Left ventricular aneurysm repair: an assessment of surgical treatment modalities

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Abstract

Objective: Different closure techniques (linear vs. circular), as well as the efficacy of revascularization in the left ventricular aneurysm repair, with regard to immediate and mid-term results, were assessed and factors having influence on the early mortality and morbidity and survival were analyzed. Method: Between January 1991 and November 1996, 248 patients underwent surgical repair for postischemic left ventricular aneurysm. A total of 26 of them were female (10.5%). Linear closure was employed in 121 patients (48.8 %) and circular (patch endoaneurysmorraphy) closure in 127 (51.2%). Coronary revascularization was added in 203 (81.9%) cases. Patients were followed for an average follow-up time of 39.3 months. Results: Early mortality rate was 6% (15 patients). The difference in mortality rate by the repair method was not statistically significant (8.3% in the linear closure group and 3.9% in the circular closure group, \( P = 0.15 \)). Absence of preoperative angina pectoris \( (P = 0.029) \), dyspnea as the presenting symptom, a preoperative left ventricular segmental wall motion scoring of 14 or greater, a cardiopulmonary bypass duration exceeding 2 h \( (P = 0.004) \), an aortic clamping time exceeding 1 h \( (P = 0.026) \) were associated with early mortality. Concomitant coronary revascularization had no effect on early mortality. However, low cardiac output state was less frequent in patients with concomitant coronary revascularization \( (P = 0.022) \). Functional status improved in both groups. Follow-up extending to 81st month revealed no difference in survival between the groups (84% for linear closure group and 92% in circular closure group, including operative mortality, \( P = 0.12 \)). However, functional status improvement was better in the patients who underwent circular repair \( (P = 0.0077) \). Revascularization appeared as having no important influence on both survival and functional status. A preoperative left ventricular segmental wall motion scoring of 14 or greater was associated with a higher incidence of early mortality, low cardiac output syndrome and poor long-term survival. Conclusion: Left ventricular aneurysm repair is an important therapeutic intervention and can be performed with reliable results, regardless of repair method, either linear or circular. Long term results revealed better functional status in circular repair group. Concomitant coronary revascularization reduced the incidence of low cardiac output state. Performance of the unaffected regions of myocardium was found to be an important determinant of both early and late outcome. © 1998 Elsevier Science B.V.

Keywords: Left ventricular aneurysm; Endoaneurysmorraphy

1. Introduction

Although the surgical treatment of the left ventricular aneurysm has been performed for nearly the last four decades, the most appropriate surgical approach to a patient with a left ventricular aneurysm is still controversial [1]. There are many studies comparing the circular or linear repair methods [2,3] and others emphasizing the importance of revascularization [4,5]. Patients who require left ventricular aneurysmectomy form a high-risk group and guidelines for the selection of those likely to obtain most benefit are ill defined. On the other hand, with the change of the patient profiles, as well as the surgical methods employed, many issues
Table 1
Summary of patient data

<table>
<thead>
<tr>
<th></th>
<th>Linear closure group</th>
<th>Patch repair group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient number</td>
<td>121</td>
<td>127</td>
</tr>
<tr>
<td>Mean age</td>
<td>52.35 ± 10.51</td>
<td>54.24 ± 8.44</td>
</tr>
<tr>
<td>Age range</td>
<td>17–71</td>
<td>33–73</td>
</tr>
<tr>
<td>Male/female</td>
<td>108/13</td>
<td>89/11</td>
</tr>
<tr>
<td>Presenting symptom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angina pectoris</td>
<td>74</td>
<td>61.2</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>25</td>
<td>20.7</td>
</tr>
<tr>
<td>Preoperative functional class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NYHA class I</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>NYHA class II</td>
<td>35</td>
<td>28.9</td>
</tr>
<tr>
<td>NYHA class III</td>
<td>78</td>
<td>64.5</td>
</tr>
<tr>
<td>NYHA class IV</td>
<td>2</td>
<td>1.7</td>
</tr>
<tr>
<td>LVEDP (mmHg)</td>
<td>21</td>
<td>23</td>
</tr>
<tr>
<td>Preop. LVS (*)</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Revascularised cases</td>
<td>111</td>
<td>91.7</td>
</tr>
<tr>
<td>LAD revascularization</td>
<td>101</td>
<td>83.5</td>
</tr>
</tbody>
</table>

* Preoperative left ventricle segmental wall motion scoring. See Appendix A for details.

about this clinical situation and the strategy for its treatment need to be revised.

