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CASE REPORT

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Ultra-high density mapping of intra-atrial reentrant tachycardia in a patient after a lateral tunnel total cavopulmonary connection

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Abstract

We report a case of an 18-year-old male with a postsurgical lateral tunnel (LT) total cavopulmonary connection (TCPC) and supraventricular tachycardia (SVT). Patients after an LT TCPC have complicated suture lines and a considerable area of damaged myocardium in the LT, which could become a complex arrhythmogenic substrate of tachycardias. Detailed three-dimensional (3D) mapping of the LT and atrium is important for a successful ablation. In this patient, successful catheter ablation of two types of complex tachycardias was accomplished using an ultra-high density 3D mapping system inside the LT.

KEYWORDS

catheter ablation, congenital heart disease, fontan operation, lateral tunnel, ultra-high density mapping

1 | INTRODUCTION

Recently, the total cavopulmonary connection (TCPC) has become a primary surgical procedure for patients with a single ventricle. Those patients may develop an intra-atrial reentrant tachycardia (IART) long after the surgery.[1] Those tachyarrhythmias may increase the mortality and hospitalizations.[2] Catheter ablation of supraventricular tachycardias (SVTs) in these patients is sometimes technically difficult but has been reported to be safe and effective.[3] We describe a patient with two types of IARTs originating from a prior suture line of a lateral tunnel (LT) TCPC using an ultra-high density three-dimensional (3D) mapping system.

2 | CASE REPORT

An 18-year-old male was referred to our hospital for radiofrequency catheter ablation (RFCA) of a SVT. At birth, he was diagnosed with hypoplastic left ventricular syndrome (HLHS), and a bilateral superior vena cava (SVC). A Norwood operation was performed at 9 days after his birth. A Glenn operation of the right-sided SVC was performed at 6 months, and that of the left-sided SVC was performed at 1 year and 10 months. A LT type TCPC and pulmonary artery (PA) plasty were performed when he was 3 years old. Then he developed pulmonary hypertension and Bosentan was started when he was 13 years old. An SVT was first noted when he was 16 years old. Cardioversion was required to terminate this tachycardia and flecainide was then started. He had an operation planned to convert the LT TCPC to an extracardiac (EC) TCPC, and therefore, he was referred to our hospital to undergo RFCA.

Cardiac computed tomography (CT) was performed before the RFCA to analyze the 3D anatomy and the RFCA was performed with the use of a high-density 3D mapping system (Rhythmia; Boston Scientific). Those procedures were performed under general anesthesia by an anesthesiologist.

Angiography from the conduit was performed to confirm the anatomy of the LT before the ablation, but no fenestration was observed. Furthermore, the mean central venous pressure in the LT was 18-20 mmHg. Since a transbaffle puncture may cause severe hypoxia to develop because of a right to left shunt, we decided to perform the ablation inside the LT.

A 5 Fr decapolar electrode catheter (Snake®; Japan Lifeline) was positioned in the left PA via the Glenn's anastomosis from the left internal jugular vein, and a 4 Fr quadripolar electrode catheter (Inquiry®; Abbot) was positioned in the single ventricle from the femoral artery. An 8.5 Fr steerable sheath (Agilis®; Abbot) was introduced into the TCPC conduit from the right femoral vein. Intravenous heparin was used to maintain the activated clotting time at 300-350 seconds.

An SVT (SVT1) with a cycle length (CL) of 372 ms was induced during atrial burst pacing (Figure 1). Ultra-high density 3D mapping was created during the tachycardia and the propagation maps revealed an intra-reentrant pattern around the scar area on the left side of the LT (Movie S1). The postpacing interval (PPI) from the posterior LT was more than 450 ms and the PPI from the left side of the LT was 380 ms Fragmented potentials were recorded at a high septal area in the LT (Figure 1A). A radiofrequency energy (30W) delivery around that area successfully terminated the SVT1 (Figure 1B,C, red tag area).

After the ablation of SVT1, another SVT (SVT2) with a CL of 500 ms was induced during atrial burst pacing. Burst pacing during the tachycardia easily terminated this tachycardia, therefore, entrainment pacing could not be performed during SVT2. Three-dimensional propagation maps of SVT2 revealed an intra-reentrant pattern around the LT (Figure 2A-H) (Movie S2). Fragmented potentials were recorded along the front side of the LT (Figure 2I, red tag area), and a radiofrequency energy delivery (30W) successfully terminated SVT2.

