ORIGINAL ARTICLE

ELECTROCARDIOGRAM CHANGES IN PATIENTS WITH POSITIVE TROPONIN I PRESENTING WITH NON-ST-ELEVATION MYOCARDIAL INFARCTION

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Objectives: Unlike "ST-segment elevation myocardial infarction (STEMI)", there is a wide spectrum of ECG changes for Non-STEMI (NSTEMI) patients with varying prognostic implications. Therefore, the purpose of this study was to determine the frequency of ECG changes in patients with positive high-sensitive troponins (hs-cTn) presenting with NSTEMI.

Methodology: This Cross sectional study included 282 patients with positive hs-cTn diagnosed with NSTEMI. Standard 12-lead ECG was performed for all the patients. The clinical profile and ECG changes such as ST elevation in aVR, T wave inversion, and ST depression were noted.

Results: Out of 282 patients, 68.1% (192) were male, mean age was 58.5 ± 10.6 years, 56.7% (160) were hypertensive, and 39.7% (112) were diabetic. The ECG was normal in 8.2% (23) while, 64.5% (182) had ST-depression, out of which 1.1% (2) had ST-depression of <1mm, 78% (142) had ST-depression of 1-2mm, and remaining 20.9% (38) had ST-depression of >2mm. T-wave inversions were observed in 45.7% (129). ST-elevation of ≥1 mm in lead aVR was noted in 19.1% (54) patients.

Conclusion: A considerable number of NSTEMI patients with positive hs-cTn showed no specific ECG changes. ST-depression followed by T wave inversion and ST-elevation in aVR were the most commonly observed ECG findings in these patients. Considering the prognostic implications and association of these changes with the severity of diseases, prompt decision-making regarding invasive management strategy could be helpful in improving the outcomes of these patients.

Keywords: NSTEMI, ECG, ST depression, T wave inversion, ST-elevation in aVR

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INTRODUCTION

Acute myocardial infarction (AMI) is the most common clinical manifestation of myocardial necrosis associated with substantial mortality and morbidity.[1] Traditionally, AMI is classified into two major subcategories on the basis of electrocardiography (ECG) findings of absence and presence of ST-segment elevation at presentation.[2] Both "ST-segment elevation myocardial infarction (STEMI)" and "non-STEMI (NSTEMI)" have similar pathophysiology, mostly due to "erosion of the coronary artery endothelium or disruption of a vulnerable atherosclerotic plaque".[2] The 12-lead ECG at presentation plays a vital role in the diagnosis and subsequent management of AMI. The ECG of a STEMI patient shows ST elevation and prominent positive T-waves at a location depending on the region of myocardial ischemia. Unlike STEMI, a wide spectrum of ECG changes can be seen in NSTEMI patients each with varying clinical and prognostic implications.[3] Some of the commonly observed ECG patterns in NSTEMI patients include T-wave abnormality, ST-segment depression, non-ischemic abnormality, or transient ST-segment elevation.[3,4]

Even though substantial developments have been made in the non-invasive cardiac assessment and diagnostic imaging, ECG remains the most valuable and universally adopted tool.[5] However, it has been observed that the ECG of around 1/5th of the individuals with NSTEMI does not express any classic ischemic ECG changes.[6-9] Hence the diagnosis of NSTEMI with ECG alone is difficult and required cardiac enzymes assessment such as cardiac troponin (cTn) and other non-invasive cardiac imaging.[10]

Nonetheless, ECG has a significant logistic advantage over cTn as typically the turnaround time for cTn testing is more than an hour and ECG can be performed immediately in the emergency room at presentation or even before hospital arrival.[10, 11] However, unlike cardiac enzyme assessment, progress in the interpretation of ECG during last few years is very low.[11]

Therefore, it is equally important to evaluate the high risk ECG features and understand their clinical implications in order to optimize the management protocols for the NSTEMI patients. Hence, the purpose of this study was to evaluate the prevalence of ECG changes in patients with positive high-sensitive troponins (hs-cTn) presenting with NSTEMI at a tertiary care cardiac center of a developing country.

