Original Article

Measures of Endocardial and Epicardial Longitudinal Strain by the Technique of Xstrain®: Are there Differences between their Values?

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Summary

Background: *Echocardiography can assess ventricular function in several ways: by measurement the ventricular ejection fraction, by visual analysis of contractility, or by the quantification of myocardial deformity. Strain is the preferred variable for the description of local function.*

Objective: *To compare the values of the endocardial and epicardial longitudinal strain of the left ventricle by the technique of Xstrain® in healthy volunteers.*

Material and Methods: *Thirty-two healthy patients were assessed with a mean age of 31.6 ± 9.8 years, being 18 men (56%). We used echocardiograph model MyLab60® of Esaote (Firenze, Italy) with multifrequency probe (1.5 MHz to 2.6 MHz), and computer program for the performance of new echocardiography techniques (MyLab Desk, v 8.0, Esaote). The strain was measured in the endocardiac and endocardiac layers to the apical 2, 3 and 4 chamber views.*

Results: *There was a statistical difference between the values of endocardial and epicardial longitudinal strain and longitudinal epicardiac strain in all segments studied ($p < 0.01$).*

Conclusion: *The values of longitudinal strain are different in endocardial and epicardial layers of the left ventricle. (Arq Bras Cardiol:imagem cardiovasc. 2014;27(1):2-6)*

Keywords: *Myocardial Contraction; Echocardiography; Ventricular Dysfunction; Stroke Volume; Heart/physiopathology.*

The assessment of ventricular function is one of the most important applications of echocardiography. The degree of ventricular dysfunction is a powerful predictor of clinical outcome for a wide spectrum of cardiovascular diseases. Echocardiography can assess ventricular function in several ways: by measurement of the ventricular ejection fraction, by visual analysis of contractility, or by the quantification of myocardial deformity. The latter can be done by various techniques (*speckle tracking* and *velocity vector imaging* to quantify myocardial *strain rate and myocardial strain*).

The concept of *strain* means the deformation tissue when it is applied to a given force, thereby expressing the local dynamic of myocardial performance[1]. During each stage of the cardiac cycle, myocardium suffers a deformation in relation to its initial dimension, its fibers may be shortened (negative deformation) or elongation (positive deformation).

The *strain rate* measures the rate of deformation of the tissue with respect to time (it is the rate of deformity), while the myocardial *strain* represents the percentage of deformation of a given segment, and is obtained by the integral value of the *strain rate*[2, 3] The normal value of the percentage of peak longitudinal systolic deformity (longitudinal *strain*) is higher than 18% +/- 2.[4]

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Strain is the preferred variable for the description of the local function. Although there is a large number of experimental and clinical studies using the rate of deformity (*strain rate*) and myocardial strain, few studies have addressed the simultaneous measurement of the deformity in both myocardial layers (endocardium and epicardium) [5].

Velocity Vector Imaging (VVI) is a new method to calculate myocardial deformation, and was incorporated by some manufacturers of echocardiographs with different names. In our study we are using X*strain* of the Italian manufacturer Esaote. It makes it possible to measure the two-dimensional deformation by point scanning, following algorithms that analyze the endocardial or epicardial border[6, 7].

The automatic evaluation of the velocity at a specific point in the myocardium is obtained from the conformation of the image dislocation around a point in two consecutive frames. The rate is calculated as the ratio between the displacement and the time interval elapsed.

This technique allows the monitoring and independent review of the endocardial and epicardial selecting each of the segments to be studied, in addition to evaluating the physiological gradient of LV contractility that exists between these two camadas[2]. As of this new technique, we evaluate healthy patients so as to observe the difference of deformity between endocardium and epicardium.

Objective

Compare the values of the endocardial and epicardial longitudinal *strain* of the left ventricle by the technique of X*strain*® in healthy volunteers.

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Material and Methods

Thirty-two healthy patients were evaluated with a mean age of 31.6 ± 9.8 years, being 18 males (56%).

We used echocardiograph model MyLab60® of Esaote (Firenze, Italy) with multifrequency probe (1.5 MHz to 2.6 MHz), and computer program for the performance of new echocardiography techniques (MyLab Desk, v 8.0, Esaote).. The images were collected in the exam room and the analysis was performed later in the workstation (Figures 1 to 3).

