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Research Article

The Value of Speckle Tracking Echocardiography in Assessment of Myocardial Viability in Comparison with Thallium-201 Scintigraphy

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Abstract

Background: Speckle-tracking echocardiography is a non-invasive imaging technique that allows for an objective and quantitative evaluation of global and regional myocardial function and it can be used for strain measurement to assess myocardial viability.

Aim of the Work: Is to assess the value of Left Ventricular Longitudinal Strain in assessment of myocardial viability using Speckle Tracking Echocardiography (STE) in comparison with Rest-Redistribution Thallium - 201 Scintigraphy.

Methods: The study included 25 patients who had a history of myocardial infarction and had regional wall motion abnormality by echocardiography requiring viability study before revascularization. Each of these patients underwent Transthoracic echocardiography measurements with the use of a 17-segment paradigm for the division of the left ventricle (LV) , as proposed by American society of Echocardiography (ASE), they also underwent Thalium scintigraphy, as well as Speckle tracking Echocardiography to analyze the deformation by the percent of wall lengthening and shortening representing longitudinal strain for each segment along with a global strain value for the LV.

Results: Of the 425 segments studied, 307 segments were viable representing 72.2% of the segments while 118 segments were non-viable representing 27.8% of the segments according to Thallium - 201 Scintigraphy. Comparing these viable and non-viable segments regarding longitudinal strain value during baseline STE, low dose dobutamine STE revealed a cut off value at baseline STE to detect viable myocardium of ≥ -10.00 (Sensitivity: 65.0% , Specificity of 70.0%), a cut off value at low dose dobutamine STE of ≥ -13.00 (Sensitivity: 75.0%, Specificity: 70.0%) and a cut off difference value of ≥ -2.00 (Sensitivity: 81.1% , Specificity:80.5%).

Conclusion: 2D speckle tracking echocardiography can assess myocardial viability with good sensitivity and specificity compared to SPECT. The change in longitudinal strain value is the most sensitive parameter to detect viable myocardium by low dose dobutamine 2D STE.

Keywords: *Speckle Tracking Echocardiography; Myocardial Viability; Thallium-201 Scintigraphy*

Introduction

Myocardial ischemia may lead to one or more of different pathophysiological end results; either leading to myocardial necrosis and then fibrosis, myocardial hibernation or myocardial stunning. If fibrosis exceeds more than of 35% of myocardial thickness myocardial dysfunction is more likely to persist after revascularization. Testing of myocardial viability is an important determinant for revascularization decision [1].

Speckle tracking echocardiography (STE) is the method we studied to assess myocardial viability. 'Speckles' are small dots or groups of myocardial pixels that are routinely created by the interaction of ultrasonic beams and the myocardium. They enable us to judge the direction of movement, the speed of such movement, and the distance of such movement of any points in the myocardium. We can derive from (STE) the different parameters of strain, strain rate, and rotational mechanics [2,3].

Strain denotes percentage thickening or deformation of the myocardium during the cardiac cycle. Strain parameters are: a) Radial strain, referring to refer to thickening of the myocardial wall during inward motion of the ventricle; b) Longitudinal strain, referring to the percentage decrease in the length of the myocardium during systole; c) Circumferential strain, referring the change in the length along the circular or circumferential perimeter.

Tagged magnetic resonance imaging (MRI) in the only method to enable an accurate analysis of the several deformation components, but its routine use is limited by its high costs, poor availability, relative complexity of acquisitions, and time- consuming image analysis.

However, Speckle-tracking echocardiography allows semi-automated elaboration of myocardial deformation in 3 spatial directions: longitudinal, radial, and circumferential. It has been recently validated against sonomicrometry and tagged MRI. The semi-automated nature guarantees good intraobserver and interobserver reproducibility.

Substantial potential limitations of this new technique are its strict dependence on the frame rate and on high-quality 2-dimensional images [4-6].

Single photon emission computed tomography (SPECT) is one of the most common modalities for assessment of myocardial viability. Initial myocardial uptake of thallium 201 is directly proportionate to coronary blood flow but also its extraction via myocytes is inversely proportionate to the coronary blood flow rate i.e. increases at low flow rate and vice versa. Giving a boost dose which is called reinjection dose enhance the filling defects suggesting viability of such myocardial segment while persistent defects are interpreted as scarred (non-viable) myocardium. SPECT also has stress protocols [7,8].

