Dynamic Cardiomyoplasty: Clinical Experience after Seven Years
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Abstract
Since 1993 Dynamic Cardiomyoplasty (CMP) was performed in 23 patients (P) aged between 33 and 68 years. Two P suffered from ischemic and 21 P from dilated cardiomyopathy. Mean preoperative NYHA class was III, LVEF 22%, CI 2.0, LVEDP 22mmHg, PAPsys 44 mmHg, VO2max 15.4 ml/kg/min and LVEDD 69mm. 15 P were in sinus rhythm, 8 had atrial fibrillation. Two P had documented sustained VT, 2 VF with successful reanimation. Chronic stimulation was performed with 6 pulses every second beat. There was only a moderate change of conventionally measured hemodynamics, whereas clinical status improved significantly. Perioperatively one P with ischemic cardiomyopathy died caused by acute myocardial infarction, a second one after 5 days because of VF and one P after 12 days because of a sepsis. 8 late deaths occurred. Three P had a sudden death after 3, 6 and 25 months, 2 P died of heart failure after 1.5 and 14 months and 3 P had a non cardiac cause of death. In 1996 four of ten of our P lived in psychosocial unstable conditions, for instance were alcohol or drug addicts. All cardiac deceased belonged to this risk group. Since then only 2 of 13 P from this risk group were operated and one of them also had a cardiac death. Until now we provided 5 P with ICD and cardiomyostimulator. All of them had episodes of VT or VF in the follow up period. On the other hand we lost 4 P because of sudden death. Our total survival rate amounts to 52% after 7 years. If you only take in account the cardiac deceased the survival rate is 70% and if you exclude the patients, who had a sudden death and were not provided with an ICD, the survival rate would be 87% and probably could be highly improved by combining an ICD with a cardiomyostimulator in every patient.

Key words: arrhythmia, cardiomyoplasty, follow up, ICD, outcome, risk factors.

Several studies have reported a discrepancy between clinical outcome and hemodynamic measurements after dynamic cardiomyoplasty. Whereas clinical improvements according to the New York Heart Association classification were observed in a majority of patients, cardiac output improvement could be demonstrated only in a minority [1, 4, 10, 11, 12, 13]. That is one of the reasons, why most cardiologists do not accept this kind of surgical treatment of heart failure. This article presents our personal experience in patients selection, major risk factors, hemodynamic alterations and clinical outcome during the past seven years.

Material and Methods
In the past seven years we only saw about 50 patients to prove the indications for cardiomyoplasty. 30% of these patients had exclusion criterias. Most of them had no sufficient drug therapy like ACE-inhibitors, digoxin and diuretics. We optimized the therapy, and if the patients did not improve within 6 months, they were candidates for cardiomyoplasty. The other exclusion criterias were: NYHA IV in spite of optimal drug treatment, preoperative dependence on inotrops, biventricular failure, mitral valve regurgitation 3 to 4, frequent sustained, not with drugs treatable ventricular tachycardias, forced vital capacity less then 55% and previous cardiac surgery. One patient had a syringomyelia.

Our indications included patients with heart failure caused by dilated or ischemic cardiomyopathy, who are in NYHA III despite maximal medical therapy at the time of operation. LVEF was less than 35% and VO2max between 10 and 20 ml/kg/min.

Finally we performed dynamic cardiomyoplasty in 23 patients aged between 33 and 68 years, 6 patients were female and 17 patients male. Twenty-one patients suffered from dilated cardiomyopathy and two patients from ischemic cardiomyopathy.
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Mean preoperative NYHA class was III, LVEF 22%, CI 2,0, LVEDP 22mmHg, PAPsys 44 mmHg, VO2max 15,4 ml/kg/min and LVEDD 69mm.(Tab. 1).

Sinus rhythm was found in 15 patients, 8 patients had an atrial fibrillation, 4 of them intermittent. Two patients had documented sustained VT and two patients VF with successful reanimation. Therefore 4 patients had an preoperative indication for an ICD implantation.

The surgical technique we used was the one described by Chachques and colleagues [5]. Dynamic cardiomyoplasty was performed without extracorporal circulation and without concomitant surgery using the left latissimus dorsi muscle. For training of the muscle in the first 20 patients the standard protocol was used, in 3 cases the progressive pulse number protocol [7] was followed. Chronic stimulation was performed with 6 pulses every second beat. The synchronization delay was adjusted under echocardiographic monitoring until aortic flow reached the highest level. In the event that the flow should not differ, burst stimulation started immediately after mitral valve closure.

After the stay in ICU drug therapy was adapted to the new hemodynamic situation. We always gave ACE-inhibitors, digoxine and diuretics and in absence of hypopotassemia low dose spironolactone. Amiodarone was given in existence of atrial fibrillation or nonsustained VT and we tried to give low dose beta-blocker. We gave ACE-inhibitors and beta-blockers as high as arterial pressure allowed us and tried not to reduce the medication during time. Most of the patients were anticoagulated with phenprocumone.

