LATE TERM RESULTS OF REPAIR OF LEFT VENTRICULAR ANEURYSM WITH ENDOVENTRICULAR CIRCULAR PATCH PLASTY TECHNIQUE

G. İPEK, M.D.,
E. AKINCI, M.D.,
M. GÜLER, M.D.,
E. EREN, M.D.,
H. TEKÜMİT, M.D.,
M. BALKANAY, M.D.,
T. BERKİ, M.D.,
A. GÜRBÜZ, M.D.,
Ö. IŞIK, M.D.,
and
C. YAKUT, M.D.

From: Koşuyolu Heart and Research Hospital, Koşuyolu, İstanbul

Adress for reprints:
G. İPEK, M.D.,
Koşuyolu Heart and Research Hospital,
Koşuyolu
81020 İSTANBUL,
TÜRKİYE

The left ventricular aneurysm is the most common late complication of transmural myocardial infarction. Both the survival rate and the quality of life can be significantly effected by this complication. In a twelve year period between 1985 and 1997 at the Koşuyolu Heart and Reserch Hospital of 12257 open heart cases, 509 patients underwent a repair of ventricular aneurysm with or without CABG. In 70 patients endoventricular circular patch plasty technique was used for reconstruction of the ventricular cavity. In 40 (63%) patients autologous pericardium treated with gluteraldehyde were used for repair of aneurysm, and in the others synthetic grafts. There were 13 female (21%) patients. Mean age were 51±14 years. Early hospital mortality rate was 4.1 % (3/70). Postoperative major complications were developed in 2 patients, including reoperation for bleeding in 1 patient and mediastinitis in 1 patient. Late mortality rate was 8.9 %(6/70). The mean follow up time was 4 years (1 to 7 years). At follow-up, for assesment of the ventricular functions hemodynamic, two dimentional echocardiographic and clinical parameters was used. Significant improvement in ejection fraction (p<0.01), LV end diastolic pressure (p<0.01), and mean pulmonary artery pressure (p<0.01) was found. End systolic and diastolic dimensions were also improved significantly (p<0.01). In the majority of patients whose postoperative ventricular functions improved also had improvement in symptoms, usually achieving functional class I or II status. We conclude that reconstruction of the ventricular cavity with endoventricular circular patch plasty technique yields good results, and is an alternative to other surgical methods.

Key words: **Left ventricular aneurysmectomy, endoventricular circular patch plasty**

Left ventricular aneurysms are a common complication of extensive transmural myocardial infarction, and this may occur in 5-30 % of all transmural infarctions[1-4]. Left ventricular failure, thromboembolism and ventricular arrhythmias are common indications for left ventricular aneurysm resection or plication [5]. In 1944, Beck [6] decribed his attempt to plicate ventricular aneurysm using facia lata. Modern surgical treatment, however has been attributed to Likoff and Bailey, who in 1955 [7] performed a closed resection of an left ventricular aneurysm using a special side-biting clamp through a thoracotomy incision. In 1958, Cooley and colleaques [8], using cardiopulmonary bypass, performed the first successful aneurysmectomy using a buttressed linear suture line.

Jatene [9], in 1985 introduced the concept of geometric reconstruction of the left ventricle using prosthetic patch material. Dor et al[10] have described a modification of this technique that they call "Endoventricular circuloplasty", which involves insertion of a patch at the junction endocardial muscle and scar to exclude the noncontracting portion of the left ventricle and septum. Endoventricular circular patch repair of left ventricular aneurysm is an innovative technique that improves left ventricular function mainly by improving left ventricular geometry which is markedly abnormal in left ventricular aneurysms [10,11]. This report reviews our experience with surgical repair of left ventricular aneurysm with endoventricular circular patch plasty technique during the past eleven years.

