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Original Article

Internal Medicine Section

Clinical and Angiographic Profile of STEMI-Equivalent Electrocardiographic Patterns in Acute Coronary Syndrome: A Prospective Observational Study

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ABSTRACT

Introduction: Prompt diagnosis of acute coronary occlusion plays an important role in lowering deaths in patients suffering from Acute Coronary Syndrome (ACS). Although ST-Elevation Myocardial Infarction (STEMI) forms the basis of reperfusion therapy, there are many high-risk non ST-segment elevation electrocardiographic presentations of ACS known as STEMI equivalents, which represent acute coronary occlusion but are frequently under-recognised.

Aim: To determine the incidence of STEMI-equivalent presentations among ACS patients, describe their clinical and angiographic characteristics, and compare in-hospital outcomes based on reperfusion strategy.

Materials and Methods: The present prospective observational study was conducted in the Emergency Department of a tertiary care teaching hospital, Datta Meghe Institute of Higher Education and Research, in Wardha, Maharashtra, India, over 24 months from August 2022 to August 2024, involving 120 patients diagnosed with ACS. Baseline demographics, including age, gender, Body Mass Index (BMI), and cardiovascular risk factors such as hypertension, diabetes mellitus, and thyroid disorders, were recorded. The clinical presentation, Electrocardiogram (ECG) findings, biochemical parameters, echo parameters, angiographic findings, reperfusion strategy, and clinical outcome were also recorded. Subjects were divided into a classical STEMI group and STEMI-equivalent groups, and comparisons were made among them and among groups based on reperfusion strategy. Continuous variables are represented as mean±Standard Deviation (SD) and were analysed using unpaired Student's t-test, while categorical variables were represented as frequency (%) and analysed using Chi-square or Fisher's exact test. A p-value of <0.05 was accepted as significant.

Results: Among 51 STEMI-equivalent patients, males constituted 33 (64.7%). The most common patterns were left bundle branch block (20, 39.2%) and Wellens' syndrome (19, 37.3%). Among STEMI-equivalent patients, the prevalence of multivessel coronary artery disease was 47.1% (24/51), compared with 30.4% (21/69) in classical STEMI patients. Similarly, reduced left ventricular ejection fraction (<50%) occurred in 54.9% (28/51) of STEMI-equivalent patients, compared with 43.5% (30/69) in classical STEMI patients. In-hospital mortality was highest in the de winter pattern (3/6, 50%) and aVR ST elevation (1/3, 33.3%); however, these estimates were based on small subgroup sizes. Survival was significantly higher in patients undergoing primary Percutaneous Coronary Intervention (PCI) than in those receiving thrombolysis (94% vs 78.1%, p=0.042).

Conclusion: A significant proportion of ACS has STEMI-equivalent patterns and is associated with poor outcomes. Prompt diagnosis and early primary PCI dramatically improve survival.

Keywords: Echocardiography, Myocardial infarction, Myocardial reperfusion, Percutaneous coronary intervention, ST-Elevation Myocardial Infarction

INTRODUCTION

The burden of serious illness and death resulting from ACS globally is enormous and it represents a considerable health challenge, especially in a developing country such as India [1]. A blockage of a coronary artery producing a heart attack, previously, was recognised and categorised as STEMI purely by an electrical pattern, ST-segment elevation in the ECG, which then directly indicated need for treatment such as primary PCI to restore blood flow [2]. It is now understood that many patients with arterial blockage may not show these ECG changes, even though a significant portion of myocardium remains at risk and morbidity is still possible [3].

Multiple international studies have shown that patients who present with STEMI-equivalent patterns often have widespread coronary artery disease, reduced heart function, larger areas of heart damage, and death rates that are as high as or even higher than those seen in classic STEMI cases [4-6]. The new Occlusion Myocardial Infarction (OMI) approach highlights the importance of considering the full clinical and ECG picture, not just the presence of ST-segment elevation, to identify acute coronary artery occlusions [7]. Despite increasing recognition of STEMI equivalents, these ECG patterns are still often missed in everyday clinical practice, particularly in busy emergency departments or in hospitals with limited resources [8].