3 | DISCUSSION

To the best of our knowledge, this is the first case report to describe the detailed mapping of an IART after an LT TCPC using an ultra-high density 3D mapping system. Patients after an LT TCPC have a complex suture line and considerable area of damaged myocardium in the LT, which could become an arrhythmogenic substrate of an IART. Detailed 3D mapping of the LT is important for a successful ablation. However, the previous mapping systems have difficulty in recording small amplitude potentials. In general, a bipolar voltage of less than 0.5 mV[4] has been considered as a low voltage area of scar tissue. On the other hand, the electrodes of the Orion catheter have a 0.4 mm^2 area with a 2.5 mm inter-electrode spacing and are useful for recording tiny potentials[5]. Rhythmia mapping showed that the local potential of SVT1 and SVT 2 at the ablation site was 0.0746 mV (Figure 1D) and 0.0913 mV (Figure 2I), respectively. Those tiny potentials would be difficult to detect using the previous mapping system. Furthermore, the Rhythmia system could also differentiate double potentials without any manual annotation. These new algorithms were useful for the accurate mapping of the LT in this patient. Figure 2J shows the local potentials close to the ablation site. Although the amplitude of those was 0.0705 mV, the Rhythmia system could differentiate the timing of the activation by the ablation site without a manual annotation.

The Rhythmia system needs two different potential references for the propagation reference, which is indispensable for accurate mapping. In our patient, the reference catheter was positioned in the PA. It could record the single atrium potentials over a broad area and was useful for the propagation reference of the Rhythmia system.

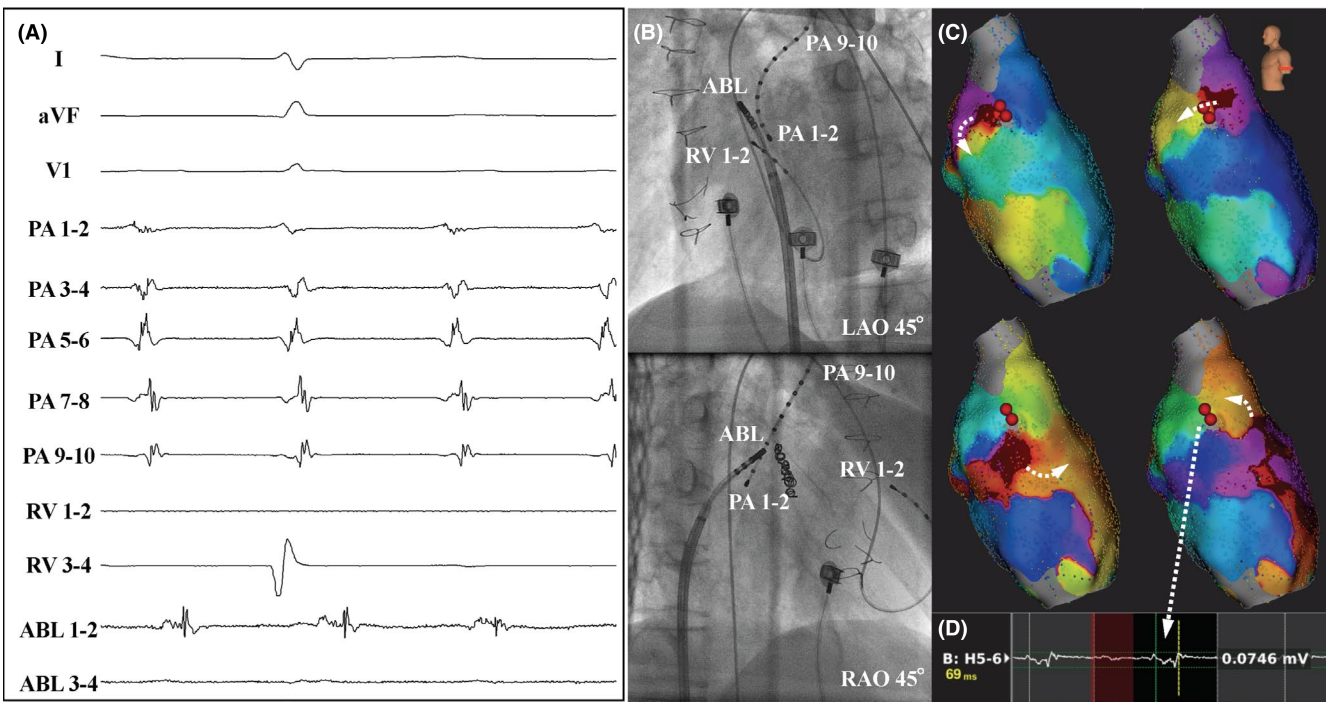

FIGURE 1 Intracardiac ECG, fluoroscopic image, and 3D mapping of SVT1. A. The intracardiac ECG of the ablation site of SVT1. B. The fluoroscopic image shows the ablation site. C. Three-dimensional mapping shows an intra-reentrant pattern around the low voltage area. Ablation succeeded at the red tag area. D. Local potential at the ablation site. ABL, ablation catheter; ECG, electrocardiogram; LAO, left anterior oblique; PA, pulmonary artery; RAO, right anterior oblique; RV, right ventricle; SVT, supraventricular tachycardia

