INTRODUCTION

Non-Q wave myocardial infarction is characterized by coronary symptoms, elevated cardiac enzyme levels, and ischemic electrocardiographic (ECG) changes without the development of Q waves (1). Although a better initial prognosis, NQMI patients had more frequent infarct extension and reinfarction, resulting in a similar or worse long-term prognosis compared with those with Q wave myocardial infarction (QMI) (2).

The investigators in multiple studies have reported the prognostic value of myocardial perfusion imaging in various patient subsets at short-to intermediate-term follow-up (3).

Myocardial perfusion data can be clinically useful in the evaluation of patients who have had an acute myocardial infarction (MI) with respect to determining infarct size, assessing the degree of myocardial salvage after reperfusion, determining myocardial viability in infarct zones, and detecting perfusion defect severity (4). In coronary artery disease (CAD) and in patients with recent acute MI, myocardial perfusion single photon emission computed tomography (SPECT)
is an effective method for risk stratification (5), diagnosis and prognosis (6). Prognosis of acute MI is also related to the degree of left ventricular dysfunction and extent and severity of CAD (7).

Gated SPECT has been a major breakthrough in the practice of nuclear cardiology, and offers important additional prognostic information over that given by perfusion data alone, the possibility to simultaneously assess both myocardial perfusion and left ventricular ejection fraction (LVEF) and left ventricular volumes (8,9).

The two most powerful predictors of prognosis (total defect size and resting LVEF) can be assessed with a single test with Gated SPECT (4). The widest experience about the prognostic value of the functional parameters derived from Gated SPECT (8).

Technetium 99m (Tc99m) labeled perfusion agents have been introduced into clinical practice to enhance the specificity of SPECT. Methoxyisobutylisonitrile (MIBI) is a lipophilic cation and passes the cell membrane by passive diffusion and also the more favorable physical characteristics of Tc99m imaging with a gamma camera is to obtain better image quality (4).

To our knowledge, no finding of short-term prognostic studies involving rest Gated SPECT imaging are currently available. The purpose of our study is to determine the short-term prognostic value of rest Tc99m–MIBI Gated SPECT findings in patients with NQMI.

**MATERIAL AND METHODS**

**Patient population**
The study group was consisted of 36 patients (21 males and 15 females), mean age 60.3±10.17 years (range: 37–78). The 20 patients had ST segment changes on the electrocardiography (ECG). NQMI was confirmed by elevation enzymatic data. All patients were identified who had undergone rest Gated SPECT within 48 (30.7±2.3) hours of admission to the coronary care unit. The occurrence of 30 days-with in-hospital-cardiac events was considered in risk stratification.

**Acquisition protocol**
Tc99m–MIBI Gated SPECT imaging was performed with a dual–head gamma camera (Marconi Axis 2000 Prism) equipped with a low energy, high resolution collimator (LEHR) and an energy interval of 140±10% keV in a 64x64 matrix. Images were acquired in a 180° orbit with 30s readings every 3°. The R–R interval in the ECG was divided into eight parts. Transverse reconstruction was automatically applied in the quantitative Gated SPECT (QGS) process (ramp filter, 180 filtered BP parallel). In the post–filtering procedure, a low–pass filter order was 5 and the cut–off was 0.21. In the pre–filtering process run before reconstruction in the CEqual analysis (Cedars–Emory quantitative analysis), the low–pass (Butterworth) filter order/cut–off values in rest study was 5/0.25.

**Image analysis**
Short–axis images were processed by using Gated SPECT algorithms with the results obtained from Gated SPECT study by quantitative analysis and left ventricular functional parameters [left ventricular ejection fraction (LVEF), end diastolic volume (EDV) and end systolic volume (ESV)], were calculated. Gated projection data sets were converted to summed non–gated data and vertical long axis, horizontal long axis, and short-axis images were reconstructed by CEqual method. This method is highly reproducible and can be used to interpret temporal changes in myocardial perfusion (10,11).