METHODOLOGY

This cross-sectional study was conducted for the dissertation for partial fulfillment of FCPS in the subject of adult cardiology from the College of Physicians and Surgeons Pakistan (CPSP). Study was conducted at the National Institute of Cardiovascular Diseases (NICVD), Karachi, Pakistan after approval from the CPSP in the year 2020. In accordance with the Declaration of Helsinki, verbal consent for participation in the study was obtained from all the patients. We included both male and female consecutive adult patients (age≥18 years) presented to the emergency department and diagnosed with NSTEMI with positive troponin I. Major exclusion criteria were; patients who refuse to participate in the study, patients with chronic kidney disease (deranged creatinine clearance), or patients with history of any cardiac related surgery or intervention.

Diagnosis of NSTEMI was confirmed based on history of chest pain (presented with a history of typical chest pain for at least 20 minutes), typical raise of high-sensitivity (hs) cardiac troponin (cTn) at presentation (threshold value of >0.05 ng/dL and >0.03 ng/dL for men and women, respectively), and with or without significant ischemic changes in ECG.

Patient related data such as demographic characteristics and co-morbid conditions such as diabetes mellitus (on anti-hyperglycemic treatment for at least 6-months) and hypertension (on anti-hypertensive treatment for at least 6-months) were obtained. A standard 12-lead ECG was performed in all the patients and it was interpreted by three independent experienced cardiologists and agreement of any two of them was taken as final diagnosis in terms of ST elevation in lead aVR, T wave inversion, and ST depression. ST depression was further quantified as depression of <1 mm, 1 to 2 mm, or >2 mm.

Statistical analysis was performed using IBM SPSS version-21. Age in years was expressed as mean ± standard deviation (SD) and categorized in to three groups as ≤ 45 years, 46 to 65 years, and >65 years. Frequency and percentages were calculated for categorical variables such as gender, age group, diabetic mellitus, hypertension, and ECG changes such as ST elevation in lead aVR, T wave inversion, and ST depression. The Association of confounders such as gender, age, gender, and risk factors (diabetes, and hypertension) was assessed with the help of appropriate Chi-square test or fisher exact test at level of significance of p-value of ≤ 0.05.

RESULTS

Out of 282 patients, 68.1% (192) were male, mean age was 58.5 ± 10.6 years, 56.7% (160) were hypertensive, and 39.7% (112) were diabetic. The ECG was normal in 8.2% (23) while, 64.5% (182) had ST-depression, out of which 1.1% (2) had ST-depression of <1mm, 78% (142) had ST-depression of 1-2mm, and remaining 20.9% (38) had ST-depression of >2mm. T-wave inversions were observed in 45.7% (129). ST-elevation of ≥1 mm in lead aVR was noted in 19.1% (54) patients (Table 1).

Table 1: Distribution of demographic characteristics and ECG changes at presentation of patients diagnosed with non-ST elevation myocardial infarction with positive troponin I

	Total
Total (N)	**282**
Gender	
Female	192 (68.1%)
Male	90 (31.9%)
Age (years)	58.5 ± 10.6
≤ 45 years	38 (13.5%)
46 to 65 years	178 (63.1%)
>65 years	66 (23.4%)
Hypertension	160 (56.7%)
Diabetes mellitus	112 (39.7%)
ECG Findings	
Normal ECG	23 (8.2%)
ST depression	182 (64.5%)
< 1 mm	2 (1.1%)
1-2 mm	142 (78%)
>2 mm	38 (20.9%)
T wave inversion	129 (45.7%)
ST-elevation in lead aVR	54 (19.1%)

Finding of ST depression was found to be associated with female gender with the prevalence of 84.4% vs. 55.2%; p<0.001 among female and male patients, respectively. ST-elevation in lead aVR was found to

be associated with hypertension with the prevalence of 23.8% vs. 13.1%; p=0.025 among hypertensive and non-hypertensive patients, respectively. While, the prevalence of ST depression was found to be more common in non-hypertensive patients compared to the hypertensive patients with prevalence rate of 72.1% vs. 58.8%; p=0.020, respectively (Table 2).

