Successful Catheter Ablation of Two Distinct Premature Ventricular Complexes Arising from Right Ventricular Outflow Tract Guided by EnSite NavX 3-D Mapping System with Multielectrode Basket Catheter

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Abstract

We present the case of a 43-year-old woman with two distinct idiopathic premature ventricular complexes (PVCs) arising from right ventricular outflow tract (RVOT) underwent catheter ablation. Type 1 PVC exhibited a high amplitude positive polarity in inferior leads with negative QRS complex in lead I. Type 2 PVC exhibited a deeply negative polarity in precordial leads with biphasic R wave in lead I. Simultaneous mappings of multielectrode basket catheter and EnSite NavX system revealed that the earliest of the both types of PVCs were identified on posteroseptal and anterolateral aspects of the RVOT, respectively. Radiofrequency (RF) applications were delivered at the both sites where the exact pace map was achieved, resulting in a disappearance of both types of PVCs. This case demonstrates that 12-lead ECG feature is essential tool for differentiating the two distinct PVCs arising from RVOT, and simultaneous mapping of EnSite NavX system with multielectrode basket catheter may potentially be helpful for safety and efficacy of RF catheter ablation with reduction in procedure time and low radiation exposure.

Key words: Premature ventricular complex, 3D mapping system, Multielectrode basket catheter, Radiofrequency catheter ablation

Introduction

Idiopathic premature ventricular contractions (PVCs) usually occur in patients without any structural heart disease, which are basically considered as benign and hemodynamically stable. However, they are often symptomatic and can limit patients' quality of life and rarely cause hemodynamic disorder. Previous report has demonstrated that right ventricular outflow tract (RVOT) is the predominant site of origin for idiopathic ventricular arrhythmias.[1)] Radiofrequency (RF) catheter ablation has become a well-established therapeutic approach for elimination of idiopathic ventricular tachycardia (VT) or PVCs arising from RVOT.[2)-4)] Localization of the optimal ablation site is mainly determined by the earliest activation site and the pace mapping methods. However, it is sometimes difficult to provide the favorable outcome in case of multifocal PVCs within RVOT. We report a case of successful catheter ablation for two distinct PVCs arising from RVOT using simultaneous mapping by EnSite NavX system with multielectrode basket catheter.

Case Report

A 43-year-old woman was referred for RF ablation of frequent PVCs. She had no episode of syncope, though she complained of palpitation and short of breath on physical

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exertion. She had no family history of sudden cardiac death. Two distinct PVC morphologies were observed in 12-lead electrocardiogram (ECG). Both types of PVCs exhibited a left bundle branch block and an inferior axis pattern of the QRS complex with R/S transition in V4 to V5 in chest leads, indicating the both PVCs arising from RVOT. Type 1 PVC exhibited a high amplitude positive polarity in inferior leads with negative QRS complex in lead I. Type 2 PVC exhibited a deeply negative polarity in precordial leads with biphasic R wave in lead I (Figure 1). A 24-hour Holter ECG showed 25,154 PVCs/day including three consecutive beats of non-sustained VT, representing 25% of all cardiac cycles. The administration of β-adrenergic blockers and Class Ia and Ic antiarrhythmic drugs were ineffective for suppressing PVCs. Echocardiography showed mild decrease of left ventricular wall motion with an ejection fraction of 50%. Coronary angiography demonstrated no evidence of significant stenosis.

