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[Martiola Kola](#)*, Naltin Shuka, [Harvey Pendell Meyers](#), [Elizana Zaimi \(Petrela\)](#), [Stephen W. Smith](#)

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Article

OMI/NOMI: Time for a New Classification of Acute Myocardial Infarction

Martiola Kola ^{1,*}, Naltin Shuka ², Harvey Pendell Meyers ³, Elizana Zaimi (Petrela) ⁴, and Stephen W. Smith ⁵

¹ Cardiology, University Hospital Center Mother Teresa, Tirana, ALB

² Cardiovascular Medicine, University Hospital Center Mother Teresa, Tirana, ALB; naltinshuka@yahoo.com

³ Emergency Medicine, Carolinas Medical Center, NC, USA; pendellmeyers@gmail.com

⁴ Public Health, Faculty of Medicine, University of Medicine, Tirana, ALB; elapetrela@yahoo.com

⁵ Emergency Medicine, Hennepin Healthcare, Minneapolis, USA; smith253@gmail.com

* Correspondence: martiola.kola@gmail.com

Abstract: Forty percent of patients with acute coronary occlusion myocardial infarction (OMI) do not present with STEMI criteria, which delays their treatment and increases morbidity and mortality. The need to identify these patients promptly is crucial, and this sets the stage for the proposed reclassification. Many of these patients can be identified by other ECG and clinical features. **Background/Objectives:** We sought to evaluate STEMI/NSTEMI cases that result in OMI and the consequences of delayed revascularization immediately among NSTEMI patients who have ACO (NSTEMI-OMI). **Methods:** The study is a retrospective analysis conducted on 334 patients who underwent coronary angiography for acute coronary syndrome at UHC "Mother Teresa," Tirana, Albania, during January-May 2023. OMI was defined as an acute culprit lesion with TIMI 0-2 flow, or TIMI 3 flow with highly elevated troponin (cTnI>10.0 ng/mL, hs-cTnI>5000 ng/L). Ejection fraction (EF), total ischemia time, hospital day stay and complications were compared between groups. **Results:** There were 334 patients included of whom NSTEMI-OMI were 98 patients (29.3%) of patients with ACS. 96 patients (40%) of OMI patients did not fulfill the STEMI criteria. Only 11 patients (11%) of STEMI(-)OMI had PCI performed within the first 12 hours vs 76 patients (77%) of STEMI(+)OMI, $p<0.001$. There was no difference in the percent of patients requiring PCI between the STEMI(+)OMI 98 patients (93%) and STEMI(-)OMI 87 patients (89%) ($p<0.001$). The overall in-hospital mortality was 19 patients (5.7 %), with subgroup mortality of 14 patients (4.2%) STEMI(+)OMI, two patients (0.6%) STEMI(+) NOMI, three patients (0.9%) STEMI(-)OMI, 0% STEMI(-)NOMI, ($p=0.013$). Patients with mechanical complications were: 67 patients (46.8%) STEMI(+)OMI and 45 patients (46.4%) STEMI(-)OMI. 26 patients (18.5%) STEMI(+)OMI and 13 patients (13.1%) STEMI(-)OMI developed electrical complications. **Conclusions:** STEMI(-)OMI patients had significant delays in catheterization, yet had angiographic findings, rate of PCI, and complications similar to STEMI(+)OMI. These data add further support to refocusing the paradigm of acute MI to improve recognition and rapid reperfusion of all OMIs, rather than only those with STEMI criteria.

Keywords: OMI; NOMI; STEMI; NSTEMI; PCI; PPCI

Introduction

Since "time is myocardium," rapid reperfusion of an acute coronary occlusion (ACO) is required in order to salvage ischemic myocardium before irreversible infarction leads to increased morbidity and mortality.

For approximately two decades, the patients who were believed to benefit from emergent revascularization have been those presenting with ST Elevation on the ECG, since ST Elevation has been assumed to be an accurate surrogate for ACO. Thus, the dichotomy of ST Elevation Myocardial Infarction (STEMI) vs. Non-STEMI has guided the use of emergency revascularization. However, we know that only 43% acute coronary occlusion MI (OMI) fulfill the STEMI millimeter (mm) criteria [1]. However NSTEMI patients with delayed treatment of OMI have almost double mortality compared

to NSTEMI patients without OMI [2]. Therefore, we support the idea of expanding the population eligible for emergent reperfusion therapy to any OMI, not only those whose ECGs manifest STEMI mm criteria. Conversely, focusing on the actual outcome of interest will also allow further research aimed at reducing false positive STEMI criteria activations [1].