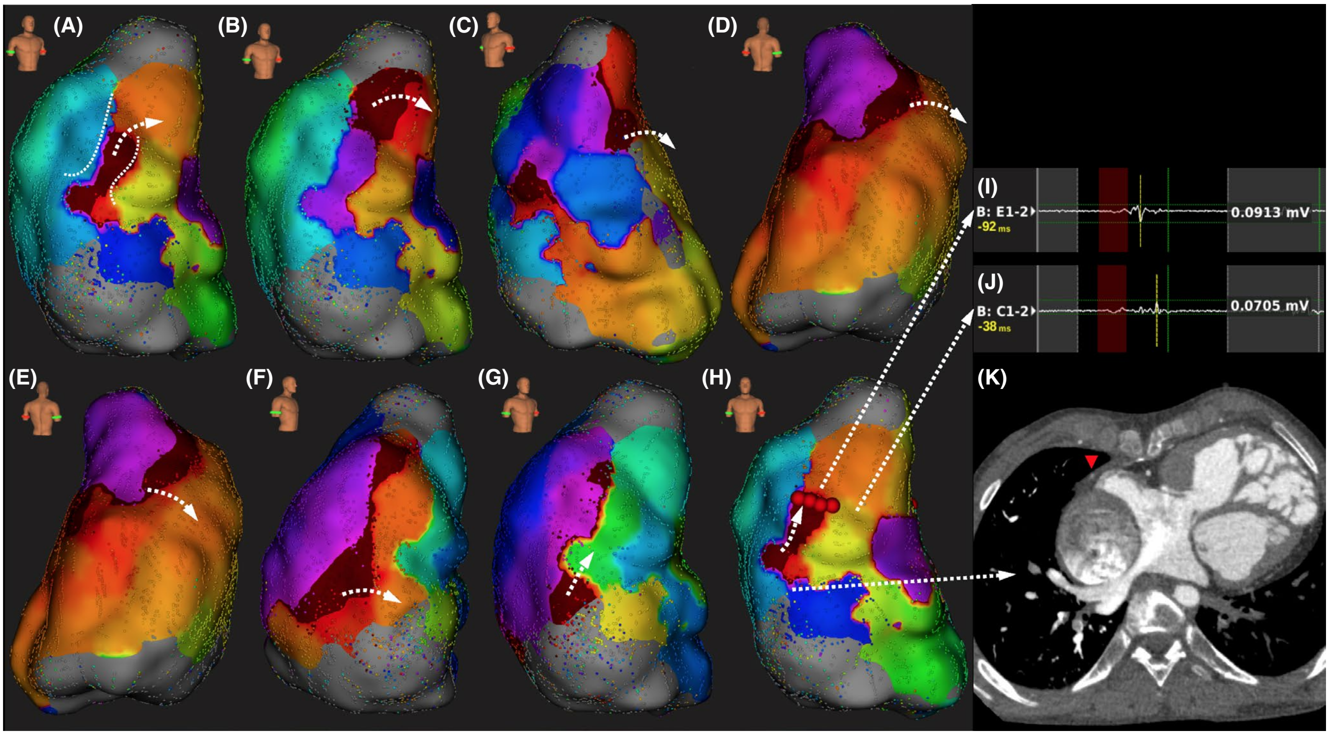

FIGURE 2 Three-dimensional mapping of SVT2. The propagation of the tachycardia wave front is shown from A to H. The tachycardia exhibited an intra-atrial reentrant pattern around the LT. Ablation (red tag) was successfully performed between the block line (white dotted line). I, Local potential at the ablation site. J, local potential close to the ablation site. K, CT image showing the atrial tissue around the LT

The LT TCPC has more complex suture lines in the atrium than the EC TCPC. The 3D mapping revealed a block line in the area in front of the LT. CT revealed a suture area with atrial tissue around the suture (Figure 2K, arrowhead). This atrial tissue between both sides of the suture line might have become an arrhythmogenic substrate of a slow conduction in SVT2.

4 | CONCLUSION

The ultra-high density 3D mapping system was useful for recording the activation map of the IART after the LT TCPC operation.

CONFLICT OF INTEREST

The authors declare no conflict of interests for this article.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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