ENDOVENTRICULAR PERICARDIAL PATCH PLASTY IN THE MANAGEMENT OF LEFT VENTRICULAR ANEURYSMS

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SUMMARY:

Background: Early and late surgical outcomes of endocardial resection and aneurysmectomy repaired with autologous pericardial patch were studied. Methods: We retrospectively studied 105 patients who underwent endoaneurysmmorphy with pericardial patch during the period from June 1993 until June 1999. 104 patients had associated coronary artery lesions and 1 had concomitant mitral valve stenosis. Preoperative, early postoperative results of all patients and late clinical outcome of 102 patients, echocardiography of 43 and hemodynamic controls of 12 patients within a mean follow-up of 42±8 months were analyzed. Results: Mean New York Heart Association Class (NYHA) improved to postoperative 1.2±0.5 from preoperative 2.7±0.4. Mean number of bypass grafts was 2.6±1.1. Left ventricular ejection fraction rate improved to 46.8±8% in the early and 50.2±9% in the late follow-up compared with the preoperative 38.2±9% (p < 0.05). Mean pulmonary artery pressure decreased to 16.3±3.2 mmHg from 22.1±2.3 mmHg (p < 0.05) in the early postoperative period. End-diastolic left ventricular pressure decreased to 11.6±2 mmHg from the preoperative 20.2±4.8 mmHg (p < 0.05) and performance score to 9.2±2 from the preoperative 14.1±2 (p < 0.01). Hospital mortality was 2.8% (3 patients) and no deaths were observed in the late follow-up. Conclusion: Endoaneurysmmorphy with pericardial patch may be an appropriate option in the management of left ventricular aneurysms with acceptable surgical results.

Key Words: Left Ventricular Aneurysms, Endoaneurysmmorphy, Pericardium-Autologous.

INTRODUCTION

For the last four decades, the standard approach to the treatment of left ventricular aneurysm has been to resect the aneurysm wall and close it in a linear fashion. During the past decade, evidence has accumulated that this simple approach may not be the most efficacious in terms of either short term ventricular function or long term survival and quality of life. Attention was then focused on finding new methods of reconstruction to restore left ventricular three-dimensional geometry. These concepts were introduced by Jatene (1), and later modified by Dor (2). Cooley finally presented intracavitary repair or endoaneurysmmorphy (3). This technique retains the aneurysm wall to allow closure over the intracavitary prosthetic patch with remodeling of the left ventricle, providing both excellent hemostasis and support for the patch from the pericardial surface. John et al. (4) and Frore et al. (5) reported the use of
autologous pericardial patch repair instead of the prosthetic material.

We have modified the endoaneurysmorrhaphy technique by using autologous pericardial patch which we believe is easier to manipulate, compliant, readily available, inexpensive, hemostatic and more resistant to infection. In this study, we have presented and discussed the early and late results of this technique.

PATIENTS AND METHODS

The study was approved by the Medical Ethics Committee of the institution on May 24th, 1993, and informed consent was obtained from each patient included in the study.

Patients: During the period from June 1993 until June 1999, 105 patients (85 male and 20 female, mean age: 54.9±8 years) underwent endoaneurysmorrhaphy with pericardial patch plasty due to left ventricular aneurysm; 104 were associated with coronary artery disease and one with mitral valve stenosis.

Eighty-seven patients suffered from angina pectoris and 18 from dyspnea as well as complaints due to congestive heart failure. 20 patients had diabetes mellitus, 43 hypertension and 20 hyperlipidemia as comorbid risk factors.

Mean preoperative NYHA was 2.7±0.4 for the patients.

Preoperative echocardiographic evaluation demonstrated mean ejection fraction as 38.2±9%, fractional shortening as 19.1±5%. Aneurysms were localized apically in all cases; with additional septal involvement in 22, lateral involvement in 17 cases, septal+lateral involvement in 11 cases and inferior involvement in 8 cases.

Preoperative routine catheterization showed that mean left ventricular end-diastolic pressure was 20.2±4.8 mmHg and mean pulmonary artery pressure was 22.1±2.3 mmHg.

Ventricular function was evaluated by the ventricular performance scoring system (6). Left ventriculogram was divided into a total of seven segments: five for the right anterolateral oblique projection (apical, anteroaxial, posteroaxial, postebral and inferior) and two for the left anterior oblique projection (septal and posterolateral). Then the following points were given for each segment and the left ventricular performance score was calculated as the sum of these scores.

