Mechanical circulatory support towards the permanent implantation

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Abstract

Experience on wearable LVAS Novacor support accumulated since the first implantation in March 1993, includes in November 1995, seven cases (six male, one female, mean age 34) of cardiogenic shock, unresponsive to optimal medical management referred for urgent transplantation. Post-implantation period was free of any major incident in all but one, allowing transplantation in five, on an elective basis, and prolongation of the waiting period, at home in two. This experience suggests that a major breakthrough in the technology of mechanical support has been achieved: patients awaiting transplantation can be discharged home, which is both the result and an contributing factor of a satisfactory quality of life. This improvement allows speculations on coming studies on permanent implantation of the wearable LVAS Novacor, as an alternative therapy to cardiac transplantation. © 1997 Elsevier Science B.V.

1. Introduction

Permanent implantation of a mechanical circulatory support system remains despite major advances in the pharmacological treatment of cardiac failure and developments of cardiac transplantation, an attractive approach in the management of end stage cardiac failure. For years, this approach has suffered from the extremely negative impact of the Jarvik experience initiated by W. De Vries, at Salt Lake City: the few patients who received a Jarvik pneumatically driven heart tragically demonstrated in the same time both the unacceptable rate of complications, directly related to the prosthesis and the questionable quality of life.

Since this first unsuccessful attempt, technology has been dramatically improved making available in 1993 the wearable left ventricular assist device. In the mean time, the need for right ventricular support in patients supported by a left ventricular assist system has appeared less necessary than expected, leading to a major simplification of the procedure of mechanical support of a failing heart. Experience accumulated throughout the world in the management of patients referred for mechanical bridge to cardiac transplantation, in cardiogenic shock, allows evaluation of the wearable LVAS as an alternative to transplantation in patients in cardiac failure. This bridge experience allows answers to the basic questions: is the technology ready for an alternative to transplantation in term of safety, reliability? What is the risk related to the device, in term of infection and thrombo-embolic complications? What is the quality of life offered to the patient when living home?

2. Clinical material

Since March 17, 1993, date of the first implantation of a wearable Novacor LVAS, to November 1st, 1995, seven patients in cardiogenic shock, unresponsive to optimal medical treatment have received a wearable LVAS Novacor as a bridge to transplantation. The pump was a N100 A in the very first case. The six other patients received a N100 PC Novacor. These patients have been highly selected [1] among a population re-
ferred, in the same time frame, for urgent cardiac transplantation and/or mechanical bridge \((n = 37)\): 13 presented some type of contra-indication for mechanical support and/or transplant [1], patients were treated with an external system including a centrifugal pump \((n = 6)\) or a pneumatically driven extracorporeal pump \((n = 11)\) (Nippon-Zeon system).

The characteristics of the seven patients selected for wearable LVAS implantation are as follows: six male, one female, mean age = 34 years (range 21–45). Cause of shock was an acute idiopathic cardiomyopathy in all but one who suffered from a toxic myopathy. Implantation occurred after 5.7 days (2–14) of intensive pharmacological support, because of the lack of improvement of the cardio-circulatory condition. At time of the decision, the main hemodynamical parameters were as follows: systolic aortic pressure: \(88 \pm 7\) mmHg; cardiac index: \(1.7 \pm 0.4\) l/min/m\(^2\); range: 1.2–2.1; mean pulmonary arterial pressure: \(337 \pm 4\) mmHg; capillary wedged pressure: \(24.4 \pm 5\) mmHg; right atrial pressure \(21 \pm 5\) mmHg. Organ function was rapidly deteriorations, evidenced by anuria in three.

Every patient was operated upon according to the protocol previously published [2]. The evolution, favorable in every patient, can be analyzed.

