Left ventricular reconstruction in ischemic cardiomyopathy
Klein, P.

Chapter 2

Early and late outcome of left ventricular reconstruction surgery in ischemic heart disease

Patrick Klein [a], Jeroen J. Bax [c], Leslee J. Shaw [b], Harm H.H. Feringa [a], Michel I.M. Versteegh [a], Robert A.E. Dion [a], Robert J.M. Klautz [a]

[a] Department of Cardiothoracic Surgery, Leiden University Medical Center, Leiden, The Netherlands
[b] Atlanta Cardiovascular Research Institute, Atlanta, GA, USA
[c] Department of Cardiology, Leiden University Medical Center, Leiden, The Netherlands

European Journal of Cardio-thoracic Surgery 34 (2008) 1149—1157

SUMMARY

A systematic review of the literature was performed to determine early and late mortality associated with left ventricular (LV) reconstruction surgery and to assess the influence of different surgical techniques, concomitant surgical procedures, clinical and hemodynamic parameters on mortality. The MEDLINE database (January 1980—January 2005) was searched and from the pooled data, hospital mortality and survival were calculated. Summary estimates of relative risks (RR) were calculated for the techniques that were used and for concomitant coronary artery bypass grafting (CABG) and mitral valve surgery. The risk-adjusted relationships between mortality and clinical and hemodynamic parameters were assessed by meta-regression. A total of 62 studies (12,331 patients) were identified.Weighted average early mortality was 6.9%. Cumulative 1-year, 5-year and 10-year survival were 88.5%, 71.5% and 53.9%, respectively. Endoventricular reconstruction (EVR) showed a reduced risk for both early (RR = 0.79, $p < 0.005$) and late (RR = 0.67, $p < 0.001$) mortality compared to the linear repair (early: RR = 1.38, $p < 0.001$; late: RR = 1.83, $p < 0.001$). Early and late mortality were mainly cardiac in origin, with as predominant cause heart failure in respectively 49.7% and 34.5% of the cases. Ventricular arrhythmias caused 16.6% of early deaths and 17.2% of late deaths. Concomitant CABG significantly decreased late mortality (RR = 0.28, $p < 0.001$) without increasing early mortality (RR = 1.018, $p = 0.858$). Concomitant mitral valve surgery showed both an increased risk for early (RR = 1.57, $p = 0.001$) and late mortality (RR = 4.28, $p < 0.001$). No clinical or hemodynamic parameters were found to influence mortality. It is noteworthy that only one third of patients included in the current analysis were operated for heart failure (14 studies, 4135 patients). In this group we noted an early mortality of 11.0% with a late mortality (3-year) of 15.2%. This analysis of pooled literature data showed that LV reconstruction surgery is performed with acceptable mortality and EVR may be the preferred technique with a reduced risk for early and late mortality. Concomitant CABG improved outcome, whereas the need for mitral valve surgery appeared an index of gravity. No clinical or hemodynamic parameters were found to influence mortality; specifically LV ejection fraction and LV volumes both did not predict outcome.

Keywords: Left ventricular reconstruction surgery; Aneurysmectomy; Surgical ventricular restoration; Dor procedure; Ischemic heart disease; Heart failure

1. INTRODUCTION

The formation of scar tissue after myocardial infarction leads to changes in left ventricular (LV) shape and function (remodeling) [1]. The normally elliptical LV tends to sphericity and chamber dilatation, while the transmurality of the myocardial scar determines whether or not a true LV aneurysm (dyskinetic segment) will develop [2]. Likoff and Bailey described the first aneurysmectomy in 1952 [3], subsequently followed by the first aneurysmectomy with linear repair using cardio-pulmonary bypass reported by Cooley in 1958 [4]. A number of different surgical techniques and modifications have since developed to restore LV shape and to improve LV function [4—9]. The most commonly used techniques are the endoventricular repair (EVR), with or without the use of an endoventricular patch, introduced by Dor in 1985 [4] and the aforementioned linear repair. Dor et al. demonstrated the feasibility of his procedure not only for the true LV aneurysms with a dyskinetic segment, but also for remodeled left ventricles with extensive akinesia [2]. Surgeons who advocate the different surgical techniques, all report on good short- and long-term results. Only a few reports are available that compare different surgical techniques, particularly in respect to long-term results [10—15,75]. The aims of this study were:

1. to compare early and late mortality in LV reconstruction surgery using different surgical techniques, based on pooled analysis of literature studies,
2. to evaluate the causes of early and late mortality in LV reconstruction surgery,
3. to evaluate the influence of factors including concomitant surgical procedures, clinical and hemodynamic parameters on early and late mortality.

LV reconstruction surgery is increasingly being employed as an alternative surgical therapy for patients with ischemic heart failure. In these patients the issues listed above are particular important and therefore a sub-analysis was conducted for this category of patients.

2. METHODS

2.1. Review of published reports

The studies were identified by means of several combined search strategies: (1) A search of the MEDLINE database (January 1980—January 2005) was conducted using the following Keywords: ‘left ventricular aneurysm’, ‘left ventricular restoration’, ‘surgical ventricular restoration’, ‘left ventricular remodeling surgery’, ‘aneurysmectomy’, and ‘Dor procedure’. (2) A manual search of six cardiothoracic surgery and cardiology journals (Annals of Thoracic Surgery, Journal of Thoracic and

Cardiovascular Surgery, European Journal of Cardiothoracic Surgery, Thoracic and Cardiovascular Surgery, Circulation and Journal of the American College of Cardiology). (3) The reference lists of the reports obtained through these searches were screened for additional articles that may have been missed. Only articles in English were considered, and reviews, editorials, animal or in vitro experimental studies, abstracts and articles concerning LV reconstruction surgery for non-ischemic heart disease were disregarded. The most recent publication or the publication concerning the largest patient population was included for analysis if multiple publications were available from the same institute to avoid double counting.

2.2. Statistical analysis

The following parameters were extracted from each article and entered into the database: pooled, average and median rates of in-hospital mortality and survival, specified causes of death (whether cardiac, subdivided in heart failure, ventricular arrhythmias, acute myocardial infarction and other, non-cardiac or unknown), follow-up duration, mean age, gender, interval post myocardial infarction, patients with ischemic heart failure (defined as LV ejection fraction (EF) ≤35% and New York Heart Association (NYHA) class III or IV), surgical technique used, mortality and survival with concomitant CABG and mitral valve surgery, LVEF, LV end-diastolic volume index (LVEDVI), LV end-systolic volume index (LVESVI), LV end-diastolic dimension (LVEDD) and LV end-systolic dimension (LVESD). From the data, pooled, median and weighted-average early and late mortality were calculated. Cumulative survival was calculated from the pooled late mortality. Using comprehensive meta-analysis software (Borrestein M, Hedges L, Higgins J, Rothstein H. Comprehensive meta-analysis Version 2, Biotstat, Englewood, NJ (2005)), the summary estimates of relative risks (RR) were calculated for the different surgical techniques that were used and for concomitant CABG and mitral valve surgery. The relative risk (with 95% confidence intervals, CI) was calculated using a random effects model. The riskadjusted relationship between mean age, time from infarction, LVEF, LVEDVI, LVESVI, LVEDD and LVESD and hospital mortality and survival was assessed by meta-regression. A sub-analysis on survival in patients with heart failure was conducted. A Chi-square test from homogeneity was calculated and Fisher's exact test was used for comparing events. A p value <0.05 was considered significant.

