



## **ROLE OF ELECTROCARDIOGRAPHIC CHANGES IN AVR AND V1 IN PREDICTING LEFT MAIN OR LEFT MAIN EQUIVALENT CORONARY ARTERY OBSTRUCTION**

**SantoshLal Shrestha<sup>1,2</sup>, Navin Adhikary<sup>1,3</sup>, Bo Yang<sup>2\*</sup>**

<sup>1</sup>Internal Medicine Resident,

<sup>2</sup>Department of Cardiology, Renmin Hospital, Wuhan University, Wuhan, China.

<sup>3</sup>Department of Endocrinology, Zhongnan Hospital, Wuhan University, Wuhan, China.

### **ABSTRACT**

To determine the electrocardiographic features associated with left main coronary artery (LMCA) or Left main equivalent coronary artery (LMEQ) obstruction. Early detection of LMCA or LMEQ coronary artery is very important in selecting the appropriate treatment strategy as delay in diagnosis can have catastrophic consequences. We randomly selected 41 angiographically proven LMCA or LMEQ coronary artery obstruction patients and manually analyzed their ECG retrospectively. ST-segment elevation was significant in lead aVR (51.2%), and lead V1 (48.8%). ST depression was significant in lead V5 (48.78%), and lead V4 (36.5%). The combination of ST elevation in aVR with ST depression in precordial leads was significant in aVR and V5 combination (39.0%), and aVR and V4 combination (34.1%). LM with TVD had the highest incidence (34.1%) followed by LM with SVD (29.3%), LM with DVD (19.5%) and LMEQ only (17.1%). ST-segment elevation in lead aVR and/or V1 can give indication of LMCA occlusion. Careful reading of ECG is vital in the diagnosis of LM or LMEQ obstruction.

**Keywords:** Left main stenosis, Lead aVR, Lead V1, ST depression, ST elevation.

### **INTRODUCTION**

Acute coronary syndrome (ACS), a leading cause of morbidity and mortality worldwide, is on the rise because of increasing prevalence of obesity and diabetes [1]. Coronary artery disease (CAD) accounts for 13.2% (7.4 million) of all deaths worldwide [2]. ACS consists of three problems, namely ST elevation myocardial infarction (STEMI), non-STEMI (NSTEMI), and unstable angina (UA). The heart is supplied by two main coronary arteries, left main coronary artery (LMCA) and right coronary artery (RCA). LMCA further bifurcates into left anterior descending (LAD) and left circumflex (LCX). LMCA usually supplies 75% of the left ventricle (LV) mass, but can supply entire LV mass if the circulation is left dominant [3]. Coronary artery obstruction is caused by atherosclerosis with superimposed thrombosis in most cases of ACS, while other rare causes such as congenital

abnormalities, spontaneous aortic root dissection, infective endocarditis, embolic events, and local thrombus formation can also contribute to obstruction.<sup>3</sup> Although isolated LMCA obstruction is found only in about 0.5% of all acute myocardial infarction (AMI) cases [4], additional significant obstruction in other branches of coronary artery can substantially increase the contribution [3]. Left ventricular dysfunction with severe hemodynamic deterioration and malignant arrhythmias are the serious, and life-threatening conditions associated with acute LMCA obstruction [5, 6]. Therefore, predicting acute LMCA obstruction by electrocardiography (ECG) at the earliest is crucial for management and prognosis [6, 7].

