

# Open chest epicardial mapping in an asymptomatic patient with Brugada syndrome



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## Introduction

ST elevation is a pivotal finding in Brugada syndrome. There has been debate for a long time as to whether the ST elevation results from a depolarization abnormality or a repolarization abnormality.<sup>1</sup> According to the repolarization abnormality hypothesis, the pathophysiology of Brugada syndrome is due to a morphologic change of the epicardial action potential and transmural dispersion of the repolarization. On the other hand, according to the depolarization abnormality hypothesis, the ST elevation is due to a voltage gradient induced by delayed epicardial conduction. Delayed potentials, which are a marker of a depolarization abnormality, usually cannot be recorded on the endocardial surface but can be recorded on the ventricular epicardium in patients with Brugada syndrome.<sup>2</sup> In 2011, Nademanee and colleagues<sup>3</sup> reported that epicardial mapping in patients with frequent ventricular fibrillation (VF) episodes revealed abnormal delayed potentials existing on the epicardial surface of the right ventricular outflow tract (RVOT). Radiofrequency catheter ablation of the area with abnormal potentials eliminated the typical Brugada-type ST elevation and prevented the occurrence of VF.<sup>3-5</sup> The results of ablation have indicated that ST elevation and arrhythmogenicity in high-risk patients are closely associated with epicardial abnormal potentials. Epicardial mapping and ablation are invasive methods and their application is now limited to high-risk patients with recurrent VF episodes.<sup>3-6</sup> However, in asymptomatic patients with Brugada syndrome, the existence and role of delayed potentials in the appearance of a type 1 electrocardiogram (ECG) have not been reported. We here report the results of epicardial mapping in an

asymptomatic patient with Brugada syndrome who received enucleation surgery of an intracardiac tumor.

## Case report

A 55-year-old man in whom a Brugada-type ECG was detected in a medical check-up was referred to our hospital in 2002. He had not experienced any syncopal episodes and did not have a family history of sudden death. His ECG was a spontaneous type 1 ECG ([Figure 1A](#)), and late potentials recorded by signal-averaged electrocardiography were positive. Programmed electrical stimulation (PES) from the right ventricular apex and RVOT with triple extra-stimuli (coupling interval  $\geq 180$  ms) did not induce any VF. The effective refractory periods were 230 ms at the right ventricular apex and 220 ms in the RVOT (basic cycle length: 600 ms). Analysis of the *SCN5A* gene showed that the patient did not have any mutations. Although he had a spontaneous type 1 ECG, we considered from the clinical characteristics and results of PES that he was at low risk for VF, and he was followed in the outpatient clinic once a year.

An ECG recorded in the outpatient clinic in August 2015 revealed frequent premature ventricular contractions (PVCs) ([Figure 1A](#)), but the patient did not experience any symptoms. An ambulatory ECG showed that the occurrence of monofocal PVCs was 10,929 beats/day (10% of the total beats) and that there were no couplets or salvos of PVCs. The occurrence of PVCs did not change during follow-up, and a re-evaluation of the risk in this patient was planned. Contrast-enhanced computed tomography showed no right ventricle (RV) abnormalities but revealed an intracardiac tumor on the intra-atrial septum of the left atrium, suggesting that it was an atrial myxoma. RV endocardial substrate mapping and ablation for PVCs were planned before the cardiac surgery to eliminate the possibility of any lethal arrhythmias during the perioperative period. After informed consent was obtained, 2 vascular sheaths were placed in the right femoral vein for a quadripolar catheter and an 8F irrigated ablation catheter (NaviStar ThermoCool SmartTouch, Biosense Webster, Diamond Bar, CA) with a D curve to be placed in the RV. Then endocardial RV voltage mapping was

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## KEY TEACHING POINTS

- Epicardial mapping was done in a patient with sporadic and entirely asymptomatic Brugada syndrome.
- Multiple abnormal potentials were recorded on the right ventricle epicardium, especially from below the pulmonary artery valve to above the tricuspid annulus.
- The electrocardiogram was normalized after ablation of the abnormal epicardial potentials.

performed using an electroanatomic mapping system (CARTO 3, Biosense Webster, Diamond Bar, CA), and the target PVCs were ablated by a pace mapping and activation mapping technique (Figure 2B). The PVCs disappeared after the ablation, but an extensive low-voltage potential region was found in the RVOT during endocardial mapping (Figures 1B and 2A). This finding suggested the existence of an epicardial abnormal substrate.