Table 2: Prevalence of ECG changes at presentation by demographic and clinical characteristics of patients diagnosed with non-ST elevation myocardial infarction with positive troponin I

	Total (N)	ECG Changes		
		ST Depression	T wave inversion	ST-elevation in lead aVR
Gender				
Male	192	106 (55.2%)	89 (46.4%)	38 (19.8%)
Female	90	76 (84.4%)	40 (44.4%)	16 (17.8%)
P-value	-	<0.001	0.764	0.689
Age				
≤ 45 years	38	26 (68.4%)	14 (36.8%)	0 (0%)
46 to 65 years	178	114 (64%)	77 (43.3%)	36 (20.2%)
>65 years	66	42 (63.6%)	38 (57.6%)	18 (27.3%)
P-value	-	0.864	0.068	0.003
Hypertension				
No	122	88 (72.1%)	58 (47.5%)	16 (13.1%)
Yes	160	94 (58.8%)	71 (44.4%)	38 (23.8%)
P-value	-	0.020	0.597	0.025
Diabetes mellitus				
No	170	110 (64.7%)	75 (44.1%)	32 (18.8%)
Yes	112	72 (64.3%)	54 (48.2%)	22 (19.6%)
P-value	-	0.942	0.499	0.864

DISCUSSION

Considering the importance of ECG in the diagnosis and subsequent management of patients with NSTEMI, we conducted this study to evaluate the prevalence of high risk ECG features in NSTEMI patients with positive hs-cTn. We observed that presenting ECG was normal in about 8.2% of the patients. ST-depression was the most prevalent (64.5%) ECG change followed by T-wave inversions (45.7%). ST-elevation of ≥1 mm in lead aVR was also noted in a significant (19.1%) number of patients. Further, ST depression was more prevalent in female gender and non-hypertensive patients. While, ST-elevation in lead aVR was found to be associated with hypertension.

Similar to our study, high prevalence of ST depression has been reported in past studies with varying degrees of clinical implications. In a study conducted by Wiśniewski P et al.,[5] ST depression in lead I, aVL, V_6 was observed in 23.6% and it was found to be an independent predictor of acute total occlusion with a high accuracy, specificity, negative and positive predictive value in predicting acute total occlusion of culprit vessel.[5] ST-depression in leads II, III, aVF and V_1-V_6 was observed in 11.5% and 37.6% of the NSTEMI patients, respectively. In a study of 148 patients by Rostoff P et al.[12] ST depression were observed in 73% with 25.0% in (I, aVL, V_6), 11.5% in (II, III, aVF), and 36.5% in leads (V_1-V_6). When compared with echocardiographic findings, the ST depression in NSTEMI patients was found to be associated with changes in diastolic function.[13]

The negative T wave in leads (I, aVL, V_6), (II, III, aVF), and (V_1-V_6) were observed in 13.3%, 12.1%, and 19.4% of NSTEMI patients, respectively.[5] Similar to our findings, T-wave inversions was observed in 45.3% of the patients in study by Rostoff P et al.[12] with 13.5% in (I, aVL, V_6), 12.8% in (II, III, aVF), and 18.9% in leads (V_1-V_6). Negative T-wave in leads V_1-V_6 was found to be associated with culprit left anterior descending coronary artery (LAD) or diagonal branch (Dg).[12] Also, the T-wave abnormalities among NSEMI patients are reported to be associated with an increased risk of myocardial edema.[4] Similarly, Sarak B et al.[14] reported T-wave inversion in at total of 45.4% of the patients, it was found to be associated with high risk clinical features, such as these patients are more likely to be older in age, higher Killip class, more cardiovascular risk factors, and higher GRACE score.[14] However, it does not offer any additional prognostic value for the prediction of 6-month mortality.[14] When compared with echocardiographic findings, the T-wave inversion in NSTEMI patients was found to be associated with systolic deterioration.[13]

