

INITIAL CLINICAL RESULTS WITH THE LEVITRONIX CENTRIMAG MECHANICAL ASSIST DEVICE AT THE UNIVERSITY HOSPITAL REBRO ZAGREB

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Summary

Background: The management of end stage heart failure has been revolutionized by the use of mechanical circulatory support. The Levitronix Centrimag ventricular assist device (VAD) is designed for short-term cardiac assistance as a bridge to a more permanent solution to the hemodynamic problem. It has been used as bridge-to-transplantation, bridge-to-bridge, bridge-to-recovery, and bridge-to-decision.

Methods: In the period between September 2008 and November 2009, six patients received mechanical cardiac assistance with the Levitronix Centrimag device at our institution. In one patient, the indication was postcardiotomy cardiogenic shock. In the remaining five patients, the device was implanted electively, due to progressive decompensation of chronic heart failure unresponsive to medical therapy.

Results: The patient having received a biventricular assist device (BIVAD) in the postcardiotomy setting was 65 years of age. His ejection fraction and EuroSCORE were 20 % and 25, respectively. His NT-pro-BNP was 9,428 pg/ml and his pre-implantation lactate was 8.8 mmol/L. The mean age in the group of patients, in whom the VAD was placed due to decompensated severe heart failure (DSHF), was 46 ± 11 years. Their ejection fraction and logistic EuroSCORE were 16 ± 2 % and 28 ± 7 , respectively. The preoperative serum lactate and NT-pro-BNP concentrations were 1.7 ± 0.8 mmol/L and 9577 ± 3674 pg/ml, respectively. Of these, three patients had evidence of end organ dysfunction. The low cardiac output was responsible for acute renal failure, requiring renal replacement therapy in one patient. Neurocognitive dysfunction and renal failure not requiring dialysis was seen in another. The third patient had long standing

primary hepatic insufficiency. A reversal of end organ dysfunction was seen in the former two patients, whereas the hepatic insufficiency was not caused by hemodynamic compromise and was, therefore, not relieved by circulatory support. The single patient, who had suffered from postcardiotomy cardiogenic shock, died shortly after receiving mechanical circulatory support. Three of five patients, in whom Levitronix Centrimag was placed electively, were successfully transplanted. The remaining two died of septic complications. In the cohort of patients, in whom ventricular assistance was placed due to DSHF, two required BIVAD placement, and three left ventricular assist devices (LVAD).

Conclusion: The Levitronix Centrimag VAD is useful in supporting circulation in patients with acute decompensation of congestive heart failure. It may also be used in patients with postcardiotomy shock. It is an imperative for the device to be placed before irreversible organ dysfunction occurs as the aftermath of malperfusion.

Keywords: Levitronix Centrimag; ventricular assist device

INTRODUCTION

The progress in pharmacological therapy has yielded significant improvements in the care of patients with heart failure. This has further been facilitated by the utilization of devices such as cardioverter/defibrillators and cardiac resynchronization therapy [1]. While heart transplantation remains an excellent therapeutic option for patients with terminal heart failure, it is available only to a minority of potential transplant candidates due to a shortage of organ donors [2]. The discrepancy between the number of heart transplantations and the number of patients, who could benefit from this form of therapy, provides a fertile milieu for the development of mechanical assist devices. Ventricular assist devices are now viable options for patients with severe heart failure symptoms as bridge-to-transplantation, bridge-to-decision, bridge-to-recovery, or as destination therapy. Various mechanical assist devices differ widely in the intended recipient patient populations. The Centrimag device (Levitronix, Waltham, MA, USA) is a contemporary adjunct to the available spectrum of short-term mechanical assist devices. It has been utilized in patients with refractory cardiogenic shock for either univentricular or biventricular support [3,4]. It has also been used for the purpose of extracorporeal membrane oxygenation [5]. The Levitronix Centrimag device is a new generation pump that offers hemodynamic support with reduced blood trauma. It does not contain rotating bearings or seals. It is also devoid of flexing valves or diaphragms. When compared to older generation centrifugal pumps, this technical design allows for longer circulatory support. Its dominant feature is a magnetically levitated rotor, which is not in contact with the housing of the device.

