Differentiating the origin of outflow tract ventricular arrhythmia using a simple, novel approach

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BACKGROUND Numerous electrocardiographic (ECG) criteria have been proposed to identify localization of outflow tract ventricular arrhythmias (OT-VAs); however, in some cases, it is difficult to accurately localize the origin of OT-VA using the surface ECG.

OBJECTIVE The purpose of this study was to assess a simple criterion for localization of OT-VAs during electrophysiology study.

METHODS We measured the interval from the onset of the earliest QRS complex of premature ventricular contractions (PVCs) to the distal right ventricular apical signal (the QRS-RVA interval) in 66 patients (31 men aged 53.3 ± 14.0 years; right ventricular outflow tract [RVOT] origin in 37) referred for ablation of symptomatic outflow tract PVCs. We prospectively validated this criterion in 39 patients (22 men aged 52 ± 15 years; RVOT origin in 19).

RESULTS Compared with patients with RVOT PVCs, the QRS-RVA interval was significantly longer in patients with left ventricular outflow tract (LVOT) PVCs (70 ± 14 vs 33.4±10 ms, $P < .001$). Receiver operating characteristic analysis showed that a QRS-RVA interval ≥49 ms had sensitivity, specificity, and positive and negative predictive values of 100%, 94.6%, 93.5%, and 100%, respectively, for prediction of an LVOT origin. The same analysis in the validation cohort showed sensitivity, specificity, and positive and negative predictive values of 94.7%, 95%, 95%, and 94.7%, respectively. When these data were combined, a QRS-RVA interval ≥49 ms had sensitivity, specificity, and positive and negative predictive values of 98%, 94.6%, 94.1%, and 98.1%, respectively, for prediction of an LVOT origin.

CONCLUSION A QRS-RVA interval ≥49 ms suggests an LVOT origin. The QRS-RVA interval is a simple and accurate criterion for differentiating the origin of outflow tract arrhythmia during electrophysiology study; however, the accuracy of this criterion in identifying OT-VA from the right coronary cusp is limited.

KEYWORDS Cardiac ablation; Left outflow tract; Outflow tract arrhythmia; QRS-RVA interval; Right outflow tract

ABBREVIATIONS ECG = electrocardigram; **EPS** = electrophysiology study; **LVOT** = left ventricular outflow tract; **OT-VA** = outflow tract ventricular arrhythmia; **PVC** = premature ventricular contraction; **QRS-RVA** = interval from onset of earliest QRS complex of premature ventricular contraction to distal right ventricular apex signal; **ROC** = receiver operating characteristic; **RVA** = right ventricular apex; **RVOT** = right ventricular outflow tract

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Introduction

Idiopathic outflow tract ventricular arrhythmias (OT-VAs) occur in the absence of clinically apparent structural heart disease and are associated with a benign prognosis.[1–4] These arrhythmias can be curatively treated with radiofrequency catheter ablation.[5,6] Precise localization of OT-VA origin before ablation is important for defining the appropriate ablation strategy and approach. There are numerous electrocardiography (ECG) algorithms for predicting the origin and differentiating the right from the left origin site of OT-VA.[7–17]

The different positioning of surface limb ECG electrodes, conduction disturbances, and the transition zone in V_3 might represent a significant challenge in prediction of the successful ablation site.[18–20] Previous studies showed that the QRS-right ventricular apical signal interval helps to differentiate the ventricular tachycardia origin from the left ventricular septal versus lateral walls.[21,22] With respect to anatomic localization of outflow tracts, we hypothesized that the spontaneous conduction time from the left ventricular outflow tract (LVOT) to the right ventricular apex (RVA) could be longer than that from the right ventricular outflow tract (RVOT) because of greater anatomic distance and longer transseptal conduction time. In addition to current ECG criteria, the QRS-RVA interval could be useful for differentiation of the site of origin in patients with OT-VAs.

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Therefore, we sought to assess this simple approach for localizing the origin of OT-VAs that could be applied routinely as an inherent part of an electrophysiology study (EPS) in these patients.

Methods

Baseline characteristics of patients

Sixty-six consecutive patients with symptomatic frequent premature ventricular outflow tract contractions (PVCs) who were admitted between December 2011 and November 2013 to our department for catheter ablation and underwent successful ablation were included in this study. The baseline clinical characteristics of patients are presented in Table 1. Left ventricular systolic function was quantified by echocardiography (using the modified Simpson method). No patient fulfilled Task Force criteria for arrhythmogenic right ventricular cardiomyopathy.[23] All patients underwent exercise stress tests or coronary angiography to exclude coronary artery disease.

