Correlation between Wall Motion Score Index (WMSI) and Anatomical M-mode (AAM) Systolic Thickening with Functional Capacity in Heart Failure among Post-myocardial Infarction Patients

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Abstract. Exercise capacity among cardiac patients is not sufficiently predicted using left ventricular ejection fraction resting measurement. The echocardiographic measurement using Wall Motion Score Index (WMSI) and Anatomical M-mode (AAM) Systolic Thickening post-myocardial infarction was studied to determine its correlation with functional capacity. We conducted a cross-sectional study of 33 consecutive post-MI patients. The inclusion criteria included heart failure patients with NYHA class I-II visiting the cardiology outpatient clinic of Soetomo Hospital, Surabaya. A resting echocardiogram, measuring WSMI and AMM systolic thickening of basal and mid-LV segments, was taken. The patients underwent a treadmill stress test using the Naughton protocol on the same day of their echocardiography examination. Samples were then analyzed using SPSS 2.0. Study subjects were 69.7% males with age 58.45±6.2 years old and BMI 24.07±3.2 kg/m². The proportion of hypertension was 60.6%, smoking 51.5%, diabetes mellitus 42.4%, and dyslipidemia 42.4%. WMSI was 1.68±0.45, mean AMM systolic thickening 39±13%, and exercise capacity 3.69±1.8 METs. There was a moderate negative correlation of WMSI and a moderate positive correlation of AMM systolic thickening with functional capacity (r = –0.466, r = 0.415 consecutively; p<0.05). WMSI and AMM systolic thickening were correlated with functional capacity in post-MI patients with heart failure.

1. Introduction
Coronary heart disease (CHD) is one of the leading causes of disability and deaths worldwide [1]. Based on Indonesia’s Health Profile 2009, CHD is the most significant cause of death that represents approximately 11% of all deaths in hospitals in 2008 [2]. Myocardial infarction is defined as myocardial damage that is associated with reduced left ventricular contractility and chamber filling performance (left ventricular, LV). Left ventricular systolic dysfunction is a commonly recognized cause of post-myocardial infarction heart failure [3]. Large scale clinical studies reported that 40% of myocardial infarction patients would develop left ventricular systolic dysfunction at some point. These studies showed that Functional Deterioration is a joint presentation of post-myocardial infarction condition [4,5]. Systolic function is traditionally assessed by volume fraction ejected in systole called
Left Ventricle Ejection Fraction (LVEF) or by dynamic visual assessment semi-quantitative of LV chamber called Wall Motion Score Index [6].

WMSI is a total score of each segment based on systolic and thickening wall motion, divided with visual estimation of the total segment. Total calculation score was associated with the severity of necrosis [7]. WMSI ≥ 1.3 reflected a significant infarct size of more than 12% [14]. WMSI has higher accuracy, reproducibility, and feasibility than ejection fraction (EF) for the evaluation of global functions. WMSI strongly correlates with the assessment of LV systolic function and the infarct size. WMSI could be an essential non-invasive assessment tool for regional and global function after myocardial infarction [7–9].

Anatomical M-mode (AMM) is another approach to assess regional LV function. The difference with WMSI, AMM technique is based on post-processing of digitally acquired two-dimensional (2D) cine loops that allow quantitative evaluation of wall motion and wall thickening in various cardiac segments. This quantitative technique has the potential to improve assessment of left ventricular wall motion and thickening and could be particularly useful for qualitative assessment of wall motion abnormality [10].

Impaired functional capacity in patients with myocardial infarction and/or heart failure is associated with reliable and consistent markers for mortality. Functional capacity is an essential parameter of cardiac rehabilitation programs for patients after myocardial infarction. Normal or near-normal functional capacity describes normal LV functions based on various studies that showed a close linear correlation between maximum oxygen consumption and maximal cardiac output [10]. Unfortunately, some of the previous studies failed to show a good correlation between LV systolic function parameters, such as EF, with functional capacity. Therefore, researchers are interested in examining WMSI and AMM systolic thickening, which are believed to be excellent parameters to describe LV function in post-MI patients and its relation to functional capacity.

