Patients with Non-ST-Segment Elevation Myocardial Infarction Present with More Severe Systolic and Diastolic Dysfunction Than Patients with Unstable Angina

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Background: Patients with non ST-segment elevation acute coronary syndrome (NSTEACS) present with diverse clinical, electrocardiographic, cardiac biomarker, echocardiographic and angiographic characteristics. We sought to determine whether there was any difference in the indices of left ventricular systolic and diastolic function among subgroups of patients with NSTEACS.

Material and Method: We studied 121 consecutive patients (mean age 68.6 ± 11.3 years, 45% male) with NSTEACS who underwent comprehensive echocardiography within 48 hours of admission. Two-dimensional and Doppler echocardiography was performed for the evaluation of left ventricular systolic and diastolic function.

Results: Non ST-segment elevation myocardial infarction (NSTEMI) and unstable angina (UA) were reported in 59% and 41% of patients, respectively. Clinical characteristics (such as age, gender, cardiovascular risk factors, prior myocardial infarction and revascularization, medication) were not significantly different between patients with NSTEMI and UA. Patients with NSTEMI were more likely to have wall motion abnormalities and lower left ventricular ejection fraction (p < 0.05) as compared to those with UA. Diastolic dysfunction was significantly more frequent and more severe in patients with NSTEMI than in those with UA.

Conclusion: Among patients with NSTEACS, left ventricular systolic and diastolic dysfunction was more frequent and more severe in patients with NSTEMI that in those with UA. These findings may be used to characterize the sicker group among patients with NSTEACS.

Keywords: Diastolic dysfunction, Echocardiography, Non ST-segment elevation myocardial infarction, Unstable angina

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comprehensive evaluation of LV function. We sought to determine whether there was any difference in the indices of systolic and diastolic function among subgroups of patients with NSTEACS.

**Material and Method**

**Study Population**

Patients with the diagnosis of NSTEACS were consecutively enrolled into the study. The study was approved by the ethical committee of Siriraj Hospital. Patients had to be \( \geq 18 \) years of age and had symptoms consistent with acute coronary syndrome accompanied by cardiac biochemical markers or ECG changes. Patients with Non-ST-segment Elevation Myocardial Infarction (NSTEMI) were defined as those with positive cardiac biochemical markers of necrosis accompanied by ST-segment changes, but without new ST-segment elevation on the index ECG. Patients with unstable angina (UA) were those who had ST-T wave changes on the index ECG, regardless of the presence of chest pain at the time of the ECG, with normal levels of cardiac biochemical markers of necrosis. Patients were excluded from the study if they had a ST-segment elevation myocardial infarction or new left bundle branch block, a permanent pacemaker, significant valvular heart disease, prosthetic valve replacement, underwent coronary revascularization within 48 hours of admission or if ECG showed right and left bundle branch block. Information about conventional coronary risk factors was obtained. Diabetes mellitus was defined according to the requirement for treatment with insulin or oral hypoglycemic agents, or a fasting plasma glucose \( \geq 126 \) mg/dl on at least two occasions. Hypertension was defined from the history or an in-hospital systolic blood pressure \( \geq 140 \) mmHg or diastolic blood pressure \( \geq 90 \) mm Hg. Patients were considered to have dyslipidemia if they were receiving lipid-lowering agents or if their total cholesterol during hospitalization was \( \geq 200 \) mg/dl, low-density lipoprotein cholesterol \( \geq 130 \) mg/dl or high-density lipoprotein cholesterol \( < 40 \) mg/dl. Family history of premature coronary artery disease was defined as the presence of coronary artery disease in a first-degree relative for male age < 55 years or female < 65 years.