Patients and Method

Study population

Twenty five patients presenting to Nuclear Imaging Laboratory in Alexandria Main University Hospital for Thallium scintigraphy with history of myocardial infarction for viability assessment.

Exclusion criteria

Patients who are more than 70 years old; Patients with uncontrolled symptomatic heart failure; cardiogenic shock; significant valvular heart disease; conduction defects in the electrocardiogram; uncontrolled cardiac arrhythmias; or those with large or mobile left ventricle (LV) apical thrombus by echocardiogram.

Clinical evaluation

After signing a written informed consent, each patient was evaluated by a) Taking a detailed medical history including: age, gender and risk factors; b) Vital signs; c) Full cardiac examination; d) Resting 12 -lead electrocardiogram (ECG) analysis.

Conventional transthoracic echocardiographic assessment

We performed transthoracic echocardiography measurements on all subjects in the left lateral position. We used all standard parasternal long- and short-axis as well as apical views to qualitatively derive the classical wall motion score, using 17-segment paradigm for the division of the LV, as proposed by the American society of echocardiography (ASE). The LV ejection fraction will be calculated by the modified Simpson`s method from apical 4-chamber view [9].

Thallium scintigraphy

We injected patients with 2.5mCi Thallium 201. We used planar imaging using a conventional gamma camera and an initial set of images were obtained 5 minutes after Thalium-201 injection. Images were acquired for 10 minutes; all images will be stored on a computer disk in 128X128 matrix pattern for later processing. Reinjection with 2.5mCi Thallium - 201, and a second set of images were obtained 1hour after the initial images in the same position [10].

Viability in the infarct territory was defined as an initial defect that is mild with less than 15% reduction in maximal thallium-201 uptake on delayed images, representing redistribution. Predicted non-viability in the infarct zone was defined as a severe defect, with a >50% reduction in maximal thallium-201 uptake on the initial scan with no evidence of redistribution We assigned a four-grade scoring system: 1) Normal tracer uptake; 2) Moderately reduced tracer uptake; 3) Severely reduced tracer uptake; 4) Absent tracer uptake. And Summed Stress Score (SSS), Summed Rest Score (SRS), Summed Difference Score(SDS) and their percent values including Summed Stress percent (SS%), Summed Rest percent (SR%) and Summed Difference percent (SD%) were calculated [11].

Speckle tracking Echocardiography

We calculated strain by Philips iE33 (Philips Medical Systems, USA), which is equipped with a S5-1 transducer, using a low-power real-time application using speckle tracking from 2D gray-scale images. For this analysis, a set of 3 longitudinal 2D image planes (apical long-axis, 2- and 4-chamber views) were used. We marked aortic valve closure timing, to determine the end of systole, in the selected views, and 3 points were anchored inside the myocardial tissue, 2 placed at the basal segments along the mitral valve annulus and 1 at the apex.

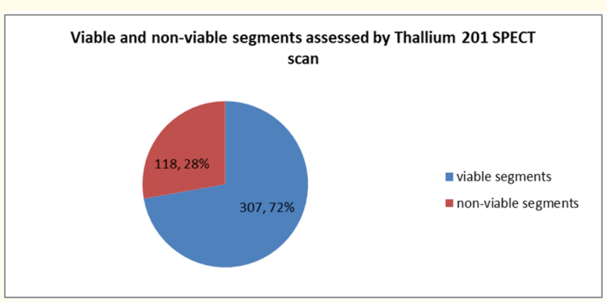
We performed the analysis of the deformation parameter of STE coupled with low dose dobutamine stress echocardiography (LDDSE) with the use of a commercially available speckle tracking system in a Philips workstation (Philips) with QLAB software 7.0 (Advanced Quantification Software, Philips Ultrasound).

The percent of wall lengthening and shortening was displayed for each plane, representing longitudinal strain. The results of all 3 planes were then combined in a single bull's-eye summary, which presented the analysis for each segment along with a global strain value for the LV and this was done during baseline study and low dose dobutamine study (5-20 ug/Kg/min). Peak systolic strain was measured from the mean strain profile for a total of 17 segments of the left ventricle. Global longitudinal was calculated separately as the average of the sum of the studied segments [12,13].

Cardiac cycles with extrasystolic beats, post extrasystolic beats or any rhythm disturbances were excluded.