3. RESULTS

Two hundred and eight citations were returned and the articles scrutinized. After excluding non-English articles, reviews, editorials, animal or in vitro experimental studies, abstracts and articles concerning LVRS for non-ischemic heart disease, 121 articles were evaluated. After exclusion of all but the most recent publication from the same institute and those not reporting deaths, 62 articles [10—70] were entered into the pooled analysis.

3.1. Early and late mortality in LV reconstruction surgery

Pooling of all data from the 62 studies [10—70] (12,331 patients) showed a pooled early mortality (defined as inhospital or 30-day mortality) of 6.8% and a median early mortality of 7.9%. Weighted average early mortality is 6.9%. Forty-seven studies also reported on long-term survival [11—53,71—74], following 8571 patients for a median of 49 months. Cumulative 1-, 5- and 10-year survival was 88.5%, 71.5% and 53.9%, respectively (Fig. 1).

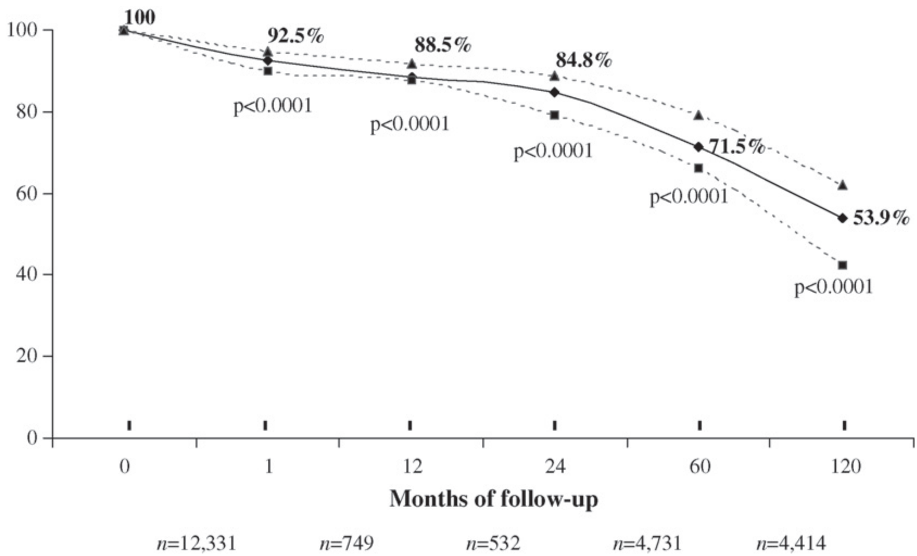

Fig. 1. Cumulative survival after LV reconstruction surgery calculated from 62 published reports (*n* = 12,331 patients) that reported on early mortality and 47 published reports following 8571 patients for a median of 49 months (25th, 75th percentile = 23, 62 months). Cumulative 1-, 5- and 10-year survival were 88.5%, 71.5% and 53.9%, respectively. Straight line: weighted average cumulative survival; dotted lines: 95% confidence intervals.

3.2. Different surgical techniques versus early and late mortality

The different techniques for LV reconstruction surgery, reported between January 1980 and January 2005, can be grouped into five main types of surgery: (1) direct reconstruction of the LV wall using a circular patch, (2) endoventricular reconstruction of the LV with or without the use of an endoventricular patch (EVR) as described by Jatene and Dor [9,60], (3) linear repair, (4) linear repair with septoplasty as described by Mickleborough et al. [5] and (5) septo-exclusion technique as described by Guilmet et al. [7] and Stoney et al. [6]. Fig. 2 shows the summary estimates of the relative risks for the different surgical techniques for early mortality. Comparing the two main techniques, EVR shows a reduced risk for early mortality (RR = 0.79, $p = 0.002$) compared to the linear repair (RR = 1.38, $p < 0.001$). In Fig. 3, the summary estimates of the relative risks for the different surgical techniques are shown for late mortality. Again, considering the two main techniques EVR shows a significantly reduced risk on late mortality (RR = 0.67, $p < 0.001$) compared to linear repair (RR = 1.83, $p < 0.001$).

Type of Surgery	Death/ Total *n*	RR	95% CI	p value
Circular	40 / 880	0.60	(0.44 – 0.81)	0.001
EVR	237 / 3,759	0.79	(0.68 – 0.92)	0.002
Linear	416 / 4,769	1.38	(1.21 – 1.58)	<0.0001
Linear with septoplasty	96 / 1,265	1.03	(0.84 – 1.27)	0.77
Septo-exclusion	8 / 117	0.93	(0.47 – 1.81)	0.82
Pooled Deaths	797 / 10,790			

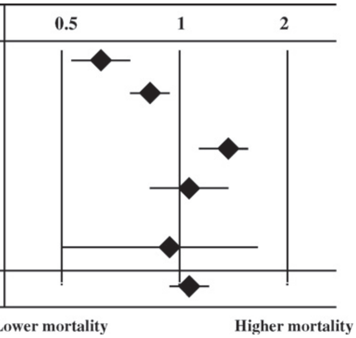

Fig. 2. Summary estimates of the relative risks for the different surgical techniques for early mortality. Comparing the two main techniques, EVR showed a reduced risk for early mortality (RR = 0.79, $p = 0.002$) compared to the linear repair (RR = 1.38, $p < 0.001$). LVRS: LV reconstruction surgery; Circular: direct reconstruction of LV wall using a circular patch; EVR: endoventricular reconstruction of the LV with or without a patch; linear: linear repair; linear with septoplasty: linear repair with a plasty of the interventricular septum; septo-exclusion: septo-exclusion technique.

Type of Surgery	Death/ Total *n*	RR	95% CI	p value
Circular	53 / 309	0.72	(0.56 – 0.93)	0.007
EVR	625 / 3,379	0.67	(0.61 – 0.73)	<0.0001
Linear	903 / 2,772	1.83	(1.68 – 1.98)	<0.0001
Linear with septoplasty	117 / 756	.634	(0.53 – 0.75)	<0.0001
Septo-exclusion	3 / 29	0.44	(0.15 – 1.29)	0.095
Pooled Deaths	1,701 / 7,245			

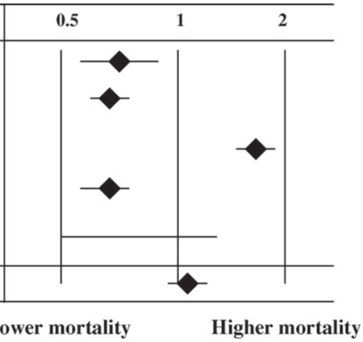

Fig. 3. Summary estimates of the relative risks for the different surgical techniques for late mortality. Comparing the two main techniques, EVR showed a significantly reduced risk on late mortality (RR = 0.67, $p < 0.001$) compared to the linear repair (RR = 1.83, $p < 0.001$). LVRS: LV reconstruction surgery; Circular: direct reconstruction of LV wall using a circular patch; EVR: endoventricular reconstruction of the LV with or without a patch; linear: linear repair; linear with septoplasty: linear repair with a plasty of the interventricular septum; septo-exclusion: septo-exclusion technique.

