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Prediction of Severity of Coronary Stenosis in the Absence of Infarction by Tissue Doppler Imaging and Conventional Echocardiography at Rest

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ABSTRACT

Tissue Doppler imaging (TDI) is a relatively new method that measures regional myocardial velocities on the basis of color Doppler imaging. The aim of this study was to investigate both systolic and diastolic parameters to diagnose coronary stenosis at rest. We examined 73 patients without previous myocardial infarction who underwent coronary angiography. Peak early and late diastolic velocities, systolic velocity, time to peak systolic velocities were measured at rest. The patients were divided to those with coronary artery disease (CAD) in the presence of stenosis of more than 50% in one coronary artery and the control group. We found no significant differences between two groups. Tissue Doppler imaging is not a reliable tool for diagnosis of CAD at rest. Systolic and diastolic velocities by pulsed-wave tissue Doppler imaging were not sensitive for diagnosing the coronary stenosis.

1. Introduction

Stress echocardiography is a well-known, cost-effective method to detect coronary artery diseases (CAD). The technique was used extensively in clinical practice after that several large scale studies reported the safety, diagnostic and prognostic accuracy of the method.[1] Bountioukos et al. reported that regional wall motion analysis is semi-qualitative analysis and there is inter and intraobserver variability.[2] In opposition, TDI method provides quantitative analysis to display abnormality in regional wall motion thorough the analysis of myocardial velocity.[3] Furthermore, the accuracy of CAD diagnosis was improved by using both stress echo and TDI (stress-TDI). Color TDI and heart systolic and diastolic velocity analysis have become a useful research and clinical tool in quantification of myocardial function at rest and stress

conditions.[4] Most investigators have studied the stress-TDI method to determine the diagnostic advantage of the method to detect coronary artery diseases.[5] However, at this time, there is no evidence to display the advantage of TDI method in the rest situation (rest-TDI). Thus, we have examined the rest-TDI in the CAD patients. Furthermore, we have analyzed the diagnosis benefit of rest-TDI to distinguish patients with coronary artery stenosis. Subsequently, validity of rest-TDI was also tested for predicting CAD.

2. Materials and Methods

In this study, 73 candidates for coronary angiography in Tabriz Madani Hospital were included. Forty three males and 30 females with mean age of 56 ± 9 year were enrolled. The patients had no history of previous myocardial infarction, atrial fibrillation or left bundle branch block. The control group was selected among patients who underwent coronary angiography (CAG) and the coronary angiogram was normal. CAG was performed in all patients. Luminal narrowing more than 50% was considered a significant coronary artery lesion. The conventional transthoracic echocardiography, as well as the TDI was carried out in patient and control groups and the results were correlated with the final angiographic diagnosis, location and severity of coronary stenosis. The exclusion criteria included arterial fibrillation, left bundle branch block, previous myocardial infarction, decreased ejection fraction.

Age, sex, ECG, cardiovascular risk factors was included as baseline variables. TDI were performed by using vivid 7 scanners (GE medical system, USA). Conventional echo and rest-TDI was performed in all subjects by using of both online and offline color coded TDI mode. Normal pattern consist of three major signals: a single systolic signal (SV), and two distinct signals in early (E'V) and late (A'V). E'V and A'V were measured in centimetres per second. The peak TDI-derived velocities (SV, E'V, and A'V) were measured at 6 basal segments of left ventricle. Peak mitral inflow early diastolic velocity (mitral E) and peak late diastolic velocity (mitral A), deceleration time of mitral E velocity, E/A ratio were measured by Doppler imaging. Time to peak contraction of all basal segments of heart was measured by tissue Doppler.

2.1. Statistics analysis

The data were expressed by means and standard deviation. A P-value<0.05 was considered to be statistically significant. The data was compared between patients and controls group by using chi-square test. All statistical analyses were performed by SPSS software version. 15.

3. Results

Seventy three patients, 43 males and 30 females with the mean age of 56.37±9.25 (42-77) years were included in this study (Table-1). According to the coronary angiography result, 72.6% of patients (53 individuals) had CAD. Of the 53 patients in this study, 17 patients had single vessel disease, 14 patients had two-vessel disease and 22 patients had three-vessel disease. Among the patients with significant disease, proximal left anterior descending (LAD) was involved in 47%, mid-LAD in 34%, proximal left circumflex artery (LCX) in 49%, proximal right coronary artery (RCA) in 42% and mid RCA in 26%. Twenty patients had normal coronary arteries. Furthermore, in comparison between patients and controls according to the territories of the related vessel a significant difference was not present. The median value of mitral E velocity according to trans thoracic echocardiography analysis was 0.7±0.2 in patients and 1.8±0.2 in control groups (P=0.94). The median value of A velocity was 0.6±0.2 and 0.8±0.2 (P=0.07) in control and study group respectively. Left ventricle ejection fraction (LVEF) was 57.6±4 in the patients compared to 58.3±3.8 in the controls (P=0.40). As mentioned previously, there was not any significantly difference between the patients and controls groups using conventional trans-thoracic echocardiography (Table-1).

