A STUDY OF ELECTROCARDIOGRAPHY IN PATIENTS WITH ACUTE CORONARY SYNDROME DUE TO LEFT CIRCUMFLEX DISEASE

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Abstract

Background: Isolated Left Circumflex (LCX) coronary artery disease is uncommon and occurs in a small percentage of patients undergoing coronary angiogram. Patients with isolated LCX-related infarction have different patterns of myocardial damage. It is imperative to associate the ECG changes in relation to the site of coronary stenosis and also to evaluate the status of left ventricular function in patients with isolated LCX disease. Therefore, we in the current study aimed to evaluate the electrocardiographic changes in patients with acute coronary syndrome due to left circumflex disease.
Methods: An observational cross-sectional study was conducted in the Department of Cardiology at Mahatma Gandhi Medical College and Research Institute Hospital, Pondicherry. A total of forty-two patients who fulfilled both inclusion and exclusion criteria were analyzed. Data were collected based on age, gender, risk factors, and indication of coronary angiogram with abnormal ECG patterns findings with respect to the distribution of stenosis in LCX.
Results: A total of 42 cases were included in this study based on the inclusion and exclusion criteria. All 42 patients with ACS (acute coronary syndrome) showed ECG changes. These changes included Q waves, ST-segment alterations (elevation, depression, or flattening), and T wave inversion. Q waves were present in 16.7% of cases, ST changes were in 71.4% of cases with ST elevation (STEMI) in 40.5% and ST depression (NSTEMI) in 28.6%, and flattened ST segment in 7.1% of cases T wave inversion was found in 45.2% cases. The most frequently involved lead was the lateral lead with 50.1% of cases. Inferior leads in 35.7%, posterior leads in 33.3% of cases, and inferolateral leads in 28.6%.
Conclusion: This study examined ECG changes in patients with isolated left circumflex artery narrowing (LCX stenosis). All patients with acute coronary syndrome (ACS, n=42) showed ECG abnormalities. These included Q waves, ST-segment shifts, and T wave inversions. Most ECG changes occurred in lateral leads (50.1%), followed by inferior (35.7%) and posterior leads (33.3%).

Keywords: Left Circumflex Artery, Electrocardiography, Acute coronary syndrome, Left coronary artery

Introduction

Acute coronary syndrome(ACS) is the most common cause of morbidity and mortality worldwide and India has reported the highest burden of ACS. Isolated Left Circumflex (LCX) coronary artery disease is uncommon and occurs in a small percentage of patients undergoing coronary angiogram [1]. Stenosis of LCX may be associated with an ECG pattern of inferior myocardial infarction, similar to that of RCA occlusion. Patients with isolated LCX-related infarction have different patterns of myocardial damage. Echocardiography is the leading and most commonly used cardiac imaging technique in patients with symptoms more suggestive of cardiac disease. Conventional echocardiography provides less information regarding the presence and extent of coronary artery disease (CAD) in patients suspected of suffering from stable angina pectoris (SAP) [2]. As myocardium in jeopardy corresponds to the sum of the amount of myocardium distal to the stenosis in the coronary artery tree, and the effectiveness of interventional therapy appears to be more significant in larger than in smaller myocardial injuries independent of site of infarction, hence it is imperative to associate the ECG and ECHO changes about the site of coronary stenosis and also to evaluate the status of left ventricular function in patients with isolated LCX disease with or without myocardial infarction [3]. The ionic changes, pathological alterations and electrophysiological characteristics that accompany different stages of clinical ischemia/infarction are well known. The classic ECG sequence that tends to appear in complete coronary occlusion is as follows. The ECG pattern of subendocardial ischemia (increase of T-wave amplitude) appears first [4]. ST-segment elevation will be present in the case of ischemia. The presence of a prominent Q wave denotes necrosis of the myocardium. clinically, the ECG pattern of changes in the T wave due to ischemia may be recorded from the left ventricular subendocardium or subepicardial in which ischemia causes a delay in repolarization. In the case of subendocardial ischemia, a more positive than normal T wave is obtained, and in the case of subepicardial ischemia (clinical practice: transmural), flattened or negative T waves are obtained [5]. An asymmetrical negative T wave is observed in the case of subepicardial ischemia (clinically transmural), usually associated with an isoelectric ST segment. It is a more common finding, especially in the case of long-term after a Q-wave myocardial infarction [6]. It may be considered to be a manifestation of acute coronary syndrome. In contrast, a common feature of subendocardial ischemia is an increase in T-wave amplitude is observed less frequently and the difficulty in diagnosing is increased because of its transient nature. ECG changes of the ST segment are recorded in the area of the myocardial subendocardium or subepicardium where a significant decrease in blood supply leads to diastolic depolarization. ST depression is recorded if the injury is dominant in the Subendocardium and ST elevation is observed if the injury is subepicardial (clinically transmural) [7]. Mirror image patterns also exist in case of subepicardial injury at the posterior part of the lateral wall of the left ventricle, ST-segment elevation will be noticed in the leads on the back and ST depression will be observed in leads V1– V2. Reciprocal changes are also very useful for locating the culprit artery and the site of the stenosis. LAD artery occlusion leads to ST-segment elevation19 predominantly in precordial leads [8], while occlusion of the right coronary artery (RCA) or left circumflex (LCX) artery leads to ST-segment elevation in inferior leads. The number of leads with ST changes („ups and downs‟) can be used to estimate the extent of myocardium at risk. These methods have some limitations, related to the pseudo-normalization of ST changes in the right precordial leads that mostly occur when the stenosis of RCA occludes to the origin of the right ventricular artery. Better analysis of ST changes in the 12-lead ECG may predict the location of the occlusion.ST elevation is noted in leads that face the head of an injury vector, while ST depression can be noted in the opposite leads as a mirror image. Hence the current study has been planned to study the electrocardiographic changes in cases with Acute Coronary syndrome (ACS).