After written informed consent was given, the electrophysiologic study and RF catheter ablation were performed. All antiarrhythmic drugs had been discontinued for 3 days prior to the ablation procedure. Multipolar mapping catheters were positioned in the high right atrium, His bundle region, coronary sinus, and right ventricle (RV). For mapping and RF ablation, a 7-French, 4-mm tip nonirrigaed quadripolar catheter (Fantasista, Japan Lifeline, Tokyo, Japan) was introduced from the right femoral vein in conjunction with an EnSite NavX system (St. Jude Medical, Minneapolis, MN, USA) through a long 8.5 French sheath (SR0, St. Jude Medical, DAIG, Minnetonka, MN, USA) to assure the stability of the ablation catheter. To introduce the multielectrode basket catheter (Constellation™; EP Technologies, Sunnyvale, CA, USA) to the RVOT, an 11-French guiding sheath (EP Technologies, San Jose, CA, USA) was inserted intravenously through the right femoral vein and positioned in the main pulmonary artery. Basket catheter was advanced through the guiding sheath and precisely positioned into the RVOT with fluoroscopic guidance taken in the right anterior oblique and left anterior oblique projection. To create the electroanatomical map, we constructed RV geometry by dragging the mapping catheter using an EnSite NavX system, and thus we generated a 3-D activation map. Both types of PVCs were documented spontaneously during the procedure. 12-lead ECG and all endocardial electrograms including 32 bipolar electrograms from multielectrode basket catheter were recorded during PVCs, and the sites of earliest activation were determined among these electrograms. Additionally, the earliest ventricular activation sites of both types of PVCs were identified by mapping using the EnSite NavX system. Anatomic localization of earliest ventricular activation sites obtained by multielectrode basket catheter was verified by EnSite activation map during PVCs. The targeted ablation points were labeled on the RVOT chamber image.

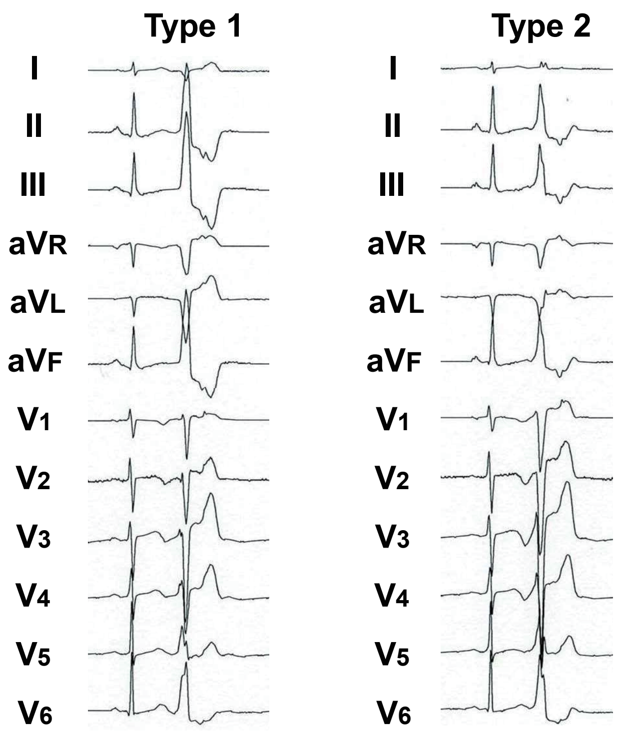

Fig. 1 Baseline ECG
12-lead ECG shows 2 types of premature ventricular contractions (PVCs) arising from right ventricular outflow tract. Type 1: PVC with negative QRS complex in lead I and higher absolute R wave in inferior leads. Type 2: PVC with biphasic QRS complex in lead I and a deeply S wave in precordial leads.

During type 1 PVCs occurrence, earliest ventricular activation was recorded in spline A5-6, which corresponded to the posteroseptal region of the RVOT confirmed by the EnSite NavX system. Pacing from the vicinity of earliest ventricular activation site preceded the QRS onset by 16 ms (Figure 2, 4A) resulted in an excellent match to the QRS complex of type 1 PVCs. RF application with a starting power output of 30 W and a maximum temperature set at 55 ℃ was delivered at that site. While type 1 PVCs was transiently suppressed by the first RF application, four additional applications near that site were required for its elimination. After completion of RF application to type 1 PVCs, mapping to type 2 PVCs were performed. During type 2 PVCs occurrence, earliest ventricular activation