With permission from Okayama University's ethics committee, epicardial mapping was planned at the time of open chest surgery to resect the cardiac tumor. Epicardial mapping was performed using a 7F decapolar catheter (DecaNav, Biosense Webster, Diamond Bar, CA) before and after infusion of pilsicainide (1 mg/kg). The total mapping points were 284 before and 292 after the pilsicainide infusion. Multiple abnormal potentials were found in the RVOT between the region below the pulmonary artery and around the tricuspid annulus before pilsicainide infusion (Figure 3). The area in

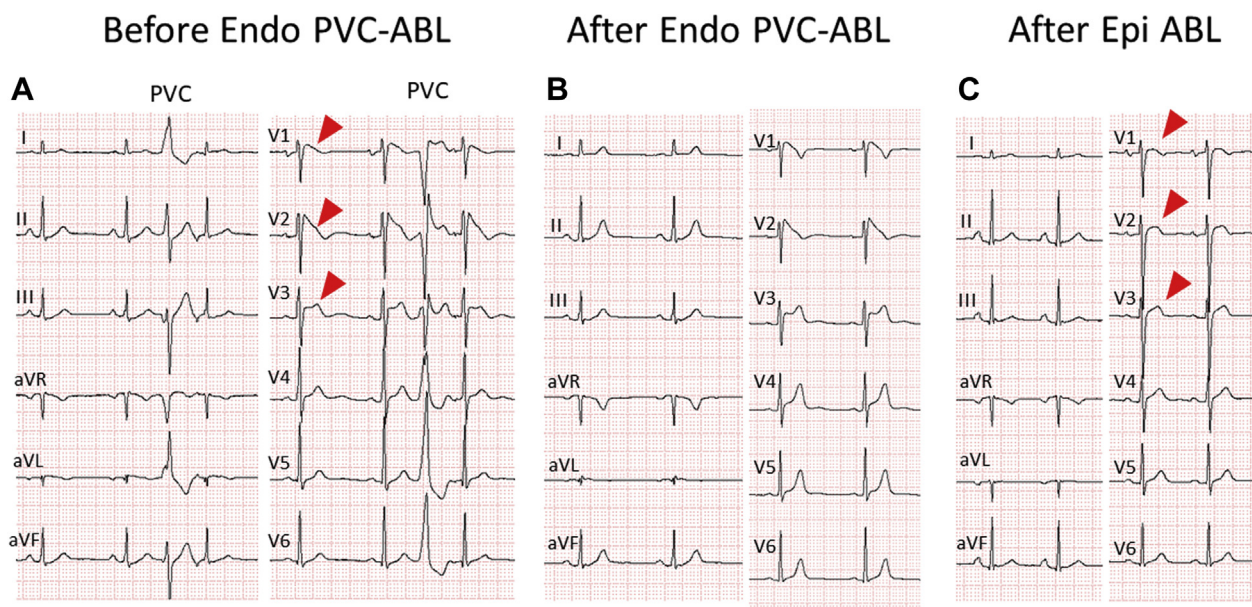
which the abnormal potentials were recorded became enlarged after pilsicainide infusion. Those potentials were ablated using an 8F irrigated ablation catheter (NaviStar ThermoCool SmartTouch, Biosense Webster) with a D curve.

After the epicardial ablation, the ECG was normalized (Figure 1C) and the late potentials were eliminated. The patient has been free from any symptoms and has not experienced any ventricular arrhythmic events.

