Comparison of Block-Matching and Optical Flow in Strain Echocardiography Analysis

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Abstract

Introduction: **Different technologies have been used to evaluate left ventricular systolic function. Of particular interest is the two-dimensional strain echocardiography (2DSTE). Two different methods have been used to quantify myocardial strain by 2DSTE: block matching and optical flow. Both are present in commercially available echocardiographs. However, there is no consensus as to whether the longitudinal strain measures using these methods are overlapping.**

Objective: **To compare the longitudinal myocardial strain peak values obtained through 2DSTE using two different methods (block matching x optical flow).**

Method: **Strain measurements in 16 left ventricular myocardial segments were taken as recommended by the American Society of Echocardiography using block matching (Vivid 7, GE, Horten, Norway) and, immediately after, using optical flow (My Lab 60, Esaote, Florence, Italy) in a randomized way and their values were compared.**

Results: **There were 28 individuals aged 27.9 ± 7.7, of whom 50% were male and all with an ejection fraction greater than 55%. Global longitudinal strain was higher using block matching (p = 0.02). In the analysis of the 16 segments, 10 segments had different values, especially the apical segments.**

Conclusion: **Longitudinal myocardial strain values obtained by different methods are not overlapping and must be used with caution. Normality values also vary according to the manufacturer and the method used. (Arq Bras Cardiol: Imagem cardiovasc. 2017;30(3):87-91)**

Keywords: **Echocardiography, Doppler/methods; Heart Diseases; Diagnostic Imaging; Image Processing Computer-Assisted/methods.**

Introduction

Advances in two-dimensional echocardiography allowed the evaluation of myocardial strain. This measure has become an important tool in the evaluation of ventricular function, especially left ventricular systolic performance. Its use is recommended by the latest guidelines of the American Society of Echocardiography and the European Association of Cardiovascular Imaging.[1] The measurement of strain seems to have better prognostic value than even ejection fraction in the evaluation of ventricular function. Its use is increasingly frequent in echocardiography these days.[2]

The measurement of myocardial strain is based on the ability of the equipment to interpret the variation in one length of the cardiac muscle throughout the cardiac cycle. It can be performed on the longitudinal, circumferential, radial axis and even shear axis.[3] In daily practice, there is more robustness in the measurements of longitudinal strain for a number of reasons: lower intraobserver and inter-observer variability; the possibility of detecting subclinical dysfunction, i.e., it does not cause any decline in left ventricular ejection fraction levels as the subendocardial fibers are primarily impaired and are preferably arranged in the longitudinal axis of the heart; and, finally, consistent prognostic information in determining longitudinal strain.[4]

Many equipment companies have developed software applications to quantify myocardial strain using two-dimensional echocardiography imaging using different scanning techniques. One is called block matching and the other is called optical flow. The first technology is performed by means of a point-scan, which uses a region of interest (ROI) of about 40 pixels and only provides medium transmural data grouped by segments and it cannot separate the endocardium from the epicardium. The second one — optical flow — derives from vector velocity, which uses a region of interest (ROI) of about 16 pixels, which allows to monitor ventricular strain by analyzing myocardial regions much smaller than those examined with point-scan.[5,6]

Block-matching technique[7] chooses a given image of the region (called kernel) and looks for, in the next frame, the pixel group that most resembles the previous region.

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Manuscript received October 7, 2016; revised December 25, 2016; accepted February 6, 2017

DOI: 10.5935/2318-8219.20170019

When it finds it, it establishes the new position for that speckle. The other method, called Optical Flow[8-11] is based on the principle of conservation of gray value. This principle assumes that a gray value does not change over time, unless this pixel has moved on to another location. Therefore, it is possible to estimate the vector velocity of each pixel of the image. As in block-matching, this procedure is repeated frame by frame to obtain a dynamic field vector velocity to quantify myocardial strain and strain rate, the muscle movement speed and its displacement by means of vector analysis.

Such technologies are incorporated into off-the-shelf echocardiographs. However, there is little evidence on both the equivalence of the measurements obtained by these methods and on the normality values. This study aims to compare the peak longitudinal strain values of myocardial segments using two-dimensional echocardiography by two different methods (block matching x optical flow).

Methods

The study was consistent with the principles set out in the Declaration of Helsinki. The informed consent was signed by all individuals.