**Echocardiography**

All patients with NSTEACS underwent comprehensive echocardiography within 48 hours of admission. Echocardiographic examination consisted of two-dimensional, M-mode, conventional Doppler, and TDI measurements. All echocardiographic parameters were reported as the average of the values of at least 3 consecutive beats. The echocardiographers (NC, RA and YS) were blinded to the final diagnosis. LV ejection fraction was determined using the Modified Simpson’s rule (biplane). LV systolic dysfunction was defined as the LV ejection fraction < 40%. LV diastolic function was evaluated by Doppler echocardiography of transmitral flow velocities and TDI of medial mitral annulus. Pulse-wave Doppler study of mitral valve inflow was determined by placing sample volume at the tip of mitral leaflets in the apical 4-chamber view. Peak early (E) and late diastolic velocities of mitral inflow and deceleration time of E were then measured. The TDI determination of diastolic function was performed in apical 4-chamber view with the sample volume at the septal aspect of mitral annulus. Longitudinal early (E’) and late diastolic myocardial velocities were measured. E/E’ ratio was defined as high if E/E’ ratio was > 15, indicating the elevation of LV end-diastolic pressure. Left atrial volume (LAV), indicating the chronicity of diastolic dysfunction, was measured using the area-length biplane method. LA enlargement was defined as LAV index \( \geq 32 \) ml/M².

**Statistical Analysis**

Categorical variables were summarized as percent (%) of patients, and continuous variables as mean \( \pm \) standard deviation. Comparison between groups was based on the independent sample t-test and the Mann-Whitney U test for continuous variables and Pearson’s Chi-square test for categorical variables. Data were analyzed using SPSS for Windows (Version 11.5, SPSS Inc., Chicago, Illinois, USA). A p-value < 0.05 was considered statistically significant.

**Results**

There were 121 patients with NSTEACS enrolled in the study. NSTEMI and UA were diagnosed in 71 (59%) and 50 (41%) patients, respectively. The mean age was 68.6 \( \pm 11.3 \) years and 45% were male gender. Cardiovascular risk factors were described as hypertension in 85%, dyslipidemia in 67%, diabetes mellitus in 64%, smoking in 11% and family history of premature coronary artery disease in 2% of patients. Prior myocardial infarction and coronary revascularization were reported in 21% and 25% of patients, respectively. Dyspnea at presentation and/or clinical heart failure (Killip class \( \geq 1 \)) was presented in 61% of patients. Clinical characteristics (such as age, gender, cardiovascular risk factors, prior myocardial infarction and revascularization, medication) were not
significantly different between patients with NSTEMI and UA (Table 1).

**Echocardiographic Findings**

The mean LV ejection fraction was 55.2 ± 14.6%. LV systolic dysfunction and regional wall motion abnormalities were present in 17% and 62% of patients, respectively. LV systolic dysfunction was more prevalent in patients with NSTEMI than in those with UA (22.5% and 8.0% of patients, respectively, p = 0.03). Patients with NSTEMI had lower LV ejection fraction than those with UA (51.8 ± 14.9% vs. 60.2 ± 12.9%, p = 0.002). Diastolic function was categorized as normal, grade 1 = abnormal relaxation, grade 2 = pseudonormalization pattern and grade 3 = restrictive filling pattern in 5%, 67%, 22% and 6% of patients, respectively. High E/E’ ratio, indicating the elevation of LV end-diastolic pressure, was found in 66% of patients. The mean LAV and LAV index were 64.4 ± 20.8 ml and 39.8 ± 13.0 ml/M², respectively. LA enlargement was detected in 71% of patients. Diastolic dysfunction was more frequent and more severe in patients with NSTEMI than in those with UA as shown in Table 2. Furthermore, most of parameters showing diastolic dysfunction (E’, E/E’ and deceleration time) remained more severe in patients with NSTEMI after adjusted for LV ejection fraction (p < 0.001).

**Discussion**

The present study shows the differences in the echocardiographic findings among the subgroups of patients with NSTEACS. The echocardiographic characteristics in patients with NSTEMI and UA were significantly different both in term of frequency and severity of LV systolic and diastolic dysfunction.

Among the subgroups of patients with NSTEACS, patients with NSTEMI represent the more severe form of the underlying coronary artery occlusion and myocardial injury than those with UA. This may lead to a variety of clinical and laboratory findings. Previous studies have shown several parameters used to risk stratify patients with NSTEACS, such as clinical, ECG, cardiac biomarkers, echocardiographic and angiographic characteristics.

