Modifications of the Dor Procedure

Introduction

Left ventricular aneurysms (LVAs) occur in up to 40% of patients after myocardial infarction. The majority of these aneurysms are caused by occlusion of the left anterior descending coronary artery resulting in an anteroapical aneurysm. At present, the natural history of decompensated congested heart failure (CHF) carries a poor prognosis despite optimal medical management. In the Randomized Evaluation of Mechanical Assistance for the Heart Failure (REMATCH) trial, only 8% percent of the patients were alive at two years despite treatment.

Current medical management options include angiotensin-converting enzyme inhibitors (ACEI), beta blockers, coronary revascularization, and the gold standard of treatment; cardiac transplantation. However, due to the limited number of cardiac donors and lack of the other viable options, non transplant options need to be available for CHF management.

Occlusion of the coronary artery causing an aneurysm can result in an area of the ventricle demarcated from the surrounding chamber by hypokinesis, akinesis, or dyskinesis. An angiographic aneurysm may relate anatomically to an obvious sac of thin scar tissue which is a classic pathological definition of an aneurysm. The pathology may also correspond to a region of mixed scar and viable muscle of variable thickness. In such a case it may not be obvious whether the region would benefit more from revascularization with the hope of recruiting hibernating myocardium and improving regional wall motion, or from resection with ventricular reconstruction. When surgical ventricular restoration (SVR) becomes the determined treatment option, the ultimate goal is aimed at restoring native heart function.

Dor was the first surgeon to demonstrate the endoventricular patch plasty repair and demonstrated it could be applied to left ventricular (LV) aneurysm as well as intervention for a dilated akinetic ischemic LV. Since the inception of this technique, several modifications of the classic left ventricular reconstruction have been developed. This chapter will focus on the concepts of these modifications along with the indications, advantages and disadvantages.

Pathophysiology

Dilated cardiomyopathy and left ventricular aneurysms are two distinct disease processes with similar pathophysiology. While dilated cardiomyopathy results in a diffuse akinesis of the ischemic wall, the aneurysmal wall itself is dyskinetic. Dilated cardiomyopathy is described as ventricular chamber enlargement and systolic dysfunction with greater LV cavity size and little or no wall hypertrophy. This chamber enlargement is primarily due to LV failure, but may also be secondary to the primary cardiomyopathic process. Although the decrease in systolic function is the primary abnormality, dilated cardiomyopathies are associated with both systolic and diastolic dysfunction resulting in an increase in the end-diastolic and end-systolic volumes. Progressive dilation can lead to significant mitral and tricuspid regurgitation, which potentially further diminishes the cardiac output and increases end-systolic volumes and ventricular wall stress, all of which results in further dilation and myocardial dysfunction.

The Frank-Starling Law explains the basis for compensation of low cardiac output by stating myocardial force at end-diastole compared with end-systole increases as muscle length increases, thereby generating a greater amount of force as the muscle is stretched. But, overstretching of the muscle leads to failure of the myocardial contractile unit. Compared to individuals with normal LV systolic function, such compensatory mechanisms are overcome resulting in further myocardial injury, dysfunction, and geometric remodeling.

Aneurysms of the left ventricle commonly occur after a myocardial infarction from acute occlusion of the left anterior descending or dominant right coronary artery. Inadequate angiographic collaterals are strongly related to the formation of the aneurysm in patients with acute myocardial infarction. The occlusion of the left anterior descending artery and the absence of reformed collateral circulation are thought to be a likely prerequisite for formation of a dyskinetic left ventricular aneurysm.

During the course of “ventricular remodeling” from the disease process, the remote non-infarcted myocardium undergoes changes in volume and shape as well. As the ventricle increases in size, its normal elliptical shape becomes spherical and global systolic function deteriorates resulting in CHF. The prognosis of patients with ischemic cardiomyopathy is reportedly more associated to LV volume rather than to ejection fraction.