3. Clinical evolution

Every patients could be weaned off IV drug within a period of 8 days. Free mobilization around the bed, in ICU, was achieved in all, before eleven days (range 8–15). Discharge off ICU occurred after 14 days. The patients were transferred to he regular ward, and submitted to an active physical rehabilitation program. In the mean time, confidence into the system was enhanced by a progressive training to a self control of the driver, charger and batteries, by temporary episodes of visits outside the hospital. Every patient become fully ambulatory inside the hospital. Every patient was proposed for being sent home: for reasons related to the living conditions, the first four patients were maintained hospitalized and were allowed to free ambulation, in and out the hospital, until transplantation. The last three patients were sent home, in a place located within a 2-h driving time distance. They lived with their relatives, as before implantation of the Novacor, taking care themselves of the daily wound dressing. They came back to the hospital once a week for 1 day to allow complete clinical examination, blood coagulation testing, and various tests such as transthoracic echocardiography, transcranial ultrasound echography (weekly), isotopic ventricular ejection fraction measurements, stress testing on a treadmill (monthly). The transplantation was performed after 100 days (52–169), as an elective procedure. Two patients were still on device, on November 1st 1995, after 200 and 51 days. The outcome of the transplantation was favorable in all. One patient died after 3 months, because of infectious complications (Aspergillus pulmonary).

4. Hemodynamical evolution

Rapid improvement during immediate post-operative period in observed in every patient. As inotropic support was progressively reduced over a period of 5–7 days, cardiac index remained stable, associated to a low left ventricular preload, progressive normalization of right atrial pressure. This profile was similar in every patient but one (toxic cardiomyopathy), in whom right ventricular dysfunction remained severe (echocardiographic right ventricular ejection fraction stable, below 20%) (Table 1). During the period of chronic support, hemodynamics was remarkably steady without any pharmacological support, except in the patient with persistent RV failure, who required diuretics.

5. Complications

Three groups of complications have been observed.

1. Effusion, both intrapericardial and in the pump pocket. Two episodes of tamponade, significant hemodynamically (decrease in stroke volume) occurred in two patients at day 13 and day 10. The episode resolved, after surgical drainage under local anesthesia. Seven episodes of pocket effusion occurred in six patients, always early in the evolution (from day 8–27). They were treated by surgical drainage, in five.

2. Septic complications: isolated fever without any positive culture was observed in three patients, resolving under IV anti-staphylococcic antibioticotherapy. In one patient, a positive blood culture (Acinortobacter) was observed, successfully treated. Pocket infection was observed in two cases after 19 days and 27 days.

Table 1

<table>
<thead>
<tr>
<th>Haemodynamic changes, following, LVAS Novacor implantation</th>
<th>Day 0 pre CPB</th>
<th>Day 7 post implant</th>
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<tbody>
<tr>
<td>Mean RAP mmHg</td>
<td>18 ± 5</td>
<td>9 ± 4</td>
</tr>
<tr>
<td>Mean PAP mmHg</td>
<td>19 ± 7</td>
<td>23 ± 17</td>
</tr>
<tr>
<td>Mean PCWP mmHg</td>
<td>26 ± 9</td>
<td>8 ± 5</td>
</tr>
<tr>
<td>Mean AoP mmHg</td>
<td>71 ± 8</td>
<td>102 ± 22</td>
</tr>
<tr>
<td>Stroke volume (ml)</td>
<td>53 ± 11</td>
<td>53 ± 9</td>
</tr>
<tr>
<td>Rate (bpm)</td>
<td>88 ± 15</td>
<td>107 ± 20</td>
</tr>
<tr>
<td>Pump rate (bpm)</td>
<td>88 ± 13</td>
<td>107 ± 20</td>
</tr>
</tbody>
</table>

Abbreviations: pre-CPB, last measurement before cardiopulmonary bypass; RAP, right atrial pressure; PAP, pulmonary arterial pressure; PCWP, capillary wedge pressure; AoP, aortic pressure.
requiring temporary local irrigation. Besides these minor episodes, one major complication occurred: inflow valve endocarditis, due to aspergillus, leading to inflow obstruction. Both valve conduits were changed via two small incisions. The patient condition immediately improved, both hemodynamically and on the mycotic point of view. Recurrence of *Aspergillus* infection occurred despite prolonged encapsulated Amphotericin B IV therapy. 3 months post-transplantation.