The idea that all patients underlying ACO without collateral circulation, regardless of ECG findings, benefit from emergent revascularization has face validity, and is recently acknowledged in the 2022 American College of Cardiology guidelines [3]. There are ECG patterns beyond ST segment elevation mm criteria which are indicative of ACO, but unfortunately the "STEMI criteria" model restricts our minds and limits us so that we only recognize and emergently intervene on the STEMI subset of OMI [4].

Therefore, in 2018, the new OMI paradigm was conceived to replace STEMI/NSTEMI [5]. Blinded physicians with special expertise in OMI ECG findings demonstrated high accuracy in diagnosing OMI using the ECG, with sensitivity more than double the STEMI criteria at equal specificity [6].

2. Materials and Methods

The study purpose : We sought to evaluate STEMI/NSTEMI cases that result in OMI and the consequences of delayed revascularization immediately among NSTEMI patients who have ACO (NSTEMI-OMI).

Study objectives : 1. Identify the percentage of OMI patients that do not fulfill the STEMI criteria. 2. Compare the total ischemic time in each of the groups according to STEMI criteria and actual OMI outcome. 3. Compare rates of intervention, ejection fraction (EF), complications and hospital day stay in each of these groups.

Study type :The study was performed via retrospective chart review.

Data Collection: Data such as patients' demographic data and comorbidities, total ischemic time (the time from the onset of symptoms to the cath lab), hospital length of stay, ejection fraction, complications, and death cases were obtained from the medical records. Angiographic and relevant treatment data were collected from the standard coronary angiography registry and report, that is currently used in the Cath lab, UHC "Mother Teresa" Tirana, Albania. Diagnosis of OMI vs NOMI was determined by angiography ("confirmed OMI"). OMI was defined as an acute culprit lesion with TIMI 0-2 flow, or TIMI 3 flow with highly elevated troponin (cTnI>10.0 ng/mL , hs-cTnI>5000 ng/L). This data was collected from 1st January - 31st May, 2023. Presence or absence of STEMI criteria was determined in the final diagnosis written on chart by cardiologist using 3rd Universal Definition of MI.

Inclusion criteria : 1. Patients with a diagnosis of STEMI or NSTEMI. 2. Patients from the 1st & 2nd clinics of cardiology and cardiology ICU who underwent coronary angiography.

Exclusionary criteria : 1. Patients who underwent coronary angiography with a diagnosis of unstable angina. 2. Patients who refused angiography or passed away before performing angiography.

Statistical analysis methodology : The statistical program SPSS 20.0 (Statistical Package for Social Sciences) was used to analyze the data. The Student's t-test and the Wilcoxon test were used to compare continuous variables, as appropriate, while the Chi-square test was used to compare categorical variables. Categorical variables were presented according to their absolute and relative frequency expressed in percentage. The statistical test of One-way ANOVA was used to determine whether there are any statistically significant differences between the means of three or more independent (unrelated) groups. Continuous data are presented with mean (M) and standard deviation (SD). Statistical significance is defined for $p \leq 0.05$. Tables were used to visualize the data.

3. Results

There were 334 patients included, 241 OMI and 93 NOMI. 98 patients (29.3%) were STEMI(-) OMI, 73 patients (21.9%) were STEMI(-)NOMI, 143 (42.8%) were STEMI(+)OMI and 20 (6.0%) were STEMI(+) NOMI (See Table 2). Only 15 patients (11%) of STEMI(-) OMI had PCI performed within

the first 12 hours, vs. 110 patients (77%) of STEMI(+)
OMI, $p<0.001$ (See Table6) .There was no difference in the percent of patients requiring PCI between the STEMI(+)
OMI 133 patients (93%) and STEMI(-)
OMI 87 patient(89%) groups ($p<0.001$) (See Table 8).

Average EF was: STEMI(+)
NOMI 44.70%, STEMI(-)
NOMI 50.47%, STEMI(-)
OMI 48.70%, STEMI(+)
OMI 42.87 %, $p<0.001$ (See Table 4). The mortality was 19 patients (5.7 %), 14 (4.2 %) STEMI(+)
OMI, 2 (0.6 %) STEMI(+)
NOMI, 3 (0.9 %) STEMI(-)
OMI, 0% STEMI(-)
NOMI, $p=0.013$ (See Table 3). The mechanical complications were present in 58 patients (46.8%) STEMI (+)
OMI and in 39 patients (46.4%) STEMI(-)
OMI. 23 patients (18.5%) of the STEMI(+)
OMI and 11 patients (13.1%) of the STEMI(-)
OMI developed electrical complications (See Table 7).