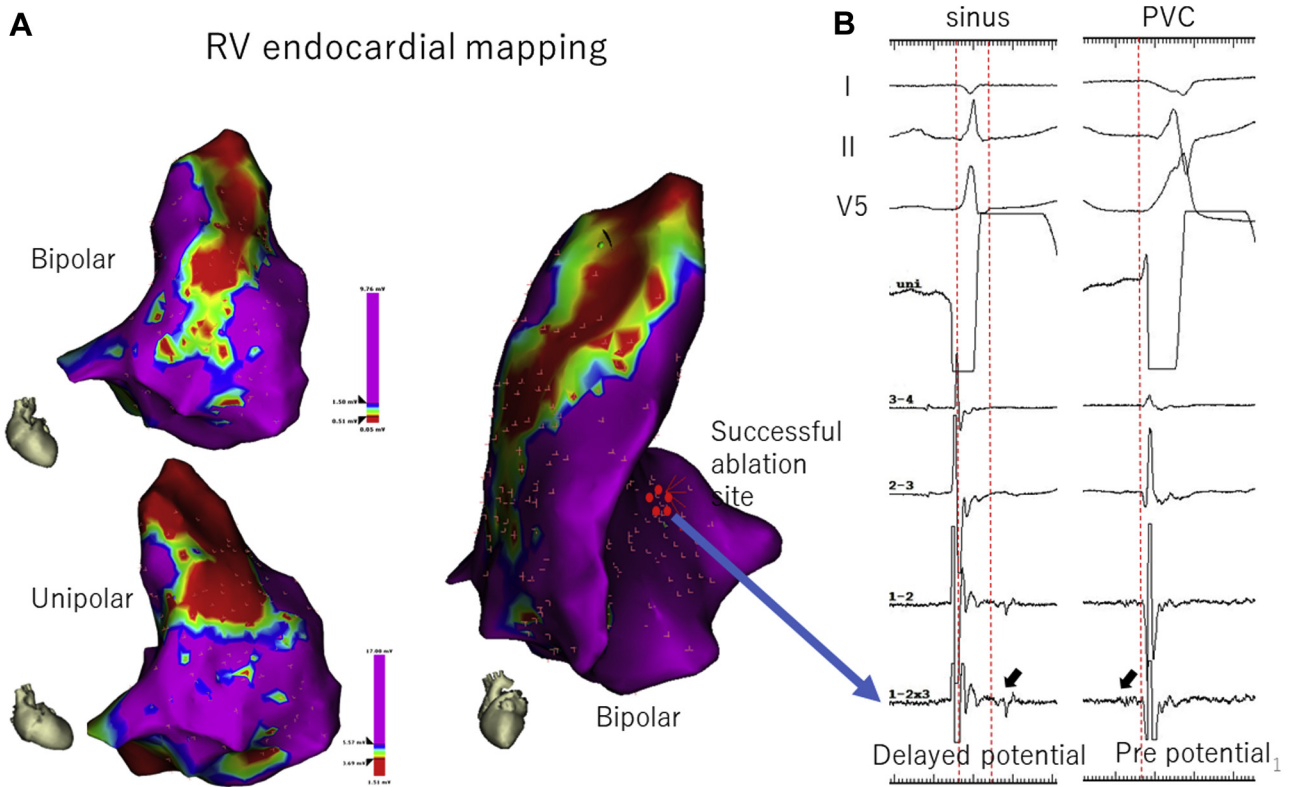
## Discussion

Here we report open chest epicardial mapping in an asymptomatic patient with Brugada syndrome. The patient did not have any symptoms or a family history of sudden death. PES failed to induce VF. This asymptomatic sporadic patient was considered to be at low risk. Open heart surgery was required for an intra-atrial myxoma that was incidentally found, and it was decided to perform epicardial mapping and ablation at the time of surgery. Various abnormal potentials including low-voltage, fragmented, and double or delayed potentials were found on the epicardial surface from the RV free wall to the RVOT. The morphologies of those abnormal potentials were similar to the potentials previously reported in high-risk patients.<sup>3-5</sup> Application of radiofrequency ablation to the abnormal potentials eliminated the Brugada-type ST elevation and normalized the ECG. Our case indicated that abnormal delayed potentials can exist even in asymptomatic sporadic patients who are thought to be at low risk.

Epicardial abnormal potentials in patients with Brugada syndrome were initially recorded through a guidewire in the conus branch of the right coronary artery. Nagase and colleagues<sup>2</sup> reported that delayed potentials were recorded in 5 patients (3 patients with VF and 2