### **MATERIALS AND METHODS**

A retrospective study of randomly selected

patients with angiographically proven left main(LM) disease and left main equivalent (LMEQ, both ostial LAD and ostial LCX narrowing) disease, either alone or with other coronary artery disease, was done. These patients underwent coronary catheterization at Hubei General Hospital (Renmin Hospital of Wuhan University)during June 2014 to July 2015. Angiographic findings of LM stenosis >50% and other vessels stenosis>70% were included. Pre-angiography ECGs were collected from hospital database and analyzed manually. The observations were specially focused at ST segment elevation of >0.05 mV occurring 80 ms from J-point in the aVR limb lead and ST segment elevation of >0.1 mV in chest lead V1. ST segment elevations >0.05 mV in other limb leads, and >0.1 mV in other precordial leads were also considered significant. Similarly, any lead with ST segment depression>0.1mV was also regarded significant. All the observations were tabulated and subjected to analyses. SPSS version 22.0 (SPSS Inc., Chicago, IL) was used for all statistical analyses and graphical representations.

## RESULTS

### Demography

Total of 41 patients were randomly selected who had percutaneous catheter intervention (PCI) in the LMCA or LMEQ lesion. Out of them, 38 (92.7%) patients were admitted through outpatient department (OPD)while 3 (7.3%) patients came through emergency department (ED).The chief indication for performing electrocardiogram (ECG) of these patients were retro-sternal chest pain and/or shortness of breath on mild exertion. We observed that male patients had a higher prevalence rate of LMCA diseases compared to females, 85.4 % (n=35) vs.14.6 % (n=6). The mean age of symptom presentation was found to be  $62.10 \pm 10.14$  (age variation from 33 to 81). Similarly, 73.2 % (n=30) of these patients had history of hypertension (HTN), 24.4 % (n=10) had diabetes mellitus (DM), and 26.8% (n=11) had history of dyslipidemia (Refer to Table 1). All of them were under medication and regular follow up.

**Table 1. Demographic Data**

	(n=41)
Age (years)	62.1±10.14
Male	35 (85.4%)
Female	6 (14.6%)
HTN	30 (73.2%)
DM	10 (24.4%)
Dyslipidemia	11 (26.8%)
HTN- hypertension; DM- diabetes mellitus	

**Table 2. Lesion Type**

	(n=41)
LMEQ	7 (17.1%)

### Coronary Angiography (CAG) and PCI

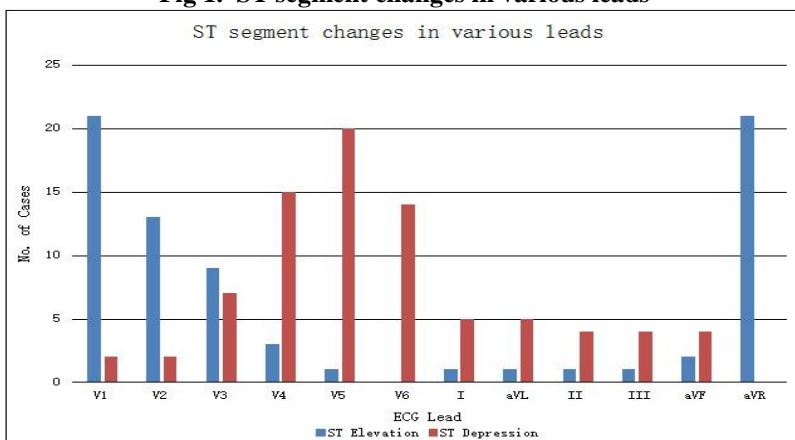
We observed that all the patients had LM lesion with some association with other coronary vessels (RCA, LAD, or LCX), and none had sole LM lesion. 17.1% (n=7) of the patients had LMEQ lesion;29.3% (n=12) had LM lesion with single vessel disease (SVD) {19.5%(n=8) in LM and LAD, 4.9%(n=2) in LM and RCA, and 4.9%(n=2) in LMEQ and RCA lesion}; 19.5% (n=8) had LM lesion with double vessel disease (DVD) {14.6%(n=6) in LM, LAD and LCX, 4.9%(n=2) had lesions in LM, LAD and RCA}; and 34.1%(n=14) had LM lesion with triple vessel disease (TVD){lesions in RCA, LAD and LCX}(Refer to Table 2). All of these patients received PCI and we observed that 19.5%(n=8) had PCI only in LM; 29.3%(n=12)in both LM and LAD; 2.4%(n=1) in LM and LCX; 2.4%(n=1) had PCI in LM and RCA; 19.5%(n=8) in LM, LAD and LCX; 2.4%(n=1) in LM, LAD and RCA; 4.9%(n=2) received PCI in LM,LAD,LCX and RCA; 14.6%(n=6) in LMEQ only; and4.9%(n=2) in LMEQ and RCA.

