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Mini Review

Difficulties and Pitfalls in Performing Speckle-Tracking Echocardiography to Assess Left Ventricular Systolic Function

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Abstract

Left ventricle systolic function is one of the most important measurements in cardiac evaluation. Transthoracic echocardiography is the most common and quickest technique to access qualitative and quantitative left ventricle systolic function mainly by the calculation of left ventricular ejection fraction (LVEF). However, despite its overwhelming clinical utility, LVEF has several limitations: it doesn't detect small changes in the contractile function and it also doesn't diagnose subclinical myocardial damage which has important implications in the therapeutic choice and in the clinical protocol. In turn, strain imaging provides an accessible, feasible and non-invasive technique to assess cardiac mechanics, and speckle tracking echocardiography (STE) is the primary modality with the utility for detection of subclinical ventricular dysfunction. For this purpose a high-quality images are required.

This article describes the main difficulties and pitfalls in the acquisition and analysis of left ventricular systolic function by STE.

Keywords: *Speckle Tracking Echocardiography; Left Ventricular Systolic Function; Ejection Fraction*

Introduction

Assessment of left ventricular systolic function is a key element in echocardiographic assessment and traditionally it is based mostly on the quantification of left ventricular ejection fraction (LVEF). But in the last years for this purpose, myocardial wall deformation (strain) calculated with speckle-tracking echocardiography (STE) has gained increasing acceptance in clinical and echocardiographic evaluation [1]. This article presents the basic concepts of STE, and describes the main difficulties and pitfalls in the acquisition and analysis of left ventricular systolic function by STE.

Definition

STE allows evaluation of myocardial mechanics, and quantification of systolic function, by strain and strain rate (SR) [1]. Strain is a measure of myocardial deformation of a segment in relation to its original dimension and it is expressed as a percentage. SR is a measure of the rate (velocity) at which that myocardial deformation occurs and it is expressed in seconds [1,2].

How does it work?

STE uses the routine gray-scale images: software allows spatial and temporal image processing with recognition of the motion of natural acoustic markers in grey scale ultrasound images that form interference patterns (speckles) representing local tissue movement. The velocity of this change in speckle position can be calculated with the information of the frame rate [1,3].

Deformation evaluation, or calculation of strain and SR, is based on the study of this change in the position of the speckles, giving information about lengthening, shortening, or thickening [1]. Positive strain means elongation, or increase in length compared to initial length; whereas negative strain is shortening, or decrease in length [4].

Left ventricular (LV) myofibers have a complex spatial orientation and contract simultaneously in different directions. The myocardial regional motion is divided into four types: longitudinal, radial, circumferential, and rotational. In 2D STE, only two directions of strain can be measured at a time: longitudinal and radial from long-axis views, and circumferential and radial from short-axis views. New techniques that are still being studied without the possibility of use in clinical routine, like 3D strain, has the possibility of calculate deformation in all three directions. In 3D imaging it's necessary to acquire multiple views of the LV from different approaches, at different times with no precise landmarks for ensuring their proper position and orientation [1,4,5].

Left ventricular systolic function

Left ventricle systolic function is one of the most important measurements in cardiac evaluation. Transthoracic echocardiography is the most common and quickest technique to access qualitative and quantitative left ventricle systolic function mainly by the calculation of left ventricular ejection fraction (LVEF). However, despite its overwhelming clinical utility, LVEF has several limitations: it doesn't detect small changes in the contractile function and it also doesn't diagnose subclinical myocardial damage which has important implications in the therapeutic choice and in the clinical protocol [7]. On the other hand, myocardial strain imaging in addition to a quantitative assessment of global and segmental systolic function, it also assesses subclinical systolic dysfunction even in the presence of a normal LVEF [4].

STE technique it is highly sought for the clinical evaluation being more and more the devices that allow this type of study. All of these devices use specific software for the treatment of myocardial deformation images, but the basic the steps involved are same [7].

Image acquisition

To obtain a high-quality image we must pay attention to the following technical aspects:

- **Standardized view:** In order to calculate the longitudinal deformation of the LV it is necessary to acquire images on the three apical views: four-chamber, two-chamber and long axis (Figure 1), whereas to measure the radial and circumferential deformation it is necessary to acquire images on the parasternal short axis in the basal, middle and apical views. Basal and apical short-axis images are also used to measure LV rotation and torsion [2,3,7].
- **Image quality:** The image has to be good enough that the software can analyze the speckles well.