Surgical Ventricular Reconstruction

Ventricular reconstruction is the attempt to surgically restore the diameter, volume and shape of the ventricle to achieve improved ventricular function. During the 1980's Dor et al. described the method of an endoventricular circular patch plasty as an alternative to heart transplantation. The result of this procedure was a reduction in ventricular size however the ventricle retained an anatomical spherical configuration. This surgical ventricular restoration has since evolved with variations of the technique such as the linear closure by Jatene, a modified linear closure by Mickleborough, a circular closure with a patch by Menicanti and Dor, and the double circling closure without a patch by O'Neill. These different techniques may all be successfully performed when the disease involves primarily the antero-apical wall, however, when the septum is deeply involved or the dilatation is only at the septal level, the original Dor technique is the only option that ensures complete treatment of the underlying disease.

Goals of Surgical Ventricular Reconstruction

The goal of SVR is to reestablish the systolic concentric contraction of the whole LV wall by connecting the contractile myocardium and repairing the myocardium as needed. The reconstruction process has the potential to treat the three components of heart failure: the ventricle, the cardiac vessels and the valve (i.e. triple V as defined by Buckberg).

This surgical technique for the repair of aneurysm of the left ventricle depends heavily on the identification of the junction between scar and normal myocardium. However, in long-standing ischemic cardiomyopathies, the ventricles are frequently globally dilated with no localized region that is amenable to repair. Additionally, the transitional boundary between scar and normal myocardium is not as definitive and easily detected outside the rim of obviously contractile myocardium. Because of this situation, the only goal that might improve left ventricular function is the reestablishment of a more reasonably sized left ventricular cavity.

Indications:

Surgical ventricular restoration (SVR) is often effective for those patients with extremely low cardiac function. In general, indications for SVR are cases where there is need to restore the dilated, distorted LV cavity in order to improve function. Despite the surgical method used, an in-depth understanding of the remodeling infrastructure is essential.

Key Points of Surgical Ventricular Restoration

- **Dilated cardiomyopathy and left ventricular aneurysms are two distinct disease processes with similar pathophysiology**
- **Rebuilding the ventricular chamber reduces wall tension thereby reducing myocardial oxygen demand.**
- **Ventricular reconstruction is the attempt to surgically restore the diameter, volume and shape of the ventricle to achieve improved ventricular function.**
- **The goal of SVR is to reestablish the systolic concentric contraction of the whole LV wall by connecting the contractile myocardium and repairing the myocardium as needed**
- **Dor was the first surgeon to demonstrate the endoventricular patch plasty repair**
- **Since the inception of the Dor technique, several modifications of the classic left ventricular reconstruction have been developed.**

The Dor Procedure of Surgical Ventricular Reconstruction

Vincent Dor first employed the technique of endoventricular circular patch plasty (EVCPP) in 1984. The Dor procedure was designed to correct not only the free wall of the left ventricular aneurysm but also the septal component which would be left unaffected by a simple aneurysm resection. In addition, Dor maintained that by excluding the involved portion of the septum and placing a “constricting” endocardial patch, normal geometry was restored of the left ventricle. Dor emphasized the concept of improving cardiac function by reducing ventricle size and reconstructing a more elliptical cavity. He proposed that the basis of good surgical outcomes results was dependent on exclusion of all diseased tissue of the ventricular wall.

Modifications of the Dor Procedure in Surgical Ventricular Reconstruction

Approach by Jatene

Previous linear repairs did not include the septal region therefore; Jatene et al. developed an approach to overcome this particular deficiency by introducing the concept of imbracating the involved portion of the septum. This is performed for stability purposes and provides the left ventricular free-wall a firm base against which it could contract. Similar to Dor, Jatene also recognized that most anteroseptal aneurysms have a dilated base, pulling the non-aneurysmal left ventricular free-wall away from the septum. Jatene's approach alleviated this problem by placing an encircling purse-string suture around the base of the aneurysm, tightening until the ventricle resumed its previous elliptical shape...