Results

This study included 25 subjects 5 of them were females and 20 were males. Their ages ranged from 47.0 - 70.0 years with a mean of 57.08 ± 5.93 years.



Figure

Risk factors	(n = 25)	
	No.	%
DM		
No	13	52.0
Yes	12	48.0
Hypertension		
No	6	24.0
Yes	19	76.0
Smoker		
No	5	20.0
Yes	18	72.0
Ex	2	8.0
Family history		
No	16	64.0
Yes	9	36.0

Table 1: *Distribution of the studied cases according to risk factors of coronary artery disease (n = 25).*

	Min. - Max.	Mean ± SD.	Median
End diastolic volume	79.0 - 290.0	177.08 ± 60.31	158.0
End systolic volume	48.0 - 180.0	112.64 ± 38.88	108.0
Ejection fraction	20.0 - 44.0	32.28 ± 6.43	35.0

Table 2: *Descriptive analysis of the studied cases according to LV volumes and ejection fraction assessed by conventional echocardiography (n = 25).*

	No.	%
Apex		
Non-Viable	20	80.0
Viable	5	20.0
Apicoanterior		
Non-Viable	15	60.0
Viable	10	40.0
Apicoseptum		
Non-Viable	15	60.0
Viable	10	40.0
Apico inferior		
Non-Viable	13	52.0
Viable	12	48.0
Apicolateral		
Non-Viable	8	32.0

Viable	17	68.0
Mid anterior		
Non-Viable	7	28.0
Viable	18	72.0
Mid anteroseptum		
Non-Viable	7	28.0
Viable	18	72.0
Mid Inferoseptum		
Non-Viable	0	0.0
Viable	25	100.0
Mid inferior		
Non-Viable	2	8.0
Viable	23	92.0
Mid inferolateral		
Non-Viable	0	0.0
Viable	25	100.0
Mid anterolateral		
Non-Viable	4	16.0
Viable	21	84.0
Basal anterior		
Non-Viable	4	16.0
Viable	21	84.0
Basal nteroseptum		
Non-Viable	4	16.0
Viable	21	84.0
Basal nferoseptum		
Non-Viable	6	24.0
Viable	19	76.0
Basal inferior		
Non-Viable	7	28.0
Viable	18	72.0
Basal Inferolateral		
Non-Viable	4	16.0
Viable	21	84.0
Basal anterolateral		
Non-Viable	2	8.0
Viable	23	92.0

Table 3: *Distribution of the studied segments according to Thallium 201 SPECT scan.*

	Min. - Max.	Mean ± SD
SSS	6.0 - 46.0	28.16 ± 10.7
SRS	2.0 - 42.0	17.76 ± 12.56
SDS	2.0 - 24.0	10.32 ± 7.49
SS%	9.0 - 67.0	41.24 ± 15.75
SR%	2.0 - 61.0	25.88 ± 18.41
SD%	3.0 - 35.0	15 ± 10.96

Table 4: *Descriptive analysis of the studied cases according to the summed score in Thallium SPECT (n = 25).*

	Viable segment		P
	Range	Mean ± S.D.	
Diabetes mellitus			
No	6.0 - 16.0	10.7 ± 3.92	0.015*
Yes	10.0 - 17.0	14.0 ± 1.95	
Hypertension			
No	7.0 - 15.0	11.0 ± 3.63	0.315
Yes	6.0 - 17.0	12.68 ± 3.46	
Smoking			
No	10 - 16	13.7 ± 2.1	0.209
Yes	6.0-17.0	11.72 ± 3.81	

Table 5: *Relation between number of viable segments detected by Thallium 201 scan and clinical data.*

**: Statistically significant at p ≤ 0.05.*

	Baseline STE	LDDSTE	Z	P
Apex				
Min. - Max.	-24.0 - -2.0	-30.0 - -3.0		
Mean ± SD.	-7.04 ± 4.72	-7.96 ± 5.88	1.988*	0.047*
Median	-7.0	-7.0		
Apicoseptum				
Min. - Max.	-25.0 - -3.0	-35.0 - -3.0		
Mean ± SD.	-9.52 ± 5.92	-10.76 ± 7.59	2.426*	0.015*
Median	-7.0	-8.0		
Apico Anterior				
Min. - Max.	-18.0 - -2.0	-25.0 - -2.0		
Mean ± SD.	-6.80 ± 4.20	-9.60 ± 7.05	1.965*	0.049*
Median	-6.0	-8.0		
Apico inferior				
Min. - Max.	-23.0 - -2.0	-26.0 - -4.0		