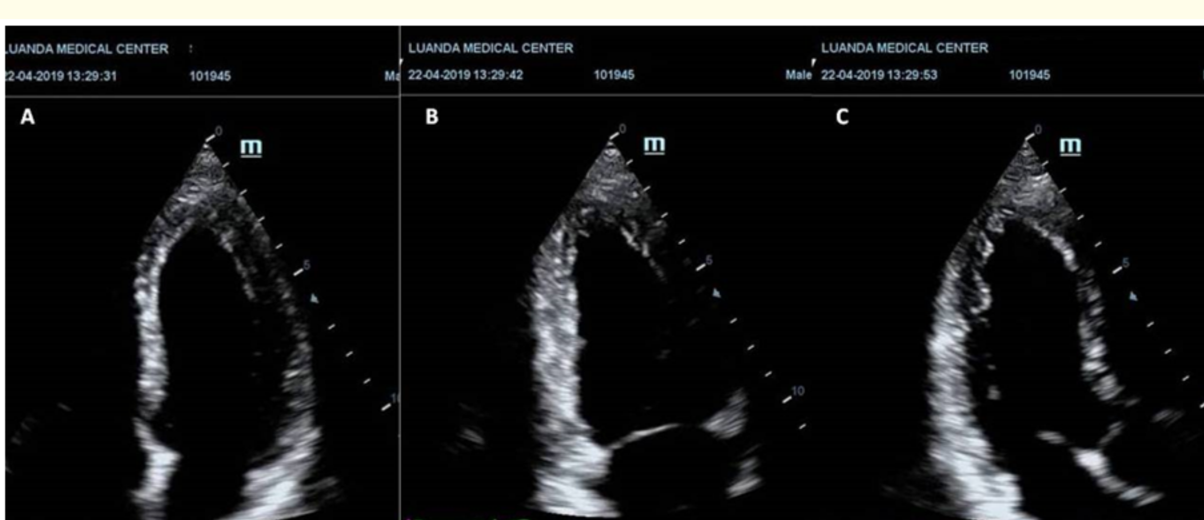

Figure 1: *Standardized views required for speckle tracking echocardiography. Left ventricular focused apical views include (A) four–chamber, (B) two-chamber and (C) long axis.*

Deformation is based on the evaluation of speckle pattern. Speckles are generated by the interaction of the US in the various interfaces of different tissues that the US will encounter as they penetrate our organism. This pattern of speckles is not stable either through-plane motion but also due to changes in tissues and changes in the angle of the US beam. Temporal stability is essential to maximize the efficiency of the tracking techniques [1,7,8].

Small random errors in detection of speckled patterns, suboptimal images and other artifacts complicate data interpretation leading to a loss of sensitivity in tracking quality being sometimes considered studies non-conclusive. Therefore, all myocardial regions must be visualized, reverberations must be avoided and spatial and temporal resolution of the image acquisition must be good avoiding variability in the results of the deformation image [8].

It's also important ensure that the entire myocardium portion we want to study is in the image sector, avoid foreshortening when using apical views, try to obtain circular LV images in the short axis and reduce all kinds of ultrasound noise that decrease tracking quality [1,7,8].

Optimizing image quality increases the definition and detection of speckle pattern, being essential to reduce inter and intra-observer variability of tracking data [1,8]. Acquiring a minimum of three cardiac cycles and with the patient on breath-hold to avoid any breathing artifacts will increase the diagnostic sensitivity of the exam [1,7,8].

Electrocardiographic-gating

To perform STE we need to know where some events are located in the cardiac cycle, and the ECG has a very important role in this, being impossible to carry out the study if the ECG is not connected.

Frame rate

The frame rate determines the image definition of the speckle in motion, and is defined as optimal in the interval 40 - 80 frames per second (FPS). Low frame rates can reduce temporal resolution too much, with decreased definition of the speckle pattern resulting in an underestimation of the strain values and high frame rates (above 100 frames per second) can make speckles so difficult to evaluate by STE software that it is impossible to calculate the deformation [1,2].

Sometimes it's not easy to reach a good frame rate especially in cardiomyopathies that have LV enlargement, making difficult to lowering depth and the image sector, but we must always prioritize having excellent spatial resolution balanced with the increase in frame rate [8].

Optimal frame rate is also related with the heart rate, and this data should be known by the users. Therefore, the frame rate should be increased with the increase in heart rate, especially in pediatric studies and during exercise stress exams or pharmacological stress exams with agents that have a tachycardic effect (e.g. dobutamine). There is no recommended frame rate for these situations, but as an extrapolation, the frame rate should increase proportionally to the increase in heart rate compared to rest heart rate [8].

After gain settings optimized, depth reduced so that the LV occupies most of the image sector, no foreshortening of the LV in long-axis views and LV cavity as circular as possible in short-axis views and frame rate in the right interval we can acquire the images.

