Left ventricular reconstruction in ischemic cardiomyopathy

Klein, P.

Chapter 10

Left ventricular volume reduction and reshape – ‘Re-STICHING’ the field

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Reply to letter regarding the article ‘Less invasive ventricular reconstruction for ischaemic heart failure’

LEFT VENTRICULAR VOLUME REDUCTION AND RESHAPE – 'RE-STICHING' THE FIELD.

Letter regarding the article 'Less invasive ventricular reconstruction for ischaemic heart failure'

We read with interest the study by Klein *et al.*[1] exploring the effect of a less invasive device in inducing left ventricular reconstruction in failing hearts post-myocardial infarction. Left ventricular remodelling following an anterior myocardial infarction has detrimental effects to the efficacy of the left ventricle. This stems not only from the Laplace law but in addition from the impaired blood flow kinetics within the remodelled left ventricle. The concept of surgical volume reduction of the dilated left ventricle is to exclude the infarcted myocardial tissue, reshape and increase the efficacy of the left ventricle.[2] This strategy faces two major challenges.

First, the final end-diastolic volume should be reduced enough in order to allow the Laplace low to take place effectively. However, the final volume should not be that small, otherwise restrictive phenomena will occur, stroke volume will be reduced, left ventricular filling pressures will rise and re-dilatation of the left ventricle might occur. In those cases, any potential benefit from volume reduction therapies will be eliminated.[3,4] In order to avoid the left ventricular excessive volume reduction during the procedure, surgeons are trying to keep the final left ventricular remaining volume close to 60 mL/m^2 using the 'balloon sizing' technique. However, even if it is true that a final volume at that level is sufficient for the normally working heart, we still do not know whether this is also true for an impaired left ventricle that has undergone remodelling.

The second challenge for left ventricular reconstruction surgeries is the restoration of a more conical shape of the left ventricle. Studies have shown that a conical shape results in better outcomes since this shape improves blood flow hydrodynamics. In the STICH trial, left ventricular geometry worsened after left ventricular reconstruction surgery and the left ventricle became more spherical.[5] Only those patients that obtained a conical left ventricular shape demonstrated improved outcomes.

Left ventricular reconstruction surgery is not a one size fits all patients, and a more individualized approach should be implemented. Klein *et al.*[1] in a less invasive approach attempted to reduce the volume of the infarcted left ventricle, excluding the non-functioning scarred myocardium. There was a significant reduction in left ventricular volumes and a significant increase in left ventricular ejection fraction.

A total of 46 out of 86 participants were characterized as ‘responders’ since they revealed improvement in the 6-min walk test and in their quality of life.

To the direction of a more individualized approach for ventricular volume reduction and reshaping therapies, it would be very helpful if authors could provide also parameters of the shape of the left ventricle before and following the application of the device (apical conicity index, left ventricular sphericity index). The device proposed by Klein *et al.*[1] has the advantage of requiring no cardiopulmonary bypass. In that way, haemodynamic parameters obtained by a Swan–Ganz catheter at the time of the deployment of the device could provide important prognostic information on the short- and long-term adaptation of the left ventricle to the newly acquired volume and shape in a real time way.

Again, we find the study of Klein *et al.*[1] a very important step for a more quantitative and personalized application of left ventricular reshaping and volume reduction therapies.

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LEFT VENTRICULAR VOLUME REDUCTION AND RESHAPE – 'RE-STICHING' THE FIELD.

Reply

We thank Bonios *et al.* for their interesting and relevant remarks to our study of the Revivent TC System as an additional personalized therapy for a specific type of patients with heart failure after myocardial infarction with scar tissue in the antero-septal or apical wall of the left ventricle.[1]

Multiple publications described the clinical and functional improvement after (open) surgical ventricular reconstruction in patients with ischaemic cardiomyopathy. In line with these findings, we demonstrated at least equivalent functional and echocardiographic improvements by hybrid left ventricular (LV) reconstruction using the Revivent TC system. The basis for the rationale of LV reconstruction is, as Bonios *et al.* rightfully refer to, formed by the LaPlace law: decrease of LV volume reduces LV wall stress and both this and the (anatomic/physiologic) reconstruction improve LV contractile properties. Pressure–volume analysis provides the most comprehensive means of assessing ventricular contractile properties and the most rigorous means of measuring these relations in the clinical setting is with the conductance catheter as used by Tulner and colleagues from the Leiden University Medical Center.[2,3] They provided the scientific and pathophysiologic proof for LV reconstruction by demonstrating improvement in systolic and diastolic function, wall stress, dyssynchrony and mechanical efficiency by pressure–volume loop measurements. After surgical ventricular reconstruction, end-diastolic and end-systolic volumes were reduced from 211±54 to 169±34 mL (P =0.03) and from 147±41 to 110±59 mL (P =0.04), respectively. LV ejection fraction (from 27±7% to 37±13%, P =0.04) and end-systolic elastance (from 1.12±0.71 to 1.57±0.63 mmHg/mL, P =0.03) improved. Peak wall stress (from 358±108 to 244±79 mmHg, P <0.01) and mechanical dyssynchrony (from 26±4% to 19±6%, P <0.01) were reduced, whereas mechanical efficiency improved (from 0.34±13 to 0.49±0.14, P =0.03). With regard to pressure–volume relations, there were leftward shifts of both end-diastolic and end-systolic pressure–volume relationships towards more normal volumes. Decreased ventricular compliance has also been demonstrated by them and also in other studies on LV reconstruction and moreover also in settings of prolonged myocardial ischaemia. Hybrid LV reconstruction or the Revivent procedure is performed on the beating heart, without cardioplegic arrest and without the use of an akinetic/stiff Dacron patch. Therefore, the impact on diastolic functional properties should be less than in its open-surgical predecessor. Essentially, it all comes down to determine the balance between the relatively beneficial effects of decreasing wall stress and the detrimental effects of increasing diastolic filling pressures as a consequence of reducing chamber volume. Michler *et al.*[4] found that an LV end-systolic volume of 60 mL/m^2 body surface area after reconstruction to be a threshold at or under which a mortality benefit was observed. As such, it does not represent a target, but rather the upper limit of the target volume. The fact that in the Revivent procedure, the heart is beating and anchors can be removed or adjusted, under-sizing would be recognized in real-time intraoperatively, and corrected. We fully agree with Bonios *et al.* that the exact/ideal volume that should be achieved after LV reconstruction in remodelled ventricles is still unclear and it could very well be that it should be personalized in every single patient.

Concerning the changes in LV shape, we agree that additional data on pre- and post-operative shape would be very interesting. However, DiDonato and the RESTORE Group published already in 2006 that the adverse effects of ischaemic cardiomyopathy are statistically evident in every parameter except global sphericity, which remained unchanged between normal patients and those with dilated hearts after anterior infarction. Both ventricular length and width increased following anterior infarction, and hence the dimensionless ratio between length and width did not change, so that the sphericity index was unaltered.[5] Classical parameters of LV shape such as the sphericity index therefore seem insufficient to assess improvements in LV shape post reconstruction and therefore there is a need for new (perhaps three-dimensional or fusion) imaging parameters on shape (and function) in LV reconstruction procedures.

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