- Normal wall motion: 1 point
- Hypokinesia: 2 points
- Akinesia: 3 points
- Dyskinesia: 4 points
- Aneurysm: 5 points

On performance score basis patients had 14.1±2 ventricular score, preoperatively. Preoperative baseline evaluation of the patients is summarized in Table 1.

Operative Technique:

After premedication with diazepam (10 mg I.M.), a radial artery catheter, two peripheral intravenous catheters and a pulmonary artery catheter were inserted.

Hemodynamic parameters: Heart rate, mean arterial pressure, central venous pressure, pulmonary artery pressure (PAP), rectal temperature and arterial blood gases were monitored throughout the procedure.

Anesthesia was induced by fentanyl (35 mcg /kg) and muscle relaxation was established with pancuronium (0.1 mg/kg). The patients were intubated endotracheally and ventilated with 100% oxygen.

Standard median sternotomy incision was used for the exposure of the heart.

The left internal mammary artery (LIMA) was harvested and saphenous vein was prepared, if necessary.

The ascending aorta was cannulated for arterial inflow, and the right atrium for venous return. Moderate hypothermia was induced at 30°C.

Following cross clamping of the aorta, the heart was arrested by using 10-15 cc/kg crystalloid potassium cardioplegia, continued with cold blood cardioplegia every 20 min and finally warm blood cardioplegia was administered before releasing the aortic cross clamp. A longitudinal incision was made over the apex at the thinnest portion of the aneurysm, parallel to the interventricular groove. After the
Table 1: Preoperative baseline evaluation of the patients.

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>AGE</strong></td>
<td>54.9±8.9</td>
</tr>
<tr>
<td><strong>SEX (Male/Female)</strong></td>
<td>85/20</td>
</tr>
<tr>
<td><strong>PRIMARY INDICATION FOR OPERATION</strong></td>
<td></td>
</tr>
<tr>
<td>A) Angina</td>
<td>87</td>
</tr>
<tr>
<td>B) Congestive Heart Failure</td>
<td>18</td>
</tr>
<tr>
<td><strong>LOCALIZATION</strong></td>
<td></td>
</tr>
<tr>
<td>A) Septal</td>
<td></td>
</tr>
<tr>
<td>B) Septal + Lateral</td>
<td></td>
</tr>
<tr>
<td>C) Lateral</td>
<td></td>
</tr>
<tr>
<td>D) Inferior</td>
<td></td>
</tr>
<tr>
<td><strong>CORONARY ARTERY DISEASE</strong></td>
<td></td>
</tr>
<tr>
<td>A) Single Vessel</td>
<td>21</td>
</tr>
<tr>
<td>B) Two-vessel</td>
<td>28</td>
</tr>
<tr>
<td>C) Triple-vessel</td>
<td>34</td>
</tr>
<tr>
<td>D) Multivessel</td>
<td>21</td>
</tr>
<tr>
<td><strong>CONCOMITANT VALVULAR DISEASE</strong></td>
<td></td>
</tr>
<tr>
<td>PREOPERATIVE NYHA</td>
<td>1</td>
</tr>
<tr>
<td>PREOPERATIVE EJECTION FRACTION</td>
<td>2.7±0.4</td>
</tr>
<tr>
<td>PREOPERATIVE END-DIASTOLIC PRESSURE</td>
<td>38.2±9 %</td>
</tr>
<tr>
<td>PREOPERATIVE MEAN PULMONARY ARTERY PRESSURE</td>
<td>26.2±4.8 mmHg</td>
</tr>
<tr>
<td>PREOPERATIVE PERFORMANCE SCORE</td>
<td>14.1±2</td>
</tr>
</tbody>
</table>

NYHA: New York Heart Association Classification

Aneurysmal cavity was opened, any thrombus found was removed. The aneurysm was then dissected until both edges of the ventriculotomy incision had a sufficient exposure up to the transition zone between the more normal, maroon-coloured myocardium and the whitish fibrous area of the scar tissue (Fig. 1A).