3.3. Causes of early and late mortality in LV reconstruction surgery

A total of 20 studies (*n* = 3729 patients) were identified that specified causes of early mortality. In Table 1, the causes of early mortality are shown. Early mortality was mainly cardiac in origin (84.7%), with as predominant cause heart failure in 49.7% of the cases. Ventricular arrhythmias were responsible for 16.5% of early mortality.

Table 1

Causes of early mortality after LVRS (20 studies, *n* = 3729 patients)

Cause of death	No. of patients	% of cardiac early mortality	% of total early mortality
Cardiac early mortality	261		84.7
Heart failure/LCO	153	58.6	49.7
VT/VF	51	19.5	16.6
AMI	34	13.0	11.0
Other	23	8.8	7.5
Non-cardiac early mortality	47		15.3
Total early mortality	308		

Early mortality was mainly cardiac in origin (84.7%), with as predominant cause heart failure in 49.7% of the cases. Ventricular arrhythmias were responsible for 16.6% of early mortality.

LCO: low cardiac output; VT/VF: ventricular tachycardia/ventricular fibrillation; AMI: acute myocardial infarction.

A total of 13 studies (*n* = 2702 patients) were identified that specified causes of late mortality. In Table 2, the causes of late mortality are summarized. Late mortality was also mainly cardiac in origin (70.2%). Heart failure constituted 34.5% and ventricular arrhythmias 17.2% of the late deaths. In 12.6% of late deaths, the cause was unknown.

Table 2

Causes of late mortality after LVRS (13 studies, *n* = 2702 patients)

Cause of death	No. of patients	% of cardiac late mortality	% of total late mortality
Cardiac late mortality	368		70.2
Heart failure/LCO	181	49.2	34.5
VT/VF	90	24.5	17.2
AMI	88	23.9	16.8
Other	9	2.5	1.7
Non-cardiac late mortality	90		17.2
Unknown	66		12.6
Total late mortality	524		

Late mortality was also mainly cardiac in origin (70.2%). Heart failure constituted 34.5% and ventricular arrhythmias 17.2% of the late death. In 12.6% of late deaths, the cause was unknown.

LCO: low Cardiac output; VT/VF: ventricular tachycardia/ventricular fibrillation; AMI: acute myocardial infarction.

3.4. Concomitant surgical procedures potentially influencing mortality

Seven studies (1525 patients) reported on concomitant CABG and early mortality in LV reconstruction surgery, and three studies (497 patients) reported on concomitant CABG and late mortality. Concerning concomitant mitral valve surgery (mitral valve repair or replacement): eight studies (524 patients) reported on early mortality in LV reconstruction surgery, two studies (84 patients) reported on late mortality. In Fig. 4, the summary estimates of the relative risks for concomitant CABG and mitral valve surgery for both early and late mortality are provided. Concomitant CABG was not associated with an increased risk for early mortality (RR = 1.018, $p = 0.858$), but was associated with a significantly lower risk for late mortality (RR = 0.28, $p < 0001$). Concomitant mitral valve surgery was associated with both an increased risk for early (RR = 1.57, $p = 0.001$) and late mortality (RR = 4.28, $p < 0.001$).

Concomitant Surgery			Pooled *n*	RR	p value
MVR	Operative mortality	56 / 524	842 / 12,331	1.57	0.001
CABG	Operative mortality	56 / 524	842 / 12,331	1.018	.858
MVR	Late mortality	81 / 84	1,556 / 6,905	4.28	0.000
CABG	Late mortality	30 / 477	1,556 / 6,905	0.28	0.000

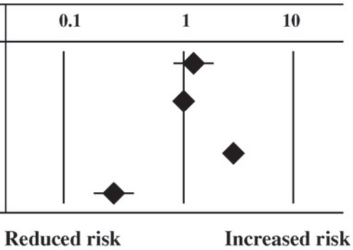

Fig. 4. Comparison of left ventricular reconstruction surgery with concomitant CABG or mitral valve surgery on early (inhospital or 30-day mortality) and late (5-year) mortality. Concomitant CABG was not associated with an increased risk for early mortality (RR = 1.018, $p = 0.858$), but was associated with a significantly lower risk for late mortality (RR = 0.28, $p < 0001$). Concomitant mitral valve surgery was associated with both an increased risk for early (RR = 1.57, $p = 0.001$) and late mortality (RR = 4.28, $p < 0.001$). MVR: mitral valve surgery (repair or replacement); CABG: coronary artery bypass grafting.

3.5. Factors potentially influencing mortality

The following parameters were evaluated: mean age, gender, interval post myocardial infarction, LVEF, LVEDVI, LVESVI, LVEDD and LVESD. None of the parameters were significantly related to early or late mortality. In particular, LVEF and indexed LV volumes were not related to early or late mortality.

3.6. Heart failure

Fourteen of the 62 (22.6%) reports included LV reconstruction surgery in patients with heart failure, with a total of 4135 patients. The pooled, median and average weighted early mortality patients with heart failure were 5.2%, 12.9% and 11.6%, respectively. Ten studies (802 patients) also reported on late mortality after LV reconstruction surgery showing a pooled, median and average weighted late mortality at 3-year follow-up of 15.7%, 14.7% and 15.7%, respectively (Fig. 5). Eight studies (n = 2376 patients) reported on EVR and early mortality in ischemic heart failure patients, four studies (1045 patients) reported on linear repair and early mortality in ischemic heart failure patients. Comparison of these two techniques for the relative risk of early mortality, revealed a significantly reduced risk for early mortality with EVR (RR = 0.66, p = 0.004, Fig. 6). There were no statistical significant relationships for any of the parameters postulated to possibly influence early and late mortality.

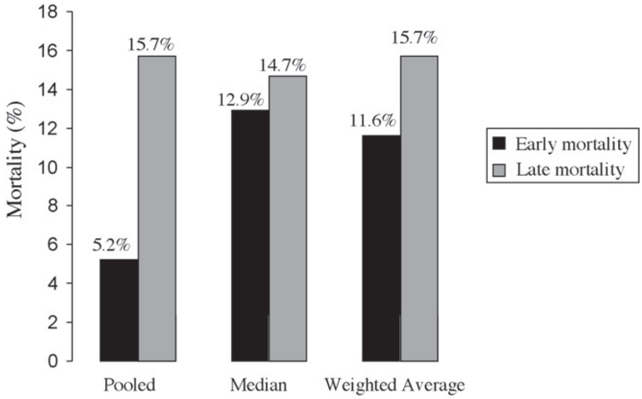

Fig. 5. Early (inhospital or 30-day mortality) and late (3-year) mortality in patients with heart failure. The pooled, median and average weighted early mortality (14 studies, n = 4135 patients) were 5.2%, 12.9% and 11.6%, respectively. The pooled, median and average weighted late mortality (10 studies, n = 802 patients) were 15.7%, 14.7% and 15.7%, respectively.

EVR	Linear repair	RR	95% CI	p value
135 / 3,005	71 / 1,045	0.66	(0.50 – 0.87)	0.004

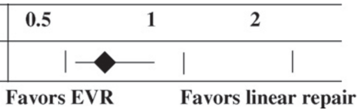

Fig. 6. Summary estimates of the relative risk for EVR (8 studies, n = 2376 patients) versus linear repair technique (4 studies, n = 1045 patients) in patients with heart failure. EVR shows a significantly reduced risk for early mortality (RR = 0.66, p = 0.004). EVR: endoventricular reconstruction of the LV with or without a patch; linear: linear repair.