2. Methods

This analytic observational study used a cross-sectional design to estimate the correlation between WMSI and AMM systolic thickening with functional capacity in post-myocardial infarction patients with heart failure. The study was conducted in the cardiology outpatient clinic and echocardiography laboratory that was located in Soetomo General Hospital, Surabaya, Indonesia, between September to December 2014. Population sampling was obtained by consecutive sample. The inclusion criteria were male or female, aged ≥45 years with a history of previous myocardial infarction (3 months post-myocardial infarction or more) with New York Heart Association (NYHA) functional class I-II that were willing to participate and sign the consent form.

Exclusion criteria were patients with NYHA functional class III-IV, inability to walk or run without assistance, have a contraindication to exercise test, history of prior coronary syndrome within 3 months since the study began, electrocardiographic (ECG) recording showing atrial fibrillation (AF), severe mitral regurgitation, right ventricular involvement MI, permanent pacemakers user, Chronic Obstructive Pulmonary Disease (COPD) history, or obesity. The patients who had an abnormal anatomy pattern from echocardiography and who were terminated from the stress test due to relative and absolute indication were considered as drop outs in this study.

Patients who met our inclusion criteria were then evaluated using electrocardiography, echocardiography, and stress test (treadmill test). Left ventricular function was measured using GE Medical System Vivid 7 pro Class I CF type echocardiography. The parameter used in this study consisted of WMSI and AMM systolic thickening.

Functional capacity was measured using a treadmill stress test on the same day echocardiography was performed. The Naughton protocol with the symptom-limited target was used in this study. The termination criteria were described as an incapability to do a further test (evaluated using the Borg scale), age-related maximal heart rate was reached, and
indicative symptoms were found. Functional capacity was measured using the maximal metabolic equivalent (METs) reached during the examination.

Samples were then analyzed using the SPSS 20.0 program. A normality test was performed using Kolmogorov-Smirnov. It would be claimed as a normal distribution if the level of significance is > 0.05. The Pearson statistical test was used to analyze the correlation between WMSI and AMM systolic thickening with functional capacity. The results were stated as statistically significant if the p-value < 0.05.

3. Results

3.1. Baseline characteristics of subjects

The subject of this study consisted of 23 (69.7%) men and 10 (30.3%) women. The average age of subjects was 58.45 ± 6.2 years, with the average onset of myocardial infarction was 9.45 ± 5.3 from the previous month. The average Body Mass Index (BMI) of patient’s study was 24.07 ± 3.2 kg/m² implies a category of overweight, but the average systolic and diastolic blood pressure was 134.85 ± 17.3 mmHg and 84.39 ± 9.7 mmHg refers to normal limits. The study confirms that hypertension is the most common modified risk factor (60.6%), followed by smoking (51.5%), and dyslipidemia (42.4%). NYHA class II has the highest proportion of cardiac decompensation (63.6%). Although nearly half of participants suffered dyslipidemia, the average cholesterol (188.48 ± 42.6 mg/dl) and triglyceride levels (132.73 ± 61.7 mg/dl) were still within the normal range. High-Density Lipoprotein (HDL) and Low-Density Lipoprotein (LDL) level, which fall outside the normal range, were 40.73 ± 10.7 mg/dl and 117.6 ± 31.3 mg/dl, respectively. The mean functional capacity of the subjects decreased to 3.69 ± 1.8 MET (Table 1).

