Postcardiotomy assisted circulation with roller pump—early and late results

Dedinje Cardiovascular Institute, Belgrade

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The incidence of postcardiotomy myocardial failure (PMF) requiring mechanical circulatory support beyond IABP is reported to be 0.2% to 1.2%. From Dec. 1989 through Dec. 1995, 18 patients (0.3% of the total pump cases) were supported with roller pump type of LVAD. Assisted flow ranged from 3.5 up to 5 L/min with average support time of 35.5 hours. Six (33.3%) patients died while on LVAD. The causes of additional seven deaths (pts weaned of LVAD) were: myocardial failure (4), stroke (2) and intractable bleeding during removal of the LVAD (1). Overall, five patients (27.8%) were successfully discharged from the hospital. Two out of five long-term survivors died later, 6 months and 4 years postoperatively, both of cardiac causes. The actuarial survival rate of long-term survivors was 60% at 7 years, all of them being in NYHA functional class II. These results have proved efficiency of roller pump driven LVAD for short-term circulatory support in pts with PMF. Results are comparable to so far published data on postcardiotomy support with the same, as well as other types of more versatile and costly devices.

Key words: postcardiotomy assisted circulation, roller pump

INTRODUCTION

Various devices have been used for cardiac support of patients who could not be weaned of the cardiopulmonary bypass (CPB) machine (about 1.5% of the 400000 pts who undergo cardiac operations in U.S.A. each year). The first and perhaps still the most frequently used technique is merely prolongation of CPB till the heart eventually recovers. The length of time that this form of support can be maintained without irreversible detrimental effects to other organs is limited. For that reason attention has been converted to other types of devices. Out of the generally available devices, the most frequently used is a centrifugal pump. We have selected a roller pump as the assist device in view of its simplicity, availability and cost effects.

MATERIAL AND METHODS

From December 1989, through December 1995, 5380 cardiac procedures using CPB were performed at our Institute, and 18 patients (0.33%) were placed on roller pump driven LVAD for postcardiotomy cardiac failure. There were 12 (66.7%) male and six female (ages ranging from 48 to 69 years, mean age being 59.7 ± 5.1 years). Bad left ventricle (EF < 30%) was present in 77.8% (14) pts, and the same percent of pts had sustained previous myocardial infarction. These pts were selected for ventricular support based solely on failure to be weaned of CPB, despite optimal pharmacological support and appropriate preload and afterload adjustments. There were no other inclusion or exclusion criteria.

These patients underwent a variety of procedures, with coronary artery bypass grafting (CABG) being the most prevalent operative procedure (61.1%). The operative procedures were as listed:

- CABG — 11 pts (open endarterectomy in 2 pts and closed endarterectomy in 1 pt, redo procedure in 1 pt),
- CABG and mitral valve annuloplasty — 4 pts (with open endarterectomy in 2 pts),
- CABG and aneurysmectomy of left ventricle — 1 pt,
- Left ventricular aneurysmectomy — 1 pt,
- Aortic valve replacement — 1 pt.

Partial left heart bypass has been usually established by cannulating the left atrium via the right superior pulmonary vein for inflow (32-36 Fr. venous cannula, 1 inch = 0.33 mm), and for outflow line we have used 24 Fr. arterial cannula in the ascending aorta or femoral artery (Fig. 1). Depending on inflow cannula size and volume load, we were able to maintain pump flow rate of 3.5 up to 5.0 L/min. Heparin was restarted 4 to 8 hours postoperatively (when the bleeding has ceased), ranging from 250 to 750
units/hr, in order to maintain activated clotting time 1.5 to 2 times normal (180-240 seconds).

Patients were evaluated daily for the possibility to be weaned of the assisted circulation. Weaning and assessment of myocardial recovery were accomplished in the following manner: VAD flows were reduced in decrements of 1.0 L/min while hemodynamics were observed. Patients who maintained adequate hemodynamics (CI greater or equal to 2.0 L/min/m², stable mean arterial pressure of over 70 mm Hg with little or no increase in filling pressures, SVR less than 1500 dynsec/cm², urine output of at least 0.5 ml/kg/min and had evidence of improving ventricular function - better EF by transthoracic echocardiography) with decreasing pump flow, were considered for device removal. After weaning criteria were met, an additional period of observation for up to 6 hours on minimal VAD support (0.5 to 1.0 L/min) was used to identify those pts who might deteriorate after LVAD removal.

RESULTS

The duration of support ranged from 1 to 144 hours, with a mean of 35.5 hours. Six patients died while on LVAD (right heart failure - 3 pts, multi-organ failure - 1 pt, extensive acute myocardial infarction - 2 pts). Statistical analysis revealed that patients able to be weaned of the assist device (12 out of 18 - 66.7 %) have had better preperative EF (30.5±9.3 % vs. 17.5±8.8, p=0.014) and better pump performances over time (ANOVA - univariant analysis for repeated measurements) i.e. higher mean arterial pressure (p<0.001) and lower left atrial pressure (p<0.001). These patients have also had lower central venous pressure (p<0.002), higher CI (p<0.02) and better pump flow (p<0.005)(Table 1). Unfortunately, we have lost additional seven patients who initially recovered their myocardial function enough to be weaned of the roller pump. Four patients died due to the further myocardial deterioration, two due to stroke and one due to intractable bleeding during removal of the device.