4. DISCUSSION

In this pooled analysis of available studies in the literature, we found that surgical treatment of a LV aneurysm has an acceptable early mortality of 6.9% and a good longterm outcome (10-year survival 53.9%). This compared favorably to the natural history of LV aneurysms with a reported 5-year survival of 12% to 47% [76,77]. Improved medical treatment of ischemic heart disease has since then undoubtedly improved survival and delayed hemodynamic decompensation, but survival in patients with a LV aneurysm is still limited. Faxon et al. demonstrated in the Coronary Artery Surgery Study (CASS) that patients with a LV aneurysm and three-vessel coronary artery disease and patients with clinical heart failure have improved survival with surgical therapy [74]. To date there have been no results from prospective randomized controlled trials comparing modern medical and surgical treatment. Historically, only a few patients with heart failure were considered for cardiac surgery in the absence of a clear need for coronary revascularization or valve repair or replacement. Indications for LV reconstruction have evolved over time from aneurysmectomy for thromboembolic complications or progressively enlarging aneurysms to LV reconstruction for improvement of ventricular function in the treatment of heart failure. One third of patients included in the current analysis were operated for heart failure (14 studies, 4135 patients). In this group we noted an early mortality of 11.0% with a late mortality (3-year) of 15.2%. Tertiary referral centers for cardiovascular care with large experience in LV reconstruction surgery for heart failure, like the Centre Cardio-Thoracique in Monaco and the San Donato Hospital in Milan, reported an early mortality ranging between 10% and 13% with survival at 3 years ranging from 62.7% to 77.2% [28,39,89]. It is noteworthy in this respect that the ‘realworld’ application of LV reconstruction surgery, as reported by Hernandez et al. in their study from the data of the STS National Cardiac Database shows higher operative risks, especially in specific subgroups of patients [95].

4.1. Surgical techniques and mortality

Comparing the two most used and reported techniques, endoventricular reconstruction of the LV with or without a patch (EVR) and linear repair, EVR shows a significantly reduced risk for early mortality (RR = 0.79, $p = 0.002$). The linear repair technique cannot exclude the septal scar, and also carries the risk of creating a restrictive residual LV cavity, especially in large aneurysms, leading to diastolic dysfunction and LV failure [27,78,79]. Sizing of the residual LV cavity in EVR, either by an intracavitary balloon or a commercially available shaper device to a volume of 50—60 ml/m^2 BSA avoids creating a residual LV cavity that is restrictive [9,29,39]. Another explanation for EVR to show better results could be that EVCPP patients were operated in a more recent era with improved myocardial protection, anesthesiological techniques, and perioperative care. Because of the limited number of patients in the currently available reports, the relative risks for early mortality calculated for the linear repair with septoplasty, and the septo-exclusion techniques did not reach statistical significance. The reconstruction of the LV wall using a circular patch did however show a significantly reduced risk for early mortality (RR = 0.60, $p = 0.001$), but again patient numbers for this technique are limited. In the meta-analysis by Parolari et al. concerning the early outcomes following different LV reconstruction techniques, the authors also concluded that geometric reconstruction carries a reduced risk for early mortality compared to linear repair [90]. In contrast, in a sub-analysis comparing geometric and linear reconstruction techniques that were carried out in the same time lag, a difference in early mortality could not be demonstrated. Mukaddirov et al. recently published a study advocating a tailored approach (linear or patch plasty repair) in LVR depending on the specific anatomy of individual patients [99].

In the current pooled analysis, EVR also showed a significantly reduced risk for late mortality (RR = 0.67, $p < 0.0001$). Possibly, the complete exclusion of the septal scar and the more anatomical reconstruction leading to a more efficient myocardial fiber orientation and systolic function contributed to this reduction in late mortality [9,80]. Also the fact that grafting the left anterior descending coronary artery is more feasible in the EVR technique and may play a role [11,81,78]. The linear repair with septoplasty and direct reconstruction of the LV wall using a circular patch also both showed a significantly reduced risk for late mortality (RR = 0.72, $p = 0.007$ and RR = 0.63, $p < 0.0001$, respectively), but for both techniques available patient numbers are limited.

The factors that may have contributed to the reduced risk for mortality with the EVR technique in the pooled analysis of all patient categories may be even more important in patients with heart failure. Generally, these patients often have severely enlarged LV volumes, associated with depressed contractile function of the remote myocardium [88,89]. Indeed, we noted that in heart failure patients both early and late mortality were less with the EVCPP technique.

4.2. Fatal-failure modes of LVR

It was noted that 50% of early deaths and 30% of late deaths were caused by heart failure. With respect to the technique of reconstructing the LV cavity, three possible explanations exist for early and late LV failure: first, the aforementioned problem of creating a restrictive residual LV cavity, leading to diastolic dysfunction and LV failure; second, leaving a too large residual LV cavity only partially reverses the remodeling process and may lead to redilatation of the left ventricle. Also a residual large akinetic area has been mentioned as possible cause for redilatation. Ueno et al. demonstrated redilatation and increasing sphericity after Dor- and SAVE-procedures at intermediate follow-up, resulting in increased wall tension with reduced compliance as possible causes for late heart failure [92]. Raman et al. associated the use of a stiff and relatively big patch in EVR as cause for some adverse long-term outcomes [94]. Patch size, shape and orientation may prove to be important in preventing adverse ventricular remodeling over time, as Cirillo et al. have shown in a small group with an EVR technique using a small, obliquely oriented and oval-shaped patch [93]. Third, insufficient residual remote myocardium to survive the procedure and to translate the surgically induced morphological changes to functional improvement leads to LV failure. No data are available on preoperative assessment of the functional capacity of the remote myocardium and used as predictor of outcome after LV reconstruction surgery.

Early and late mortality due to ventricular arrhythmias in this study were 16.5% and 17.2%, respectively (of note, it is unknown whether these patients already had ventricular arrhythmias preoperatively). Early ventricular arrhythmias after LV reconstruction surgery can be ascribed to electrolyte abnormalities, tissue edema and inflammation. Late ventricular arrhythmias have been related to ventricular dilatation with high wall stress and stretch [96]. It has been postulated that LV reconstruction surgery due to volume reduction reduces arrhythmogenicity. Exclusion of the myocardial scar, concomitant complete revascularization and mechanical resynchronization further reduces the trigger for electrical instability and may render the need for an implantable cardioverter-defibrillator (ICD) unnecessary [96,97]. Some authors like Dor et al. [79] and Mickleborough et al. [5] advocate routine use of concomitant endocardiectomy of the border zone of viable and non-viable myocardium and cryotherapy to further decrease the risk of ventricular arrhythmias. These authors have reported a low late incidence of ventricular arrhythmias with this strategy. The relatively high incidence of death due to ventricular arrhythmias observed in the present pooled analysis raises the question whether LV reshaping with volume reduction, scar exclusion and revascularization is sufficient antiarrhythmogenic to make adjunctive device therapy of little use. O'Neill et al. demonstrated a high incidence of ventricular arrhythmias after LV reconstruction surgery and advocate the use of predischarge electrophysiological studies and/or ICD implantation before hospital discharge [98]. More studies are needed to clarify the need for device therapy after LV reconstruction surgery.