PATIENTS AND METHODS

In six patients, short-term mechanical circulatory support was instituted using the Levitronix Centrimag device between September 2008 and November 2009 at the University Hospital Rebro Zagreb. The records of these patients were reviewed. In one patient, the device was implanted in the setting of prolonged postcardiotomy cardiogenic shock. In five patients, the indication for ventricular assistance was decompensated severe heart failure (DSHF). These patients were analyzed separately, since the clinical settings were quite different. The patient in postcardiotomy shock received biventricular assist device placement (BIVAD). Of the five elective patients, who suffered from decompensated severe heart failure, three underwent solely left ventricular assistance, whereas in the remaining two a BIVAD was placed.

Technical considerations

The components of the Centrimag system include a centrifugal blood pump, a motor, a console and a flow probe. The magnetic force, generated by the motors, levitates the impeller in the pump housing in addition to creating the torque that translates into unidirectional flow out the device. The priming volume is 31 ml.

Implantation technique

The device was inserted through a median sternotomy in all patients. In three patients, the Centrimag was implanted for biventricular support, and in the remaining three patients, only the left ventricle was assisted. In three patients, the device was implanted with the use of cardiopulmonary bypass (CPB). The decompression of the heart made the placement of the left atrial and pulmonary artery cannulae simpler in those cases. In the remaining three patients, the Centrimag was implanted without CPB. All patients received a bolus dose of heparin, in order to achieve an activated clotting time greater than 450 seconds prior to the implantation. Antifibrinolytic therapy with tranexamic acid was administered to every patient. All cannulae were placed through two 2/0 Prolene purse-string sutures, reinforced with Teflon pledgets. The sizes of individual cannulae were tailored to the patient body surface area. Intraoperatively, heparin was fully reversed with protamine after the ventricular assistance had commenced.

Postoperative management

Anticoagulation with intravenous heparin was started 12-24 hours after the implantation of the Centrimag, provided that the chest tube output was minimal. The

target ACT was 180 to 200 seconds. Once the patients achieved hemodynamic stability in the intensive care unit, their sedation was discontinued, and subsequently, they followed the standard protocols for weaning off mechanical ventilation.

RESULTS

Six consecutive patients, undergoing Centrimag ventricular assistance, were included into our study. The patient demographic data are presented in Table 1. The patient, who underwent the salvage placement of the Centrimag device in the setting of postpericardiotomy shock, is presented isolated from the remaining five patients, since his clinical scenario differed greatly from the remaining patients. Irreversible organ dysfunction was likely present at the time of the ventricular assist

Table 1. Preoperative patient characteristics

	PCS*	DSHF**
N	1	5
Age (yrs)	65	46±11
Gender (n/%)		
Male	1 (100)	4 (80)
Female	0 (0)	1 (20)
Ejection fraction	20	16 ± 2
EuroSCORE	25	28 ± 7
DDRF	0	1 (20)
Non-DDRF	0	1 (20)
Hepatic failure	0	1 (20)
Neurocognitive dysfunction	0	1 (20)
Inotropes	1 (100)	5 (100)
Sodium ion (mmol/L)	135	127±9
Bilirubin	40	29±22
Alkaline phosphatase (IU/L)	119	178±245
Alanine aminotransferase (IU/L)	143	171±271
Urea (mmol/L)	12	12±5
Creatinine (mmol/L)	109	154±116
Mechanical ventilation	1 (100)	0 (0)
Lactate (mmol/L)	8.8	1.7±0.8

PCS = Postcardiotomy cardiogenic shock

DSHF = Decompensated severe heart failure

DDRF = Dialysis-dependant renal failure

device placement, which was instituted as salvage therapy. The patient was reoperated for bleeding on multiple occasions, due to a severe and resistant coagulopathy, and died within 24 hours of placing the device.