Mean ± SD.	-9.92 ± 4.68	-12.24 ± 5.87	3.120*	0.002*
Median	-11.0	-12.0		
Apicolateral				
Min. - Max.	-25.0 - -2.0	-25.0 - -1.0		
Mean ± SD.	-6.80 ± 5.79	-8.24 ± 5.40	1.702	0.089
Median	-6.0	-8.0		
Mid anterior				
Min. - Max.	-20.0 - -1.0	-36.0 - -3.0		
Mean ± SD.	-8.60 ± 4.74	-14.76 ± 7.77	3.242*	0.001*
Median	-8.0	-16.0		
Mid anteroseptum				
Min. - Max.	-20.0 - -1.0	-22.0 - -2.0		
Mean ± SD.	-11.0 ± 5.89	-12.52 ± 6.36	3.227*	0.001*
Median	-12.0	-13.0		
Mid inferoseptum				
Min. - Max.	-20.0 - -3.0	-22.0 - -4.0		
Mean ± SD.	-9.72 ± 4.35	-12.92 ± 5.28	3.721*	< 0.001*
Median	-9.0	-14.0		
Mid inferior				
Min. - Max.	-34.0 - -3.0	-37.0 - -3.0		
Mean ± SD.	-12.0 ± 8.18	-15.64 ± 8.92	3.946*	< 0.001*
Median	-10.0	-15.0		
Mid inferolateral				
Min. - Max.	-28.0 - -3.0	-32.0 - -10.0		
Mean ± SD.	-10.68 ± 5.64	-17.32 ± 4.78	4.382*	< 0.001*
Median	-10.0	-18.0		
Mid anterolateral				
Min. - Max.	-23.0 - -4.0	-25.0 - -4.0		
Mean ± SD.	-13.56 ± 5.81	-17.12 ± 5.85	3.768*	< 0.001*
Median	-12.0	-18.0		
Basal Anterior				
Min. - Max.	-25.0 - -1.0	-28.0 - -13.0		
Mean ± SD.	-16.20 ± 6.24	-20.88 ± 4.02	4.222*	< 0.001*
Median	-16.0	-20.0		
Basal anteroseptum				
Min. - Max.	-24.0 - -5.0	-27.0 - -5.0		
Mean ± SD.	-12.16 ± 5.84	-16.24 ± 7.91	3.736*	< 0.001*
Median	-15.0	-18.0		

Basal inferoseptum				
Min. - Max.	-23.0 - -3.0	-26.0 - -3.0		
Mean ± SD.	-10.64 ± 5.05	-14.64 ± 7.01	3.703*	< 0.001*
Median	-10.0	-14.0		
Basal inferior				
Min. - Max.	-18.0 - -6.0	-25.0 - -5.0		
Mean ± SD.	-11.60 ± 4.07	-16.08±5.93	3.815*	< 0.001*
Median	-11.0	-16.0		
Basal inferolateral				
Min. - Max.	-23.0 - -3.0	-29.0 - -3.0		
Mean ± SD.	-12.24 ± 5.80	-16.76 ± 6.72	3.904*	< 0.001*
Median	-11.0	-17.0		
Basal anterolateral				
Min. - Max.	-30.0 - -6.0	-35.0 - -8.0		
Mean ± SD.	-15.40 ± 5.28	-20.16 ± 6.05	4.064*	< 0.001*
Median	-15.0	-19.0		

Table 6: *Comparison between longitudinal strain value during the baseline and low dose dobutamine speckle tracking echocardiography (n = 25).*

*Z and p values for Wilcoxon signed ranks test for comparing between baseline and low dose *: Statistically significant at p ≤ 0.05.*

Speckle tracking/Low dose	Baseline	Low dose	Z	P
GLS				
Min. - Max.	-7.00 - -17.00	-8.00 - -23.00		
Mean ± SD.	-10.82 ± 2.66	-14.34 ± 3.45	4.373*	< 0.001*
Median	-10.00	-14.00		

Table 7: *Comparison between the baseline and low dose dobutamine STE according to Global Longitudinal Strain (GLS) (n = 25).*

