SCIENTIFIC RESEARCH

ENDOCARDIAL 2D SPECKLE-TRACKING ECHOCARDIOGRAPHY IN PATIENTS WITH CORONARY ARTERY DISEASE

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SUMMARY

Objectives: study the left ventricular myocardial function with two-dimensional speckle tracking echocardiography and the agreement between endocardial 2DSTE and coronary angiography on the localization of coronary artery stenosis.

Subjects and methods: A cross-sectional study was conducted on 60 patients with coronary artery disease at Hue University Hospital. All of them were examined 2DSTE (using endocardial layer strain analysis) and coronary angiography.

Results: 60 patients (34 men, 26 women, 69,08 ± 12,44 yrs), Statistically significant 2D-STE reduction of the deformation parameters: global longitudinal strain (GLS) (−8.84% ± 4,74, P <0.05); global circumferential strain (GCS) (−12.49% ± 6,02, P < .05). The agreement of the GLS segment and coronary artery stenosis by coronary angiography were k=0.34 (p<0,05) at anterior wall, k= 0,53 (p<0,05) at lateral wall, k= 0,24 (p<0,05) at inferior wall.

Conclusions: The study using strain on 2DSTE shows the left ventricular systolic function reduced in patients with CAD. There is various agreement (not good) about the location of coronary lesions between 2D STE (endocardial strain analysis) and coronary angiography.

Keywords: *Ischemic heart disease, Digital Subtraction Angiography, Two-dimensional speckle tracking echocardiography.*

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INTRODUCTION

Coronary artery disease (CAD) is a common disease in developed countries and tends to increase rapidly in developing countries. Recently, myocardial deformation parameters have been used as a tool to assess early decline in cardiac function [10]. 2DSTE helps to assess cardiac function in different axis regardless of the angle and also to identify the local motion abnormalities. Ischemic heart disease causes regional myocardial disorders. The endocardial layer is often used to measure the strain for the early discovery of the reduced function of the left ventricle but we don't know its agreement with angiography to identify the lesions of myocardial segments. Therefore, we conducted this study with the aims:

1. Study the parameters of endocardial strain on 2DSTE in patients with ischemic heart disease
2. Find out the agreement between 2DSTE and coronary angiography on the coronary lesions.

METHODS

The cross-sectional description study with 60 patients undergoing treatment at the center of Cardiology, Hue University Hospital with ischemic heart disease. Selection criteria: CAD patients confirmed by invasive coronary angiography. Exclusion criteria: Patients disagreeing to participate the study, patients with severe heart failure, malignancy, blood disease, renal failure with glomerular filtration rate <60ml / min / 1.73m^2, anemic patients, hyperthyroidism, COPD, pregnant women.

Data were processed by the statistics software SPSS 20.0. t-test to compare 2 averages. The correlation between two quantitative variables: using Pearson correlation coefficient and linear regression, $p < 0.05$ is considered statistically significant. Cohen's kappa statistic measures agreement between 2DSTE and angiography on the location of coronary stenosis.

The study variables: risk factors, heart rate, blood pressure, echocardiography parameters: LVDs, LVDd, LVPWs, LVPWd, IVSd, IVSs GLS, GLSR, GCS, GCSR GRS.

Echocardiography: The system Philips Afinity 70 with probe 1-5 MGh. From echocardiographic grayscale images, offline analysis using two-dimensional speckle tracking with commercially available software (Qlab12) was performed by a single investigator blinded to other clinical information and imaging results of the patient. 2DSTE was performed in the two-chamber, three-chamber, and four-chamber views by tracking the endocardial border from images with the highest available frame rate. In each apical view, one point on each side of the mitral annulus (basal LV) and one point at the LV apex were defined in end-systole. 2DSTE was also performed in the short axis to track the endocardial layer. Speckle motion was carefully inspected, and segments with poor tracking were manually readjusted and excluded if they exhibited persistently inadequate tracking throughout the cardiac cycle.

The software then automatically traced the endocardial border for the entire LV myocardium and measured layer-specific GLS (global longitudinal strain), GCS (global circumferential strain) from speckle tracking of endocardial layer and calculated endocardial GLS, GLSR (global longitudinal strain rate), GCS, GCSR (global circumferential strain rate).

Coronary angiography:

Selective coronary angiography was performed using a GE system with the standard technique. All views were acquired and reviewed by 2 experienced interventionists. Both were blinded with the echocardiographic findings. Diagnosis of significant CAD was considered when ≥50% reduction of vessel diameter by quantitative coronary angiography was observed in at least one major coronary artery. The distribution of each coronary artery territory on myocardial segments was displayed.

