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Research Article

Speckle Tracking to Assess the Improvement of Myocardial Activity After OPCABG

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Abstract

Speckle tracking (ST) is an echocardiographic method for measuring regional and global deformation of the myocardium. In our study, longitudinal strain (LS) on ST imaging was chosen to investigate the changes in myocardial function after off-pump coronary artery bypass grafting (OPCABG) in order to verify the accuracy of this technique compared to the more common ejection fraction (EF) and segmental kinetics (SK) of the left ventricle (LV). We also aimed to quantify the cost - benefit balance in terms the relative duration of the two examination, and we finally tried to assess if this not-invasive method could replace more invasive viability investigations. From January 2016 to December 2017, 320 consecutive patients with triple coronary artery disease and EF > 45% were enrolled and underwent complete OPCABG. A routinely 2D TTE testing EF, LV kinetics, and LS were performed the week before surgery, 3 months, 6 months, and 12 months after OPCABG. The follow up was completed at 100%. LS, EF, LV end-diastolic dimension (LVEDD), LV end-diastolic volume (LVEDV), and stroke volume (SV) significantly improved at 6 months after OPCABG ($P < 0.05$). Significant correlation was found between the coronary lesions, which were detected by the angiogram, and the corresponding impaired heart zones, which were shown by reduction in global and segmental LS ($P < 0.05$). No significant correlation was found between angiographic lesion and EF, LVD, and LVV ($P > 0.05$).

Keywords: *Speackle Tracking; Strain; OPCABG; Myocardial Revascularization; Myocardial Function*

Introduction

Myocardial strain is a principle for quantification of left ventricular (LV) function, which is now feasible with speckle-tracking echocardiography [1,2]. The best evaluated parameter of the strain is the global longitudinal strain (GLS), which is more sensitive than left ventricular ejection fraction (LVEF) as a measure of LV systolic function. For this reason, it may be used to identify sub-clinical LV dysfunction in cardiomyopathies [3,4]. Furthermore, GLS is recommended as routine measurement in patients undergoing chemotherapy and/or radiotherapy in order to detect possible reduction in LV function prior to fall in LVEF. Inter-segmental variability in timing of peak myocardial strain has been suggested as predictor of risk of ventricular arrhythmias [6,7]. Strain imaging may be used to guide placement of the LV pacing lead in patients receiving cardiac resynchronization therapy [8,9]. Strain may be used to diagnose myocardial ischemia, but till now this technology is not sufficiently standardized to be recommended as a general diagnostic tool for this purpose [4,5,10-15]. In our study, longitudinal strain (LS) on ST imaging was chosen to investigate the changes in myocardial function after off-pump coronary artery bypass grafting (OPCABG) in order to verify the accuracy of this technique compared to the more common ejection fraction (EF) and segmental kinetics (SK) of the left ventricle (LV). We also aimed to quantify the cost - benefit balance in terms the relative duration of the two examination, and we finally tried to assess if this not-invasive method could replace more invasive viability investigations. Data statistical analysis was performed and a p value of less than or equal to 0.05 was considered statistically significant.

Material and Method

From January 2016 to December 2017, 320 consecutive patients with triple coronary artery disease and EF > 45% were enrolled and underwent complete OPCABG. Mean age was 66.2 +/- 4.7 year old, mean EuroScore II was 4.38 +/- 1.28, and mean Syntax score was 29 +/- 5.2. The demographic characteristics are listed in table 1. Exclusion criteria were previous cardiac surgery, age > 80y, urgency OPCABG, coagulopathy, HCV+, HIV+, kidney failure stage III or more, diabetes type I, malnutrition, cancer, autoimmune diseases, and chronic bowel diseases. A routinely 2D TTE testing EF, LV kinetics, and LS were performed the week before surgery, 3 months, 6 months, and 12 months after OPCABG. For the present study a General Electrics Vivid E90 and a Philips iE33 with the Speackle Tracking integrated software analysis were used. The 2D TEE examination included EF (3 samples and the mean results by the Simpson method), LVEDD (volume and diameter), LVESD (volume and diameter) in four-chamber, three-chamber, and two-chamber view. The wall motion score index was calculated (WMSI) and the Speackle Tracking analysis was performed without acceptance of interpolation for the segmental analysis. The Syntax score was calculated and used to evaluate the coronary artery stenosis grade.