3.1. Tables

Table 1. Clinical Characteristics of all Patients in Each Subgroup .

Characteristic	STEMI(+) OMI n =143	STEMI(+) NOMI n =20	STEMI(-) OMI n = 98	STEMI(-) NOMI n = 73
Age, y, mean(SD)	65.06 (13.33)	59.16 (12.43)	64.31 (10.43)	68.94 (11.78)
Female , n (%)	41 (28.6 %)	5 (25%)	22 (22.4%)	29 (39.7%)
Known CAD , n (%)	9 (6,5 %)	0 (0%)	9 (9.1%)	8 (10,9 %)
Prior CABG , n (%)	2 (1.3 %)	0 (0%)	5 (5.1%)	3 (4.1 %)
Prior CVA , n (%)	2 (1.3 %)	1 (5 %)	0 (0%)	3 (4.1 %)
CKD , n (%)	11 (7.7 %)	1 (5 %)	5 (5.1%)	7 (9.5%)
CHF , n (%)	56 (39.1%)	6 (30%)	64 (65.9%)	49 (67.1%)
Diabetes, type 2, n (%)	16 (11.2%)	6 (30%)	42 (42.8 %)	38 (52%)
IGT , n (%)	3 (2%)	1 (5%)	5 (5.1%)	2 (2.7%)
HLD, n (%)	100 (70%)	8 (40%)	88 (89.7%)	54 (73.9%)
HTN, n (%)	108 (75.5%)	10 (50%)	88 (89.7%)	50 (68.4%)
PVD , n (%)	3 (2%)	0 (0%)	2 (2%)	0 (0%)

CABG = coronary artery bypass grafting ; CAD = coronary artery disease ; CKD = chronic kidney disease ; CVA = cerebrovascular accident ; IGT= Impaired Glucose Tolerance ; HLD = hyperlipidemia ; HTN = hypertension ; NOMI = non-occlusion MI ; NSTEMI = non-ST-segment elevation MI ; OMI = occlusion Mi ; PVD = peripheral vascular disease ; SD = standard deviation ; STEMI = ST-segment elevation myocardial infarction.

Table 2. The results of the OMI/NOMI classification .

	OMI or NOMI		Total
	OMI	NOMI	
STEMI	143	20	163
	42.8%	6.0%	48.8%
NSTEMI	98	73	171
	29.3%	21.9%	51.2%
Total	241	93	334
	72.2%	27.8%	100.0%

334 patients were included, of whom 241 patients(72.2%) had OMI and 93 patients (27.8 %) had NOMI: 98patients (29.3%) were STEMI(-)OMI, 73 patients (21.9%) were STEMI (-)NOMI, 143patients (42.8%) were STEMI (+)OMI and 20 patients (6.0%) were STEMI (+) NOMI.

Table 3. In-hospital mortality after PCI in each of the groups.

Exitus	Groups				Total
	STEMI + OMI	STEMI + NOMI	STEMI - OMI	STEMI- NOMI	
Yes	14 4.2%	2 0.6%	3 0.9%	0 0%	19 5.7%
Total	143	20	98	73	334

$\chi^2=10.84, p=0.013$ 19 patients (5.7 %) died, 14patients (4.2 %) were STEMI (+) OMI, 2patients (0.6 %) were STEMI(+) NOMI, 3patients (0.9 %) were STEMI(-) OMI, and 0 patient were STEMI(-)NOMI. 14 patients (10%) of patients from STEMI(+)OMI group and 3patients (3%) of patients from STEMI(-) OMI died .

Table 4. Average hospital length of stay in each groups .

	N	Mean (day)	SD	95% Confidence Interval for Mean		Minimum (day)	Maximum (day)
STEMI (+) OMI	143	5.30	3.95	4.65	5.95	1.00	30.00
STEMI (+) NOMI	20	9.15	13.22	2.96	15.34	1.00	64.00

STEMI (-) OMI	98	5.66	3.08	5.05	6.28	0.00	19.00
STEMI (-) NOMI	73	6.44	2.92	5.76	7.12	2.00	17.00
Total	334	5.89	4.70	5.38	6.39	0.00	64.00

One-way ANOVA, $F=4,495$, $p=0.004$.

The average of the highest days of stay resulted in the group of STEMI (+) NOMI patients with 9.15 days, followed by STEMI(-) NOMI with 6.44 days, STEMI(-)OMI patients with 5.66 days and those STEMI(+) OMI with 5.30 days (One-way ANOVA $F=4,495$, $p=0.004$).

Table 5. Ejection fraction in each of the groups.