The clinical importance of recognising STEMI-equivalent patterns is especially pronounced in the Indian healthcare system [9]. Several factors contribute to this, such as patients often arriving late for treatment, a high rate of risk factors like diabetes and high blood pressure, and inconsistent access to 24/7 PCI facilities [9,10]. Because of these challenges, many hospitals still rely heavily on thrombolytic therapy to treat heart attacks, as more advanced interventions may not always be available [9,10]. In these settings, missing a STEMI-equivalent ECG pattern can further delay the right treatment and worsen patient outcomes [11].

While international research has shed light on the frequency and significance of STEMI-equivalent ECG patterns, there is still a lack of prospective data from India on how often these patterns occur, their angiographic and echocardiographic features, and what happens to patients during their hospital stay. Most of the existing Indian studies are case reports or retrospective reviews, or focus on specific ECG

patterns rather than providing a broad overview of multiple STEMI equivalents across ACS patient groups [12]. There is also limited information on how different treatments, especially primary PCI versus thrombolytic therapy, compare in real-world emergency situations among patients with STEMI-equivalent patterns. This gap highlights the need for more comprehensive research in the Indian context [13].

Therefore, the present study was undertaken to determine the incidence and distribution of STEMI-equivalent patterns, assess their clinical, biochemical, echocardiographic, and angiographic characteristics, and evaluate in-hospital outcomes by reperfusion strategy.

MATERIALS AND METHODS

The present prospective observational study was conducted from August 2022 to August 2024 at the Emergency Department of a tertiary-care teaching hospital, Datta Meghe Institute of Higher Education and Research in India. Consecutive sampling was done, and in all, 120 eligible patients who presented during the study duration were recruited. Institutional Ethics Committee (IEC) approval was received from the Datta Meghe Institute of Higher Education & Research (IEC approval no: DMIMS(DU)/IEC/2022/1053).

Inclusion criteria: Adult patients aged ≥18 years presenting to the emergency department with chest pain or anginal-equivalent symptoms such as dyspnoea, diaphoresis, or syncope and diagnosed with ACS according to American College of Cardiology guideline-based criteria were included in the study [14]. Consecutive eligible patients presenting during the study period were enrolled.

Exclusion criteria: Patients with non cardiac causes of chest pain, prior coronary artery bypass graft surgery, previous myocardial infarction with baseline electrocardiographic abnormalities interfering with interpretation, paced cardiac rhythms precluding electrocardiographic assessment, refusal to provide informed consent, or incomplete clinical data were excluded from the study.

Study Procedure

All enrolled patients underwent a detailed clinical evaluation, including history-taking, physical examination, and standard 12-lead electrocardiography at presentation. Based on electrocardiographic findings at presentation, patients were categorised into classical STEMI and STEMI-equivalent patterns [2]. STEMI equivalents were defined as high-risk non ST-segment elevation electrocardiographic patterns suggestive of acute coronary occlusion, including left bundle branch block, Wellens' syndrome, de Winter's pattern, posterior wall myocardial infarction, and ST-segment elevation in lead aVR with diffuse ST depression [15]. Electrocardiographic interpretation was performed by the treating emergency physician and subsequently confirmed by an on-call cardiologist prior to initiation of reperfusion therapy, with no discrepancies observed. Demographic characteristics (age and sex), cardiovascular risk factors and co-morbidities (including diabetes mellitus, hypertension, and thyroid disorders), and clinical presentation were obtained from patients' medical records and clinical history. Serum troponin and Creatine Kinase-Myocardial Band (CK-MB) levels were measured using standard hospital laboratory assays. Echocardiographic findings, including left ventricular ejection fraction and regional wall motion abnormalities, were assessed by transthoracic echocardiography. Coronary angiographic findings, including culprit vessel involvement, degree of coronary stenosis, presence of single or multivessel coronary artery disease, and angiographic severity, were determined from coronary angiography performed during hospitalisation.CK-MB values were grouped into three categories (<100 ng/mL, 100-200 ng/mL, and >200 ng/mL) based on the distribution of biomarker levels in the study population to facilitate subgroup comparisons between STEMI and STEMI-equivalent presentations [16]. Troponin levels were categorised as 0-100 ng/L, 101-1000 ng/L, and >1000 ng/L based on the magnitude of biomarker elevation to facilitate assessment of myocardial injury severity and comparison across STEMI-equivalent ECG patterns [17].

