Time series analysis of physiologic left ventricular reconstruction in ischemic cardiomyopathy

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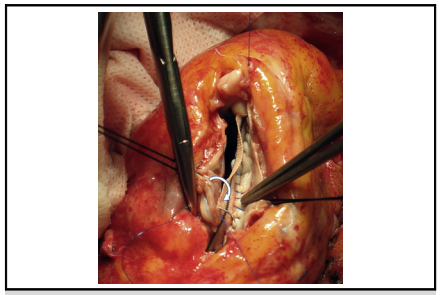
ABSTRACT

Objective: The history of left ventricular reconstruction has demonstrated that the full spectrum of recoverable physiologic parameters is essential for a good functional result. We report the long-term outcome of a new surgical technique that arranges myocardial fibers in a near-normal disposition, also recovering left ventricular twisting.

Methods: Between May 2006 and October 2013, 29 consecutive patients with previous anterior myocardial infarction and heart failure symptoms underwent physiologic left ventricular reconstruction surgery and coronary revascularization. Patients were examined by means of standard echocardiography and 2-dimensional speckle tracking at 8 time steps until 7 years after surgery. Ten geometric and functional parameters were evaluated at each step and analyzed by the linear mixed model test.

Results: Hospital mortality was 0%. The mean percentage of indexed end-diastolic and end-systolic volume reduction was 45.7% and 50.9%, respectively. Ejection fraction and all of the volumes were significantly different in the postoperative period with a steady correction during time. Diastolic parameters were not worsened by surgical reconstruction. Ejection fraction and deceleration time showed a significant improvement during time. Left ventricular torsion increased immediately after the surgical correction from 2.8 ± 4.4 degrees to 8.7 ± 3.9 degrees ($P = .02$) and was still present 4 years after surgery.

Conclusions: Surgical conduction of ventricular reconstruction should be standardized to achieve the full spectrum of recoverable physiologic parameters. The renewal of ventricular torsion should be pursued as an adjunctive element of ventricular efficiency, mainly in ventricles that work at a critical level in the Frank–Starling relationship and pressure-volume loop. (J Thorac Cardiovasc Surg 2016;■:1-10)



Physiologic reconstruction of the LV with respect to the orientation of the fibers.

Central Message

Surgically induced renewal of twisting helps remodeling in reconstructed ischemic ventricles working with critical mechanics.

Perspective

Surgical LV reconstruction should make all recoverable physiologic parameters effective. The renewal of ventricular torsion could be an adjunctive element of ventricular efficiency, mainly in ventricles working with critical mechanics. Further studies should include high-resolution speckle-tracking analysis to infer a more precise surgical planning for the arrangement of fibers.

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The history of left ventricular (LV) reconstruction, from the first successful open excision[1] to the Surgical Treatment for Ischemic Heart Failure (STICH) trial,[2] has clearly demonstrated that significant volume reduction is essential to obtain a good functional result, but it is not the only parameter to rely on. From endoventricular circular patch plasty[3] up to date, several studies have shown[4-8] that LV shape and geometry have at least an equivalent value to restore cardiac function and obtain steady clinical results. The role of myocardial fibers' orientation and their direct functional expression, LV torsion, recently have gained attention and interest both in normal hearts and in pathologic conditions, including

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Abbreviations and Acronyms

DT = deceleration time
EDVi = end-diastolic volume index
EF = ejection fraction
ESVi = end-systolic volume index
LV = left ventricle, left ventricular
MAPSE = mitral annular plane systolic excursion
STICH = Surgical Treatment for Ischemic Heart Failure
2D = 2-dimensional

ischemic cardiomyopathy.[9-14] Torsion is the functional expression of the normal 3-dimensional architecture of the LV wall. The shortening of obliquely oriented fiber bundles obtains the opposite twisting of the apex and the base of the ventricle, squeezing the ventricular chamber in high-efficiency, energy-sparing mechanics.[15] This movement is lost when the 3-dimensional structure is altered, as in ischemic cardiomyopathy. The unexpected potential to restore ventricular torsion after surgical treatment for ischemic cardiomyopathy was demonstrated in some clinical reports.[16,17] According to this concept, we recently devised a new technique of LV reconstruction aimed at redirecting myocardial fibers to an almost normal setting.[18,19] Renewal of LV torsion, as expression of restored fibers' orientation and good global ventricular function and efficiency, could contribute to achieve systolic contraction and diastolic relaxation with a lower energy consumption,[20,21] mimicking its role in normal hearts. We report the long-term results of this new surgical approach with serial echocardiographic assessments over a 7-year follow-up period with the aim of demonstrating the time course of postoperative remodeling in these cases.

