Outcomes of left ventricular reconstruction when established parameters are followed, and subsequent questions

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The 2010 Task Force guidelines from the European Society of Cardiology/European Association of Cardiothoracic Surgery (ESC/EACTS) recommend ‘consideration of surgical ventricular restoration (SVR) to treat ischemic dilated cardiomyopathy, following measurement of ventricular volume and assessment of myocardial scar in centers with high experience’ [1]. This issue contains a report by Cho et al. [2] concerning ‘Long-term results and mid-term features of left ventricular reconstruction procedures on left ventricular volume, geometry, function and mitral regurgitation’ that amplifies the importance of surgical ventricular restoration (SVR) to architecturally remedy the failing hearts of patients with ischaemic dilated cardiomyopathy. Their superb results confirm how this procedure carries a very low perioperative mortality (1.6%), dramatically diminishes rehospitalization for cardiac causes over a 7-year interval and allows 79% long-term survival. These beneficial results are in concert with the broad number of world-wide SVR reports [3] and thus provide yet another contradiction to the flawed Surgical Treatment for Ischemic Heart Failure (STICH) study [4], whose misguided results have caused global curtailment of properly treating ischaemic dilated cardiomyopathy.

Cho et al. precisely followed the benchmark SVR entry criteria of >60 ml/m² left ventricular end-systolic volume index (LVESVI), >35% scarring of the left ventricle (LV) perimeter and achieved the requisite ~40% reduction of ventricular volume to reduce the LVESVI of <60 ml/m². These SVR-induced changes show why LVESVI <60 ml/m² is an independent predictor of prognosis [5], as the very low 7-year mortality ‘resulted from the natural events of neoplasm and infection’ rather than from pump failure or sudden death.

These splendid results were similarly achieved by the Dor, linear closure and septal anterior ventricular exclusion (SAVE) procedures, yet each outcome was accompanied by creating a more spherical ventricle instead of the intended elliptical form. Confirmation of improved systolic performance was garnered from the increased systolic eccentricity index that indicated the smaller remote muscle contracted more efficiently as it became more helical during ejection. Moreover, late findings in patients with larger pre-SVR ventricular volumes showed the development of a 22% incidence of mitral regurgitation (MR), which parallels Di Donato’s report of 38% later mitral insufficiency in patients with even larger preoperative ventricular volumes [6]. These shape and MR change direct attention towards how the procedure execution influenced these findings, since Pocar recently pointed out the disadvantage of a more spherical chamber and functional MR [7].

VENTRICULAR SIZE AND SHAPE

The surgical targets in heart failure are the ‘triple V’ of the vessel, valve and ventricle. SVR markedly changes the volume of the chamber as shown in Figure 1 of their report [2], but each of their procedures rendered the ventricle more spherical. These changes in ventricular architecture relate to interventions that shorten the long axis but may leave the short axis unchanged [6]. This architectural change happens because the reconstruction target has always been the exclusion of the scar, rather than directed towards rebuilding of the architectural shape whose components include a ‘ventricular trilogy’ that comprises the conical apex, equatorial mid-wall and ventricular base that contains the mitral annulus [8] (Fig. 1). It is important to consider each component, since rebuilding the elliptical configuration enhances the recovery of the twisting capacity [9], a retained extensive mid-wall equator amplifies late SVR mortality [10], and the widened base influences mitral valve performance by limiting leaflet coaptation.

In anterior infarction, the scar involves the free wall and septum. The septum’s mid-ventricular wall is often the site of fibrosis termination, and this transitional zone is consistently addressed by the Dor and linear closure procedures that reduce ventricular volume. In larger chambers, a more spherical shape may be the consequence, because more stretched remote muscle is retained, as shown in Figure 2, which contrasts addressing the disease against creating an elliptical form. Suma et al. [11] showed that both ‘size and shape were the goals’ in the SAVE procedure. The Fontan suture is not used and a narrow (1-cm) patch is placed into ‘non-scarred’, but stretched septum muscle that is adjacent to the aortic valve to rebuild an elliptical...
shape, which consistently narrows the mid-wall (Fig. 3). The current study employed the SAVE procedure in patients with very recent recurrent infarction, and I suspect their selection of connecting a 4-cm rather than 1-cm diameter patch into the surrounding remote muscle added stiffness to the widened rebuilt chamber. In contrast, Isomura et al. [12] utilized the narrow SAVE patch, significantly reduced the sphericity index from 0.62 to 0.55, employed a <90 ml/m² volume reduction as a favourable endpoint and improved 7-year survival to 71.5 vs 61.5% after the Dor procedure.

MITRAL INSUFFICIENCY

Functional MR exists in dilated cardiomyopathy because the spherical LV chamber interferes with several components of the mitral valve apparatus that include i) the dilated annulus, ii) the tethered leaflets, chords and papillary muscles, iii) widened papillary muscles bases that alter the angulation of the mitral annulus/chordae/leaflet connection to impact leaflet coaptation and iv) wall muscle nutrition if ischaemia is present. Conventional approaches to SVR reduce tethering by shrinking the chamber, and also add revascularization of ischaemic muscle, but do not address the widened annulus unless there is marked resting regurgitation, and may not alter the widened papillary muscle width.

Annuloplasty is now recommended in non-heart-failure patients with a widened left ventricular end-systolic dimension (LVDs) of >36 mm to improve the functional outcomes [13], so mild MR at rest in dilated hearts should make mitral repair a consideration, especially if annulus size is >32–35 mm. The normal size is ≏29 mm, and testing of MR during exercise should likely be a part of the preoperative evaluation; its development may become an indication for mitral repair. Moreover, the current report shows that SVR significantly reduces MR from 1.9 to 1.7; but such retention of regurgitation may be both a cause and effect of further dilation. Of equal importance, the annulus is a part of the base of the spherical chamber and its return to a normal size will likely help the restoration process, as inferred by the Pocar suggestion [7].