The Jatene modification is performed after determining the location of the junction between functioning and nonfunctioning septal myocardium, the nonfunctioning portion of the ventricular septum is imburcated. This is performed by placing large pledgeted sutures in a posterior-to-anterior direction beginning at the base of the dysfunctional septal area and progressing towards the apex with subsequent horizontal mattress sutures. The first is placed at the base of the involved portion of the septum where the amount of the septum which is imburcated is greatest. By imburcating less septum with the suture placed nearer to the apex, the septum is tapered towards the apex as it was before ischemic injury (*FIG. 7*).

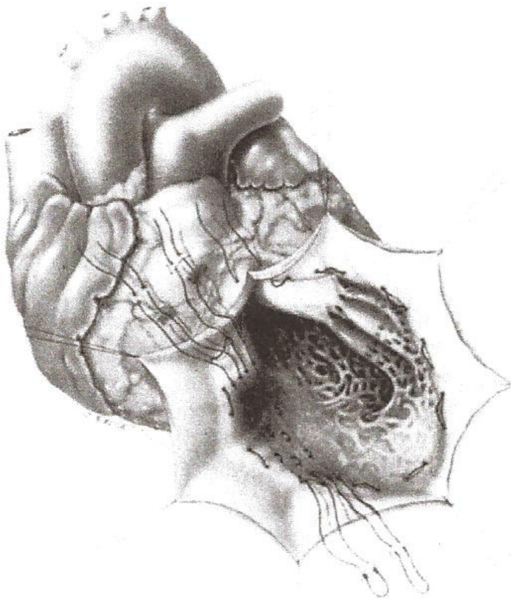

FIG. 7

Once the septum has been stabilized, an endocardial purse-string suture is placed circumferentially around the base of the aneurysm. *(FIG. 8)* The purse string is then tightened, bringing the ventricular free-wall back towards the septum and restoring the shape and “orienting” the myocardial fibers.

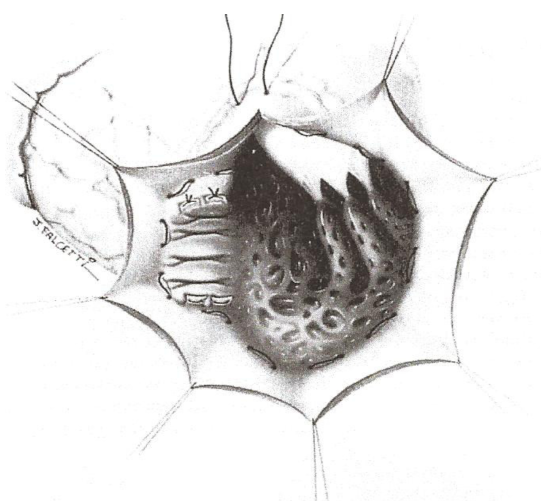

FIG. 8

The degree to which the purse-string is tightened determines the size of the opening left in the ventricle and therefore determines whether a patch is required for closure. If after tightening the purse-string suture the opening is 3 cm or more, it is preferable to use a patch.

Menicanti Modification

More recently, Menicanti et al introduced the use of a sizer/shaper intraventricular device as a refinement of the Dor technique, emphasizing the importance of re-shaping the LV cavity through patch positioning, which should be inserted deep in the septum and obliquely towards the aortic flow tract in order to obtain an elliptical new cavity. The positioning of the patch follows the Fontan suture that is performed in an oblique plane parallel to the septum, at the level of the transitional zone. In this way, the risk of making the new cavity too spherical, as can happen with the standard Dor technique, has been potentially overcome.

Mickelborough Modification: Modified Linear Closure

The modified linear closure technique has been proposed to be applicable for all types of aneurysms; such as broad-based, narrow-necked, true or false. The technique is simple can be easily modified and unlike the Dor can be performed on the beating heart especially useful in patients who might not tolerate a prolonged period of ischemia.