In this retrospective study, we reviewed the results of two different repair techniques (linear and circular closure), as well as the effect of the coronary revascularization on immediate and mid-term outcome after left ventricular aneurysm repair. Factors thought to possess influence on the early mortality and morbidity and on mid-term survival, were also analyzed and discussed. This study encompasses only the cases operated on after 1991, the year which we started to use circular repair (patch endoaneurysmorraphy) in a routine manner.

2. Materials and methods

Between January 1991 and November 1996, 248 consecutive patients underwent surgical repair for postischemic left ventricular apical-anterior aneurysm. A total of 26 of them were female (10.5%). Indications for operation were, left ventricular postischemic aneurysm with angina pectoris and/or dyspnea, as the presenting symptoms. The diagnosis of left ventricular aneurysm was made preoperatively by the angiographic appearance of the left ventricular cavity and, confirmed intraoperatively by the surgeon.

Preoperative data is presented in Table 1. Linear closure was employed in 121 patients and circular closure (patch endoaneurysmorraphy) in 127. Generally, the choice for the repair technique is not made randomly, but rather it depends on the size and extension of the scarred tissue. The appearance of the aneurysms neck and its relation with the ventricular cavity, number and localization of the involved segments, size of the dyskinetic region are assessed by left ventriculography. All those may give an idea for choosing the repair method, but the final decision is made intraoperatively.

An extensive and definite fibrotic aneurysmal sac with a well formed neck generally leads the surgeon to the circular repair; while in a small wide-based aneurysm, vaguely separated from the surrounding viable myocardium, a small plication is usually preferred. In cases with extensive septal involvement, either patch endoaneurysmorraphy is employed or septal plication is added to the linear repair. Coronary revascularization was added in 203 cases (81.9%). Our indications for adding revascularization to aneurysm repair were, either a stenotic LAD which remained graftable after the aneurysm repair, or significant stenotic lesions in other coronary systems. Complete revascularization was the goal. Early and mid-term results, in regard to surgical techniques were assessed and factors having influence on the early mortality and morbidity and survival, were analyzed. To assess the residual myocardial function as a determinant of outcome, we employed a commonly used preoperative left ventricular segmental wall motion scoring system on the basis of left ventriculography which is described in Appendix A.

2.1. Operative technique

Our operative technique was either simple plication reinforced with teflon stripes with or without septal plication (for larger aneurysms with extensive septal involvement) in the linear closure group; or the patch
endoaneurysmorrhaphy in the circular closure group. Our patch endoaneurysmorrhaphy technique was very similar to that which is described by Cooley [6]. We used a smaller (≈ 2 × 2.5 cm, in dimensions) tear-drop shaped teflon patch. Suturing started from the upper, sharp-pointed tip of the patch, wedged into the most cephalad corner of the ventricular incision; then continued bilaterally toward the round caudal corner, using a continuous 2-0 double armed monoflaman polypropylene suture. All the operations were performed on cardiopulmonary bypass with myocardial preservation by systemic core cooling, topical cold saline hypothermia and cardioplegic arrest (Plegisol, Abbot). Our cardioplegia protocol consisted of antegrade: retrograde cold crystalloid cardioplegia for induction, retrograde cold blood cardioplegia for maintenance and terminal retrograde warm blood cardioplegia.

2.2. Follow-up

The mean follow-up time was 39.3 months, ranging between 0 and 81 months (a total of 9,128 patient months). Follow-up was accomplished by means of office visits, hospital records, letters or telephone contact with the patient.