We measured the *strain* in the endocardial and epicardial layers at the apical cuts of 2, 3 and 4 chambers (basal, mid and apical segments of the septal, lateral, inferior, anterior, posterior and anterosseptal walls) totaling 1,152 analyzed segments.

The epicardial longitudinal *strain* measurements were compared with those of the endocardial in each one of the segments. Then the average values per segment was taken. Statistical analysis was performed using the Student *t* test and fixed the value of the alpha error at 0.05 or 5%.

Results

There was a statistical difference between the values of endocardial and epicardial longitudinal strain (SLEndo) and longitudinal epicardiac strain (SLEpi) in all segments studied (all with $p < 0.01$), although with different behaviors: in the basal and middle segments SLEndo was lower than SLEpi (-19.1% x 26.0% and 19.5% to 22.2%), contrary to the situation observed in the apical region where SLEndo was larger (23.1% x -15.9%). The mean values of *strain* in each segment are shown in Figure 4.

Discussion

The muscle bundles that form the ventricular walls have a circumferential arrangement in mesocardium while in the epicardium and endocardium are oriented predominantly in the longitudinal direction. The architecture of myocardial fibers, along with the rotation and twisting movements of the left ventricle, contribute to generate gradients of contraction and relaxation along the cardiac cycle[8,9].

It is believed that in a normal heart, the subendocardial longitudinal deformation is greater than the subepicardial and the pathophysiological explanation for this may be the complex orientation of the myocardial fibers and the characteristics of the non-compressive tissue.[2] Under normal conditions during ventricular systole, the longitudinal fibers become short until the apex and become thick in the radial direction, while the transverse fibers converge towards the center, reducing ventricular cavity.[5]

This gradient between endocardial and epicardial layers was demonstrated by cardiac magnetic resonance and can be clearly evidenced with the technical analysis of the velocity vector.

This technique can also be used in various cardiac diseases and should be alert to the difference in handling the three layers depending on the regional location in the myocardium (basal or apical region). Matre et al[5]. evaluated the difference of the mobility inducing ischemia in the anterior descending artery in the radial cut in pigs hearts with extracorporeal circulation.

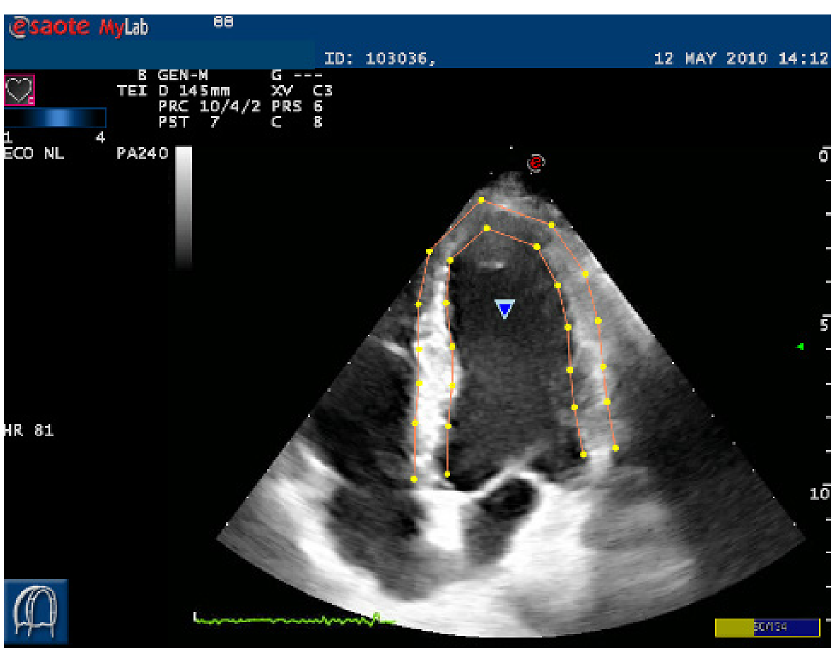

Figure 1 - *Example of demarcation of reference points from which the vectors of intersection with the endocardium and epicardium were traced.*