In the cohort of patients with decompensated severe heart failure (n=5), the mean duration of support was 21±23 days. The mean duration of ventilatory support was 14±6 hours. All patients remained in the intensive care unit for the duration of the ventricular assistance. One patient had to be taken back to the operating room 8 days after the implant procedure for bleeding. She was found to have an iatrogenic intercostal artery injury after a pleural tap had been performed. This was unrelated to the placement of the device. There were no permanent strokes.

Three of these five patients suffered from some degree of end-organ dysfunction prior to the placement of the device. In one patient, in whom the renal function recovered after the placement of the Centrimag as an LVAD up to a point where he could be weaned off renal replacement therapy, it was dialysis-dependant renal failure. The neurocognitive function in a second patient also improved upon the institution of Centrimag support. This patient also had non-dialysis-dependant renal failure, which did not show any significant improvement following VAD placement. The hepatic failure, seen in another one of the patients, did not improve with the

Table 2. Perioperative data

	PCS*	DSHF**
N	1	5
Duration of VAD support (days)	1	21±23
Mechanical ventilation (hrs)	20	14±6
Lactate POD 1 (mmol/L)	> 15	1.2±0.4
BIVAD	1 (100)	2 (40)
LVAD	0	3 (60)
Off pump placement	0	3 (60)
Duration of CPB (min)	281	37±20
Cerebrovascular incident	Unknown	0 (0)
DDRF	1 (100)	0 (0)
Bleeding (resterotomy)	1 (100)	1 (20)
Mortality	1 (100)	2 (40)
Bridge to transplantation	0 (0)	3 (60)

VAD = ventricular assist device

BIVAD = biventricular assist device

POD1 = postoperative day 1

CPB = cardiopulmonary bypass

DDRF = Dialysis-dependant renal failure

hemodynamic support. This patient suffered from hemochromatosis and had intrinsic liver failure. He underwent successful heart transplantation after having been supported on the Centrimag for 11 days, and is currently being evaluated for liver transplantation. Three of the five patients with decompensated severe heart failure underwent heart transplantation. There were no deaths following the transplant procedure. The remaining two patients on Centrimag support, who were not transplanted, died. One died after 9 days of Centrimag LVAD support of pulmonary complications that progressed to septic shock. The device was supporting the second patient in this cohort, who died, for 62 days. She was initially found to have a panel reactive antibody (PRA) titer in excess of 90 %. The process of desensitization included the treatment with plasmapheresis, intravenous immunoglobulins and rituximab. Unfortunately, the PRA titer remained high, and the patient ultimately developed a sepsis with subsequent multiple organ failure, which led to death. Detailed perioperative data are presented in Table 2.

DISCUSSION

The challenges of heart transplantation include organ donor shortages; complex immunobiologic responses leading to acute rejection; complications of immunosuppressive treatment; and organ failure due to chronic rejection and allograft vasculopathy [1]. The limitations of transplant surgery have invoked innovations in VAD designs, making devices increasingly more appealing for the management of severe heart failure. The ventricular assist devices vary greatly, in terms of duration of intended support; type of flow augmentation; levels of possible ambulation; hence, they are designed for various patient populations. The Levitronix Centrimag is a short-term VAD, designed as a bridge-to-recovery, bridge-to-decision, bridge-to-bridge or bridge-to-transplantation [4,6]. We have found its versatile design simple to operate and useful in the settings of both uni- or biventricular failure. It has the ability to reverse end-organ dysfunction, provided that the potential for its recovery still exists. The level of ambulation these patients can achieve is limited, but physical therapy is nevertheless critical to the successful management of these patients. We have instituted the Centrimag support as a bridge-to-transplantation in five patients, and as a bridge-to-decision in the scenario of postcardiotomy shock in one patient. Three patients were successfully transplanted and have been discharged home. Our small series illustrates the feasibility of using the concept of short-term mechanical assistance in patients with severe decompensated heart failure as a bridge-to-transplantation, allowing for recovery of end-organ function secondary to malperfusion. This, in turn, allows for the transplant procedure to be performed

in optimal conditions for the patients. The device certainly has the potential to be used in the postcardiotomy failure scenario. It is paramount, however, to institute circulatory support prior to the development of irreversible end-organ damage.