PATIENTS AND METHODS

Patients

Between May 2006 and October 2013, 29 consecutive patients with previous anterior myocardial infarction, ischemic cardiomyopathy, dominant anterior akinesia/dyskinesia, and prevalent heart failure symptoms underwent LV restoration surgery and coronary revascularization. The mean age of patients was 64 ± 10 years, and 10 patients were female. Mitral regurgitation was absent in 27 patients and mild in 2 patients. Eight patients who underwent operation in the same period but who required combined mitral surgery have been excluded from the analysis to have good basal residual function and the possibility to study diastolic parameters. The time interval from myocardial infarction was 71 ± 74 months (range, 6-274 months). The mean apical rotation was 0.8 ± 4.4 degrees, and LV

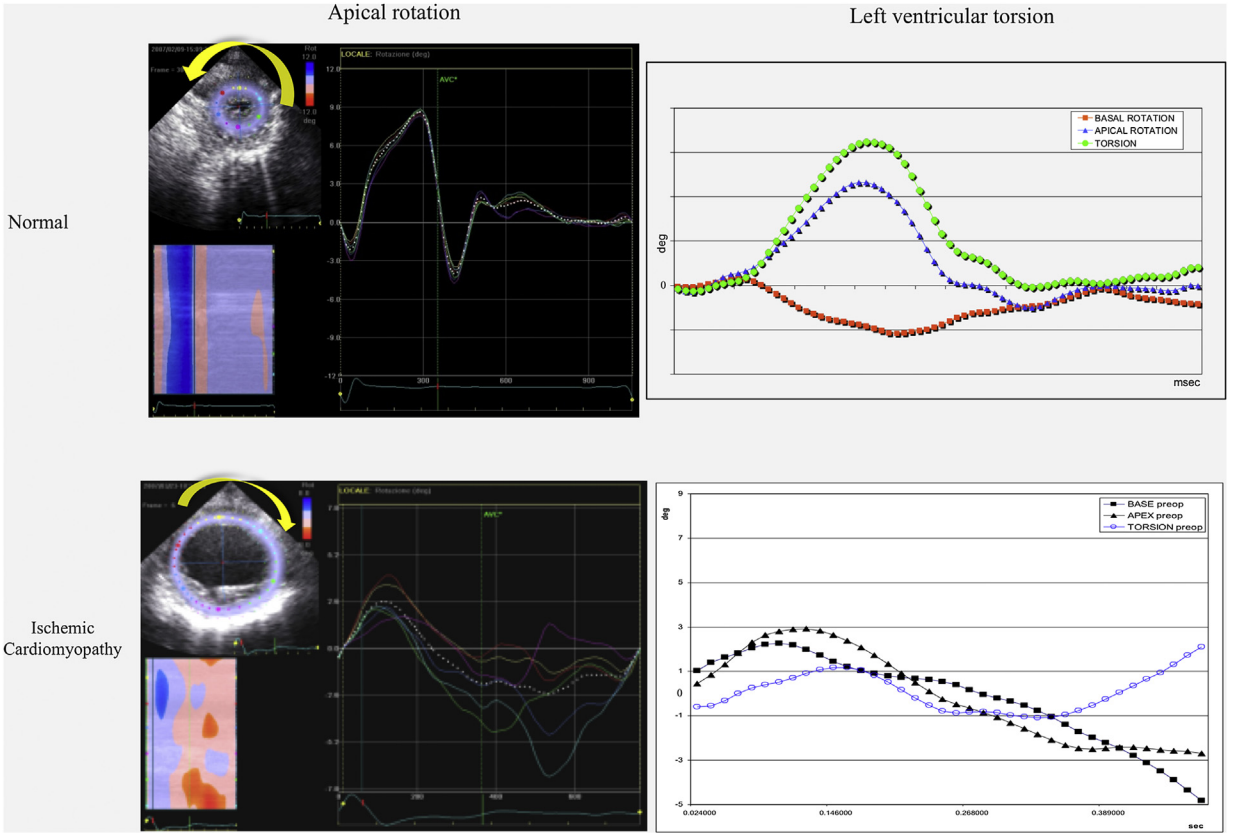

FIGURE 1. Comparison between apical rotation and LV torsion in normalcy and ischemic cardiomyopathy. In normalcy, apical rotation (counterclockwise) is opposite to the base (clockwise), all myocardial walls move synchronously, and the result is LV torsion. After anterior myocardial infarction and the loss of arrangement of fibers, apical rotation is consensual to the base (clockwise), and this nullifies LV torsion.