### Table 1. Baseline characteristics of patients with NSTEMI and UA

<table>
<thead>
<tr>
<th></th>
<th>NSTEMI</th>
<th>UA</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>69.1 ± 10.6</td>
<td>67.8 ± 12.4</td>
<td>0.87</td>
</tr>
<tr>
<td>Male gender</td>
<td>34 (47.9%)</td>
<td>21 (42.0%)</td>
<td>0.52</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>48 (67.6%)</td>
<td>29 (58.0%)</td>
<td>0.28</td>
</tr>
<tr>
<td>Hypertension</td>
<td>61 (85.9%)</td>
<td>42 (84.0%)</td>
<td>0.77</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>47 (66.2%)</td>
<td>34 (68.0%)</td>
<td>0.84</td>
</tr>
<tr>
<td>Smoking</td>
<td>10 (14.1%)</td>
<td>3 (6.0%)</td>
<td>0.16</td>
</tr>
<tr>
<td>Prior myocardial infarction</td>
<td>17 (23.9%)</td>
<td>8 (16.0%)</td>
<td>0.29</td>
</tr>
<tr>
<td>Prior revascularization</td>
<td>16 (22.5%)</td>
<td>14 (28.0%)</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± standard deviation and the number (%) of patients

### Table 2. Indices of diastolic function in patients with NSTEMI and UA

<table>
<thead>
<tr>
<th></th>
<th>NSTEMI</th>
<th>UA</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>E (cm/s)</td>
<td>100.3 ± 11.8</td>
<td>74.6 ± 14.3</td>
<td>0.03</td>
</tr>
<tr>
<td>E’ (cm/s)*</td>
<td>3.0 (1.0, 15.0)</td>
<td>4.5 (1.0, 18.0)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>E/E’ ratio*</td>
<td>22.6 (5.7, 68.7)</td>
<td>15.0 (3.1, 49.0)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>E/E’ ratio &gt; 15</td>
<td>56 (80)</td>
<td>25 (52)</td>
<td>0.001</td>
</tr>
<tr>
<td>DT (ms)</td>
<td>201.2 ± 90.8</td>
<td>245.2 ± 87.0</td>
<td>0.006</td>
</tr>
<tr>
<td>LAV (ml)</td>
<td>67.3 ± 20.4</td>
<td>60.2 ± 20.8</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± standard deviation, median (min, max) and the number (%) of patients. * Compare median using the Mann-Whitney U test. DT = deceleration time, E = early transmural flow velocity, E’ = early diastolic septal mitral annulus velocity, LAV = left atrial volume.
TIMI risk score is one of the examples for risk stratification among patients with NSTEACS, using the combination of various parameters, such as clinical setting, ST-segment deviation and cardiac marker, to categorize the risk of death and ischemic events.

In the setting of acute coronary syndrome, echocardiography is of paramount importance in the diagnosis and prognostication. Losses of myocardial contractile function/tissue and changes in ventricular geometry have been described in the setting of acute coronary syndrome. These abnormalities can modify LV systolic and diastolic function and furthermore, affect the clinical course. LV systolic dysfunction contributes to impaired LV pump function and leads to mortality and morbidity after acute myocardial infarction (AMI). Furthermore, LV diastolic dysfunction after AMI contributes to symptoms and disability associated with heart failure and even death. LV systolic function has long been a classic echocardiographic characteristic in determining the prognosis after AMI. Several previous studies showed that LV systolic dysfunction strongly predicted adverse clinical outcomes, such as mortality and heart failure, after AMI. Most of such studies were conducted in patients with AMI and the majority was from patients with ST-segment elevation myocardial infarction. Information from the present study is unique in that it was obtained specifically from patients with NSTEACS, which includes both underlying pathology of myocardial infarction (represented by patients with NSTEMI) and myocardial ischemia (represented by patients with UA). The results showed that LV systolic dysfunction and the more advanced LV diastolic dysfunction were more prevalent in patients with NSTEMI than those with UA, which may reflect the severity of underlying acute coronary pathology and extent of myocardial injury.

