Diagnostic Value of Electrocardiographic T Wave Inversion in Lead aVL in Diagnosing Coronary Artery Disease in Patients with Chronic Stable Angina

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Abstract

Objectives: The clinical value of T wave inversion in lead aVL in diagnosing coronary artery disease (CAD) remains unclear. This study aims to investigate the correlation between aVL T wave inversion and CAD in patients with chronic stable angina.

Methods: Electrocardiograms (ECGs) of 257 consecutive patients undergoing coronary angiography were analyzed. All patients had chronic stable angina. All patients with secondary T wave inversion had been excluded (66 patients). The remaining 191 patients constituted the study population. Detailed ECG interpretation and coronary angiographic findings were conducted by experienced cardiologists.

Results: T wave inversion in aVL was identified in 89 ECGs (46.8%) with definite ischemic Q-ST-T changes in different leads in 97 ECGs (50.8%). Stand alone aVL T wave inversion was found in 27 ECGs (14.1%) while ischemic changes in other leads with normal aVL were identified in 36 ECGs (18.8%). The incidence of CAD was 86.3%. Single, two- and multi-vessel CAD were found in 38.8%, 28.5% and 32.7% of cases respectively. The prevalence of left main, left anterior descending, left circumflex and right coronary arteries were 4.7%, 61.2%, 29.3% and 44.5%, respectively. T wave inversion in aVL was found to be the only ECG variable significantly predicting mid segment left anterior descending artery (LAD) lesions (Odds Ratio 2.93, 95% Confidence Interval 1.59-5.37, p=0.001).

Conclusion: This study provides new information relating to T wave inversion in lead aVL to mid segment LAD lesions. Implication of this simple finding may help in bedside diagnosis of CAD typically mid LAD lesions. However, further studies are needed to corroborate this finding.

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Introduction

The electrocardiogram (ECG) is a simple and non-invasive bedside diagnostic tool with a well-established role in the diagnosis of coronary artery disease (CAD). Many studies have found that the admission of ECG provides important prognostic information in patients admitted with chest pain. For instance, T wave inversion in anterior or inferior location and or ST-segment depression has been associated with high incidence of CAD.[1-11] However, little is known about the prognostic significance of the lead aVL as a predictor for CAD in patients with chronic stable angina. In terms of the scope of this study, this issue has not been addressed before.

Accordingly, the objective of this study is to assess the ability of T wave inversion in lead aVL to predict CAD in patients with chronic stable angina admitted for coronary angiography at the Sultan Qaboos University Hospital, Oman.

Methods

This was a prospective observational study conducted in patients admitted at the hospital or referred from secondary hospitals with documented CAD as proved by non invasive test (ECG, echocardiography, treadmill exercise, myocardial perfusion imaging or multisided CT scan coronary angiography) requiring invasive coronary angiography. The study population was composed of patients admitted in a 5-month period between December 2008 to April 2009.

All patients referred for coronary angiography with no absolute contraindication aged > 18 years old were included in this study.[12]

The exclusion criteria included clinical situations that may result in secondary aVL lead T wave inversion and or ST segment depression from analysis as Bundle branch block either left or right, aortic stenosis, left ventricular hypertrophy and strain and paced ventricular rhythms.[13]

ECGs were recorded in 12-lead format at a paper speed of 25 mms and calibrated correctly. Detailed 12-lead ECG data were interpreted by senior cardiologists who were blinded to the outcomes. Special interest was made to record ST-T changes and pathological Qs suggestive of CAD with more focus on T wave direction in aVL lead. T waves in aVL were categorized into one of 3 groups, upright, flat or inverted and ST segment depression as isoelectric or depressed.

An informed consent was obtained from each patient prior to the procedure. The angiographic view displaying the greatest degree of luminal diameter reduction of the stenosed coronary segment

was selected. The criteria for the choice of the optimal angle of view included elimination of vessel overlapping and minimization of segment foreshortening. Coronary angiograms were analyzed by interventional cardiologist. Left main coronary artery (LM), LAD, left circumflex (LCX), Ramus Intermedius (RI) and right coronary artery (RCA) with all their branches were defined and plotted on the data sheet. The ostial lesion was defined as lesion affecting the origin of the vessel and or within 3 millimeters (mm) from the origin. Proximal LAD was defined as segment 3 mm from LAD origin to the first diagonal branch (D1), mid LAD from D1 to second diagonal branch (D2) and distal LAD segment was beyond D2. Proximal LVX was defined as segment 3 mm after the origin of LCX to first obtuse marginal branch (OM1), mid LCX from OM1 to second obtuse marginal branch (OM2) and distal LCX was the segment beyond OM2. Proximal RCA 3 mm from RCA origin to the right ventricular branch, mid RCA from the right ventricular branch to RCA bifurcation and distal RCA was the segment beyond its bifurcation.

