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Short Term Results between Linear Closure (Cooley) and Endoventricular Patch Plasty (Dor) Procedure for Left Ventricular Aneurysm Reconstruction

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ABSTRACT

OBJECTIVE

Repair of left ventricular aneurysm following myocardial infraction is an accepted option for better left ventricular performance and improvement of the clinical symptoms. We studied the effect on myocardial function after LVA repair. This study aimed to compare the short term outcome of LVA repair in linear closure and endoventricular patch repair (Dor procedure).

METHODS

We retrospectively collected data of patients who had LVA repair between 2013 - 2019. Our inclusion criteria were left ventricular aneurysm repair with or without other cardiac surgery. 32 patients underwent repair of LVA during that period. Seventeen patients underwent linear closure and fifteen patients had Dor repair. Preoperatively, 100% of patients in linear were in NYHA functional class III or IV vs. 93.4% in the Dor group (p = 0.54, not statistically significant). Arrhythmia and ventricular thrombus were seen in 15% and 35.4% in linear group *vs.* 11.8% and 0% in Dor group respectively. Mean left ventricular end diastolic and left ventricular end systolic volumes were 173.53 ml and 114.35 ml in linear group and 213.27 ml and 143.07 ml in Dor group respectively. The mean left ventricular ejection fraction was 41.82 in linear group *vs.* 31.33 in Dor group (p = 0.294, not statistically significant).

RESULTS

Thirty day mortality was 3.12% as one patient died in linear group immediate postoperatively due to multi organ failure. The echocardiography after the surgery revealed significant reduction in mean left ventricular volume and ejection fraction. The left ventricular end diastolic and end systolic were reduced to 124.71 ml and 77 ml in linear closure and 149.47 ml and 94.76 ml in Dor group respectively. There is significant progress in the clinical profile of the patients. 77% of patients in linear closure improved to NYHA functional class I or II *vs.* 80% in Dor group. The major complications were also similar in the two groups.

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CONCLUSION

Post operatively, our study did not demonstrate any difference in echocardiographic finding or functional status between linear closure and Dor Repair. We suggest choice of repair compelled by surgeons' preference and experience and morphology of diseased ventricle.

KEYWORDS

Left ventricular aneurysm; Linear closure; Endoventricular patch plasty

INTRODUCTION

One of the most serious complications after myocardial infraction is left ventricular aneurysm (LVA). Contemporary approach with timely and adequate revascularisation in the setting of acute myocardial infraction decreases the occurrence of aneurysm formation. However, the incidence of LVA is still high, ranges from 10% to 35% after myocardial infraction [1,2]. In acute myocardial infraction, abrupt cessation of blood supply and insufficient collateral circulation result in myocardial necrosis and left ventricular aneurysm formation. The scarred myocardium becomes increasingly thin and develops abnormal movement (akinesia or dyskinesia). Following the Laplace law, the aneurysmal segments contribute to increased left ventricular end diastolic and end systolic volume. The stress in the myocardium induces high oxygen increased consumption and demand. These culminate in congestive cardiac failure, malignant cardiac arrhythmia and thromboembolic complication. Surgical correction of LVA with heart failure and arrhythmia provides both symptomatic and prognostic benefits. Geometrical reconstruction of the left ventricle by surgical intervention minimizes the wall tension and ceases further remodelling of the myocardium. Usually the surgical intervention for LVA is delayed to allow maturation of scarred tissues and stabilize the patient from ischemic insult. Nevertheless, the patient with cardiogenic shock, haemodynamic instability, on-going ischemia and systemic thromboembolism, urgent surgery is impediment for a better outcome.

Cooley et al. [3] introduced the linear repair technique. This approach was simple and reproducible. In 1984, Dor et al developed end ventricular patch plasty (EVPP) by intracavitary exclusion of ischemic area [4]. The exclusion of infracted segment, and implantation of circular plasty allow to maintain more physiological left ventricular geometry without restraining or compromising the size of the left ventricle. Both of them showed improvement in left ventricular dimension and pump function. The mortality rate after the procedure is not high 2-6% [5-8].

