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Does T wave inversion in lead aVL predict mid-segment left anterior descending lesions in acute coronary syndrome? A retrospective study

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ABSTRACT

Objectives: Limited data are available regarding the predictive value of electrocardiographic T wave inversion in lead aVL for mid-segment left anterior descending (MLAD) lesions among patients with acute coronary syndrome (ACS).

Setting: Retrospective single-centre study, using a prospectively-collected coronary angiography database from January 2012 to December 2013.

Participants: We included consecutive adult patients with ACS who underwent urgent percutaneous coronary intervention (PCI) within 24 h after arriving at the hospital. We excluded patients who did not undergo an ECG before PCI, patients with proximal MLAD occlusion and patients diagnosed with vasospastic angina.

Primary and secondary outcome measures: The primary outcome was MLAD lesion >50%. The other outcome of interest was MLAD lesion as a cause of ACS. First, we evaluated the diagnostic values of T wave inversion in lead aVL regardless of other T wave changes for each outcome. Second, we evaluated the diagnostic values of isolated T wave inversion in lead aVL.

Results: Overall, 219 patients were eligible for the analysis. T wave inversion in lead aVL regardless of other T wave changes had a sensitivity of 32.9%, specificity of 48.2%, positive predictive value of 27.6% and negative predictive value of 54.5% for predicting MLAD lesions. Isolated T wave inversion in lead aVL had a sensitivity of 9.8%, specificity of 86.9%, positive predictive value of 30.8% and negative predictive value of 61.7% for predicting MLAD lesions. These diagnostic values did not change materially when focusing on patients with MLAD lesion as the cause.

Conclusions: While T wave inversion in lead aVL regardless of other T wave changes had low diagnostic values for predicting MLAD lesions, isolated T wave inversion in lead aVL had a high specificity. Our inferences underscore the importance of a cautious interpretation of T wave inversion in lead aVL among patients with ACS.

Strengths and limitations of this study

- This is the first study to evaluate the diagnostic value of T wave inversion in lead aVL for mid-segment left anterior descending (MLAD) lesions among patients with acute coronary syndrome (ACS).
- Although previous studies demonstrated the usefulness of diagnostic values of T wave inversion in lead aVL for MLAD lesions, our observation did not show the usefulness among patients with ACS.
- Since this study is a single-centre, retrospective study, the generalisability of our inferences might be limited.
- Our inferences underscore the importance of a cautious interpretation of T wave inversion in lead aVL among patients with ACS.

INTRODUCTION

The 12-lead ECG is a fundamental tool used to diagnose acute coronary syndrome (ACS) because ST-T changes in ECG reflect myocardial ischaemia and myocardial necrosis after myocardial ischaemia. Based on the diagnosis and prediction of ischaemic lesions using ECG, cardiologists can provide early therapeutic intervention for patients with ACS.[1] T wave inversion in lead aVL has been reported to be a reciprocal change of inferior wall infarctions, mostly caused by right coronary artery lesions.[2 3]

However, several recent, small studies have suggested that T wave inversion in lead aVL is associated with mid-segment left anterior descending (MLAD) lesions.[4–6] For example, a prospective observational study reported that the T wave inversion in lead aVL was significantly associated with a MLAD lesion in >50% of patients with chronic stable angina.[5] Another retrospective study from the USA, using data from 431 patients who underwent percutaneous coronary intervention (PCI), reported that the sensitivity of isolated T wave inversion in lead aVL for predicting a MLAD lesion in >50% of patients was 76.7%, and the specificity was 71.4%.[4] However, these studies were conducted in limited population samples (eg, single-centre studies, including non-urgent PCI), thereby limiting the generalisability of their inferences for patients with suspected ACS. Despite the clinical significance of T wave inversion in lead aVL for the early detection of ischaemic lesions, the association between T wave inversion in lead aVL and a MLAD lesion >50% of patients with ACS is yet to be elucidated.

To address this gap in the current literature, we aimed to investigate the diagnostic value of T wave inversion in lead aVL for MLAD lesions among patients who underwent urgent PCI for ACS.

METHODS

Study design and settings

This is a retrospective analysis using data from the coronary angiography (CAG) database at the Ise Red Cross Hospital from January 2012 to December 2013. The Ise Red Cross Hospital had 655 beds (medical and surgical), with approximately 243 000 outpatients and 230 000 admissions in 2013. There were 18 000 emergency department visits, and 400 PCIs were performed annually (including 120 cases of urgent PCI for ACS). Since 1985, all CAG and PCI data have been prospectively collected for the CAG database. All data including patient's demographics, ECG findings, CAG findings and treatment data, were registered by cardiologists.

