Speckle Tracking Echocardiography

a report by

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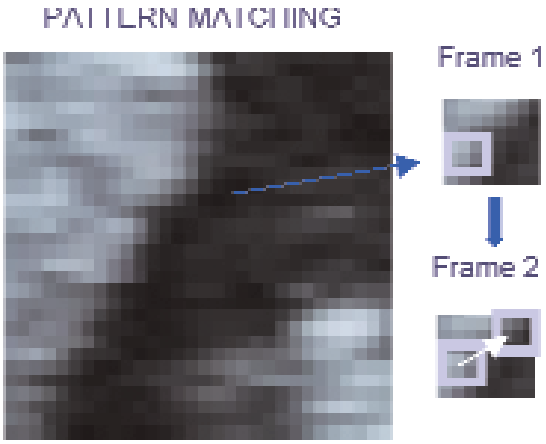
Philips

Speckle tracking echocardiography (STE) is a new, non-invasive method for the assessment of left ventricular (LV) global and regional function. STE offers the opportunity to track myocardial deformation independently of both cardiac translation and the insonation angle. Before the advent of STE, the only technique for angle-independent assessment of LV deformation and rotation was tagged cardiac magnetic resonance (cMR). Although tagged cMR remains the reference method for the assessment of LV deformation, its use is limited by an inherent low frame rate acquisition, high cost, and time-consuming and complex data analysis. Recently, STE was proposed as an alternative method to assess LV deformation and torsion, and it has been systematically validated by reference to sonomicrometry, tagged cMR and colour-coded tissue Doppler echocardiography. Several studies have proven its accuracy and consistency.

Because of scattering, reflection and interference of the ultrasound beam in myocardial tissue, speckles appear in grey scale two-dimensional (2-D) echographic images. These speckles represent tissue markers that can be tracked from frame to frame throughout the cardiac cycle (see *Figure1*).

Figure 1: Speckle Tracking Pattern



These fingerprints are randomly distributed throughout the myocardium. Each speckle can be identified and tracked by calculating frame to frame changes – similar to analysis with tagged cMR – using a sum of absolute difference algorithms. Motion is analysed by integrating frame to frame changes. Out-of-plane motion occurs due to rotation and motion of the heart into the chest cavity, and may cause the disappearance of the speckles over a few frames, but rarely within two consecutive frames. Philips Tissue Motion Quantification (TMQ) software allows spatial and temporal processing of these markers on 2-D ultrasound images. TMQ speckle tracking also offers an alternative to techniques such as colour-coded tissue Doppler for strain, and strain rate imaging, overcoming many of the problems traditionally associated with angle dependence. A significant advantage consists in the possibility of interrogating radial, circumferential and longitudinal deformation simultaneously from the same acquired loop. By tracking these speckles, the strain, strain rate, tissue velocity and LV rotation can be easily calculated.

Clinical Applications

Myocardial Strain Measurement

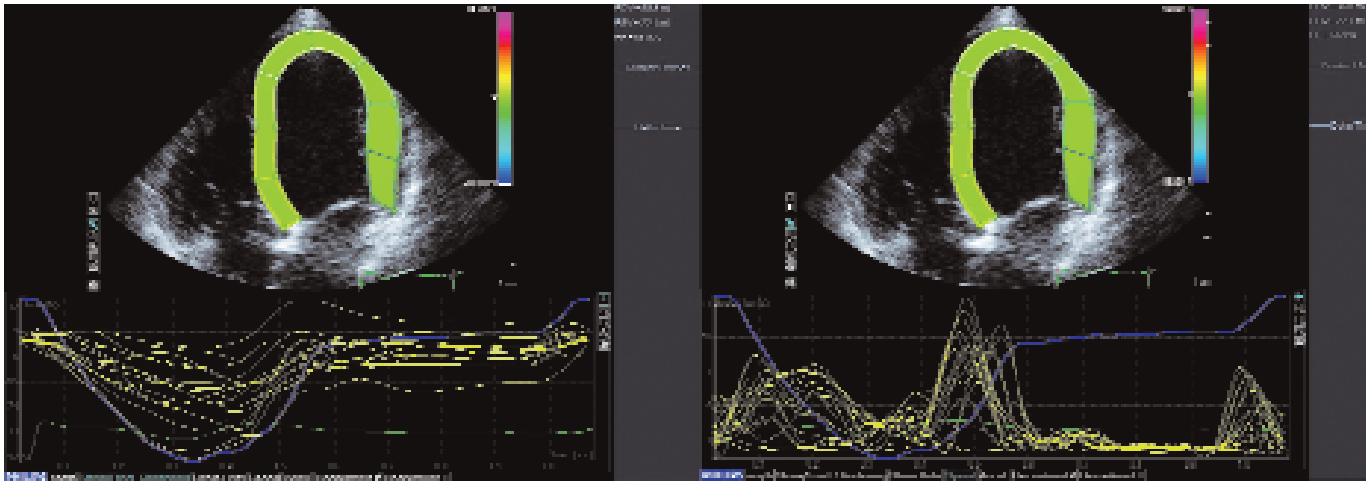
2-D echocardiography is currently the first-line imaging modality for assessing global and regional function. Using 2-D echocardiography, LV function is most often evaluated visually. 2-D echocardiography also offers the opportunity to measure end diastolic and end systolic volumes, by use of a modified Simpson rule, and thereby to calculate LV ejection fraction. Myocardial thickening and segmental wall motion can also be assessed, although these measures are even harder to assess, and are therefore most often visually estimated on the 2-D ultrasound images. This qualitative approach suffers obvious limitations. Its accuracy, depends on the expertise of the reader, resulting in large intra- and interobserver variabilities.