Material and methods

The present study was a cross-sectional analytical study, conducted in Mahatma Gandhi Medical College and Research Institute, Tertiary Care Hospital, Puducherry. The study was done for a period of one to one and a half years after getting clearance from the institutional ethical committee. All patients with Acute Coronary Syndrome (aged >18 years) requiring coronary angiography in the Department of Cardiology in MGMCRI were identified.

Inclusion criteria

Those patients with Acute Coronary Syndrome whose coronary angiogram showed isolated left circumflex coronary artery disease as the culprit vessel were included in our study.

Exclusion criteria

1. Multi-vessel disease with obstructive disease in the Left Anterior Descending (LAD) and Right Coronary Artery (RCA)
2. Prior angioplasty/ CABG
3. Patients with advanced heart failure
4. Chronic kidney disease
5. Patients with Dual Territory Myocardial Infarction (DTMI)-Anterior Wall Myocardial Infarction (AWMI) + Inferior Wall Myocardial Infarction (IWMI).

All Patients whose coronary angiogram showed isolated left circumflex coronary artery disease, receiving care in the Department of Cardiology, Mahatma Gandhi Medical College and Research Institute, Puducherry during the study period and satisfying the inclusion and exclusion criteria were selected. In patients whose coronary angiogram showed isolated left coronary circumflex artery disease following parameters were studied

1) Mode of clinical presentation (Non-ST Segment Elevation Myocardial Infarction {NSTEMI}, ST Segment Elevation (NSTEMI) Myocardial Infarction {STEMI})
2) Electrocardiographic findings and their distribution and pattern in various leads. ST segment J point elevation >1mm and ST segment depression >1mm in two or more contiguous leads (V5, V6, I, aVL, and lead II, III, and aVF) were considered as STEMI and NSTEMI in our study. T inversion and Q wave >1 mm from the iso-electrical line of all leads were considered as significant.

Clinical presentation: The mode of clinical presentation of the study population was assessed with respect to presentation as effort angina, unstable angina, NSTEMI, and STEMI. Rhythm disturbance during acute presentation as STEMI was also assessed. Hemodynamic parameters were specifically looked for in patients presenting with STEMI.