Study population

We included consecutive adult patients who underwent urgent PCI. Urgent PCI was defined as a PCI performed for patients with suspected ACS within 24 h after arriving at the hospital.[7,8] In patients with suspected non-ST elevation myocardial infarction, board-certificated cardiologists assessed the need for coronary angiography based on the information on patient's symptoms, laboratory findings, ECG findings and ultrasonographic findings. We excluded patients who met the following criteria: (1) patients who did not undergo an ECG before PCI, (2) patients with complete occlusion of the left main trunk and proximal-segment left anterior descending artery (ie, we could not evaluate the MLAD lesion) and (3) patients diagnosed with vasospastic angina.

T wave inversion

Based on a joint recommendation of the American Heart Association (AHA), the American College of Cardiology Foundation (ACCP) and the Heart Rhythm Society (HRP),[9] we defined the T wave inversion as T wave ≤−0.1 mV, compared with the baseline from the end of the T wave to the beginning of the P wave (see online supplementary figure 1A, B). The T wave inversion in lead aVL was measured by cardiologists who were blinded to the results. In addition, we defined isolated T wave inversion as the presence of T wave inversion only in lead aVL regardless of ST elevation in other leads, using a previously described classification scheme for isolated T wave inversion (see online Supplementary figure 2A, B).[4,9]

Outcome and measured variables

The primary outcome was MLAD lesion >50%. MLAD was defined as the first septal branch to the point where the left anterior descending artery forms an angle in the right anterior oblique view.[10] The other outcome of interest was the MLAD lesion as the cause for ACS. The MLAD lesion as the cause for ACS was defined as (1) the MLAD lesion where PCI was performed or (2) the MLAD lesion diagnosed as the cause by the PCI operator in cases with multivessel disease. Data on patient demographics, including age, sex, smoking, family history of coronary artery diseases, hypertension, history of myocardial infarction, diabetes mellitus and dyslipidaemia, were collected from the database and medical charts of our hospital.

Statistical analyses

Continuous data were presented as the median (IQR), whereas categorical data were expressed as number (%), with differences analysed using the χ^2 test or Fisher's exact test, as appropriate. We calculated the sensitivity, specificity and predictive values of T wave inversion in lead aVL for predicting MLAD lesions (positive predictive value (PPV) and negative predictive value (NPV)). First, we examined the association between T wave inversion in lead aVL regardless of other T wave changes and MLAD lesion. Second, we repeated the analysis focusing on isolated T wave inversion.[4]

For sensitivity analysis, we repeated the analysis after excluding the patients with left ventricular hypertrophy and bundle branch block because these are associated with T wave inversion.[4,11] Data analyses were conducted using R statistical software V.3.0.3 (R Development Core Team, Vienna, Austria). All statistical tests were two-tailed, and the chosen type 1 error rate was $p<0.05$.

RESULTS

A total of 745 patients underwent PCI at the Ise Red Cross Hospital from January 2012 to December 2013. Among these, 263 patients underwent urgent PCI. Of 44 patients who did not meet the inclusion criteria, 2 patients did not undergo ECG before PCI, and 42 patients had complete occlusion of the left main trunk or proximal-segment left anterior descending artery; therefore, 219 patients were eligible for analysis (figure 1).

The median age of the patients was 71 (63–78) years, and 167 patients were male (76%, table 1). The most common coronary risk factors were hypertension (74%), dyslipidaemia (65%) and smoking (50%). Of 219 patients, 137 (63%) patients were diagnosed with ST-elevation myocardial infarction and the remaining 82 (37%) patients were diagnosed with non-ST-elevation myocardial infarction (table 2). The right coronary artery was the site of the most frequent causative lesion,