MATERIALS AND METHODS

In the past twelve years, between 1985 and 1997, 12257 patients were undertaken open heart surgery, 509 patients underwent a repair of ventricular aneurysm with or without coronary artery bypass grafts (CABG). In 433 patients linear repair or plication performed for the left ventricular aneurysm. Generally plications were reserved for small scars in patients who did not have serious left ventricular dysfunction. In 76 (14.9%) patients endoventricular circular patch plasty technique was used for reconstruction of the left ventricular cavity. There were 15 women and 61 (80.26%) men whose mean age was 51±14 years, ranging 31 to 77 years. The most common locations of the left ventricular aneurysm were anterior (93%), and the others were inferior (7%). Of these patients, 54 (71%) had angina pectoris, 19 (25%) had congestive heart failure, 2 (3%) had thromboembolism and 2(3%) had arrhythmia. Table I summarizes clinical data of these

Table I. Clinical data of 57 patients.

	mean age	
Age	51±14	
Sex	No.of pts	%
Male	48	(84%)
Female	9	(16%)
Indications for operation		
Angina pectoris	42	(74%)
Congestive heart failure	19	(25%)
Thromboembolism	2	(3%)
Site of aneurysm		
Anterior	53	(93%)
Inferior	4	(7%)
Coronary lesions		
Left main stenosis	7	(12%)
One vessel	11	(19%)
Two vessels	29	(38%)
Three vessels	16	(28%)
Mitral regurgitation (+2 or more)	6	

patients. All patients underwent heart catheterization and coronary arteriography before operation. Left ventricular functions were assessed angiografically and Doppler echocardiografically in all patients.

End-diastolic pressure (LVEDP), ejection fraction (EF) and mean pulmonary artery pressure at rest were used as clinical parameters of left ventricular function preoperatively in all of the patients, and in 50 of the patients postoperatively (Table II). Preoperative and postoperative Doppler echocardiographic studies were performed in all patients; left ventricular dimensions, mitral regurgitation and segmentar LV wall motion were assessed (Table III).

Univariate analyses were performed by using Student's t test, chi-square analysis. The difference between preoperative and postoperative EF- LVEDP and PA pressure were analyzed by using the paired t test. A p value of 0.01 or less was considered statistically significant. Echocardiographic assessment of left ventricular systolic and diastolic dimension showed correlation with angiographic studies.

Preoperative cardiac status of patients according to the NewYork Heart Association Classification are shown in Figure 1.

CABG was performed in 55 patients. The average number of grafted coronary arteries was 2.1 per patient. Other concomittant procedures performed were: in 1 patient mitral valve replacement, in 1 patient mitral valvuloplasty and in 1 patient ventricular septal defect repair. The aortic cross-clamp time was 52±16 minutes and total perfusion time was 76±21 minutes (Table IV).

OPERATIVE TECHNIQUE

The technique for left ventricular aneurysm repair with endoventricular circular patch plasty procedure was performed by standard cardioplumonary bypass and cardioplegic arrest. Until 1991 myocardial protection was achieved with intermittant antegrade cardioplegia, and in the last 6 years with isothermic continous retrograde blood cardioplegia. The aneurysm of left ventricle opened with a longitudinal incision in the

Table II. Preoperative and postoperative angiographic evaluation of clinical parameters (all of the patients were evaluated preoperatively, while of 50 patients postoperatively).

	Preoperative	**Postoperative**	**p value**
LVEDP	22.4±4.1 mmHg	17.6±2.4mmHg	p<0.01
EF	28.1%±8%	38.2%±10%	p<0.01
PA	25.1±4.4mmHg	18.2±3.1 mmHg	p<0.01

LVEDP: Left ventricular end-diastolic pressure, EF: ejection fraction, PA: mean pulmonary artery pressure

Table III. Preoperative and postoperative Doppler echocardiographic evaluation of LV sistolic and diastolic dimensions in all patients.

	Preoperative	**Postoperative**	**p value**
LVEDD	59.3±10.3mm	52.2±8.7mm	p<0.01
LVESD	49.4±9.1mm	41.8±8.3mm	p<0.01

LVEDD: left ventricular end-diastolic dimention, LVESD: left ventricular end-systolic dimension

