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Research paper

Diagnostic value of speckle tracking echocardiography (STE) in the determination of myocardial ischemia: a pilot study

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Abstract

Introduction: As 2D-speckle tracking echocardiography (STE) has supposed to be a novel and non-invasive imaging modality for the early recognition of ischemic heart disease before angiography, further study of this diagnostic method is of great importance.

Aim: This study was intended to weigh the diagnostic value of STE in the revealing of myocardial ischemia before and after efficacious revascularization.

Material and methods: 25 patients with an indication for revascularization – angioplasty or coronary artery bypass grafting (CABG) – diagnosed by an experienced cardiologist and based on accepted criteria, underwent two-dimensional (2D) STE; and global systolic longitudinal strain for each of the sections in the apical 2-chamber and 4-chamber views was evaluated.

Results and discussion: The mean of longitudinal strain before revascularization procedures was 14.94% ± 2.32% and after procedures was 19.08% ± 2.83%. ($P < 0.001$). After procedure, 6 patients (24%) showed longitudinal strain under 18% in spite of revascularization; mean longitudinal strain was significantly lower in these 6 patients compared to other 19 patients who revealed longitudinal strain over 18% after revascularization (15.45% ± 2.35% vs. 20.22% ± 1.84 %, $P < 0.001$). We found that the sensitivity and specificity of longitudinal strain differences at the cut-off point 4.1% for predicting ischemia with 0.281 area under the ROC curve were 100%, 53%, 40%, 100%, and 64%, respectively.

Conclusions: Our results showed that predicting and diagnosing myocardial ischemia by STE is a precise method with high sensitivity and specificity values.

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1. INTRODUCTION

The routine protocol for rule in or rule out of ischemic heart disease is based on clinical symptoms, changes in the pattern of ECG, and a significant rise of cardiac troponins levels.[1–3] However, there are some limitations for this approach with regard to low sensitivity and specificity. On the other hand, various stress tests regularly used, could be potentially difficult to be executed and may provoke myocardial ischemia.[4]

Speckle tracking echocardiography (STE), which is based on tracing pixel groups in grayness scale, is a novel echocardiographic modality for assessing and determining myocardium strains and strain rates including longitudinal, circumferential, radial, and transverse – the detailed indices of ventricle function.[5] Moreover, STE has an adequate sensitivity and specificity in the diagnosis of coronary artery disease, valvular heart disease with coronary artery disease, and cardiac systolic and diastolic dysfunctions.[6–9]

As STE is a safe and non-invasive method for the early detection of ischemic heart disease before angiography, this study was designed to evaluate the diagnostic value of STE in the determination of myocardial ischemia before and after successful revascularization.

2. AIM

This study was intended to weigh the diagnostic value of STE in the revealing of myocardial ischemia before and after efficacious revascularization.

3. MATERIAL AND METHODS

3.1. Participants and target group

This diagnostic clinical study was conducted in Cardiology Department of Shahid Beheshti University of Medical Sciences, Tehran, Iran from August 2015 to December 2015. Inclusion criteria consisted of patients referred from diabetes clinic with at least 70% stenosis on coronary angiography, strain less than 18% in 2D STE and having capability to perform angioplasty. Exclusion criteria consisted of patients who were candidates for other treatment except coronary artery revascularization (such as medical treatment), did not consent to revascularization procedure, patients with unsuccessful revascularization, very poor image quality, and having previous pacemaker or cardioverter-defibrillator implantation.

3.2. Study design

Twenty-eight patients with an indication for revascularization – angioplasty or coronary artery bypass grafting (CABG) – diagnosed by an experienced cardiologist and based on inclusion and exclusion criteria, were included. The study received ethics approval from the Ethics Committee of Shahid Beheshti University of Medical Sciences (approval Number: 2015-155); and all the participants gave written informed consent. The STE findings were measured before and after revascularization procedure.