Once the extent of the defect was determined, the optimal size and shape of the pericardium needed to restore the normal three-dimensional geometry and volume of the ventricle was decided. An elliptical pericardial patch was tailored to fit the single apical defects, asymmetric elliptical patch for the cases with additional septal, lateral and inferior involvement. The patch was not treated by gluteraldehyde.

Starting from the septum, the pericardial patch was secured by 3-0 continuous polypropylene sutures into the firm fibrous tissue adjacent to the transition zone, then sewn endocavitarily on the lateral and inferior walls.

![Fig. 1: Exposure of the defect to be repaired (A). Pericardial patch is tailored to fit the defect (B).](image)
with running stitches closer on the patch side and wider on the ventricular side (1X distance from
the patch and 1.5-2 X distance from the ventricular wall) for remodelling of the ventricular cavity (Fig. 1B).

In 2 cases, the pericardial patch was tightened by a dacron patch, with pericardium on the
ventricular side since the pericardium was too thin and damaged at the suture line. Ventricular
walls were trimmed in appropriate cases and finally the ventriculotomy was repaired by using
continuous 3-0 continuous polypropylene sutures.

Felt strips were used to buttress the suture line, if the fibrous tissue was not strong enough.
Air was evacuated from the left ventricle before the warm blood cardioplegia was administered
and the aortic cross clamp was released.

Mitrail valve replacement was performed via ventriculotomy before aneurysm repair. Coronary
artery bypass grafting were performed following aneurysm repair. Internal mammary graft was
used for LAD lesions and saphenous vein grafts for the remainder.

Cardiopulmonary bypass was discontinued after rewarming and the operation was then
finished by standard procedure.

Hospital Data:

Patient medical records were reviewed retrospectively. Data collected included the
following:

1) Demographic information: Sex, age, primary indication for operation

2) Preoperative functional status (NYHA) and type of angina

3) Comorbid risk factors: Diabetes mellitus, hypertension, hyperlipidemia, prior
cerebrovascular disease, smoking, chronic obstructive pulmonary disease, chronic renal
failure.

4) Preoperative echocardiographic and angiographic evaluation: Localization of
aneurysm, coronary artery stenosis, valvular lesions, ejection fraction rate, end-diastolic
pressure, mean pulmonary artery pressure and ventricular performance score

5) Operative data: concomitant procedures, valve replacement, coronary artery bypass
grafting, thrombus, cardiopulmonary bypass and aortic cross clamp time, use of inotropic agents
and intraaortic balloon pumping (IABP), intraoperative complications, operative mortality

6) Postoperative complications: Postoperative mortality, substantial morbidity
defined as reoperation for bleeding, mediastinal infection, respiratory support, cerebrovascular
and respiratory complications, perioperative myocardial infarction, low cardiac output and the
need for inotropic support or IABP and other major complications, postoperative improvement
in echocardiographic measurements, pulmonary artery pressure.

Long-term Follow-up:

All clinical records were reviewed. Data obtained included survival, functional status,
long-term medical management, procedure related complications, echocardiography controls
and repeated angiography for coronary restenosis.

Statistical Analysis:

Data were expressed as mean±standard error
of mean. The two-tailed paired t test was used to
analyze continuous variables. p value less than
0.05 was considered significant.

RESULTS

Early Results:

104 patients received coronary artery bypass
grafts and 1 had mitral valve replacement in
addition to endoaneurysmorrhaphy repair with
autologous pericardium.

Operative profiles of the study group is
demonstrated in Table 2.

ICU follow-up data is summarized in Table 3.
30 patients suffered from perioperative
arrhythmia; 18 from atrial fibrillation (AF), 8
from ventricular premature beats (VPB), 2 from
AF+VPB and 2 from ventricular fibrillation
(VF). Patients with AF received slow infusion of
propafenon HCI 70 mg r i.v and 14 cases were
treated. The remaining 16 patients responded
to amidaron HCL infusion of 150 mg r. i.v.

4 patients with VPB responded well to bolus
lidocaine 100 mg r i.v. 2 patients were treated with
propafenon HCI infusion of 70 mg r i.v. and 2
with amiodaron HCl 150 mgr i.v. infusion.

Two patients with VF were defibrillated and responded well to lidocaine infusion.

Two cases underwent revision due to hemorrhage. 2 patients had Adult Respiratory Distress Syndrome in the early postoperative period. One needed supportive respiratory therapy, and the response was good.