The present study highlights our experience with liners closure (Cooley procedure) and EVPP (Dor linear procedure). We used preoperative and post-operative echocardiography to demonstrate the left ventricular function and dimension.

METHODS

Patients

A retrospective analysis was carried out on patients undergoing left ventricular aneurysm reconstruction between 2013-2019. Symptomatic patients with substantial enlargement of the left ventricles verified by echocardiography and ventriculography were selected for surgery. The patients provided informed consent to participate in the study.

Surgical Technique

All operations were performed through a median sternotomy, cardiopulmonary bypass with moderate hypothermia, antegrade and retrograde cold blood

cardioplegia. Firstly, distal anastomosis was performed, then aneurysm was visualized. At this point, the linear closure or EVPP were chosen as per anatomical characteristic of the aneurysm (size, location and maturity). An incision was given parallel to the left anterior descending artery. In linear closure, the part of the aneurysm was excised leaving sufficient scar tissue for closure of the left ventricle. The felt stripes were used for approximation of both sides of the ventricles. In EVPP, the aneurysm was opened. One layer of circular stitches was applied at the border of viable and non-viable myocardium situated in between the free wall of left ventricle and the septum. Elliptical patch was sutured using continuous stitches to create new geometrical shape of the left ventricle. Aneurysmal sac was closed by using felt stripes over the patch.

Follow-Up

The follow-up was conducted in outpatient clinic in 6 weeks after the surgery.

Statistical Analysis

Statistical analysis was performed using an extensively admissive software program, the SAS software (version 9.4; SAS Institute Inc., Cary, NC, USA). Data were presented as percentages for categorical variables. All the P values < 0.05 were considered statistically significant.

RESULTS

Baseline Characteristics

Table 1 shows the preoperative data of both groups of patients. The mean age is similarly 62.82 in linear group and 61.60 in Dor repair group. Sex distribution is similar in both groups M: F, 3:1. There is no significant difference in incidence of diabetes, hypertension, chronic obstructive pulmonary diseases, cerebrovascular accident and renal dysfunction.

Variable	Linear Closure	DOR Repair	P Value
Mean Age Years	62.82	61.6	0.726
%Male	70.6	73.3	0.614
%Recent MI	64.7	46.9	0.155
%NYHA 1-2	0	6.7	0.08
%NYHA 3-4	100	93.4	0.546
%Arrhythmia	15.4	11.8	0.618
%Thrombus	35.4	0	0.088
%3 Vessel dis	70.6	73.3	0.942
%DM	47.1	33.3	0.292
%Stroke (%)	16.7	26.7	0.918
%Pulmonary Disease	11.8	13.4	0.903
%CKD	11.8	0	0.346
%Severe Mitral Regurgitation	41.1	40	-
%Dyskinesia	17.6	60	0.024
%Akinesia	64.7	20	0.43
Mean LVEDD mls	173.53	213.27	0.34
Mean LVESD mls	114.35	143.07	0.077
Mean EF	40.82	31.33	0.294
Mean Pulmonary Pressure	42.29	48.33	0.143

Table 1: Showing the base line characteristics.

Variable	Linear Closure	Dor Repair	P Value
Mean Cross Clamp Time	48.47	40.13	0.327
Mean CPB Time	126.35	110.53	0.369
% Repair on Beating Heart	47.1	80	0.053
% Repair on x Clamp	52.9	20	0.059
% Mitral Surgery	41.1	40	-
% >3 Anastomosis	47	53.4	0.557
% IABP Preop	11.8	0	0.0597
% VSD Repair	11.7	6.6	-
Mean Temp C	32.12	32.4	0.56

Table 2: Intra-operative characteristics.