3.3. Speckle tracking echocardiography (STE)

2D STE was accomplished for all patients before and after the revascularization procedures. All the patients were tested in the left lateral decubitus position using a 3.5 MHz transducer in the standard views. STE was executed using the automated function imaging algorithm by the commercial imaging analysis software (STE Toshiba, Medical System, Japan) and recorded 2D gray-scale images. End-systole was described as an aortic valve closure in the apical long-axis view using continuous wave Doppler recording. The endocardial borders were manually traced in an end-systole through marking the mitral annulus level and at the apex on each digital loop with the myocardium in the region of interest (ROI). Then the position and the size of the ROI were manually augmented. The software scrutinized the speckles within the myocardium and estimated the global systolic longitudinal strain for each of the sections in the apical 2-chamber and 4-chamber views.

3.4. Data analysis

Data were examined and reported only for patients who completed the study. Statistical analysis of data was achieved using SPSS v. 22 software. To match qualitative variables between groups, χ^2 test was used. The normal distribution of all studied parameters was evaluated using Kolmogorov-Smirnov test. Student *t*-test and paired *t*-test were carried out for variables allocated in a normal way, besides Mann-Whitney and Wilcoxon test were done for variables that have not normal distribution. The two tailed *P*-value less than 0.05 were defined as significant. Using ROC curve and Youden's $\mathcal{J}$ statistic, the best predicted cut-off for the related variable, was obtained.

4. RESULTS

Three patients were dropped out and finally, 25 patients completed the study. The mean age of the patients was 59.36 ± 11.99 years and 17 (68%) cases were male. Moreover, the mean of longitudinal strain before revascularization procedures was $14.94\% \pm 2.32\%$ and after procedures was $19.08\% \pm 2.83\%$. ($P < 0.001$). As mentioned, our current study was a pilot study of the patients who were referred from diabetes clinic; all of the included patients had known diabetes type 2; 24 (96%) of them had hypertension; 4 (16%) had history of smoking in the past but were not smoker at least for 2 years; as well, all of them received Statin therapy. In total, 2(8%), 5(20%) and 18 (72%) cases showed 1-vessel disease, 2-vessel disease and 3-vessel disease in coronary angiography, respectively.

After procedure, 6 (24%) patients showed typical angina and longitudinal strain under 18% in spite of revascularization; mean longitudinal strain was significantly lower in these 6 patients compared to other 19 patients who revealed

Table. Sensitivity, specificity, PPV and NPV (in percent) of STE differences (cut-off point 4.1%) in predicting ischemic events.

Method	Area	True point	False positive	True negative	False negative	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Positive likelihood ratio	Accuracy
STE difference	0.719	6	9	10	0	100%	53%	40%	100%	2.11	64%

no complaint of angina and longitudinal strain over 18% after revascularization (15.45% ± 2.35% vs. 20.22% ± 1.84%, $P < 0.001$). Moreover, we did not find any significant differences in longitudinal strain based on gender, before and after revascularization procedures ($P = 0.24$, $P = 0.423$, respectively). Furthermore, longitudinal strain before and after revascularization procedures did not have significant correlation with age ($r = 0.289$, $P = 0.161$, $r = 0.09$, $P = 0.669$, respectively). We found that the sensitivity and specificity of longitudinal strain differences at the cut-off point 4.1% for predicting ischemia with 0.281 area under the ROC curve were 100%, 53%, 40%, 100%, and 64 %, respectively (Table, Figure).

5. DISCUSSION

We found that for predicting ischemic events, the sensitivity and specificity of longitudinal strain after revascularization were 100% at the cut-off point 18%, while for longitudinal strain before revascularization at the cut-off point 14.05% were 100%, 78.9% and for STE score differences in cut-off point 4.1% were 100%, and 52.6%. These data suggest that measuring longitudinal strain after revascularization had the highest diagnostic accuracy in detecting myocardial ischemia; moreover, evaluating longitudinal strain before revascularization can predict 100% of myocardial ischemia with zero false negative. According to our best knowledge, this study is one of the first studies on the diagnostic accuracy of STE before and after revascularization for the prediction and diagnosis of myocardial ischemia.

Ozawa et al. showed that the longitudinal strain of STE with the best cut-off points of 12% had a high sensitivity (70.4%) and specificity (57.9%).[10] These results were lower in comparison with our results, which may be due to the small sample size of our study, different ultrasonic devices and operators.