4.3. Concomitant surgical procedures potentially influencing mortality

We found that concomitant myocardial revascularization with LV reconstruction surgery improved late survival without increasing the risk for early mortality. Besides symptomatic relief of angina, revascularization of viable, remote myocardium in non-scarred segments may improve compensatory contractile function [82]. Also, revascularization of the proximal left anterior descending coronary artery to improve septal perfusion may contribute favorably [11]. Another contributing factor could be that revascularization further reduced the risk for late ventricular arrhythmias. These factors probably outweigh the increase in operative and extracorporal circulation time and thus did not result in higher early mortality. This finding underlines the importance of (complete) revascularization in these patients.

Concomitant mitral valve surgery, whether repair or replacement, shows an increased risk for early (RR = 1.57, $p = 0.001$) and late mortality (RR = 4.28, $p < 0.001$). In patients with previous anterior myocardial infarction, functional mitral regurgitation occurs mainly in the setting of LV dilatation, with tethering of the mitral valve leaflets, displacement of the subvalvular apparatus and dilatation of the mitral annulus causing secondary incompetence of the mitral valve. Functional mitral regurgitation therefore mainly reflects a more advanced stage of disease, and has been shown to be associated with an increased mortality, independent of the degree of underlying LV dysfunction [85—87]. The need for mitral valve surgery in LV reconstruction surgery is therefore an index of gravity. This is by no means an argument not to perform mitral valve surgery in these patients, since mitral regurgitation-related volume overload has been shown to promote further LV remodeling and progression of heart failure. Correcting mitral regurgitation improves clinical functional class and may prevent LV redilatation [39,72,91]. However, this analysis does not permit any conclusion on the benefits of mitral valve surgery, since no comparison between treated and non-treated patients was available in the literature.

4.4. Factors potentially influencing mortality

Besides the surgical technique and concomitant procedures, a number of parameters have been traditionally identified that influence early and late mortality. A low LVEF has been reported in earlier reports to be a predictor of higher early and late mortality [12,49,51,80]. The observation that LV dilatation is more closely related to outcome than (decreased) LVEF was first described by White at al., showing the correlation between increased LV volumes after myocardial infarction with increased mortality [83]. This work was subsequently confirmed by DiDonato et al. and Dor et al. for ventricular restoration procedures [26].

These authors have published that mortality after EVR procedures increased with larger preoperative LV volumes, irrespective of baseline LVEF [82]. Interestingly, we could neither confirm the relationship of LVEF with mortality, nor that of LV volumes in the current pooled analysis. An important explanation for this phenomenon may be the heterogeneity in the functional capacity of the residual remote myocardium. Since stroke volume is relatively constant at rest, LVEF is mainly determined by the LV enddiastolic volume. If the LVend-diastolic volume is large due to a localized (dyskinetic) scar tissue, the improvement in LVEF after a LVR procedure will parallel improvement in function. On the other hand, if the LV end-diastolic volume is large due to remodeling or cardiomyopathy, a reduction will not be accompanied by improvement in LV function. Therefore neither LVEF, nor LV volumes per se can predict improvement in LV function and outcome [84]. The failure of LVEF, LV volumes, age, gender and time interval post-myocardial infarction in predicting outcome, questions the use of these parameters in risk stratification for these patients. Newer models using advanced imaging techniques that can test for the functional capacity of the remote myocardium, like (contrast-enhanced) magnetic resonance imaging or (3D) echocardiographically derived wall motion score indexes, may prove useful for improved risk stratification.

5. LIMITATIONS

A pooled analysis, when well designed and appropriately performed, is a powerful tool to combine in a single conclusion the results of different studies conducted on the same topic. Random effect models were used to control for within-study and between-study variability (random effects modeling). In addition, meta-regression analysis was used to adjust for the influence of patient demographics and prognostic indicators that covaried with the dependent variable. Despite the advantages of a pooled analysis, such as increased statistical power of a comparison and improved estimation of the effect of a treatment, several limitations of the current analysis should be addressed. Publication bias may have influenced our results, since observational studies with a poor outcome may not have been published in fulllength papers. Second and most important, surgical techniques and approaches have improved over time, which affects the current results. Third, since to date no prospectively randomized controlled trials have been published concerning LV reconstruction surgery, all studies included in this analysis were observational reports.

REFERENCES

[1] Gaudron P, Eilles C, Ertl G, Kochsiek K. Compensatory and non-compensatory left ventricular dilatation after myocardial infarction: time course and hemodynamic consequences at rest and during exercise. Am Heart J 1992;123:377—85.

[2] Di Donato M, Sabatier M, Dor V, Toso A, Maioli M, Fantini F. Akinetic versus dyskinetic postinfarction scar: relation to surgical outcome in patients undergoing endoventricular patch plasty repair. J Am Coll Cardiol 1997; 29:1569—75.

[3] Likoff W, Bailey CP. Ventriculoplasty: excision of myocardial aneurysm. Report of a successful case. JAMA 1955;158:915—20.

[4] Cooley DA, Collins HA, Morris GC, Chapman DW. Ventricular aneurysm after myocardial infarction: surgical excision with the use of temporary cardiopulmonary bypass. JAMA 1958;167:557—60.

[5] Mickleborough LL, Carson S, Ivanov J. Repair of dyskinetic or akinetic left ventricular aneurysm: results obtained with a modified linear closure. J Thorac Cardiovasc Surg 2001;121:675—82.

[6] Stoney WS, Alford Jr WC, Burrus GR, Thomas Jr CS. Repair of anteroseptal ventricular aneurysm. Ann Thorac Surg 1973;15:394—404.

[7] Guilmet D, Popoff G, Dubois C, Tawil N, Bachet J, Goudot B, Guermonprez JL, Brodaty D, Schlumberger S. Nouvelle technique chirurgicale pour la cure des aneurysmes du ventricle gauche. Archivie des maladie du coeur 1984;77:953—8.

[8] Dor V, Kreitmann P, Jourdan J. Interest of ‘‘physiological’’ closure (circumferential plasty on contractile areas) of left ventricle after resection and endocardectomy for aneurysm or akinetic zone: comparison with classical technique about a series of 209 left ventricular resections [abstract]. J Cardiovasc Surg 1985;26:73.

[9] Dor V, Saab M, Coste P, Kornazewska M, Montiglio F. Left ventricular aneurysm: new surgical approach. J Thorac Cardiovasc Surg 1989;37: 11—9.

[10] Sinatra R, Macrina F, Braccio M, Melina G, Luzi G, Ruvolo G, Marino B. Left ventricular aneurysmectomy: comparison between two techniques; early and late results. Eur J Cardiothorac Surg 1997;12:291—7.

[11] Lundblad R, Abdelnoor M, Svennevig JL. Surgery for left ventricular aneurysm: early and late survival after simple linear repair and endoventricular patch plasty. J Thorac Cardiovasc Surg 2004;128:449—56.

[12] Tavakoli R, Bettex D, Weber A, Brunner H, Genono M, Pretre R, Jenni R, Turina M. Repair of postinfarction dyskinetic LV aneurysm with either linear or patch technique. Eur J Cardiothorac Surg 2002;22: 129—34.