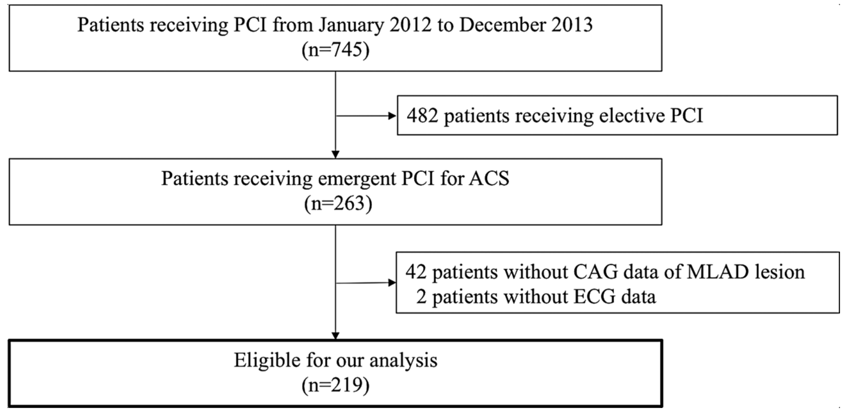

Figure 1 Flow chart of patients included in this study. ACS, acute coronary syndrome; CAG, coronary angiography; MLAD, mid-segment left anterior descending; PCI, percutaneous coronary intervention.

followed by the left anterior descending artery. Single-vessel disease was diagnosed in approximately half of the patients.

Among 219 patients, a total of 98 patients had T wave inversion in lead aVL regardless of other T wave changes and 26 patients had isolated T wave inversion in lead aVL (table 3). There was no difference in the time from symptom onset to initial ECG between patients with T wave inversion and those without (157 (97–293) min vs 173 (78–344) min; p=0.85). Overall, 82 patients had a MLAD lesion >50%. T wave inversion in lead aVL regardless of other T wave changes had a sensitivity of 32.9% (95% CI 22.9% to 44.2%), specificity of 48.2% (95% CI 39.6% to 56.9%), PPV of 27.6% (95% CI 19.0% to 37.5%) and NPV of 54.5% (95% CI 45.2% to 63.6%) for predicting MLAD lesions. By contrast, isolated T wave inversion in lead aVL had a sensitivity of 9.8% (95% CI 4.3% to 18.3%), specificity of 86.9% (95% CI 80.0% to 92.0%), PPV of 30.8% (95% CI 14.3% to 51.8%) and NPV of 61.7% (95% CI 54.4% to 68.5%) for predicting MLAD lesions. Focusing on patients with the MLAD lesion as the cause, T wave inversion in lead aVL regardless of other T wave changes had a sensitivity of 13.5% (95% CI 4.5% to 28.8%), specificity of 48.9% (95% CI 41.4% to 56.4%), PPV of 5.1% (95% CI 1.7% to 11.5%) and NPV of 73.6% (95% CI 64.8% to 81.2%) for predicting the MLAD lesion as the cause. By contrast, isolated T wave inversion in lead aVL had a higher specificity of 86.3% (95% CI 80.4% to 90.9%) for predicting the MLAD lesion as the cause.

In sensitivity analysis after excluding patients with left ventricular hypertrophy and bundle branch block, the performance of the T wave inversion in lead aVL regardless of other T wave changes for predicting MLAD lesions did not change materially (table 4). Focusing on patients with the MLAD lesion as the cause, isolated T wave inversion in lead aVL had a higher specificity of 85.6% (95% CI 78.2% to 91.2%) for predicting the MLAD lesion as the cause.

DISCUSSION

In this retrospective study using data from the CAG database at the Ise Red Cross Hospital from January 2012 to

Table 1 Baseline characteristics of patients who underwent urgent percutaneous coronary intervention

Variables	Overall (n=219)
Age, median (IQR)	71 (63–78)
Male sex	167 (76)
Type of coronary risk factors	
Smoking	110 (50)
Family history of coronary artery diseases	37 (18)
Hypertension	161 (74)
History of myocardial infarction	27 (12)
Diabetes mellitus	76 (35)
Dyslipidaemia	143 (65)
Hyper triglyceride (TG)	51 (23)
Hyper low-density lipoprotein (LDL)	89 (41)
Low high-density lipoprotein (HDL)	32 (15)

Data were expressed as n (%) unless otherwise indicated.

Table 2 Angiographic data of patients who underwent urgent percutaneous coronary intervention

Variables	Overall (n=219)
ST-elevation myocardial infarction	137 (63)
Non-ST-elevation myocardial infarction	82 (37)
Causative lesion	
Right coronary artery	101 (46)
Left main trunk	5 (2)
Left anterior descending artery	78 (36)
Left circumflex artery	32 (15)
High lateral branch	3 (1)
Coronary lesions	
Single-vessel disease	101 (46)
Double-vessel disease	65 (30)
Triple-vessel disease	53 (24)
Number of lesions in left anterior descending artery*	
0	86 (39)
1	108 (49)
2	23 (11)
3	2 (1)

Data were expressed as n (%).
*Number of lesions in left anterior descending artery does not include diagonal branch.