### ECG findings

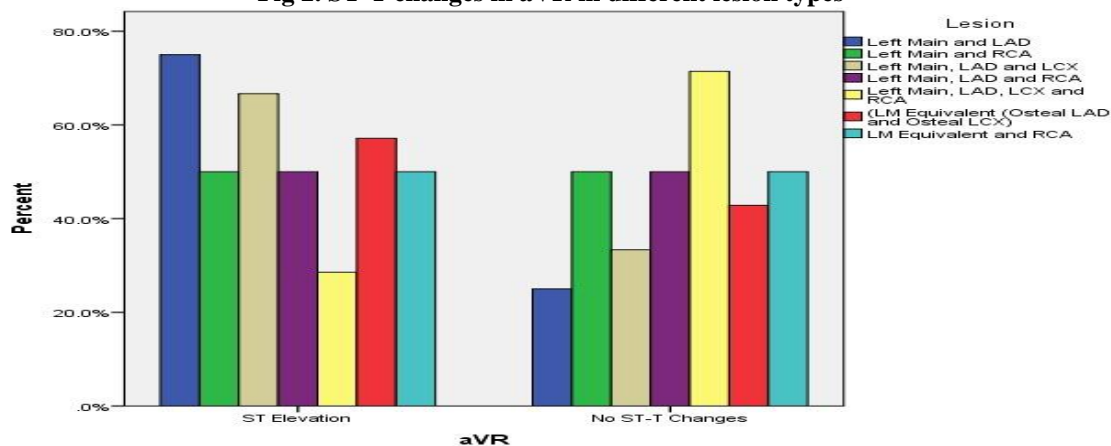
We noticed that majority of the patients had a normal QRS axis 92.7 % (n=38),4.9%(n=2) had left axis deviation, and only 2.4%(n=1) had extreme axis deviation. Similarly, ST elevation was found in 51.2%(n=21) patients in lead aVR, 48.8%(n=20) in lead V1, 2.43% (n=1) in the inferior leads (II, III, aVF). Also, ST depression was seen in 36.5%(n=15) patients in lead V4, 48.78% (n=20)in lead V5, 34.14% (n=14) in lead V6, 9.75% (n=4) in leads II, III, aVF and 12.19% (n=5) in leads I, aVL. When we looked into the combination of ST elevation in aVR with ST depression in precordial leads,we found that 39.0% (n=16) had aVR and V5 combination, 34.1% (n=14) had aVR and V4 combination and 31.7% (n=13) had aVR and V6 combination. ST changes in various leads are depicted in Figure 1. Similarly, ST-T changes due to different lesion types in leads aVR, V1, V4, and V5 are demonstrated in Figure 2, 3, 4 and 5. Figure 6 and 7 show ST elevation in leads aVR and V1, along with ST-T changes in other leads.

LM and SVD	12 (29.3%)
LM and DVD	8 (19.5%)
LM and TVD	14 (34.1%)
LM- left main; LMEQ-left main equivalent; SVD- single vessel disease; DVD- double vessel disease; TVD- triple vessel disease	