Image analysis

After the acquisition of the videos in all the incidences, we will evaluate each acquisition/video in post-processing in the workstation. We must start analyzing the apical long axis, where we can mark the timing of the aortic valve closure (Figure 1C) by the movement of the aortic valve leaflets, essential for the software to perform the deformation analysis measuring displacement or deformation at the reference position (displacement) or reference length (strain) [7]. It is also possible to manually choose the best frame for the software to evaluate.

Region of interest

After this we need to define the myocardial region of interest (ROI), automatically or user-dependent manually. ROI is characterized by the endocardial border (the inner contour of the myocardium), epicardial border (the outer contour of the myocardium) and myocardial midline (the middle ROI axis defined in the middle) (Figure 2). Extreme care should be taken in the definition of ROI: in the apical views the ROI should begin at the MV annulus, progressing to the apex and ending at the opposite MV annulus and not including the pericardium because it will result in a reduction of the measured strain [1,7,8].

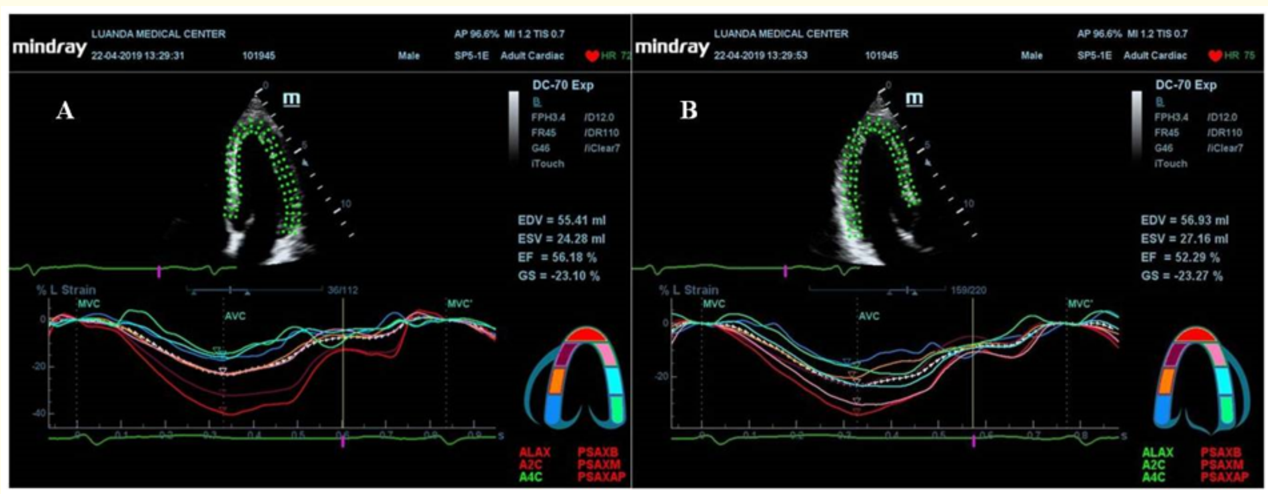

Figure 2: *Correct region of interest placement (ROI). Left ventricular focused apical (A) four–chamber, (B) long axis.*

After the software evaluates the speckles it generates a moving image, allowing the operator to determine the appropriateness of the tracking. If the operator is not satisfied with the choice of the software, it is possible to go back and readjust parts of the ROI or even the whole ROI [7].

Then the same process should be done in the apical four-chamber and two chamber view. The software calculates strain values for all segments and global longitudinal strain through an average. Some devices present the calculated data in a kind of schematic representation of the heart board, called Bull's eye plot (Figure 3), allowing easy visualization of segmental deformation [7].

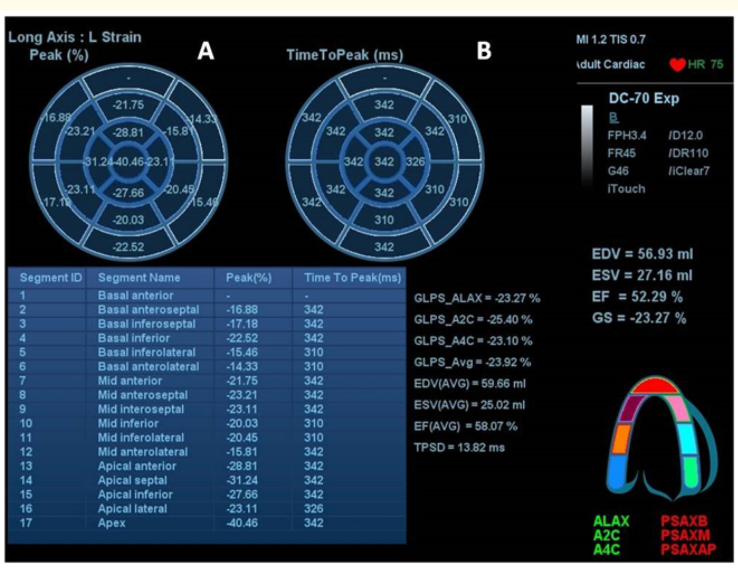

Figure 3: *Left ventricular bullseye plots. (A) Peak systolic strain, (B) time to peak longitudinal strain.*