[13] Calafiore AM, Gallina S, Di Mauro M, Pano M, Teodori G, Di Giammarco G, Contini M, Iaco` AL, Vitolla G. Left ventricular aneurysmectomy: endoventricular circular patch plasty or septoexclusion. J Card Surg 2003; 18:93—100.

[14] Doss M, Martens S, Sayour S, Hemmer W. Long term follow up of left ventricular function after repair of left ventricular aneurysm. A comparison of linear closure versus patch plasty. Eur J Cardiothorac Surg 2001; 20:783—5.

[15] Vural KM, Sener E, Ozatik MA, Tas¸demir O, Bayazit K. Left ventricular aneurysm repair: an assessment of surgical treatment modalities. Eur J Cardiothorac Surg 1998;13:49—56.

[16] Akins CW. Resection of left ventricular aneurysm during hypothermic fibrillatory arrest without aortic occlusion. J Thorac Cardiovasc Surg 1986;91:610—8.

[17] Alloni A, Rinaldi M, Gazzoli F. Left ventricular aneurysm resection with port-access surgery: a new mini-invasive surgical approach. Ann Thorac Surg 2003;75:786—9.
[18] Athanasuleas CL, Buckberg GD, Stanley AW, Siler W, Dor V, Di Donato M, Menicanti L, Almeida de Oliveira S, Beyersdorf F, Kron IL, Suma H, Kouchoukos NT, Moore W, McCarthy PM, Oz MC, Fontan F, Scott ML, Accola KA, RESTORE group. Surgical ventricular restoration in the treatment of congestive heart failure due to post-infarction ventricular dilatation. J Am Coll Cardiol 2004;44:1439—45.
[19] Barratt-Boyes BG, White HD, Agnex TM, Pemberton JR, Wild CJ. The results of surgical treatment of left ventricular aneurysm: an assessment of risk factors affecting early and late mortality. J Thorac Cardiovasc Surg 1984;89:87—8.
[20] Matthias Bechtel JF, To¨lg R, Graf B, Richardt G, Noetzold A, Kraatz EG, Sievers HH, Bartels C. High incidence of sudden death late after anterior LV-aneurysm repair. Eur J Cardiothorac Surg 2004;25:807—11.
[21] Brawley RK, Magovern Jr GJ, Gott VL, Donahoo Js, Gardner TJ, Watkins Jr L. Left ventricular aneurysmectomy: factors influencing postoperative results. J Thorac Cardiovasc Surg 1983;85:712—7.
[22] Cherniavsky AM, Karaskov AM, Marchenko AV, Mikova NV. Preoperative modelling of an optimal left ventricle volume for surgical treatment of ventricular aneurysm. Eur J Cardiothorac Surg 2001;21:777—82.
[23] Coltharp WH, Hoff SJ, Stoney WS, Alford Jr WC, Burrus GR, Glassford Jr DM, Lea 4th JW, Petracek MR, Starkey TD, Shuman TA. Ventricular aneurysmectomy: a 25- year experience. Ann Surg 1994;219:707—14.
[24] Couper GS, Bunton RW, Birjiniuk V, DiSesa VJ, Fallon MP, Collins Jr JJ, Cohn LH. Relative risks of left ventricular aneurysmectomy on patients with akinetic scars versus true dyskinetic aneurysms. Circulation 1990;82(Suppl. IV):IV248—56.
[25] Crosby IK, Wellons HA, Martin RP, Schuch D, Muller Jr WH. Employability. A new indication for aneurysmectomy and coronary revascularization. Circulation 1980;62(Suppl. I):I79—83.
[26] Di Donato M, Toso A, Maioli M, Sabatier M, Stanely Jr AW, Dor V, RESTORE Group. Intermediate survival and predictors of death after surgical ventricular restoration. Semin Thorac Cardiovasc Surg 2001;13:468—75.
[27] Di Mattia DG, Di Biasi P, Salati M, Mangini A, Fundaro` P, Santoli C. Surgical treatment of left ventricular post-infarction aneurysm with endoventriculoplasty: late clinical and functional results. Eur J Cardiothorac Surg 1999;15:413—8.
[28] Dor V. The endoventricular circular patch plasty (''Dor procedure'') in ischemic akinetic dilated ventricles. Heart Fail Rev 2001;6:187—93.
[29] Fundaro P, Pocar M, Marchetto G, Moneta A, Mattioli R, Donatelli F, Grossi A. Early surgical anteroseptal ventricular endocardial restoration after acute myocardial infarction. Pathophysiology and surgical considerations. Ital Heart J 2003;4:252—6.
[30] Grossi EA, Chinitz LA, Galloway AC, Delianides J, Schwartz DS, McLoughlin DE, Keller N, Kronzon I, Spencer FC, Colvin SB. Endoventricular remodeling of left ventricular aneurysm: functional, clinical and electrophysiological results. Circulation 1995;92(Suppl. I):II98—100.
[31] Isomura T, Suma H, Yamaguchi A, Kobashi T, Yuda A. Left ventricular restoration for ischemic cardiomyopathy — comparison of presence and absence of mitral valve procedure. Eur J Cardiothorac Surg 2003;23:614—9.

[32] Jais JM, Marchand M, de Riberolles C, Dubuis C, Neveux JY, Hazan E. Surgery of post-myocardial infarction scar: early and late results in 70 patients. Br Heart J 1980;43:436.

[33] Kokaji K, Shin H, Hotoda K, Mori M, Kumamaru H, Yozu R. Changes in left ventricular volume and predictors of cardiac events after endoventricular circular patch plasty. Jpn J Thorac Cardiovasc Surg 2004;52:551—9.

[34] Komeda M, David TE, Malik A, Ivanov J, Sun Z. Operative risks and longterm results of operation for left ventricular aneurysm. Ann Thorac Surg 1992;53:22—8.

[35] Lee GT, Newton MC, Crosby IK, Burwell LR, Wellons HA. Evaluating candidates for ventricular aneurysmectomy. South Med J 1980;73. p. 611—4, 617.

[36] Louagie Y, Alouini T, Lesperance J, Pelletier LC. Left ventricular aneurysm complicated by congestive heart failure: an analysis of long term results and risk factors of surgical treatment. J Cardiovasc Surg (Torino) 1989;30: 648—55.

[37] Magovern GJ, Sakert T, Simpson K, Laub GW, Park SB, Liebler G, Burkholder J, Maher T, Benckart D, Magovern Jr GJ. Surgical therapy for left ventricular aneurysm: a ten years' experience. Circulation 1989;79(Suppl.): I102—7.

[38] Maxey TS, Reece TB, Ellman PI, Butler PD, Kern JA, Bosch X, Lesperance J, Pelletier LC, Kron IL. Coronary artery bypass with ventricular restoration is superior to coronary artery bypass alone in patients with ischemic cardiomyopathy. J Thorac Cardiovasc Surg 2004;127:428—34.

[39] Menicanti L, Di Donato M, Frigiola A, Buckberg G, Santambrogio C, Ranucci M, Santo D, RESTORE Group. Ischemic mitral regurgitation: intraventricular papillary muscle imbrication without mitral ring during left ventricular restoration. J Thorac Cardiovasc Surg 2002;123:1041—50.