Semiquantitative visual interpretation of myocardial perfusion images was done by consensus of two experienced readers without knowledge of specific diagnosis or patient’s identity. Myocardial perfusion was scored using a 17 segment model, on a 0 to 4 scale (0: normal perfusion, 1: mild decrease of photon counts, 2: moderate decrease of photon counts, 3: severe decrease of photon counts, 4: absent photon counts) (12). The summed rest score (SRS) was calculated by adding the scores for all segments, for perfusion defect extent (extent score: ES) was also determined by adding the number of abnormal segments.

**Coronary Angiography**
Coronary angiography (CAG) was applied all patients after Gated SPECT study. CAG was performed by Judkin’s technique. The stenosis in the coronary arteries were classified as normal, mild
(50–70%) and severe (70–100%) by two cardiologists according to the coronary flow thrombolysis in myocardial infarction classification.

Medical record review
We assessed clinical risk factors by reviewing the medical record. Clinical variables considered were age, sex, hypertension, diabetes mellitus, dyslipidemia, menopause, smoke, family, ST segment changes and CAG.

The patients were divided into two groups according to their prognosis in which the patients who had new clinical event, were assigned as poor prognosis. And the patients who had well outcome, describe as good prognosis. All clinical data and rest Gated SPECT findings were compared among the two groups (Table 1).

Patient follow-up
Follow–up was obtained for 30 days–in hospital and after discharge–with a mean of 30.65±0.49 days. Telephone interviews were performed, and hospital charts reviewed and primary physicians contacted for confirmation. Cardiac events included reinfarction, revascularization, congestive heart failure and death.

Statistical analysis
All parametric results were expressed as mean ± standard deviation for each group. Shapiro–Wilks test was performed to check the normality of the data before running tests. Comparisons of the between groups subjects were performed using the t test and Mann-whitney U test. Chi–square and Fisher’s Exact test were performed nonparametric results. Relative risk (RR) with 95% confidence intervals (CI) was calculated by logistic regression analysis. The relative risk with the 95% confidence intervals (CI) are presented. A p–value less than 0.05 was considered to be statistically significant.

RESULTS
During the follow-up period (include hospitalization) (30.65±0.49 day), 12 patients (33%) had a new clinical event, (4 congestive heart failure (11%), 7 revascularization (19%), 1 reinfarct (2%) and no death), whereas 24 patients (66%) showed a good outcome. Clinical data and rest Gated SPECT findings in patients with short–term prognosis are shown in Table 1. There were no statistitical differences in age, sex, risk factors, ST segment changes, and CAG result (two or three vessel lesion) between two groups. Creatine Kinase–Myocardial Binding (CK–MB) enzyme levels were significantly
different in two groups (p=0.037) and troponin levels were not different.

There were significant differences in LVEF, EDV, ESV, SRS and ES values between poor and good prognosis group (p=0.011, p=0.016, p=0.017, p<0.001, p<0.001, respectively). The relationships between scintigraphic quantitative parameters (EF, SRS) and cardiac event rate are shown in figures 1 and 2. By univariate analysis, Gated SPECT parameters; Rest LVEF<40% (RR= 7.66, CI 1.60 to 35.90), ESV>70 ml (RR=5.31, CI 1.17 to 24.14), SRS≥7 (RR=7.00, CI 1.25 to 39.14) and ES≥3 (RR=6.59 CI 0.72 to 60.02) were predictors of cardiac events (Table 2).

DISCUSSION

Although left ventricular functions are protected by perfusional alterations in subendocardial area in NQMI patients, the ratio of possible new cardiac events are almost the same (13). Patients with an acute MI may be benefit from simultaneous evaluation of left ventricular function and myocardial perfusion using Gated SPECT imaging because both LVEF and perfusion defect size are prognostically important (14).