We selected 28 healthy volunteers with no associated cardiovascular risk factors. All of them were in sinus rhythm and had no echocardiographic image that precluded the test from being run. The echocardiographic scans were performed by the same operator, one immediately after the other in a randomized way, using the devices GE Vivid 7® (Horten, Norway) and Esaote MyLab60® (Florence, Italy). International recommendations have been followed to obtaining apical views.[1] For each image, a sequence of 3 consecutive cycles was obtained. The time resolution was adjusted between 40-80Hz for GE and between 40-64 Hz for Esaote. After the acquisition of digital clips, the strain measures were taken. The analysis software used for GE Vivid7® (block matching) was GE EchoPAC 6.1®. Peak velocity of systolic strain in 16 myocardial segments was analyzed according to international recommendations.[4] The images obtained through Esaote MyLab60® (Optical Flow) were also analyzed in XStrain® software (Figure 1).

Statistical Analysis

Distributions of continuous variables were expressed as mean ± standard deviation. Distributions of nominal variables were expressed in absolute values as well as frequencies and/or percentages.

To compare the variables with parametric distribution, t test was used. Wilcoxon test was used for those with nonparametric distribution. The analyses used two-tailed tests with significance level of $\alpha = 0.05$. The data analysis software was Epi Info version 3.5.2. (Atlanta, USA).

Results

The 28 volunteers had a mean age of 27.9 ± 7.7 years, of whom 50% were males and all with a left ventricular ejection fraction greater than 55%.

All 896 segments were analyzed. The mean global longitudinal strain (in absolute values) was greater when obtained by block matching (21.5 ± 2.6% vs 19.5 ± 1.9%, p = 0.02). Comparing the 16 segments, there was no difference in the value measured in ten of the 16 segments, representing 62.5% of the segments analyzed. In nine of the ten segments with different measures, the value obtained using optical flow was lower. There was a greater inconsistency in the measures of apical segments as shown in Table 1.

There was no difference in values as to gender or age.

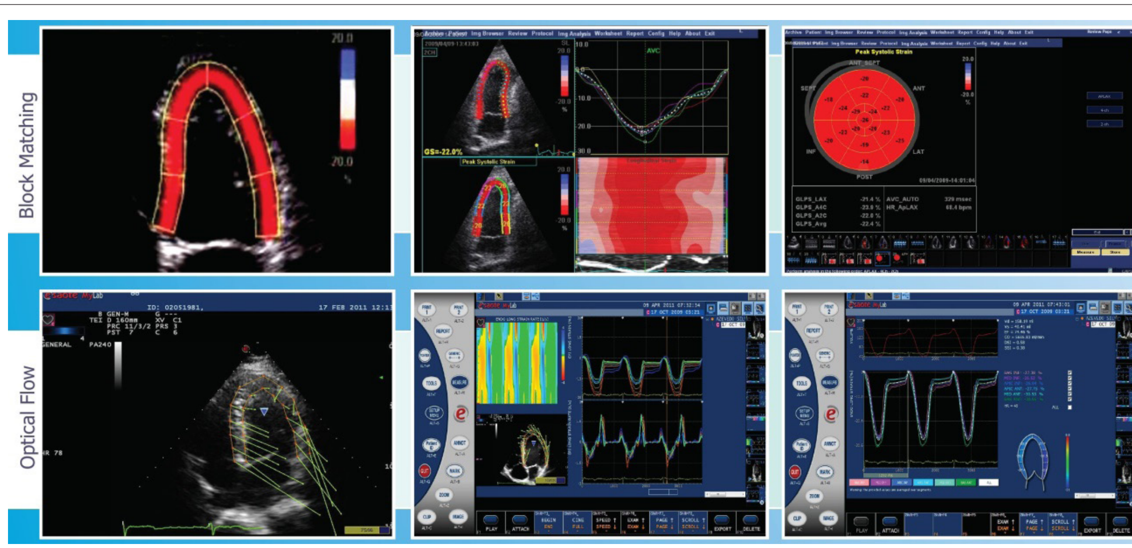

Figure 1 – *Two-dimensional echocardiography scans conducted to quantify longitudinal systolic strain using GE's block matching (top panel) and Esaote optical flow (lower panel).*