Variable	n.	%
Female	96	30
Male	224	70
CCS 3 - 4	86	27
NYHA III-IV	64	20
Hypertension	320	100
Diabetes type II	128	40
Current Smoker	121	38
No Smoker	104	32
COPD	206	64
BMI > 30	206	64
Stress	64	20
Previous MI	90	28
Previous PCI	32	10
Peripheral Artery Disease	26	8
Previous Stroke	20	6
Atrial Fibrillation	40	12
Mitral Regurgitation (4+)	4	1

Table 1: *Demographics Data.*

Statistical analysis was performed on SPSS 20.0 (IBM Corporation, New York, New York, U.S.), and STATA 12.1 (STATA-Corp., College Station, Texas, U.S.) software. Segmental and global LV speackle tracking measure were compared in the preoperative and postoperative setting. Additional comparison between the 3 and 6, and 12 months follow up was performed. It was also evaluated the right ventricle

(RV) function by the Tricuspid Annular Plane Systolic Excursion (TAPSE). Pearson's - Bravais correlation analysis between preoperative EF and preoperative GLS, and postoperative EF and GLS was calculated. Finally, was pointed out attention on the time consuming of the procedure and a comparison between the overall duration of the cluster of examination was performed in order to assess the operator learning curve. The differences for categorical variables were compared using χ^2 or Fisher's exact test as appropriate. Continuous variables with normally distributed data were compared with an unpaired Student *t* test. If the data were skewed a nonparametric test (Kruskal-Wallis) was used. A p value of less than or equal to 0.05 was considered statistically significant.

Results

All patients were followed up as planned and a 100% follow up data are collected. LS, EF, left ventricular end-diastolic dimension (LVEDD), left ventricular end-diastolic volume (LVEDV), and stroke volume (SV) significantly improved at 6 months after OPCABG ($P < 0.05$). In figure 1 is presented the pre operatively and 12 months follow up bull eye of two patients. Significant correlation was found between the coronary lesions, which were detected by the angiogram, and the corresponding impaired heart zones, which were shown by reduction in global and segmental LS ($P < 0.05$) as shown in figure 2. No significant correlation was found between angiographic lesion and EF, LVD, and LVV ($P > 0.05$). Significant difference in terms of time taken to perform LS and EF - SK was observed for the first 20 patient cluster. In table 2 the preoperative and 6 months follow up echocardiographic data are summarized.

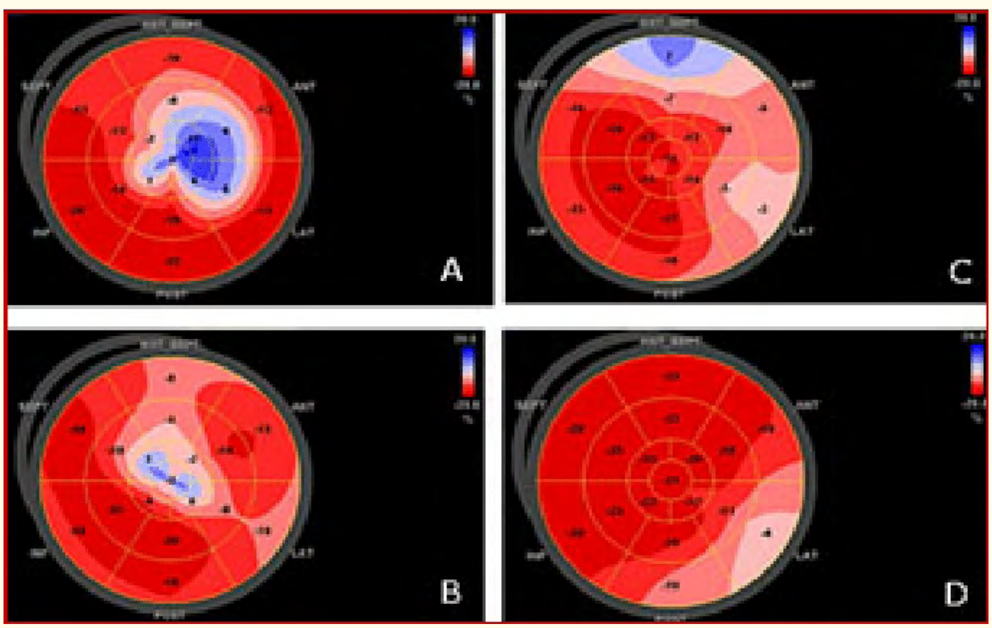

Figure 1: *A-C preoperative, B-D 12 months follow up.*
In A is showed an antero-lateral reduction in myocardial deformation at the GLS analysis, while B reported the significant improvement of the anterolateral elasticity and contractility after surgical revascularization. In C is presented the bull eye with an anterior stunning which is simulating a myocardial scar after AMI and in D is showed the 12 months FU with the complete recovery of the myocardial contractility after OPCABG.