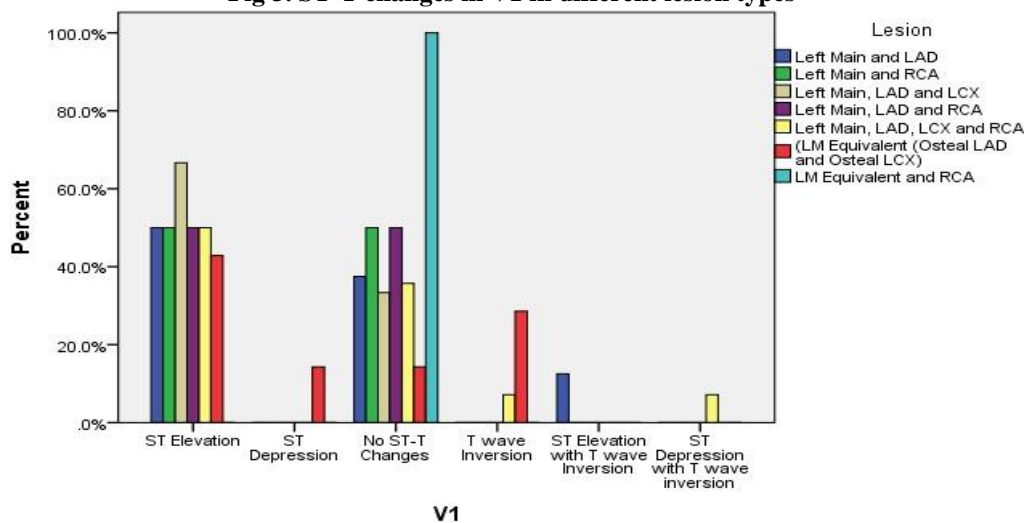
**Fig 1. ST segment changes in various leads**