Descriptive statistics were used to describe the data. For categorical variables, frequencies and percentages were reported. Differences between groups were analyzed using Pearson's chi-squared test. For continuous variables, means and standard deviations (±SD) were presented.

A priori two-tailed level of significance was set at the 0.05 level. Statistical analysis was conducted using STATA version 10.1 (STATA Corporation, College Station, TX).

Results

Out of the 257 patients enrolled in this study, 66 were excluded because they met the exclusion criteria (left bundle branch block 23, right bundle branch block 8, aortic stenosis 18, left ventricular hypertrophy and strain caused by hypertension 16 and paced ventricular rhythm in one patient).

The study population comprised of the remaining 191 patients. Old myocardial infarction either STEMI or NSTEMI was documented in 49 patients (25.7%).

In terms of demographic and clinical data, the baseline characteristics of the patients with respect to gender, mean age, and risk factors for CAD are depicted in Table 1. Patients enrolled in this study were predominantly males (71.2%), with a mean age of 55.2±11.5 years with multiple risk factors for coronary artery disease. The incidence of hypertension was very high (84 patients, 44%) as well as diabetes mellitus (71 patients, 37.2%) reflecting high risk patients for CAD.

Table 1: Baseline demographic criteria

Parameter	Number	Percent
Age, mean±SD, years	55.2±11.5	
Male gender	136	71.2
Hypertension	84	44
Diabetes mellitus	71	37.2
Dyslipidemia	40	21
Old myocardial infarction	49	25.7
Old CABG	9	4.7
Old CVA	1	0.5

SD=Standard deviation; CABG=Coronary artery bypass graft; CVA=Cerebrovascular accident

Angiographic characteristics are detailed in Tables 2A and 2B. The incidence of CAD in the studied population was 86.3%, other coronary angiograms proved evidence of normal coronaries except 3 angiograms that demonstrated slow flow (1.57%) and another one (0.5%) with myocardial bridge. Single, two and multivessel CAD was found in 38.8%, 28.5% and 32.7% respectively. The prevalence of left main, left anterior descending, left circumflex and right coronary arteries were 4.7%, 61.2%, 29.3% and 44.5% respectively. Table 2B detailed lesion location in all main vessels.

The baseline ECG characteristics according to ST changes suggestive of CAD are listed in Table 3. There were 89 patients (46.8%) who had T wave inversion in aVL and only 9 patients (4.7%) had ST depression in aVL. Overall, ECG changes suggestive of CAD were noticed in 97 patients (50.8%) with stand alone T wave inversion in lead aVL found in 27 ECGs (14.1%) while ischemic changes in other leads with normal aVL were identified in 36 ECGs (18.8%).

Table 2A: Baseline angiographic characteristics

Vessel	Number	Percent
Left main artery	9	4.7
LAD	117	61.2
Diagonal arteries	64	33.5
Left circumflex artery	56	29.3
Obtuse marginal arteries	50	26.1
Ramus Intermedius artery	11	5.7
Right coronary artery	85	44.5
Posterior descending artery	11	8.9
Posterolateral artery	8	4.2

LAD=Left anterior descending artery.

Table 2B: Location of coronary artery disease lesions

Location of the artery	Ostial	Proximal	Mid	Distal	*p*-value
LAD, (%)	8.5	55.5	62.4	21.4	0.002
LCX, (%)	12.7	38.2	50.9	12.7	0.001
RCA, (%)	2.4	42.3	52.9	27.1	0.001

LAD=Left anterior descending; LCX=Left circumflex; RCA=Right coronary artery.

Table 3: Baseline ECG characteristics

Parameter	Number	Percent
Heart rate		70.47±13.9
Sinus rhythm	181	94.7
Axis:		
normal		86.9
LAD	22	11.5
RAD	3	1.6
aVL T wave:		
upright	77	40.4
flat	24	12.8
inverted	89	46.8
aVL ST segment depression	9	4.7
CAD evidence in other leads	97	50.8
T wave inversion in aVL with no CAD Evidence in other leads	27	14.1
Evidence of CAD in ECG leads with Normal aVL.	36	18.1

Discussion

The ECG has been established in medical literature as an applicable and reproducible non-invasive diagnostic tool for assessing myocardial ischemia.[14] In the setting of acute coronary syndrome, several ECG findings help to localize the occlusion site of the LAD coronary artery with respect to its major branches as ST segment elevation in lead aVR was found to be very useful in identifying LAD occlusion proximal to first septal perforator.[15,16]

Until now, it is to the authors' understanding that the value of lead aVL in diagnosing CAD in patients with chronic stable angina has not yet been addressed in literature. Wellens syndrome refers to "LAD coronary T-wave syndrome", the criteria of which includes history of anginal chest pain, normal or minimally elevated cardiac enzyme levels, and finally, ECG changes without Q waves with deep inversion of the T-wave in the precordial leads.[17,18,19] In contrast to Wellens syndrome, this study addressed patients with chronic stable angina and relevance of lead aVL in diagnosis of CAD. Given into account the increasing frequency of CAD and limited health resources, it is crucial to identify patients with increased risk for cardiac events for further intervention.