LVEF and measurement of left ventricular volumes have important clinical implications for prognosis of patients with cardiac disease (15), and those parameters are powerful independent prognostic variables (16). Multiple studies have shown that resting and exercise LVEF, measured by radionuclide methods, are powerful predictors of cardiac events (17), and have incremental prognostic value in patients with acute MI (18).

But, the functional parameters obtained using a post–stress Gated SPECT can be partly influenced by the presence of post–ischemic stunning and thus should be considered slightly different from a true resting LVEF (8).

The first and most obvious prognostic parameter is the resting LVEF, this parameter has a predictive value for the development of heart failure, cardiac death and hard events in patients with a first non–complicated myocardial infarction (8,18). In this study, rest EF was a most
powerful predictor of all cardiac events, and the patients with congestive heart failure had EF less than 30.

Various investigators have used different LVEF (30%-50%, EF) values for determining risk stratification and prognosis (4,19,20,21). All of these studies were about middle–long term prognosis and risk stratification. We could not found any study in the literature about short-term risk stratification and prognosis on NQMI using rest Tc99m–MIBI GATED SPECT to make a comparison with our findings. We think that our study is a preliminary study that showed the short term prognosis of NQMI patients by performing Tc99m–MIBI Gated SPECT. In our study; new cardiac event rate was 66%, this results in a hazard ratio of 7.6 for patients with a LVEF lower than 40% (CI 1.60 to 35.90).

Other indicators of high risk; increased EDV and ESV in CAD (22). Sharir et al. (17) described; threshold values for ESV: 70 ml and EDV: 120ml for prognosis, and showed that an ESV>70 ml was related to high death rate in patients with mild–to–moderate or severe perfusion defect in CAD. The annual cardiac mortality rate was 10.4 % in patients with a resting end-systolic volume greater than 70 ml, resulting in a hazard ratio of 4.5 (23).

In our study, with the ESV>70 ml and mild–to–severe perfusion defects of patients had no death but new cardiac event rate was 100%, with a hazard ratio of 5.31 (CI 1.17 to 24.14, p=0.027).

If EDV>120 ml is high risk for cardiac death (17), in our study; new cardiac event rate was 50% in the patients with EDV>120 ml.

Hachamovitch et al. (24) showed the enhanced prognostic value of myocardial perfusion imaging. Multiple perfusion abnormalities (large perfusion defect size), multi–vessel disease scan pattern with defects in two or more vascular supply regions, shows high–risk myocardial perfusion scan variables after acute MI (4,6).

Mildly abnormal perfusion studies are associated with a low risk of cardiac death or myocardial infarction, whereas markedly abnormal scans are associated with a high risk of cardiac events (24). Patients with normal images or small defects have a significantly better outcome

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**Table 1. Clinical data, rest Gated SPECT findings and perfusion scores of the both groups**

| Number of cases | Poor Prognosis | Good Prognosis | p value |
|-----------------|----------------|----------------|---------|
| Age (years)     | 58.3±11.6      | 61.2±9.9       | ns      |
| Sex (m/f)       | (8/4)          | (13/11)        | ns      |
| Risk factors    |                |                |         |
| Hypertension    | 8(66)          | 12(50)         | ns      |
| Diabetes mellitus | 4(33)        | 7(29)          | ns      |
| Dyslipidemia    | 4(33)          | 10(41)         | ns      |
| Menopause       | 3(25)          | 7(29)          | ns      |
| Smoke           | 7(58)          | 8(33)          | ns      |
| Family          | 2(16)          | 5(20)          | ns      |
| ST segment changes | 9(75)        | 11(45)         | ns      |
| KAG             |                |                |         |
| Three vessel lesion | 6(50)      | 10(42)         | ns      |
| Two and less vessel lesion | 6(50) | 14(58) | ns |
| Enzymes         |                |                |         |
| CK-MB           | 164.3±168.2    | 81.4±97.6      | 0.037   |
| Troponin        | 2.1±3.3        | 0.6±0.7        | ns      |
| Rest Gated Parameters |            |                |         |
| LVEF            | 35.9±14.5      | 46.7±10.0      | 0.011   |
| EDV             | 137.2±56.6     | 100.8±47.7     | 0.016   |
| ESV             | 98.3±59.9      | 56.3±36.3      | 0.017   |
| Perfusion Scores |            |                |         |
| SRS             | 12.7±3.1       | 7.8±3.8        | <0.001  |
| ES              | 6.0±4.9        | 2.9±1.2        | <0.001  |