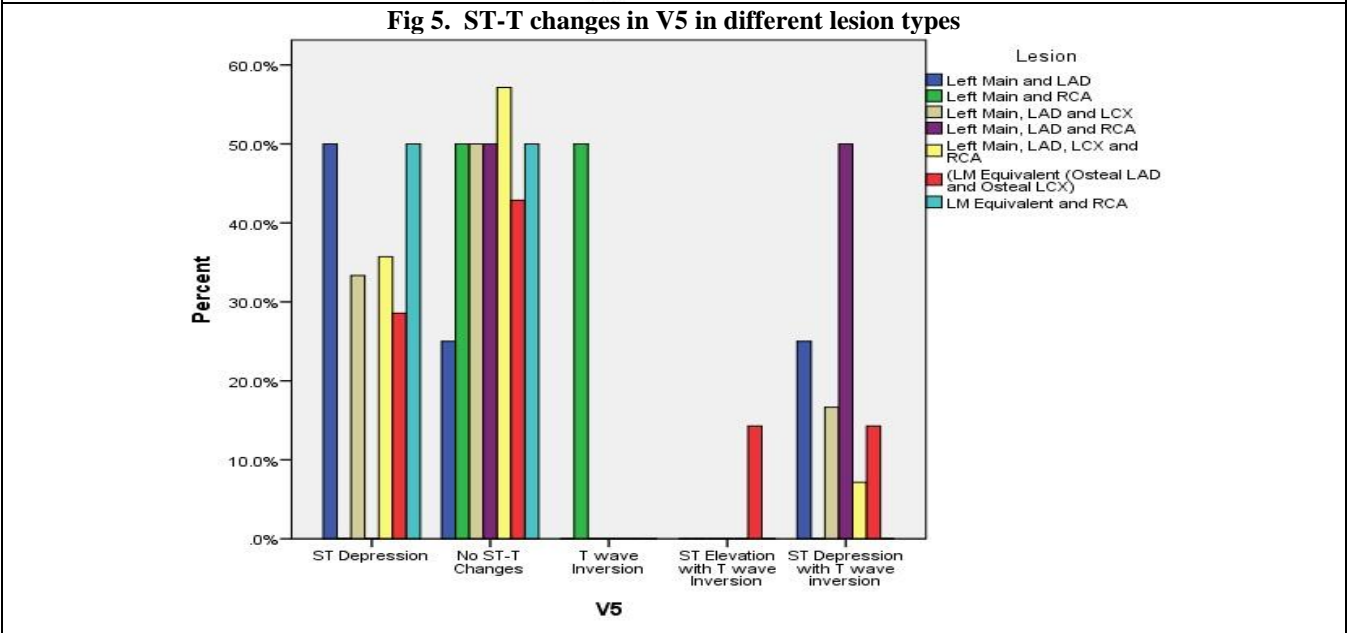
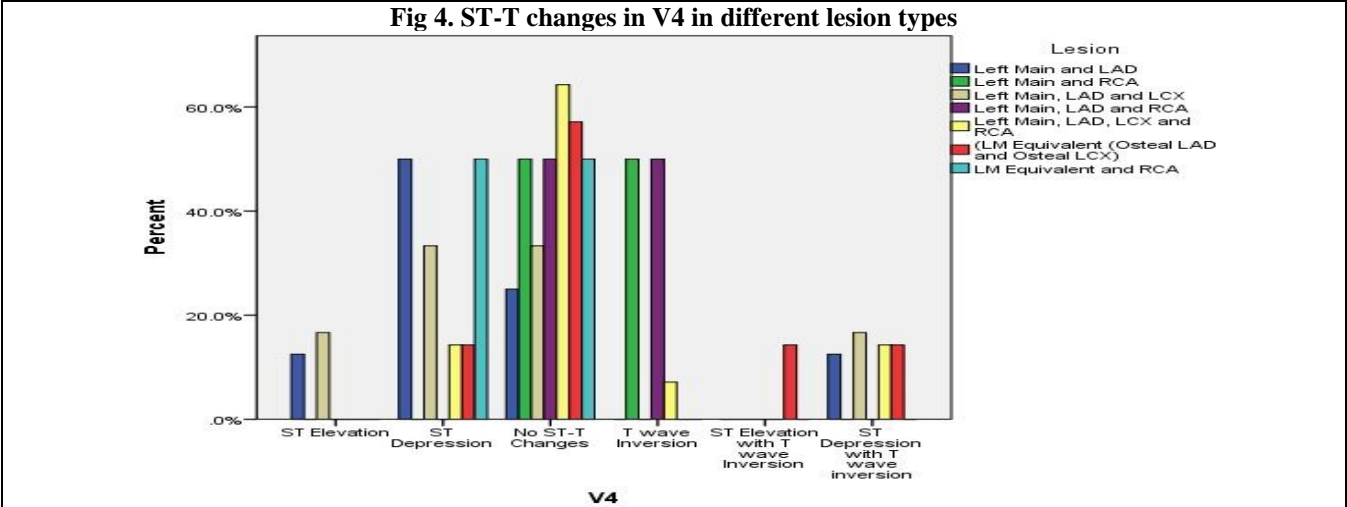


