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DIAGNOSTIC SIGNIFICANCE OF ST-SEGMENT DEPRESSION IN LEAD A VR FOR IDENTIFYING CULPRIT ARTERIES IN INFERIOR WALL ST-ELEVATION MYOCARDIAL INFARCTION

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ABSTRACT

Introduction: A blockage in either the right coronary artery (RCA) or left circumflex artery (LCx) creates the most frequent cause of inferior wall ST-elevation myocardial infarction (IW-STEMI). The necessity to recognize the affected artery rapidly permits immediate treatment. The measurement of ST segment depression in the lead aVR proves valuable as an indicator during these circumstances.

Objective: The study evaluates whether ST-segment depression in lead aVR helps diagnose the blockage artery for IW-STEMI patients.

Material and Methods: Descriptive cross-sectional research occurred at multi centers including Department of Cardiology, Ayub Teaching Hospital, Abbottabad and Hayatabad Medical Complex, Peshawar in the duration from January, 2023 to December, 2023. The research analysis included 150 IW-STEMI patient participants. Experts examined the ST depression in lead aVR through ECGs to find correlations with angiographic results.

Result: The diagnosis of Left Coronary Artery blockage with ST depression in lead aVR showed 88.6% sensitivity while offering 55.0% specificity. The evidence shows that when lead aVR displays depressed waves, it suggests that the LCx artery is blocked ($p<0.001$).

Conclusion: A valuable diagnostic indicator for LCx artery involvement exists in ST depression found in lead aVR during IW-STEMI.

Keywords: STEMI, lead aVR, ST-segment depression, inferior wall MI, culprit artery, electrocardiogram, LCx, RCA.

INTRODUCTION

Diagnosing which artery caused the inferior wall ST-elevation myocardial infarction (IW-STEMI) is an essential challenge within cardiology. Proper CV disease diagnosis at the right time enables optimal reperfusion therapy that directly influences patient results. One of the most widely utilized yet economical and fast methods to detect myocardial ischemia and infarct form is the 12 lead (lead/cardioversion ECG) (1). Research now centers its focus on understanding how specific ECG changes, particularly ST segment deviations, assist in arterial occlusion site diagnosis. IW-STEMI can be diagnosed using ST segment depression in lead aVR as this marker provides accurate indications of the culprit artery (2). Although clinical staff commonly fail to interpret lead aVR, it offers limited yet important diagnostic information if used alongside other electrocardiographic findings.

Physicians identified RCA and LCx as the sources of IW-STEMI while determining which culprit vessel would mold the management approach (3). Many studies have attempted to derive ECG patterns for repeated assessment of cardio catheterization to discriminate between RCA and LCx occlusions. A surrogate marker that reflects the direction and magnitude of myocardial injury vectors has arisen. ST-segment depression in lead aVR is often accompanied by reciprocal changes in other leads (4). An example of this would include patients with ST depression in aVR who may have Eastern or lateral ischemia dominance (5) suggested by LCx involvement. However, the diagnostic accuracy of this pattern has been variable and further validated in different populations and clinical settings.

ST-segment depression in lead aVR in IW-STEMI is based on the vectorial sum of the injury currents. When the inferior wall is involved, the electrical vector usually shifts away from aVR. However, ST depression may occur. Any difference might be more evident when the LCx is included, as it supplies anatomical territory (6). Therefore, ST depression in aVR can also be seen with proximal RCA occlusions, especially in the presence of a right ventricle contribution, complicated by confusion in interpretation (7). Additionally, there is a high degree of diagnostic uncertainty regarding coronary circulation due to electrocardiographic findings that have also been shown to be influenced by coronary circulation dominance (8).

Several researchers sought to use artificial intelligence and machine learning to improve ECG interpretation to overcome these. They trained deep learning models to identify STEMI patterns with high accuracy and suggested that these models can separate culprit arteries based only on ECG (9). Although these technologies need to integrate into clinical workflows and be validated in real-time emergency settings, they exist for use in the clinical context. At the same time, more conventional approaches have also been improved. This has included, for example, the value of assessing coronary microvascular dysfunction in conjunction with ST depression in aVR in assessing quantitative ischemic burden, localizing infarct-related artery, and localizing plaque burden and the potential for microvascular disease (10).

Other studies have noted that using multiple ECG leads instead of a single marker is essential. The culprit artery was assessed by ST depression in anterior leads, posterior lead patterns, and right precordial leads, as well as aVR, in an attempt to improve the specificity and sensitivity (11, 12). However, even with these improvements, an error is possible, as patients with multivessel disease or variations in the anatomy (13) often can be misclassified. For example, in patients with coexisting RCA and LCx ischemic burden, ST changes are not due to a discrete occlusion, and cumulative ischemia may complicate interpretation (14).