Three patients died in the perioperative period. The data of these patients is summarized in Table 4. They were preoperative high-risk patients.

For hemodynamic comparison, all patients underwent Doppler echocardiographic evaluation before discharge. Mean postoperative pulmonary pressure was also recorded via pulmonary artery catheter before discharging the patients from the intensive care unit (ICU).

Table 4: Overall evaluation of mortality (three patients).

<table>
<thead>
<tr>
<th>Gender/Age</th>
<th>Patient</th>
<th>II Patient</th>
<th>III Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative EF</td>
<td>Female/72</td>
<td>Female/68</td>
<td>Female/69</td>
</tr>
<tr>
<td>Preoperative EDP</td>
<td>32%</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>Preoperative PAP</td>
<td>20 mmHg</td>
<td>25 mmHg</td>
<td>25 mmHg</td>
</tr>
<tr>
<td>Preoperative PS</td>
<td>35 mmHg</td>
<td>38 mmHg</td>
<td>35 mmHg</td>
</tr>
<tr>
<td>Complications</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Support</td>
<td>ARDS, LCO</td>
<td>Acute Renal Insuff, LCO</td>
<td>IABP</td>
</tr>
<tr>
<td>Inotropes</td>
<td>Dopamine+Dobutamine+</td>
<td>Dopamine+Dobutamine+</td>
<td>Dopamine+Dobutamine+</td>
</tr>
<tr>
<td>Survival</td>
<td>2 days</td>
<td>14 days</td>
<td>3 days</td>
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EF: Ejection Fraction  
PS: Performance score  
LCO: Low cardiac output  
EDP: End-diastolic pressure  
PAP: Pulmonary artery pressure  
ARDS: Adult respiratory distress syndrome  
IABP: Intraaortic balloon pumping
Comparing the data of preoperative 105 and postoperative 102 patients, mean pulmonary artery pressure decreased to 16.3±3.2 mmHg from preoperative 22.1±2.3 mmHg (p<0.05, paired t test, Fig. 2A); echocardiographic measurement of left ventricular ejection fraction on discharge increased to 46.8±8.2% versus preoperative 38.2±9% (p<0.05, paired t test, Fig. 2B).

Mean functional status was 1.6±0.7 for these patients. Preoperative EF of 35±2.4% improved well up to 45.1±3.6% (p<0.05, paired t test). 20.2±4.8 mmHg of end-diastolic pressure decreased to 11.6±2.1, demonstrating better ventricular functions and better ventricular geometry (Fig. 3A and 3B). Control angiography was negative for 3 patients. Restenosis was detected in 6 patients and new stenotic lesions were observed in 3 patients.

The follow-up of other patients was uneventful.

**DISCUSSION**

There has been considerable change in recent years regarding surgical repair of left ventricular aneurysms. The frequency of aneurysm operations has declined precipitously due to the use of thrombolytic therapy very early after myocardial infarction leading to a healing process with retained viable myocardium with no potential for dilatation. Aneurysmectomy procedure associated with a complete myocardial revascularization, in particular of LAD, and a larger use of LIMA may permit by means of reconstruction of the left ventricular geometry, a better outcome for the patients (7). We have performed concomitant coronary artery bypass grafting in all patients with coronary artery disease as extensive as possible and utilized IMA in every case to obtain better postoperative ventricular performance.
Fig. 3: Angiographic view of a patient before (A) and after the pericardial patch repair (B).