Electrocardiographic findings: ECGs of the patients enrolled were scrutinized with respect to the presence or absence of Q waves and, the presence or absence of ischemic ST- T changes. The location and magnitude of ST-T changes were analyzed. A combination of Q waves and ST-T changes have been specifically looked for, especially in patients presenting with STEMI. The location of ECG changes with respect to leads were also analyzed. These ECG changes were then correlated with the location of the lesion angiographically LCX. Patterns of high lateral MI and RV MI were also analyzed. Posterior MI was assessed by posterior leads in addition to standard ECG leads. RVMI was assessed by right-sided chest leads in addition to standard chest leads. The pattern of ECG changes with respect to various locations of stenosis in LCX was also studied. Other associated features such as LBBB, RBBB, and LVH were also analyzed.

Risk factor analysis: The patients enrolled were assessed for the presence of major risk factors for CAD. These include hypertension, diabetes mellitus, a family history of coronary artery disease, smoking, and hypercholesterolemia. The average number of risk factors per patient was noted. The number of risk factors (single, multiple, or no risk factor) and the nature of risk factors in the patient population were assessed with respect to the outcome (LCX disease).

Statistical analysis: The data was entered in Microsoft Excel and analyzed using standard statistical packages (eg: SPSS, STATA, JASP, etc.,). The data was presented in the form of frequency and percentages for qualitative variables and mean & SD/median & IQR for quantitative variables. A suitable statistical test (according to the nature and distribution of data and type of variable, e.g. independent t-test/ chi-square test, etc.,) was applied to assess the significance of study findings. A p-value of less than 0.05 will be considered statistically significant. Correlation analysis was done to assess the relationship between the site of stenosis (central vs peripheral) and electrocardiographic patterns/ speckle tracking echocardiographic findings.

Results

A total of forty-two patients who fulfilled both inclusion and exclusion criteria were analyzed. Data were collected based on age, gender, risk factors, and an indication of coronary angiogram with abnormal ECG patterns findings with respect to the distribution of stenosis in LCX the demographic profile of cases is depicted in Table 1.

Table 1: Demographic profile of cases included in the study

Gender	*Frequency*	*Percentage*
Female	7	16.7
Male	35	83.3
Total	42	100.0

Prevalence of Risk Factors: Prevalence of risk factors among the ACS cases was categorized. Among the study population, only 16.7% of patients were female and the rest 83.3% of patients were male. Hence in our study males predominated among ACS cases with isolated LCX disease. In our study, 54.8% of cases were smokers, 47.6% had systemic hypertension, 42.9% of cases had Diabetes Mellitus, 40.5% cases had a family history of CAD and 35.7% of cases had hypercholesterolemia (Table 2).

Table 2: Distribution of risk factors in cases of the study

Risk factors	*Frequency*	*Percentage*
Hyper Cholesterolemia	15	35.7
Systemic Hypertension	20	47.6
Smoking	23	54.8
DM	18	42.9
Family History	17	40.5

Electrocardiographic changes in isolated LCX Stenosis: Among the included cases of ACS, there were STEMI cases(n=17) of 40.5%. NSTEMI cases (n=20) of 47.6% and unstable angina cases(n=5) of 11.9%. Out of 40.5% of STEMI cases, High lateral wall MI was noticed in 5.8% of cases (Table 3).

Table 3: Distribution of ACS

Diagnosis	*Frequency*	*Percentage*
STEMI	17	40.5
NSTEMI	20	47.6
Unstable Angina	5	11.9
Total	42	100.0

ECG changes were observed in all 42 cases, and they were analyzed based on the presence of Q wave, ST -T changes like ST elevation or depression or flattening, presence or absence of T wave inversion Among 42 ACS cases, the presence of Q wave was noted in 7 cases (16.7%). Among 71.4% of cases with ST changes, ST elevation(n=17) was noted in 40.5% of cases, ST depression(n=12) in 28.6% of cases, and flattened ST changes(n=3) were noted in 7.1% of cases. T wave inversion was noticed in 19 cases (45.2%) depicted in Table 4.

Table 4: Distribution of ECG changes

ECG changes	*Frequency*	*Percentage*
ST elevation	17	40.5

ST depression	12	28.6
ST flattening	3	7.1
T wave inversion	19	45.2
Q waves	7	16.7

ECG changes were noticed in 21 cases (50.1%) with lateral lead changes, 15 cases (35.7%) with inferior lead changes, 12 cases (28.6%) with inferolateral lead, 14 cases (33.3%) with posterior lead and 4 cases (9.5%) with RVMI. Out of 21 cases with lateral lead ECG changes,2.4% of cases(n=2) presented high lateral lead MI, and 4.8% of cases(n=4) presented with 100% occlusion in Central LCX stenosis. Early prominent R wave in a VR was found in 6 cases constituted 14.3% and T wave inversion(n=12) in V4R was noticed in 28.6% of cases depicted in Table 5.