Furthermore, it estimates only radial deformations of the myocardium, whereas others – such as thickening, shortening and twisting – are ignored. Recently, strain and strain rate imaging – using colour-coded tissue Doppler imaging – have emerged as a quantitative technique to estimate myocardial function and contractility, and the clinical utility of these measurements has been demonstrated in numerous studies.[1-8] However, analysis of myocardial strain by tissue Doppler is restricted along the axis parallel to the ultrasound beam, and is thus limited by this angle dependence. By analysing speckle motion, STE offers the opportunity to assess myocardial tissue velocity, strain and strain rate independently of cardiac translation and beam angle. STE is simple to perform, it requires only one cardiac cycle, and further processing and interpretation can be done offline. The software only requires harmonic and high frame rate imaging (see *Figure 2*).

The real power of speckle analysis is the ability to examine several components or planes (i.e. radial, longitudinal and circumferential) in a single data set.

Myocardial strain quantification by STE has been well validated, using sonomicrometry and tagged cMR as reference methods.[9] STE strain measurements are accurate, with minimal bias and low intra- and interobserver variabilities, and are valid in patients with and without wall motion abnormalities. More recently, STE has been used to evaluate new

Figure 2: Apical Four-Chamber View. Strain and Absolute Velocity Curves and Parametric Imaging.

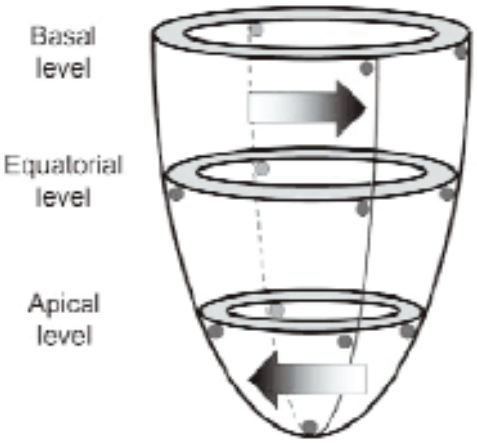


indices of systolic function, particularly longitudinal strain, which was shown to be a sensitive and specific index in post myocardial infarct. Therefore, STE has become a simple, rapid and accurate technique to evaluate myocardial function.

Evaluation of Left Ventricular Torsion

STE also offers the unique opportunity to assess torsional deformation of the LV. Indeed, LV contraction not only generates shortening and thickening, but also torsion. Due to the orientation of LV muscle fibres varying across the LV wall – from a right hand helix in the subendocardium, through circumferential fibres in the midwall, to a left hand helix in the subepicardium – the shortening of obliquely oriented LV fibres generates a wringing motion responsible for LV torsion. During the cardiac cycle, a systolic twist and an early diastolic untwist are generated by opposite basal and apical rotations. When viewed from the apex during systole, the apex rotates counter clockwise relativel to the base (see Figure 3). Torsion, or twist, plays an important role in ejection and in the storage of potential energy at end systole, the release of this energy as elastic recoil during early diastole assists ventricular suction. Torsion has been studied in clinical and experimental studies, and it is well established that LV rotation is sensitive to changes in LV function. It is, therefore, of obvious clinical interest to assess LV torsion non-invasively. Until recently, tagged cMR was the only method capable of assessing LV torsion non-invasively. It is also not surprising that it is currently considered as the reference. With the advent of STE, LV torsional deformation can also be looked at with echocardiography, thus permitting a broader use of this new functional approach.[10,11] The TMQ software allows for the assessment of LV torsion and untwisting in subendocardial, midwall and subepicardial layers (see *Figure 4*). Estimates of LV torsion and LV twisting velocities measured by STE in patients with or without cardiomyopathy are well correlated to those measured by tagged cMR.

Figure 3: Left Ventricular Twist. Apical Versus Basal Rotation



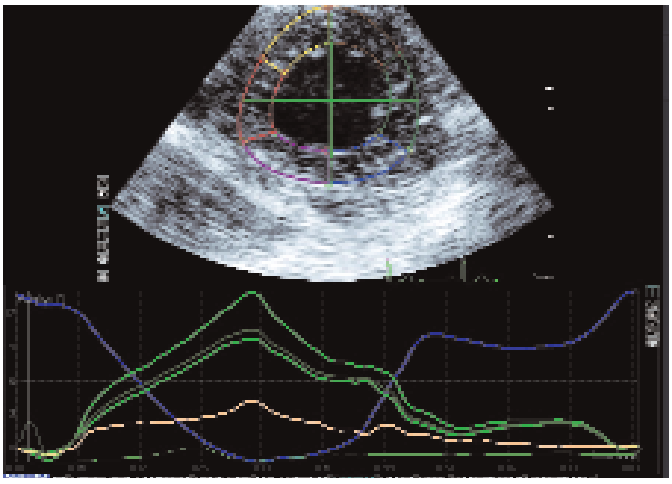
Speckle Tracking Echocardiography and Cardiac Resynchronisation Therapy

Another potential clinical application of STE is the evaluation of patients prior to cardiac resynchronisation therapy (CRT). Since several clinical randomised studies demonstrated that some patients selected on the basis of standard clinical criteria do not respond to CRT, quantification of LV dyssynchrony by echocardiography has been increasingly used to predict patients' response to CRT. Several echographic parameters have been described to evaluate patient response to CRT. Because of its high spatial and temporal resolution, STE can also be used for this purpose.[12] It should, therefore, not be surprising if dyssynchrony measured by this novel approach were already proved to have high sensitivity and reproducibility.

Conclusion

Speckle tracking echocardiography is a new simple, easy and inexpensive method with the potential of becoming the reference clinical bedside tool for the evaluation of LV function (shortening, thickening and torsion).■

Figure 4: Left Ventricular Apical Rotation



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