ns: non-significant
than patients with abnormal images or large defects (14). Iskandrian et al. (25) found that the total number of myocardial perfusion defects was the single best predictor of subsequent event, and both extent and severity of hypoperfusion were exponentially correlated with event rate. Similar in our study; increased severity and extent of perfusion defect caused increased cardiac event rate.

Sharir et al. (26) the prediction of cardiac death demonstrated that the most powerful predictor was the SRS in randomize patients who had myocardial perfusion SPECT. In a study; the value of SRS was higher at cardiac death compared to MI at the patient who had SPECT study (24).

Douglas et al. (27) stated that cardiac event rate is higher in patients with perfusion defect score over 7. In our study, the patients, whose SRS was greater than 7, had a 50% cardiac event and relative risk was 7.00 with CI 1.25 to 39.14 in 30 days, and severity and extent of perfusion defect were a predictor for new cardiac event, SRS was more predictive than ES. As another word, increased the severity of perfusion defect, increased the probability of new cardiac events for NQMI in 30 days.

According to Sharir et al. (17); the perfusion data were superior to function in predicting total events, whereas function data were superior to perfusion in predicting cardiac death. The greater impact of perfusion compared with function information on early referral for revascularization and on the crossover of patients from medical to revascularization treatment may account for the higher prognostic power of EF and ESV in the prediction of cardiac death compared with perfusion information, because patients with significant perfusion abnormalities are referred for aggressive treatment. Further incorporation of Gated SPECT data (EF and ESV) into the decision process of referral for revascularization may result in a reduction of the cardiac death rate (17).

The event rate increased with decreased EF and with increased ESV, SRS and ES (18). In our study, LVEF<40%, increased EDV, ESV, SRS and ES were related high cardiac event. The prognostic value of the resting LVEF and ESV had a higher predictive value for all cardiac event than SRS and ES (p=0.005, p=0.027, p=0.032, p=0.037, respectively).

Patients with EF<40% / resting perfusion defects / increased EDV and ESV, have a higher risk of multivessel CAD and have worse clinical outcomes (6). The event rate increased with decreasing values of EF and with increasing values of rest perfusion and ischemic scores (18). In our study; cardiac event rate was increased in these patients, but cardiac event rate of the patient with three vessel lesions was more less than the patients with two or more less vessel lesion on CAG.

The presence of ST segment changes

| Characteristic            | Patients n % | Events n % | p value | Relative Risk (95%CI) |
|---------------------------|--------------|------------|---------|-----------------------|
| Hypertension              | 20(55)       | 8(40)      | ns      | 2.00 (0.47–8.46)      |
| Diabetes mellitus         | 11(30)       | 4(36)      | ns      | 1.21 (0.27–5.37)      |
| Dyslipidemia              | 14(38)       | 4(28)      | ns      | 0.57 (0.16–2.98)      |
| Menopause                 | 10(27)       | 3(30)      | ns      | 1.00 (0.23–4.34)      |
| Smoke                     | 15(41)       | 7(46)      | ns      | 2.00 (0.66–12.77)     |
| Family                    | 7(19)        | 2(28)      | ns      | 0.58 (0.08–2.80)      |
| ST segment changes        | 20(55)       | 9(45)      | ns      | 3.54 (0.79–16.4)      |
| Rest LVEF <40             | 13(36)       | 8(66)      | 0.005   | 7.60 (1.60–35.90)     |
| ESV >70 ml                | 12(33)       | 7(58)      | 0.027   | 5.31 (1.17–24.14)     |
| EDV >120 ml               | 10(27)       | 5(50)      | ns      | 2.71(0.59–12.31)      |
| SRS ≥7                    | 20(55)       | 10(50)     | 0.032   | 7.00 (1.25–39.14)     |
| ES ≥3                     | 26(72)       | 11(42)     | 0.037   | 6.59 (0.72–60.02)     |