Table 1. Baseline characteristics of the subject (n=33)

| Variable                              | n (%) or average ± SD |
|---------------------------------------|-----------------------|
| Age (years)                           | 58.45 ± 6.2           |
| Myocardial infarction (MI) disease duration (month) | 9.45 ± 5.3          |
| BMI (kg/m²)                           | 24.07 ± 3.2           |
| Systolic Blood Pressure (mmHg)        | 134.85 ± 17.3         |
| Diastolic blood pressure (mmHg)       | 84.39 ± 9.7           |
| Heart rate (beats a minute)           | 76.76 ± 13.9          |
| Male                                  | 23 (69.7)             |
| Type II Diabetes                      | 14 (42.4)             |
| Hypertension                          | 20 (60.6)             |
| Dyslipidemia                          | 14 (42.4)             |
| Smoking                               | 17 (51.5)             |
| NYHA class II                         | 21 (63.6)             |
| Total cholesterol level (mg/dl)       | 188.48 ± 42.6         |
| Total triglycerides level (mg/dl)     | 132.73 ± 61.7         |
| Total HDL level (mg/dl)               | 40.73 ± 10.7          |
| Total LDL level (mg/dl)               | 117.6 ± 31.3          |
| Functional capacity (MET)             | 3.69 ± 1.8            |

3.2. Echocardiographic parameters of left ventricular systolic function

Table 2. Echocardiographic parameters of research subjects (n=33)

| Variable                              | Average ± SD |
|---------------------------------------|--------------|
| WMSI                                  | 1.68 ± 0.45  |
| LV segmental AMM systolic thickening at basal level (%) |               |
Table 2 shows the echocardiographic parameters which were used to assess the systolic function of LV study subjects descriptively. The mean wall motion score index (WMSI) and AMM systolic thickening were 1.68 ± 0.45 and 39 ± 13% respectively.

3.3. Correlation analysis between echocardiographic parameters of left ventricular systolic function with functional capacity

| Variable                  | Average ± SB (Min – Max) | p     | r      |
|---------------------------|--------------------------|-------|--------|
| WMSI                      | 1.68 ± 0.45 (1.13 – 2.69) | 0.006 | -0.466 |
| AMM systolic thickening   | 39 ± 13 (14 – 66)        | 0.016 | 0.415  |
| Functional capacity (MET) | 3.69 ± 1.8 (1.07 – 8.4)  |       |        |

There was a significant negative correlation between WMSI and functional capacity (p <0.05, r = -0.466), which means a higher WMSI value was associated with lower functional capacity. This study also showed a moderate positive correlation between AMM systolic thickening and functional capacity (p <0.05, r = 0.415) which means the higher AMM systolic thickening was associated with higher functional capacity (Table 3).

4. Discussion

A majority of subjects were male (69.7%). The average age of subjects was 58.45 ± 6.2 years. Baseline characteristics in this study were consistent with previous literature, which showed that men of an advanced age have higher CHD risk. Individuals who are older than 45 years have eight times greater risk for AMI, and less than 10% of the population under the age of 45 years would have AMI [11].

Other traditional risk factors were found in the study subjects. The highest risk factor was hypertension in 60 subjects (60.6%). A study from 939 patients by Ciruzzi et al., reported that hypertension was an independent and strong risk factor for the occurrence of AMI [12].

GISSI 2 and GUSTO I studies have demonstrated that the incidence of acute coronary thrombosis was higher in diabetic patients than non-diabetic patients. Furthermore, the issue of lipid abnormalities such as the role of elevated triglycerides, LDL level, and also low HDL levels, is associated with an increase in cardiovascular events. Dyslipidemia and diabetes were both found in 14 subjects (42.4%). Smoking is a significant risk factor for atherosclerosis. As much as 17 patients (51.5%) of our subjects were active smokers. A study published by Khot et al. showed that active smokers developed CHD earlier than in non-smokers [12].
Previous studies have suggested that measurements of left ventricular systolic function such as ejection fraction (EF) at rest showed a weak correlation with symptoms and functional capacity [10,13–17]. In this study, we examined the echocardiographic correlation parameters of left ventricular systolic function, including the assessment of WMSI and which meant AMM systolic thickening between functional capacity in post-acute myocardial infarction heart failure patients. This parameter is believed to provide a more precise parameter of LV systolic function in post-MI patients. Evaluation of post-MI patient by echocardiography is the most commonly used tool in daily clinical practice.

