Ablation of Premature Ventricular Complexes Exclusively Guided by Three-Dimensional Noninvasive Mapping

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KEYWORDS

• Ablation • Ventricular arrhythmia • Premature ventricular contraction
• Electrocardiographic mapping • Noninvasive three-dimensional mapping • ECVUE

KEY POINTS

- ECVUE performance is superior to that of the body surface ECG in premature ventricular complex (PVC) mapping.
- Current data demonstrate that accurate preprocedural PVC localization is responsible for increased ablation procedure efficacy resulting in fewer RF applications required to terminate PVCs, decreased time to first RF application, and decreased total procedure time.
- ECVUE increased patient radiation exposure caused by the requisite CT scan.

INTRODUCTION

The prevalence of idiopathic premature ventricular complexes (PVCs) is reported to be as high as 2.2% in otherwise normal individuals.[1] Alarmingly, increased PVC burden in structurally normal hearts in patients older than 30 years, especially under exercise testing, is reported to be associated with increased risk for sudden cardiac death.[2,3] PVCs and runs of nonsustained ventricular tachycardias in individuals with structural heart disease increases mortality risk.[4,5] Ablation is recommended[6] in patients who are at low risk for sudden cardiac death, have drug-resistant symptomatic predominantly monomorphic PVCs and/or nonsustained monomorphic ventricular tachycardia, or who are drug intolerant or refuse long-term drug therapy.

Preprocedural mapping of PVC origin is conventionally performed with the body surface 12-lead electrocardiogram (ECG). However, 12-lead ECG arrhythmia-origin algorithms have limitations and may negatively influence ablation outcome. For example, erroneous interpretation of the site or chamber of origin from the ECG (right or left ventricle) may result in unnecessary exploratory catheter mapping or failure to identify the treatable target. ECVUE (CardioInsight, Cleveland, OH), a three-dimensional, noninvasive, single-beat mapping system, offers a solution for preprocedure PVC characterization and localization with high accuracy, which has the potential to improve clinical outcome.

Conflict of Interest: T. Neumann has received speakers' honoraria from CardioInsight.

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NONINVASIVE PREMATURE VENTRICULAR COMPLEXES MAPPING: ECVUE TECHNOLOGY

The computational methods used in the reconstruction of ECVUE maps using multiple body surface electrodes have been described previously.[7] Briefly, a 252-electrode vest is applied to the patient's torso to record surface potentials. Following a noncontrast, low-dose thoracic computed tomography (CT) scan, the heart and vest electrodes are segmented. The electrode positions and three-dimensional epicardial biventricular geometry are used by the ECVUE system to reconstruct epicardial potentials and unipolar electrograms for each beat of interest.[8,9] The clinical PVC is processed by the ECVUE system to display a color-coded activation sequence of origin and propagation of the PVC beat. Several electrophysiologic characteristics are reviewed to confirm the diagnosis as follows: pattern or activation, where the chamber harboring the arrhythmia is the first to activate, whereas the passive chamber activates last (**Figs. 1** and **2**); and unipolar electrogram morphology at the earliest epicardial breakthrough, where presence of a large Q wave denotes epicardial origin and rS morphology denotes endocardial origin. A flow chart of the diagnostic algorithm for noninvasive mapping is in **Fig. 3**.

ABLATION ACCURACY AND SUCCESS

The feasibility and accuracy of PVC mapping using the ECVUE system has been previously reported.[10–12] Specifically, two studies compared accuracy of PVC mapping using ECVUE with the standard 12-lead body surface ECG.[10,11] In both studies, ECVUE was first used to localize the PVC origin to either the right or left chamber, and second to sublocalize the origin within the ventricular chambers. Jamil-Copley and coworkers[10] conducted a prospective single-center study, which included 24 patients, most of whom had idiopathic PVCs emanating from the outflow tracts (**Fig. 4**). The ECVUE system was used to correctly identify the chamber and sublocalize the PVC origin in 96% of the cases. In contrast, using several established 12-lead body surface ECG algorithms,[13–15] accurate identification of chamber of PVC origin was achieved in only 50% to 88% of the cases and sublocalization within the right ventricular outflow tract (RVOT) in only 37% to 58%. Ground truth of PVC origin was established by an invasive electrophysiology study (EP).

More recently, Erkapic and colleagues[11] published a prospective randomized study including 42 patients (mostly idiopathic PVCs). Similar to Jamil-Copley and coworkers, Erkapic and colleagues found that established 12-lead ECG algorithms correctly identified the chamber harboring the PVC in only 76.2% of the cases compared with 95.2% with the ECVUE system. Moreover, accurate sublocalization of the ventricular arrhythmia within the chambers was significantly superior using ECVUE versus the standard 12-lead ECG (95.2% vs 38.1%, respectively; **Table 1**).

Accurate identification of PVC origin may be challenging even with the ECVUE system, especially for more septal locations. For example, in the studies of Jamil-Copley and coworkers[10] and Erkapic and colleagues,[11] ECVUE failed to correctly localize PVC origin in two patients (one patient in each study, respectively). Jamil-Copley and coworkers[10] reported ECVUE localization of the PVC origin at the inferoseptal RVOT, preprocedurally, but during the EP study, the PVC origin was identified in the left ventricular outflow tract

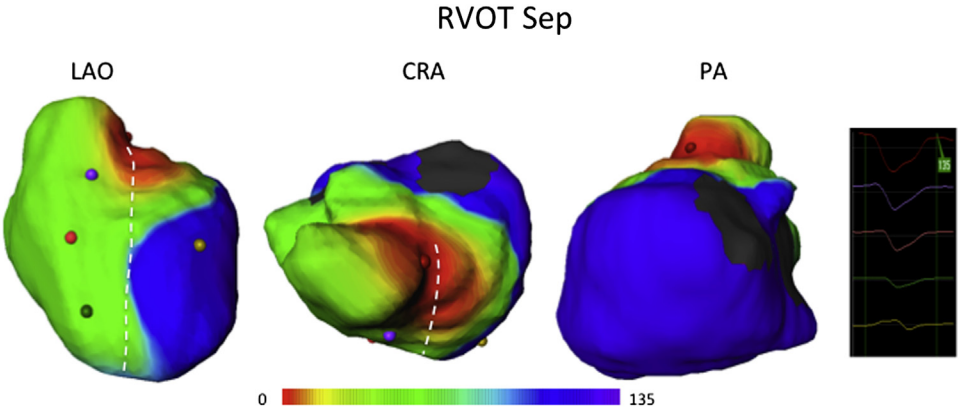

Fig. 1. PVC originating in the right ventricular outflow tract (RVOT). Activation maps of a PVC originating in the RVOT in left anterior oblique (LAO), cranial (CRA), and posterior-anterior (PA) views. Earliest activation is localized to the septal RVOT with a typical Q-wave morphology electrogram. Activation then rapidly spreads down the right ventricle, with the left ventricle activating last.