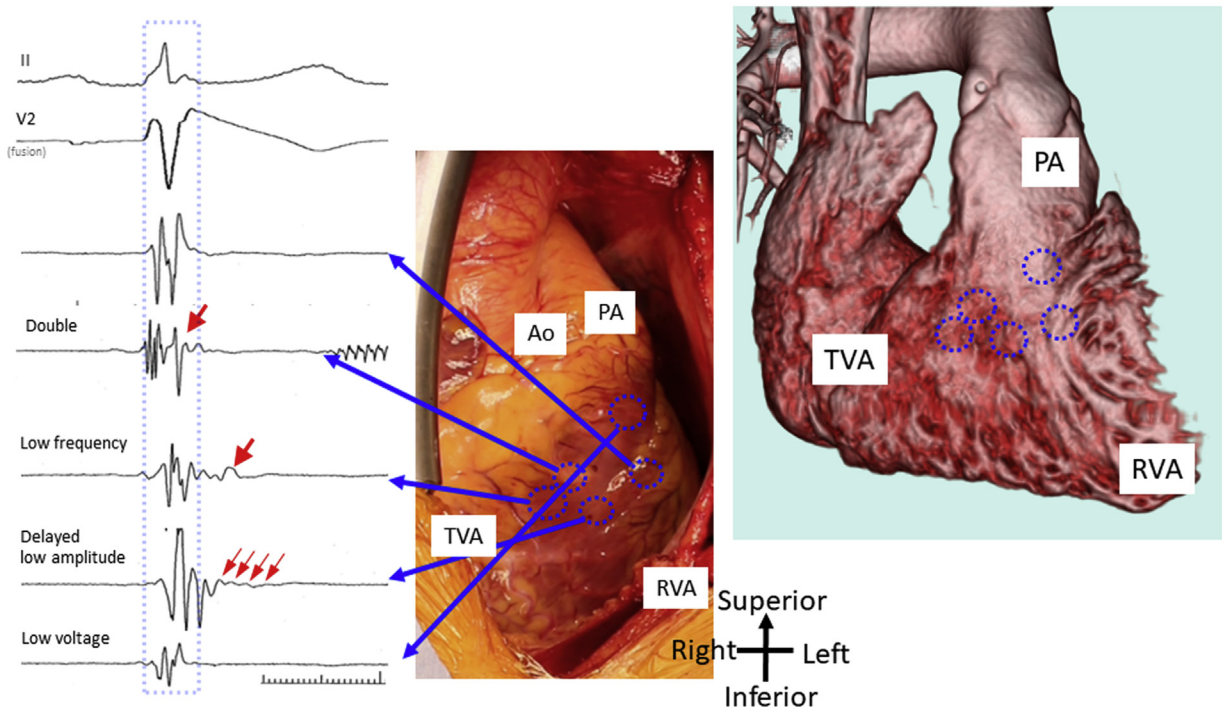


**Figure 1** A: Typical Brugada-type electrocardiogram (ECG) during sinus rhythm before endocardial ablation of frequent premature ventricular contractions (PVCs). B: Typical Brugada-type ECG remaining after PVC ablation. C: Normalized ECG after epicardial ablation. ABL = ablation; Endo = endocardial; Epi = epicardial.



**Figure 2** A: Right ventricle (RV) endocardial mapping and a low-voltage area in the right ventricular outflow tract from the pulmonary artery to tricuspid valve. B: Late potentials at the ablation site of the targeted premature ventricular contraction (PVC) during sinus rhythm (left) and pre-potentials recorded immediately before the targeted PVC (right).

Epicardial mapping



**Figure 3** Multiple abnormal potentials on the right ventricle recorded by epicardial mapping during open heart surgery. Ao = aorta; PA = pulmonary artery; RVA = right ventricular apex; TVA = tricuspid valve annulus.

asymptomatic patients) and were augmented after the administration of a sodium channel blocker. PES induced VF in 2 asymptomatic patients and an asymptomatic patient died suddenly after 10 years. In 2011, Nademanee and colleagues<sup>3</sup> reported the results of direct epicardial mapping and radiofrequency catheter ablation in 9 patients with Brugada syndrome who had recurrent VF episodes. All of the patients had low-voltage, widening, and fractionated late potentials in the anterior aspect of the RVOT epicardium. After that report, Brugada and colleagues<sup>4</sup> reported epicardial mapping and ablation in 14 symptomatic patients with induced VT/VF, and Zhang and colleagues<sup>5</sup> also reported 11 patients with syncope or VF. Both reports showed abnormal potentials similar to those in Nademanee's study.<sup>3</sup> Histologic examination revealed that a reduction in connexin 43, increased interstitial collagen, and replacement of fibrosis occurred in the RVOT epicardium and that those pathologic changes generated abnormal potentials.<sup>6</sup> Fibrosis in the epicardial layer causes delayed activation and conduction block at the epicardium and promotes ST elevation by a current-to-load mismatch.<sup>7</sup>

Most of the patients in the previous studies were high-risk patients who had syncope, VF episodes, or PES-induced VF. One study included an asymptomatic patient with drug-induced Brugada syndrome who had atrial fibrillation.<sup>7</sup> That patient had longer fractionated potentials than those in the controls. The present case had a spontaneous type 1 ECG but did not have a family history of sudden death or PES-induced VF. Direct epicardial mapping and ablation were performed during open chest surgery and complete detailed mapping on the epicardial surface of the RV was achieved. Although there are not sufficient epicardial mapping data for asymptomatic patients, the results of the epicardial mapping in the present case showed that the epicardial fractionated potentials are most likely to be associated with

the generation of ST elevation even in asymptomatic low-risk patients with Brugada syndrome.

We did not evaluate epicardial repolarization, and the results presented in this case report therefore cannot deny the repolarization abnormality hypothesis. A delayed upstroke of the phase 2 dome in the epicardial action potential and a concealed phase 2 reentry could also explain the fractionated potentials.<sup>8</sup> Evaluation of repolarization abnormalities by using, for example, monophasic action potentials is needed to determine the mechanism of ST elevation and arrhythmogenesis in Brugada syndrome.

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