Prognosis of post-MI patients depends on several factors, including the extent of the infarct and the function of left ventricular. WMSI proved to have an excellent correlation between both factors. WMSI was derived as the sum of all scores of thickening and systolic motion of each LV segment divided by the number of segments visualized. WMSI is a better echocardiographic parameter to identify in patients with extensive infarction earlier so that it may benefit from early therapy. WMSI shows semi-quantitative data that has been shown to have a good correlation with LVEF. The study by Duncan et al. concluded that WMSI-derived LVEF seems to be a better technique for evaluating LVEF than LVEF from Simpson's biplane method [18,19].

The mean value of WMSI in this study was 1.68 ± 0.45. Our result demonstrated a significantly higher cut-off value than previous literature to distinguish small infarcts with large infarct [20,21]. Cut-off value was 1.14 in the study conducted by Thorstensen and 1.3 in the study conducted by Eek et al. WMSI in our study showed a higher result compared to a result of 1.22 ± 0.36 in the D’Andrea et al. study [8,21,22], but was still similar with 1.67 in the Carluccio et al. study for predictors of cardiac events (death, unstable angina, non-fatal reinfarction and congestive heart failure) [23]. Based on WMSI data obtained, the average subject in this study experienced a large estimated infarct area. Based on WMSI data obtained, it was estimated that the majority of subjects had large infarct.

Several studies showed a good correlation between the quantitative measurements of systolic thickening using the AMM technique with the qualitative assessment of wall motion abnormalities [11]. That the results were consistent with our reports demonstrated that there was a robust correlation between WMSI and systolic thickening using the AMM technique (p <0.05; with r = -0.932). Marwick et al. stated that the normal range of AMM systolic thickening is challenging to determine because of the thickening variation at baseline [11].

In this study, both WMSI and the mean AMM systolic thickening showed a significant correlation with the functional capacity of post-acute myocardial infarction heart failure (p <0.05; with r = -0.466 and 0.415 respectively). WMSI shows a negative correlation, if the value of WMSI increases, the value of LV systolic function and functional capacity decreases. The mean AMM systolic thickening has a positive correlation with functional capacity, which implies that if the average AMM systolic thickening decreases, LV systolic function, and functional capacity will deteriorate. This finding was similar to Urek et al. in which the result showed that WMSI was strongly correlated with exercise duration in uncomplicated post-MI patients [24]. Therefore patients with mildly impaired contractility function had a higher functional capacity and longer exercise duration [25].

Based on this study, higher WMSI in post-MI patients who have had myocardial necrosis/disturbance showed decreased LV contractility function. Therefore, in this subject group, there will be a decrease in functional capacity. The mean functional capacity of the subjects in this study was 3.69 ± 1.8 MET. Decreases in mean functional capacity in this study were correlated with mean of massive infarction among subjects (mean WMSI 1.68 ± 0.45). In post-MI, MET level or exercise duration achieved is a powerful predictor of future adverse cardiac events which are commonly used a marker for increased risk if there is a failure to achieve 5 METs during treadmill exercise [20].

The most accurate assessment of functional capacity should be done by directly measuring VO2 max or maximal oxygen consumption. The limitation of our study was the VO2 max measurement tool, which was unavailable in our center. Assessment and control of variables that may
influence echocardiographic parameters of the left ventricle were age, gender, risk control, adjustment of therapy and presence or absence of revascularization, which were not done to rule out possible confounding factors.

5. Conclusion
The study aimed to analyze the correlation between a left ventricular systolic function with functional capacity in patients after myocardial infarction with heart failure. In conclusion, there was a significant negative correlation between the wall motion score index and functional capacity but a significant positive correlation between AMM systolic thickening and functional capacity in patients after myocardial infarction with heart failure.

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