3. Thrombo-embolism: one patient only presented embolic complications: a first one at day 22, minor (1 min episode of aphasia), a second one, major at day 156 (seizure, followed by coma, related to vertebral artery embolism). Each time, the episode occurred as atrial fibrillation spontaneously resolved into sinus rhythm. The last episode was followed by a progressive recovery of the cerebral function: on November 1st, the patient is still at the rehabilitation center, improving, again fully self ambulatory.

6. Comments

The initial experience with the wearable LVAS Novacor allows some comments both on the bridge strategy and the permanent implantation. The system offers during the period of mechanical bridge, a quality of life which is by far quite superior to what we were used to observe with external, pneumatically driven ventricles. In addition, the ultimate goal of a bridge system, which is to allow safe and comfortable waiting time until an elective transplantation has been reached: rate of infection, thrombo embolic complications, is minimal, as reliability of the system is fully satisfactory. These two observations lead to conclude that, as far as the patient selection and timing [3] are optimal, wearable LVAS Novacor offers a quite acceptable solution to the problems related to the lack of immediate availability of grafts for urgent patients.

This preliminary experience also suggests that time has come for discussion of a permanent implantation of a wearable assist device in patients in cardiac failure as an alternative to cardiac transplantation. The shortage of organs and the increasing number of patients proposed for transplantation is leading in our department as in other transplant centers to an increasing waiting time on the list and increased rate of death prior to the transplantation. The same organ shortage leads to more strict criteria for listing, with a major consequence, for patients, with relative contra-indications such as borderline age, associated problems (hyperlipemia and diabetes); the lack of any chance to be selected for transplantation. For these two categories of cardiac failure cases, the good transplantation candidates and the non-transplantable candidates, wearable implanted LVAS should allow a prolonged survival with an acceptable quality of life.

Various approaches to the use of the wearable LVAS as an alternative to transplantation are possible. In the good transplantation candidates, the prolongation of the bridge period, in the patients who received early a wearable LVAS as a life saving procedure, as they were admitted in cardiogenic shock. This is the approach followed by our group, since 18 months. A more interesting approach, on a methodological point of view, is the design of a prospective study, to be performed on stable cardiac failure patients, good candidates to transplantation, comparing two different therapeutic approaches: elective implantation of a LVAS Novacor, definitive, vs. transplantation. The end points of the study would be the comparison of survival, quality of life, incidence of complications (thrombo embolic, infection in the Novacor group; acute decompensation as awaiting the transplantation, infection, rejection graft failure rate in the transplantation group) and if possible the cost of patient management. For ethical reasons, cross overs should be allowed: from the mechanical support group to rapid transplantation, in case of device related complication or deteriorated quality of life; from the transplantation group to the mechanical support group in case of deterioration during the waiting period. Also for ethical reasons, the patients with a poor prognosis in term of chances to survive until transplantation should receive priority to be proposed to enter the study. Various indices of severe prognostic such as hyponatriemia, rhythm complications, low adrenergic reserve should help [4].

Evaluation of the implanted wearable LVAS as a permanent support should also be performed on patients with a borderline indication to transplantation, unlikely to be ever transplanted or on patients with contra indications to transplantation. A randomized trial comparing optimal medical therapy and mechanical support efficacy in these stable patients should bring important information. Nevertheless, this study is probably difficult to perform. Analysis of this group of patients shows that age is most often the criteria of the relative contra-indication. Patients above 60-65 years are not, a priori, those in whom post-operative rehabilitation will be the easiest. This comment may not be valid in patients, stable, with optimal medical management in the pre implantation period.

In conclusion, the experience presently accumulated in patients referred in cardiogenic shock, for mechanical bridge to transplantation suggests that technology and clinical management have improved at a point where permanent implantation, electively, on selected patients in stable cardiac failure should be started.
References


