JACC: CLINICAL ELECTROPHYSIOLOGY
VOL. ■, NO. ■, 2017

ISSN 2405-500X/$36.00
PUBLISHED BY ELSEVIER
http://dx.doi.org/10.1016/j.jacep.2016.12.018

Value of a Posterior Electrocardiographic Lead for Localization of Ventricular Outflow Tract Arrhythmias

The V4/V8 Ratio

Fengxiang Zhang, MD,[a] David Hamon, MD,[b] Zhen Fang, MD,[a] Yan Xu, MD,[a] Bing Yang, MD,[a] Weizhu Ju, MD,[a] Jason Bradfield, MD,[b] Kalyanam Shivkumar, MD, PHD,[b] Minglong Chen, MD,[a] Roderick Tung, MD[c]

ABSTRACT

OBJECTIVES This study sought to prospectively evaluate the value of a dedicated electrocardiographic posterior lead to create an anteroposterior ratio to localize premature ventricular complexes (PVCs) between the right ventricular outflow tract and left ventricular outflow tract for catheter ablation.

BACKGROUND The anteroposterior relationship between the right and left outflow tract has not been explored for electrocardiographic localization of ventricular arrhythmia.

METHODS Standard V5 and V6 leads were placed posteriorly and ablation was performed with activation mapping. The site of successful ablation was correlated with the ratio of the R-wave in V4 to the R-wave in V8. Normalization of the V4/V8 ratio to a V4/V8 index was achieved by dividing the V4/V8 ratio by sinus V4/V8. After determination of optimal cutoffs, comparison with V2 transition ratio and V2S/V3R was subsequently performed using receiver operating characteristic curves in a prospective validation cohort.

RESULTS A total of 134 patients underwent ablation of PVCs with 2 modified posterior leads. PVCs successfully ablated from the left side had a statistically significantly higher V4/V8 ratio compared with right-sided PVCs (11.7 ± 10.6 vs. 2.3 ± 2.4, $p < 0.001$). At a cutoff of >3, the V4/V8 ratio had a sensitivity of 88% with a specificity of 77% for left-sided locations. At a cutoff of >2.28, the V4/V8 index had a sensitivity of 67% with a specificity of 98%. In the prospective validation cohort ($n = 40$), the V4/V8 ratio exhibited the highest sensitivity of 75% with a negative predictive value of 89% compared with the V4/V8 index, V2 transition ratio, and V2S/V3R. The V4/V8 index had the highest specificity of 96% with positive predictive value of 89% compared to the other predictive ratios. When analyzing cases with a V3 transition, the V4/V8 index demonstrated 100% specificity and positive predictive value.

CONCLUSIONS A simple modification of V5 to V8 posteriorly may provide incremental diagnostic value for localizing PVCs arising from the outflow tracts. Normalizing PVC localization criteria to the sinus rhythm results in the highest specificity when compared with other validated criteria. (J Am Coll Cardiol EP 2017;■:■–■) © 2017 by the American College of Cardiology Foundation.

Idiopathic ventricular tachycardia and premature ventricular complexes (PVCs) arising from the ventricular outflow tracts (OTs) are the most common type of ventricular arrhythmias in the absence of structural heart disease. Catheter ablation has been demonstrated to be a curative therapy, with >80% success rates (1). An accurate method to predict the site of successful ablation can guide and facilitate

From the [a]First Affiliated Hospital of Nanjing Medical University, Nanjing, China; [b]UCLA Cardiac Arrhythmia Center, UCLA Health System, Los Angeles, California; and the [c]University of Chicago Medicine, Center for Arrhythmia Care, Heart and Vascular Center, Chicago, Illinois. Dr. Hamon has received a grant from the Federation Francaise de Cardiologie. Drs. Zhang, Fang, Xu, Yang, Ju, and Chen were supported by grants from the National Natural Science Foundation of China (Grant no. 81470456), by the National "Twelfth Five-Year" Plan for Science & Technology Support (Grant no. 2011BAI11B13), a by "A Project Funded by the Priority Academic Program Development of Jiangsu Higher Education Institutions, and by NIH R01 HL084261 & NIH OT2OD023848. Drs. Zhang and Hamon contributed equally to this work.

Manuscript received October 28, 2016; revised manuscript received December 13, 2016, accepted December 22, 2016.