In another study, transverse SI-DI at rest showed 79% sensitivity and 73% specificity for sever coronary artery disease.[11] In a study SI-DI ratio had 97% sensitivity and 93% specificity for detection of stenosis more than 50%. Regional left ventricle delayed relaxation diagnosis with strain imaging is a sensitive and reliable method after treadmill stress test.[12]

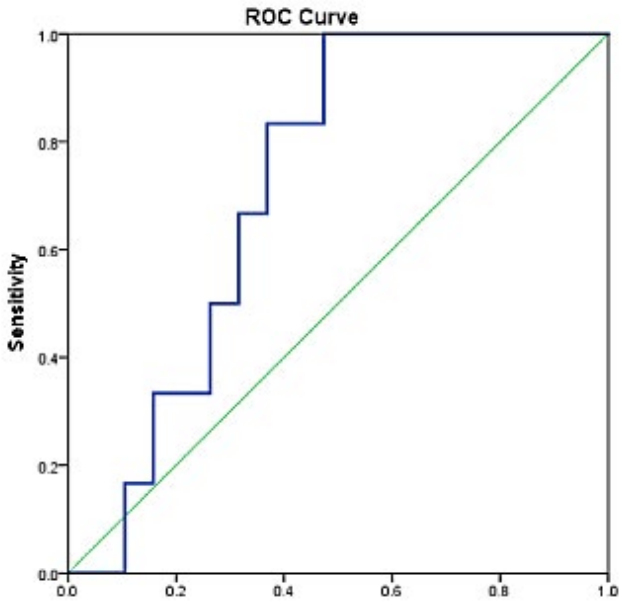
Wang et al. showed that with receiver operating characteristic curve analysis, the longitudinal strain had the highest diagnostic value and when the cutoff was –13.8%, the area under the curve was 0.84, with 70.6% sensitivity and 87.5% specificity. Significant differences of myocardial strain parameters were observed between segments with and without trans-mural myocardials ($P < 0.01$). 3D-STE myocardial strain parameters evaluated left ventricle global myocardial infarctions; and 3D longitudinal strain had the highest diagnostic value. It also preliminarily gauged the degree of ischemia and necrosis of regional myocardial segments.[13]

Systematic review performed by Farokhnejad et al. demonstrated that in all articles (4 reviewed articles), the coronary artery tracking with significant stenosis was possible by regional deformation analysis through 2D strain. Finally, they concluded that strain imaging is a reasonable method for evaluation of ischemia as a low cost non-invasive test with high accuracy.[14]

Stress tests are the standard of exams which may reveal latent ischemia. An imbalance between myocardial blood supply and demand is the best explanation for these tests; however, during the preceding years, the evaluation of various types of strain by speckle tracking can potentially predict myocardial ischemia and occlusion in animal models and human studies.[13–18] This will be so reassuring to have a non-invasive and angle-independent tool to give some helpful clues about myocardial ischemic memory; particularly in the settings that stress tests are not available or are contraindicated. It is inevitable that further large studies are required to deeply elucidate the definite roles of speckle tracking echocardiography in detection of ischemia.

Available modalities in diagnosis of myocardial ischemia are single-photon emission computed tomography (SPECT) or CT angiography which both are high cost, invasive methods with variable degrees of sensitivity and specificity, as well as special safety precautions (Radioactive Isotope –X-Ray Contrast), while STE is low cost, non-invasive, with high validity

Figure. ROC curve of STE differences in predicting ischemic events.



proved by many studies in the literature and with no special precautions. Pre- and post-coronary intervention speckle tracking studies are recommended for the functional rather than anatomical assessment of cost benefit value of those highly expensive procedures and for follow up of post-intervention patients at early, intermediate and long term stages to monitor the changes in regional and global cardiac functions.

It is undeniable fact that the small size of this study is considered as a limitation and this study with such a small sample size cannot answer to all questions; however, as a pilot and single center study it could add some information about the role of speckle tracking in detection of ischemia and be a trigger for future large and comprehensive investigations and reviews to explore new findings in this field.

6. CONCLUSIONS

Our results showed that predicting and diagnosing myocardial ischemia by STE is an accurate method with high sensitivity and specificity values. It allows predicting myocardial ischemia before revascularization procedures and more critically ill patients may benefit from these advantages of this method; therefore, expanding this method between cardiologists should be considered. However, further studies are required to confirm our findings.

Conflict of interest

The authors indicated that they have no conflicts of interests regarding the content of this article.

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