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Left Ventricular Aneurysm Repair with Endoaneurysmorrhaphy Technique: An Assessment of Two Different Ventriculotomy Closure Methods

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ABSTRACT

Background: Left ventricular aneurysm is a serious mechanical complication of myocardial infarction and has an incidence of 10-35% after myocardial infarction. Ventricular aneurysm in patients with angina, heart failure, and ventricular arrhythmia should be surgically treated. Endoaneurysmorrhaphy is one of the repair techniques that results in better left ventricular geometry and function. After this surgical procedure the ventriculotomy is repaired either with Teflon felt strips or by direct suture of the epicardium.

Methods: In this study, we described the postoperative early outcomes of two ventriculotomy closing techniques such as Teflon felt versus direct closure after aneurysm repair. This retrospective study included a total of 73 patients (mean age > 70 years) with left ventricular aneurysm, who underwent endoaneurysmorrhaphy repair between 1997 and 2009. All selected patients were divided into two groups according to the ventriculotomy closure technique either by Teflon felt or direct by epicardial closure. The pre-, intra-, and postoperative results of these patients were analyzed accordingly.

Results: The postoperative early mortality rate and postoperative bleeding were not significantly different between the Teflon felt and primary closure groups (P = .246 and P = .371 respectively), but postoperative arrhythmias were significantly higher in the Teflon felt repair group (P = .049).

Conclusion: Endoaneurysmorrhaphy is a better surgical technique in left ventricle aneurysm to restore the internal contour and preserve the surface anatomy of the ventricle. The ventriculotomy closure can be performed with two different approaches, including Teflon felt strips or by direct suture of the epicardium. Based on this study's findings, two repair techniques have similar impact on the early outcomes. However, with overall outcomes with respect to Teflon felt repair, direct closure of the ventriculotomy after endoaneurysmorrhaphy was superior.

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INTRODUCTION

Left ventricular aneurysm (LVA) is a serious mechanical complication of myocardial infarction (MI). The reported incidence varies between 10-35% after MI, and its incidence has declined primarily due to the treatment of a myocardial infarction with coronary angioplasty performed in the acute phase of the event [Antunes 2005; Parachuri 2008]. Heart failure, ventricular arrhythmias, systemic embolization, and ventricular rupture are the main complications of LVA. The surgical indications are in patients with angina, intractable ventricular arrhythmias, systemic embolization, and heart failure unresponsive to treatment. There are several types of surgical repair techniques that have been performed for LVA: plication, linear circular patch [Jatene 1985], and endoventricular patch [Dor 1998]. Endoaneurysmorrhaphy was first described by Cooley et al [Cooley 1989]. The concept of ventricular endoaneurysmorrhaphy articulates restoration of normal left ventricular volume and shape in diastole, while reducing volume in systole. This procedure is accomplished with a woven Dacron patch that restores the overall geometry of the ventricle and heart. After LVA repair, the ventriculotomy is repaired either with Teflon felt strips for reinforcement or by direct suture of the epicardium. We assessed the postoperative early mortality and complications to compare the effect of the two different ventriculotomy closure methods after LVA repair with endoaneurysmorrhaphy.

PATIENTS AND METHODS

This study was conducted in compliance with the human-study guidelines of the authors' institutions and was in compliance. The protocol was approved by the institutional review board and was granted a waiver of informed consent. Our study investigates the operative outcomes of two different ventricular closing techniques either by Teflon felt or by direct epicardial closure among patients with LVA who underwent endoaneurysmorrhaphy. We collected data between January 1997 and February 2009. In total, 138 patients underwent LVA repair with endoaneurysmorrhaphy techniques. Of the total patients, 65 were excluded from the study because of these reasons: previous arrhythmias (n = 15); anticoagulations (n = 4); kidney failure (n = 5), posterobasal aneurysm repair (n =18), concomitant mitral valve replacement (n = 10), mitral valve repair (n = 7), ventricular septal defect repair (n = 4), atrial septal defect repair (n = 2). The remaining 73 patients

