



## Catheter ablation of a right epicardial accessory pathway via the small cardiac vein: Two case reports

### Small cardiac vein-related accessory pathway

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#### Introduction

Accessory pathway (AP) is an anomalous muscular connection between atrium and ventricle that bypasses the atrioventricular node. Although radiofrequency (RF) catheter ablation of AP-mediated supraventricular tachycardia is recommended as first-line therapy with an overall success rate exceeding 90%, ablation of right-sided AP remains challenging [1]. Atypical configuration of AP or cardiac structural abnormalities result in a lower initial success rate and a higher recurrence rate. In a previous study, 8% of prolonged or failed ablation of AP was due to the presence of epicardial AP [2]. We here describe two rare cases of successful ablation of small cardiac vein (SCV) mediated atrioventricular reentrant tachycardia (AVRT).

#### Case report

##### Case one

An 11-year-old Chinese boy with a structurally normal heart, drug-refractory palpitations and documented recurrent episodes of narrow QRS complex AVRT, was referred to our hospital (Beijing Anzhen Hospital, China) for elective ablation of an overt AP. He had undergone an unsuccessful RF ablation 1 month before and had supraventricular tachycardia recurrence 10 days thereafter. His resting surface electrocardiogram (ECG) prior to the index procedure suggested a right lateral AP, which was further confirmed during the same procedure. The initial ablation site was located at the 9 o'clock position of the tricuspid annulus (TA).

Before the procedure, resting ECG was obtained but revealed no pre-excitation. Multipolar catheters were placed in the coronary sinus and right ventricular apex and a 7-Fr open irrigated ablation contact force catheter (Thermocool SmartTouch™, D curve, Biosense Webster) was used. The electroanatomical mapping was performed using the Carto™ 3-dimensional system (Biosense Webster, Inc., Diamond Bar, CA, USA). Because no antegrade conduction over AP was recorded, electrophysiological study was conducted and revealed persistent

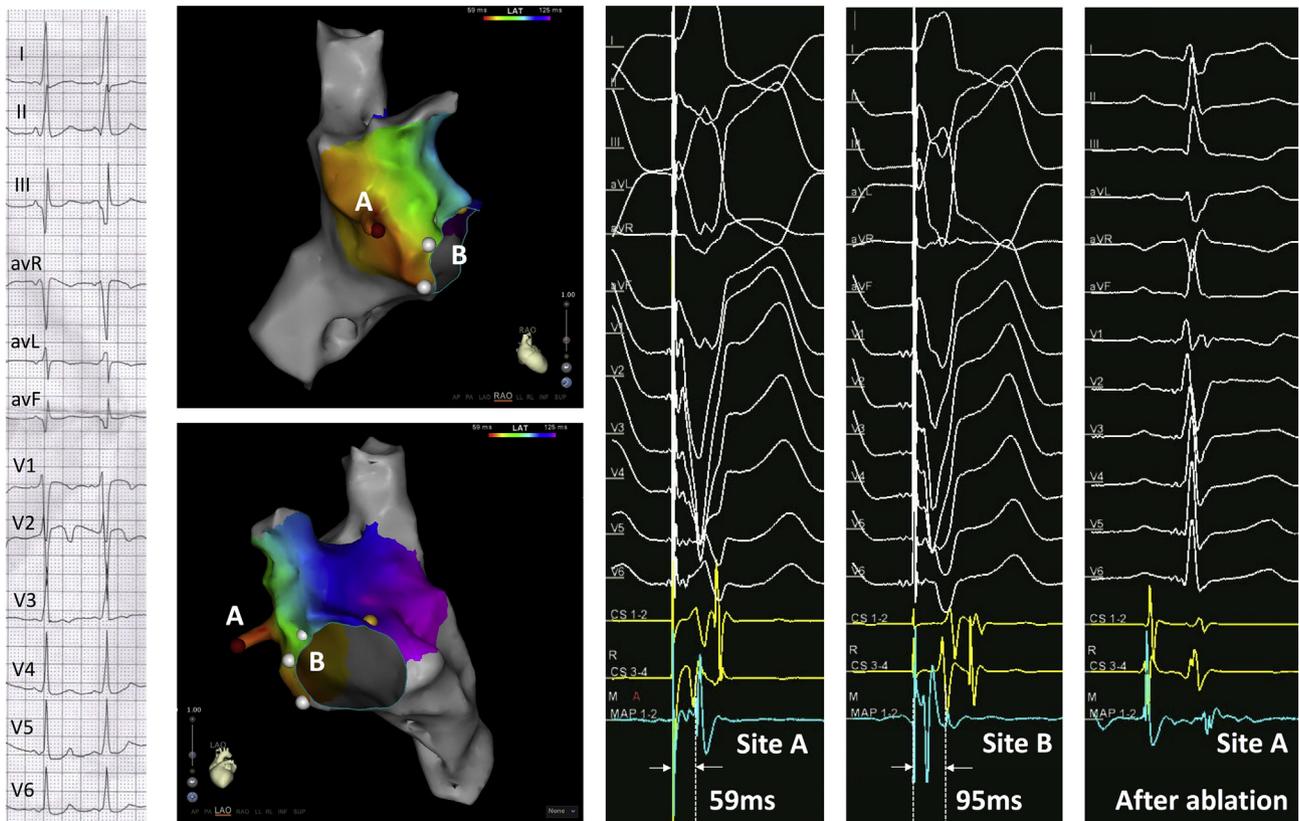
retrograde conduction over AP mediating the AVRT. The earliest retrograde atrial activation was documented at the atrial side of TA (9 o'clock) during right ventricular apex pacing. The distance between the atrial insertion sites and the TA was 20 mm (Fig. 1). While maneuvering the catheter in this region for further mapping, it was positioned into an orifice which protruded from the right atrium (RA) with impedance rising to 200-Ω. Selected venography revealed the presence of the SCV flowing into the RA (Supplementary Fig. 1). RF ablation within the SCV (4 mm from the orifice), with temperature, power and saline irrigation speed set at 43 °C, 20 W and 30 mL/min, respectively, successfully eliminated the retrograde conduction of the AP within 3 s, and ablation was continued to 60 s. No periprocedural complications occurred and ECG showed no evidence of ventricular pre-excitation after ablation. At 1 year follow-up, the patient experienced no tachycardia recurrence.