ns: non-significant
and elevations of troponin and CK–MB are objective correlates of adverse short–and long–term prognosis with NQMI (28). In our study, in 45% of patients with ST segment alteration had new cardiac event and the patients with higher levels of CK-MB had poor short term prognosis.

Study Limitations; The use of left ventricular ejection fraction measurement as a predictor of outcome in the very early acute phase of myocardial infarction has some limitations. Some patients may demonstrate substantial hyperkinesis of the normally perfused zone, which influences global performance to some degree. This may falsely rise the left ventricular ejection fraction. However, large scale study is needed for obtaining reliable outcomes for determination of short–term prognosis in patients with NQMI.

In conclusion, the main findings from the our study; left ventricular parameters (EF, ESV) and perfusion scores (SRS, ES) which obtained by rest Tc99m–MIBI Gated SPECT, provide useful information for short–term prognosis after NQMI in 30 days. This study demonstrates poor prognosis related decreased LVEF, increased ESV, SRS and ES. The prognostic value of the resting LVEF and ESV had a higher predictive value for all cardiac event than either perfusion SPECT or clinical parameters, and SRS and ES nearly these parameters.

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REFERENCES

1. Phibbs B. “Transmural” versus “subendocardial” myocardial infarction: An electrocardiographic myth. J Am Coll Cardiol 1983;1:561–4
2. Goodman SG, Langer A, Ross AM, et al. Non–Q wave versus Q wave myocardial infarction after thrombolytic therapy angiographic and prognostic insights from the Global Utilization of Streptokinase and Tissue Plasminogen Activator for Occluded Coronary Arteries–I Angiographic Substudy. Circulation 1998;97:444–50
3. Schinkel AFL, Elhendy A, van Domburg RT, et al. Long-term prognostic value of dobutamine stres 99mTc-Seastamibi SPECT: Single-Center Experience with 8-year Follow-up. Radiology 2002;225:701–6
4. Beller GA, Zaret BL. Contributions of nuclear cardiology to diagnosis and prognosis of patients with coronary artery disease. Circulation 2000;101:1465–78
5. Zellweger MJ, Dubois EA, Lai S, et al. Risk stratification in patients with remote prior myocardial infarction using rest-stress myocardial perfusion SPECT: Prognostic value and impact on referral to early catheterization. J Nucl Cardiol 2002;9:23–32
6. Clark AN, Beller GA. The present role of nuclear cardiology in clinical practice. Q J Nucl Med Mol Imaging 2005;49:43–58
7. De Feyter PJ, van Eenige MJ, Dighton DH, Visser FC, de Jong J, Roos JP. Prognostic value of exercise testing, coronary angiography and left ventriculography 6–8 weeks after myocardial infarction. Circulation 1982;66:527–36
8. Sciagra R, Leoncini M. Gated single-photon emission computed tomography The present–day “one-stop-shop” for cardiac imaging. Q J Nucl Med 2005;49:19–29
9. Germano G, Kiat H, Kavanagh PB, et al. Automatic quantification of ejection fraction from gated myocardial perfusion SPECT. J Nucl Med 1995;36:2138–48
10. Garcia EV, Cooke CD, Van Train KF, et al. Technical aspects of myocardial SPECT imaging with technetium-99m sestamibi. Am J Cardiol 1990;66:23E–31E
11. Berman DS, Kiat H, Van Train K, Garcia E, Friedman J, Maddahi J. Technetium 99m sestamibi in the assessment of chronic coronary artery disease. Semin Nucl Med 1991;21:190–212