Additionally, the integration of advanced ECG interpretation methods with clinical history, biochemical markers, and imaging findings is required to be complete. Furthermore, acute coronary syndrome management has been shifted to a paradigm of localization of infarction by deep learning networks that not only localized presence but were able to localize specifically the artery involved with high precision (15). However, such advances are still suboptimal, and there is still a clear requirement for simpler, more generalizable bedside instruments, an urgent necessity in resource-constrained settings, such as many hospitals in Pakistan. ST depression on lead aVR has the potential as a low-cost clinical adjunct, and it is focused on clinical testing as a low-cost diagnostic test that would add to the early identification of culprit arteries and time-critical endovascular intervention in IW STEMIs.

Objective

The diagnostic significance of ST-segment depression in the lead aVR for the accurate identification of the culprit artery in patients with inferior wall ST-elevation myocardial infarction is evaluated (IW-STEMI).

MATERIALS AND METHODS

Study Design: Descriptive cross-sectional study.

Methods: The study was conducted at multi centers including Department of Cardiology, Ayub Teaching Hospital Abbottabad and Hayatabad Medical Complex Peshawar

Time Frame: Data were collected for one year, from January, 2023 to December, 2023.

Inclusion Criteria

All patients over 18 years old with acute inferior wall ST-elevation myocardial infarction as diagnosed from 12 lead ECG were included. Data were selected if they had had a coronary angiogram within 24 hours of presentation and had full ECG and angiogram data.

Exclusion Criteria

Exclusion criteria include patients with previous myocardial infarction, left bundle branch block, paced rhythm, left ventricular hypertrophy, or any ECG abnormality that may interfere with the interpretation of the ST segment in the ECG. E. coli were also excluded if their angiographic or ECG records were incomplete.

Methods

After obtaining informed consent, all eligible patients presenting with IW STEMI were enrolled. An immediate 12 lead standard ECG was recorded upon admittance. ST segment depression in lead aVR of $\geq$0.05 mV below baseline, with particular attention, was given. Coronary angiography was done within 24 hours in patients to identify the culprit vessel by angiographic definition of acute thrombotic occlusion. The relationship between ST segment depression in aVR and the localization of the culprit artery (right coronary artery or left circumflex artery) on angiogram is analyzed. Two experienced cardiologists interpreted ECG independently of angiographic findings in order to reduce bias. A structured proforma was used to record the data and be analyzed statistically using SPSS version 25. A predictive value of lead aVR in culprit artery identification was assessed using descriptive statistics, chi-square tests, and sensitivity/specificity analysis. Statistically significant was considered a p-value <0.05.

RESULTS

The study also included 150 patients diagnosed with IW-STEMI. The mean age of patients was 58.3 ± 11.2 years, male predominance (72%). Ninety-six patients (64%) had right coronary artery (RCA), and 54 patients (36%) had left circumflex artery (LCx) involvement out of the total cases. In 98 patients (65.3%), ST depression in lead aVR was observed. Among these, 62 patients (63.3%) were diagnosed with LCx, and 36 patients (36.7%) had the RCA as the culprit artery. However, in patients without ST depression in lead aVR, only 8 (15.4%) had LCx involvement, and 44 (84.6%) had RCA involvement.

Table 1: Distribution of Culprit Artery Based on Lead aVR ST-Segment Depression

ST Depression in Lead aVR	RCA (n)	LCx (n)	Total (n)
Present	36	62	98
Absent	44	8	52
Total	**80**	**70**	**150**

A statistically significant ($p < 0.001$) association was found between ST depression in lead aVR and involvement in LCx. This would provide a substantial predictive value for LCx as it is the culprit artery in IW-STEMI.

The analysis further demonstrated the great sensitivity of ST-segment depression in lead aVR in detecting LCx occlusion at 88.6% and specificity at 55%. The PPV was 63.3%, and the NPV was 84.6%.

Table 2: Diagnostic Accuracy of ST-Segment Depression in Lead aVR for LCx Occlusion

Parameter	Value (%)
Sensitivity	88.6
Specificity	55.0
Positive Predictive Value	63.3
Negative Predictive Value	84.6

The demographic and clinical characteristics of patients with RCA and LCx involvement were compared equally. Baseline characteristics such as hypertension, diabetes, or smoking status did not vary significantly between them. Similarly, LCx, LCx-related IW STEMI patients more often had ST depression in anterior leads (p=0.041), which supports the unique ECG pattern associated with LCx occlusions.

Table 3: Comparison of Clinical Features Between RCA and LCx Groups

Variable	RCA Group (n=96)	LCx Group (n=54)	p-value
Age (mean ± SD)	57.9 ± 10.8	58.9 ± 11.6	0.62
Male Gender (%)	71.8	72.2	0.95
Diabetes Mellitus (%)	42.7	46.3	0.66
Smoking (%)	55.2	51.8	0.70
Ant. Lead Depression	26.0	46.3	0.041

However, these findings indicate that ST segment depression in lead aVR is a strong marker for LCx involvement in IW-STEMI.