Table 1. Preoperative Characteristics

	Epicardial Closure Group, n (%)	Teflon Group, n (%)	*P*
Male sex	34 (94.4)	32 (86.5)	.226
Age > 70	5 (13.9)	3 (8.1)	.34
Diabetes mellitus	6 (16.7)	8 (21.6)	.406
Hyperlipidemia	16 (44.4)	11 (29.7)	.291
Hypertension	22 (61.2)	15 (40.5)	.064
Smoking	21 (58.3)	24 (64.5)	.838
Peripheral vascular disease	2 (5.6)	2 (5.4)	.682
Preoperative medication			
B-Blocker	12 (33.3)	9 (24.3)	.277
Ca Channel Blocker	8 (22.2)	4 (10.8)	.159
ACE inhibitors	25 (69.4)	15 (40.5)	.12
Digitals	5 (13.9)	9 (24.3)	.202
Stable Angina	29 (80.6)	26 (70.3)	.228
NYHA Class 3-4	14 (38.9)	18 (48.6)	.273
ECHO findings			
EF < 30%	7 (19.4)	11 (29.7)	.107
LVT	20 (55.6)	13 (35.1)	.203
LVEDD > 55 mm	8 (22.2)	13 (35.1)	.169
Coronary angiography findings			
Single-vessel disease	4 (11.1)	11 (29.7)	.045*
Multivessel disease	26 (72.2)	15 (40.5)	.006*
LMCA disease	0	1 (2.7)	.507
Pulmonary hypertension	18 (50)	15 (40.5)	.282

*Statistically significant. ACE indicates angiotensin converting enzyme; NYHA, New York Heart Association; ECHO, echocardiography; EF, ejection fraction; LVT, left ventricular thrombus; LVEDD, left ventricular end-diastolic diameter; LMCA, left main coronary artery disease.

with anterolateral LVA repair were included in the study. Of the 73 patients, 36 patients ventriculotomy were closed with direct epicardial closure and 37 patients were closed with Teflon felt strip. The mean age of patients was higher than 70 years. All operations were held under elective conditions.

All preoperative, intraoperative, and postoperative data were gathered retrospectively from the patient records. The 73 patients' preoperative characteristics appear in Table 1. Echocardiography, coronary arteriography, and left ventriculography were performed preoperatively in all patients. Motion of ventricular walls were evaluated by assessing the velocity and displacement. Wall motions were graded as normal, hypokinetic, dyskinetic, or akinetic. The diagnosis of the left ventricular aneurysm was made preoperatively by angiographic appearance (akinesia or dyskinesia during ventricular contraction), and confirmed with direct visual examination intraoperatively. Patients were also followed by swan-ganz catheter during the operation and intensive care unit (ICU) course to monitor the pulmonary artery pressures.

The variables selected for analysis were as follows: age, sex, diabetes mellitus (DM), hypertension (HT), hyperlipidemia (HL), smoking, history of peripheral vascular disease, preoperative medication (including B-blocker, Ca channel blocker, angiotensin converting enzyme inhibitor, digitalis), functional status (New York Heart Association [NYHA]), presence of stable angina, number of vessel disease, left main disease, left ventricular function (in terms of left ventricle end-diastolic dimension [LVEDD] and ejection fraction [EF]), presence of thrombus in the aneurysmal cavity, cardiopulmonary bypass (CPB) and cross-clamp times, number of grafts, use of left internal mammary artery (LIMA), perioperative cardiac index and pulmonary hypertension (PHT), perioperative mortality, postoperative use of adrenaline and intra aortic balloon pump (IABP), acute renal failure and dialysis, prolonged ventilation, stroke, low cardiac output (LCO), prolonged ICU stay, arrhythmias, chest tube outputs, PHT, reoperation for bleeding, and postoperative early mortality.