The follow up time ranged from 18 to 65 months. Follow-up examinations, including left and right heart catheterisation, were performed after 6 months, 12 months and every following year. Hemodynamic values were determined with and without muscle stimulation for 15 minutes. 14 patients were in the 2 years follow up.

Results

Perioperatively, one patient with ischemic cardiomyopathy died immediately after the procedure because of acute myocardial infarction, a second one after 5 days due to ventricular fibrillation. One patient died after 12 days as a result of a septic shock after an acute infection of the gall bladder. In the follow up period of 86 months 8 late deaths occurred. Three patients had a sudden death after 3, 6 and 25 months, 2 patients died of heart failure after 1,5 and 14 months and 3 patients had a noncardiac cause of death, two after 17 and one after 22 months (Tab. 2).

Until 1996 40% of our patients lived in psychosocial unstable conditions, for instance were homeless or were alcohol or drug addicts. All cardiac deceased belonged to this risk group. Since then only 2 out of 13 patients belonged to this risk group and one of them also had a cardiac death.

Cardiac output and cardiac index showed a slight increase of 17% from 4,1 to 4,8 and 2,1 to 2,5, respectively. Without stimulation both values stayed at the same level (Fig. 1)

The systolic pulmonary artery pressure and the wedge pressure decreased slightly (Fig. 2).

The left ventricular ejection fraction increased from 23% to 35%. Without myostimulation the ejection fraction decreased but didn’t reach the preoperative values (Fig. 3).

In all patients an evident functional improvement from class III to class I to II was seen. The mean was 1,3 (Fig. 4).

All 5 patients with ICD implantation had episodes of VT or VF postoperatively (Tab. 2).

Discussion

Long-lasting left ventricular dysfunction due to myocardial disease is characterized by a poor prognosis. Despite recent advances, cardiac transplantation cannot provide effective treatment for end-stage heart failure, because of limited donor pool. Although progress in medical therapy has improved survival in these patients, the long-term prognosis is still disappointing. Since 1985 cardiomyoplasty has been applied as permanent biomechanical cardiac support in almost 900 patients affected by chronic heart failure refractory to medical therapy. The technique of cardiomyoplasty has the advantage of using the patients own living tissues and thereby avoiding rejection and related problems. In addition to improved survival a significant functional improvement was found in the majority of the patients [1, 4, 10, 11, 12, 13].

In our patients evident functional improvement was seen from class III to class I to II, with a mean of 1,3. Most disappointing is the fact, that functional improvement did not always imply hemodynamic improvement. In this respect it is well known, that no correlation exists between functional status, exercise capacity and left ventricular function in patients with severe congestive heart failure [6, 7]. In our study ejection fraction in-

<table>
<thead>
<tr>
<th>LVEF</th>
<th>LVEDP</th>
<th>CI</th>
<th>PAP</th>
<th>PCWP</th>
<th>VO2 max</th>
<th>LVEDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>mmHg</td>
<td>l/min/m²</td>
<td>mmHg</td>
<td>mmHg</td>
<td>ml/kg/min</td>
<td>mm</td>
</tr>
<tr>
<td>22,1 ± 9</td>
<td>22,2 ± 11,9</td>
<td>2 ± 0,5</td>
<td>43,7 ± 16,1</td>
<td>21,3 ± 10</td>
<td>15,4 ± 3,8</td>
<td>68,7 ±6</td>
</tr>
</tbody>
</table>
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Table 2. Causes of death.

<table>
<thead>
<tr>
<th>Cause</th>
<th>n</th>
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<tbody>
<tr>
<td>Myocardial infarction</td>
<td>1</td>
</tr>
<tr>
<td>Heart failure</td>
<td>2</td>
</tr>
<tr>
<td>Ventricular fibrillation</td>
<td>2</td>
</tr>
<tr>
<td>Sudden death</td>
<td>2</td>
</tr>
<tr>
<td>Non-cardiac cause</td>
<td>4</td>
</tr>
</tbody>
</table>

creased in the majority of the patients, but no significant changes could be detected in filling pressures. However, there was a tendency of reduction of the systolic pulmonary artery pressure and the wedge pressure. These findings were also reported by Jatene et al [8]. Significant improvement in left ventricular function was observed in patients, whose left ventricular diastolic diameter was below 70 mmHg, whereas no change was detected in patients with a left ventricular diastolic diameter larger than 75 mm.

