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Evaluating value of positive T wave in lead V1 and TV1 > TV6 pattern in predicting significant coronary artery disease in patients undergoing coronary angiography

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Original Article

Abstract

BACKGROUND: The aim of this study was to predict significant coronary artery disease (CAD) in patients undergoing coronary angiography.

METHODS: In this cross-sectional study, data of 384 patients who underwent angiography during 2015-2017 were reviewed. Electrocardiograms (ECGs) were evaluated in terms of having positive T wave in lead V1 (TV1) described as T wave with amplitude of more than 0.15 mV and angiography records were assessed for presence of significant CAD defined as presence of ≥ 70% internal diameter stenosis in at least one major epicardial coronary artery or more than 50% stenosis in left main artery (LMA).

RESULTS: Out of 384 patients who participated in this study with mean age of 63.6 ± 10.2 years (40-89 years), 71.6% showed positive TV1 and significant CAD simultaneously and left anterior descending artery (LAD) and left circumflex artery (LCX) lesions were more frequently reported in coronary angiography. Based on chi-square test, the prevalence of significant CAD was obviously more in those with positive TV1 as compared to those without this finding [odds ratio (OR) = 2.74, 95% confidence interval (CI): 1.80-4.19, P < 0.001]. Mann-Whitney test showed significant difference in number of coronary arteries involved in CAD between presence of positive and negative T wave in lead V1 (P < 0.001). Great number of patients with significant CAD had remarkably higher T wave amplitude in lead V1 in comparison to lead V6 (OR = 6.22, 95% CI: 3.14-12.30, P < 0.001).

CONCLUSION: Positive TV1 and TV1 > TV6 pattern can be considered as a predictor for significant CAD in patients with otherwise normal ECG.

Keywords: Coronary Artery Disease; Electrocardiography; Angiography

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Introduction

Cardiovascular events are the most common cause of mortality among non-infectious diseases around the world and coronary artery disease (CAD) which is described as intraluminal stenosis of coronary arteries accounts for more than half of the cases.[1,2]

Electrocardiography (ECG) is still an important, simple, and noninvasive tool for evaluating cardiac disease including CAD. Although different findings in ECG including ST segment depression, negative T wave, and presence of Q wave increase probability of underlying CAD, resting ECG has a limited power to diagnose CAD in early stages.[3-5]

There have been many attempts to stablish link

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between T wave abnormalities and cardiac diseases and studies have demonstrated that isolated T wave abnormalities at the time of emergency department presentation have a predictive value for 30-day cardiovascular events.[6]

In ECG, T wave appears for ventricular repolarization and T wave in pre-cordial lead V1 (TV1) represents repolarization process of anterior and posterior myocardial surface which could be influenced by ischemic events and leads to T wave morphology changes.[7] However, T wave abnormalities have been seen in different conditions which are not necessarily related to heart diseases.[8]

Studies done on T wave have demonstrated that positive T wave in precordial lead V1 presents as a normal variant in healthy adults, infants, and young adults.[9] On the other hand, this finding has been found in some more serious conditions like posterior myocardial infarction (MI) and posterior wall asynergy.[10,11]

Initial work in this field on patients undergoing cardiac catheterization has reported that positive TV1 was frequently seen in patients with left circumflex artery (LCX) involvement.[12] Moreover, some other researches have addressed the presence of positive TV1 in patients with inferior MI resulting from right ventricular (RV) ischemia.[13] It has been also reported that upright T wave in lead aVR (TaVR) results in cardiac death owing to cardiac arrhythmia.[9,14] There have been few researches that considered TV1 taller than T wave in lead V6 (TV6) as an indicator for cardiac diseases.[15,16]

In spite of all studies done on patients with CAD, the predictive value of positive TV1 for underlying CAD has not been well stablished. The current study takes a new look at two fields: 1) to determine whether positive TV1 as a single finding in ECG has the potentiality to predict significant CAD and 2) to determine the link between taller TV1 rather than TV6 pattern and CAD in patients undergoing coronary angiography.