The preoperative distribution of patients in accordance with New York Heart Association classification was as follows: in the epicardial closure group 19 patients (52.8%) were in Class I-II and 13 patients (38.4%) were in Class III-IV (1.4%). In the Teflon group 19 patients were in Class I-II (51.4%), 18 patients were in Class III-IV (48.6%). There was no significant difference between preoperative echocardiographic findings (EF, left ventricular thrombus, and LVEDD) between groups. On the basis of coronary angiography, patients were classified as having single- or multiple-vessel disease, depending on whether or not they had significant (>50%) obstructions in the left anterior descending, right, or circumflex coronary arterial systems. The preoperative coronary angiography revealed that the incidence of single-vessel disease was significantly higher in the Teflon group (P = .045) but multivessel disease was higher in the epicardial closure group (P = .006). There were no significant differences between groups in preoperative characteristics including age, sex, diabetes mellitus, hypertension, hyperlipidemia, smoking, history of peripheral vascular disease, preoperative medication, presence of stable angina, left main disease, left ventricular function, and presence of thrombus.

Operative Technique

The operation was performed through a median sternotomy, with the cross-clamped aorta and under cardioplegic arrest. Cardiopulmonary bypass with moderate hypothermia (28-30°C) and multidose blood cardioplegia were used in all patients for myocardial protection. The vent cannula was inserted in the right superior pulmonary vein. Upon asystole, repair of the left ventricular aneurysm was begun. The diagnosis of the LVA was confirmed visually and by palpation of the thinned wall of the left ventricle. A longitudinal left ventricle incision was made parallel to the left anterior descending artery, 2-3 cm laterally to it. If present, intraventricular clots were removed and the ventricle was irrigated with saline. After opening the left ventricle, the transition zone between viable myocardium and the fibrotic scar area was identified,

Table 2. Operative Data

	Epicardial Closure Group, n (%)	Teflon Group, n (%)	*P*
Coronary artery bypass grafting			
Single-vessel bypass	2 (5.6)	10 (27)	.014*
Multivessel bypass	26 (72.2)	15 (40.5)	.006*
Use of LIMA	35 (97.2)	28 (75.7)	.008*
Aortic cross-clamp time			
80-100 min	23 (63.9)	7 (18.9)	.0001*
>100 min	8 (22.2)	3 (8.1)	.087
CPB time > 120 min	15 (41.7)	11 (29.7)	.206
Cardiac index < 2.4	11 (31.4)	15 (40.5)	.288
Perioperative PHT	14 (38.9)	11 (30.6)	.311

*Statistically significant. LIMA indicates left internal mammary artery; CPB, cardiopulmonary bypass; PHT, perioperative pulmonary hypertension.

then a circular patch graft of woven Dacron fabric was prepared to replace the diseased area in the ventricular cavity, and was secured with a continuous suture of 3-0 polypropylene. Then ventriculotomy was repaired either with Teflon felt strips for buttress or by direct epicardial suture. 2-0 polypropylene suture was used in direct closure technique with running fashion. In Teflon felt closure technique the excess aneurysm wall was resected, leaving a residual portion that was closed using a linear repair in 2 layers, buttressed with a Teflon strip. In making the repair, it is important not to damage the left anterior descending artery, even if the artery is severely diseased or totally occluded in both techniques. Once ventricular repair was completed, coronary artery bypass grafting was performed in patients who required it.

The operative data are detailed in Table 2. There was no significant difference in data related to perioperative cardiac index, pulmonary artery pressure, and CPB time between groups. Multivessel bypass and LIMA graft were performed significantly more in the epicardial closure group, and cross-clamp time was higher, as expected, due to longer time required for performing multiple distal anastomoses ($P = .006$). Single-vessel bypass was performed significantly more in the Teflon group ($P = .014$). There were no intraoperative deaths.

Statistical Analysis

Data are presented as n (%) for all discrete variables. Continuous variables are presented as mean ± standard deviation as appropriate. Categorical variables were compared using univariate analysis (Fisher exact test), and original data were compared using Student t test. Multivariable forward stepwise logistic regression analysis was used to determine the independent predictors of postoperative early mortality. The statistical analysis was done using SPSS for Windows, version 7.5.1 (Chicago, IL, USA). Associations were considered statistically significant when P was less than .05.