**Fig 2. ST-T changes in aVR in different lesion types**

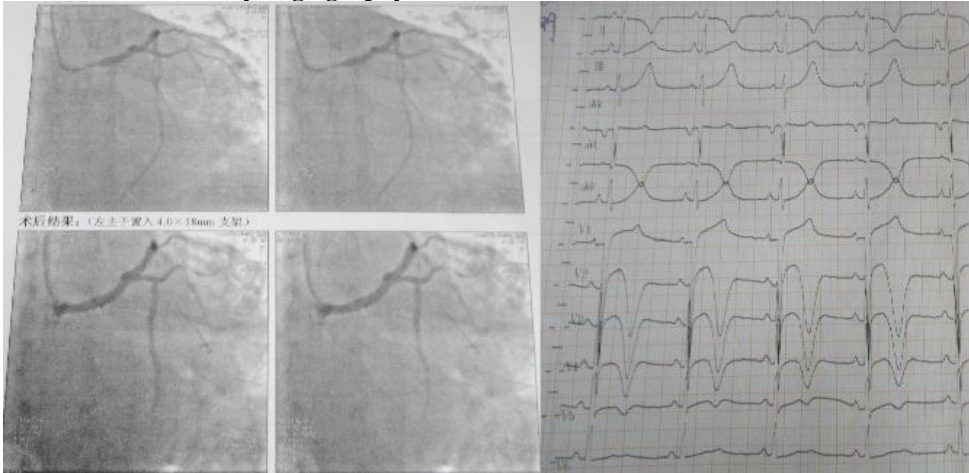


**Fig 3. ST-T changes in V1 in different lesion types**

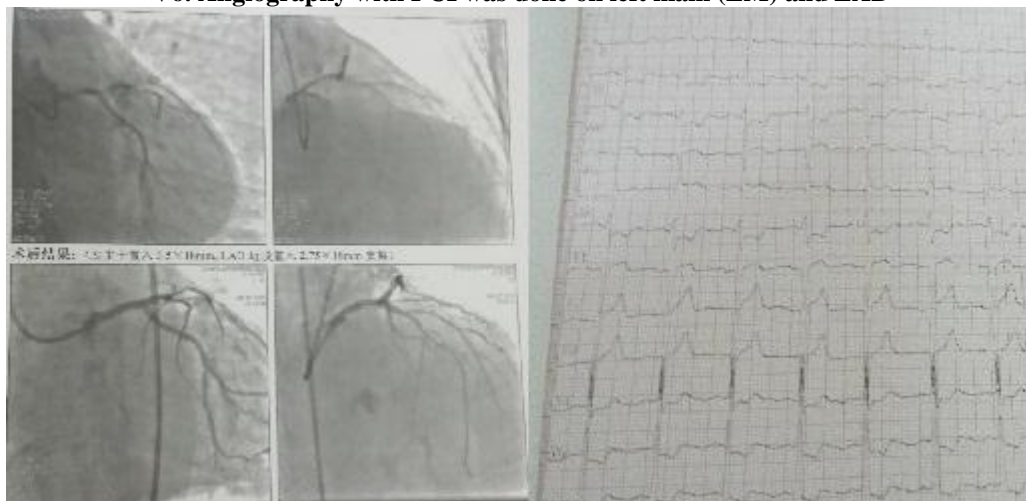




**Fig 6. 49 years old man, a known case of T2DM, presented with the complaint of retrosternal chest pain and shortness of breath. There was ST-elevation in lead aVR, V1-V3 with T wave inversion in lead V2-V5, I, aVL. Coronary angiography with PCI was done in left main (LM)**



**Fig 7. 81 years old man presented with the chief complaint of retrosternal chest pain and shortness of breath on mild exertion. There was ST-elevation in lead aVR,V1,V2,V3 and ST depression in the inferior leads and leads V4-V6. Angiography with PCI was done on left main (LM) and LAD**



## DISCUSSION

ECG finding, that is specific for isolated LMCA obstruction, is quite a difficult observation. The ECG changes of LMCA occlusion is mostly witnessed along with associated lesions in other coronary vessels. There commendation for diagnosing LMCA obstruction or MVD (multi vessel disease) by the AHA (American Heart Association)/ACCF (American College of Cardiology Foundation)/HRS (Heart Rhythm Society) for resting ECG that reveals ST segment elevation in aVR and/or V1 with ST segment depression  $> 0.1\text{mv}$  in 8 or more body surface leads is associated with 75% predictive accuracy [8]. However, many studies have identified other ECG leads that could also aid in diagnosing LMCA or MVD in clinical practice.