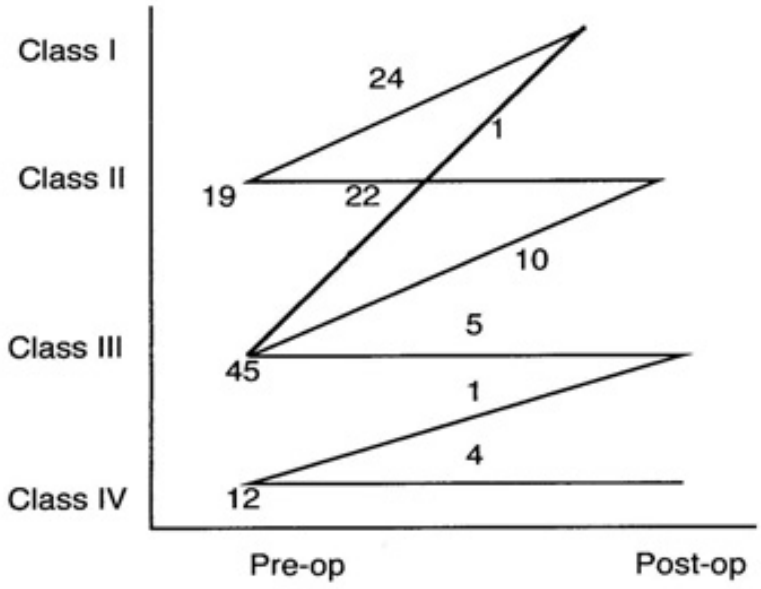

Figure 1. Preoperative and postoperative congestive heart failure status (NYHA) of patients in whom endoventricular circular patch plasty technique was achieved.

Table IV. Operative data

Concomittant procedures	
CABG	55 pts.
No. of distal anastomosis	2.1
MVR	2
Mitral valvuloplasty	1
Aortic cross-clamp time (mn)	52±16 mn
Total cardioplumonary bypass time (mn)	76±21 mn

CABG: Coronary artery bypass graft, MVR: Mitral valve replacement, mn: minute

Table V. Postoperative Complications.

	No. of pts.	
IABP support	9	11.8 %
Inotropic support	16	21.1 %
Ventricular arrhythmia	7	9.2 %
Hemorrhage requiring reexploratien	1	1.3 %
Mediastinitis	1	1.3 %
Early mortality	4	3.9 %

IABP: Intraaortic balloon pump

middle of the thinnest and akinetic portion . After blood is aspirated from the left ventricle and thrombus is removed carefully, the transition zone between viable myocardium and scarred area is identified. A synthetic patch or autologous pericardium is tailored to restore a normal volume to the left ventricular cavity. To prevent fibrous retraction of the autologous pericardial patch it is treated with gluteraldehyde. The patch is secured with continous Gore-Tex or polyprophylene sutures to the transition zone. The remaining aneurysmal wall is then plicated to repair the ventriculotomy. If the coronary bypass has been indicated by preoperative coronary angiography, grafts are placed next.

RESULTS

Postoperative major complications developed in two patients: reexploration of the mediastinum for bleeding in one patient, and mediastinitis in one patient (Table V).

Infectious complications with the use of synthetic graft was seen in one patient, and reexploration was necessitated for a second operation, and the infected tephlone felt was removed. The left ventricular wall was closed with an autologous pericardial patch. To avoid such infectious complications, we recommend the use of autologous pericardial tissue in the repair of left ventricular aneurysms as an alternative to synthetic materials. This technique should be considered to minimize the risk of infection. Intraaortic balloon pump (IABP) support was required in 6 patients.

The angiografically determined EF, as one of the most important clinical parameter of ventricular function has improved significally after the operation from an average of 28.1%±8.0% to 38.2%±10.0%, indicating a marked improvement of the pump function of the ventricle ($p<0.01$). This was also confirmed by the measurement of LVDEP and PA pressure values respectively, ($p<0.01$) ($p<0.01$)(Table II).

Preoperative Doppler echocardiographic studies showed significant mitral regurgitation (second degree orimore) in six of the 70 patients studied. In two of these patients MVR was performed. In all of the patients who survived postoperatively control Doppler echocardiographic study was done before they were discharged. In three of these patients with mitral regurgitation, the amount of regurgitation was improved by at least one grade. Preoperative and postoperative echocardiographic studies revealed detailed analysis of LV dimensions. End-diastolic dimension decreased from 59.3±10.3 mm preoperatively to 52.2±8.7 mm postoperatively ($p<0.01$), and end-systolic dimensions decreased from 49.4±9.1 mm before operation to 41.8±8.3 mm after operation ($p<0.01$)(Table III).

Among the survivors (53 of 61, 86.8% were symptomatically improved at the most recent follow-up with 40(65.5%) in NYHA Class I, and 10 (16.4%) in NYHA Class II. One patient improved from Class IV to Class III. Ten patients (16.4%) did not show any functional improvement (Figure 1).