Table 3 Performance of T wave inversion in lead aVL for predicting mid-segment left anterior descending lesion

MLAD lesion	Overall (n=219)	MLAD >50% n=82	MLAD ≤50% n=137	p Value
T wave inversion in lead aVL regardless of other T wave changes*	98 (45)	27 (33)	71 (52)	<0.01
Isolated T wave inversion in lead aVL†	26 (12)	8 (10)	18 (13)	0.59
MLAD lesion as the cause	**Overall (n=219)**	**Cause (+) n=37**	**Cause (−) n=182**	**p Value**
T wave inversion in lead aVL regardless of other T wave changes‡	98 (45)	5 (14)	93 (51)	<0.01
Isolated T wave inversion in lead aVL§	26 (12)	1 (3)	25 (14)	0.09

Data were expressed as n (%).
*Sensitivity 32.9% (95% CI 22.9% to 44.2%), specificity 48.2% (95% CI 39.6% to 56.9%), positive predictive value 27.6% (95% CI 19.0% to 37.5%) and negative predictive value 54.5% (95% CI 45.2% to 63.6%).
†Sensitivity 9.8% (95% CI 4.3% to 18.3%), specificity 86.9% (95% CI 80.0% to 92.0%), positive predictive value 30.8% (95% CI 14.3% to 51.8%) and negative predictive value 61.7% (95% CI 54.4% to 68.5%).
‡Sensitivity 13.5% (95% CI 4.5% to 28.8%), specificity 48.9% (95% CI 41.4% to 56.4%), positive predictive value 5.1% (95% CI 1.7% to 11.5%) and negative predictive value 73.6% (95% CI 64.8% to 81.2%).
§Sensitivity 2.7% (95% CI 0.1% to 14.2%), specificity 86.3% (95% CI 80.4% to 90.9%), positive predictive value 3.8% (95% CI 0.1% to 19.6%) and negative predictive value 81.3% (95% CI 75.1% to 86.6%).
MLAD, mid-segment left anterior descending artery.

December 2013, we found that, among patients with ACS, the diagnostic value of T wave inversion in lead aVL regardless of other T wave changes for predicting MLAD lesions was unsatisfactory. However, isolated T wave inversion in lead aVL had high specificity for predicting MLAD lesions, even after excluding patients with left ventricular hypertrophy and bundle branch block. To the best of our knowledge, this is the first study to evaluate the diagnostic value of T wave inversion in lead aVL for MLAD lesions among patients who underwent urgent PCI for ACS.

T wave inversion in ECG is vital to the early diagnosis and detection of ischaemic lesions in patients with suspected ACS. Reciprocal changes in ECG are recognised earlier than the ST elevation as the reflection of the ischaemic lesion in ACS,[2 3] and 6% of patients with ACS had only reciprocal changes without ST elevation.[3] To date, several studies have focused on the diagnostic values of T wave inversion for predicting MLAD lesions.[4 5 12] Among patients with chronic stable angina, the OR of T wave inversion in lead aVL for predicting MLAD lesions was 2.93.[5] In another study, T wave inversion in leads aVL and I had a sensitivity of 86.5% and specificity of 55.6% for predicting MLAD lesions.[4] However, in our study, T wave inversion in lead aVL regardless of other T wave changes had a low sensitivity of 32.9% and a specificity of 48.2% for predicting MLAD lesions.

The reasons for the disparities in the diagnostic values among studies are likely multifactorial. First, although the definition of T wave inversion was unclear in previous studies,[5 6 12] we clearly defined T wave

Table 4 Performance of T wave inversion in lead aVL for predicting mid-segment left anterior descending lesion, after excluding patients with left ventricular hypertrophy and bundle branch block

MLAD lesion	Overall (n=154)	MLAD >50% n=58	MLAD ≤50% n=96	p Value
T wave inversion in lead aVL regardless of other T wave changes*	65 (42)	18 (31)	47 (49)	0.04
Isolated T wave inversion in lead aVL†	19 (12)	5 (9)	14 (15)	0.40
MLAD lesion as the cause	**Overall (n=154)**	**Cause (+) n=29**	**Cause (−) n=125**	**p Value**
T wave inversion in lead aVL regardless of other T wave changes‡	65 (42)	4 (14)	61 (49)	< 0.01
Isolated T wave inversion in lead aVL§	19 (12)	1 (3)	18 (14)	0.13