Multiple other complications were noticed in our patients: renal failure in 6 pts (33.3%), respiratory insufficiency in 8 pts (44.4%) and neurological complications in 3 pts (16.7%). Although the bleeding period in postoperative period was 3450±1842 ml, we have had only one rethoracotomy due to cardiac tamponade. There were no signs of ongoing infection in our patients, neither signs of mechanical failure of roller pump driven VAD.

Overall, five patients (27.8%) were successfully discharged from the hospital. Two out of five long-term survivors died later, 6 months and 4 years postoperatively, both of cardiac causes. The actuarial survival rate of long-term survivors was 60% at 7 years, all of them being in NYHA functional class II.

DISCUSSION

Nowadays variety of devices for mechanical support of the failing heart are available. These devices are currently used in three broad categories:

1) acute cardiac assist with support < 1 month;
2) for prolonged support lasting from 30 days to 1 year; and
3) permanent support as an alternative to transplantation.

The acute, short-term group includes patients who have myocardial failure due to acute myocardial infarction, acute cardiomyopathy due to myocarditis or other causes, as well as postcardiotomy myocardial deterioration, with a potential likelihood of recovery.

Profound postoperative myocardial failure can be caused by multiple factors including previous myocardial infarction with depressed ventricular dysfunction, active ongoing ischemia or infarction, inadequate myocardial protection and incomplete myocardial revascularization. In addition, vasospasm in native coronary artery, vein graft or internal mammary graft can cause severe cardiac arrhythmias and subsequent myocardial failure. Some patients can have persistent cardiac failure because of the stunned myocardium.

Outcomes of post-cardiotomy support are similar regardless of the device employed and relate primarily to the age of recipient, timing of insertion and completed MI. Survival rates range from 20-40%, complication being bleeding (25%-40%), renal failure (20%-30%), thromboembolism (4%-20%), neurological deficit (5%-20%) and infections (35%-60%), out of which only 5% to 10% are actually device related. In the minority of patients in whom mechanical support was the bridge to transplantation, the overall survival rate was 40% to 60%.

Roller-pump driven system proved to be efficient, reliable, easy to operate and monitor. These results have proved the ability of the roller-pump driven LVAD for successful short-term circulatory support in patients with postcardiotomy heart failure. We can conclude that these results are comparable to so far published data on post-
<table>
<thead>
<tr>
<th>Variable</th>
<th>Weaned</th>
<th>Never weaned</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean arterial pressure - mmHg</td>
<td>75.20 +/- 10.01*</td>
<td>50.50 +/- 8.05*</td>
<td>&lt;0.001</td>
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<td>Left atrial pressure - mmHg</td>
<td>13.80 +/- 1.10*</td>
<td>18.60 +/- 1.80*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Central venous pressure - mmHg</td>
<td>10.05 +/- 1.05</td>
<td>14.08 +/- 1.60</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td>Cardiac index - L/min/m²</td>
<td>2.68 +/- 0.20*</td>
<td>2.01 +/- 0.30*</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>Pump flow - L/min</td>
<td>3.65 +/- 0.33*</td>
<td>2.80 +/- 0.20</td>
<td>&lt;0.005</td>
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*These data were measured 12 hours after assisted circulation was initiated.

Cardiotomy support regarding the same, as well as other types of more versatile and costly devices.

**REZIME**

Incidenca postoperativnog popuštanja miokarda u kardiokhirurgiji koje zahvata mehaničku potporu cirku- ljacije sistemima koji nadvisu mogućnosti intraortne balon pompe, procjenjuje se na 0.2% do 1.2%. Od de- cembra 1989. godine do decembra 1995. godine, 18 pacijenata (0.3% od ukupnog broja operisanih) zahvalo je postoperativnu mehaničku potporu cirku- ljacije. Upotrebljena je roller pumpa koja je ostvarila proširenji asistirani protok od 3.5 do 5.0 litara u minuti, a prošežno trajanje asistirane cirku- ljacije iznosilo je 35.5 sati.

Šest (33.3%) bolnika je umrlo tokom trajanja meha- ničke potpore cirku- ljacije. Od 12 pacijenata koji su us- pešno odvojeni od asistirane cirku- ljacije naknadno je umr- lo još sedam (ponovno popuštanje miokarda - 4, fatalni cerebrovaskularni inzult - 2, iskrivanje kod vadi- jenja sistema - 1). Pet bolesnika (27.8%) je otpušteno kući. U udaljenom praćenju zabeležene su još dve smrti, obe kardijalnog uzroka (nakon 6 meseci, odnosno 4 godine). Aktualna kriva preživljavanja nakon 7 godina iznosi 60%. Svi preveli su u NYHA II klasi.

Ovi rezultati potvrđili su efikasnost roller pumpe kao kratkotrajnog sistema mehaničke potpore cirku- ljacije u postoperativnom popuštanju miokarda nakon kardio- hirurških procedura. Ostvareni rezultati su komparabilni sa do skora publikovanim ostvarenjima uz upotrebu mnogo skupljih i sofističiranih sistema asistirane cirku- ljacije.

**Ključne reči:** asistirana cirku- lacija, kardiokhirurgija, roller pumpa

**BIBLIOGRAPHY**