Hospital mortality rate was 5.2% (4/76). Three patients died as a result of low cardiac output and 1 patient died of sepsis. During late follow-up there were 6 deaths 8.9% of the survivors. Three of the patients died of congestive heart failure. Other causes of death included refractory ventricular arrhythmia in 2, sepsis in 1. The mean follow up time is 4.7 years (range 6 months to 10.3 years).

DISCUSSION

The adverse effects of LV aneurysms depend upon the extent of muscle damage, the size of dyskinetic area, presence of clot, arrythmias, extent of coronary artery disease, and functional quality of the remaining LV muscle. The results of surgical repair are related to the magnitute of the geometric effects on the remaining left ventricle. It should always be remembered that the normal heart has an elaborate architecture with fibers and muscle layers moving in different directions. The formation of an LV aneurysm distends and enlarges the ventricular cavity, grossly distorting the directions of the muscle fibers.

In 1958, Cooley[8] using cardiopulmonary

bypass, performed the first successful aneurysmectomy using a buttressed linear suture line. This "standart linear repair" is still the most common repair used today. A major disadvantage of this conventional repair is that the lateral and medial (septal) wall of the LV are sutured together at a point where they would naturally lie several centimeters apart, there by significantly decreasing the functional LV cavity size, and distorting the natural LV geometry.

Jatene,[9] in 1985, introduced the concept of geometric reconstruction of the left ventricle using prosthetic patch material.

He had observed that the sandwich repair of ventricular aneurysms lead to varying degrees of left ventricular dysfunctions. He noted that the maldirection of normal spiral muscle bundles after infarction, and ventricular aneurysm formation caused bundle distortion in the transverse and longitudinal direction. His theory is to redirect the normal muscle bundles as much as possible to their original position and orientation, resulting in reshaping the LV cavity in such a way that it resembles an infarcted LV in which distention of the infarcted area did not occur [5].

Jatene reported a reduction in operative mortality from 12.6% to 3.5% using this technique. Two variations of circular closure have subsequently been reported. Cooley [12] has more recently described "endoaneurysmorrhapy" which involves suturing an elliptic prosthetic patch within the aneurysm orifice, followed by aneurysm closure without resection to minimize bleeding. Among 42 patients who underwent this type of repair; 76% had postoperative improvement in ejection fraction as measured by gated nuclear medicine studies, compared with only 51% of patients in whom the classic linear closure was used. "Endoventricular circuloplasty" a variation of this technique, has been described by Dor and colleaques [10], who reported 90 cases with a mean increase in global ejection fraction from 36% to 52% following the repair. Keiler[13] compared the effectiveness of linear closure (40 patients) and circular closure (22 patients) as techniques to repair LV aneurysms. They observed no significant difference between the two techniques. Krawcer[14] reported that improvement of mean ejection fraction was 10.9%±1.2% in technique of endoaneurysmorrhaphy. The early mortality rate was 4%, late mortality rate was 7% in their series.

Our results showe that repair of left ventricular aneurysm with circular patch plasty technique has a low surgical risk. According to some studies for left ventricular function after aneurysmectomy there was improvement in ventricular functions while some other studies showed no improvement [10-14]. The prognosis of patients with anterior wall aneurysm mainly depends on the size of the aneurysm, and the function of the residual myocardium[11]. Linear repair of left ventricular aneurysm may lead to varying degrees of ventricular dysfunction[15]. Endoventricular circular patch plasty technique restores geometry and volume of left ventricle and yields good results and an alternative to other surgical methods. In most of the cases we prefered to use gluteraldehyd-treated autologous pericardium. Adventages of using pericardial substitute could be summarized such as:using an autologous patch material, much more easier hemostasis, healing of the patch to the surrounding tissues, thromboresistance, a lesser risk of infarction, minimally fibrosis and calcification, no patch deformation and pseudoaneurysm, no cost when compared with synthetic grafts.

Infectious complications associated with the use of tephlone felt buttressed in left ventricular aneurysm (LVA) repair have been reported[20,21]. Use of an autologous pericardial patch is an alternative approach that should be considered [22].