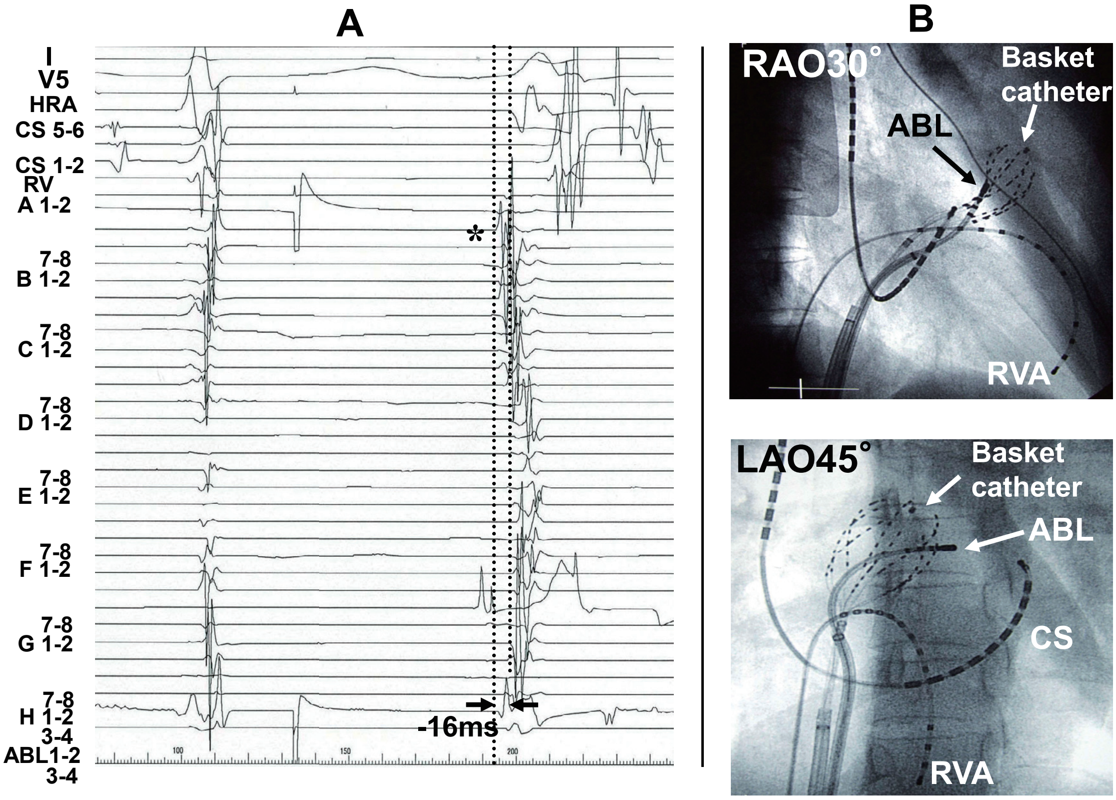

Fig. 2 Successful ablation site of type 1 PVC

A: * indicates that spline A5-6 in basket catheter was the earliest ventricular activation site at type 1 PVCs occurrence. Local ventricular electrogram preceded the onset of QRS wave in surface ECG by 16ms.

B: Right anterior and left anterior oblique views of fluoroscopic imaging. RAO, right anterior oblique; LAO, left anterior oblique; CS, coronary sinus; ABL, ablation catheter; RVA, right ventricular apex.

was recorded in spline F1-2 by the multielectrode basket catheter. Activation mapping of the target type 2 PVCs showed that the earliest activation was located at the anterolateral aspect of the RV free wall by EnSite NavX system. A local electrogram at the optimal RF ablation site preceded the onset of the QRS complex by 18ms（Figure 3, 4B）, and pacing at that site produced an identical QRS morphology to that of type 2 PVCs. RF application was delivered at that site, resulting in a suppression of type 2 PVCs. Thereafter, additional applications in the vicinity of first application site were required for its elimination. Both types of PVCs were no inducible by programmed electrical stimulation, either from the RV apex, or RVOT before and during isoproterenol infusion.

