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ARAŞTIRMA / RESEARCH

Assessment of myocardial function by tissue Doppler imaging myocardial performance index in patients with acute ischemic stroke

Akut iskemik inmeli hastalarda miyokard fonksiyonunun doku Doppler miyokardiyal performans indeksi ile değerlendirilmesi

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Abstract

Purpose: The aim of this study is to investigate the relationship between myocardial function assessed by tissue Doppler imaging myocardial performance index (TDI-MPI) and National Institutes of Health Stroke Scale (NIHSS) score in patients with acute ischemic stroke.

Materials and Methods: The study comprised 128 patients (males, 55; females, 73; 68 ± 19 years) with acute ischemic stroke. 20 patients were excluded. Patients were divided into two groups based on the calculated NIHSS score (Group 1, NIHSS score < 16; Group 2, NIHSS score ≥ 16). Demographic, clinical, and laboratory data for all patients were collected. Cardiac function was evaluated by transthorasic echocardiography within 48 hours of admission to the neurology care unit.

Results: There were no significant differences among demographic parameters of patients. Tissue Doppler myocardial performance index was significantly higher in Group 2 patients than in Group 1 patients (0.62±0.28 vs 0.46±0.16).

Conclusion: Our results suggest that TDI-MPI is associated with stroke severity on admission in patients with acute ischemic stroke. TDI-MPI is an indicator of global myocardial dysfunction with a different from LVEF. TDI-MPI, which includes both systolic and diastolic time intervals to assess the global cardiac dysfunction.

Keywords: Ventricular dysfunction, left ventricular, echocardiography, stroke

Öz

Amaç: Bu çalışmanın amacı, akut iskemik inmeli hastalarda National Institutes of Health Stroke Ölçeği (NIHSS) ile doku Doppler miyokard performans indeksi ile değerlendirilen miyokard fonksiyonları arasındaki ilişkiyi araştırmaktır.

Gereç ve Yöntem: Çalışmaya akut iskemik inme geçiren 128 hasta (erkek,55; kadın, 73; yaş, 68 ± 19) alındı. 20 hasta çalışmadan çıkarıldı. NIHSS skoruna göre hastalar iki gruba ayrıldı (Grup 1, NIHSS skor <16; Grup 2, NIHSS skoru ≥ 16). Bütün hastalardan demografik, klinik ve laboratuvar verileri toplandı. Hastaların kardiyak fonksiyonları, nöroloji yoğun bakım ünitesine yatırıldıktan sonraki 48 saat içerisinde transtorasik ekokardiyografi değerlendirildi.

Bulgular: Hastaların demografik özellikleri açısından gruplar arasında anlamlı farklılık saptanmadı. Doku Doppler miyokard performans indeksi, Grup 2 hastalarında, Grup 1 hastalarına göre anlamlı derecede daha yüksek bulundu (0.62±0.28 ile 0.46±0.16).

Sonuç: Yapmış olduğumuz bu çalışmada, akut iskemik inme ile yatan hastalarda, inme şiddeti ile doku doper miyokard performans indeksi arasında bir ilişki olduğu sonucuna varılabilir. Doku Doppler MPİ, LV EF'dan farklı olarak, global miyokardiyal disfonksiyonunun bir göstergesidir. Doku Doppler MPİ, hem sistolik, hem de diyastolik zaman intervallerini içermekte olup, global kardiyak disfonksiyonu değerlendirir.

Anahtar kelimeler: Ventrikül disfonksiyonu, sol ventrikül, ekokardiyografi, inme

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INTRODUCTION

Acute stroke is an important cause of morbidity and mortality[1], and cardiovascular complications are common after an acute stroke[2]. Myocardial injury is an important complication of acute cerebrovascular events. Autonomic nervous system dysregulation after acute cerebrovascular events possibly cause sympathetic activation resulting in hypercontraction of cardiac myocytes and subsequent myocardial injury. Neurogenic stress cardiomyopathy (NSC) is a condition of acute myocardial systolic dysfunction that can be observed after acute cerebrovascular events, such as acute ischemic or hemorrhagic stroke, cranial trauma, subarachnoid hemorrhage, and seizures[3].