##### Case two

A 25-year-old man with Wolff-Parkinson-White syndrome was referred for re-evaluation after a failed attempt of ablation of right free-wall AP. Repeated RF applications along the TA failed to interrupt the AP conduction.

Similar technique and strategy as described for case 1 were used in the index procedure. During the reciprocating tachycardia, the retrograde atrial activation distributed over a relatively wide range at 8 to 10 o'clock of the TA (Fig. 2). Initial RF ablation in the TA had no effect on AP conduction. Further catheter dislodgment in the cavity of RA transiently suppressed AP function with impedance rising from 150-Ω to 300-Ω. Intracardiac 3-D electroanatomic mapping suggested that the catheter was displaced into a chamber located lateral to the RA. Local meticulous mapping showed that the earliest atrial activation was recorded within the chamber and 19-mm away from the TA. Selected angiography confirmed the presence of SCV (Supplementary Fig. 2). When gently pulling back the catheter to the ostium of SCV, the monitor system showed that the impedance decreased sharply from 300 Ω to 200 Ω. A second RF pulse (43 °C, 20 W with 30 mL/min flow duration of 30 s) at this site with the aid of a long sheath resulted in AP block within 1 s of RF delivery. After a 30-min waiting period, there was no sign of AP conduction recurrence and no complications occurred. An A:V ratio of about 5:1 was observed in the local electrogram after the ablation.

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**Fig. 1.** Electrophysiological characteristics of small cardiac vein related accessory pathway (Case One). Left panel exhibits the positive delta waves in leads V1, I, aVL and II, suggesting the presence of right lateral accessory pathway before initial ablation. Middle panel demonstrates the electroanatomic mapping of the accessory pathway in the right atrium during right ventricle (RV) pacing using CARTO system. The earliest activation location (Site A: ablation point) is on the proximal portion of the small cardiac vein (SCV). Right panel presents the scalar ECG and intracardiac recordings of coronary sinus (CS 1–2 and CS 3–4) and mapping catheter (MAP 1–2). Although the RV pacing catheter position shifted during procedure (different pacing QRS morphologies), Site A showed the shortest stimulus-to-atrial conduction interval (59-ms) with a large A and small V after ablation, compared to Site B (95-ms) at the tricuspid annulus.