During 10-month of follow-up, patient has remained asymptomatic without any antiarrhythmic drugs. PVCs frequency in 24-hour Holter ECG decreased to a total of isolated 3 beats a day. Echocardiography revealed hemodynamic improvement of left ventricular function with increase in ejection fraction from 50 to 63%.

Discussion

The present case demonstrates that PVCs originate from different areas within the RVOT. Although the RF ablation therapy to multiple origin of RVOT may still be challenging because of the close anatomic relationship and different anatomic compartments of the outflow tract area, 12-lead ECG algorisms and mapping procedure may be helpful in predicting the area of origin. Especially, a 12-lead ECG evaluation is essential tool as the first step for approaching the RF ablation to determine the appropriate site of the PVCs origin. Some reports have been described that QRS duration and amplitude of S waves in anterior precordial leads V_2 and V_3 were useful for distinguishing RV free wall from septal sites of origin[5)-7)]. Tada et al.[5)] demonstrated that RR' pattern in lead I and inferior leads, prolongation of QRS complex duration, and S-wave amplitude of at least 3.0mV in lead V2 showed identifiable morphology pattern in PVCs arising in the free wall of RVOT. This reflects phased excitation from RV free wall

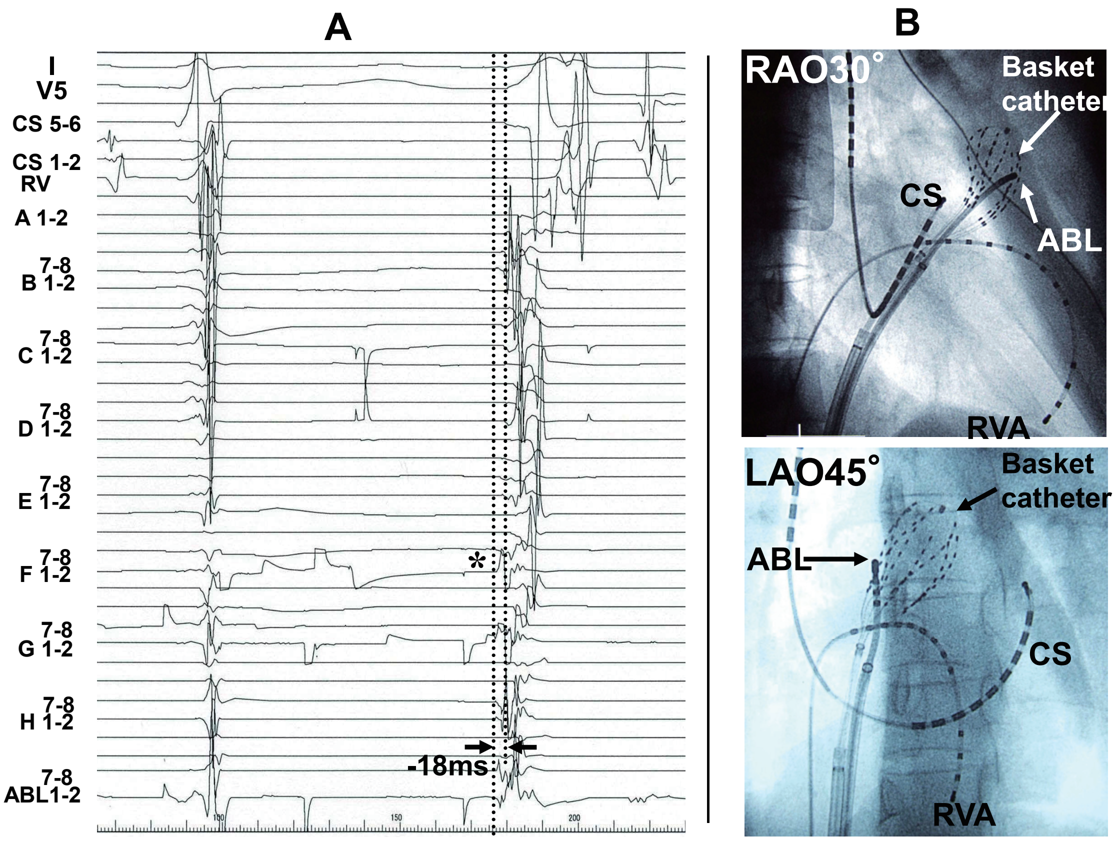

Fig. 3 Successful ablation site of type 2 PVC

A: * indicates that spline F1-2 in basket catheter was the earliest ventricular activation site at type 2 PVCs occurrence. Local ventricular electrogram preceded the onset of QRS wave in surface ECG by 18ms.

B: Right anterior and left anterior oblique views of fluoroscopic imaging. RAO, right anterior oblique; LAO, left anterior oblique; CS, coronary sinus; ABL, ablation catheter; RVA, right ventricular apex.