Materials and Methods

In this cross-sectional study, data of 384 patients who underwent coronary angiography during 2015-2017 were reviewed. Patients with following criteria were included in the study: 1) experiencing angiography in hospital from April 2015 to January 2017, 2) having medical records in hospital, 3) aged more than 18 years, and 4) having written consent form in their medical records which allowed researchers to access and use their medical data with considering patient's privacy. Patients with any findings in ECG that affected repolarization process including inverted T waves beyond lead V1, ST segment abnormalities, bundle branch and/or fascicular block, left ventricular hypertrophy (LVH), intraventricular conduction delay (IVCD), early repolarization pattern, significant valvular heart disease, unreadable lead V1, flat T wave in V1, and those with electrolyte abnormalities were excluded from the study. Patients with history of MI were eligible to be included in the study provided that they had normal resting ECG.

Patients were selected based on non-randomized simple sampling method. Then, patients' medical records were extracted from hospital archives and evaluated. The standard 12-lead ECGs at a speed of 25 mm/sec and amplitude of 10 mm/mV were obtained from patients at the time of admission and TP segment was considered as isoelectric line. Patients' ECGs were interpreted by two different cardiologists who were blinded to this study. Demographic data (age and gender), past medical history, cardiovascular risk factors, and angiography findings were extracted. Angiography records were re-evaluated by two independent cardiologists visually and also by using software tool for quantitative coronary assessment (QCA) (Syngo Circulation, Simens Medical Solutions, Forchheim, Germany). In cases where there was a discrepancy between the information of ECG and angiography obtained by the two investigators, data were evaluated by a third cardiologist. Significant CAD was defined as ≥ 70% intraluminal stenosis in at least one of major epicardial coronary arteries or more than 50% stenosis in left main artery (LMA). Positive T wave in lead V1 referred to T wave with voltage more than 0.15 mV.[5,12,16] The mean amplitude of T wave in leads V1 and V6 was also calculated. The study was approved by Regional Bioethics Committee of Isfahan University of Medical Sciences, Isfahan, Iran.

Statistical analysis: Data were entered to SPSS software (version 20, IBM Corporation, Armonk, NY, USA) and then analyzed. Kolmogorov-Smirnov test was used for checking normality assumption and according to result, appropriate test was used. For reporting quantitative and qualitative data, mean ± standard deviation (SD) and number (%) were used, respectively. Univariate analyses using Student's t-test (for continuous variables with normal distribution), Mann-Whitney test (for ordinal or continuous variables without normal distribution), and chi-square test (for categorical variables) were employed for analyzing variables.

P-value less than 0.050 was considered significant.

Results

This study evaluated the correlation between positive T wave in precordial lead V1 and significant CAD. Out of 384 patients who enrolled in the study with mean age of 63.6 ± 10.2 years (40-89 years), more than half of patients (59.1%, n = 227) were men. According to angiography reports and ECG findings, 61.2% (n = 235) had significant CAD and 56.0% (n = 215) had positive T wave in lead V1. Table 1 summarized baseline characteristics of the patients with CAD and without CAD. Chi-square test revealed that the prevalence of significant CAD was more frequent in those with positive T wave in lead V1 compared to those without this [odds ratio (OR) = 2.74, 95% confidence interval (CI): 1.80-4.19, P < 0.001] (Table 2). Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were 65.5%, 59.1%, 71.6%, and 52.1%, respectively.

Table 1. Demographic characteristics of the patients

Variables	With CAD (n = 235)	Without CAD (n = 149)	P*
Age (year)	68.3 ± 9.3	65.1 ± 12.5	0.004
BMI (kg/m^2)	28.0 ± 4.2	27.1 ± 3.8	0.340
Gender (male)	140 (59.8)	87 (58.3)	0.001
Smoker	56 (23.8)	22 (14.7)	0.031
DM	76 (32.3)	28 (18.8)	0.003
HTN	89 (37.8)	36 (24.1)	0.005
HLP	97 (41.2)	46 (31.1)	0.043
Family history of early CAD	58 (24.6)	21 (14.1)	0.012

Continues and categorical data were reported as mean ± standard deviation (SD) and number (%), respectively

* Independent t-test was used for continues and chi-square test for categorical variables

BMI: Body mass index; DM: Diabetes mellitus; HTN: Hypertension; HLP: Hyperlipidemia; CAD: Coronary artery disease