Many studies have been conducted by different institution, mainly presenting their hospital database based cohorts. Most of the studies have highlighted and established the diagnostic criteria such as ST-elevation in lead aVR and extensive endocardial injury [9, 10]. This idea was reinforced by another study that also identified ST elevation in aVR alone as a strong predictor of LMCA obstruction or TVD [11]. Moreover, studies have also reported that ST-segment elevation  $>0.05\text{ mV}$  in lead aVR is 80% sensitive and 93% specific for LM or TVD in NSTEMI patients [12]. Some studies have identified ST-elevation in lead aVR with concomitant ST depression in leads I, II and V4-V6 as predictive of LMCA obstruction or TVD, especially when the total magnitude of ST changes exceeded 12 mm [13]. While some scholars have observed ST-elevation in lead aVR  $\geq$  ST elevation in lead V1 as a distinguishing feature of LMCA occlusion from LAD and RCA occlusion with high validity [14]. Similarly, Taglieri et al reported ST elevation in lead aVR with ST depression in other leads in 42% of patients with

NSTE-ACS (non-ST elevation-acute coronary syndrome) due to LMCA stenosis [15]. The ECG findings of ST-segment depression in leads II, III and V4-V6 may point toward an inferolateral ischemia, but the concurrent ST-segment elevation in lead aVR is a positive indication of LM or TVD [16]. Also, another study identified ST-segment depression in lead V3-V5 (more in lead V4) and ST-segment elevation in leads V1 and aVR in angiographically proven LMCA disease [9].

Surprisingly, one prospective study, involving NSTE-ACS patients with ST-segment depression with positive and negative T deflections in leads V4-5, showed 76% of the patients with negative T wave deflections had LM or LMEQ disease, whereas positively T wave deflected group had non-severe TVD in 20% and LM disease in 8% of the patients [17]. This finding also brings into light the importance of T wave deflection, whether positive or negative, in the leads V4-5 in conjunction with ST segment depression in the diagnosis of LMCA related diseases [17, 18]. Adding to this, another study suggested that ECG findings of anterior ST-segment elevation, ST-segment depression in the chest leads, right bundle branch block (RBBB) and ST-segment elevation in leads I and aVL, could suggest LMCA occlusion [19]. Similarly, RBBB, a widespread ST-segment depression with maximal shift in lead V4-6, and anterolateral ST-segment elevation have also been noticed in LMCA occlusion or TVD.

## LIMITATIONS

This study is a single-center based study and suffers from a limited number of cases. ECG were recorded mostly in the OPD, in patients with history of retro-sternal chest pain and/or shortness of breath on mid exertion. The timing of ECG, in concordance with chest

pain, could have resulted in typical findings as described in other relevant studies. Pure LMCA occlusion can progress forward to other coronary vessels, or can be the result of backward progression from other coronary vessel. The exact sequence and pattern demands serial ECG, pre-angiography ECGs and careful follow up of chest pain, which was not done in our study. A case of non-atherosclerotic occlusion was not entertained. Besides HTN and DM, many anatomical and pathophysiological factors as well as severity of stenosis can also influence the ECG patterns.

## CONCLUSION

The present study showed that ST-elevation in

Lead aVR and V1 may give us an indication of LMCA occlusion. A careful examination of ECG adds a predictive importance towards diagnosing LMCA occlusion or LMEQ obstruction. Ignoring ECG changes in aVR, a so called “neglected lead”, may lead to cardiac catastrophe.

## ACKNOWLEDGEMENT

None.

## CONFLICT OF INTEREST

The authors do not have any conflict of interest to declare.

