Original Article

Association of Positive TwaVR/STaVR ECG Changes with Adverse Outcomes in Heart Failure Patients with Reduced Ejection Fraction Undergoing CABG in Turkey: A Retrospective Study

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Received: 28-Nov-2023;
Revision: 28-Jun-2024;
Accepted: 12-Jul-2024;
Published: 26-Aug-2024

ABSTRACT

Background: Positive T-wave polarity in the augmented vector right lead (Tw-aVR) and ST-segment deviation in the augmented vector right lead (STaVR) have been identified as potential predictors of adverse outcomes in various cardiac conditions. **Aim:** The aim of the study was to examine the effect of positive Tw-aVR and STaVR on in-hospital mortality after coronary artery bypass grafting (CABG) surgery in patients with heart failure with reduced ejection fraction (HFrEF). **Methods:** A five-year retrospective study was conducted on 250 HFrEF patients who underwent CABG at a tertiary care hospital between January 2018 and December 2022. The primary outcome was in-hospital mortality, and the main exposures were positive Tw-aVR and STaVR on preoperative electrocardiograms. Logistic regression models were used to assess the factors associated with in-hospital mortality. **Results:** Two hundred and fifty patients with a mean age of 67.4 ± 8.1 years were studied. Males constituted 68% of the participants. Among the participants, 60 (24%) had positive Tw-aVR, and 96 (38.4%) had STaVR. The overall in-hospital mortality rate was 7.6%, and patients with positive Tw-aVR and STaVR had significantly higher mortality rates than those without (odds ratio: 3.62 and 2.87, respectively, $P < 0.01$). These associations remained significant even after controlling for potential confounders such as age (adjusted odds ratio [AOR]: 1.11; 95% confidence interval [CI]: 1.03–1.20; $P = 0.008$), sex (AOR: 0.82; 95% CI: 0.31–2.18; $P = 0.684$), diabetes mellitus (AOR: 2.12; 95% CI: 0.88–5.12; $P = 0.091$), and chronic kidney disease (AOR: 1.79; 95% CI: 0.75–4.27; $P = 0.194$). **Conclusion:** Positive Tw-aVR and STaVR were found to be associated with in-hospital mortality in HFrEF patients after CABG. These findings suggest that identifying patients with positive Tw-aVR and STaVR may help identify those at higher risk of adverse outcomes and facilitate closer monitoring and more aggressive interventions.

Keywords: *Coronary artery bypass surgery, heart failure, mortality, STaVR, Tw-aVR*

Introduction

Cardiovascular diseases remain a significant cause of death and illness on a global scale.[1] Coronary artery bypass grafting (CABG) is frequently utilized in patients with advanced coronary artery disease, despite the associated risks involved, particularly in those with heart failure with reduced ejection fraction (HFrEF).[2] CABG is an important treatment option for patients with HFrEF. CABG has been associated with improved outcomes in this population such as a decreased mortality rate,

Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/njcp.njcp_827_23

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How to cite this article: Uncu H, Badak TO, Ucak HA, Cereb F, Cakallioglu A, Yıldırım A. Association of positive TwaVR/STaVR ECG changes with adverse outcomes in heart failure patients with reduced ejection fraction undergoing CABG in Turkey: A retrospective study. Niger J Clin Pract 2024;27:972-6.

improved symptom control, and fewer hospitalizations.[3] In a meta-analysis of 25 separate studies that included over 6,600 participants, CABG was found to be significantly beneficial to HFrEF patients compared to medical therapy alone.[4] Additionally, CABG has also been associated with better outcomes than percutaneous coronary intervention in terms of mortality rates and rates of major adverse cardiovascular events.[5] However, it should be noted that the overall risk-benefit ratio remains controversial due to the potential complications associated with CABG. Although CABG is generally successful, these patients carry a greater likelihood of postoperative complications and in-hospital mortality.[6]

Electrocardiography (ECG) is a non-invasive diagnostic tool used to assess cardiovascular health. The lead augmented vector right (aVR) is a commonly used ECG lead that provides information about the electrical activity of the heart from a unique angle. Normally, the aVR lead has negative T-wave polarity (Tw-aVR) on the ECG. However, in some patients with cardiovascular disease, the lead aVR may have positive T-wave polarity and ST segmental deviation (STaVR).[7] Lead aVR is one of the standard twelve leads in a surface ECG that is used to assess the electrical activity of the heart. While not commonly considered by clinicians and researchers, lead aVR has emerged as an important tool for predicting cardiovascular risk and outcomes. It provides a unique view of the electrical conduction system of the heart, particularly the right ventricle, and has been shown to have important prognostic value in a range of cardiac conditions.[8,9] In this context, exploring the utility of lead aVR in cardiac risk stratification has become an area of interest for researchers alike. Understanding the significance of lead aVR in surface ECG would allow clinicians to better utilize this tool in the detection, diagnosis, and management of cardiac disease.