The majority of patients with positive T wave had stenosis in left anterior descending artery (LAD) and LCX. Based on chi-square test, a significant relation between LAD and LCX artery stenosis and presence of positive T wave in lead V1 was found (P-value for LAD: < 0.001 and P-value for LCX: 0.03) (Table 3). About one-third (34.4%) of patients with positive TV1 and CAD had single vessel disease and Mann-Whitney test showed higher coronary artery involvement in patients with positive T wave in lead V1 (P < 0.001) (Table 3). The mean amplitude for T wave in lead V1 and V6 was 0.228 ± 0.660 and 0.208 ± 0.580 mV, respectively. Of the study population, the great number of patients with significant CAD had TV1/TV6 ratio remarkably over 1 (OR: 6.22, 95% CI: 3.14-12.30, P < 0.001) with 64.9% sensitivity, 77.0% specificity, 87.7% PPV, and 53.3% NPV for predicting CAD (Table 4). Patients with TV1 > TV6 had significantly more LAD and LCX artery stenosis than patients with TV1 < TV6 (P-values for LAD: < 0.001 and P-value for LCX: 0.03) (Table 5). Nearly half of the patients (44.7%) with TV1 taller than TV6 and CAD had single coronary artery stenosis and based on Mann-Whitney test, the number of coronary arteries involved was prominently related to TV1/TV6 > 1 (P < 0.001) (Table 5).

Discussion

Our data of cross-sectional study on patients referred for coronary angiography demonstrated a strong correlation between positive T wave in lead V1 and significant CAD, especially in LAD and LCX involvement. Based on what we found, patients with positive TV1 were 2.74 times more likely to have significant CAD, compared to those with negative one. Our findings also revealed that patients with taller T wave in lead V1 than lead V6 (TV1 > TV6) had a 6.4 times higher chance for showing significant CAD in their coronary angiography.

Given the fact that T wave represents ventricular repolarization, abnormalities in T waves are commonly difficult to interpret.[17] In a review of 250 ECGs, positive T wave in lead V1 was found in 22% of subjects without any evidence of CAD.[9] It is also reported that positive TV1 presents as a normal variant in 0%-2% of children aged 10 days to 10 years and 4% of 11-15 years old children.[18]

Table 2. Coronary artery disease (CAD) distribution in patients with positive and negative T wave in lead V1

Variable	Positive TV1 (n = 215) n (%)	Negative TV1 (n = 169) n (%)	P	OR	95% CI
With CAD (n = 235)	154 (71.6)	81 (47.9)	< 0.001*	2.74	1.80-4.10
Without CAD (n = 149)	61 (28.4)	88 (52.1)			

* Chi-square test showed significant relation between CAD and presence of positive TV1

CAD: Coronary artery disease; TV1: T wave in lead V1; OR: Odds ratio; CI: Confidence interval

http://arya.mui.ac.ir 15 Jan.

Table 3. Presence of positive and negative T wave in lead V1 (TV1) and type and number of coronary arteries involved in coronary artery disease (CAD)

Variable		Negative TV1 (n = 215)	Negative TV1 (n = 169)	P
		n (%)	n (%)	
Coronary artery	LAD (n = 166)	121 (56.3)	45 (26.6)	< 0.001*
	LCX (n = 136)	85 (39.5)	51 (30.2)	0.030*
	RCA (n = 99)	59 (27.4)	40 (23.7)	0.400
	LM (n = 26)	13 (6.0)	13 (7.7)	0.520
Number of coronary arteries	0 (n = 149)	61 (28.4)	88 (52.1)	< 0.001**
	1 (n = 107)	74 (34.4)	33 (19.5)	
	2 (n = 64)	36 (16.7)	28 (16.6)	
	3 (n = 64)	44 (20.5)	20 (11.8)	

* Chi-square test showed significant relation between LAD and LCX involvement and positive TV1
** Mann-Whitney test showed significant relation between number of coronary arteries and positive TV1
LAD: Left anterior descending; LCX: Left circumflex; RCA: Right coronary artery; LM: Left main; TV1: T wave in lead V1

Inversely, findings from a prospective study carried out on large scale of 1964 consecutive patients with angiographically-proved CAD, who were followed up for 6 years, revealed that T wave morphology parameters in CAD had a high predictive value for cardiac death.[19]

Apart from slight differences, our results share a number of similarities with previous works.