Table 1 – Strain values in each segment according to the techniques

Segment	SL peak value (%) block matching	Peak LS value (%) optical flow	p
Anterior basal	–18.9	–22.4	> 0.05
Inferior basal	–19.8	–16.7	< 0.05
Septal basal	–18.3	–18.1	> 0.05
Anterolateral basal	–18.1	–22.6	< 0.05
Inferolateral basal	–19.0	–17.3	> 0.05
Anteroseptal basal	–21.7	–18.2	< 0.05
Anterior medial	–21.5	–19.7	> 0.05
Inferior medial	–21.7	–18.2	< 0.01
Septal medial	–20.1	–19.5	> 0.05
Anterolateral medial	–20.7	–21.1	> 0.05
Inferolateral medial	–21.2	–18.2	< 0.05
Anteroseptal medial	–21.7	–18.4	< 0.01
Apical anterior	–25.5	–18.0	< 0.01
Apical inferior	–26.7	–22.2	< 0.01
Apical septal	–24.1	–21.6	< 0.05
Apical lateral	–24.4	–19.4	< 0.01

LS: longitudinal strain.

Discussion

The study revealed that in healthy patients, there is a difference between peak longitudinal strain values obtained through two different techniques, with the highest value occurring in optical flow. Ventricular evaluation is one of the most important applications of echocardiography.

In the evaluation of left ventricular function, global longitudinal strain measurement is currently considered of significant diagnostic and prognostic value. The latest American/European guidelines[1] determined that this index should be used, and any values below -20% (percentage segment strain > 20%) ensure the absence of systolic dysfunction, even if it is subclinical. This fact is consistent with our study as this cutoff value is consistent with the data obtained. Regardless of the method used, some very reliable information is ensured.

Myocardial strain measurement software is usually validated by experimental studies with sonomicrometry or magnetic resonance imaging. However, despite this validation, it is recognized that different software applications may have disparate values and manufacturers of these software applications must make an effort to make sure that the values obtained overlap.[12]

Farsalinos et al.[13] studied 62 individuals and compared the global longitudinal strain values using 7 different software applications. Similar to our study, the global longitudinal strain values were different between block matching and optical flow,[13] with values quite similar to that obtained in our study.

One possible explanation would be different hemodynamic states of the individuals studied when the tests were conducted on different echocardiographs.[14] However, the study design does not allow this assumption, since the tests were done one immediately after the other. We believe that these differences occur much more because of the different algorithms used in different software applications.

Some studies have compared the longitudinal strain results obtained by the two techniques exposed regionally. Castel et al.[15] examined 57 patients with various heart diseases and seven individuals comparing the two techniques, observing values frequently different when the segments were compared to each other. In spite of using two different techniques, only for the measurements derived from the block matching technique, the same software used in this study was used. Optical flow was measured by a software application other than XStrain®.

Similar to the above study, using the same myocardial strain analysis programs, Patrianakos et al.[16] conducted echocardiography scans with both techniques in 32 individuals with no heart disease, obtaining, however, a better ratio of segment-to-segment peak systolic strain values.[16] Once again, the analysis software was not XStrain®.

In the latest echocardiographic guidelines, which addresses the quantification of cardiac chambers,[1] the committee in charge describes differences in the results due to the intersoftware variability of each equipment used. Therefore, it recommends that if consecutive tests have to be done, each patient should use the equipment and software from a single vendor in consecutive scans, as evidenced in this study. We also recommend, if possible, using the same observer.

This study has limitations, such as low variability of strain values, as all patients were healthy with ventricular systolic function within the normal range and the impossibility of performing serial tests to assess the reproducibility of the measurements.

However, this study stands out for being one of the few studies in the literature that compared two techniques with GE and Esaote software applications.

Conclusion

The peak systolic longitudinal strain values obtained by different methods are not overlapping and must be used with caution. Normality values also vary according to the manufacturer and the method used.