3.1. TDI findings

TDI -derived variable included systolic velocity, early diastolic velocity E, late diastolic velocity. Analysis of systolic velocity (SV), early diastolic velocity (E'V), late diastolic velocity (A'V) indices between the patients and control groups didn't reach significant difference. In order to perform a detailed analysis, the most informative segments were selected. In this study Doppler parameters of all myocardial segments were examined and no statistically significant differences between ischemic and control was reported (Table-1). No significant differences of rest-TDI were found between two groups in systolic (SV) and both of diastolic (E 'and A') velocities according to coronary territory. Pulsed-wave TDI method didn't show any value in diagnosing the obstructive coronary lesions at rest.

Table 1- Comparison of Trans thoracic and tissue Doppler Imaging parameters between patients with CAD and without CAD.

parameters	CAD-	CAD+	Pv	parameters	CAD-	CAD+	Pv
EF (%)	58.3±3.8	57.6±4	0.49	Basal Inf (SV) (cm/s)	6.1±4.4	7.4±3.9	0.24
MVEV (m/s)	1.8±0.2	0.7±0.2	0.94	Basal Inf (EV) (cm/s)	5.5±4.8	6.7±3.9	0.29
MVAV(m/s)	0.6±0.2	0.8 ±0.2	0.07	Basal Inf (AV) (cm/s)	6.5±4.9	8.3±4.5	0.14
E/A	1.2±0.4	0.9±0.3	0.85	Basal Inf (TPC) (s)	0.22±0.27	0.15±0.14	0.12
DT(ms)	269.7±86.9	261.1±60.6	0.68	Basal AS (SV) (cm/s)	4.1±3.5	6.1±4.4	0.15
Basal Lat (SV) (cm/s)	6.1±5	7.7±4.5	0.21	Basal As (EV) (cm/s)	3.4±3.5	4.7±3.5	0.23
Basal Lat (EV) (cm/s)	7.0±5.6	7.9±4.7	0.53	Basal As (AV) (cm/s)	4.1±4.6	6.1±4.9	0.21
Basal Lat (AV) (cm/s)	6.8±5.7	7.8±4.3	0.44	Basal As (TPC) (s)	0.18±0.21	0.17±0.19	0.79
Basal Lat (TPC)(s)	0.14±0.09	0.2±0.22	0.2	Basal Pos (SV) (cm/s)	4.6±4.5	6.8±4.7	0.14
Basal Sep (SV) (cm/s)	5.3±3.8	6.9±3.9	0.13	Basal Pos (EV) (cm/s)	4.5± 5.1	7.0±5.0	0.13
Basal Sep (EV) (cm/s)	4.8±3.8	6.2± 3.7	0.16	Basal Pos (AV) (cm/s)	5.3±5.3	7.1±4.7	0.26
Basal Sep (AV) (cm/s)	6.0±4.6	7.9±4.5	0.14	Basal Pos (cm/s)	0.19±0.20	0.17±0.19	0.70
Basal Sep (TPC) (s)	0.14±0.08	0.18±0.21	0.37	RV FW (SV) (cm/s)	7.6±7.6	11.3±6.0	0.08
Basal Ant (SV) (cm/s)	6.0± 4.4	7.6±4.2	0.19	RV FW (EV) (cm/s)	6.6±7.0	9.0±5.7	0.21
Basal Ant (EV) (cm/s)	6.0±4.9	7.4±4.3	0.3	RV FW (AV) (cm/s)	8.3±8.5	13.2±7.4	0.05
Basal Ant (AV) (cm/s)	6.7±5	8.01± 4.6	0.28				
Basal Ant (TPC) (s)	0.22±0.08	0.15 ± 0.04	0.12				

EF=Ejection Fraction, MV_{EV}=Mitral Valve Early diastolic velocity, MV_{AV}= Mitral Valve late diastolic velocity (Atrial Contraction), CAD=Coronary Artery Disease, Basal Lat= Basal Lateral, Basal Inf=Basal Inferior, Basal AS=Basal Anterospetal, Basal Pos= Basal Posterior, Basal Sep=Basal septal, Basal Ant=Basal Anterior, SV=Systolic Velocity, EV=Early Diastolic Velocity, AV= Atrial Late Diastolic Velocity, TPC=Time to Peak Contraction
Data were expressed in mean±SD.