Primary works in this field have suggested that tall T wave with the height more than 10 mm in precordial leads is one of the earliest changes emerged in anterior and posterior MI which disappears 24 hours after anterior infarction, while persists up to 4 years in posterior wall ischemia.[20]

In a similar study performed on 126 patients with upright or negative T wave in lead V1 with otherwise normal ECG, positive TV1 increases the likelihood of having significant CAD 4 times more than negative TV1. As data stated, LCX and LAD lesions were more frequently seen in subjects with upright T wave.[5]

Another cross-sectional study which was designed to evaluate the relation between CAD and positive TV1 (T wave > 1.5 mm) in patients complaining chest pain or having positive non-invasive stress test noted male gender and upright TV1 as factors increasing the risk of CADs.[21]

In 1983, a research performed on 218 patients who experienced cardiac catheterization reported that a great number of subjects showed positive TV1 (> 0.15 mV) and significant CAD simultaneously, which accords with what we found. However, in contrast to our results, this finding was only significant for LCX artery disease and there was no identified link between LAD involvement and positive TV1.[12] Recently, a retrospective study of 624 patients found the same result and proved additional support for strong association between significant CAD and positive TV1 specifically in LCX involvement but rarely in LAD involvement.[22]

Our result is in good agreement with previous literature about the correlation between TV1 > TV6 pattern and significant CAD.

In 1960, a review of 7500 patients suggested that changes in T wave amplitude in lead V1 and taller TV1 than in V6 pattern could be considered as an initial sign of myocardial diseases in patients with otherwise normal ECG.[15] Years later, this hypothesis was re-examined on population in which patients with ECG signs of previous MI were eligible to be included in the study. The result of this study with exclusion of patients with LVH indicated that TV1 > TV6 pattern, regardless of other ECG abnormalities, was a worthwhile criterion proposing CAD, specifically in LAD stenosis.[16]

Our study had some limitations that must be taken into account in the interpretation and generalization of the results. This study has a small sample size that is too small to generalize to society.

Table 4. Relation between coronary artery disease (CAD) and T wave in lead V1 (TV1) > T wave in lead V6 (TV6)

Variable	TV1 > TV6 (n = 114)	TV1 < TV6 (n = 101)	P	OR	95% CI
	n (%)	n (%)			
With CAD (n = 154)	100 (87.7)	54 (53.5)	< 0.001*	6.22	3.14-12.30
Without CAD (n = 61)	14 (12.3)	47 (46.5)			

* Chi-square test showed significant relation between CAD and presence of TV1 > TV6
CAD: Coronary artery disease; TV1: T wave in lead V1; TV6: T wave in lead V6; OR: Odds ratio; CI: Confidence interval

Table 5. Presence of T wave in lead V1 (TV1) > T wave in lead V6 (TV6) and type and number of coronary arteries involved in coronary artery disease (CAD)

Variable		TV1 > TV6 (n = 114)	TV1 < TV6 (n = 101)	P
		n (%)	n (%)	
Coronary artery	LAD (n = 121)	82 (71.9)	39 (38.6)	< 0.001*
	LCX (n = 85)	53 (46.5)	32 (31.7)	0.030*
	RCA (n = 59)	30 (26.3)	29 (28.7)	0.690
	LM (n = 15)	8 (7.0)	5 (5.0)	0.530
Number of coronary arteries	0 (n = 61)	14 (12.3)	47 (46.5)	< 0.001**
	1 (n = 74)	51 (44.7)	23 (22.8)	
	2 (n = 36)	25 (21.9)	11 (10.9)	
	3 (n = 44)	24 (21.1)	20 (19.8)	

* Chi-square test showed significant relation between LAD and LCX involvement and TV1 > TV6
** Mann-Whitney test showed significant relation between number of coronary arteries and TV1 > TV6
LAD: Left anterior descending; LCX: Left circumflex; RCA: Right coronary artery; LM: Left main; TV1: T wave in lead V1; TV6: T wave in lead V6

Conclusion

Positive T wave in TV1 and TV1 > TV6 pattern can be considered as a predictor for significant CAD in patients with otherwise normal ECG.

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Conflict of Interests

Authors have no conflict of interests.

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