Often, NSC can be very similar to myocardial infarction, presenting with ischemic ECG changes, including ST segment and T wave deviations, reduced ejection fraction, elevated troponin levels, and ventricular wall motion abnormalities. However, there is no significant obstruction of the coronary arteries in patients with NSC. Acute heart failure due to NSC is an important cause of lethal ventricular arrhythmias and mortality[4].

The tissue doppler imaging myocardial performance index (TDI-MPI), combining time intervals of LV contraction and relaxation, is a powerful predictor of death and congestive heart failure after MI[5]. Noninvasive measurements of time intervals have historically been used for evaluation of both systolic and diastolic function, but because of logistical difficulties in obtaining the intervals, these measure ments have not often been applied clinically. Pulsed TDI was performed and mitral annular peak systolic (s') velocity as well as early (e') and late (a') diastolic velocities were also obtained with the sample volume positioned at the septal annulus on the apical 4-chamber view. This index can be obtained easily, is reproducible and independent of the ventricular geometry, and has been shown to have potential for clinical application in the assessment of overall cardiac function in various disorders[6,7].

In this study, we aimed to investigate the relationship between tissue doppler imaging myocardial performance index and National Institutes of Health Stroke Scale (NIHSS) score in patients with acute ischemic stroke.

MATERIALS AND METHODS

We prospectively studied consecutive 128 adult patients (males, 55; females, 73; mean age, 68±19 years; range 40–89 years) with acute ischemic stroke (≤24 hours of symptom onset) admitted to the neurology care unit, between October 2016 and December 2018. 20 patients were excluded. Demographic and baseline clinical data, including neurological deficit severity assesment with NIHSS on admission to the neurology care unit were recorded. Patient clinical data, history of cardiovascular risk factors, and stroke onset were determined, and neurologic examination was conducted at the time of admission. The diagnosis was made on the basis of neurologic examination and cranial imaging within 24 hours of symptom onset. Patients with a well-defined time of ischemic stroke symptom onset were included in the study and those with any previous history of cerebrovascular disease or transient ischemic attack, cerebral hemorrhage, documented atrial fibrillation, coronary heart disease, congestive heart failure, serious valvular heart disease, congenital heart disease, chronic obstructive pulmonary disease, chronic renal failure were excluded. In addition, patients in whom a proper position could not be obtained during echocardiography and those with poor echocardiographic image quality, were excluded. Seventeen patients were excluded because of previous history of cerebrovascular disease (n=4), documented atrial fibrillation (n=5), congestive heart failure (n=3), coronary heart disease (n=5), serious valvular heart disease (n= 2), a poor echocardiographic image quality (n=1). Baseline stroke severity was assessed using the NIHSS score[8]

All patients underwent immediate computed tomography after being admitted to emergency care unit. Troponin levels were measured and electrocardiogram (ECG) was recorded after admission to the neurology care unit. Echocardiography was performed within the first 48 hours of admission to the neurology care unit. The NIHSS evaluation and echocardiographic examination were conducted by blinded investigators (U.O and O.O, respectively). The study was approved by the Ethics Committee of our hospital (Date:09 September 2016, Ethics committee number:57), and informed consent was obtained. The study was conducted in accordance with the the principles of the Declaration of Helsinki.

Echocardiographic examination

Two-dimensional echocardiography

All patients underwent comprehensive transthoracic echocardiography examinations, which were conducted according to the guidelines of the American Society of Echocardiography. An ultrasound system (Philips EPIQ 7C, Philips Healthcare, Andover, MA, USA) equipped with a multifrequency transducer (3–8 MHz) and tissue harmonic imaging capability was used. Single-lead electrocardiogram was continuously recorded. Patients were kept in the left lateral decubitus position. Images were obtained from the parasternal long- and short-axes, apical two- and four-chamber, and long-axis views. All echocardiograms included at least three cardiac cycles and were digitally stored for offline analysis. In addition to LVEF, end-systolic and end-diastolic volumes were measured from the apical two- and four-chamber views, using the standard biplane Simpson's technique. Interventricular septum, posterior wall thickness, LV end-diastolic diameter, and left atrial antero-posterior diameter were measured from a parasternal long-axis view[9]. Echocardiographic parameters were calculated by qualified physician (O.O.), and echocardiographic examination was conducted by an investigator who was blinded to the patients' clinical information.