2.3. Statistical analysis

Analysis for determining the factors associated with early hospital mortality and low cardiac output state, was performed with $\chi^2$ test or Fisher’s exact test. Proportions such as mortality rates were compared with $\chi^2$ test or Fisher’s exact test. Survival curves were estimated using the Kaplan–Meier method. All parameters and subgroups were compared using the LogRank test for the analysis of possible influences on mid-term survival. Since functional class is on a scale from 1 to 4, it is unlikely that the necessary distributional assumptions for a standard variance analysis will hold. Therefore, Wilcoxon matched-pairs signed-ranks test was used for performing pairwise comparisons of preoperative and postoperative functional capacities. Mann-Whitney U-test was performed for the comparison of surgical methods (linear vs. circular repair and revascularized vs. non-revascularized) with regard to preoperative and postoperative functional status. SPSS software (SPSS, Chicago, IL.) was used in data analysis and $P \leq 0.05$ was considered as statistically important.

3. Results

3.1. Early mortality

Operative mortality was 6% (15 patients). Causes for mortality are presented in Table 2. Low cardiac output was the cause in the majority (13 of cases), respiratory insufficiency in one patient and cerebral embolism in the other patient.

Mortality rates for two closure techniques were 8.3% (10 patients) for the linear closure group and 3.9% (5 patients) for the circular closure group. Mortality rate did not differ between these two groups ($P = 0.15$). Factors statistically analyzed for any possible association with early mortality are presented in Table 3. Preoperative dyspnea (as the presenting symptom), absence of angina pectoris, a preoperative left ventricular segmental wall motion scoring of $\geq 14$, a cardiopulmonary bypass duration $> 2$ h and an aortic clamping

<table>
<thead>
<tr>
<th>Cause</th>
<th>number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early postoperative period</td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td></td>
</tr>
<tr>
<td>Low cardiac output/multisystem failure</td>
<td>13</td>
</tr>
<tr>
<td>Neurological (coma)</td>
<td>1</td>
</tr>
<tr>
<td>Respiratory insufficiency</td>
<td>1</td>
</tr>
<tr>
<td>Morbidty</td>
<td></td>
</tr>
<tr>
<td>Low cardiac output</td>
<td>72</td>
</tr>
<tr>
<td>Neurological (stroke)</td>
<td>2</td>
</tr>
<tr>
<td>Respiratory insufficiency</td>
<td>2</td>
</tr>
<tr>
<td>Follow-up</td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td></td>
</tr>
<tr>
<td>Cardiac (confirmed)</td>
<td>2</td>
</tr>
<tr>
<td>Sudden death</td>
<td>3</td>
</tr>
<tr>
<td>Stroke</td>
<td>2</td>
</tr>
<tr>
<td>Leukemia</td>
<td>1</td>
</tr>
<tr>
<td>Morbidty</td>
<td></td>
</tr>
<tr>
<td>Control angiography</td>
<td>7</td>
</tr>
<tr>
<td>PTCA</td>
<td>2</td>
</tr>
<tr>
<td>Reoperation (CABG)</td>
<td>1</td>
</tr>
<tr>
<td>Stroke</td>
<td>1</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 3

Univariate analysis for early mortality and low cardiac output state

<table>
<thead>
<tr>
<th></th>
<th>Mortality</th>
<th>Low cardiac output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>NS</td>
<td>0.0026</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>NS</td>
<td>0.037</td>
</tr>
<tr>
<td>Dyspnea as present symptom</td>
<td>0.03</td>
<td>NS</td>
</tr>
<tr>
<td>Preoperative NYHA class</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Absence of angina pectoris</td>
<td>0.029</td>
<td>NS</td>
</tr>
<tr>
<td>LVEDP $&lt; 20$ mmHg</td>
<td>0.078</td>
<td>0.01</td>
</tr>
<tr>
<td>Preop. LVS $\geq 14$</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>Operative parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronary revascularization</td>
<td>NS</td>
<td>0.022</td>
</tr>
<tr>
<td>Closure method (patch or linear)</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>CPB duration $&gt; 2$ h</td>
<td>0.004</td>
<td>0.00005</td>
</tr>
<tr>
<td>Aortic clamping time $&gt; 1$ h</td>
<td>0.026</td>
<td>0.0179</td>
</tr>
</tbody>
</table>