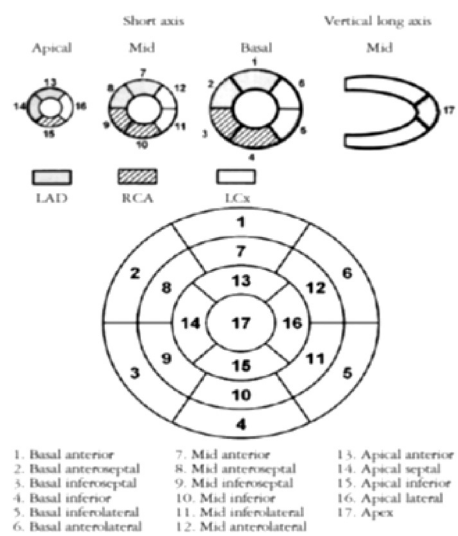

Figure 1. Nomenclature of left ventricular myocardial segments with their distribution according to coronary artery territories. LAD: Left anterior descending, RCA: right coronary artery, LCx: left circumflex.

RESULTS

Table 1. Clinical aspects of the study population (n=60)

	(%) or X± SD
Male/Female	34/26 (56,7/43,3)
Age	69,08 ± 12,44
<60	16 (26,7)
60-79	30 (50,0)
≥80	14 (23,3)
BMI (kg/m²)	21,61 ± 3,52
Risk factors	
Hypertension	40 (66,7)
Dyslipidemia	23 (38,3)
Smoking	31 (51,7)
Hyperglycemia	18 (30,0)
Obesity	2 (3,3)
Sedentary lifestyle	24 (40,0)
Glycemia (mmol/l)	8,28 ± 5,28
Total Cholesterol (mmol/l)	4,35 ± 1,32
Triglycerid (mmol/l)	1,82 ± 1,28
Cholesterol-LDL (mmol/l)	3,02 ± 1,28
Cholesterol-HDL (mmol/l)	1,09 ± 0,30

The participants in the study had an average age of 69.08 ± 12.44, the 60-79-year-old group predominated. Hypertension and smoking as the higher rate of risk factors. There were 38,3% of patients with dyslipidemia while the average cholesterol index was within normal limits.

Table2. Results of Coronary angiography

Coronary Artery	Normal	Stenosis <50%	Stenosis >50 %	Occlusion
LMA	54 (90,0%)	4 (6,7%)	2 (3,3%)	0 (0,0%)
LCX	24 (40,0%)	15 (35,0%)	19 (31,7%)	2 (3,3%)
LAD	13 (21,7%)	7 (11,7%)	31 (51,7%)	9 (15,0%)
RCA	16 (26,7%)	20 (33,3%)	21 (35,0%)	3 (5,0%)

The highest rate of stenosis belongs to the LAD (66,7%).

Table 3. Results of 2D STE strains on the various views

	Strain (%)	Reference Value	p
LS 2C	-8,75±6,46	-19,7	<0,05
LS 3C	-7,90±7,21	-19,7	<0,05
LS 4C	-9,99±3,92	-19,7	<0,05
GLS	-8,84±4,74	-19,7	<0,05
CS basal	-13,79±6,25	-23,3	<0,05
CS midle	-11,37±8,26	-23,3	<0,05
CS apex	-12,64±7,28	-23,3	<0,05
GCS	-12,49±6,02	-23,3	<0,05

There was a statistically significant difference between the strains of patients and the normal population (p<0,05)

Table 4. Correlation between strains and EF

	EF 2C	EF 4C
GLS	**-0,500**	**-0,612**
	< 0,05	< 0,05
LSR	**-0,428**	**-0,580**
	< 0,05	< 0,05
GCS	**-0,462**	**-0,704**
	< 0,05	< 0,05
CSR	**-0,370**	**-0,52**
	< 0,05	< 0,05
Longitudinal-Circumferential Index	**-0,528**	**-0,730**
	< 0,05	< 0,05

There was a good correlation between the systolic strains GLS, LSR, GCS, CSR, and EF (p<0,05).