## REFERENCES

1. Thom T, Haase N, Rosamond W, et al. Heart disease and stroke statistics–2006 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation*, 113(6), 2006, e85–e151.
2. <http://www.who.int/mediacentre/factsheets/fs310/en/index.html>.
3. Nikus KC. Electrocardiographic presentations of acute total occlusion of the left main coronary artery. *J Electrocardiol*, 45(5), 2012, 491-493.
4. Aygul N, Ozdemir K, Tokac M, et al. Value of lead aVR in predicting acute occlusion of proximal left anterior descending coronary artery and in-hospital outcome in ST-elevation myocardial infarction: an electrocardiographic predictor of poor prognosis. *J Electrocardiol*, 41(4), 2008, 335-341.
5. Wong SC, Sanborn T, Sleeper LA, et al. Angiographic findings and clinical correlates in patients with cardiogenic shock complicating acute myocardial infarction: a report from the SHOCK Trial Registry. Should we emergently revascularize Occluded Coronaries for cardiogenic shock? *J Am CollCardiol*, 36(3), 2008, 1077-1083.
6. Feyter PJ, Serruys PW. Thrombolysis of acute total occlusion of the left main coronary artery in evolving myocardial infarction. *Am J Cardiol*, 53(11), 1989, 1727-1728.
7. Nikus KC, Eskola MJ. Electrocardiogram patterns in acute left main coronary artery occlusion. *J Electrocardiol*, 41(6), 2008, 626-629.
8. Wagner GS, Macfarlane P, Wellens H, et al. AHA/ACCF/HRS recommendations for the standardization and interpretation of the electrocardiogram: part VI: acute ischemia/infarction: a scientific statement from the American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Cardiology; the American College of Cardiology Foundation; and the Heart Rhythm Society. endorsed by the International Society for Computerized Electrocardiology. *J Am CollCardiol*, 53(11), 2009, 1003-1011.
9. Atie J, Brugada P, Brugada J, et al. Clinical presentation and prognosis of left main coronary artery disease in the 1980s. *Eur Heart J*, 12(4), 1991, 495-502.
10. Gorgels AP, Vos MA, Mulleneers R, de Zwaan C, Bär FW, Wellens HJ. Value of the electrocardiogram in diagnosing the number of severely narrowed coronary arteries in rest angina pectoris. *Am J Cardiol*, 72(14), 1993, 999-1003.
11. Kosuge M, Kimura K, Ishikawa T, et al. Predictors of left main or three-vessel disease in patients who have acute coronary syndromes with non-ST-segment elevation. *Am J Cardiol*, 95(11), 2005, 1366-1369.
12. Kosuge M, Ebina T, Hibi K, et al. An early and simple predictor of severe left main and/or three-vessel disease in patients with non-STsegment elevation acute coronary syndrome. *Am J Cardiol*, 107(4), 2011, 495-500.
13. Gorgels AP, Engelen DJ, Wellens HJ. Lead aVR, a mostly ignored but very valuable lead in clinical electrocardiology. *J Am CollCardiol*, 38(5), 2001, 1355-1356.
14. Yamaji H, Iwasaki K, Kusachi S, et al. Prediction of acute left main coronary artery obstruction by 12-lead electrocardiography. ST segment elevation in lead aVR with less ST segment elevation in lead. *J Am CollCardiol*, 38(5), 2001, 1348-1354.
15. Taglieri N, Marzocchi A, Saia F, et al. Short- and long-term prognostic significance of ST-segment elevation in lead aVR in patients with non-ST-segment elevation acute coronary syndrome. *Am J Cardiol*, 108(1), 2011, 21-28.
16. Kireyev D, Arkhipov MV, Zador ST, Paris JA, Boden WE. Clinical utility of aVR-the neglected electrocardiographic lead. *Ann Noninvasive Electrocardiol*, 15(2), 2010, 175-180.
17. Nikus KC, Eskola MJ, Virtanen VK, et al. ST-depression with negative T waves in leads V4-V5--a marker of severe coronary artery disease in non-ST elevation acute coronary syndrome: a prospective study of angina at rest, with

- troponin, clinical, electrocardiographic, and angiographic correlation. *Ann NoninvasiveElectrocardiol*, 9(3), 2004, 207-214.
18. Sclarovsky S, Rechavia E, Strasberg B, et al. Unstable angina: ST segment depression with positive versus negative T wave deflections--clinical course, ECG evolution, and angiographic correlation. *Am Heart J*, 116(4), 1998, 933-941.
  19. Martins C, Matias F, Pereira H, Carrageta M. Acute myocardial infarction due to occlusion of the left main. *Rev Port Cardiol*, 19(9), 2000, 931-932.