The spherical chamber widens the distance between papillary muscle bases, and measurement of this dimension should become a component of preoperative evaluation by using a mid-wall echocardiogram to record this curved measurement at the level of the papillary muscles. Stretching of the remote muscle widens this dimension; Hvass and Joudinaud [14] narrowed this width from within the atrium by placing a band around the bases of the papillary muscles, and this distance can also become narrowed from within the ventricle [15]. Figure 4 differs from the original diagram [15] by showing suture placement at the bases of the papillary muscles to permit normal angulation of its free conical portions. In contrast, attachment of

Figure 1: The ventricular trilogy, comprised of the conical apex, equatorial mid-wall and ventricular base containing the mitral valve annulus (reproduced from Buckberg [21] with kind permission from Springer Science and Business Media).

Figure 2: Ventricular shape after SVR excludes the culprit scar. Lower left shows the placement of the patch at the level of disease in a large chamber. Note the smaller, but more spherical chamber that results from not excluding the retained stretched remote non-scared septum muscle. Lower right shows the SAVE procedure, where the patch is placed below the aortic valve to result in creating a more normal elliptical shape.
Figure 3: The SAVE procedure, developed by SUMA, rebuilds an elliptical shape, as the narrow ~1-cm patch is inserted from the apex to the non-scarred ventricular septum just below the aortic valve (reproduced with permission from Hisayoshi Suma).

Figure 4: Upper left shows the normal distance between the papillary muscles. Upper right shows how stretch of non-scarred remote muscle widens this dimension. Lower left shows the placement of sutures into the bases of the papillary muscles, together with their insertion into the muscle between them to rebuild the more normal dimension. Lower right shows the sutures secured to both narrow the stretched remote muscle between the papillary muscles and reconstruct a more normal dimension.
the papillary muscles’ free conical component to the adjacent, now narrowed, ventricular wall may impair their function.

**DIASTOLIC DYSFUNCTION**

The low incidence (18%) of early diastolic dysfunction was further reduced at 1 year, and the use of an intraventricular balloon avoided excessive volume reduction as a cause of this complication. One aetiology, not yet considered, is related to the methods of myocardial protection. Temporary injury to the septum is caused by stunning of its endocardial or descending segment component of the apical loop of the helical heart configuration [16]. This same segment simultaneously comprises the inner layer of the LV free wall, and its prolonged contraction compromises untwisting—the keynote to the diastolic dysfunction complication [17]. Substantiation of this correlation has not yet been made by independent studies, but such temporary septum damage is now preventable. [16] I strongly suspect there will be a tight correlation between diastolic dysfunction and septum damage, as both may be offset by available methods of myocardial protection.

**THE STICH TRIAL**

The authors’ contradiction of the STICH conclusions of no benefits of SVR and coronary artery bypass grafting (CABG) over CABG alone is completely linked with their accurately fulfilling the STICH Surgical Therapy Committee’s definition of a safe procedure, whereby >30% reduction of LVESVI was accomplished in patients with akinesia or dyskinesia with <35% ejection fraction, after proper measurement of ventricular volume and necrosis [3]. In contrast, analysis of the STICH Trial patient selection and SVR execution demonstrates an absence of creditable evidence.

The recent STICH echo report shows that 18.5% of patients had an ejection fraction of >35% and these patients should have been excluded [18], together with the 9% of SVR cohort patients who did not have a ventricular restoration procedure [19]. Furthermore, the STICH 2010 presentation at the American College of Cardiology still remains unpublished, but reports that 44% of patients had no volume measurement. Moreover, there was no reported measurement of necrosis, and 42% did not have akinesia or dyskinesia [20]. SVR decisions were left to ‘surgical judgment’, and I suspect that the findings of no scar following ventricular incision accounted for the fact that ‘26% had no volume reduction’, the normal non-scared wall was simply closed. Only 19% had 30% volume reduction after SVR was done for LVESVI >60 ml/m², and these proper results from a ‘satisfactory SVR procedure’ have never been reported.

These misguided STICH findings have also impacted the surgical community, as the 2012 American Association of Thoracic Surgery (AATS) Adult Cardiac Surgery program invited a talk entitled ‘Ventricular remodeling operations: Is there a need?’ Fortunately, STICH limitations became evident in Europe and the 2010 Task Force guidelines from the ESC/EACTS contradicted STICH conclusions by ‘recommending consideration of SVR following measurement of necrosis and ventricular volume in centers with high experience’ [1].

**CONCLUSIONS**

The outstanding report by Cho et al. adds further evidence that ventricular restoration markedly changes the morbidity and mortality of ischaemic dilated cardiomyopathy. Favourable results are the centerpiece of this fine report, yet they happened despite the construction of a more spherical chamber; future considerations should address rebuilding the form to offset this spherical shape that may limit recovery. Additionally, supplemental methods to offset the postoperative development of MR in patients with larger preoperative ventricular volumes should include mitral repair to narrow the ventricular base and restore the normal dimension between widened papillary muscles to further diminish how increased sphericity, and MR may limit outcomes. The excellent Cho report adheres to the initial STICH criteria for entry and proper execution, and thereby demonstrates the conclusions that would have been expected if this flawed trial had followed creditable guidelines.

**Conflict of interest:** none declared.

**REFERENCES**