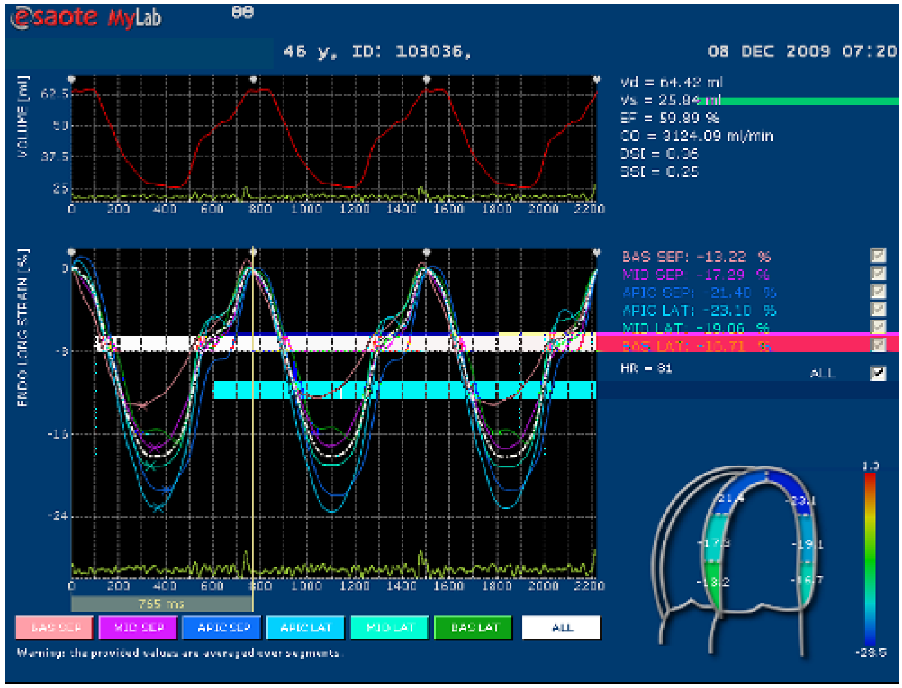

Figure 2 - *Curves of endocardial longitudinal strain in cutting 4 chambers.*

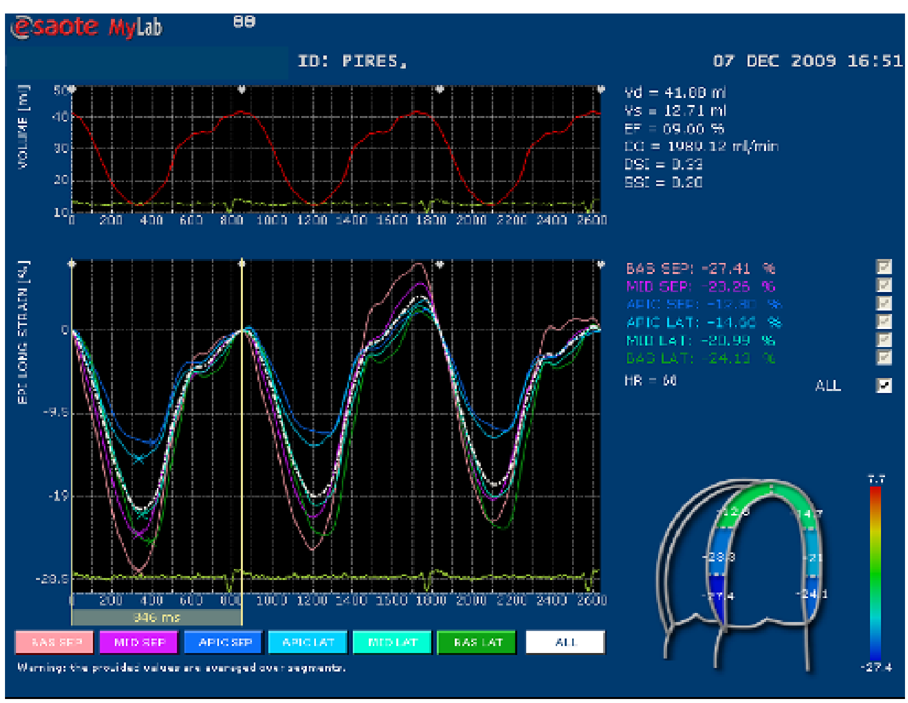

Figure 3 - *Curves of endocardial longitudinal strain in cutting 4 chambers.*

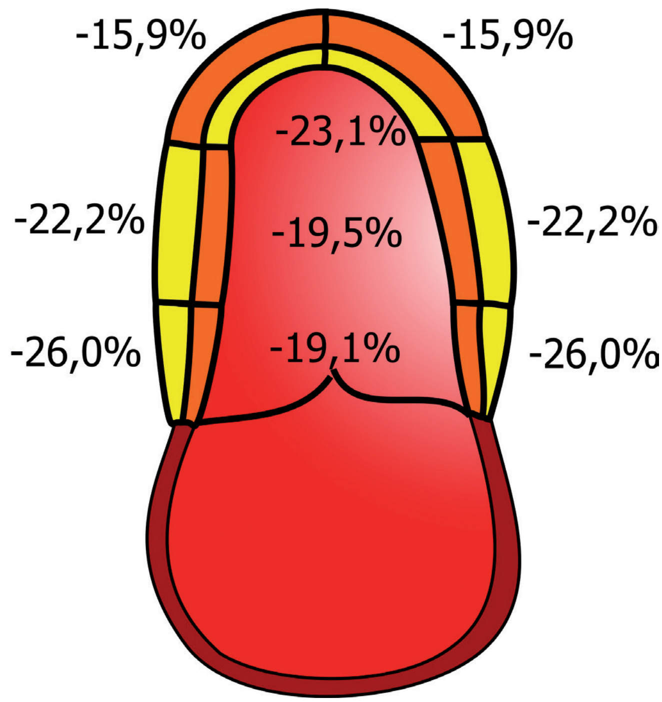

Figure 4 - *Mean values of the endocardial and epicardial longitudinal strain in different segments studied.*

Di Bella et al[10] used the *strain* technique to study 11 patients with cardiac amyloidosis and the same number of patients with hypertrophic cardiomyopathy, all with functional class < II by the New York Heart Association (NYHA). The authors evaluated the longitudinal, circumferential and radial deformation between the two groups of patients and observed impairment of epicardial and endocardial *strain* despite the normal ejection fraction, with greater involvement of the epicardial layer circumferential analysis in patients with amyloidosis cardíaca[10].

Leitman et al. evaluated, by the *speckle traking* method, the longitudinal and circumferential *strain* of the three cardiac layers, in 20 normal patients, by means of echocardiography and observed that the longitudinal and circumferential *strain* are larger in the endocardium and smaller in the epicardium; they also observed, as we did, that the longitudinal *strain* of the endocardium and of the mesocardium is larger in the peak and smaller on the base; however, they did not observe differences in the longitudinal epicardiac *strain*, contrary to our findings.[11]

The technique of velocity vector may study, independently, the endocardial and epicardial therefore allows to study the so-called "septal skeleton". The two edges of the interventricular septum is formed by myocardial fibers with different spatial orientations, belonging to different components of the helical ventricular myocardial band, besides presenting a distinct pattern of longitudinal deformation limit septum between the right and the left, visible in anatomical projections prepared as in echocardiographic projections.[2,7]

The left septal fibers belong to the descending segment of the internal helix that covers almost the entire left portion of the septum, and are oriented in anteroposterior direction. The right portion is formed by the ascending segment of the internal helix, the posterior region, while the anterior portion is connected to the outer helix that joins the outflow tract of the right ventricle: all fibers have a straight path.

The side wall of the right ventricle is comprised of fibers disposed almost exclusively in longitudinal direction as well as in the right portion of the interventricular septum. This characteristic of the arrangement of the fibers is that the right septum (which corresponds to our findings epicardial portion), the longitudinal deformation values are always higher than those of the left septum[7].

We believe that the values observed in the basal and middle epicardium were higher than the endocardium because they are, in fact, measuring the deformation of longitudinal fibers, as measured in endocardial a mixed longitudinal and transverse fibers. Since the apical portion of the largest value of the endocardial *strain* can be explained by the rotation of heart motion which is much higher in this region.

Conclusion

The left ventricle is composed of three layers. Not long ago, only MRI was a noninvasive method capable of performing the review of each. Currently, the technique of X*strain*, could individually assess the epicardial and endocardial layers. Our study evaluated healthy subjects, the results showed that longitudinal strain values are different in endocardial and epicardial left ventricular layers.

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