Table 5: Distribution of ECG changes with respect to regional lead

ECG changes	*Frequency*	*Percentage*
Lateral lead changes	21	50.00
Inferior lead changes	15	35.7
Inferior lateral lead changes	12	28.6
Posterior	14	33.3
RVMI	4	9.50
R in AVR	6	14.3
V4 R T inversion	12	28.6

The relationship between the site of LCX stenosis and ECG changes was analyzed. There was evidence of significant lateral lead ECG changes noted in 18 cases of central LCX stenosis (Table 6) and also significant inferior lead ECG changes noted in peripheral LCX stenosis given in Table 7.

Table 6: Relationship between site of LCX stenosis and lateral lead ECG changes.

Lateral lead ECG changes	*LCX stenosis*		*p-value*
	Central	Peripheral	
Absent	11	10	0.043*
	37.93%	76.92%	
Present	18	3	
	62.07%	23.08%	
Total	29	13	
	100%	100%	

*Significant

Table 7: Relationship between site of LCX stenosis and Inferior lead ECG changes.

Inferior lead ECG changes	*LCX stenosis*		*p-value*
	Central	Peripheral	
Absent	20	7	0.488
	68.97%	53.85%	
Present	9	6	
	31.03%	46.15%	
Total	29	13	
	100%	100%	

In our study, the total number of STEMI cases was 17 out of which 8 cases of inferior wall MI were associated with peripheral LCX stenosis (non-dominant LCX 3 cases and dominant LCX 5 cases) and 9 cases of lateral wall MI associated with central LCX stenosis (non-dominant LCX 5 cases and dominant LCX 4 cases) given in table 8.

Table 8: Relationship between ECG leads changes with the site of LCX stenosis in STEMI

STEMI	*Central LCX stenosis*	*Peripheral LCX stenosis*	*Total*	*Nondominant LCX*	*Dominant LCX*	*Total*
Inferior lead changes	0	8	8	3	5	8
	0%	100%	100%	37.5%	62.5%	100%
Lateral lead changes	9	0	9	5	4	9
	100%	0%	100%	52.9%	44.4%	100%
Inferolateral lead changes	1 (with peripheral)	2	3	2	1	3
	33.33%	66.67%	100%	66.67%	33.33%	100%
Posterior lead changes	7	2	9	3	6	9
	77.78%	22.22%	100%	33.33%	66.67%	100

Out of 20 NSTEMI cases in our study, 10 cases had ST depression in the lateral lead of which 9 cases had central LCX stenosis and only 1 case had peripheral stenosis. There were 6 cases with inferior lead changes of which 5 cases had peripheral stenosis and only 1 case had central LCX stenosis. Here mostly nondominant LCX was found in inferior wall MI with peripheral LCX stenosis and the dominant LCX was found in lateral wall MI with central LCX stenosis given in Table 9.

Table 9: Relationship between ECG leads changes with the site of LCX stenosis in NSTEMI

NSTEMI	Central LCX stenosis	Peripheral LCX stenosis	Total	Nondominant LCX	Dominant LCX	Total
Inferior lead changes	1	5	6	4	2	6
16.7%	83.3%%	100%	66.7%	33.3%	100%	
Lateral lead changes	9	1	10	4	6	10
90%	10%	100%	40%	60%	100%	
Inferolateral lead changes	6	1	7	2	5	7
	85.71%	14.29%	100%	28.57%	71.43%	100%
Posterior lead changes	5	0	5	2	3	5
100%	0%	100%	40%	60%	100	