	N	Mean	SD	95% Confidence Interval for Mean
STEMI (+) OMI	143	42.9	9.52	42.87 +/- 1.58
STEMI (+) NOMI	20	44.7	11.11	44.70 +/- 5.2
STEMI (-) OMI	98	48.7	12.00	48.70 +/- 2.4
STEMI (-) NOMI	73	50.5	10.77	50.47 +/- 2.51
Total	334	46.4	11.13	46.355 +/- 1.22

One-way ANOVA, $F=20,630$, $p<0.001$.

Average EF was: STEMI(+)NOMI 44.70%, STEMI(-)NOMI 50.47%, STEMI(-)OMI 48.70%, STEMI(+)OMI 42.87 %, $p<0.001$.

Table 6. Total ischemic time in each of the groups.

Time interval (hours)	Groups				Total
	STEMI (+) OMI	STEMI (+) NOMI	STEMI (-) OMI	STEMI (-) NOMI	
0-2	7 4.9%	0 0.0%	1 1.0%	0 0.0%	8 2.4%
2-6	52 36.4%	5 25.0%	2 2.1%	2 2.8%	61 18.4%
6-12	51 35.7%	7 35.0%	12 12.5%	6 8.3%	76 23.0%
12-24	15 10.5%	2 10.0%	26 27.1%	12 16.7%	55 16.6%
24-48	3 2.1%	1 5.0%	21 21.9%	15 19.4%	40 11.8%

	15	5	36	38	94
> 48	10.5%	25.0%	35.4%	52.8%	27.8%
Total	143	20	98	73	334
	100.0%	100.0%	100.0%	100.0%	100.0%
Median ischemic time	8.0000	10.0000	48.0000	72.0000	
IQR	7.00	113.75	48.00	96.00	

$\chi^2=145.89, p<0.001$.

110 patients (77%) of STEMI (+) OMI patients had PCI performed PCI within the first 12 hours, vs. 15 patients (11%) of STEMI (-) OMI. 125 patients (87.4%) of STEMI (+) OMI patients performed PCI within 24 hours vs. 41 patients (42.7%) in the STEMI (-) OMI group. The majority of patients belonging to the STEMI (-) OMI group, 55 patients (57.3%) underwent PCI after 24 hours, 34 patients of which (61.7%) underwent PCI after 48 hours.

Table 7. The balance of intrahospital complications in each of the groups.

Complications	Groups				Total
	STEMI (+) OMI	STEMI (+) NOMI	STEMI(-) OMI	STEMI (-) NOMI	
None	36	3	33	29	101
	29.0%	15.8%	39.3%	44.6%	34.6%
* Mechanical complications	58	11	39	26	134
	46.8%	57.9%	46.4%	40.0%	45.9%
* Electrical complications	23	3	11	7	44
	18.5%	15.8%	13.1%	10.8%	15.1%
Mechanical & electrical complications	7	2	1	3	13
	5.6%	10.5%	1.2%	4.6%	4.5%
Total	124	19	84	65	292
	100.0%	100.0%	100.0%	100.0%	100.0%

*As mechanical complications we have included: acute ventricular failure, cardiogenic shock, rupture of the interventricular septum, rupture of the free wall, rupture of the papillary muscle, pericarditis. * As electrical complications we have included: ventricular, supraventricular arrhythmias and atrioventricular & interventricular blocks.

The group with fewer complications were STEMI (-) NOMI, 29 patients (44.6%). In total, 101 patients (34.6% of patients) had no complications. 134 patients (45.9%) had only mechanical complications, whereas STEMI(+) OMI and STEMI(-) OMI had a similar frequency of complications. The mechanical complications were present in 58 patients (46.8%) STEMI (+)OMI and in 39 patients (46.4%) STEMI(-)OMI. 23 patients (18.5%) of the STEMI(+)OMI and 11 patients (13.1%) of the STEMI(-) OMI developed electrical complications. Patients who had electrical and mechanical complications make up the smallest group, only 13 patients (4.5% of the total).

Table 8. STEMI(+) OMI vs. STEMI(-) OMI interventions.

Interventions	STEMI (+) OMI	STEMI (-) OMI	STEMI (+) NOMI	STEMI (-) NOMI
Angiogram	143 (100%)	98(100%)	20 (100%)	73(100%)
PCI	134 (93%)	87 (88,7%)	0 (0%)	61 (83.6%)
CABG *	5 (3,4%)	6 (6,2%)	0 (0%)	0 (0%)
PCI + CABG *	4 (2,6%)	5 (5,1%)	0 (0%)	9 (12.4%)
Total	143 (100%)	98 (100%)	20 (100%)	73 (100%)

$\chi^2=14.390$, $p=0.496$ *Urgent CABG * PCI followed by CABG in a second moment.