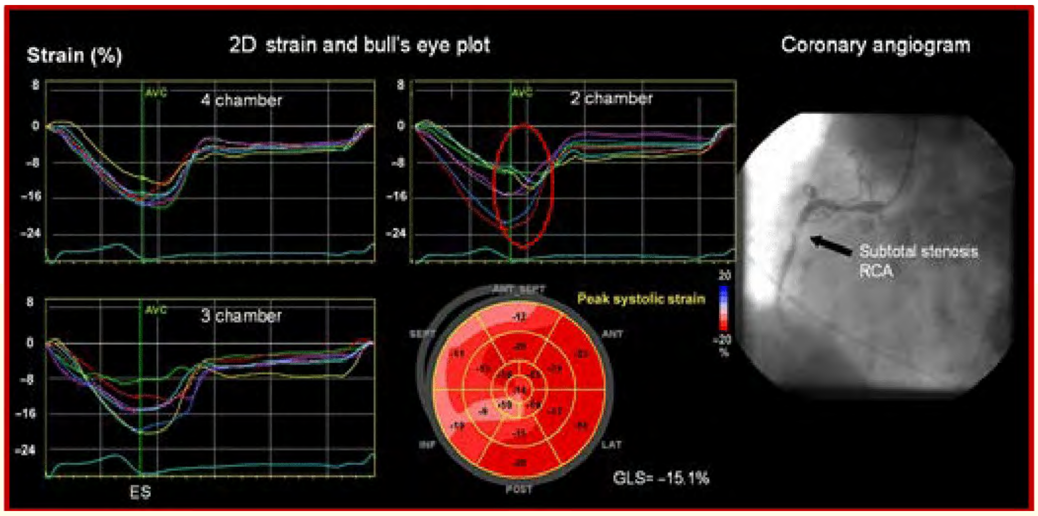

Figure 2: *Correlation between RCA lesion and echocardiographic LS findings. The RCA narrowing causes an acute reduction in the contractility of the posterior wall of the LV and the inter ventricular posterior septum (light red) but not a stunning or scaring as it is also confirmed by the 2 chamber curves which detected a depression in the elasticity of the posterior and inferior LV area (curves in the red circle).*

Echocardiographic variable	Pre operative	Follow up	P value*
Ejection Fraction (%)	64.23	69.93	0.0001
LVDV (ml)	83.97	73.93	0.014
LVSV (ml)	30.47	21.43	0.006
GLS	-16.71	-17.82	0.15
Anterior Basal	-12.6	-12.09	0.38
Anteroseptal Basal	-11.62	-14.09	0.05
Septal Basal	-15.40	-15.09	0.33
Inferior Basal	-17.65	-16.68	0.18
Posterior Basal	-15.80	-13.75	0.05
Lateral Basal	-10.40	-12.34	0.09
Middle Anterior	-15.47	-16.80	0.11
Middle Anteroseptal	-14.92	-17.07	0.05
Middle Septal	-19.15	-19.53	0.25
Middle Inferior	-18.10	-19.75	0.05
Middle Posterior	-16.17	-16.04	0.42
Middle Lateral	-12.40	-14.58	0.05
Anterior Apical	-17.80	-20.21	0.05
Septal Apical	-19.45	-19.68	0.32
Inferior Apical	-19.12	-21.12	0.05
Lateral Apical	-17.20	-18.00	0.26
Apex	-18.65	-19.85	0.12
TAPSE (mm)	24.8	22.4	0.012
E/E’	8.2	7.3	0.10