DISCUSSION

This study looked at the diagnostic value when ST segment depression in the lead aVR was present in inferior wall ST-elevation myocardial infarction (IW-STEMI). It was found that ST depression in lead aVR was highly associated with LCx involvement and had high sensitivity and moderate specificity to predict LCx as the culprit artery. These results contribute to the growing evidence that aVR contributes clinically helpful information in the early risk stratification and management of patients with IW-STEMI. This is consistent with the work of Zhou et al., who performed a meta-analysis concluding that particular ECG patterns, including ST depression in aVR, have high discriminating value in differentiating the culprit artery in IW-STEMI SRC, either RCA or LCx (1). The vector direction of myocardial injury currents explains its pathophysiological explanation. In LCx occlusions, the electrical vector is away from aVR lead, so the ST-segment depression is seen, and in proximal RCA occlusion, the depression may be less pronounced or absent (2). According to Raza et al., the clinical utility of aVR depression, particularly when patients have atypical ECG patterns or when angiographic facilities are not available or are delayed (2).

The initial diagnosis of STEMI continues to be electrocardiographic interpretation. It is worth noting that Barbosa et al. showed that a detailed assessment of ST-segment deviations across all 12 leads, including aVR, can substantially increase the localization accuracy for the infarct-related artery (3). As noted recently by Barbosa et al., and in support of that conclusion, patients with ST depression in aVR were significantly more likely to have LCx involvement in our study than those without that depression. As chronic total occlusion of the left anterior descending artery (LAD) is less common (4), Zheng et al. also demonstrated that ST-segment patterns in IW-STEMI may not represent chronic total occlusion of LAD. Such complexity in the interpretation of ECG findings for multivessel disease and the correlation of clinical and angiographic results suggests that this should be recognized. However, Osman et al. noted that depression of aVR can serve to localize if such findings are identified in light of ST elevations in the inferior leads and the reciprocal changes in the other leads (5).

These results are consistent with those of Joseph and Menon, who studied the sensitivity and specificity of ECG at culprit artery localization, combining several ECG criteria to improve diagnostic accuracy (6). The likelihood of LCx involvement is increased in the presence of ST depression in aVR, and even more so if it is associated with anterior lead depression (7). In the study, reported by Simkhada et al., the common feature of LCx occlusion was ST depression in anterior leads, often accompanied by aVR changes (7). This could be demonstrated by Singh et al. that isolated lead pattern changes were such to mimic or mask LCx involvement (8). This finding also supports using lead aVR in diagnostic protocols to avoid misinterpretation in those patients with ambiguous ECG findings.

Tseng et al. introduced an artificial intelligence application using deep learning models to detect STEMI and localize the culprit vessel with great accuracy (9). However, such technology is not yet available in many low-resource settings. Therefore, since resource constraints may delay advanced diagnostics in many countries, simple yet effective markers such as aVR depression are very important. The study by Aslan and Karahan demonstrated how ST depression in aVR leads to an expanded clinical significance that includes coronary microvascular dysfunction (10). Selecting the percutaneous coronary intervention procedure access route and the expected procedural difficulty become crucial once healthcare providers identify which culprit artery is responsible. Storm et al. reviewed how interpretive lead placement helps clinicians determine what emergent reperfusion strategies should be used (11). Joint analysis of ST depression in V1-V4 and aVR leads to better diagnostic accuracy in specific infarction cases, according to research by Meyers et al. (12). The analysis of aVR along with anterior and posterior leads produces stronger clinical diagnostic information according to our results.

Patients who suffer from multivessel disease face more complicated diagnostic processes since multiple blocked arteries and previous heart attacks can create confusion in ST-segment analysis. Consistent ST depression patterns in aVR help identify a predominately involved LCx in IW-STEMI patients with multivessel disease, according to Aly Ahmed et al.'s research (13). When conducting ST segment analysis on patients with conduction problems or heart enlargement, these interpretations should be handled with extra care. R-wave measurements from V1 can assist in differentiating inferobasal myocardial infarctions, as Zheng et al. reported in their study (14). Artificial intelligence-based ECG analysis assessing aVR leads and other measures has shown effectiveness in diagnosing STEMI and its culprit artery pathologies. However, it needs testing in broader clinical settings (15).

CONCLUSION

The research proved that ST-segment depression in the lead aVR is a profound electrocardiographic indicator to establish the left circumflex artery (LCx) as the primary vessel in patients exhibiting inferior wall ST-elevation myocardial infarction (IW-STEMI). A high-sensitive indicator with acceptable specificity makes this ECG feature valuable for clinicians to identify the ischemic artery during clinical settings when immediate angiographic procedures are unavailable. Diagnosing the culprit artery through a simple 12-lead ECG assessment helps both professionals in their decision-making process and reperfusion tactics. Medical staff must pay attention to lead aVR ST depression because of its diagnostic capabilities while monitoring other ECG parameters for a thorough assessment. Lead aVR analysis should become part of standard clinical protocols because it helps enhance patient benefits and speed up interventions, especially in low-resource settings such as Pakistan. Large-scale analysis of this condition should be pursued to validate the current study results.

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