After initiation of bypass, the left ventricle is opened; any obvious thinned transmural scar is excised. Before final trimming, the size and shape of the remaining left ventricular cavity is evaluated. If the residual chamber is relatively normal in size and shape, linear closure can be easily accomplished. But in patients with a more extensive defect. It may not possible to restore the ventricular. In such patients, for linear closure to be accomplished without distorting left ventricular geometry (specifically the relationship between papillary muscle and the septum) a portion of the nonfunctioning wall may have to be left behind. In these difficult cases, the final resection margins are determined with these considerations in mind.

In cases of a septal aneurysm or thinning of the septum, Mickelborough recommends a patch septoplasty, should be performed using bovine preserved pericardium. The patch is applied to the left ventricular aspect of the septum and sewn in place to the surrounding normal myocardium on three sides with 4-0 prolene *(FIG. 16 B).* Anteriorly, the patch is incorporated into the linear ventriculotomy repair *(FIG. 16 C).*

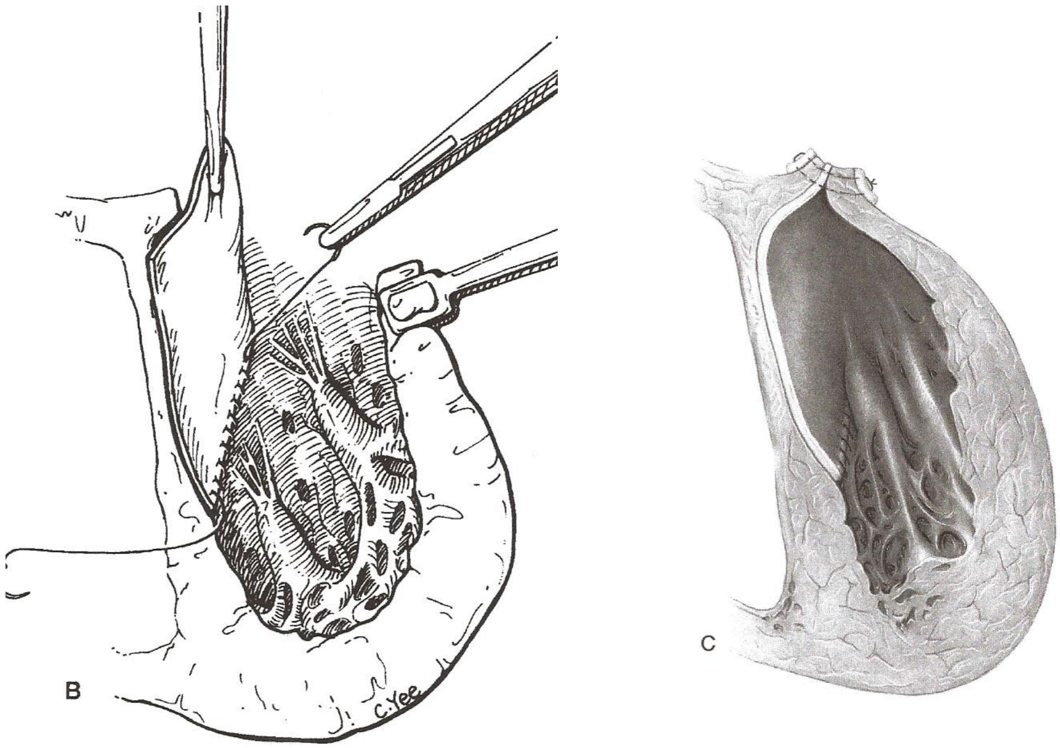

FIG 16

Once the excision is completed and the edges of the resection margin are illustrated. The incision is closed with mattress sutures of 2-0 prolene buttressed by felt strips. Sutures are generally placed further apart on the tissue than on the felt so as to plicate the length of the incision in the closure. This technique helps to restore the shape of the ventricle towards normal (Fig 17).