Numbers in the columns represent $P$ values for $\chi^2$ (Pearson) or Fisher’s exact test $P$ values. CPB, cardiopulmonary bypass; LVEDP, left ventricular end-diastolic pressure; NYHA, New York Heart Association; Preop LVS, preoperative left ventricle segmental wall motion scoring. See Appendix A for details; NS, not significant.
Table 4
Analysis for factors having influence on mid-term survival

LogRank analysis on Kaplan–Meier survival rates

<table>
<thead>
<tr>
<th>Preoperative parameters</th>
<th>Survival without parameter (%)</th>
<th>Survival with parameter (%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female sex</td>
<td>84</td>
<td>82</td>
<td>NS</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>92</td>
<td>45</td>
<td>0.01</td>
</tr>
<tr>
<td>Preoperative NYHA class IV</td>
<td>84</td>
<td>50</td>
<td>0.009</td>
</tr>
<tr>
<td>Dyspnea as presenting symptom</td>
<td>85</td>
<td>84</td>
<td>NS</td>
</tr>
<tr>
<td>Preoperative I.a.b. insertion</td>
<td>84</td>
<td>67</td>
<td>0.05</td>
</tr>
<tr>
<td>Left main coronary artery disease</td>
<td>84</td>
<td>92</td>
<td>NS</td>
</tr>
<tr>
<td>Left ventricular end-diastolic pressure</td>
<td>81</td>
<td>90</td>
<td>NS</td>
</tr>
<tr>
<td>Preop. LVS ≥ 14*</td>
<td>92</td>
<td>45</td>
<td>0.01</td>
</tr>
<tr>
<td>Operative parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronary revascularization</td>
<td>87</td>
<td>92</td>
<td>NS</td>
</tr>
<tr>
<td>Closure method (patch or linear)</td>
<td>84 (linear)</td>
<td>92 (patch)</td>
<td>NS</td>
</tr>
<tr>
<td>Cpb duration &gt; 2 h</td>
<td>85</td>
<td>72</td>
<td>0.0006</td>
</tr>
<tr>
<td>Low cardiac output state</td>
<td>90</td>
<td>73</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

* Preoperative left ventricle segmental wall motion scoring. See Appendix A for details.

time > 1 h were associated with early mortality. Closure technique (linear or circular) or adding revascularization of left anterior descending artery and/or other coronary systems appeared as having no influence on early mortality. Result of this analysis are presented in Table 3.

3.2. Major complications in the early postoperative period

Three patients suffered from respiratory insufficiency (one died) and three from neurologic complications (one died). In 85 patients, low cardiac output state was developed (Table 2).

3.3. Low cardiac output

Low cardiac output, as being the most frequent early postoperative complication, developed in 85 (34.3%) patients. Also, 84.7% (72 patients) of those could have been discharged and 13 died (Table 2).

Female sex, diabetes mellitus, a left ventricular end diastolic pressure (LVEDP) > 20 mmHg, a preoperative left ventricular segmental wall motion scoring of 14 or greater, repair without coronary revascularization, a cardiopulmonary bypass duration > 2 h and an aortic clamping time > 1 h were associated with postoperative low cardiac output state (Table 3).

3.4. Survival analysis

There were eight additional deaths in the follow-up (five in the linear group and three in the patch group, P = NS). Global survival rate was 88%, for a follow-up extending to 81 months. Survival rate was 84% in the linear closure group and 92% in the circular repair group (operative mortality included). However, comparison with LogRank test revealed no statistical difference in survival rate between these two groups (P = 0.12, Table 4, Fig. 1).

Comparison for influence of certain parameters on mid-term survival was established performing LogRank test on Kaplan–Meier survival curves obtained for each parameter. This evaluation included both operative and late mortality. Results of this analysis are presented in Table 4. Diabetes mellitus, class IV preoperative functional capacity, a preoperative left ventricular segmental wall motion scoring of ≥ 14, a cardiopulmonary bypass duration > 2 h, preoperatively inserted intraaortic balloon and low cardiac output state in the early postoperative period were associated with significantly lower survival rates (Table 4).