EPS and ablation

The study protocol was approved by our ethics committee. All patients gave written informed consent for the EPS and ablation procedure. All antiarrhythmic medications were discontinued at least 5 half-lives before the ablation. We performed the ablation with patients in a primary nonsedated state. Quadripolar and decapolar catheters were placed in the RVA and coronary sinus, respectively. Particular attention was paid to the correct and consistent positioning of catheter in the RVA (Figure 1).

Mapping and radiofrequency catheter ablation were performed either with a 4-mm-tip catheter (Navistar, Biosense Webster, Inc, Diamond Bar, CA) with a power setting of 50 W and temperature limit of 60°C or with a 3.5-mm open irrigated-tip ablation catheter (Thermocool-Navistar or Navistar-RMT, Biosense Webster) with a temperature limit of 48°C, a power setting of 30 to 35 W, and a flow rate of 30 mL/min. Three-dimensional electroanatomic mapping with the CARTO 3 mapping system (Biosense Webster) was performed for precise catheter navigation and localization of the origin of OT-VAs. The ablation target site was identified by activation mapping combined with pace mapping in a stepwise manner as described previously by Arya et al.[18]

Mapping of the LVOT was performed via a retrograde aortic approach. A heparin bolus of 60 IU/kg was administered, followed by further doses to maintain an activated clotting time >250 seconds. Patients with OT-VAs that originated from the aortic sinus cusp underwent coronary angiography to assess the anatomic proximity of the main coronary artery ostia to the ablation site. Acute procedural ablation success was defined as the absence of spontaneous or induced clinical PVCs at 30 minutes after the last radiofrequency energy application.

Measurement protocol

The QRS-RVA interval was measured from the onset of the QRS complex to the distal RVA signal at a paper speed of 100 mm/s. The onset of the QRS complex was defined in the lead with the earliest initial deflection from the isoelectric line on the 12-lead surface ECG (Figure 2). All measurements were performed offline by 2 electrophysiologists (E.E. and W.-J.A.), who were blinded to the final diagnosis and the site of origin, using electronic calipers on the Prucka CardioLab recording system (GE Healthcare, Pittsburgh, PA). The accuracy of measurements at a paper speed of 100 mm/s is approximately ±5 ms.[24] Therefore, in case of a difference in measurements <6 ms, the mean value of the 2 measurements was used. Among 105 patients (66 in the initial cohort, 39 in the validation cohort) the measured difference was ≥6 ms in 11 cases (10.5%). In these patients, to reach a consensus, the measurement was repeated in the presence of a third experienced electrophysiologist (A.A.), who was also blinded to the final diagnosis. This measurement then was entered into the database and used for the final analysis.

Validation cohort

Thirty-nine consecutive patients with symptomatic frequent PVCs who were admitted and underwent successful ablation

Table 1 Clinical und electrophysiological characteristics of 66 patients with outflow tract arrhythmia

	Initial cohort				Validation cohort			
	All	RVOT	LVOT	*P* value	All	RVOT	LVOT	*P* value
Patients, n (%)	66	37 (56)	29 (44)	NA	39	19	20	NA
Age (y)	53 ± 14	51 ± 14	56 ± 14	.283	52 ± 15	42 ± 12	62 ± 12	<.05
Women, n (%)	35 (53)	26 (65)	11 (38)	.03	17 (44)	12 (63)	5 (25)	.025
LVEF, (%)	57 ± 9	61 ± 7	56 ± 10	.009	57 ± 7	57 ± 6	58 ± 9	.904
QRS duration, ms	139 ± 16	137 ± 15	142 ± 16	.250	137 ± 7	137 ± 3	138 ± 5	.133
QRS-RVA interval, ms	49 ± 22	33 ± 10	70 ± 14	<.0001	47 ± 17	32 ± 8	60 ± 10	<.0001
Procedure time, min	109 ± 36	102 ± 35	118 ± 36	.078	112 ± 45	88 ± 27	132 ± 47	.002
Fluoroscopy time, min	14 ± 12	11 ± 8	18 ± 14	.014	14 ± 12	6 ± 4	21 ± 11	<.0001
Prior ablation, patients, n (%)	6 (9)	2 (5)	4 (14)	NA	3 (8)	1 (5)	2 (10)	NA
TICMP, n (%)	8 (12)	6 (16)	2 (7)	NA	5 (13)	3 (16)	2 (10)	NA

LVEF = left ventricular ejection fraction; LVOT = left ventricular outflow tract; NA = not applicable; RVA = right ventricular apex; RVOT = right ventricular outflow tract; TICMP = tachycardia induced cardiomyopathy.