[40] Mickleborough LL, Merchant N, Ivanov J, Rao V, Carson S. Left ventricular reconstruction: early and late results. J Thorac Cardiovasc Surg 2004;128: 127—37.

[41] Novick RJ, Stefaniszyn HJ, Morin JE, Symes JF, Sniderman AD, Dobell AR. Surgery for postinfarction left ventricular aneurysm. Prognosis and longterm follow-up. Can J Surg 1984;27:161—7.

[42] Olearchyk AS, Lemole GM, Spagna PM. Left ventricular aneurysm: ten years' experience in surgical treatment of 244 cases. Improved clinical status, hemodynamics, and long-term longevity. J Thorac Cardiovasc Surg 1983;88:544—53.

[43] Pasini S, Gagliardotto P, Punta G, Del Ponte S, Serra M, Parisi F, Ottino G, Di Summa M. Early and late results after surgical therapy of postinfarction left ventricular aneurysm. J Cardiovasc Surg 1998;39:209—15.

[44] Ratcliffe PJ, Kay P, Oldershaw PJ, Dawkins K, Cotter L, Lennox SC, Paneth M. Long- term survival following left ventricular aneurysmectomy. J Cardiovasc Surg 1983;24:461—6.

[45] Reddy SB, Cooley DA, Duncan JM, Norman JC. Left ventricular aneurysm: twenty-year surgical experience with 1572 patients at the Texas Heart Institute. Cardiovasc Dis Bull Tex Heart Inst 1981;8:165.

[46] Salati M, Di Biasi P, Paje A, Santoli C. Left ventricular geometry after endoventriculoplasty. Eur J Cardiothorac Surg 1993;7:574—9.

[47] Sosa E, Scanavacca M, d'Avila A, Fukushima J, Jatene A. Long-term results of visually guided left ventricular reconstruction as single therapy to treat ventricular tachycardia associated with postinfarction anteroseptal aneurysm. J Cardiovasc Electrophysiol 1998;9:1133—43.

[48] Suzer K, Yorgancioglu C, Gunaydin S, Tokmakoglu H, Tezcaner T. Surgical management of left ventricular aneurysms by endoventricular pericardial patch plasty. Cardiovasc Surg 2002;10:216—21.

[49] Ural E, Yuksel H, Pehlivanoglu S, Bakay C, Olga R. Short and long term survival of surgical treatment of left ventricular aneurysms. Ten years experience. Jpn Heart J 2002;43:379—87.

[50] Vauthey JN, Berry DW, Snyder DW, Gilmore JC, Sundgaard-Riise K, Mills NL, Ochsner JL. Left ventricular aneurysm repair with myocardial revascularization: an analysis of 246 consecutive patients over 15 years. Ann Thorac Surg 1988;46:29—35.

[51] Vicol C, Rupp G, Fischer S, Summer C, Dietrich Bolte H, Struck E. Linear repair versus ventricular reconstruction for the treatment of left ventricular aneurysm: a 10-year experience. J Cardiovasc Surg 1998;39:461—8.

[52] Wright JS, Stacey RB, Albrecht H, Murton MM. Left ventricular aneurysm surgery: determinants of results. J Thorac Cardiovasc Surg 1987;28:85—8.

[53] Yamaguchi A, Adachi H, Kawahito K, Murata S, Ino T. Left ventricular reconstruction benefits patients with dilated ischemic cardiomyopathy. Ann Thorac Surg 2005;79:456—61.

[54] Bolooki H, DeMarchena E, Mallon SM, Katariya K, Barron M, Bolooki HM, Thurer RJ, Novak S, Duncan RC. Factors affecting late survival after surgical remodeling of left ventricular aneurysms. J Thorac Cardiovasc Surg 2003;126:374—83.

[55] Castiglioni A, Quarti A, Schreuder J, Blasio A, Benussi S, Torracca L, Maisano F, Alfieri O. Surgical restoration of the left ventricle for postinfarction aneurysm. Ital Heart J 2002;3:370—4.

[56] Cooley DA, Frazier OH, Duncan JM, Reul GJ, Krajcer Z. Intracavitary repair of ventricular aneurysm and regional dyskinesia. Ann Surg 1992;215:417—23.

[57] Cosgrove DM, Lytle BW, Taylor PC, Stewart RW, Golding LA, Mahfood S, Goormastic M, Loop FD. Ventricular aneurysm resection: trends in surgical risk. Circulation 1989;79(Suppl. I):I-97—101.

[58] Cotrufo M, Romano GP, De Santo LS, Della Corte A, Amarelli C, Cafarella G, Maiello C, Scardone M. Treatment of extensive ischemic cardiomyopathy: quality of life following two different surgical strategies. Eur J Cardiothorac Surg 2005;27:481—7.

[59] Gonzalez-Santos JM, Ennabli K, Galinanes M, Bosch X, Lesperance J, Pelletier LC. Surgical treatment of the post infarction left ventricular aneurysm. Factors influencing early and late results. J Thorac Cardiovasc Surg 1985;33:86—93.

[60] Jatene AD. Left ventricular aneurysmectomy: resection or reconstruction. J Thorac Cardiovasc Surg 1985;89:321—31.

[61] Jones EI, Craver JM, Hurst JW, Bradford JA, Bone DK, Robinson PH, Cobbs BW, Thompkins TR, Hatcher Jr CR. Influence of left ventricular aneurysm on survival following coronary bypass operations. Ann Surg 1981;193: 733—41.

[62] Kaza AK, Patel MR, Fiser SM, Long SM, Kern JA, Tribble CG, Kron IL. Ventricular reconstruction results in improved left ventricular function and amelioration of mitral insufficiency. Ann Surg 2002;235:828—32.

[63] Mangschau A, Simonsen S, Abdelnoor M, Laake B, Geiran O. Evaluation of left ventricular aneurysm resection: a prospective study of clinical and hemodynamic characteristics. Eur J Cardiothorac Surg 1989;3:58—64.

[64] Marchenko AV, Cherniavsky AM, Volokitina TL, Alsov SA, Karaskov AM. Left ventricular dimension and shape after postinfarction aneurysm repair. Eur J Cardiothorac Surg 2005;27:475—80.

[65] Parrino PE, Kron IL, RESTORE Group. The role of left ventricular reconstruction for cardiogenic shock. Semin Thorac Cardiovasc Surg 2001;13: 476—9.

[66] Prates PR, Homsi Neto A, Lovato LM, Teiseira GF, Sant'Anna JR, Yordi LM, Kalil RA, Nesralla IA. Late results of endoventricular patch plasty repair in akinetic and dyskinetic areas after acute myocardial infarction. Arq Bras Cardiol 2002;79:107—16.

[67] Raman J, Dixit A, Storer M, Hare D, Buxton BF. Geometric endo-ventricular patch repair of inferior left ventricular scars improves mitral regurgitation and clinical outcome. Ann Thorac Surg 2001;72:S1055—8.

[68] Roscitano A, Capuano F, Simon C, Filippelli S, Mazzesi G, Tonelli E, Sinatra R. Left ventricular aneurysm repair: early survival. Ital Heart J 2005;6: 143—9.

[69] Sartipy U, Alba°ge A, Lindblom D. The Dor procedure for left ventricular reconstruction. Ten-year clinical experience. Eur J Cardiothorac Surg 2005;27:1005—10.