Table 3. Postoperative Data

	Epicardial Closure Group, n (%)	Teflon Group, n (%)	*P*
Acute renal failure	0	1 (2.8)	.5
Dialysis	0	1 (2.8)	.5
Postoperative PHT	6 (16.7)	2 (5.6)	.13
Prolonged mechanical ventilation (>48 hours)	0	2 (5.6)	.246
Stroke	0	0	
Prolonged ICU stay (>3 days)	6 (16.7)	7 (18.9)	.48
Low cardiac output	5 (13.9)	9 (25)	.186
Arrhythmia (atrial and ventricular)	15 (41.7)	23 (63.9)	.049*
Adrenaline	5 (13.9)	11 (29.7)	.144
IABP	0	5 (13.5)	.43
24-hour chest tube output > 1000 cc	3 (8.3)	5 (13.5)	.371
Reoperation for bleeding	0	1 (2.8)	.5
Mortality	0	2 (5.6)	.246

*Statistically significant. PHT indicates postoperative pulmonary hypertension; ICU, intensive care unit; IABP, intra-aortic balloon pump.

RESULTS

The data comparing both techniques are shown in Table 3.

Epicardial closure group: there was no hospital mortality in postoperative course, LCO was seen in 5 patients (13.9%), 5 patients (13.9%) needed adrenaline. Six patients (16.7%) had pulmonary artery pressure of higher than 30 mmHg. Atrial and ventricular arrhythmias were seen in 15 patients (41.7%). Length of ICU stay was longer than three days in 6 patients (16.7%). Twenty-four hour chest tube output was higher than 1000 cc in 3 patients (8.3%) but none of the patients had reoperation for bleeding, respiratory failure, renal failure, and IABP support postoperatively.

Teflon group: the hospital mortality rate was 5.4% (2 patients), and these patients died of low cardiac output. Nine patients (25%) developed LCO syndrome, 11 patients (29.7%) needed adrenalin support, and IABP was placed in 5 patients (13.5%). Pulmonary artery pressure measured higher than 30 mmHg in 2 patients (5.6%). Atrial and ventricular arrhythmias were significantly higher in this group, with 23 patients (63.7%) having atrial or ventricular arrhythmias ($P < .049$). Twenty-four hour chest tube output was higher than 1000 cc in 5 patients (13.5%) and one of them (2.8%) underwent reoperation due to bleeding. Two patients (5%) needed mechanical ventilation for longer than 48 hours. One patient (2.8%) developed acute renal failure that recovered with dialysis. Length of ICU stay was longer than three days in 7 patients (18.9%).

Table 4. Univariate and Multivariate Analysis of Prognostic Factors for Early Mortality

		Odds Ratio	Univariate Analysis	
		Confidence	Multivariate	
	P	Interval (95%)	Analysis	*P*
Age > 70	.014*	8.899	0.57-138.68	.119
Diabetes mellitus	.015*	8.008	1.063-60.462	.043*
EF < 30	.042*	0.123	0.01-1.491	.100
LVEDD > 55 mm	.003*	1.134	0.993-1.296	.064
Ventriculotomy repair techniques	.015*	0.129	0.019-0.878	.036*
24-hour chest tube output > 1000 cc	.014*	3.593	0.41-31.492	.248
Postoperative LCO	.002*	9.099	1.246-6.462	.030*

*Statistically significant. EF indicates ejection fraction; LVEDD, left ventricular end-diastolic diameter; LCO, low cardiac output.

The overall postoperative mortality was 5.4% and the postoperative early mortality was not significantly different between the two groups. In univariate analysis, the postoperative early mortality was significantly higher in the Teflon group with diabetic patients and those aged older than 70 years, a low EF and dilated left ventricle (LVEDD > 55 mm), history of postoperative LCO, and 24-hour chest tube output of more than 1000 cc (Table 4). Multivariate analysis was performed for independent predictors of postoperative mortality based on different variables (preoperative, intraoperative, and postoperative). The results showed that 3 variables were significantly associated to postoperative early mortality: diabetes mellitus, ventriculotomy repair technique, and postoperative LCO. The ventriculotomy closure method affects the occurrence of the outcome of interest as well as postoperative complications such as arrhythmias.