Sometimes more than 2 segments in the same view have what is considered suboptimal image, being advisable to quantify LV systolic function by other methods [4].

Interpretation

The analysis software calculates global longitudinal strain, SR, rotation and twist curves. From these curves we can use many clinically relevant values like peak strain and peak systolic SR, time to peak strain and post systolic index, and not so usual in the clinical evaluation: peak early diastolic and peak late diastolic SRs; peak systolic apical and basal rotation; twist and torsion values; and peak twist and untwist rate [1].

Global longitudinal strain (GLS) is more reproducible compared with radial and circumferential strain or rotation, and is more reproducible than the segmental strain, being the most frequently used to assess left ventricular function in clinical practice.

The normal GLS is usually in the range of -16 to -22% or more (i.e. more negative), circumferential strain is usually in the range of 21% to 28%, being normally higher than longitudinal strain, and the average radial strain is in the range of -36 to -59% [1]. Due to high variability of rotation and torsion there are no reference values [7].

It is important to take into account that there are several differences between the different brands of devices, so it is important to know the reference values of strain and SR for each brand [7].

Clinical application

A high-quality exam allows a correct and reproducible measurement of left ventricular deformation and SR, showing to be extremely useful in assessing left ventricular systolic function in the following clinical situations [4,7-9]:

- In identifying sub-clinical LV dysfunction, which is very important in individuals who are evaluated for cardiomyopathy in early stages (for example the family screening for hypertrophic myocardiopathy, hypertensive cardiomyopathy);
- In patients undergoing chemotherapy, it allows the identification of sub-clinical LV dysfunction;
- In patients with valvular heart disease, reduced GLS reflects negative impact of the valve lesion on myocardial function prior to fall in LVEF;
- In patients with high risk of ventricular arrhythmias, the mechanical dispersion is altered;
- In patients with myocardial ischemia, the affected segments have lower strain values and post systolic shortening;
- In patients eligible for cardiac resynchronization therapy (CRT), strain helps guiding placement of the LV pacing lead.

Conclusion

The study of myocardial deformation by the STE technique is increasingly accessible, safe and reproducible, allowing a more complete and sensitive assessment of the left ventricular systolic function. However, it is important to know its limitations and requirements for better image quality.

Conflict of Interests

None to declare.

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Bibliography

1. Johnson C., *et al*. "Practical tips and tricks in measuring strain, strain rate and twist for the left and right ventricles". *Echo Research and Practice* 6.3 (2019): R87-R98.

2. Lang RM., *et al*. "Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging". *Journal of the American Society of Echocardiography* 28 (2015): 1-39.

3. Mor-Avi V., *et al*. "Current and Evolving Echocardiographic Techniques for the Quantitative Evaluation of Cardiac Mechanics: ASE/EAE Consensus Statement on Methodology and Indications". *Journal of the American Society of Echocardiography* 24.3 (2011): 277-313.

4. Smiseth AO., *et al*. "Myocardial strain imaging: how useful is it in clinical decision making?" *European Heart Journal* 37.15 (2016): 1196-1207.

5. Muraru D., *et al*. "Three-dimensional speckle-tracking echocardiography: benefits and limitations of integrating myocardial mechanics with three-dimensional". *Cardiovascular Diagnosis and Therapy* 8.1 (2018): 101-117.

6. Chengode S. "Left ventricular global systolic function assessment by echocardiography". *Annals of Cardiac Anaesthesia* 19.1 (2016): S26-S34.

7. Bansal M., *et al*. "How do I do it? Speckle-tracking echocardiography". *Indian Heart Journal* 65.1 (2013): 117-123.

8. Voigt JU., *et al*. "Definitions for a common standard for 2D speckle tracking echocardiography: consensus document of the EACVI/ASE/Industry Task Force to standardize deformation imaging". *European Heart Journal - Cardiovascular Imaging* 16.1 (2015): 1-11.

9. Trivedi SJ., *et al*. "Echocardiographic Strain in Clinical Practice". *Heart, Lung and Circulation* 28.9 (2019): 1320-1330.

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