Assessment of LV Function

Pulsed TDI was performed and mitral annular peak systolic (s') velocity as well as early (e') and late (a') diastolic velocities were also obtained with the sample volume positioned at the septal annulus on the apical 4-chamber view [5]. Regarding the TDI-derived index, TDI-MPI was calculated as $(a - b)/b$ where a is the time interval from the end to the onset of the mitral annular velocity pattern and b is the duration of s' wave (Figure 1).

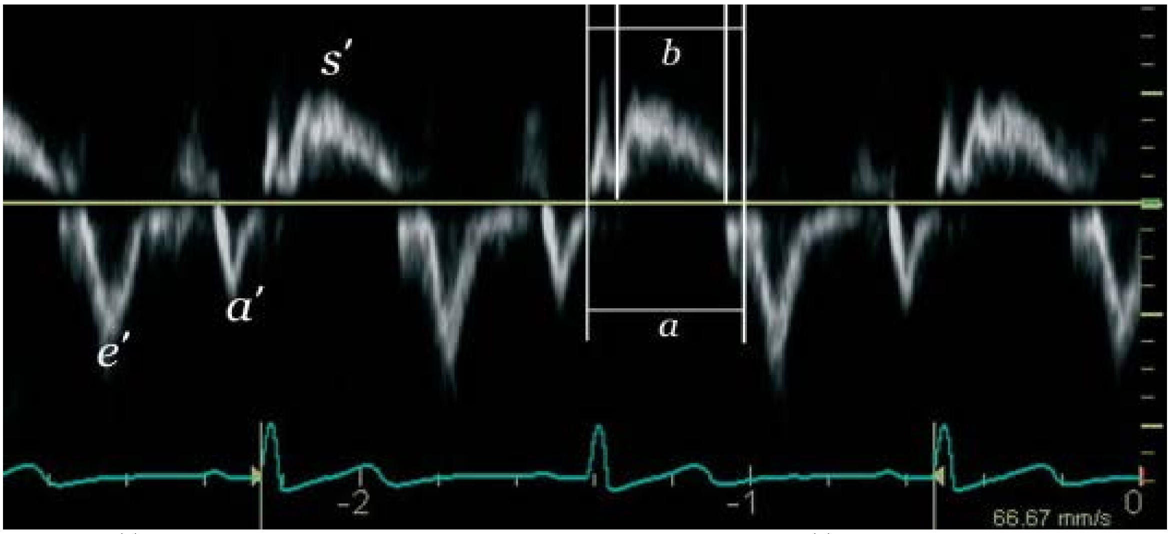

Figure 1. Tissue Doppler imaging-derived myocardial performance index (TDI-MPI) at the mitral septal annulus.

TDI-MPI is defined as $(a - b)/b$, where a is the time interval from the end of late mitral annular diastolic wave (a') to the onset of early mitral annular diastolic wave (e'), and b is the time interval between the start and the end of mitral annular systolic wave (s') of TDI.

Definition of stroke and assesment of stroke severity

According to the updated definition of stroke in the American Heart Association/American Stroke Association guidelines, ischemic stroke is diagnosed based on the combination of symptoms and/or signs of typical neurological dysfunction and imaging evidence of central nervous system infarction. Therefore, ischemic stroke is defined as a neurological dysfunction episode caused by focal cerebral, spinal, or retinal infarction on imaging[10].

NIHSS is a simple, valid, and realiable systematic assessment tool that measures acute stroke-related neurologic deficit[8]. The NIHSS score is very important scale for clinical assessment as it enables determination of appropriate treatment, prediction of lesion size, measurement of stroke severity, and prediction of patient outcome in patients with acute ischemic stroke. The NIHSS comprises 11 different elements evaluating specific ability. Each ability is scored between 0 and 4, where 0 corresponds to normal functioning and 4 corresponds to complete impairment. A patient's NIHSS score is calculated by adding the score for each element of the scale; 42 is the highest score possible. A higher NIHSS score corresponds to greater impairment of cerebral function in a stroke patient.