DISCUSSION

Left ventricular aneurysms are serious complications of myocardial infarction. Although the exact mechanism of the aneurysm formation is not well known, a transmural infarction is required. Some studies have suggested that poor coronary collateral flow after infarction leads to continued necrosis of the infarcted tissue and increases the transmural scarring [Hirai 1989]. The scar can become aneurysmal when it is subjected to increased systolic wall tension. The substantial decrease in EF caused by akinetic or paradoxical motion resulted in main physiologic changes. Other studies showed that patients with LVA tend to have multivessel disease compared to a single-vessel stenosis [Dor 1995; Rogers 1978]. The aneurysm absorbs part of the left ventricular ejection, eventually leading to cardiac failure, which may be refractory to medical therapy and require surgical treatment. 15-30% of patients with myocardial infarction had ventricular aneurysm [Grondin 1979]. When pulmonary congestive symptoms, angina pectoris, LCO, malignant arrhythmias, or embolization occur surgical treatment should be performed.

The first LVA repair was performed by Likoff et al [Likoff 1955]. The first repair was reported under cardiopulmonary bypass by Cooley and associates who used the linear closure method [Cooley 1958]. Endoaneurysmorrhaphy was first described by Cooley et al [Cooley 1989]. In this technique an elliptical woven Dacron patch graft is prepared to replace the diseased area in the ventricular cavity, and to exclude the nonfunctioning fibrous area. This method emphasizes restoration of normal left ventricular volume and contour in diastole, while reducing volume in systole with improved left ventricular function. This technique also restores the internal contour and preserves the surface anatomy of the ventricle, and permits revascularization of the anterior descending or other coronary arteries when indicated. Up to the present, endoaneurysmorrhaphy still remains the better option in the treatment of LVA. Plenty of studies evaluating outcomes after endoaneurysmorrhaphy are attainable in the literature and many studies have shown the effect of the endoaneurysmorrhaphy technique, which resulted in better left ventricular geometry and function. But ventriculotomy closure methods have not been assessed yet. In the present study, we evaluated our experience with endoaneurysmorrhaphy for the treatment of LVA centering on the incidence and risk factors for postoperative early mortality with two different ventricle closure approaches. Our in-hospital mortality rate, as we have mentioned, was 5.6%, and this is slightly similar to that reported in previous studies on LVA, with a hospital mortality rate between 3.7-9.8 % [Wang 2012; Vicol 1998; Lange 2005].

In our study, we did not observe a significant difference in postoperative early mortality and bleeding between the two closure techniques. However, the postoperative arrhythmias were significantly higher in the Teflon group; as well the results of univariate and multivariate analysis remarked that ventriculotomy closure method by Teflon felt was a prognostic factor for early mortality. Some physicians prefer Teflon felt during the ventriculotomy closure to support the aneurysmal ventricular wall and to minimize the bleeding from the ventriculotomy, but on the other hand, we believe that Teflon has some adverse effects including acting as a foreign body and making excessive adhesions, increasing risk of infections, injuring distal left anterior descending (LAD) territory, and affecting ventricle surface geometry. However, according to our experience, after Dacron patch placement, the remaining aneurysmal ventricular space is not affected by ventricular pressure. For that reason, the ventriculotomy after endoaneurysmorrhaphy can easily be closed with direct epicardial closure. As a consequence, by simple epicardial closure we can exclude the adverse effects of Teflon felt closure.

Study Limitations

The present study has several limitations. First of all this is a retrospective study with a small sample size in a single center, which could be a significant flaw. The inclusion of postoperative variables in our analysis is somehow questionable; it may be confounding for some factors such as neurologic and pulmonary complications, bleeding, etc. It could be difficult to determine their exact temporal relation with the dependent variable. The findings should be interpreted with some caution as the study size was quite limited. Large and long-term prospective studies are required to confirm our findings.

Conclusion

In conclusion, ventriculotomy closure can be conducted through Teflon felt or by direct epicardial closure approaches after LVA repair with endoaneurysmorrhaphy. According to our judgement, these two repair techniques have similar impacts on the early outcomes, but direct epicardial closure of ventriculotomy can be more beneficial compared to Teflon felt closure.

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