3.5. Functional capacity in survivors

In all but 3 patients, regardless of repair type, functional status was improved (P < 0.0001). In linear closure group, one patient remained in class III and one patient, who was in class II preoperatively, regressed to class III after the operation. In circular closure group, one patient remained in class III. In survivors, functional capacity was significantly better in the circular repair group (P = 0.0077). Patients with totally occluded left anterior descending artery appeared as having better functional status, regardless to whether LAD revascularization had been performed or not (P = 0.008). However, adding revascularization to left ventricular aneurysm repair did not affect the functional status.
3.6. Late mortality

Eight more patients were lost in the follow-up after a mean follow-up time of 684 days (range 75–1848 days). Causes for late mortality were resumed in Table 2. One patient died due to leukemia and others due to possible cardiac related events.

3.7. Other events

Coronary angiography was repeated in seven patients suffering from residual angina. Two of them underwent PTCA, another underwent reCABG. Congestive heart failure developed in three patients. Mean duration for developing congestive heart failure after the operation was 965 days (range 220–1653). One patient suffered from stroke (hemiplegia).

3.8. Impact of revascularization

Revascularization, in general means—adding any coronary artery bypass grafting to aneurysm repair—had no influence on early or late mortality. When the influence of LAD revascularization, circumflex coronary artery system revascularization and/or right coronary artery system revascularization were separately analyzed, there was, again, no evidence of any effect on survival. Further, another analysis designed for previously speculated ‘the necessity for right coronary artery system revascularization in the absence of LAD revascularization with patients having totally occluded or stenotic LAD coronary artery’. This analysis, again, revealed no supporting evidence for any effect on early mortality or late survival.

Apart from the results obtained for early or late mortality, analysis for low cardiac output state revealed superior results in revascularized patients. Low cardiac output was less frequently encountered when coronary artery bypass grafting was added to aneurysm repair ($P = 0.022$). Data analysis for the impact of revascularization is represented in Tables 3 and 4 in detail.

When cases with atherosclerosis in coronary systems other than LAD were excluded, there was, again, no difference with regard to mortality or survival. In this case,
selected group, however, low cardiac output incidence was lower in the revascularized patients ($P = 0.01$).

3.9. Impact of repair method (circular vs. linear)

Data analysis for the impact of the employed repair method (linear vs. circular) is represented in Tables 3 and 4, in detail. The only statistical difference appeared as the better functional status in the patch repair group during follow-up ($P = 0.0077$).

4. Discussion

Following myocardial infarction, a left ventricular aneurysm will develop in 4–20% of patients [7]. Initially it may be relatively well tolerated, but the long-term prognosis is poor. Five year survival rates of between 12 and 27% have been reported [8,9] and the average time from infarction to death has been quoted at 4.8 years [10]. Most of these are data obtained prior to the surgical era. Improved medical treatment, not only initially but also in the follow-up, has undoubtedly improved survival in patients with LV aneurysm, just as it has decreased the incidence of left ventricular aneurysm. Left ventricular aneurysmectomy has been widely performed in patients whose symptoms could not have been adequately controlled by medical treatment. Long term symptomatic improvement after surgical repair has been reported [2,3,7], with the early mortality rate being 2–23% [1].

Repair of left ventricular post ischemic aneurysms go back in history to 1955. Bailey was the first to successfully perform left ventricular aneurysmectomy with the application of a partially occluding, side-biting clamp on a beating heart [11]. In 1958, Cooley first performed left ventricular aneurysmectomy with a plication in a manner of linear closure with the use of extracorporeal circulation [12]. With the considerations of maintaining the left ventricular geometry arouse, restoring the spherical shape of left ventricle, as far as possible, becomes an important issue. Then, Dagget and Jatene became the first to point out the circular repair of left ventricular aneurysms [13,14]. In 1989, Cooley, again, described the circular endoaneurysmmorrhaphy technique for the left ventricular aneurysm repair and this technique substantiates an important basis for most of the derivatives that recently have been used [6].