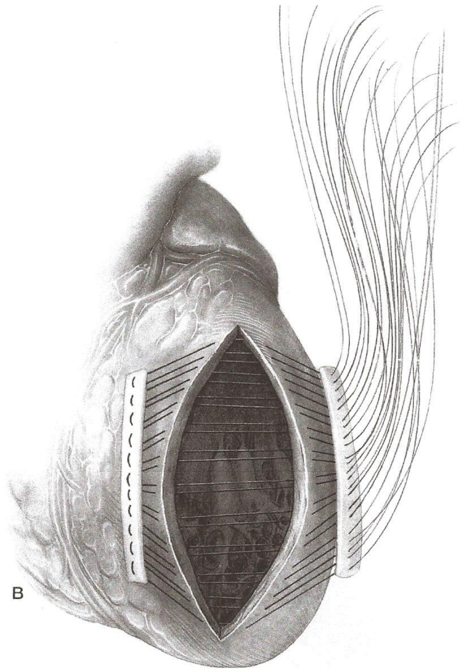

FIG 17

Evidence

Evaluating the role of cardiac surgery in the treatment of patients with coronary artery disease and left ventricular systolic dysfunction: The STITCH trial

The Surgical Treatment for Ischemic Heart Failure (STICH) trial was designed to evaluate the role of cardiac surgery in the treatment of patients with coronary artery disease and left ventricular systolic dysfunction. A major hypothesis of the trial was that CABG plus intensive medical therapy based on current guidelines, as compared with medical therapy alone, would reduce mortality. Before the STITCH trial, less than 1000 patients with ischemic cardiomyopathy had been studied in randomized comparisons of medical therapy versus coronary artery bypass grafting.

Controversies have followed publications of the trial's results with several articles from respected peer reviewed journals stating that the STICH trial is misleading because SVR procedures were not uniformly performed in properly selected patients. Some authors from the United States and abroad claimed the STICH has failed to meet the goals expected from an evidence-based study. It has since been reported that internists and cardiologists must be aware of the extensive registry data that confirms the long-term efficacy of SVR in a select group of patients operated on by experienced surgeons who can reliably exclude scarred LV segments that will reduce volume and reshaping the chamber. Extensive worldwide application of SVR does confirm its beneficial effect on remote muscle function, regional wall synchronicity, and global systolic function. Surgical ventricular reconstruction improves the functional status of CHF patients and a single flawed study cannot ignore that surgical ventricular reconstruction is an effective operation when performed by properly trained surgeons in correctly selected patients.

Outcomes of SVR

Restoration of ventricular geometry has also been shown by research to improve both systolic and diastolic left ventricular function. These reports also confirm the observation of authors finding that improved left ventricular function persists into the late postoperative period.

In a study by Raman et al., it was found that a significant number of patients improved at least one NYHA functional class with most patients improving to NYHA class I or II. It was discovered that not only did left ventricular function improve from the procedure, but indicators of quality of life improved substantially as well.

In another study by Raman et al researchers compared linear repair to intracavitary repair and discovered that only 51% of patients who underwent linear repair improved after their operations. In contrast, 76% of those patients who underwent intracavitary repair improved. Raman states other investigators have also noted similar improvements in patients who undergo an endoventricular type of repair. It is proposed that when ventricular geometry is restored, paradoxical contractile forces and end-diastolic volume both decrease, which, along with increased perfusion from bypass grafting, could account for the improved left ventricular function seen in patients who undergo intracavitary repair. Based on their results, Ramanet and researchers consider endoventricular types of repair to yield the best results, even though linear repair of ventricular aneurysms is yet a common approach. Such results led researchers to believe that the technique of endoaneurysmorrhaphy or intracavitary repair appears to be the simplest and most effective of the endoventricular type repair techniques.

As noted throughout this chapter, many modifications of the classic Dor procedure of left ventricular reconstruction have been developed. The procedure referred to as Complex Ventricular Reconstruction (CVR) is now being employed in conjunction with a sizable amount of data written about the technique and descriptions of the patients who benefit from this surgical technique. However, little is mentioned about the patients who have a poor outcome. In any kind of new procedure, case selection is important to achieve optimal results and it becomes important to look at the failure mode of left ventricular reconstructive procedures to help provide valuable information regarding how and when these techniques should be utilized.

