anaesthesia was performed with air/oxygen mixture and fentanyl/midazolam/rocuronium. Thereafter, a central venous catheter was introduced into the right internal jugular vein and the TEE probe was inserted to the oesophagus. The patient received dobutamine, dopamine and milrinone infusions throughout the procedure. For anticoagulation, 50 mg of heparin was used to keep the activated coagulation time between 250-270 seconds. A Levitronix® CentriMag VAD was implanted under total intravenous anaesthesia (TIVA), without using of cardio-pulmonary bypass (off-pump); the inflow cannula was placed in the left ventricular apex and the outflow cannula was inserted into the ascending aorta. The placement of cannulas was confirmed with TEE. After a three-hour surgery, the patient was transferred to the recovery room and extubated without any problem after two hours. On the 16th day of surgery, the removal of VAD was planned upon clinical improvement, ventricular recovery and increase in EF up to 40%. Fentanyl, midazolam and rocuronium were used for induction

Table 1. Intraoperative information about the patient

	At the beginning	Output 1.5 L	Before cross-clamping	Output 0,5 L	After cross-clamping	5 minutes after VAD is turned off	10 minutes after VAD is turned off	After Decannulation	At the end of operation
SAP (mmHg)	130	144	138	142	148	141	120	128	115
DAP (mmHg)	64	75	80	67	68	54	59	54	52
HR (min)	104	110	100	98	98	89	107	109	131
CO (L/min)	5.2	5.8	6.2	7.1	8.6	7.6	8.6	9	11
SVV	15	12	16	7	5	10	9	6	13

VAD: Ventricular assist device, SAP: Systolic arterial pressure, DAP: Diastolic arterial pressure, HR: Heart rate, CO: Cardiac output, SVV: Stroke volume variation

and maintenance of anaesthesia. During the removal of VAD, cardiac output (Vigileo monitor, Edwards Lifesciences, USA) and TEE monitoring was performed along with routine anaesthesia monitoring. While the patient was receiving continuous milrinone infusion, the output was gradually decreased and the VAD was turned off (Table 1). The VAD output was gradually decreased by 500 mL each time and the decision for further decrease was made according to the performance of heart, which was assessed using Vigileo cardiac output monitoring. VAD positioning and ventricular functions were continuously monitored with TEE. After the VAD was completely shut down, decannulation was performed. There were no complications and the patient had adequate urine output and received 2 units of blood transfusions during the three-hour operation. After removal of the VAD, protamine was administered to reverse heparin (50 mg) anticoagulation. The patient was extubated at 2 hours after surgery and discharged with good recovery on postoperative day 7. In the following days, the patient's informed consent was taken in order to report the case.

Discussion

In this case report, the VAD successfully served as a bridge to heart recovery. It is expected that the heart regain its function to maintain the circulation while reducing the output of the VAD. Therefore, monitoring the cardiac output is of importance in the intraoperative assessment of patients during VAD removal. As our patient recovered from the acute injury following myocarditis, when his clinical and laboratory findings improved, every effort was made to ensure maximum patient safety by using cardiac output and TEE monitoring during removal of the VAD.

The VAD takes over the pumping function of the ventricle in part or completely. This helps resting of the heart and allows the healing of a serious but reversible injury. When the ventricular volume is reduced, there is a decrease in myocardial wall tension, pressure and myocardial oxygen consumption. As the assist device takes over the functions of the ventricle, direct effects of the anaesthetics, especially on the ventricle, are not of significance. However, in order for VAD to maintain an adequate flow, it is of importance to prevent the reduction in preload caused by the vasodilator effects of anaesthetics. Development of hypercarbia and increase in pulmonary vascular pressure may decrease pulmonary blood flow. In this situation, use of drugs that reduce hypoxic pulmonary vasoconstriction may cause serious systemic hypoxemia by reducing pulmonary vascular resistance. In this situation, the recovering heart will undertake too much during turning off the device that has taken over ventricular workload (4). Therefore, close monitoring of the momentary changes in hemodynamic status, adequacy of heart functions, oxygenation and fluid management is mandatory during anaesthetic management of these patients. For this purpose, cardiac output monitoring gives a

great advantage. Cardiac output monitoring may not only be performed by introducing a pulmonary artery catheter but may also be performed using less invasive techniques. As pulmonary catheterization has serious complications, it is advantageous to use less invasive techniques in critical patients (5). Following acute injury, it should be monitored during the recovery period that how much of the myocardial functions reversed or permanently lost. In particular, the response of the myocardium to gradual flow reduction should be assessed during VAD removal. Considering that the hemodynamic variables, such as systolic-diastolic blood pressure and heart rate are affected by a variety of factors including anaesthesia, fluid balance, vasoactive support, myocardial performance and venous pressure, continuous monitoring of the cardiac output, together with the assessment of ventricular wall motion using TEE allows optimization of perioperative management. In addition, TEE provides early and reliable information about the location of VAD cannulas and also about problems that arise after their removal (6).

Ventricular assist devices are being used to help patients to gain time while waiting for a heart donor and also for destination therapy in patients with high risk of morbidity. Also, it is implanted to help recovery in cases of myocarditis complicated with acute heart failure. Mirabel et al. (7) reported that mechanical circulatory support was successful in 68% of patients who had resistant circulatory failure due to fulminant myocarditis.

Conclusion

In the case presented here, VAD helped recovery of the ventricular functions of the patient. During the anaesthetic management of this slow and susceptible period, it is quite useful to monitor the cardiac output in a continuous and less invasive fashion without introducing a pulmonary artery catheter and to assess the ventricle functions using continuous TEE monitoring.

Conflict of Interest

No conflict of interest was declared by the authors.

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Informed Consent: Written informed consent was obtained from patients who participated in this case.

Author Contributions

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