A recent study has shown that there may be a significant link between positive Tw-aVR and STaVR and heightened adverse outcomes for patients undergoing revascularization.[10] It has been suggested that the presence of either of these markers could raise the risk of in-hospital mortality, as well as other adverse outcomes such as postoperative heart failure, arrhythmias, and stroke.[11]

One theory put forward to explain this hypothesis is that positive Tw-aVR and STaVR are likely indications of more widespread or severe underlying coronary artery disease, which could result in more extensive damage to the heart muscle during the surgical intervention.[12] In addition, the markers may also be a sign of increased inflammation, electrolyte imbalances, or other underlying health conditions that could further elevate the likelihood of adverse outcomes in this patient population.[13,14]

Future research in this area will be important in determining the underlying mechanisms and developing more tailored interventions to address the negative impact of positive Tw-aVR and STaVR on this patient population. This study determined the effect of positive Tw-aVR and STaVR on in-hospital mortality after CABG HFrEF.

Materials and Methods

This was a five-year retrospective study conducted at the University of Health Sciences Adana City Training and Research Hospital in Turkey. The data were obtained from the electronic medical records of patients who underwent CABG surgery between January 2018 and December 2022. The study sample consisted of all patients who met the inclusion criteria. Patients with ischemic HFrEF who underwent CABG surgery during the study period and had a pre-operative 12-lead ECG that included aVR were included. Patients with missing or incomplete medical records, a history of previous cardiac surgery or other cardiac interventions, or missing or incomplete ECG data were excluded.

All ECGs were obtained preoperatively. A T-wave exceeding 0 mV in the lead aVR was classified as positive and ST-segment elevation in the lead aVR was deemed positive when the elevation surpassed 0.05 mV. The primary variable of interest in this study was the presence of positive Tw-aVR and STaVR on the pre-operative ECG. Additional variables included were age, sex, body mass index, smoking history, comorbidities, left ventricular ejection fraction (LVEF), and the presence of other ECG abnormalities.

Data analysis

Statistical analysis was performed using Statistical Package for the Social Sciences 17.0 statistical software (SPSS, Chicago, IL, USA). Descriptive statistics were used to summarize relevant characteristics of the group of individuals under examination. Univariate analysis and a multivariate logistic regression model were employed to assess any association between positive Tw-aVR and STaVR and in-hospital mortality following CABG in HFrEF patients. In cases where missing data were determined to be completely random, the missing data were handled using appropriate imputation techniques, such as multiple imputation, to estimate missing values based on observed data patterns. Sensitivity analyses were conducted for assess the robustness of the findings to different imputation methods. A *P* value of less than 0.05 was considered significant.

Ethical consideration

This study was approved by the Institutional Review Board of Adana City Training and Research Hospital (27.04.2023/125/2538). Informed consent was not required as this was a retrospective study that utilized de-identified data. The privacy and confidentiality of all study participants were protected in accordance with the Health Insurance Portability and Accountability Act (HIPAA) regulations.

Results

A total of 250 HFrEF who underwent CABG were included in the study. The mean age of the study population was 67.4 years (standard deviation = 8.1), and 68.4% were male [Table 1]. Of the 250 patients, 60 (24%) had a positive Tw-aVR, and 96 (38.4%) had STaVR. The baseline characteristics of patients with and without positive Tw-aVR and STaVR were similar.

The overall in-hospital mortality rate was 7.6%. The mortality rate was significantly higher in patients with positive Tw-aVR compared to those with negative Tw-aVR (odds ratio [OR]: 3.62; 95% confidence interval [CI]: 1.39–9.46; P = 0.008). Likewise, patients who had STaVR had a notably higher mortality rate in comparison to those who did not exhibit STaVR (OR: 2.87; 95% CI: 1.35–1.609; P = 0.006) [Table 2].

After controlling for potential confounding variables such as age, sex, underlying health conditions, and LVEF, positive Tw-aVR and STaVR were associated with in-hospital mortality [Table 2]. The multivariate logistic regression model utilized to evaluate various factors associated with in-hospital mortality following CABG surgery in patients with HFrEF showed that several other factors, such as older age, diabetes mellitus, and lower LVEF, were also associated with mortality following CABG surgery in HFrEF patients [Table 2].

For multivariate analysis, the significant factors associated with mortality were: positive Tw-aVR (adjusted odds ratio [AOR]: 3.28; 95% CI: 1.20–8.98; P = 0.021); STaVR (AOR: 2.71; 95% CI: 1.18–6.21; P = 0.019); age (AOR: 1.11; 95% CI: 1.03–1.20; P = 0.008); diabetes mellitus (AOR: 2.12; 95% CI: 0.88–5.12; P = 0.091); chronic kidney disease (AOR: 1.79; 95% CI: 0.75–4.27; P = 0.194).