Preoperatively, 100% of patients in linear were in NYHA functional class III or IV *vs.* 93.4% in the Dor group (p = 0.54, not statistically significant). Above 70% patients had triple vessel coronary artery disease in both groups. Arrhythmia and ventricular thrombus were seen in 15%

and 35.4% in linear group *vs*. 11.8% and 0% in Dor group respectively. Severe Mitral regurgitation was identified in 41.1% and 40% in linear closure and Dor group.

Variable	Linear Repair	Dor Repair	P Value
% Post op IABP	23.6	33.3	0.907
% Re Exploration	0	13.3	0.297
% Respiratory Failure	23.5	13.3	-
% Multiorgan Failure	5.8	13.3	-
Mean LVEDV mls	124.71	149.47	0.038
Mean EF	43	39.14	0.294
Mean LVESV mls	77	94.76	0.056
% NYHA 3-4	23.5	20	0.576
Length of Hospital Stay	Median 13.9	Median 17.2	-

Table 3: Post-operative outcome.

Echocardiography Examination

The echocardiography was performed immediately before surgery. Mean left ventricular end diastolic and left ventricular end systolic volume were 173.53 ml and 114.35 ml in linear group and 213.27 ml and 143.07 ml in Dor group respectively. The mean left ventricular ejection fraction was 41.82 in linear group *vs.* 31.33 in Dor group ($p = 0.294$, not statistically significant). Preoperatively, echocardiography showed 17.6% dyskinesia and 64.7% akinesia in linear group, whereas 60% dyskinesia and 20% akinesia in Dor group.

Postoperative echocardiography was done after surgery within 6 weeks. Left ventricular volume in the two groups was decreased significantly. The echocardiography after the surgery revealed mean left ventricular end diastolic volume and left ventricular end systolic volume was reduced to 124.71 ml and 77 ml in linear group and 149.47 ml and 94.76 ml in Dor group respectively. Ejection fraction increased in both groups, but better improvement was noticed with EVPP. The mean left ventricular ejection fraction improved from 41.82 to 43 in linear group *vs.* from 31.33 to 39 in Dor group.

Intraoperative Characteristics

Coronary artery bypass graft was performed in all patients. However, more than three vessels anastomosis was done in 47% and 53.4% in linear and DOR group respectively. There is no statistically difference in mean cross clamp time and cardiopulmonary bypass time. However, 80% Dor repair was done on a beating heart, whereas 47.1% linear repair was done on beating heart. Mitral surgery was done in 41.1% and 40% in linear and Dor group respectively.VSD repair was accomplished only in linear group (13.4%). Preoperative IABP used in 11.8% in linear group.

Procedural Outcome

The 30-day mortality was 3.12%, only one patient from linear group died immediate post operatively due to multi-organ failure. Post operatively IABP was used in 23.6% in linear group *vs.* 33.3% in Dor repair group. Multi-organ failure developed in 5.8% in linear group whereas 13.3% in Dor group. The length of stay in hospital (LOS) was in between 7-30 days in both groups, median stay was 13.9 days and 17.2 days in linear closure and Dor group respectively.

DISCUSSION

Left ventricular aneurysm is not an uncommon mechanical complication after myocardial infraction. Though the incidences reduce due to rapid thrombolysis and percutaneous intervention still the rate varies from 10% - 35% [1,2,9]. It usually occurs after acute transmural ischaemia in the absence of effective collateral circulation. Left ventricular remodelling is a dynamic process, starts soon after MI due to fibrotic transformation of the necrotic area with elongation and thinning of the infarcted area. In order to maintain cardiac output, left ventricular volume

and pressure are increased to compensate impaired left ventricular function. This causes high wall tension in accordance of Laplace's law resulting in eccentric hypertrophy of the viable zones and further enlargement and modification of the left ventricle. If the aneurysm is left untreated, the remodelling will continue and further affect the left ventricular dimension and function. The surgical purpose in left ventricular aneurysm repair is to relieve the excess workload placed on the viable myocardium, by a reduction in the size of LV, reshaping the ventricular cavity and exclusion of the necrotic part of the septum.