Because an active systolic assist has been seen inconsistent in spite of an improvement of clinical symptoms, Kass et al evaluated the mechanical effect of cardiomyoplasty by performing serial left ventricular pressure-volume analysis in patients undergoing cardiomyoplasty [9]. The results showed a leftward shift in the end-systolic pressure-volume relationship and a stabilization of the enddiastolic pressure-volume relationship. These data suggests, that cardiomyoplasty can reverse chronic chamber remodeling. They also found a minimal evidence of an acute systolic assist from myostimulation. In our series we investigated hemodynamic effects with and without muscle stimulation for 15 min by left ventricular angiography. Our results showed a slight increase in cardiac output during the assisted period, whereas other groups couldn’t demonstrate an active systolic assistance. Besides the dynamic effect of cardiomyoplasty, experimental investigations confirmed, that the passive muscle wrap, that means “adynamic” cardiomyoplasty, can delay ventricular dilatation [3, 17-19]. The causes of long-term mortality after dynamic cardiomyoplasty can be equally divided into primary ven-

tricular failure and arrhythmic death in all clinical series. In the cardiomyoplasty follow up the incidence of sudden death ranges from 5 to 8% per year. Our data prove that all 5 patients with an ICD had episodes of VT or VF in the follow up period (Tab. 3). On the other hand we lost 4 patients, who were not provided with an ICD, because of sudden death. Our total survival rate amounts to 52% after 7 years. Only considering the cardiac deceased the survival rate is 70% and if the patients, who had a sudden death and were not provided with an ICD were excluded, the survival rate would be 87% and probably could be highly improved by combining an ICD with an cardiomystimulator in every patient (Fig. 5). Therefore, if there were no cost limits, we would recommend the implantation of an ICD in...
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Table 3. Episodes of ventricular tachycardia (VT) and ventricular fibrillation (VF) after ICD-Implantation.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Period</th>
<th>Kind of arrhythmia</th>
<th>Event after ICD Implantation</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td># 1</td>
<td>preoperative</td>
<td>VT</td>
<td>VT</td>
<td>1</td>
</tr>
<tr>
<td># 2</td>
<td>preoperative</td>
<td>VT</td>
<td>VT</td>
<td>6</td>
</tr>
<tr>
<td># 3</td>
<td>preoperative</td>
<td>VF</td>
<td>VT</td>
<td>1</td>
</tr>
<tr>
<td># 4</td>
<td>postoperative</td>
<td>VT</td>
<td>VF</td>
<td>4</td>
</tr>
<tr>
<td># 5</td>
<td>postoperative</td>
<td>VF</td>
<td>VT</td>
<td>4</td>
</tr>
</tbody>
</table>

Our center, along with others, found, that the outcome of patients with ischemic cardiomyopathy and morphological unfavourable coronary disease is not as good as with dilative cardiomyopathy [16]. The patient, who died because of acute myocardial infarction had two infarctions of the anterior wall and three stent-implantations of the LAD. In addition the right coronary artery was occluded. In the angiographic control multiple stenosis of the LAD, not more than 50%, were seen. In the autopsy these stenosis were much higher than assumed on account of the angiographic examination and additionally there was a septal infarction. The second patient with ischemic cardiomyopathy had a complete occlusion of LAD and right coronary artery, the circumflex coronary artery had a stenosis of 50%. He died 14 months postoperatively after several episodes of cardiac decompensation. In the autopsy a marked calcification of most of the myocardium was seen.

Therefore all patients with ischemic cardiomyopathy are examined with stress echocardiography and scintigraphy of the myocardium. If there are coronary stenosis higher than 70% and vital myocardium, we prefer a CABG operation. If there are severe stenosis and only a myocardial scar we recommend a transplantation. In our opinion, the long term results in ischemic patients with cardiomyoplasty are reduced due to progression of coronary disease.

At the beginning of our experience, patients were applied to us, who not only had physical contraindications for transplantation as age, but also psychosocial contraindications. When we updated our data in 1996 it turned out, that all cardiac deceased belonged to this psychosocial risk group. From 1996 we saw unsolved psychosocial problems as a relative contraindication for cardiomyoplasty. Since then only 2 patients from this risk group were operated and one of them also had a cardiac death, so that in our opinion cardiomyoplasty only has good long term results in patients, who have the same psychosocial risk profile as transplant patients.

In conclusion dynamic cardiomyoplasty is still a considerable surgical alternative for the treatment of refractory heart failure, especially for patients who refuse to be transplanted or with contraindications for transplantation.

In spite of the progress concerning surgical technique and postoperative treatment, dynamic cardiomyoplasty remains an investigational procedure. Many studies show an improvement in hemodynamic function in some patients but all the evidence seems to indicate that the main effect of cardiomyoplasty consists in remodeling the ventricular chamber. Additional investigations are necessary first to select those patients, who will have a benefit from the procedure and second to ensure a better protection of the stimulated muscle.

Figure 5. Follow up mortality.

Figure 6. Strategy for ICD implantation, amiodarone therapy and electro-physiological-study (EPS).
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