Table 2: *Preoperative and 6 months follow up echocardiographic data.*

Discussion

In order to evaluate mid and the long-term efficacy of OPCABG, it is fundamental to determine the recovery rate of myocardial function. Our study pointed out that speckle-tracking imaging parameters appear to be more effective than EF and they perfectly reflect the post-OPCABG myocardial function. They also provide reproducible data on myocardial deformation not only in the radial and circumferential directions but, above all in the longitudinal direction. The myocardial wall layers are organized in longitudinal and circumferential myocardial fibers. The part more precociously vulnerable to ischemia is the sub-endocardium, which is predominantly composed by longitudinal fibers. The longitudinal strain rate on 2D-STE is extremely suitable for the study of myocardial ischemia because it perfectly detects the longitudinal movements of the LV [2-4]. Therefore, the systolic longitudinal strain could also be used to track improvements in the global and regional LV systolic function after surgical reperfusion. In the post-operative period, this prospective study showed an increase in regional strain in the segments which have been analyzed. This is the expression of the myocardial wall recovery in strength, resilience, and contractility after OPCABG [5]. As shown in the table 2, the segments in which a remarkable increase was observed ($p < 0.05$) are the lateral and apical septum. They represent the heart territories, which are sprayed by LAD and OMs. Pearson's - Bravais correlation analysis between preoperative EF and preoperative GLS is absolute ($r = +1$) and the same finding appears between postoperative EF and postoperative GLS ($r = +1$). These data demonstrate that the two echocardiographic measures are specular to each other. Figure 1 shows the overall increase in the postoperative strain (B - D) compared to the preoperative data (A - C) using the bull eyes representation. In figure 2 is presented the correlation between the strain curves, the corresponding bull eye, and the coronary lesion detected by the angiography. Because an improvement in LV function can positively affect the RV function, we assessed the RV contraction by measuring TAPSE and, as it was hypothesized, the RV benefited from complete LV revascularization. In effect, RV showed a significant increase in postoperative TAPSE compared with the preoperative data ($p < 0.05$). An interesting finding is the worsening of the strain in the posterior basal segment. A possible explanation of this phenomenon is related to the different ways in which the vessels of the anterior wall are approached with respect to those of the posterior and lateral posterior wall. In fact, the vessels of the front wall can be approached in two ways. The former one is laying the heart on two gauzes properly positioned in the pericardial cavity and exerting traction on the left pericardium. The second way consists in laying the heart on a band of gauze positioned appropriately by means of a deep stitch (a stitch that goes deep into the diaphragmatic face of the pericardium). On the other hand, the approach to posterolateral and inferior coronary arteries dislocating the heart using a cardiac position (i.e. Medtronic Starfish®). This dislocation could result in a negative effect due to the stretching of the myocardial fibers, which is proportional to the weight of the heart. The cardiac stretch reaches its maximum entity in the boundary zone between the middle portion and the basal portion of the LV. This twisting could cause damage to the muscle cells and it would explain the worsening of the strain, which was found in those segments. Another contributory cause is related to the position of the anastomosis. If the anastomosis is too far to the basal segment, there may not be adequate revascularization of the corresponding zone. In this view, a precocious detection of changes in regional and global deformation of the LV can lead to a precocious diagnosis and intervention in the perioperative, early, and late postoperative period. Our reported data showed that LS is more effective than EF, LVEDD, and LVEDV for monitoring the improvement in myocardial function after OPCABG, despite its marginally longer duration. LS could guide the revascularization strategy because it significantly correlates with the coronary lesions, and it may be used to diagnose ischemia in patients' post CABG follow up. An interesting application of LS is in the evaluation of patients with suspected stable angina pectoris where it was shown to be an independent predictor of significant coronary heart disease. In our data, another promising application of strain imaging is the identification of the relatively large subgroup of non ST-elevation myocardial infarction patients with total coronary occlusion, who needs urgent revascularization. Post systolic strain has been proposed as a marker of viability, but should not be used as a stand-alone index since post-systolic shortening also occurs in myocardium with mural necrosis or scar. It is also important to highlight that a passive segment in the first few hours after coronary occlusion, may recover its function after reperfusion, as well as in the chronic phase after a myocardial infarction. In our data, an entirely passive strain curve is most likely a sign of scarring as it is showed in figure 1 (blue areas), and we detected this finding in the 30.6% of the enrolled patients.

Conclusion

Our data showed that LS is more effective than EF, LVEDD, and LVEDV for monitoring the improvement in myocardial function after OPCABG, despite its marginally longer duration. LS could guide the revascularization strategy because it significantly correlates with the coronary lesions, and it may be used to diagnose ischemia in patients' post CABG follow up. An interesting application of LS is in the evaluation of patients with suspected stable angina pectoris where it was shown to be an independent predictor of significant coronary heart disease. In our data, another promising application of strain imaging is the identification of the relatively large subgroup of non ST-elevation myocardial infarction patients with total coronary occlusion, who needs urgent revascularization. Because there are limited clinical data to verify these concepts and as far as we concern for a CT surgeon it is important to know the fine technical details of each echocardiographic method, our research group desired to provide data in this not completely explored field. For this purpose, we also aim to use this echocardiographic technique to compare the OPCABG data with the on pump CABG, because we are convinced that further data series are needed in order to confirm the evidence we have highlighted so far.

Informed Consent

Informed consent was collected from each enrolled patient.

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