Diastolic dysfunction occurs early after acute coronary artery occlusion with or without LV systolic dysfunction. Several diastolic parameters assessed by transthoracic echocardiography have also been shown to be strong prognostic indicators after AMI. LV diastolic dysfunction contributes to signs and symptoms of heart failure and mortality after AMI, regardless of LV systolic function. Data from previous studies showed that the more severe the diastolic dysfunction the worse the prognosis after AMI. Therefore, an appropriate treatment to lessen the severity of diastolic function should improve the clinical outcomes after AMI. E/E' ratio, Doppler-derived deceleration time and LAV have reflected the severity of diastolic function. E/E' has been shown to be the most accurate non-invasive predictor of elevated LV filling pressure and pulmonary capillary wedge pressure and high E/E' was associated with adverse outcomes and worse survival after AMI. Short deceleration time has also been reported to be an important prognostic value after AMI and correlated with the well-documented prognostic value of clinical indicators of LV filling pressures, such as Killip class. Previous study has found that myocardial ischemia resulted in significant LA dilation, depressed LA systolic function, and altered LA diastolic stiffness. LAV has been described as an important predictor of survival after acute AMI. The present study showed that among patients with NSTEACS, the more severe-group, patients with NSTEMI, presented more frequently with the more advanced LV diastolic dysfunction as described by shorter deceleration time, higher E/E' ratio and larger LAV. The study was exclusively conducted in patients with NSTEACS to echocardiographically differentiate those with NSTEMI and UA. These findings may have prognostic and therapeutic implications among the subgroup of patients with NSTEACS.

Study Limitations

The echocardiography was performed mostly in the intensive care unit and the in-patient medicine wards, not in the standard echocardiography laboratory and some of them were performed during out-of-office hours. Therefore, data regarding the inter-observer variability were not available.

Conclusion

Data from the present study demonstrate that, among patients with NSTEACS, LV systolic and diastolic dysfunction was more frequent and more severe in patients with NSTEMI that in those with UA. This may therefore assist in the risk stratification and clinical decision-making of patients with NSTEACS.

Potential conflicts of interest

None.

References

2. Hellermann JP, Jacobsen SJ, Redfield MM, Reeder


ผู้ป่วยกล้านแนวท้วงใจตายเฉียบพลันชนิด ST ไม่ยก มีความมิติกิตติในการปิบตัวและคลายตัวของกล้ามเนื้อท้วงใจแบบรุนแรงกว่าผู้ป่วยกล้านแนวท้วงใจขาดเลือดแบบ unstable angina

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ภูมิหลัง: ผู้ป่วยกล้านแนวท้วงใจขาดเลือดเฉียบพลันชนิด ST ไม่ยก (NSTEMACS) มีความหลากหลายในหลายๆด้านได้แก่อาการทางคลินิก คลื่นไฟฟ้าหัวใจ คลื่นไฟฟ้าคลื่นเส้นหัวใจ ผลการตรวจคลื่นเส้นหัวใจ หัวใจทั้งหมด เป็นหลักของการศึกษา เพื่อหาความแตกต่างของตัวแปรที่บ่งชี้การเป็นตัวและคลายตัวของกล้ามเนื้อท้วงใจในกลุ่ม NSTEMACS

วัสดุและวิธีการ: ผู้ป่วย NSTEMACS จำนวน 121 คน (อายุเฉลี่ย 68.6 ปี เพศชายร้อยละ 45) ได้รับการตรวจคลื่นเส้นหัวใจภายใน 48 ชั่วโมง ที่รับเข้าที่โรงพยาบาลศิริราช

ผลการศึกษา: มีผู้ป่วยกล้านแนวท้วงใจขาดเลือดเฉียบพลันชนิด ST ไม่ยก (NSTEMI) ร้อยละ 59 และรู้ว่ากล้านแนวท้วงใจขาดเลือดแบบ unstable angina (UA) ร้อยละ 41 และไม่พบความแตกต่างของข้อมูลพื้นฐานทางคลินิกระหว่าง 2 กลุ่ม ผู้ป่วยกลุ่มน STEMIM มีความเสี่ยงปกติของกล้ามเนื้อท้วงใจบางตำแหน่ง และการเป็นตัวของหัวใจลดลงกว่าปกติมากกว่าในกลุ่ม UA ผู้ป่วยกลุ่มน STEMIM พบความเสี่ยงปกติในการคลายตัวของหัวใจบ่อยและรุนแรงกว่ากลุ่ม UA

สรุป: ผู้ป่วยกลุ่มน STEMIM พบความเสี่ยงปกติในการเป็นตัวและคลายตัวของหัวใจบ่อยและรุนแรงกว่าในกลุ่ม UA ข้อมูลนี้อาจเป็นประโยชน์ในการประเมินความเสี่ยงและการพยากรณ์โรคในกลุ่ม NSTEMACS ได้