Among various other high risk ECG features, the ST-elevation in lead aVR has great clinical significance. Similar to our finding, the ST-elevation in lead aVR is a less frequent findings in the literature but it carries a significant prognostic implications, the reported prevalence of ST-elevation in lead aVR is ranging from 7.4% to 40.3%.[5, 12, 15-19] A meta-analysis of 27 studies, conducted by Lee GK et al.,[15] reported a pooled prevalence of 24.7% for ST-elevation of ≥ 0.05 mV in lead aVR and it was reported to be associated with an increased risk of left main coronary artery

disease.[15] Similarly, Separham A et al.[16] conducted a prospective study of 400 NSTEMI patients and ST-elevation in lead aVR was reported in 30.5% of the patients. In a study by Badry MF et al.,[17] ST-elevation in lead aVR was found to be associated with left main and multi-vessel disease and it has be argued to be a useful diagnostic and prognostic indicator with potential to improve accuracy of traditional risk stratification models.[17] The clinical significance of ST-elevation in lead aVR has been reported by yet another study, in study of 129 patients by Nabati M et al.,[18] ST-elevation of >0.05mV in lead aVR was observed in 40.3% of the patients and it was strongly associated with cardiac enzyme rising. Also patients with ST-elevation in lead aVR were more likely to have higher incidence of mitral regurgitation, lower left ventricular ejection fraction, atherosclerosis severity, and multi-vessel diseases which eventually raised the risk of 3-month mortality down the line.[18] A similar prognostic and diagnostic role of ST-elevation in lead aVR has been also reported by Usman HT et al.[19] in our local population. It was reported to be 62.35% sensitive and 50.57% specific in identifying patients with left main stem stenosis and 77.14% sensitive and 53.62% specific in identifying patients with triple vessel disease.[19]

Our study has certain limitation, observational design of the study with single center coverage and relatively small sample size are the key limitation. Secondly, evaluation of ECG was limited to only three most common findings. Finally, due to the cross-section design of the study, no association of these changes with angiographic findings and outcomes could be established. Further studies are warranted to evaluate the diagnostic and prognostic significance of ECG changes in NSTEMI patients.

CONCLUSION

A considerable number of NSTEMI patients with positive hs-cTn showed no specific ECG changes. ST-depression followed by T wave inversion and ST-elevation in aVR were the most commonly observed ECG findings in these patients. Considering the prognostic implications and association of these changes with the severity of disease, prompt decision-making regarding invasive management strategy could be helpful in improving the outcomes of these patients.

AUTHORS' CONTRIBUTION

RK and AK: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. WK, AA, MK, and JAS: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