Table 2 - Comparison of Tissue Doppler parameters between patients with LAD stenosis and non LAD stenosis.

parameters	LAD-	LAD+	Pv	N (LAD-/ LAD+)
Basal Lat (SV) (cm/s)	6.7±4.8	7.6±4.7	0.51	36/22
Basal Lat (EV) (cm/s)	7.1±5.1	7.4±4.7	0.8	36/22
Basal Lat (AV) (cm/s)	7.2±5.1	7.7±4.7	0.72	36/22
Basal Lat (TPC) (s)	0.12±0.06	0.13±0.04	0.74	36/21
Basal Sep (SV) (cm/s)	6.5±4.0	6.5±3.9	0.95	50/22
Basal Sep (EV) (cm/s)	5.9±3.9	5.6±3.5	0.77	50/22
Basal Sep (AV) (cm/s)	7.3±4.6	7.7±4.6	0.71	49/22
Basal Sep (TPC) (s)	0.13±0.07	0.16±0.18	0.25	50/21
Basal Ant (SV) (cm/s)	7.2±4.3	7.0±4.3	0.9	49/22
Basal Ant (EV) (cm/s)	7.2±4.5	6.6±4.5	0.6	49/22
Basal Ant (AV) (cm/s)	7.6±4.7	7.8±4.8	0.88	49/22
Basal Ant (TPC) (s)	0.17±0.2	0.15±0.14	0.64	49/20
Basal AS (SV) (cm/s)	5.4±3.7	6.5±4.0	0.69	35/15
Basal AS (EV) (cm/s)	4.4±3.4	4.2±4.0	0.85	36/15
Basal AS(AV) (cm/s)	5.1±4.0	6.8±6.5	0.27	35/15
Basal AS (TPC) (s)	0.15±0.02	0.016±0.03	0.28	40/13

Basal Last: Basal Lateral, Basal Sep: Basal Septal, Basal Ant: Basal Anterior, Basal AS: Basal Anterospetal, SV: Systolic Velocity, EV: Early Diastolic Velocity, AV:(Atrial) Late diastolic Velocity, TPC: Time to Peak Contraction, LAD: Left Anterior Descending Data were expressed in mean±SD

Table 3 - Comparison of tissue parameters between patients With LCX stenosis and non LCX stenosis.

parameters	LCX-	LCX+	Pv	N (LCX-/ LCX+)
Basal Lat (SV) (cm/s)	6.7±4.8	7.6±4.4	0.47	36/26
Basal Lat (EV) (cm/s)	7.1±5.1	8.6±4.9	0.26	36/26
Basal Lat (AV) (cm/s)	7.2±5.1	7.6±4.0	0.70	36/26
Basal Lat (TPC) (s)	0.14±0.07	0.12±0.04	0.14	36/26
Basal Pos (SV) (cm/s)	5.4±4.7	6.7±4.6	0.38	25/19
Basal Pos (EV) (cm/s)	5.3±5.0	7.1±4.9	0.23	25/19
Basal Pos (AV) (cm/s)	5.8±5.1	7.3±4.7	0.32	25/19
Basal Pos (TPC) (s)	0.15±0.15	0.21±0.26	0.24	27/19

RCA: Right Coronary Artery, Basal Inf: Basal Inferior
Basal Pos: Basal posterior, RVFW: Right Ventricle Free Wall

Table 4- Comparison of tissue Doppler parameter between patients with stenosis of proximal RCA and patients without stenosis of proximal RCA.

parameters	RAC-	RCA+	Pv	N(RCA-/ RCA+)
Basal Inf (SV) (cm/s)	6.7±4.3	8.0±3.2	0.22	52/19
Basal Inf (EV) (cm/s)	6.2±4.4	7.4±3.3	0.48	52/19
Basal Inf (AV) (cm/s)	7.5±4.9	8.8±3.6	0.29	52/19
Basal Inf (TPC) (s)	0.16±0.17	0.12±0.03	0.25	51/19
Basal Pos (SV) (cm/s)	5.4±4.7	7.6±4.0	0.17	25/12
Basal Pos (EV) (cm/s)	5.3±5.0	7.3±4.2	0.25	25/12
Basal Pos (AV) (cm/s)	5.8±5.1	7.6±3.8	0.28	25/12
Basal Pos (cm/s)	0.2±0.2	0.1±0.2	1.00	27/13
RV FW (SV) (cm/s)	9.5±7.0	12.0±5.7	0.22	33/15
RV FW (EV) (cm/s)	8.1±6.5	8.9±5.5	0.68	33/15
RV FW (AV) (cm/s)	11.0±8.3	13.0±7.0	0.34	34/15