Authors' contributions

Research creation and design: Linhares RR, Silva CES, Monaco CG, Gil MA; Data acquisition: Linhares RR, Silva CES, Monaco CG, Gil MA; Analysis and interpretation of data: Linhares RR, Barreto RBM, Silva CES, Peixoto LB, Cruz AP, Monaco CG, Gil MA; Statistical analysis: Linhares RR, Barreto RBM, Silva CES, Le Bihan DCS, Peixoto LB, Cruz AP, Garcia LP; Manuscript drafting: Linhares RR, Barreto RBM, Silva CES, Le Bihan DCS, Peixoto LB, Cruz AP, Garcia LP; Critical revision of the manuscript as for important intellectual content: Linhares RR, Barreto RBM, Silva CES, Le Bihan DCS, Peixoto LB, Cruz AP, Garcia LP.

Potential Conflicts of Interest

There are no relevant conflicts of interest.

Sources of Funding

This study had no external funding sources.

Academic Association

This study is not associated with any graduate program.

References

1. Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ermande L, 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. J Am Soc Echocardiogr. 2015;28(1):1-39, e14.
2. Kalam K, Otahal P, Marwick TH. Prognostic implications of global LV dysfunction: a systematic review and meta-analysis of global longitudinal strain and ejection fraction. Heart 2014;100(21):1673-80.
3. Silva CES. Ecocardiografia: princípios e aplicações clínicas. 2nd ed. Rio de Janeiro: Revinter;2012.
4. Mor-Avi V, Lang RM, Badano LP, Belohlavek M, Cardim NM, Derumeaux G , et al. Current and evolving echocardiographic techniques for the quantitative evaluation of cardiac mechanics: ASE/EAE consensus statement on methodology and indications endorsed by the Japanese Society of Echocardiography. J Am Soc Echocardiogr. 2011;24(3):277-313.
5. Bussadori C, Moreo A, Di Donato M, De Chiara B, Negura D, Dall'Aglio E, et al. A new 2D-based method for myocardial velocity strain and strain rate quantification in a normal adult and paediatric population: assessment of reference values. Cardiovasc Ultrasound. 2009;7:8.
6. Perk G, Tunick PA, Kronzon I. Non-Doppler two-dimensional strain imaging by echocardiography--from technical considerations to clinical applications. J Am Soc Echocardiogr. 2007;20(3):234-43.
7. Langeland S, D'hooge J, Torp H, Bijnens B, Suetens P. Comparison of time-domain displacement estimators for two-dimensional RF tracking. Ultrasound Med Biol 2003;29(8):1177-86.
8. Horn BK, Schunk BG. Determining optical flow. Artificial Intelligence.1981;17:185-203.
9. Mailloux G, Bleau A, Bertrand M, Petitclerc R. Computer analysis of heart motion from 2-dimensional echocardiograms. IEEE Trans Biomed Eng 1987;34(5):356-64.
10. Meunier J, Bertrand M, Mailloux G. Local myocardial deformation computed from speckle motion. Proceedings of the IEEE Meeting on Computers in Cardiology; 25-28 Aug 1988; Chicago(IL). Computers in Cardiology.Proceedings;1988;p.133-6.
11. Suhling M, Arigovindan M, Jansen C, Hunziker P, Unser M. Myocardial motion analysis from B-mode echocardiograms. IEEE Trans Image Process 2005; 14(4):525–36.
12. Voigt JU, Pedrizzetti G, Lysyansky P, Marwick TH, Houle H, Baumann R, 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. J Am Soc Echocardiogr.2015;28(2):183-93.
13. Farsalinos KE, Daraban AM, Unlu S, Thomas JD, Badano LP, Voigt JU. Head-to-head comparison of global longitudinal strain measurements among nine different vendors: The EACVI/ASE Inter-Vendor Comparison Study. J Am Soc Echocardiogr. 2015;28(10):1171-81,e2.
14. Yingchoncharoen T, Agarwal S, Popovic ZB, Marwick TH. Normal ranges of left ventricular strain: a meta-analysis. J Am Soc Echocardiogr.2013;26(2):185-91.
15. Castel AL, Szymanski C, Delelis F, Levy F, Menet A, Mailliet A, et al. Prospective comparison of speckle tracking longitudinal bidimensional strain between two vendors. Arch Cardiovasc Dis.2014;107(2):96-104.
16. Patrianakos AP, Zacharaki AA, Kalogerakis A, Solidakis G, Parthenakis FI, Vardas PE. Two-dimensional global and segmental longitudinal strain: are the results from software in different high-end ultrasound systems comparable? Echo Res Pract.2015;2(1):29-39.