Discussion

There are only a few studies in the literature comparing ECG abnormalities in patients with that of the location of isolated left circumflex stenosis. Isolated left coronary circumflex artery stenosis is an uncommon cardiovascular event that accounts for 20% of myocardial infarction and poses a diagnostic dilemma, primarily when the ECG findings are nondiagnostic for STEMI. LCX stenoses are associated with an increased risk of heart failure and mortality at 1 year when compared to RCA and LAD lesions [9]. Most of the patients in our study had documented myocardial infarction/ischemia and underwent coronary angiogram as per standard indicators. In a similar study by Somani AP et al. [10] for the prevalence of risk factors in acute coronary syndrome. They reported a higher incidence of ACS cases among which 48% were > 60 years of age,73% were male, 68.5% were hypertension, 54.5% were smokers, 47.5% were Diabetes Mellitus and 46% were hyperlipidemia. These findings were similar to our study. In a clinical study of 1562 ACS cases conducted by Sharma R et al. [11], most patients had STEMI(63.7%) followed by unstable angina (25%) and NSTEMI accounted for 11.3%. When compared to our study, among the 42 ACS cases, there were STEMI cases of 40.5%, NSTEMI cases of 47.6%, and unstable angina cases of 11.9%. In our study, the higher incidence of NSTEMI cases could be due to the inclusion criteria we used and a similar report had already been observed in a previous study by Anumeha Singh et al. [12] O'Keefe et al. [13] stated that ECG changes in LCX occlusions are highly variable. Approximately 30 – 50% of patients present with ST elevation, usually in the inferior leads II, III, and aVF, ST depression in leads V1 to V4, or occasionally a tall R wave in lead V1. In up to 38% of patients, there was no detectable ST elevation.

In our study, ECG changes were noticed in all 42 cases out of which 7 cases(16.7%) presented with Q wave in lateral lead(3 cases), inferior lead(4 cases), inferolateral lead(1 case), and posterior lead(3 cases). Among 71.4% of cases with ST-T changes, ST elevation(n=17) was noted in 40.5% of cases, ST depression(n=12) was noted in 28.6% of cases, and T wave inversion was noted in 19 cases(45.2%).21 cases(50.1%) had lateral lead changes, 15 cases (35.7%) had inferior lead changes, 12 cases (28.6%) had inferolateral lead, 14 cases(33.3%) had posterior lead changes and 4 cases(9.5%) had changes in lead V4R. Shen et al. [14] conducted a clinical study about the relation of electrocardiographic patterns to clinical and angiographic features in 89 patients with isolated left circumflex coronary artery disease (46 with MI and 43 without MI). ECG abnormalities were noticed in 75 patients such as isolated Q waves in 20 cases, an abnormal R wave in V1 lead with or without inferior and/or lateral Q wave found in 21 cases, and isolated ST-T wave changes found in 34 cases. Inferior lead abnormalities on ECG were noticed in patients with both proximal and distal LCX stenosis, but an abnormal R wave in lead V1 correlated with proximal LCX stenosis (p less than 0.01). Lateral lead abnormalities were more common in stenosis of the obtuse marginal branch and proximal LCX than in distal stenosis (all p less than 0.01). In our study, there was no significant abnormal R wave in V1 lead but we had 6 cases with early prominent R wave in AVR lead which correlated to inferior wall MI. In our study, the relationship between the site of LCX stenosis and ECG changes was analyzed. There was evidence of significant lateral lead ECG changes in 18 cases of central LCX stenosis out of which 10 cases had dominant LCX. The inferior lead ECG changes in 15 cases of peripheral LCX stenosis out of which 9 cases had nondominant LCX. In our study, we observed that among patients with NSTEMI ST-T changes were noted in inferior leads that correlated with the site of stenosis at peripheral LCX and they had mostly a non-dominant LCX. And if ST-T changes were noted predominantly in lateral leads then the site of occlusion was mostly central with a dominant LCX.

Conclusion

This study examined ECG changes in patients with isolated left circumflex artery narrowing (LCX stenosis). All patients with acute coronary syndrome (ACS, n=42) showed ECG abnormalities. These included Q waves, ST-segment shifts, and T wave inversions. Most ECG changes occurred in lateral leads (50.1%), followed by inferior (35.7%) and posterior leads (33.3%). Interestingly, the location of stenosis impacted ECG findings. Central stenosis (proximal artery) was more common and linked to lateral lead changes, while peripheral stenosis (distal artery) was associated with inferior lead changes. This suggests ECG can be a useful tool to pinpoint the location of LCX stenosis.

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