[70] Silveira WL, Leite AF, Soares EC, Nery MW, Carneiro AF, Oliveira VG. Shortterm follow-up of patients after aneurysmectomy of the left ventricle. Arq ras Cardiol 2000;75:401—4.

[71] Kawata T, Kitamura S, Kawachi K, Morita R, Yoshida Y, Hasegawa J. Systolic and diastolic function after patch reconstruction of left ventricular aneurysms. Ann Thorac Surg 1995;59:403—7.

[72] Qin JX, Shiota T, McCarthy PM, Asher CR, Hail M, Agler DA, Popovic´ ZB, Greenberg NL, Smedira NG, Starling RC, Young JB, Thomas JD. Importance of mitral valve repair associated with left ventricular reconstruction for patients with ischemic cardiomyopathy: a real-time threedimensional echocardiographic study. Circulation 2003;108(Suppl. 1): II241—6.

[73] Salati M, Di Biasi P, Paje A, Cialfi A, Bozzi G, Santoli CL. Functional results of left ventricular reconstruction. Ann Thorac Surg 1993;53:316—22.

[74] Faxon DP, Myers WO, McGabe CH, Davis KB, Schaff HV, Wilson JW, Ryan TJ. The influence of surgery on the natural history of angiographically documented left ventricular aneurysm: the Coronary Artery Study. Circulation 1986;74(Suppl.):I110—8.

[75] Shapira OM, Davidoff R, Hilkert RJ, Aldea GS, Fitzgerald CA, Shemin RJ. Repair of left ventricular aneurysm: long-term results of linear repair versus endoaneurysmorrhaphy. Ann Thorac Surg 1997;63:701—5.

[76] Schlicter J, Hellerstein HK, Katz LN. Aneurysm of the heart: a correlative study of 102 proven cases. Medicine 1954;33:43.

[77] Grondin P, Kretz JG, Bical O, Donzeau-Gouge P, Petitclerc R, Campeau L. Natural history of saccular aneurysms of the left ventricle. J Thorac Cardiovasc Surg 1979;77:57—64.

[78] Dor V, Sabatier M, Di Donato M, Maioli M, Toso A, Montiglio F. Late hemodynamic results after left ventricular patch repair associated with coronary grafting in patients with postinfarction akinetic or dyskinetic aneurysm of the left ventricle. J Thorac Cardiovasc Surg 1995;110: 1291—301.

[79] Dor V, Sabatier M, Di Donato M, Montiglio F, Toso A, Maioli M. Efficacy of endoventricular patch plasty repair in large postinfarction akinetic scar and severe left ventricular dysfunction: comparison with a series of large dyskinetic scar. J Thorac Cardiovasc Surg 1998;116:50—9.

[80] Menicanti L, Di Donato M. The Dor procedure: What has changed after fifteen years of clinical practice? Editorial. J Thorac Cardiovasc Surg 2002;124:886—90.
[81] Mills NL, Everson CT, Hockmuth DR. Technical advances in the treatment of left ventricular aneurysm. Ann Thorac Surg 1993;55:792—800.
[82] Buckberg GD. Questions and answers about the STICH trial: a different perspective. J Thorac Cardiovasc Surg 2005;130:245—9.
[83] White HD, Norris RM, Brown MA, Brandt PW, Whitlock RM, Wild CJ. Left ventricular end-systolic volume as the major determinant of survival after recovery from myocardial infarction. Circulation 1987;76: 44—51.
[84] Dor V. Left ventricular reconstruction: the aim and the reality after twenty years. J Thorac Cardiovasc Surg 2004;128:17—20.
[85] Menicanti L, Di Donato M, Castelvecchio S, Santambrogio C, Montericcio V, Frigiola A, Buckberg G, RESTORE group. Functional ischemic mitral regurgitation in anterior ventricular remodeling: results of surgical ventricular restoration with and without mitral repair. Heart Fail Rev 2004;9:317—27.
[86] Enriquez-Sarano M, Schaff HV, Frye RL. Mitral regurgitation: what causes the leakage is fundamental to the outcome of valve repair. Circulation 2003;108:253—6.
[87] Grigioni F, Enriquez-Sarano M, Zehr KJ, Bailey KR, Tajik AJ. Ischemic mitral regurgitation : long term outcome and prognostic implications with quantitative Doppler assessment. Circulation 2001;103:1759—64.
[88] Stanley Jr AW, Athanasuleas CL, Buckberg GD. Heart failure following anterior myocardial infarction: an indication for ventricular restoration, a surgical method to reverse post-infarction remodeling. Heart Fail Rev 2004;9:241—54.
[89] Buckberg GD. Overview: ventricular restoration — a surgical approach to reverse ventricular remodeling. Heart Fail Rev 2004;9:233—9.
[90] Parolari A, Naliato M, Loardi C, Denti P, Trezzi M, Zanobini M, Porqueddu M, Roberto M, Kassem S, Alamanni F, Tremoli E, Biglioli P. Surgery of left ventricular aneurysm: a meta-analysis of early outcomes following different reconstruction techniques. Ann Thorac Surg 2007;83:2009—16.
[91] Romano SA, Bolling SF. Update on mitral repair in dilated cardiomyopathy. J Card Surg 2004;19:396—400.
[92] Ueno T, Sakata R, Igura Y, Yamamoto H, Ueno M, Ueno T, Matsumoto K. Mid-term changes of left ventricular geometry and function after Dor, SAVE, and overlapping procedures. Eur J Cardiothorac Surg 2007;32: 52—7.
[93] Cirillo M, Amaduci A, Quaini E, Villa E, Tomba MD, Mhagna Z, Brunelli F, Messina A, Troise G. Patch size, shape and orientation affect geometrical outcomes of surgical anterior ventricular restoration. J Cardiovasc Med (Hagerstown) 2008;9:389—95.
[94] Raman J, Dixit A, Bolotin G, Jeevanandam V. Failure modes of left ventricular reconstruction or the Dor procedure: a multiple-institutional perspective. Eur J Cardiothorac Surg 2006;30:347—52.
[95] Hernandez AF, Velazquez EJ, Dullum MK, O'Brien S, Ferguson TB, Peterson ED. Contemporary performance of surgical ventricular restoration procedures: data from the Society of Thoracic Surgeons' National Cardiac Database. Am Heart J 2006;152:494—9.
[96] Di Donato, Sabatier M, Menicanti L, Dor V. Incidence of ventricular arrhythmias after left ventricular reconstructive surgery. J Thorac Cardiovasc Surg 2007;133:289—91.

[97] Buckberg GD. Congestive heart failure: treat the disease, not the symptom — return to normalcy. J Thorac Cardiovasc Surg 2001;121:628—37.

[98] O'Neill J, Starling RC, Khaykin Y, McCarthy PM, Young JB, Hail M, Albert N, Smedira N, Chung MK. Residual high incidence of ventricular arrhythmias after left ventricular reconstruction surgery. J Thorac Cardiovasc Surg 2005;130:1250—6.

[99] Mukaddirov M, Frapier JM, Demaria RG, Albat B. Surgical treatment of postinfarction anterior left ventricular aneurysms: linear vs patch plasty repair. Interact Cardiovasc Thorac Surg 2008;7:256—61.