The higher the NIHSS score, the higher the impairment of a stroke patient. According to NIHSS score, there are five stroke severity groups: NIHSS =0 (no stroke), NIHSS=1-4 (minor stroke), NIHSS=5-15 (moderate stroke), NIHSS=16-20 (moderate to severe stroke), NIHSS=21-42 (severe stroke). A baseline NIHSS score greater than 16 indicates a strong probability of patient disability and death[7]. Stroke severity at admission to the neurology care unit was assessed by the NIHSS score by a neurologist (U.O). Patients were categorized into two groups; Group 1 comprised of patients with non-severe stroke (NIHSS<16; n=75), whereas Group 2 comprised of patients with severe stroke (NIHSS≥16; n=33).

Statistical analysis

Statistical analysis was conducted with the SPSS statistical package (Version 12.0; SPSS Inc., Chicago, IL, USA). All baseline parameters were analyzed. Continuous variables are expressed as mean±SD, and categorical variables are expressed as percentages. Intra-observer variability was calculated as the absolute difference between the two measurements as a percentage of their mean. Mann–Whitney U test and Chi-square test were used for comparison of data as appropriate. p values <0.05 were considered statistically significant. Pearson's correlation was used to determine the relationship between LV MPI and other echocardiographic parameters. The Pearson's or Spearman's correlation was used for assessing correlations between variables.

RESULTS

Baseline characteristics of patients are summarized in Table 1. Clinical characteristics of groups were similar with respect to age, gender, hypertension, diabetes, smoking (p>0.05). Systolic blood pressure (BP), diastolic BP, heart rate, dyslipidemia, and troponin levels in Group 2 patients were signficantly higher than Group 1 patients (p<0.05). Serum hemoglobin HbA1c and low density lipoprotein cholesterol levels were significantly higher in Group 2 patients than Group 1 patients (p<0.05).

Echocardiographic findings are summarized in Table 2. LV wall thickness and E/e' values were significantly higher in Group 2 patients than in Group 1 patients (p < 0.05).

Table 1. Clinical characteristics of patients

Variables	Group 1 (NIHSS <16) n=75	Group 2 (NIHSS≥16) n=33	p Value
Age (years)	64.3±13.9	71.5±18.4	0.572
Gender (F/M), n	42 / 33	19 / 14	0.718
Hypertension, n %	33 (45%)	19 (57%)	0.057
SBP (mmHg)	141.3±16.7	164.2±17.8	0.039
DBP (mmHg)	74.6±8.2	87.1±13.9	0.042
Heart Rate (bpm)	91.2±13.4	118±18.1	0.032
Diabetes Mellitus, n %	19 (26%)	9 (28%)	0.072
Smoking, n %	9 (13%)	5 (15%)	0.086
Dyslipidemia, n %	12 (17%)	11 (34%)	0.036
Troponin (ng/L)	5.26	18.91	0.025
HbA1c (%)	6.17±1.52	9.29±1.89	0.008
Glucose (mg/dl)	142.9±33.8	198.2±45.9	0.035
Creatinine (mg/dL)	1.3±0.4	1.8±0.6	0.023
LDL cholesterol (mg/dL)	101.8±24.8	132.8±41.7	0.009
HDL cholesterol (mg/dL)	40.9±14.4	37.5±9.2	0.472

*F:Female, † M:Male, ‡ SBP: Systolic Blood Pressure, § DBP: Diastolic Blood Pressure, || LDL: Low Density Lipoprotein, ¶ HDL: High Density Lipoprotein.

LV TDI-MPI were significantly lower in Group 1 patients having lower NIHSS scores than in Group 2 patients having higher NIHSS. LVEF were significantly higher in Group 1 patients having lower NIHSS scores than in Group 2 patients having higher NIHSS. Intra-observer and inter-observer variability were calculated. 10 (12 %) patients were randomly assigned to assess variability. Interobserver variability was 5 % and intraobserver variability was 4 %.