Data were expressed as n (%).
*Sensitivity 31.0% (95% CI,19.5% to 44.5%), specificity 51.0% (95% CI 40.6% to 61.4%), positive predictive value 27.7% (95% CI 17.3% to 40.2%) and negative predictive value 55.1% (95% CI 44.1% to 65.6%).
†Sensitivity 8.6% (95% CI 2.9% to 19.0%), specificity 85.4% (95% CI 76.7% to 91.8%), positive predictive value 26.3% (95% CI 9.1% to 51.2%) and negative predictive value 60.7% (95% CI 52.0% to 69.0%).
‡Sensitivity 13.8% (95% CI 3.9% to 31.7%), specificity 51.2% (95% CI 42.1% to 60.2%), positive predictive value 6.2% (95% CI 1.7% to 15.0%) and negative predictive value 71.9% (95% CI 61.4% to 80.9%).
§Sensitivity 3.4% (95% CI 0.1% to 17.8%), specificity 85.6% (95% CI 78.2% to 91.2%), positive predictive value 5.3% (95% CI 0.1% to 26.0%) and negative predictive value 79.3% (95% CI 71.4% to 85.8%).
MLAD, mid-segment left anterior descending artery.

inversion according to the AHA definition;[9] therefore, our findings were less likely to be subject to information bias. Second, a previous study used a combination of T wave inversion in lead aVL and lead I to estimate the diagnostic values.[4] Third, the disparities in the diagnostic values may be attributable to the differences in study population, settings, or any combination of these factors. For example, the study by Farhan *et al*,[5] which reported the effectiveness of T wave inversion in lead aVL in diagnosing coronary artery disease, was limited to patients with chronic stable angina. Another study included patients who underwent non-urgent PCI (ie, elective PCI).[4] Fourth, in general, multivessel lesions cause complicated ECG changes, thereby the differences in the proportions of multivessel lesions compared with previous studies may have been influential.[2] Indeed, the previous two studies had more multivessel lesions than our study did, (53.9% in our study vs 61.2% in Farhan's study, p=0.16; and vs 70.7% in Hassen's study, p<0.01).[4 5]

Although we did not show the diagnostic usefulness of T wave inversion in lead aVL regardless of other T wave changes, isolated T wave inversion in lead aVL (ie, the presence of T wave inversion only in lead aVL) had a high specificity of 86.9% for predicting MLAD lesions. Since treatment strategy and complications depend on the infarction site,[7] isolated T wave inversion in lead aVL might help to predict the site of the ischaemic lesion, resulting in improved patient outcome. Moreover, previous studies reported that approximately 75% of physicians missed an isolated T wave inversion in lead aVL and that the best single lead for the emergency detection of ACS was lead aVL.[12 13] In agreement with this literature, our findings underscore the importance of cautious interpretation of T wave inversion in lead aVL as a clue to predict ischaemic lesions in ACS.

Limitations

Our study has several potential limitations. First, because this study is a single-centre study, the generalisability of our inferences is limited. Nevertheless, we analysed the consecutive data during 2012–2013 with the definition of T wave inversion based on AHA guidelines.[9] Moreover, all T wave inversions were evaluated by cardiologists who were blinded to the results of the PCIs. Second, this study is limited by the small sample size. In particular, isolated T wave inversion was observed in only 12% of patients; therefore, our observations should be validated by a larger study. Third, in this analysis, we did not measure the association between T wave inversion and diagonal lesions.[14] However, to maintain the consistency with the previous literature,[4 5] we focused on the association between T wave inversion in lead aVL and MLAD lesion regardless of the presence of diagonal lesions. Fourth, as with any other observational studies focused on patients with ACS, we could not differentiate whether the MLAD lesion had or had not newly occurred. However, our inferences were not changed materially among patients with ACS caused by the MLAD lesion. Finally, we included patients who underwent PCI. Therefore, our inferences should be used for predicting ischaemic lesions, and not for diagnosing ACS.

CONCLUSIONS

In our study, T wave inversion in lead aVL regardless of other T wave changes had low sensitivity and specificity for predicting MLAD lesions. However, isolated T wave inversion in lead aVL had high specificity. Our inferences underscore the importance of a cautious interpretation of T wave inversion in lead aVL among patients with suspected ACS. In addition, our findings facilitate further studies to validate the diagnostic values of T wave inversion in lead aVL for predicting ischaemic lesions.

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