## Discussion

In the present report, we describe two cases of right lateral AP that were successfully treated with RF ablation in SCV after a prior failure. The angiography and electroanatomic mapping showed that the SCV located far from TA and drained directly into the RA.

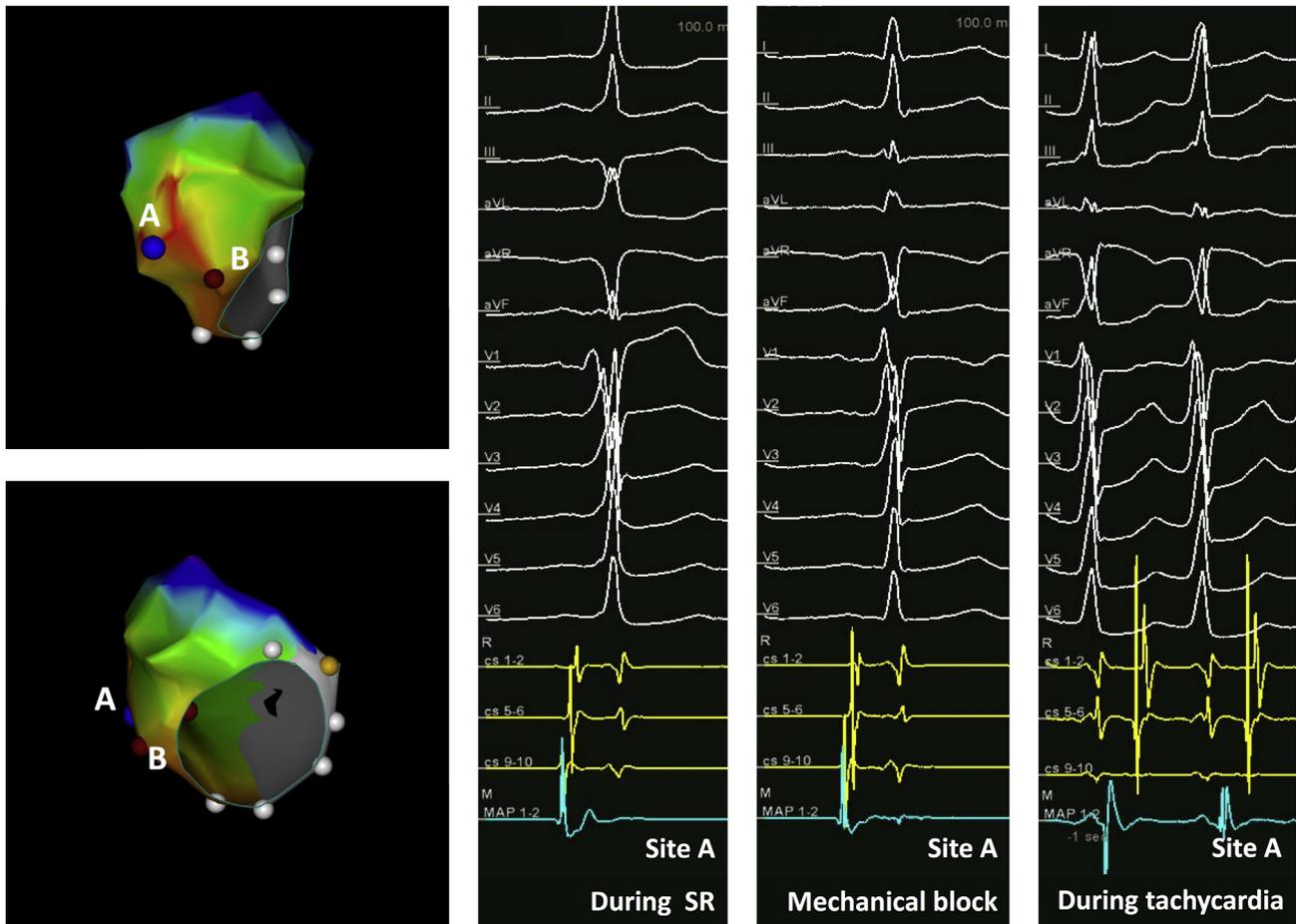
In clinical practice, routine mapping of AP insertion is generally performed along the edge of mitral and tricuspid annuli. Recently, right-sided APs with atrial insertion far from TA were reported [3,4]. In our case, the successful RF target localized to the atrial side of TA protruding from the RA. Local mapping excluded a pouch-like extension of cardiac muscles and angiography confirmed the opening of the SCV. Compared to AP mediated by epicardial connection extending between the atrial appendage and the ventricle, SCV-mediated AP is a novel variant of pre-excitation.