In conclusion, repair of LV aneurysm with endoventricular circular patch plasty is associated with significant improvement in LV functions and symptomatology. This technique restores left ventricle geometry, permitting revascularization of the left anterior descending or other coronary arteries when indicated. Intracavitary repair allows better physologic function to be achieved in patients undergoing repair of LV aneurysm. We conclude that reconstruction of the ventricular cavity with endoventricular patch plasty technique yields good results and an alternative to other surgical methods.

REFERENCE

1. Abrams DL, Edelist A, Luria MH, Miller AJ: Ventricular aneurysm: A reappraisal based on a study of sixty-five consecutive autopsied cases. Circulation 1963;27:164-169.
2. Schlichter J, Hellerstein HK, Katy LN: Aneurysm of the heart: A correlation study of 102 proved cases. Medicine 1954;33:42-86.
3. Gorlin R, Klien MD, Sullivan JM: Mechanistic concept and clinical recognition of left ventricular aneurysms. Am J Med 1967;42:512-523.
4. Magovern GJ, Sahert T, Simpson K: Surgical theraphy for left ventricular aneurysms. Circulation 1989;79 (suppl I):1-102-1-107.
5. Mills NL, Everson CT, Hochmuth DR: Technical advances in the treatment of left ventricular aneurysm. Ann Thorac Surg 1993;55:792-800.
6. Beck CS: Operation for aneurysm of the heart . Ann Surg 1944;120:34.
7. Lihoff W, Bailey CP: Ventriculoplasty exision of myocardial aneurysm. Report of a successful case. JAMA 1955;158: 915-920.
8. Cooley DA, Collins HA, Morris GC Jr, Chapman DW: Ventricular aneurysm after myocardial infarction. Surgical excision with use of temporary bypass.JAMA 1958;167:555-560.
9. Jatene A: Left ventricular aneurysmectomy. J Thorac Cardiovasc Surg 1985; 89:321-331.
10. Dor V, Saab M, Coste P: Left ventricular aneurysm: A new surgical approach. Thorac Cardiovasc Surg 1989; 37:11-19.
11. Cooley DA: Ventricular endoaneurysmorrhaphy: Results of an improed method of repair. Tex Heart Inst J 1989; 16:72-75.
12. Cooley DA: Repair of post-infarction aneurysm of the left ventricle. Cardiac Surg: State of Art Rev 1990;4:309-19.
13. Kesler KA, Plore AC, Naunheim KS, et al: Anterior wall left ventricular aneurysm repair: A comparison of linear versus circularn closure. J Thorac Cardiovasc Surg 1992;103:841.
14. Krajcer Z, Elayda MA, Cuasay L: Ventricular endoaneurysmorrhapy. Texas Heart Institute Journal 1992;19: 42-46.
15. Froclich RT, Falsetti HL, Doty DB, et al: Prospective study of surgery for left ventricular aneurysm. Am J Cardiol 1980;45:923-931.
16. Taylor NC, Barber R, Crossland P, Wraight EP: Does left ventricular aneurysmectomy improve ventricular function in patients undergoing coronary bypass surgery? Br Heart J 1985;54:145-152.
17. Dymond DS, Stephens JD, Stone DL, Elliot AT: Combined exercise radionuclide and hemodynamic evaluation of left ventricular aneurysmectomy. Am Heart J 1982;104:977-987.
18. Stones WS, Alford WC, Burrus GR, Thomas CR: Repair of anteroseptal ventricular aneurysm. Ann Thorac Surg 1973;15:394-404.
19. Smulyan H, Eich RH, Johnson LW, Parker FB, Potts JL, Tracy GP: An evaluation of the results of left ventricular aneurysmectomy: Use of a simplified method of analysis. Am Heart J 1979;41:79-87.
20. Looser KG, Allmendinger PD, Tahata H, et al: Infection of cardiac suture line after ventricular aneurysmectomy. Report of two cases. J Thorac Cardiovasc Surg 1976;72:280-281.
21. Engleman RM, Saxena A, Levitsky S: Delayed mediastinal infection after ventricular aneurysm resection. Ann Thorac Surg 1978;25:470-473.
22. Iguidbashian JP, Follotte DM, Contino JP, et al: Pericardial patch repair of left ventricular aneurysm. Ann Thorac Surg 1993;55:1022-1024.