Longitudinal strain value		N	Max.	Min.	Mean	Std. Deviation	t-test	Sig.
Baseline STE	Viable	307	-34.00	-1.00	-11.4039	6.16916	10.789	.001*
	Non-viable	118	-25.00	-2.00	-9.2881	5.32227		
LDDSTE	Viable	307	-37.00	-1.00	-15.9153	7.15875	57.185	.0001**
	Non-viable	118	-29.00	-2.00	-10.2542	6.21851		
Difference	Viable	307	-25.00	10.00	-4.5114	4.60985	57.001	.0001**
	Non-viable	118	-14.00	13.00	-.9661	3.51780		
	Total	425	-25.00	13.00	-3.5271	4.61283		

Table 8: *Comparison between viable and non-viable segments detected by Thallium 201 scan regarding longitudinal strain value during baseline STE, low dose dobutamine STE and difference values between baseline and low dose dobutamine studies.*

**: Statistically significant at p ≤ 0.05.*

		SSS	SRS	SDS	SS%	SR%	SD%
GLS. Baseline STE	Pearson Correlation	-.231	-.092	-.202	-.228	-.093	-.211
	Sig. (2-tailed)	.267	.662	.332	.273	.659	.310
GLS. Low dose dobutamine STE	Pearson Correlation	-.433*	-.362	-.040	-.428*	-.363	-.048
	Sig. (2-tailed)	.031	.075	.851	.033	.074	.821
GLS. Difference value	Pearson Correlation	-.559**	-.640**	.258	-.552**	-.640**	.256
	Sig. (2-tailed)	.004	.001	.213	.004	.001	.217

Table 9: *Correlation between Summed score assessed by Thallium 201 scan and GLS values during baseline and low dose STE and difference value.*

** Significant at level 0.05.*

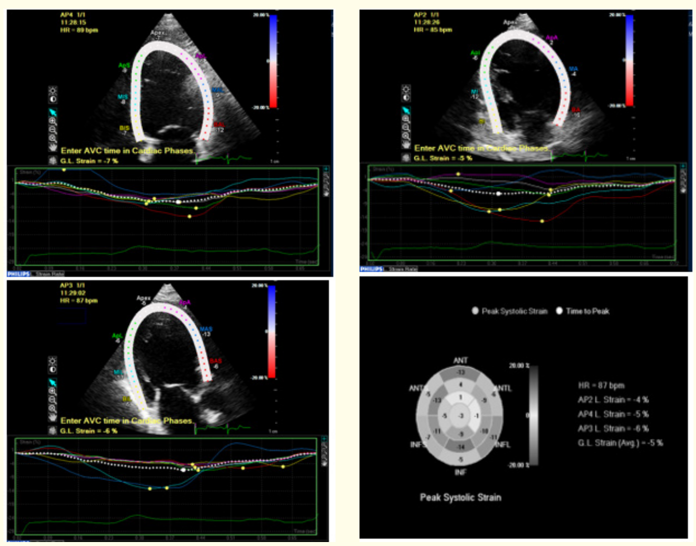


Figure 1: *Longitudinal strain values and G.L. strain of baseline speckle tracking echocardiography of patient No. 6.*

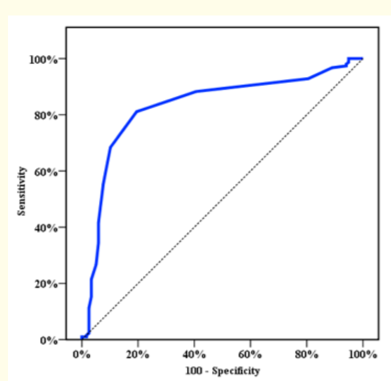


Figure 2: *ROC curve for longitudinal strain difference value to detect viable myocardium in cases.*

Analysis revealed a cut off value for longitudinal strain difference value of ≥-2.00 with sensitivity of 81.1% and a specificity of 80.5% with a positive predictive value (PPV) of 91.54% and negative predictive value of 62.09%.