ABBREVIATIONS AND ACRONYMS

AIV = interventricular vein

AUC = area under the curve

BBB = bundle branch block

ECG = electrocardiogram

GCV = great cardiac vein

LCC = left coronary cusp

LVOT = left ventricular outflow tract

NPV = negative predictive value

OT = outflow tract

PPV = positive predictive value

PVC = premature ventricular complex

RCC = right coronary cusp

RVOT = right ventricular outflow tract

the procedural strategy for mapping and ablation. However, the accuracy of 12-lead electrocardiographic localization can be affected and thereby limited by body surface anatomy, cardiac anatomy, rotation, and variability in electrocardiogram (ECG) lead placement (2).

Several electrocardiographic criteria have been proposed to differentiate and localize the site of origin of outflow tract PVCs (3–10). Although multiple electrocardiographic criteria have been shown to have diagnostic accuracy, the vast majority incorporate the precordial transition into the localization algorithm. Because the right ventricular outflow tract (RVOT) and left ventricular outflow tract (LVOT) have an anteroposterior anatomic relationship, we sought to prospectively evaluate the value of a dedicated electrocardiographic posterior lead to localize the site of PVC origin between the RVOT and LVOT for catheter ablation. The prospective study was conducted in 2 phases: 1) derivation cohort for optimal cutoff determination; and 2) validation cohort with comparison to 2 other published criteria.

METHODS

Consecutive patients referred for ablation of idiopathic OT PVCs at 2 academic centers between 2013 and 2015 were prospectively assessed. Standard V5 and V6 leads were placed on the back of the patient, with V5 located at the inferior tip of left scapular (V8) and V6 just left of the spine at the same level (V9) (**Figure 1**). This method was chosen to obviate the need for additional leads beyond the standard 12-lead system because the incremental clinical value of V5 and V6 for outflow tract PVCs is low. Patients with structural heart disease, permanent pacing, and bundle branch block (BBB) were excluded. The institutional review boards at both participating centers approved review of this data.

Diagnostic catheterization and ablation were performed via the right femoral venous approach for mapping of the RVOT and retrograde aortic approach was used for mapping of the LVOT. Systemic heparinization was administered (goal: 250 to 300 s) during LVOT mapping and ablation. Isoproterenol was administered intravenously if spontaneous PVCs were not present in the baseline state or under conscious sedation. Ablation was performed with standard activation mapping using electroanatomic mapping systems (CARTO, Biosense Webster, Diamond Bar, California, or NAVX, St. Jude Medical, Minneapolis, Minnesota). Irrigated catheters were used for ablation (ThermoCool, Biosense Webster, Diamond Bar, California, or CoolFlex, St. Jude Medical, Minneapolis, Minnesota). The flow rate was 17 to 30 ml/min and applications were applied for 60 s (power: 30 to 50 W; temperature limit: 42°C). The location of the PVC was defined by the successful site where radiofrequency application permanently suppressed ventricular ectopy during the procedure. The RVOT was subcategorized into 6 sections: 1) anterior free wall; 2) free wall; 3) posterior free wall; 4) posteroseptal; 5) septal; 6) anteroseptal; and 7) pulmonary artery. The LVOT was subcategorized into: 1) right coronary cusp (RCC); 2) RCC-left coronary cusp (LCC) junction (RCC/LCC); 3) LCC; 4) aortomitral continuity region; and 5) coronary venous system (great cardiac vein [GCV]-interventricular vein [AIV] junction).

ELECTROCARDIOGRAPHIC ANALYSIS: V4/V8 RATIO. In all patients, the 12-lead ECG (V1 and V2 in the fourth intercostal space) was recorded during sinus rhythm and PVCs and measurements were made using the electronic caliper of the recording system (Prucka Cardiolab, GE Healthcare, Waukesha, Wisconsin, and EP LabSystem, Bard, Lowell, Massachusetts) at a sweep speed of 100 mm/s with uniform lead gain. Amplitudes were measured using the vertical caliper tool and ratios were manually calculated. The T-P segment was used as the isoelectric baseline for R and S amplitude measurement. R-wave duration was measure from the first deflection from baseline back to the return to baseline (T-P segment).

The following measurements were made for all patients during both sinus rhythm and the PVC:

1. R-wave duration in V1
2. R-wave amplitude in V1-V4
3. Precordial transition defined as the lead with R>S
4. R and S wave amplitude of V2
5. R-wave amplitude of V8 and V9, if there was no R-wave present on V8 or V9, this was considered to be zero
6. Ratio of PVC R-wave V4/V8
7. Ratio of sinus rhythm R-wave V4/V8
8. V4/V8 Index defined as the normalized ratio of PVC V4/V8 divided by sinus rhythm V4/V8 (**Figure 1**)

R-waves were measured from the isoelectric line as the reference for both amplitude and duration. In the prospective validation cohort, the V4/V8 ratio and V4/V8 index were compared with the V2 transition