Reperfusion strategies including primary PCI, thrombolytic therapy, or conservative medical management were recorded. The choice of reperfusion strategy was based on the patient's clinical status, electrocardiographic findings, time from symptom onset, haemodynamic stability, contraindications to thrombolysis, availability of catheterisation laboratory facilities, and treating cardiologist's decision in accordance with institutional protocols and contemporary ACS management guidelines [18]. The primary outcome measure was in-hospital mortality. Secondary outcome measures included reduced left ventricular ejection fraction (<50%), presence of multivessel coronary artery disease, Major Adverse Cardiovascular Events (MACE), Duration of intensive care unit stay, occurrence of arrhythmias, cardiogenic shock, heart failure, and other in-hospital complications.

STATISTICAL ANALYSIS

All statistical analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables are expressed as mean±SD. They were compared between the classical STEMI and STEMI-equivalent groups using the unpaired Student's t-test. Categorical variables are expressed as counts and percentages; they are analysed using the Chi-square test or Fisher's exact test when appropriate. Clinical outcome comparison based on reperfusion strategy was analysed by Chi-square test. A p-value of <0.05 is considered significant.

RESULTS

STEMI-equivalent presentations were predominantly observed in patients older than 50 years, accounting for 34 of 51 cases (66.7%). Conversely, classical STEMI patients were more frequently aged ≤50 years (53.6%) [Table/Fig-1]. A male predominance was observed across all STEMI-equivalent subtypes, with males accounting for 33 of 51 patients (64.7%) [Table/Fig-2]. Diabetes mellitus was the most prevalent comorbidity in both classical STEMI (31/69, 44.9%) and STEMI-equivalent patients (30/51, 58.8%) [Table/Fig-3].

CK-MB values were grouped into three categories (<100 ng/mL, 100-200 ng/mL, and >200 ng/mL) based on the distribution of biomarker levels within the study population [16]. Higher proportions of markedly elevated CK-MB levels (>200 ng/mL) were observed in de Winter pattern and aVR subgroups, although elevated levels were also seen in other patterns [Table/Fig-4].

Troponin levels >1000 ng/L were observed in 34.8% of classical STEMI patients and 33.3% of STEMI-equivalent patients overall [Table/Fig-5].

Reduced left ventricular ejection fraction (<50%) was observed in 43.5% of classical STEMI patients and 54.9% of STEMI-equivalent patients overall [Table/Fig-6].

Age Category	PWMI (n=3)	Wellens' (n=19)	de Winter pattern (n=6)	aVR (n=3)	LBBB (n=20)	Total	STEMI (n=69)
≤50 years	1 (33.3%)	6 (31.6%)	0	1 (33.3%)	9 (45.0%)	17	37 (53.6%)
>50 years	2 (66.7%)	13 (68.4%)	6 (100%)	2 (66.7%)	11 (55.0%)	34	32 (46.4%)
Total	3	19	6	3	20	51	69

[Table/Fig-1]: Age distribution of classical STEMI and STEMI-equivalent ECG presentations (N=120).
PWMI: Posterior wall myocardial infarction

Gender	PWMI (n=3)	Wellens' (n=19)	de Winter pattern (n=6)	aVR (n=3)	LBBB (n=20)	Total
Female	0	9 (47.4%)	2 (33.3%)	1 (33.3%)	6 (30.0%)	18
Male	3 (100%)	10 (52.6%)	4 (66.7%)	2 (66.7%)	14 (70.0%)	33
Total	3	19	6	3	20	51

[Table/Fig-2]: Gender distribution of STEMI-equivalent subtypes (N=51).
PWMI: Posterior wall myocardial infarction