These findings underscore the importance of identifying patients with positive Tw-aVR and STaVR, as well as considering age and underlying health conditions, to better predict and manage the risk of in-hospital mortality following CABG surgery in HFrEF patients.

Discussion

This retrospective study examined the potential effect of Tw-aVR and STaVR on in-hospital death following CABG surgery in patients with HFrEF. This study found that positive Tw-aVR and STaVR were significant factors associated with in-hospital mortality in this subset of patients. In addition, this study showed that individuals who had positive Tw-aVR and STaVR had

Table 1: Baseline characteristics of the study population with and without positive Tw-aVR and STaVR

Characteristics	All participants (*n*=250)	Positive Tw-aVR (*n*=60)	Negative Tw-aVR (*n*=190)	*P*	STaVR (*n*=96)	No STaVR (*n*=154)	*P*
Age, years (mean±SD)	67.4±8.1	68.1±8.2	67.3±8.0	0.374	67.8±8.4	67.1±7.8	0.298
Male, *n* (%)	170 (68.0)	41 (68.3)	129 (67.9)	0.942	66 (68.8)	104 (67.5)	0.809
Hypertension, *n* (%)	213 (85.2)	52 (86.7)	161 (84.7)	0.689	83 (86.5)	130 (84.4)	0.670
Diabetes mellitus, *n* (%)	90 (36.0)	27 (45.0)	63 (33.2)	0.105	47 (48.9)	43 (27.9)	0.002
Chronic kidney disease, *n* (%)	91 (36.4)	24 (40.0)	67 (35.3)	0.528	42 (43.8)	49 (31.8)	0.055
Left ventricular ejection fraction, % (mean±SD)	32.0±5.9	31.7±6.1	32.1±5.8	0.594	31.5±6.3	32.1±5.6	0.375

Tw-aVR: T-wave polarity in the augmented vector right lead; STaVR: ST-segment deviation in the augmented vector right lead; SD: Standard deviation

Table 2: Factors associated with in-hospital mortality after CABG surgery in HFrEF patients

Variables	Unadjusted OR (95% CI)	*P*	AOR* (95% CI)	*P*
Positive Tw-aVR	3.62 (1.39–9.46)	0.008	3.28 (1.20–8.98)	0.021
STaVR	2.87 (1.35–6.09)	0.006	2.71 (1.18–6.21)	0.019
Age	1.10 (1.02–1.19)	0.014	1.11 (1.03–1.20)	0.008
Male gender	0.93 (0.40–2.14)	0.871	0.82 (0.31–2.18)	0.684
Diabetes mellitus	2.16 (0.94–4.96)	0.071	2.12 (0.88–5.12)	0.091
Chronic kidney disease	1.83 (0.82–4.08)	0.138	1.79 (0.75–4.27)	0.194

TwaVR: Lead augmented vector right; STaVR: ST segment deviation in lead aVR; HFrEF: Heart failure with reduced ejection fraction; CI: Confidence interval. *Adjusted for age, gender, diabetes mellitus, and chronic kidney disease

higher mortality rates. This finding is similar to the reports of previous studies.[14–16] The finding of this study also corroborates reports of some previous studies that showed a higher prevalence of adverse outcomes such as heart failure, arrhythmias, and increased mortality rates for patients with positive Tw-aVR and STaVR.[17,18]

The mechanisms underlying the association between positive Tw-aVR and STaVR and adverse outcomes are not fully understood. Positive Tw-aVR and STaVR have been found to be frequently associated with negative clinical outcomes in previous studies.[19–21] Kosuge *et al*.[22] found that positive Tw-aVR was associated with morbidity rates in the appropriate risk group such as pulmonary embolism.[22] Some studies reported no significant association between Tw-aVR positivity and postoperative mortality when stents were applied, while others found that the application of stents did not improve survival rates in these patients.[22,23] However, it is possible that these ECG findings may reflect a more severe underlying cardiac pathology, such as ischemia or myocardial infarction.[24,25] In addition, positive Tw-aVR and STaVR may indicate global electrical instability, which could predispose patients to arrhythmias and sudden cardiac death.[26]

This study's limitation was that, being a retrospective study, it was subject to selection bias and confounders. However, attempts to minimize these factors by adjusting for potential confounding variables were made during statistical analysis. Also, the result is not generalizable because it was a single-center study.

Despite these limitations, our study has important clinical implications. The presence of positive Tw-aVR and STaVR in HFrEF patients undergoing CABG surgery may help identify patients at higher risk of adverse outcomes. These patients may benefit from closer monitoring and more aggressive interventions, such as optimization of medical therapy or referral for cardiac rehabilitation.

In conclusion, the study suggests that positive Tw-aVR and STaVR are significantly associated with in-hospital mortality after CABG surgery in HFrEF patients. Further studies are needed to better understand the mechanisms underlying this association and to determine optimal strategies for risk stratification and management of these patients.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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