Data were expressed in mean±SD

4. Discussion

Several studies have shown that TDI parameters could be used to interpret stress echocardiography parameters.[6] Furthermore, a MYDISE study in multicenter, multinational groups showed that tissue Doppler data had high reproducibility and minor interobserver variability.[7] Celutkiene et al. reported the possibility for using TDI during stress echocardiography and they showed that the technique is very sensitive and has reproducible results.[1] Several investigators have incorporated TDI method in stress echocardiography and proposed the diagnostic criteria to induce myocardial ischemia.[8] Celutkiente et al. confirmed the diagnostic value of these parameters during stress echocardiography.[1] In this study, the diagnostic capacity of pulsed-wave tissue Doppler imaging for detection of coronary stenosis, was evaluated by off-line analysis of digitized tissue Doppler imaging in 73 patients who were referred for coronary angiography .The presence of coronary stenosis was verified angiographically but since both the patients and also control subject were selected after coronary angiography selection bias could not be avoided. Impairment of relaxation in patients with CAD and normal LV systolic function has been detected using pulsed–wave TDI.[9] Several studies,[10] using TDI have shown impairment of longitudinal systolic function in patients with CAD without myocardial infarction. However not all studies have shown this response of regional systolic function.[11] Other studies, using TDI or strain rate imaging have found no significant decrease in systolic velocity or strain rate in normokinetic segments in patients with CAD,[4] these results is consistent with our finding. Accordingly, our data showed that there is no difference in systolic and early and late diastolic velocity between patients and control group at rest. Some investigators suggest that the absolute magnitude of peak systolic velocities is not necessarily a parameter to distinguish between normal and impaired myocardial contraction in chronic ischemia.[12] Thus, we thought it may be practical if we can perform the technique in rest. We measured systolic and diastolic velocity parameter in patients at rest condition. Transthoracic echocardiography parameters including LVEF, mitral E velocity, mitral A velocity, E/A ratio, deceleration time were shown the similar results that weren't significantly different between patients and controls. No significant difference was found between patients and control groups in this study. Hence analysis of tissue Doppler imaging at rest in patients with CAD but preserved myocardial LVEF does not appear to be an efficient or easy way for diagnosis. It suggests that TDI method is not a reliable tool to diagnose CAD at rest even though stress echocardiography was shown to have high sensitivity and specificity. However, the ability of the method to detect coronary stenosis had not changed depending on the anatomical location of stensois or the vessels which were involved. This shows pulsed-wave parameter of TDI for diagnosis of significant coronary artery stenosis is not a reliable tool at rest. We suggest

that systolic and diastolic velocity does not change in patients with normal LVEF. Diastolic function was measured by mitral E velocity/mitral A velocity and mitral E velocity/early myocardial diastolic velocity (EV) in patients and control group. The comparison between control and CAD groups in term of diastolic dysfunction showed the decrease in regional diastolic function in segments with severe coronary stenosis which may reflect structural changes of myocardium in normokinetic segments supplied by severe coronary stenosis.[13] However, both groups in our study displayed the same diastolic function. Also, aging, as expected, has a significant effect on all measured Doppler velocities[5] but our study groups was age matched thus they did not display any significant difference.

Study limitation

We are aware that angiographic coronary stenosis does not always reflect the potential alteration in regional myocardial perfusion. The control group might not have a normal myocardial perfusion. Besides, the accuracy of myocardial velocities in the analysis of myocardial contractility is limited compared to strain/strain rate imaging, as the latter method eliminates tissue tethering and motion of cardiac translation.

5. Conclusion

The pulse-wave tissue Doppler imaging is not a reliable method for diagnosing CAD at rest in patients with preserved LVEF. Also, ischemia in the patients didn't change the peak velocity in myocardium and time to peak contraction in basal segments at rest. Further studies using automated functional imaging (AFI) to evaluate global peak systolic strain at rest could be helpful in differentiation of patients with CAD and control healthy subjects.

Ethical issues

The study was approved by the Ethical Committee of the University.

Conflict of interests

No conflict of interest to be declared.

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