Co-morbidity	PWMI (n=3)	Wellens' (n=19)	de Winter pattern (n=6)	aVR (n=3)	LBBB (n=20)	STEMI (n=69)
Diabetes Mellitus	2 (66.7%)	10 (52.6%)	3 (50.0%)	2 (66.7%)	13 (65.0%)	31 (44.9)
Hypertension	1 (33.3%)	7 (36.9%)	2 (33.3%)	1 (33.3%)	6 (30.0%)	26 (37.6)
Thyroid Disorder	0	2 (10.5%)	1 (16.7%)	0	1 (5.0%)	12 (17.5)

[Table/Fig-3]: Distribution of co-morbidities among classical STEMI and STEMI-equivalent ECG presentations (N=120).
PWMI: Posterior wall myocardial infarction

ACS subtype	<100 ng/mL	100-200 ng/mL	>200 ng/mL
STEMI	12 (17.4%)	33 (47.8%)	24 (34.8%)
LBBB	4 (20.0%)	8 (40.0%)	8 (40.0%)
Wellens' pattern	3 (15.8%)	12 (63.2%)	4 (21.1%)
de Winter pattern	0	2 (33.3%)	4 (66.7%)
aVR	0	1 (33.3%)	2 (66.7%)
PWMI	1 (33.3%)	1 (33.3%)	1 (33.3%)

[Table/Fig-4]: CK-MB distribution across STEMI and STEMI-equivalent subtypes.
PWMI: Posterior wall myocardial infarction

Troponin level (ng/L)	Wellens' syndrome (n=19)	de Winter pattern (n=6)	LBBB (n=20)	aVR (n=3)	PWMI (n=3)	Total (n=51)	STEMI (n=69)
0-100	3 (15.8%)	1 (16.7%)	4 (20.0%)	1 (33.3%)	1 (33.3%)	10 (19.6%)	16 (23.2)
101-1000	10 (52.6%)	2 (33.3%)	9 (45.0%)	1 (33.3%)	2 (66.7%)	24 (47.1%)	29 (42.0)
>1000	6 (31.6%)	3 (50.0%)	7 (35.0%)	1 (33.3%)	0	17 (33.3%)	24 (34.8)
Total	19 (100%)	6 (100%)	20 (100%)	3 (100%)	3 (100%)	51 (100%)	69 (100%)

[Table/Fig-5]: Distribution of high-sensitivity troponin levels across classical STEMI and STEMI-equivalent ECG subtypes (N=120).
PWMI: Posterior wall myocardial infarction

ACS subtype	Reduced EF (<50%) (%)
STEMI	30 (43.5%)
LBBB	11 (55.0%)
Wellens' syndrome	8 (42.1%)
de Winter pattern	5 (83.3%)
aVR	3 (100.0%)
PWMI	1 (33.3%)

[Table/Fig-6]: Echocardiographic findings.

Angiographic assessment revealed Multi-Vessel Disease (MVD) in 30.4% in typical STEMI. Among equivalents, de Winter pattern (66.7%) and aVR (100%) patterns had the highest MVD burden [Table/Fig-7].

ACS subtype	Single vessel disease (%)	Multi-vessel disease n (%)
STEMI	48 (69.6%)	21 (30.4%)
LBBB	12 (60.0%)	8 (40.0%)
Wellens'syndrome	11 (57.9%)	8 (42.1%)
de Winter pattern	2 (33.3%)	4 (66.7%)
aVR	0 (0.0%)	3 (100.0%)
PWMI	2 (66.7%)	1 (33.3%)

[Table/Fig-7]: Coronary angiography profile.

A total of 82 patients (68.3%) underwent primary percutaneous coronary intervention, and 32 patients (26.7%) received thrombolytic therapy. Six patients (5%) were managed conservatively by loading aspirin 325mg, clopidogrel 300 mg, atorvastatin 80 mg, along with pain management with nitrates and morphine [Table/Fig-8].

Reperfusion strategy	n	Survival (n%)	Mortality (n%)	p-value
Primary PCI	82	77 (94.0%)	5 (6.0%)	0.042
Thrombolysis	32	25 (78.1%)	7 (21.9%)	
Medical management	6	4 (66.7%)	2 (33.3%)	
Total	120	106 (88.3%)	14 (11.7%)	

[Table/Fig-8]: Reperfusion strategy distribution (n=120).