Surgical intervention is justified when a patient develops congestive cardiac failure, malignant arrhythmia, and thromboembolic complication. Repair is not indicated merely for left ventricular aneurysm. Concomitant revascularisations of diseased vessels are performed in the same occasion. Repair of left ventricular aneurysm improves the functional status of the left ventricle. Restoring the size and geometry of the left ventricle not only improve the anatomical configuration of the ventricle, but also prevent the focal point for clot formation and re-entry circuit for arrhythmia. In literature early post-operative mortality is acceptable [6,7].

Cooley's technique is developed in 1958 by excising the scar tissue with reinforcement of the adjacent myocardium with Teflon felt [3]. This procedure allows reducing the size of the cavity of the left ventricle, resulting in decreasing the LVEDV and LVESV. Next three decades, many surgeons develop other methods. Due to technical difficulty and a longer learning curve most of them are not adapted. Dor's endoventricular patch repair is well accepted by the surgeons [4]. It involves exclusion of the scar tissues. Theoretically DOR repair does not have any advantage over linear repair in small apical aneurysm. Moreover, patch acts as an akinetic tissue in the ventricular cavity. Some authors showed the advantages of the patch plasty [10,11]. Nevertheless, no clear consensus was documented about the benefit of patch over linear closure. No randomised controlled trail was carried out to compare the superiority of the EVPP over linear repair. Several authors did not observe benefit of the EVPP over linear repair in functional and clinical outcome [12,13]. The repair method does not affect the outcome. The better result depends on the size of the aneurysm and function of the residual myocardium. Most authors shared the same view that the performance of unaffected myocardium is the important determinant factor for the long and short term outcome. Theoretically, patients with smaller aneurysm treated with linear repair are expected to have more preserved functional myocardium. But it does not always follow the rules. To compare two different approaches are not easy to interpret. The choice of the procedure is determined by size, dimension, location and maturity of the aneurysm and surgeon's preference and experience.

We adapt different approaches depending on the location, size and involvement of the septum. In our series, we prefer to complete the repair after removal of the cross clamp for ensuring less ischemic time. All patients underwent coronary artery bypass graft. Concomitant mitral surgery was considered in severe preoperative mitral regurgitation. There is no difference in cross clamp time and bypass time in between two groups.

In early post-operative days, our results did not reveal any differences in IABP usage. 23.6% and 33.3% patients required IABP respectively in linear and Dor group (not statistically significant). Post-operative complication such as respiratory failure and multi-organ failure are similar in both groups. 23.5% patients develop respiratory failure and 5.8% developed multi-organ failure in linear group, whereas 13.3% patients develop respiratory and multi organ failure in EVPP group. The hospital stay for linear closure patients ranges from 7- 30 days, median stay is

13.9 days and length of stay for EVPP ranges from 7-28 days, median 17.2 days.

After surgery, we noted more than 75% achieved NYHAI/II status. Post-operative echocardiography revealed decreased in LVEDV and LVESV and also improvement of ejection fraction result [7,14,15]. We did not observe any difference in short term which are reported by other author, outcome in two groups. Our mortality was 3.12% in early post-operative day (<30 days). The mortality matches with other authors using linear or EVPP ranging from 3.7% - 9.8% [5-8]. Cardiac transplant is pre-empted for heart failure patients. However, lack of organ availability and presence of comorbidity, organ transplant is not an option for every patient. In these cases, left ventricular aneurysm reconstruction can be used as an alternative procedure with acceptable surgical risk.

CONCLUSION

Left ventricular aneurysm repair is well established surgical intervention with acceptable operative risk and good functional and clinical outcome. Our study showed that a similar improvement in left ventricular function and no difference in short term outcomes with linear closure and EVPP. The choice of repair is compelled by the surgeon's experience and altered geometry of the ventricle. Multi centre randomised controlled trial is warranted to prove the superiorly of one above another.

STUDY LIMITATION

The study had several limitations. It was a retrospective study and the population size was small. The echocardiography was performed by different technician. We should be cautious to apply our result with the general population.

CONFLICT OF INTEREST

None

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