In evaluating the prognostic value of lead aVL T wave inversion in patients with chronic stable angina; after excluding secondary etiologies that may alter the T wave polarity such bundle branch block, left ventricular out flow tract obstruction, hypertension with strain pattern and paced ventricular rhythms, the results from this study showed that T wave inversion in lead aVL significantly predicts LAD lesion typically mid segment.

On ECG ischemic changes, pathological Qs and or ST-T changes suggestive of CAD were identified in 50.8% of all ECGs. The baseline coronary angiographic data proved evidence of obstructive CAD in 86.7% of patients. In the presence of obstructive CAD, there was higher prevalence of left anterior descending artery lesions (61.2%) especially in mid segments (62.4%). Lead aVL T wave inversion was the only abnormal finding that predicted mid LAD lesions (odds ratio 2.931955, 95% confidence interval 1.59-5.37, p=0.001). Despite the fact that there was a trend to predict proximal LAD lesions, it did not however reach statistical significance (p=0.066).

In terms of the prevalence of T wave inversion in lead aVL, interestingly, T wave inversion in lead aVL found in 46.8%, flat and upright T wave seen in 12.8% and 40.4% respectively. Neither flat nor upright T wave in such lead predicted CAD. More interestingly, stand alone T wave inversion in lead aVL was found in 27 ECGs (14.1%) with no pathological Qs and or ST-T changes in other leads, all these ECGs have been described as normal ECG by the referring physicians. (Fig. 1)

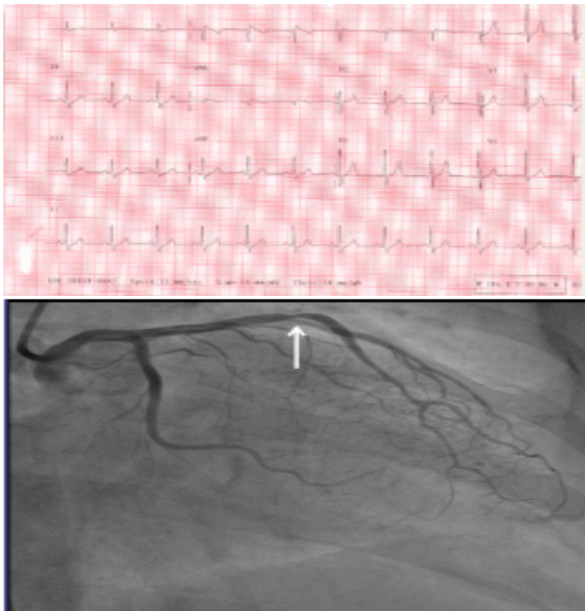

Figure 1: ECG of 60 years old diabetic female who presented with progressive shortness of breath. Note that, the only ECG changes are subtle T wave inversion and small Q wave in lead aVL with no evidence of CAD in other leads. Coronary angiography depicted mid LAD lesion with normal other vessels.

Other ECG ischemic changes in lead aVL: In this series, significant (more than 1 mm) ST segment depression in lead aVL denoting CAD was found in 4.7% of the study population with no statistical correlation with the diagnosis of CAD. The mechanism by which why only T wave inversion in lead aVL predicts CAD, namely mid LAD lesions as opposed to ST segment depression and or pathological Qs or even flat T wave in the same lead is beyond the scope of this study.

The strength of the association between ECG findings and subsequent CAD with increasing morbidity and mortality is particularly interesting when comparing their prognostic value with that of established risk factors such as hypertension, diabetes, smoking, hyperlipidaemia, obesity, and family history of CAD. The observations from this study suggest that aVL lead T wave inversion should alert the health care providers during ECG interpretation in absence of secondary causes that might alter the polarity of T wave amplitude especially in presence of major risk factors for CAD. It is the understanding of the authors that this is the only report showing the high relative importance of this ECG finding in relation to CAD.

Conclusions

This study confirmed the prognostic value of T wave inversion in lead aVL with coronary artery disease typically mid left anterior descending artery lesions in patients with chronic stable angina in absence of secondary ST-T changes. Such undemanding findings add important information to the medical field especially to general practitioners during routine check up or cardiac risk assessment before non cardiac surgery.

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