Table 2. Echocardiographic parameters of patients

Variables	Group 1 (NIHSS <16) n=75	Group 2 (NIHSS ≥16) n=33	p Value
LV septal thickness, mm	11.4±1.7	12.9±1.8	0.032
LVDd (mm)	51.6±5.7	55.8±6.7	0.452
LV posterior Wall thickness, mm	10.6±1.6	12.4±1.9	0.037
LVDs (mm)	41.7±4.8	44.6±5.2	0.289
LVEDV (mL)	87.5±18.27	96.3±28.2	0.232
LVESV (mL)	40.8±13.9	46.5±15.2	0.341
LAD (mm)	38.7±4.9	44.5±4.2	0.563
RAD (mm)	33.4±3.2	35.6±3.2	0.476
RVDd (mm)	29.4±2.8	32.5 ± 3.1	0.294
LVEF (%)	58.7±4.8	52.7±7.1	0.028
LV TDI-MPI	0.46±0.16	0.62±0.28	0.003
E/e’	8.2±3.4	11.7 ±3.9	0.016

* NIHSS: National Institutes of Health Stroke Scale, † LV: Left Ventricle, ‡ LVDd: Left ventricular diastolic diameter, § LVDs: Left ventricular systolic diameter, | | LVEDV: Left ventricular end-diastolic volume, ¶ LVESV: Left ventricular end-systolic volume, ** LAD: Left atrial diameter, †† RAD: Right atrial diameter, ‡‡ RVDd: Right ventricular diastolic diameter, *** LVEF: Left ventricular ejection fraction, ††† LV TDI-MPI: Left ventricular tissue doppler imaging myocardial performance index.

Correlation analysis performed to investigate the relationship between NIHSS score and echocardiographic parameters, showed a negative correlation between the NIHSS score and LVEF . In addition, there was a positive correlation between absolute value of the NIHSS score and LV TDI-MPI, age, heart rate and E/e’. (Table 3).

Table 3. Correlation between NIHSS score and clinical parameters

Parameters	Pearson’s correlation coefficient (r value)	p Value
LV TDI-MPI	0.492	0.023
LVEF	-0.356	0.032
E/e’	0.342	0.029
Age	0.374	0.045
Heart rate	0.482	0.038

* NIHSS: National Institutes of Health Stroke Scale, † LV TDI-MPI: Left ventricular tissue doppler imaging myocardial performance index, ‡ LVEF: Left ventricular ejection fraction.

DISCUSSION

Ischemic stroke and heart failure are important causes of morbidity and mortality. It has been previously reported that heart failure is associated with an increased risk of ischemic stroke. Heart failure is also reportedly associated with a poor prognosis in patients with stroke[10,11]. In addition, LV dysfunction occurs frequently after cerebrovascular events[12-14]. LV systolic and diastolic dysfunctions result from complex and interrelated alterations in cardiac function and structure, peripheral vasculature, and neurohumoral regulation. Neurogenic stunned myocardium (NSM) is defined as myocardial injury and dysfunction of the autonomic nervous system, that occurs after cerebrovascular events.

Previous studies have suggested that severe neurologic injury, female gender, and elevated plasma troponin and brain natriuretic peptide levels are independent predictors of NSM[15,16]. LVEF is a useful marker of systolic function; however, it was not detected in diastolic dysfunction. The effect of ischemic stroke severity on LV function is not very well known, and there are only a few studies investigating this relationship[17,18]. Sung PH et al. found that the severe acute ischemic stroke patients had lower LVEF[19]. In our study we found that LV EF value was significantly lower in severe stroke patients. TDI-MPI is an indicator of global myocardial dysfunction with a different from LVEF. Tissue Doppler Imaging - Myocardial Performance Index, which includes both systolic and diastolic time intervals to assess the global cardiac dysfunction.