The actuarial survivals of a series of very dissimilar patient populations (series with pure or predominant aneurysmectomy and those in combinations with other cardiac surgery procedures, such as coronary artery bypass grafting or valvular procedures) after surgical repair have been published up to the present. Despite the limitations in the interpretation of compiled data from the literature, it can be assumed that the surgical and hospital mortality in combined operations averaging $11 \pm 5.6\%$ (range 2–23\%) is not significantly higher than in exclusive aneurysmectomy, with an average of $9.4 \pm 5.2\%$ (range 0–20\%). As far as they were specified in the respective publications, the actuarial survivals also did not show any significant difference between aneurysmectomies with an average 5 year survival of 75\% and series with aneurysmectomies plus additional coronary bypass operations with an average survival of $\sim 70\%$, 5 years after the operation [1].

Postinfarction ventricular aneurysm distorts the normal left ventricular geometry of a prolate spheroid, which is a compromise between a sphere that would optimize diastolic filling and a tubular shape that would permit maximal conversion tension generated by the myocardium into cavitary pressure [15]. During surgical repair, linear closure may reduce the ventricular cross-sectional area, particularly at the mid-portion of the closure, as well as potentially distort this normal geometry. Recent closure techniques have attempted to maintain original ventricular geometry and size by circular reduction of the defect and frequent incorporation of a Dacron circular approximately the size of original infarction [6,14,16]. In the study of Kesler et al. [2], these two techniques of left ventricular aneurysm repair were compared by assessment of clinical status and echocardiographic measurements of left ventricular dimensions and function. In that study, no significant difference between the linear and circular closure techniques with respect to standard echocardiographic parameters, functional classification and survival, were detected.

Since 1975, about 1,000 cases underwent surgical treatment for left ventricular post infarct aneurysm repair in our institution. We introduced the circular endoaneurysmmorrhaphy technique in 1990. Until 1991, the date that circular repair was employed in a routine manner, most of our standard operative practice in large aneurysms was septal plication or septoplasty procedure. Smaller aneurysms without a well formed neck used to be managed by simple plication. Septoplasty, had also been popularized in an attempt to create more geometrically favored repair, but it was rather a variant of linear closure. After 1991, circular repair replaced the septoplasty as the standard aneurysm repair. Plication, again, continued being reserved for less extensive aneurysms. This study included only the cases after the beginning of 1991, for a more appropriate comparison.

In our retrospective study, we tried to evaluate, especially, two issues of concern for the treatment of left ventricular aneurysm repair. First, we tried to investigate whether the circular repair offers any advantage over the linear closure technique by means of immediate and mid-term results. Then, the influence of revascularization on early and late results was stressed.
One of the limitations for such a comparison was the fact that the preoperative cardiac states of those two repair groups (circular and linear) were not identical. Generally, the choice for the repair technique is not made randomly, but rather it depends on factors such as size and extension of the scarred tissue. An extensive and definite fibrotic aneurysmal sac with a well formed neck generally leads the surgeon to the circular repair; while in a small wide-based aneurysm vaguely separated from the surrounding viable myocardium, a small plication is usually preferred. In cases with extensive septal involvement, either septal plication is added to the linear repair or patch endoaneurysmorrhaphy is employed. The prognosis of patients with anterior wall aneurysm mainly depends on the size of the aneurysm and the function of the residual myocardium [1]. So, it can be speculated that, hearts operated on with simple plication technique, consisting of a major part of our linear closure group, were expected to have better preoperative cardiac status. So, better immediate outcome and late survival is expected in patients with plications. The following comments must be considered with this fact kept in mind.

The repair method (circular vs. linear) did not influence early mortality or survival; further, there was no evidence for any superiority of circular repair on immediate cardiac performance, by means of low cardiac output development. But among the survivors, most patients in class I were the patients who had undergone circular repair. Then, it can be concluded that, circular repair may bring some advantages, such as better functional capacity when late results are considered, despite the worse preoperative cardiac condition stressed above. Thus, better outcome was expected in the linear closure group which consisted of patients with smaller aneurysms and better myocardial reserve than those in the circular group. In contrast, although the two repair groups were not identical as described above, a more favorable functional status was obtained in the circular closure group, possibly accentuating the advantage of this type of repair.