to the left ventricle. In the present case, morphology in type 1 PVCs shows shorter QRS complex duration and higher absolute R wave magnitude, indicating the generation from the septal aspects in RVOT. Regarding to type 2 PVCs, although RR' pattern in lead I and inferior leads reflecting phased excitation were less dominant, morphology was similar to free wall type of PVCs in RVOT. Yoshida et al.[8)] reported the pace mapping study using a multielectrode basket catheter to identify the precise origin of idiopathic VT arising from RVOT, and that R in lead I and Rr' configuration pattern in lead II, III were associated with a posterolateral attachment side of the free wall. This was consistent with the present type 2 PVCs morphology pattern, and localization of origin was verified by EnSite activation map. These findings indicate that surface 12-lead ECG algorithm is helpful to predict the optimal RF ablation sites. However, various origins of ventricular arrhythmias in the RVOT are known to exist within a small region. Especially, the posterior aspect of the RVOT is closely related to the right coronary cusp and junction between right and left coronary cusps. Therefore, the 12-lead ECG characteristics are difficult to differentiate in those regions[9), 10)], and ECG algorithm sometimes causes considerable limitation regarding to detailed localization analysis including close sites in small areas.

Clinical usefulness of a multielectrode basket catheter for idiopathic ventricular arrhythmias originating from RVOT was previously described,[11)] and revealed that the multielectrode basket catheter permitted easy identification of each site of earliest activity and activation sequence even if more than 2 PVCs arising from RVOT were recorded on the 12-lead ECG. However, the splines of basket catheter might not always completely cover the entire endocardium of RVOT in case of enlargement or anomalous change of RVOT. The EnSite NavX system allows visualization of all catheters used during an ablation procedure, 3-D reconstruction of the heart chambers, and activation and voltage maps. The ablation catheters can be visualized and navigated easily within the previously constructed cardiac chambers under NavX guidance. Though the fluoroscopy