There is no difference in the percent of patients requiring PCI between the STEMI(+)OMI 133 patients (93%) and STEMI(-)OMI 87 patients (89%) groups.

4. Discussion

Contemporary articles are displaying the same essence: "The STEMI criteria underestimates many patients with the same risk as STEMI ones " [1–8]. Our results support the idea that the STEMI criteria fail to diagnose a large proportion of OMI and fail to identify patients who require emergent reperfusion and who will have complications. STEMI(-) OMI patients with the same pathology and risk as STEMI(+) OMI patients.

For years, authors have attempted to compensate this discrepancy with terminologies such as “STEMI equivalents,” “subtle STEMI” or “semi-STEMI.” Nevertheless, only 11 patients (11%) of patients with STEMI(-) OMI received reperfusion therapy within 12 hours in our cohort. The terminology "STEMI" suggests that what is important is ST elevation when in reality it is the acute coronary occlusion that is important [1,5,6].

Thus, in our cohort, “STEMI” and “ST Elevation” were obstacles for improving the management of AMI in 96 patients (40% of our OMI patients). When we see an ECG in the setting of potential ischemia, we should first look for any pattern that reliably predicts OMI, because these are the patients who benefit from emergency reperfusion [1–7]. In addition to ischemic ST elevation, we must consider: minimal ST elevations that do not meet the classic criteria, hyperacute T waves (including the de Winter pattern), reciprocal ST depressions and/or hyperacute negative T waves, depressions of ST in V1-V4 indicative of posterior AMI, acute pathological Q waves (Q waves associated with minimal ST elevation, not attributable to a previous myocardial infarction), terminal QRS distortion (loss of the preceding S wave in the context of minimal ST elevation), any inferior ST elevation with any ST depression or T wave inversion in aVL, and modified Sgarbossa criteria for patients with LBBB or paced rhythm [1–8].

Lindow et al. in their article included 623 patients, among which 441 (71%) had LBBB and 182 (29%) had VPR. 82 (13%) of these patients were diagnosed with AMI, and an OMI was identified in 15 (2.4%) cases. Sensitivity/specificity of the original unweighted Sgarbossa criteria were 26.7/86.2%, for Barcelona criteria 53.3/82.2%, for MSC 60.0/86.0%, and for Selvester criteria 46.7/88.3%. In this

setting with low prevalence of OMI, positive predictive values were low (Sgarbossa: 4.6%; MSC: 9.4%; Barcelona criteria: 6.9%; Selvester criteria: 9.0%) and negative predictive values were high (all >98.0%). Their results suggest that ECG criteria alone are insufficient in predicting presence of OMI in an ED setting with low prevalence of OMI, and the search for better rapid diagnostic instruments in this setting should continue [8]. Recently, a deep neural network has been shown to diagnose OMI with twice the sensitivity of STEMI criteria at the same specificity [7].

It is important to highlight that the new AMI classification will face implementation challenges. Paradigm shift requires changes on the AMI management protocols and this may lead to potential confusion to the involved medical staff. Therefore in such conditions multidisciplinary trainings, seminars or lectures will be continuously required. In this way these protocols will be understood and implemented easily.

On the other hand, since the current paradigm excludes 40% of OMI from immediate revascularization, we will need greater capacities and more human resources to cope with 40% more immediate revascularizations.

5. Study's Limitations

First, the study is a retrospective analysis conducted on 334 patients and all cases were obtained from a single tertiary center that offers emergency coronary angiography service (24/7). Therefore, despite the small sample size and the length of follow-up, this study suffers from the basic limitations of a retrospective registry, and these conclusions should therefore be confirmed in a randomised study.

Second, data on chest pain onset times were obtained from the patient's cardiology referral note on the chart. Third, of 375 patients who were initially identified, 41 patients were excluded because they refused PCI or passed away before performing PCI. Fourth, among 334 included patients, 42 patients' data were missing displaying potential complications. Thus not fulfilling at the end the wished statistical significance due to the restricted number of events.

6. Conclusions

STEMI(-) OMI patients had significant delays in catheterization, and had complications similar to STEMI(+) OMI. These data add further support to refocusing the paradigm of acute MI to improve recognition and rapid reperfusion of all OMIs, rather than only those with STEMI criteria. Clinicians should keep in mind that OMI is a clinical diagnosis, which includes OMI ECG findings but also clinical parameters, and is not defined entirely by the ECG or angiogram. Critical next steps of this paradigm shift include finding reliable methods to quickly identify all OMI patients for emergent reperfusion.

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