Let’s twist

Marcel L. Geleijnse* and Bas M. van Dalen

Department of Cardiac Imaging, Erasmus Medical Center, Thoraxcenter Room Ba304, ‘s-Gravendijkwal 230, 3015 CE Rotterdam, The Netherlands

Received 11 August 2008; accepted after revision 25 August 2008; online publish-ahead-of-print 17 September 2008

In the 16th century, Leonardo DaVinci already described the rotational motion of the left ventricle (LV)1,2 and in 1669, Richard Lower observed that myocardial contraction could be compared with ‘the wringing of a linen cloth to squeeze out the water’.3 Three centuries later, the use of radiopaque markers in cineradiographic studies made it possible to measure this wringing motion in the human heart, as was shown by Ian McDonald and Neil Ingels.4,5 The mechanistic basis for this wringing motion or twist lies in the complex spiral architecture of the LV as revealed by the anatomical studies of Streeter et al.6 and Greenbaum et al.7 The LV consists of obliquely oriented muscle fiber(s) that vary from a small-radius, right-handed helix at the subendocardium to a larger-radius, left-handed helix at the subepicardium. The functional result of this three-dimensional helical structure is a cyclic systolic twisting and diastolic untwisting of the LV apex relative to the base. LV twist plays a pivotal role in the mechanical efficiency of the heart, making it possible that only 15% fiber(s) shortening results in a 60% reduction in LV volume,8 and untwist plays a crucial role in diastolic suction.9 Studies on LV twist may yield new or additional information about cardiac (patho-)physiology, beyond the traditional measurements of radial and longitudinal function.

In the last decades, LV rotation has mainly been studied with tagged magnetic resonance imaging. However, lack of availability, limited temporal resolution, and the time-consuming and complex data analysis have precluded its use in routine clinical practice. More recently, it became also possible to study LV rotation with tissue Doppler techniques and two-dimensional (2D) speckle tracking echocardiography. This latter technique offers the opportunity to track myocardial deformation independently of both cardiac translation and the insonation angle.

The contribution of Gustafsson et al.10 in this issue is the first article in the European Journal of Echocardiography describing LV rotation. In 40 healthy volunteers with structurally normal hearts and no history of hypertension, ‘regional’ LV rotation was studied for the first time with speckle tracking echocardiography. Their main findings are (i) systolic rotation at the basal level (but not at the apical level) is increased in the posterior segments and (ii) there is a temporal dispersion in apical and basal de-rotation during diastole. In magnetic resonance studies on ‘regional’ rotation conflicting results have been reported.11–13 However, unpublished data from the ‘Thoraxcenter’ confirm the findings presented by Gustafsson et al. More importantly, the presence of relatively more oblique fiber(s) in the posterior segments may provide an anatomical base for their finding of increased rotation in the posterior segments.7 As shown in other studies, ~40% of LV de-rotation occurred during the isovolumic relaxation phase. Interestingly, in particular at the LV basal level, there was still profound de-rotation from mitral valve opening until the peak velocity of passive LV inflow. This may be explained by the temporal dispersion in basal and apical repolarization. Since the basal endocardial fiber(s) are the latest to be repolarized, an extra de-rotating force may still be present during this period at the basal level. After the peak velocity of passive LV inflow, there is still de-rotation at the apical level but a brief period of re-rotation at the basal level. Since rotation is related to an increase in LV pressure and de-rotation is related to a decrease in LV pressure, this may facilitate blood flow to the apex.

Although the results of this study are of great interest, and the investigators should be congratulated for their study, there are a few considerations and some caveats that should be considered before widely applying LV rotation and twist measurements in larger groups of patients. First of all, there should be consensus on the used nomenclature. Twist and torsion are currently often mixed-up in the literature. Twist describes the instantaneous difference between LV basal and apical rotation (expressed in degrees) and torsion describes twist corrected for the distance between the two measured short-axis plains (expressed in degrees per cm). Because with 2D speckle tracking echocardiography this latter distance is actually not known, only twist can be calculated from the rotational data. Second, longitudinal motion of the LV causes through plane motion of the basal...
short-axis image, so that the originally defined speckles move out of the plane. Furthermore, the imaged epicardium is sometimes too bright, causing signal saturation, which precludes discrimination of the subtleties of image contrast that allows speckle tracking to work. Also, the size of a tracking point is in reality larger as the one that is displayed. Therefore, placement of a tracking point in the epicardium can potentially result in stationary artefacts by tracking of non-moving speckles outside the heart. Motion of the mitral valve leaflets in the area of tracking points placed on the endocardium will potentially interfere with proper speckle tracking as well. Finally, and probably most importantly, in a significant number of patients, true apical rotation will be underestimated to a variable extent because of inability to visualize the true LV apex. The short-axis recordings and analyses should be done meticulously. Currently, the anatomical landmarks are to loosely defined and in particular attention should be made to record the correct cross-section at the LV apical level. This may partially explain the differences between measured LV twist in normal middle-aged human subjects in the literature (ranging from 8º to 20º). Despite proposed distance normalization algorithms, only 3D speckle tracking echocardiography can definitely solve this important limitation.

Chubby Checker’s song ‘The Twist’ changed dancing forever by separating the dancers and is one of only two songs to move out of the plane. Furthermore, the imaged epicardium is sometimes too bright, causing signal saturation, which precludes discrimination of the subtleties of image contrast that allows speckle tracking to work. Also, the size of a tracking point is in reality larger as the one that is displayed. Therefore, placement of a tracking point in the epicardium can potentially result in stationary artefacts by tracking of non-moving speckles outside the heart. Motion of the mitral valve leaflets in the area of tracking points placed on the endocardium will potentially interfere with proper speckle tracking as well. Finally, and probably most importantly, in a significant number of patients, true apical rotation will be underestimated to a variable extent because of inability to visualize the true LV apex. The short-axis recordings and analyses should be done meticulously. Currently, the anatomical landmarks are to loosely defined and in particular attention should be made to record the correct cross-section at the LV apical level. This may partially explain the differences between measured LV twist in normal middle-aged human subjects in the literature (ranging from 8º to 20º). Despite proposed distance normalization algorithms, only 3D speckle tracking echocardiography can definitely solve this important limitation.

Chubby Checker’s song ‘The Twist’ changed dancing forever by separating the dancers and is one of only two songs to re-enter the Hot 100 list and return to the number 1 position. After an era of LV rotation research with magnetic resonance imaging, echocardiography may bring cardiac twisting and untwisting back into the spotlight again and provide new insights into cardiac (patho)physiology.

References
4. McDonald IG. The shape and movements of the human left ventricle during systole. A study by cineangioigraphy and by cineradioiogy of epica
7. Greenbaum RA, Ho SY, Gibson DG, Becker AE, Anderson RH. Left ventric
10. Gustafsson U, Lindqvist P, Werner S, Waldenström A. Assessment of
11. Rademakers FE, Buchalter MB, Rogers WJ, Zerhouni EA, Weisfeldt ML,
Weiss JL et al. Dissociation between left ventricular untwisting and fil
pic stimulation contributes to increased left ventricular torsion and radial strain in normal subjects: quantitative assessment utilizing a novel automated tissue tracking technique. Circ J 2007;71:661–8.
14. van Dalen BM, Vletter WB, Soliman OI, ten Cate FJ, Gelijnsje ML. Impor
15. Tanaka H, Oishi Y, Mizuguchi Y, Miyoshi H, Ishimoto T, Nagase N et al. Contribution of the pericardium to left ventricular torsion and regional myocardial function in patients with total absence of the left pericar