ACS subtype	Total cases (n)	Deaths (n)	Mortality (%)
STEMI	69	7	10.1%
LBBB	20	2	10.0%
Wellens' syndrome	19	1	5.3%
de Winter pattern	6	3	50.0%
aVR	3	1	33.3%
PWMI	3	0	0.0%
Total	120	14	11.7%

[Table/Fig-9]: In-hospital mortality and survival outcomes across STEMI and STEMI-equivalent subtypes.

The overall in-hospital mortality was 14/120 (11.7%). The highest mortality was observed in de Winter's pattern (50.0%) [Table/Fig-9].

DISCUSSION

In the present study, STEMI-equivalent electrocardiographic pat terns were predominantly observed among middle-aged and elderly male patients with a high burden of cardiovascular risk factors, particularly diabetes mellitus and hypertension. Similar observations were reported by Verouden NJ et al., who found that STEMI-equivalent ECG patterns, particularly the de Winter pattern, were predominantly observed in male patients with underlying coronary artery disease and cardiovascular risk factors [19]. The higher prevalence of co-morbidities among STEMI-equivalent patients may indicate more advanced coronary artery disease and delayed presentation, thereby contributing to poorer myocardial perfusion and adverse clinical outcomes [20].

The present study identified left bundle branch block, Wellens' syndrome, de Winter's pattern, posterior wall myocardial infarction, and ST-segment elevation in lead aVR with diffuse ST

depression as important STEMI-equivalent patterns associated with acute coronary occlusion. Similar electrocardiographic findings have been described in previous studies by de Winter RJ et al., for de Winter's pattern, de Zwaan C et al., for Wellens' syndrome, and Knotts RJ et al., for ST-segment elevation in lead aVR with diffuse ST depression, which emphasised the importance of early recognition of these atypical ECG presentations in ACS [21-23].

In the present study, STEMI-equivalent patients demonstrated a higher prevalence of multivessel coronary artery disease and greater left ventricular systolic dysfunction compared with classical STEMI patients. These findings suggest that STEMI-equivalent ECG patterns may be associated with more extensive coronary artery involvement and adverse ventricular remodelling. The increased prevalence of multivessel disease in the present study may explain the higher incidence of reduced left ventricular ejection fraction and adverse in-hospital complications among STEMI-equivalent patients [24]. These findings highlight the importance of comprehensive angiographic evaluation and aggressive early management in this high-risk subgroup.

Mortality in these patients was predominantly associated with cardiogenic shock, severe left ventricular dysfunction, malignant arrhythmias, and extensive multivessel coronary artery disease, particularly among patients presenting with de Winter pattern and aVR ST-segment elevation, which are known to reflect proximal coronary occlusion and large ischaemic burden, which may contribute to the observed adverse clinical outcomes and increased in-hospital mortality.

The present study also evaluated reperfusion strategies and demonstrated that primary percutaneous coronary intervention was associated with better clinical outcomes compared with thrombolytic therapy and conservative management. These findings are consistent with Zhou S et al., who reported that Primary PCI offers a mortality benefit compared with Onsite Fibrinolytic Therapy (O-FT) in patients with timely treatment of STEMI, but treatment delays can mitigate this benefit [25].

Limitation(s)

There are several limitations to the present study. One such limitation is that the number of participants in some subgroups, especially those in PWMI, was relatively low, making it difficult to generalise the results from these subgroups. Another limitation is that troponin levels were measured at the time of admission and thus may not have been at their peak. As the study was conducted at a tertiary care referral centre using consecutive sampling, referral bias cannot be excluded, which may have influenced the observed clinical profile and severity distribution of STEMI-equivalent presentations.

CONCLUSION(S)

The STEMI equivalent ECG pattern is a significant portion of ACS, which comprises an especially high-risk subgroup. They tend to have more advanced coronary artery disease and poorer left ventricular function. Patients with STEMI equivalents may have different cardiac marker values. Prompt diagnosis and intervention using revascularisation techniques, especially primary PCI, greatly increases the likelihood of survival.

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