Two dimensional Speckle Tracking Echocardiography
An overview

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One of the main demands on echocardiography was the evaluation of regional and global left ventricular function. In the early days of echocardiography the M Mode based ejection fraction was considered to be the main tool for this purpose. Eventually this was found to be totally inaccurate in most cases, so much so, no less a person than Feigenbaum declared publicly that he does not do ejection fractions any more. There haven attempts to identify other parameters for LV function assessment as time progressed. Ejection fractions based on 3 dimensional volume determinations added the accuracy, but was constrained by the increased time and effort needed. Doppler based tissue velocity based studies, especially the mitral annular velocities offered some relief. But this was again criticized as inaccurate because of the inherent problems of the insonation angle discrepancies. Strain and strain rate studies offered some hope, but this was also based on Doppler technology which was again not totally acceptable.

In early 2000, the 2 D based speckle tracking concept gained prominence. This overcame the problem of Doppler velocities being used to measure displacement. Speckle Tracking Echocardiography (STE) is a unique imaging technique where the motion of ultrasonic interference patterns called “speckles” are monitored to derive strain patterns.

Regional STRAIN is a dimensionless measurement of deformation, expressed as percentage change from the original dimension. (1) During a cardiac cycle, stretching and shortening occur in the myocardium during systole and diastole. Essentially this is a deformation from the original state. This is known as the Langrangian Strain, and is used by the speckle tracking technology. The end diastolic myocardial dimension is taken as the reference point against which the deformation is analysed. (2) Studies of LV myocardial contraction, mainly by Partho Sen Gupta and Bijoy Khandheria from Mayo clinic, have shown twist or torsional deformation

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occurs during ejection, which when viewed from the apex appears as clockwise rotation at the apex and counterclockwise at the base. (3). To describe these movements, terms such as twist, rotation and torsion are used. But by convention, “rotation “ refers to the rotation seen in short axis vies of LV. The term “torsion” to the difference in rotation that occurs along the longitudinal axis. The ability to quantify these data was made possible with the application of speckle tracking technology. This has made a tremendous stride in the evaluation LV function especially in various stages of myocardial ischemia.

The accuracy of speckle tracking has been compared with the existing techniques like microsonometry, tagged MRI and tissue Doppler strain measurements and has been found to correlate significantly with all these methods.(4,5)

In 2D speckle strain examinations, the commonly used parameters are (i) Peak systolic strain, (ii)Strain rates, (iii) time to peak measurements, (iv) circumferential strains (v)diastolic measurements. Using these studies in various clinical states haven undertake.

1. Coronary artery disease

In myocardial ischemia, the longitudinal strain values, especially in the endocardium shows evidence of hypoperfusion. This would be translated into attenuated values in the longitudinal direction. According to Choi et al, a strain value less than – 17.9 % was correlated with severe 3 vessel disease.(6)

2. Myocardial infarction

Myocardial infarctions result in changes in LV functions like ejection fraction an regional wall abnormalities. STE studies have been shown abnormal strain patterns in such situations. These strain patterns have been found to be correlated to the severity and extent of infarcted areas. (7,8). These results have been of prognosis value also.

3. Stress echocardiography

One of the major difficulties faced in stress echocardiography was the problem of quantification of the ventricular deformation imaging. The inter observer values were notoriously variable. Attempts were made to use tissue velocity imaging, but was constrained by it’s inability to study radial contractions. A breakthrough in stress echo quantification has been attempted with the use of STE in systolic and diastolic phases of the cardiac cycle, using longitudinal, radial and circumferential directional values. (9)
Long axis and graph in LV Dysfunction

1. Coronary artery disease
Using these studies in various measurements, (iv) circumferential strain rates, (iii) time to peak strain, and has been found to correlate significantly with all tagged MRI and tissue Doppler strain measurements. The accuracy of speckle tracking has been compared especially in various stages of myocardial ischemia. This has made a breakthrough in stress echo quantification. These data was made possible with the application of "torsion" to the difference in rotation that occurs during ejection, which when viewed from the apex appears as clockwise rotation at the apex and counterclockwise at the base. To describe these movements, terms such as twist, rotation and torsion are used. But by convention, "rotation" refers to the rotational movements in the horizontal plane. However, subclinical LV dysfunction can occur early in the disease. STE can identify these abnormalities if done serially and can be made use of in determining the time of surgery.