A

B

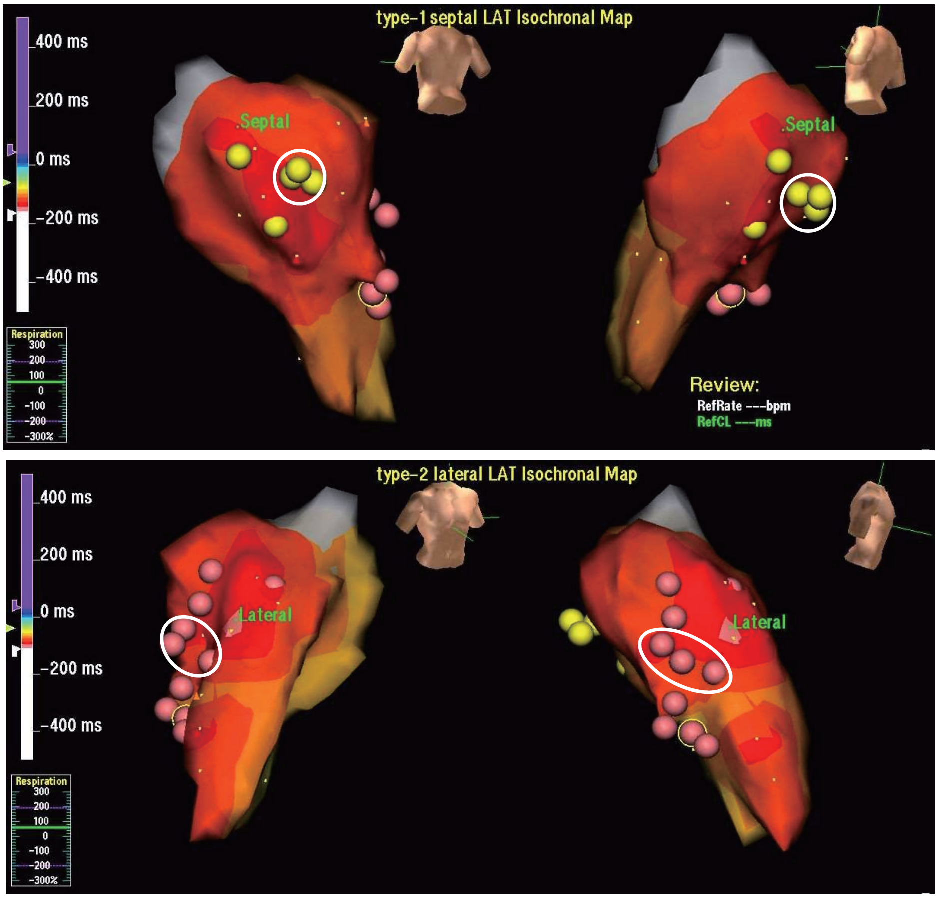

Fig. 4 EnSite NavX three-dimensional activation maps of right ventricular outflow tract (RVOT)

Panel A: Posteroseptal view of three-dimensional RVOT geometry reconstructed by EnSite NavX system at type 1 PVC occurrence. Type 1 PVC generally originated from the posteroseptal aspect in RVOT (white circle).

Panel B: Anterolateral view of RVOT geometry reconstructed by EnSite NavX system at type 2 PVC occurrence. Type 2 PVC generally originated from the anterolateral aspect in RVOT free wall (white oval).

Yellow and pink dots indicate ablation sites.

Rectangular objects located in each left side of panel A and B shows the measurements of electrical activation displayed by color coded.

time required varies depending on the operator's experience and the technique used, EnSite NavX-guided ablation reduces the total radiation exposure, procedure time, and number of RF applications compared with the conventional fluoroscopy-guided ablation.[12), 13)]

Additional use of 3-D electro-anatomical map might be compensated such procedural limitation of basket catheter and disadvantage of 12-lead ECG algorithm. EnSite system allows obtaining quickly and completely anatomical maps of the RVOT, which is capable of continuously and automatically acquiring multiple location points for each electrode from basket catheter. Thus, we can generate 3-D map with the advantage of shorter mapping and radiation times. Additionally, because multielectrode basket catheter enables to perform pace mapping method from each electrode pair covering RVOT, ablation catheter can be navigated easily to the point where the best pace-matched score was obtained under guidance of EnSite activation map.

The present case demonstrates that knowledge of 12-lead ECG characteristics can be useful for differentiating the origins of septal from the origins of free wall aspects in RVOT, which also may be indicative of a more suitable RF ablation sites. Simultaneous mapping of EnSite NavX system with multielectrode basket catheter helps the physician guide precisely the ablation catheter to the point where treatment is needed. Because the outflow tract regions have complex three-dimensional anatomical relationships, ablation procedure might be technically difficult with increasing the radiation dose. Therefore, the better understanding of the anatomical relationships using an EnSite NavX system provides the profound insights regarding to the interpretation of 12-lead ECG for estimating and differentiating the origin of outflow ventricular arrhythmias. Finally, simultaneous mapping of EnSite NavX system with multielectrode basket catheter may potentially be helpful for safety and efficacy of RF catheter ablation with reduction in procedure time and low radiation exposure, such in patients with multifocal PVCs.

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