Table 5: Data of patients that underwent control coronary angiography.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Prior Symptom-free Interval</th>
<th>NYHA</th>
<th>Indication</th>
<th>Preop EF (%)</th>
<th>Postop EF</th>
<th>Preop EDP (mmHg)</th>
<th>Postop EDP</th>
<th>Findings</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64M</td>
<td>3</td>
<td>4 years</td>
<td>1</td>
<td>sap</td>
<td>34</td>
<td>43</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>56M</td>
<td>3</td>
<td>4 years</td>
<td>1</td>
<td>sap</td>
<td>35</td>
<td>47</td>
<td>25</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>54M</td>
<td>1</td>
<td>2 years</td>
<td>2</td>
<td>uap+Arhyt</td>
<td>32</td>
<td>48</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>49M</td>
<td>3</td>
<td>2 years</td>
<td>3</td>
<td>uap+CHF</td>
<td>36</td>
<td>49</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>62M</td>
<td>2</td>
<td>3 years</td>
<td>1</td>
<td>uap</td>
<td>35</td>
<td>47</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>67M</td>
<td>1</td>
<td>1 year</td>
<td>2</td>
<td>sap</td>
<td>34</td>
<td>42</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>47M</td>
<td>2</td>
<td>1 year</td>
<td>2</td>
<td>uap+Arhyt</td>
<td>32</td>
<td>44</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>65F</td>
<td>3</td>
<td>2 years</td>
<td>1</td>
<td>sap</td>
<td>39</td>
<td>45</td>
<td>25</td>
<td>14</td>
</tr>
<tr>
<td>9</td>
<td>69F</td>
<td>3</td>
<td>3 years</td>
<td>1</td>
<td>sap</td>
<td>40</td>
<td>52</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>70M</td>
<td>3</td>
<td>1 year</td>
<td>3</td>
<td>uap+CHF</td>
<td>34</td>
<td>43</td>
<td>25</td>
<td>13</td>
</tr>
<tr>
<td>11</td>
<td>55M</td>
<td>3</td>
<td>6 months</td>
<td>2</td>
<td>uap+Arhyt</td>
<td>33</td>
<td>38</td>
<td>20</td>
<td>12</td>
</tr>
</tbody>
</table>

CABG: Coronary artery bypass grafting  
EF: Ejection fraction  
Sap: Stable angina pectoris  
CHF: Congestive heart failure  
PDA: Posterior descending coronary artery  
RCA: Right coronary artery  
NYHA: New York heart association class  
EDP: Enddiastolic pressure  
Uap: Unstable angina pectoris  
PTCA: Percutaneous transluminal coronary angioplasty  
LIMA: Left internal mammary artery  
OM: Obsolete marginal coronary artery

Alterations have also occurred in operative technique, with the most prominent change being the introduction of endoventricular patch plasty which aims at replacing the aneurysmal
myocardial wall with an elliptical patch to restore the geometry, contour and volume of left ventricle in diastole while simultaneously reducing end-systolic volume. Patch reconstruction allows circular reorganization of the remaining left ventricular muscle which can not be accomplished using traditional linear closure, also using circular reconstruction permitting easier LAD revascularization (8). Our technique is also based on endoventricular aneurrysmorhaphy. Our results also demonstrated significant improvement in left ventricular geometry, performance and clinical status of the patients and decreased end-diastolic and pulmonary artery pressures as well.

Many authors have been using synthetic material as a patch in surgical repair. However, usually the synthetic material is bulky, non-compliant and prone to infection (9). Autologous pericardium is compliant, readily available, inexpensive and hemostatic as well as resistant to infections (10). It has several applications in the current treatment techniques. Surgeons using Dacron as the primary circular patch material, have sewn the pericardium onto Dacron patch lining so that the smooth visceral pericardial surface becomes the pseudoendocardium, potentially reducing the risk of clot formation onto the patch (11). Many surgeons still use pericardium as pledges or as linear strips to reinforce any of the suture lines during circular reconstruction (12).

Considering various types of utilization of pericardium, we have used it as the primary material to restore circular geometry following left ventricular reconstruction. We observed no infection and only 2 early reoperations for hemorrhage due to aneurysm repair in the study group.

Mean postoperative follow-up is not very long (42±8 months), since 102 patients are living in different parts of the country but may be reliable enough to demonstrate the functional indices of the ventricular function.

We have demonstrated a significant improvement in ejection fraction and performance score in the early as well as in the late postoperative period. The number of late postoperative echocardiography is 45 (44.1%). However we used echocardiographic control only when some symptoms were present.

We had the opportunity to control only 12 patients angiographically because of anginal symptoms, arrhythmia or signs of congestive heart failure. This 11.7% patient population may give an idea about the hemodynamic improvement following operation, although they had probable coronary restenosis. We observed a significant difference in end-diastolic pressure and ejection fraction rates.

Our aim is to increase our patient population and follow-up period as well as late postoperative controls of echocardiography and angiography in the ongoing study.

Considering our data, it may be concluded that endoventricular pericardial patch plasty in the surgery of left ventricular aneurysms would be an alternative option with acceptable surgical and perioperative results.

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