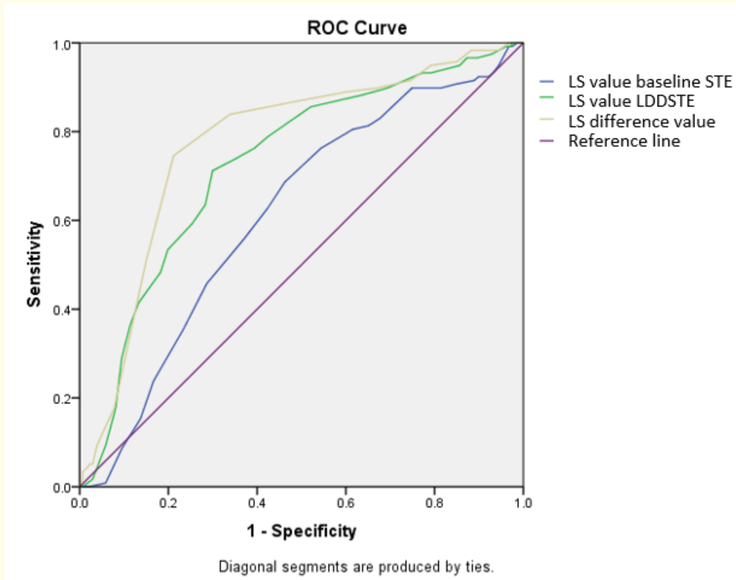


Figure 3: *ROC curve for longitudinal strain value at baseline STE and LDDSTE to detect viable myocardium.*
Also the analysis revealed a cut off value for longitudinal strain value at baseline STE detect viable myocardium of ≥-10.00 with sensitivity of 65.0% and a specificity of 70.0%. A cut off value for longitudinal strain value at low dose dobutamine STE detect viable myocardium of ≥-13.00 with sensitivity of 75.0% and a specificity of 70.0%.

Discussion

Our results come in agreement with Shokr., *et al*. who conducted a study in 2016 to determine the relative accuracy of Tissue Doppler imaging (TDI)-based and STE-based measurements of myocardial strain and strain rate for the detection of myocardial viability before revascularization using SPECT imaging as a gold standard, and came to the result that lower strain and strain rate values exist at rest using STE in the non-viable segments compared to the viable groups of the corresponding territory and an increase of strain and strain rate values in response to LDD was detected in the viable group but not in the non-viable ones, and they found a cut-off point to predict myocardial viability using the ROC curve, at > -4.5% peak longitudinal systolic strain by STE at LDD chosen as a cut-off point, with a sensitivity of 87.24% and a specificity of 84.10% [14].

Also Martin., *et al*. in 2013, who aimed to compare speckle tracking echocardiography (STE) derived systolic longitudinal strain with rest single photon emission computed tomography (SPECT) perfusion imaging, and to define the optimal cut-offs for (SLSmax) to discriminate transmural scar on contrast-enhanced magnetic resonance imaging (ceCMR), and found that the cut-off value of -5.3% longitudinal peak systolic longitudinal 2D strain enabled them to identify non-viable segments with transmural scar tissue with a high accuracy, and it can be used to select patients who will benefit from revascularization, also they found that STE is more accurate in predicting non-viable myocardium [15].

Also to be mentioned, in March 2018, Saleh., *et al*. evaluated STE as tool to detect myocardial viability in comparison to cardiac MRI in post-STEMI patients, they came to the conclusion that global strain was related to the total infarct size (R 0.75, p < 0.001), used it to differentiate transmural from non-transmural infarction at a cut-off value of -10.15, also to predict hospital readmission by ACS or other cardiac symptoms [16].

Loïc Bière., *et al*. assessed in 2014 the value of STE performed early after a first STEMI to predict infarct size and functional recovery at 3-month follow-up, and found that infarct size significantly correlated with GLS (R = 0.601, p < 0.00), WMSI (R = 0.539, p = 0.001) and other parameters, while baseline ejection fraction and GLS were independent predictors of 3-month infarct size, and GLS was the only independent predictor of microvascular obstruction mass (p = 0.015) [17].

We noted that the number of viable segments was significantly different between diabetics and non -diabetics (14.0 ± 1.95 vs. 10.7 ± 3.92, p = 0.015) such paradox was noted earlier and discussed by Niccoli et al in 2012 when they proposed that in spite of potent pro-inflammatory, pro-oxidant and pro-thrombotic stimuli operating in type II diabetes, diabetic patients exhibit substantially more severe coronary atherosclerosis than non-diabetic patients at the time of a first acute coronary event allowing better collateral development towards the culprit vessel as well as other factors [18].

Conclusion

2D speckle tracking echocardiography can assess myocardial viability with good sensitivity and specificity compared to SPECT. The change in longitudinal strain value is the most sensitive parameter to detect viable myocardium by low dose dobutamine 2D STE.

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