12. Levine MG, Ahlberg AW, Mann A, et al. Comparison of exercise, dipyridamole, adenosine, and dobutamine stress with the use of Tc-99m tetrofosmin tomographic imaging. J Nucl Cardiol 1999;6:389–96
13. Gibson RS. Non-Q wave myocardial infarction: diagnosis, prognosis, and management. Curr Probl Cardiol 1988;13:1–72
14. Iskander S, Iskandrian AE. Risk assessment using single-photon emission computed tomographic technetium-99m sestamibi imaging. J Am Coll Cardiol 1998;32:57–62
15. Daou D, Harel F, Helal BO, et al. Electrocardiographically gated blood-pool SPECT and left ventricular function: comparative value of 3 methods for ejection fraction and volume estimation. J Nucl Med 2001;42:1043–9
16. Go V, Bhatt MR, Hendel RC. The diagnostic and prognostic value of ECG-gated SPECT myocardial perfusion imaging. J Nucl Med
17. Sharir T, Germano G, Kavanagh PB, et al. Incremental prognostic value of post-stress left ventricular ejection fraction and volume by gated myocardial perfusion single photon emission computed tomography. Circulation 1999;100:1035–42
18. Hashimoto J, Suzuki T, Nakahara T, Kosuda S, Kubo A. Preoperative risk stratification using stress myocardial perfusion scintigraphy with electrocardiographic gating. J Nucl Med 2003;44:385–90
19. Cacciabaudo JM, Szulc M. Gated cardiac SPECT: has the addition of function to perfusion strengthened the value of myocardial perfusion imaging? J Nucl Med 2001;42:1050–2
20. Sharir T, Germano G, Kang X, et al. Prediction of myocardial infarction versus cardiac death by gated myocardial perfusion SPECT: risk stratification by the amount of stress-induced ischemia and the poststress ejection fraction. J Nucl Med 2001;42:831–7
21. Kroll D, Farah W, McKendall GR, Reinert SE, Johnson LL. Prognostic Value of Stress-Gated Tc-99m Sestamibi SPECT After Acute Myocardial Infarction. Am J Cardiol 2001;87:381–6
22. McLaughlin MG, Danias PG. Transient ischemic dilation: a powerful diagnostic and prognostic finding of stress myocardial perfusion imaging. J Nucl Cardiol 2002;9:663–7
23. De Winter O, Velghe A, Van de Veire N, et al. Incremental prognostic value of combined perfusion and function assessment during myocardial gated SPECT in patients aged 75 years or older. J Nucl Cardiol 2005;12:662–70
24. Hachamovitch R, Berman DS, Shaw LJ, et al. Incremental prognostic value of myocardial perfusion single photon emission computed tomography for the prediction of cardiac death: differential stratification for risk of cardiac death and myocardial infarction. Circulation 1998;97:535–43
25. Iskandrian AS, Hakki AH, Kane-Marsch S. Prognostic implications of exercise thallium–201 scintigraphy in patients with suspected or known coronary artery disease. Am Heart J 1985;110:135–43
26. Sharir T, Berman DS, Lewin HC, et al. Incremental prognostic value of rest-redistribution 201TI single-photon emission computed tomography. Circulation 1999;100:1964–70
27. Kroll D, Farah W, McKendall GR, Reinert SE, Johnson LL. Prognostic value of stress-gated Tc-99m sestamibi SPECT after acute myocardial infarction. Am J Cardiol 2001;87:381–6
28. Mathis AS, Meswani P, Spinler SA. Risk stratification in non-ST segment elevation acute coronary syndromes with special focus on recent guidelines. Pharmacotherapy 2001;21:954–87