In the study of Komeda et al. [3], the importance of complete revascularization was emphasized. They believe that complete revascularization should include bypassing the proximal third of the left anterior descending artery or the first septal perforator branch if the proximal part of the septum is found not to be scarred at operation. Another detail that was accentuated in that study, was the frequent ligation at the distal half of the anterior descending artery during closure of the ventriculotomy. It was concluded that, this ligature may interfere with the principal source of collaterals to the marginal branches of an occluded right coronary artery. In our study, revascularization appeared to lower incidence of low cardiac output state, but did not decrease early mortality and did not improve long-term survival. We feel that the revascularization of the first septal branches, as well as other coronary systems, such as right or circumflex coronary artery or their branches, which shows atherosclerotic involvement, is useful for achieving optimal benefit when postoperative cardiac performance is considered. Our strategy is obtaining complete revascularization, as far as possible. Especially when right coronary artery stenotic or occluded, it is logical to supply blood flow to right coronary artery either directly by a graft or indirectly (via collaterals) by grafting the proximal left anterior descending coronary artery. However, in our study, statistical analysis did not support this hypothesis.

As emphasized above, the prognosis of patients with anterior wall aneurysm mainly depends on the size of the aneurysm and the function of the residual myocardium [1]. To assess the residual myocardial function as a determinant of outcome, we employed a commonly used preoperative left ventricular segmental wall motion scoring system, on the basis of left ventriculography which is described in Appendix A. A preoperative left ventricular segmental wall motion scoring of \( \geq 14 \) was found to be a risk factor for both early outcome (by means of hospital mortality and low cardiac output) and long-term survival.

With regard to presenting symptoms, absence of angina pectoris and dyspnea as the predominating symptom was associated with early mortality. Similarly, in the study of Komeda et al., lack of angina was an independent predictor for operative mortality [3]. It can be speculated that, preoperative angina, probably but not necessarily, may indicate viable myocardial tissue existence, which is capable of generating power during systole, more compliant during diastole and have less compromising effects on ventricular geometry when compared to a totally fibrotic aneurysmal sac.

In the study by Stahle et al., internal mammary artery using as the graft conduit decreased the mortality when compared to vein grafts and this is attributed to the excellent early and late patency rates of this arterial graft [17]. In our study, we did not find any influence of graft type on early mortality or survival supporting this conclusion. However, the long-term survival, after repair of left ventricular aneurysm in our series, is comparable with that of other reports. Most investigators have identified poor left ventricular function as an important predictor of late mortality [3,7]. In our study, a preoperative NYHA class IV, preoperatively inserted intraaortic balloon, a preoperative left ventricular segmental wall motion scoring of \( \geq 14 \) and patients suffering from low cardiac output state in the early postoperative period, appeared as having poor midterm survivals (Table 4). All these parameters are well-recognized reflections of poor myocardial reserve for postoperative survival.
In conclusion, both methods of treating left ventricular aneurysms provided satisfactory results. Circular repair appeared as a good technique in repair of extensive aneurysms, having no worse immediate and mid-term results than those obtained with plication of relatively small aneurysms, which were expected to have better myocardial reserve. Revascularization favored early postoperative course by decreasing the low cardiac output state incidence and must be added in cases with a LAD remained graftable after repair, or in cases with significant lesions in other coronary systems. In this study, results of an average follow-up of 39.3 months were presented and more accurate analyses can be performed once the longer periods of follow-up are obtained. Performance of the unaffected regions of myocardium was found to be an important determinant of both early and late outcome. Left ventricular aneurysm repair is an important therapeutic intervention which improves the survival and conditions of patients with left ventricular aneurysms. It can be performed with reliable results, regardless of repair method, either linear or circular. Circular closure should be reserved for larger, well formed aneurysms; while simple plication is usually satisfactory with smaller ones without remarkable aneurysmal necks.*

Appendix A. Scoring system for preoperative left ventricle performance

Biplane left ventriculogram is divided into a total of seven segments (5 for the right anterior oblique projection -apical, anterobasal, anterolateral, posterobasal and inferior-, and 2 for the left anterior oblique projection -septal and posterolateral-). Then, the following points are given for each segment and the left ventricle performance score is calculated as the sum of these scores.

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

References