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Sažetak

Rezultati ugradnje Levitronix Centrimag mehaničke potpore srcu u Kliničkom bolničkom centru Zagreb

Uvod: Liječenje terminalne faze srčanog popuštanja je revolucionarizirano uvođenjem mehaničke potpore srcu. Levitronix Centrimag je uređaj dizajniran u svrhu kratkoročne hemodinamske potpore prije nego što trajnije rješenje cirkulatornog problema postane moguće. Do sad se primijenjivao kao podrška srcu do transplantacije srca, do oporavka srčane funkcije ili do ugradnje trajnijeg oblika mehaničke potpore srcu.

Metode: U periodu između rujna 2008 i studenog 2009 Levitronix Centrimag je u našoj ustanovi ugrađen u 6 bolesnika. U jednog bolesnika radilo se o postkardiotomijskom sindromu niskog minutnog volumena. U preostalih pet bolesnika ovaj je oblik mehaničke potpore srcu ugrađen elektivno radi progresivnog kliničkog pogoršanja bolesnika u terminalnoj fazi srčanog popuštanja koje je postalo rezistentno na konzervativnu terapiju.

Rezultati: Bolesnik u kojeg je indikacija za mehaničkom potporom srcu bila postavljena hitno u postkardiotomijskom srčanom popuštanju bio je 65 godina star. Imao je ejeckijsku frakciju od 20% dok mu je logistički EuroSCORE bio 25. Prijeoperacijski NT-pro-BNP bio je 9428 pg/ml dok su serumске vrijednosti laktata prije implantacije Centrimaga bile 8.8 mmol/L. Prosječna dob u skupini bolesnika u kojih je indikacija za mehaničku potporu srcu bila progresivna dekompenzacija srčane funkcije bila je 46 ± 11 godinu. Navedeni bolesnici su imali prosječnu ejeckijsku frakciju od $16 \pm 2\%$ dok im je logistički EuroSCORE bio 28 ± 7 . Prijeoperacijske vrijednosti serumskog laktata i NT-pro-BNP bile su 1.7 ± 0.8 mmol/L i 9577 ± 3674 pg/ml. U troje bolesnika bila je evidentna kompromitacija funkcije nekog od ostalih organskih sustava. U jednog bolesnika se radilo o akutnom renalnom zatajenju ovisnog o hemodijalizi, u drugog o neurokognitivnoj disfunkciji praćenog sa bubrežnim zatajenjem ali bez potrebe za dijalizom. U trećeg bolesnika radilo se o primarnoj hepatalnoj insuficijenciji. U prva dva bolesnika došlo je do poboljšanja organskih funkcija nakon uspostave mehaničke potpore srcu, dok u trećeg bolesnika nije došlo do promjene hepatalne funkcije budući da ista nije bila uzrokovana malperfuzijom. Bolesnik u kojeg je mehanička potpora srcu stavljena zbog postkardiotomijskog kardiogenog šoka je umro. Troje od pet bolesnika kod kojih je Levitronix Centrimag ugrađen radi dekompenzacije kroničnog zatajenja srca su uspješno transplantirani. Preostalo dvoje bolesnika je umrlo od septičnih komplikacija. U kohorti bolesnika u kojoj je mehanička potpora srcu ugrađena elektivno, dvoje bolesnika je zahtijevalo potporu oba ventrikula dok je u troje ugrađena potpora samo lijevom.

Zaključak: Levitronix Centrimag pruža efikasnu hemodinamsku potporu bolesnicima sa kompromitiranom srčanom funkcijom. Neophodno je započeti sa mehaničkom potporom srcu prije nego što se pojave ireverzibilne disfunkcije ostalih organskih sustava.

Ključne riječi: Levitronix Centrimag; mehanička potpora srcu