Table 5. Agreement of 2DSTE versus DSA in LAD stenosis

Septal anterior wall <50%		DSA		
		>50% or cclusion	Total	
2DSTE	No	9	8	17
	Yes	8	35	43
	Total	17	43	60
Kappa		0,34		

For the significant coronary stenosis (> 50%), the agreement of diagnosis between 2DSTE and DSA with k = 0.34

Table 6. Agreement of 2DSTE versus DSA in LCX stenosis

Lateral Wall <50%		DSA		
		>50% or occlusion	Total	
2DSTE	No	36	2	38
	Yes	10	12	22
	Total	46	14	60
Kappa		0,53		

For the significant coronary stenosis (> 50%), the agreement of diagnosis between 2DSTE and DSA with k = 0,53.

Table 7. Agreement of 2DSTE versus DSA in RCA stenosis

Inferior wall <50%		DSA		
		>50% or occlusion	Total	
2DSTE	No	19	9	28
	Yes	14	18	32
	Total	33	27	60
Kappa		0,24		

For the significant coronary stenosis (> 50%), the agreement of diagnosis between 2DSTE and DSA with = 0,24.

DISCUSSION

Strain is a measure of tissue deformation, and strain rate is deformation rate. As the ventricle contracts, the muscle shortens in the longitudinal and circumferential dimensions (a negative strain) and thickens or lengthens in the radial direction (a positive strain). Strain rate measures the time course of deformation and is the primary parameter of deformation. STE is a new technique based on tracking the movement of natural acoustic markers (speckles) present on standard greyscale images. Speckle is a unique acoustic pattern resulting from the interaction of ultrasound energy with tissue. Strain and strain rate parameters are relatively independent of wall tethering and loading conditions. In healthy individuals, the average peak systolic LV longitudinal strain assessed by speckle tracking technique is in the range of −18 – −20. The ischemic myocardium is characterized by reduced regional systolic longitudinal strain. In patients with CAD, the presence of coronary artery occlusions might be identified by STE [10].

In this study, we used the 2DSTE technique in 60 patients with ischemic heart disease confirmed by coronary angiography. Our research results in Table 3.1 show that the average age of the patients in the study group is 69.08 ± 12.44. the ratio of males to females is about 1.31. According to our data, all patients had a lesion in at least one of the coronary arteries.18 patients with diabetes. 40 patients with hypertension, 23 patients with dyslipidemia, 31 smokers. Among the cardiovascular risk factors, the rate of hypertension and smoking are the highest.

The prevalence of significant CAD in our study is 100 %. Table 2 shows that the rate of stenosis for LAD and RCA was 78.3% and 73.3%. The stenosis rate of LMA is 3.3%. In our study, the global longitudinal strain is -8.84 ± 4.74, circumferential strain -12.49 ± 6.02, theses parameters decreased in comparing to the normal value.

Choi et al. reported that a midsegment and basal segmental peak longitudinal strain cutoff value of –17.9% were capable of discriminating severe 3 vessel disease or LMCA disease from diseases with less severity with a sensitivity of 78.9% and specificity of 79.3%.[3] The myocardial fibers most susceptible to ischemia are the longitudinally orientated fibers that are located subendocardial. Measurements of longitudinal motion and deformation are therefore the most sensitive markers of CAD. Despite preserved LV ejection fraction (LVEF), the longitudinal systolic function of the LV in terms of GLS proved to be impaired among patients with CAD. Previous studies have demonstrated a similarly early impairment of the longitudinal systolic function in patients with CAD and preserved regional wall motion in addition to a normal LVEF.

Zhang L [9] conducted a study in patients with and without complex coronary artery disease and concluded that the strains, particularly endocardial GLS and TLS measurement by 2DSTE might enable a non-invasive method to identify complex CAD and predict the severity of coronary lesions in patients with NSTE-ACS.

The subendocardium is the area of LV most vulnerable to the effects of hypoperfusion and ischemia. LV longitudinal mechanics at rest may, therefore, be attenuated in patients with CAD. Ischemic myocardium with reduced active force will lengthen when LV pressure rises during early systole before the onset of systolic shortening. Because strain and strain rates are homogeneously distributed across the myocardium; the detection of even subtle changes in either measure suggests myocardial dysfunction. In patients with SAP and preserved LVEF, layer-specific GLS at rest identifies patients with reversible ischemia [3]. Madhavan S showed that GLS by 2DSTE correlates well with angiographic severity of CAD and can predict significant coronary lesion with a sensitivity of 94% and specificity of 76% in female patients with effort angina [6]. Hagemann, however, in direct comparison, epicardial and mid-myocardial GLS had a significantly higher diagnostic performance compared to endocardial GLS (P = 0.038 and P = 0.031, respectively). They concluded that the layer-specific GLS from 2DSTE at rest was significantly impaired in patients with significant CAD. In addition, epicardial and mid-myocardial GLS were independent predictors of CAD. [7]