In one particular retrospective study also by Raman, the identification of risk factors resulting in adverse outcomes of left ventricular reconstructive techniques were studied in patients over an 8-year period in three major hospitals on two continents. Authors studied 284 patients who underwent geometric left ventricular reconstructive procedures (including the Dor procedure)from 1997 to 2005 at the University of Melbourne Hospitals, University of Hobart Hospital and the University of Chicago Hospitals.

Complications were classified as fatal and non-fatal. All deaths as a consequence of the surgery, however remote, were recorded to derive the operative mortality. Table 1 shows a list of non fatal complications identified in the study while Table 2 depicts the operative mortality rate.

Table 1

Non-fatal Complications
-Low cardiac output **-End-organ dysfunction,** **-Ventricular arrhythmias** **-Neurological dysfunction ie CVA** **-Persistent congestive heart failure** **-Prolonged respiratory support as a consequence of cardiac decompensation** **-Persistent cardiac failure** **-Need for prolonged ventricular assistance** **-Recurrence of cardiac failure and late decompensation,**

Table 2

Operative Mortality Rate
-Total: 23 (8%)
-Urgency of surgery and cardiogenic shock: 15 (5.3%) **-Stroke: 5 (1.8%)** **-Post-operative biventricular failure: 3 (1%).**

Non-fatal failure modes accounted for morbidity in 26 patients. Breakdown of these modes included in the study were septal dyskinesis, persistent mitral regurgitation, post-operative ventricular tachycardia and sub-optimal myocardial protection. One hundred and ninety-nine of the surviving 261 patients (76%) were in NYHA class I. Twenty patients were lost to follow-up. All patients in NYHA class I were maintained on a combination of angiotensin-converting enzyme (ACE) inhibitors, beta blockers and diuretics. There were no instances of recurrent ischemia or heart failure decompensation in this group.

On the basis of the researcher's findings, it was stated that left ventricular reconstruction in the presence of cardiogenic shock or as an emergent procedure carries a considerable risk of mortality. If there was end-organ failure, the strategy focused on connecting the patient to some kind of mechanical ventricular assistance. Ventricular arrhythmias can frequently be a complication and cause of poor outcome in patients undergoing left ventricular reconstruction. Researchers therefore have adopted various techniques to reduce the incidence of these arrhythmias post-operatively, ranging from intra-operative ablation of the endocardium to electrophysiology studies and insertion of ICD's. Extensive research has been done and continues in this area to help develop principles in dealing with ventricular arrhythmias.

Through enhancing proper patient selection and optimal surgical planning, cardiac magnetic resonance imaging (MRI) has played a role in improving SVR outcomes. In a recent study, Lloyd et al document the benefits in the diagnosis, operative planning, and follow-up of SVR. Cardiac MRI offers accurate assessments of ventricular volume measurements such as the measurement of the end systolic volume index which can allow improved selection of those most likely to benefit from SVR.

In order for this imaging technique to provide optimal preoperative information that is clear and defined within measured parameters, there needs to be effective communication between the interpreting imaging physician and the surgeon. The ability of the surgeon to incorporate imaging information is important in the process of formulating an appropriate, comprehensive surgical strategy. Another positive aspect of cardiac MRI is the fact the entire imaging study can be performed in less than one hour making cardiac MRI a truly useful and comprehensive tool in planning SVR, and for subsequently evaluating outcomes.

One of the main disadvantages of cardiac MRI are its lack of present day availability. Another drawback affecting a small number of patients are the contraindications to MRI in general such as claustrophobia and the presence of implantable cardiac devices, Also considered as a negative aspect of this form of MRI is the lack of a focus upon a scheme of specific measurements that can guide decision-making for cardiologists and surgeons in the diagnosis, operative planning, and followup intervals.
Despite some of these drawbacks, cardiac MRI can be very beneficial and effective cooperation and communication is essential between the cardiologist and/or radiologist and the surgeon performing SVR in order to convey the necessary information to achieve optimal surgical outcomes.

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