LV TDI-MPI is a useful marker for assesment of global LV function. Very less is known about the relationship between acute ischemic stroke severity and LV TDI-MPI. Importantly, this is the first study assessing LV function by LV TDI-MPI in the early period of acute ischemic stroke. The novel and most important finding of our study is that both LV systolic dysfunction and LV diastolic function was detected with LV TDI-MPI after acute ischemic stroke. We found that TDI-MPI was significantly higher in patients with higher NIHSS scores than in those with lower NIHSS scores.

Hypertension, hyperlipidemia and Diabetes Mellitus are important risk factors for atherosclerotic cerebrovascular disease. We found that, blood pressure at admission is significantly higher in severe ischemic stroke patients. However, Bonardo P et al found that, young patients with acute ischemic stroke, large infarct volume was not associated with high blood pressure at admission[20]. In our study, we found that LDL cholesterol and HbA1c were signficantly higher in patients with higher NIHSS scores than in those with lower NIHSS scores. Hendrix P et al. found that diabetes mellitus history is an important predictor of stroke severity[21].

Acute stroke is characterized by profound autonomic dysregulation, including alterations in the autonomic reflex pathways, central autonomic neuroanatomical sites, and hormonal factors. Stroke-related sympathetic activation is high in patients with higher NIHSS score. Irrespective of prior cardiovascular status, an acute phase of stroke markedly influences systemic BP, heart rate, LV function, and biochemical parameters (Glucose, troponin, creatinin)[14]. In this study, we found that troponin levels were significantly higher in severe ischemic stroke patients. Chang et al observed that cardiac biomarkers, particularly serum troponin levels, are associated with acute large vessel occlusion in patients with ischemic stroke[22]. Lindsberg et al observed elevated blood glucose is common in the early phase of stroke. In our study blood glucose levels were significantly higher in severe stroke patients on admission. Although up to one-third of severe acute ischemic stroke patients have diagnosed diabetes, probably a major proportion of patients have stress hyperglycemia mediated partly by the release of cortisol and norepinephrine[23]. In our study we found that E/é value was significantly higher in severe stroke patients. Ryu WS et al. suggested that E/e' ratios were associated with arterial occlusion in AF-related stroke and may play a role in identifying patients at high risk of severe stroke[24]. In this study we found that creatinine levels were significantly higher in severe stroke patients. Mostofsky E et al suggesting that, shared risk factors underlying vascular diseases including age, diabetes mellitus, hypertension, left ventricular hypertrophy may represent a unique vascular pathogenesis resulting from reduced renal clearence. Renal function predicts survival in patients with acute ischemic stroke[25].

Our study has several limitations. Although we excluded patients with major cardiac history, it is possible that chronic heart failure was missed. However, we excluded patients with echocardiographic parameters that are compatible with chronic heart failure, such as segmental dyskinesis, dilated or hypertrophic cardiomyopathy, or severe valvular disease. Moreover, elevation of cardiac troponin levels over time is in accordance with the current definition of stress cardiomyopathy. Therefore, we suggest that stress cardiomyopathy features should be studied in patients with acute ischemic stroke and without chronic asymptomatic heart failure.

The results of our study suggest that LV TDI-MPI is associated with stroke severity on admission in patients with acute ischemic stroke. Myocardial Performance Index, which includes both systolic and diastolic time intervals to assess the global cardiac dysfunction. LV MPI can help to evaluate LV systolic and diastolic function in patients with acute neurologic diseases.Therefore, this study suggests that LV MPI can asess LV myocardial dysfunction in patients with acute ischemic stroke.

Yazar Katkıları: Çalışma konsepti/Tasarımı: ÜÖ, ÖÖ; Veri toplama: ÜÖ, ÖÖ; Veri analizi ve yorumlama: ÜÖ, ÖÖ, YT; Yazı taslağı: ÜÖ, ÖÖ; İçeriğin eleştirel incelenmesi: ÜÖ, ÖÖ, YT; Son onay ve sorumluluk: ÜÖ, ÖÖ, YT; Teknik ve malzeme desteği: ÜÖ, ÖÖ; Süpervizyon: YT; Fon sağlama (mevcut ise): yok.
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