It is unknown whether layer□specific global longitudinal strain (GLS) has incremental value in the diagnosis of patients with reversible ischemia assessed by single-photon emission computed tomography (SPECT).In patients with SAP and preserved LVEF, layer□specific GLS at rest identifies patients with reversible ischemia. This seems to be evident only in patients with a true□ positive SPECT, thus, 2DSTE at rest might improve the diagnostic accuracy of a positive SPECT. In this study, the author found that the epicardial GLS was the only independent predictor of coronary artery disease. [2]

Ashraf M. Anwar and al showed that the measurement of global and segmental LS using STE is a more sensitive and accurate tool in the identification of WMA at rest than visual analysis. This supports its use to identify and risk-stratify atherosclerotic CAD.[1]

With small myocardial infarction and normal EF, longitudinal and short-axis deformations decrease yet normal rotational, twist deformation. In massive infarction, the rotational strain also decreases. The STE technique has a higher specificity and sensitivity than tissue Doppler in determining the extension of myocardial infarction[10]. Jamal et al. in their study showed that strain rate and strain can better assess segmental dysfunction severity than myocardial velocities alone after acute myocardial infarction.[5]

Ola et al. reported that global strain measured by 2D-STE is an excellent predictor of myocardial infarct size in chronic ischemic heart disease. Territorial strain is a specific index of the infracted coronary artery. Peak systolic strain measured by 2DSTE discriminates between non-infarcted, transmural infarcted, and subendocardial-infarcted segments [8].

Tables 5, 6, 7 compare the wall-motion abnormalities on 2DSTE and the coronary artery lesions. Our results show the agreement between 2DSTE and coronary angiography with kappa 0.34 for LAD; kappa 0.53 for LCX; kappa 0.21 for RCA (for the stenosis >50%). We found that the agreement between 2DSTE and angiography is not good with the endocardial setting of Qlab 12 software to identify the segmental motion abnormalities. In the same case, the layer analytic results may be different to identify the ill segments with the Qlab software. The segmental motion abnormalities viewed in 2D echocardiography maybe not to recognized on the endocardial 2DSTE. The epicardial strain analysis may resolve problems in these cases if we change the layer setting on the Qlab software.

Ashraf M. Anwar [1] found the sensitivity, specificity for the detection of myocardial ischemia in each coronary artery by the STE 68.6% and 77% respectively. Ehab E El-Hefny [4] concluded that myocardial strain by speckle tracking is superior to conventional Echo. Parameters measurements of global and segmental LS using 2DSTE and it is a more sensitive tool in the identification of wall motion abnormality at rest than visual analysis and that support its use to risk stratify atherosclerotic CAD. It may help in identifying which coronary artery is affected. It is found-and for the first time-that 2DSTE is not inferior to the myocardial perfusion image in the noninvasive diagnosis of CAD. [4]

Correlation between the affected artery and identified segment using strain parameters showed that BA, BAS, MA, MIS, MAS, AI, and AL segments were found to be a significant predictor of LAD stenosis and BP and MP are a significant predictor of LCX stenosis while BI is a predictor to RCA stenosis, also the authors found that strain rate parameters at BA, MA, MAS, AI, AL, and apical segments were found to be a significant predictor of LAD stenosis, BL, BP and ML as a predictor of LCX stenosis while BI and MI are a predictor of RCA stenosis.

Study Limitation: There are some limitations to our study. First, the number of patients enrolled is relatively small so we did not divide into the subgroups of the patients with different kinds of motion abnormalities on the 2D echocardiography (hypokinesia, akinesia, dyskinesia). Second, this study included only the endocardial strain analysis. The agreement between the abnormal wall motion on 2DSTE and the location of coronary artery lesions on coronary angiography may be affected by the kind of motion trouble and the layer analysis (endocardial, middle, epicardial layers).

CONCLUSION

The study using endocardial strain on 2DSTE shows the reduced left ventricular systolic function in patients with CAD. There is various agreement (not good) about the location of coronary lesions between the 2D STE method (endocardial strain analysis) and coronary angiography.

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Recieved: 05/10/2021. Assessed: 27/10/2021. Reviewed:16/11/2021. Accepted: 03/12/2021