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REFERENCES

1. Anderson JL, Morrow DA. Acute myocardial infarction. N Engl J Med. 2017;376(21):2053-64.
2. Reed GW, Rossi JE, Cannon CP. Acute myocardial infarction. Lancet. 2017;389(10065):197-210.
3. Tuohinen SS, Rankinen J, Skyttä T, Huhtala H, Virtanen V, Kellokumpu-Lehtinen PL, et al. Associations between ECG changes and echocardiographic findings in patients with acute non-ST elevation myocardial infarction. J Electrocardiol. 2018;51(2):188-94.
4. Cardona A, Zareba KM, Nagaraja HN, Schaal SF, Simonetti OP, Ambrosio G, et al. T-wave abnormality as electrocardiographic signature of myocardial edema in non-ST-elevation acute coronary syndromes. J Am Heart Assoc. 2018 Jan 30;7(3):e007118.
5. Wiśniewski P, Rostoff P, Gajos G, Nessler J, Kruszelnicka O. Predictive value of electrocardiographic ST-segment elevation myocardial infarction equivalents for detecting acute coronary artery occlusion in patients with non–ST-segment elevation myocardial infarction. Kardiol Pol. 2019;77(6):624-31.
6. Roffi M, Patrono C, Collet JP, Mueller C, Valgimigli M, Andreotti F, et al. 2015 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: Task Force for the Management of Acute Coronary Syndromes in Patients Presenting without Persistent ST-Segment Elevation of the European Society of Cardiology (ESC). Eur Heart J. 2016;37(3):267-315.
7. Figueras J, Otaegui I, Marti G, Domingo E, Bañeras J, Barrabés JA, et al. Area at risk and collateral circulation in a first acute myocardial infarction with occluded culprit artery. STEMI vs non-STEMI patients. Int J Cardiol. 2018;259:14-9.
8. Karwowski J, Gierlotka M, Gąsior M, Poloński L, Ciszewski J, Bęćkowski M, et al. Relationship between infarct artery location, acute total coronary occlusion, and mortality in STEMI and NSTEMI patients. Pol Arch Intern Med. 2017;127(6):401-11.
9. Karwowski J, Poloński L, Gierlotka M, Ciszewski A, Hawranek M, Bęćkowski M, et al. Total coronary occlusion of infarct-related arteries in patients with non-ST-elevation myocardial infarction undergoing percutaneous coronary revascularisation. Kardiol Pol. 2017;75(2):108-16.
10. Strebel I, Twerenbold R, Boeddinghaus J, Abächerli R, Rubini Giménez M, Wildi K, et al. Diagnostic value of the cardiac electrical biomarker, a novel ECG marker indicating myocardial injury, in patients with symptoms suggestive of non-ST-elevation myocardial infarction. Ann Noninvasive Electrocardiol. 2018 Jul;23(4):e12538.
11. Abächerli R, Twerenbold R, Boeddinghaus J, Nestelberger T, Mächler P, Sassi R, et al. Diagnostic and prognostic values of the V-index, a novel ECG marker quantifying spatial heterogeneity of ventricular repolarization, in patients with symptoms suggestive of non-ST-elevation myocardial infarction. Int J Cardiol. 2017;236:23-9.
12. Rostoff P, Wisniewski P, Gajos G, Konduracka E, Nessler J, Kruszelnicka O. Electrocardiographic identification of the culprit coronary artery in acute non-ST-elevation myocardial infarction: predictive value of N-wave and T-wave precordial instability. Coron Artery Dis. 2020;31(7):590-6.
13. Tuohinen SS, Rankinen J, Skyttä T, Huhtala H, Virtanen V, Kellokumpu-Lehtinen PL, et al. Associations between ECG changes and echocardiographic findings in patients with acute non-ST elevation myocardial infarction. J Electrocardiol. 2018;51(2):188-94.

14. Sarak B, Goodman SG, Yan RT, Tan MK, Steg PG, Tan NS, et al. Prognostic value of dynamic electrocardiographic T wave changes in non-ST elevation acute coronary syndrome. Heart. 2016;102(17):1396-402.
15. Lee GK, Hsieh YP, Hsu SW, Lan SJ, Soni K. Value of ST-segment change in lead aVR in diagnosing left main disease in Non-ST-elevation acute coronary syndrome—A meta-analysis. Ann Noninvasive Electrocardiol. 2019 Nov;24(6):e12692.
16. Separham A, Sohrabi B, Tajlil A, Pourafkari L, Sadeghi R, Ghaffari S, et al. Prognostic value of positive T wave in lead aVR in patients with non-ST segment myocardial infarction. Ann Noninvasive Electrocardiol. 2018 Sep;23(5):e12554.
17. Badry MF, Elmaghraby KM, Helmy HA, Demitry SR. The added value of ST-elevation in lead aVR to clinical thrombolysis in myocardial infarction risk score in predicting the angiographic severity and extent of coronary artery disease in patients with non-ST-elevation acute coronary syndrome. J Curr Med Res Pract. 2018;3(2):100.
18. Nabati M, Emadi M, Mollaalipour M, Bagheri B, Nouraei M. ST-segment elevation in lead aVR in the setting of acute coronary syndrome. Acta Cardiol. 2016;71(1):47-54.
19. Usman HT, Hashmi KA, Saleemi MS, Akhtar A. Association of ST Elevation in Lead aVR with Left Main Stem and Triple Vessel Diseases in Patients with Non-ST Elevation Myocardial Infarction. Pak Heart J. 2021;54(4):348-51.

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