Similar to the posterior septal AP mediated by middle cardiac vein, the connections between vein musculature and ventricular myocardium are the anatomic basis of SCV-related AP. The SCV is characterized by its highly variable course and ostium. Based on a previous study, the SCV is missing in 64% of cases, with the rest belonging to the coronary sinus system [5]. Further study revealed that only 2% (1/50) of SCV have a direct opening into the RA [6]. Our fluoroscopic imaging indicated that the SCV arose from the right ventricle and left atrium and drained into the cavity of RA as a single vessel. It is an extremely rare condition for such a lengthy cardiac vein musculature to transmit an electrical impulse from RA to the right ventricle.

Of note, the initial endocardial ablation in our patients failed to interrupt the AP conduction and resulted in tachycardia recurrence

or failure in AP conduction block. We posited that this could be due to incomplete mapping of AP, which in turn may lead to inaccurate localization and inappropriate RF energy application. Several reports have highlighted the importance of electroanatomic mapping guided by 3-dimensional system in right free-wall AP [3,4] by possibly facilitating identification of atrial insertions, providing anatomic landmarks and avoiding unnecessary radiation exposure. The conventional approach to identify atrial insertion of right free-wall AP is to map along the TA during right ventricular apex pacing or tachycardia. Patients with prior failed ablation of AP may have APs with unique anatomical substrates such as SCV pathways. It is feasible to enlarge the range of electroanatomic mapping region to identify atrial or ventricular insertion far from the corresponding side of the annulus. Interestingly, the serendipitous discovery of SCV in these cases was partially due to the sudden rise in impedance and catheter dislodgment. Thus, if the atrial insertion is found in an atrial orifice far from TA and the local impedance is above 200  $\Omega$ , a SCV-related AP should be considered.

In a cohort study, ablation failure of right lateral AP was mainly secondary to lack of catheter stability [7]. However, in the 2 cases presented here, the SCV and its ostium provided more stable catheter position and tissue contact. Another distinctive characteristic of SCV-related AP is the vulnerability to RF energy. In the cases described here, AP conduction block was achieved within 3 s, and catheter-induced mechanical block of pathway conduction was seen in one case. Additionally, in previously reported case, a conventional non-irrigated catheter could not abolish AP conduction because of impedance rise and poor power delivery [8]. It seems that an irrigated-tip catheter is mandatory for SCV-related AP to deliver



**Fig. 2.** Electrophysiological characteristics of small cardiac vein related accessory pathway (Case Two). Left panel demonstrates the electroanatomic mapping of the accessory pathway (AP) in the right atrium during reciprocating tachycardia using CARTO system. The earliest retrograde atrial activation has a relatively wide distribution along the tricuspid annulus. Initial ablation (Site B: ablation point) failed to produce block of ventriculoatrial conduction. Catheter in the ostium of the small cardiac vein (Site A marked in blue) produced transient block in AP conduction. Right panel presents the scalar ECG and intracardiac recordings of coronary sinus (CS 1–2, CS 5–6 and CS 9–10) and mapping catheter (MAP 1–2) in Site A. Pre-excitation is evident during sinus rhythm, suggesting a right lateral AP. Catheter-induced mechanical block of pathway conduction is captured in Site A, resulting in a prolonged A-V interval in the MAP 1–2 and elimination of pre-excitation. Local electrograms show a large atrial potential with a very small ventricular potential.

sufficient current and prevent frequent impedance rises. With precise activation mapping and cautious power delivery, endocardial catheter ablation of SCV with an irrigated catheter appears to be effective and safe, which might render it the first choice for this uncommon type of AP.

## Conclusion

As illustrated by the cases presented here, the SCV can serve as an anatomical substrate of supraventricular tachycardia, and SCV-related AP which can be identified and ablated endocardially using an irrigation tip catheter within the SCV should be considered when the earliest retrograde atrial activation is documented far from the TA.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jelectrocard.2018.12.002>.

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