2. Myocardial infarction
Myocardial infarctions result to the severity and extent of regional wall abnormalities. These strain patterns have been shown abnormal strain patterns in such situations. STE studies have been agreed that in the LVH found in athletes the strains are high. According to Choi et al, a strain value less than –17.9% was correlated with severe hypertension the longitudinal strain shows reduction, probably due to the associated fibrosis. (11) This has to be evaluated in the light of radial strains which often are paradoxical. The other condition with LVH is hypertrophic cardiomyopathy. Here again the universal opinion is that the STE values are diminished reflecting the myocardial fibre disarray found in the pathology of the disease. (12) STE can also identify the coexisting diastolic dysfunction also which the hallmark of this condition.

3. Stress cardiomyopathy
Cardiomyopathy, known as Takotsubo cardiomyopathy, is attributed to be stress related and is usually reversible. STE can play a significant role in the diagnosis because of the regional strain patterns not related to any coronary distribution. STE also can be used to monitor the recovery patterns. (14)

4. Revascularization
The role of STE in revascularization is to identify the damages during balloon occlusion, viability of tissues and the impact of successful procedure.

5. Valvular heart disease
Even severe valve disease like aortic stenosis can remain asymptomatic for a long time. However, subclinical LV dysfunction can occur early in the disease. STE can identify these abnormalities if done serially and can be made use of in determining the time of surgery.

6. LV hypertrophy
One of unique advantages of STE is in the identification of the nature and causes of LV hypertrophy in different conditions. Though there are different opinions, it is generally agreed that in the LVH found in in athletes the strains are high. (10) In the LVH in hypertension the longitudinal strain shows reduction, probably due to the associated fibrosis. (11) This has to be evaluated in the light of radial strains which often are paradoxical. The other condition with LVH is hypertrophic cardiomyopathy. Here again the universal opinion is that the STE values are diminished reflecting the myocardial fibre disarray found in the pathology of the disease. (12) STE can also identify the coexisting diastolic dysfunction also which the hallmark of this condition.

7. Dilated cardiomyopathy
In dilated cardiomyopathy, strain is reduced in all 3 directions, as expected. The values can be utilized to assess the beneficial effect of treatment or worsening, on repeated exams. (13)

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9. Pericardial disease
Specific STE patterns have been described in various stages of pericardial disease. In constrictive pericarditis, the circumferential strain is impaired while the longitudinal might be preserved. Conversely, in restrictive conditions like amyloidosis, it is the longitudinal strain that is reduced. This feature can be of significant in doubtful cases. (15)

10. Evaluation of heart failure
STE studies have played a major role in the understanding of myocardial mechanics in cardiac failure. Contrary to the older model of separation of systolic and diastolic LV dysfunction, the new insight is to take these as expressions of a continuum of events. STE studies have revealed overlapping values in diastolic and systolic hear failure syndromes. (16,17)

11. Resynchronization Therapy
The increasing acceptance of resynchronization therapy sought newer modalities for the evaluation LV dysfunction. Since the technology was based mainly on the radial contractility STE with it's unique ability to evaluate radial and circumferential functions became the focus of intense interest. Newer indices were developed using STE to identify ideal candidates for CRT and responders. (18,19) STE was also used to monitor the prognosis as well.

12. Cardiac involvement in systemic diseases
One of the major fallouts of STE was the identification of subtle cardiac involvement I n
diabetes. Longitudinal and global strain changes have been noted (20, 21) This would be of great importance in the context of concerns of the complications of drugs like glitazones which are incriminated in LV dysfunction, and which may lead on to cardiac failure, The other area of interest would be the cardiotoxicity induced by anthracycline like molecules while being treated for malignancy. Early detection using STE can be of help in altering treatment.

Personal experience

In the department of cardiology SRE studies have been undertaken for the past one year, using Philips iE 33 ultrasound machine. There was a learning curve and it continues. There was also the factor of regular software upgrades which contributed which have contributed to accuracy of results.

In an analysis of 50 cases, these were our preliminary observations.

1. In a case of obvious global dysfunction all the STE values were very low. This denoted that STE can be an independent index of contractility.
2. In cases of myocardial infarction, the STE values ranged from normal to abnormal. Further studies are undertaken to identify the role of reperfusion.
3. There were cases of angiographically proven 3 vessel disease where the STE values were in the normal range. We are trying to correlate with prognosis.
4. Further studies are planned to to identify the patterns of STE in different states of LVH
5. Serial STE studies would identify the state of LV myocardium after medical or invasive revascularization.

Conclusion

A growing body of evidence suggests that the LV myocardial status can be assessed with STE to identify, the current contractility, which would be correlated to myocardial micro and macro vascular blood flow independent of the angiographic scenery. STE hopefully can address this position apart from all the other tasks for which it can be employed.

References


