Refractory inappropriate sinus tachycardia post sinus node sparing hybrid thoracoscopic ablation originating from the arcuate ridge

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Introduction

Inappropriate sinus tachycardia (IST) often presents with debilitating symptoms and requires complex management. Sinus node (SN) sparing hybrid ablation is a recently developed procedure with endocardial and epicardial ablation that offers an effective and safe treatment option for these patients. Yet, the persistence of IST and management post ablation must be better understood. We present a case of a young woman with IST who was referred for hybrid ablation and only experienced relief after a repeat ablation of the arcuate ridge (AR).

Case report

A 27-year-old woman with longstanding symptomatic IST was referred to our center for SN sparing hybrid ablation. She had undergone an electrophysiology (EP) study 2 years prior for continued symptoms of palpitations, fatigue, and dizziness, for which she underwent ablation of a concealed left lateral accessory pathway with no inducible tachycardia at that time. Severe lifestyle-limiting symptoms refractory to verapamil, flecainide, sotalol, ivabradine, and midodrine persisted, with elevated resting heart rate (HR) between 100 and 110 beats/min. After shared decision making, she proceeded with SN sparing hybrid ablation.

She was taken to the hybrid EP laboratory, where she was noted to have sinus tachycardia with an HR of 105 beats/min under general anesthesia. A 3-port thoracoscopic approach was used to access the pericardium, which was opened with the EnSeal X1 Tissue Sealer device (Ethicon, Raritan, NJ). The oblique sinus was then opened to better access the right-sided pulmonary veins. SN activity was localized next to the anterolateral aspect of the superior vena cava (SVC) and right atrial (RA) appendage junction on voltage and activation mapping with high-definition mapping catheter (Advisor HD Grid, Abbott, Chicago, IL) with EnSite X EP System (Abbott) mapping software through the right femoral vein without use of intracardiac echocardiography (ICE). The epicardial SN location was marked with methylene blue for surgical reference. Epicardial ablation of the SVC, crista-terminalis (CT), and inferior vena cava was performed using a bipolar, bidirectional, radiofrequency clamp (EMR2 Isolator Synergy Clamp, Atricure, Mason, OH). Each location was ablated with 2, 9, and 3 sets of lesions. The right-sided pulmonary veins and CT were tested for entrance and exit block. Repeat endocardial voltage mapping was performed and demonstrated a small connection along the

KEY TEACHING POINTS

- Treatment with sinus node sparing hybrid thoracoscopic ablation for patients with inappropriate sinus tachycardia may not be effective in patients in whom tachycardia originates elsewhere.
- The arcuate ridge—a band of myocardium adjacent to the superior vena cava and right atrial appendage junction—may be an alternative target for ablation in these patients.
- Intracardiac echocardiography is an important technique used with electroanatomic voltage mapping and intracardiac electrograms to assist with the origin of cardiac conduction.

KEYWORDS Ablation; Arcuate ridge; Inappropriate sinus tachycardia; Postural orthostatic tachycardia syndrome; Sinus node sparing hybrid ablation; Syncope

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mid CT, which was re-ablated. An implantable loop recorder was also inserted. The patient's HR decreased to only 88 beats/min post procedure, and she was admitted to the intensive care unit with an HR remaining at approximately 100 beats/min at rest, with no improvement in symptoms as she began ambulating. After discussions over 2 days and persistent debilitating symptoms, she elected to return to the EP laboratory just 4 days later for repeat ablation for potential SN modification. She understood the risk of permanent pacemaker (PPM) implantation and favored having one if symptoms could be controlled.

Under moderate sedation, HR remained at 100–105 beats/min. High-definition voltage and activation maps were performed with CARTO mapping system (Biosense Webster, Irvine, CA) and Octaray mapping catheter (Biosense Webster). A ViewFlex Xtra ICE (Abbott) was used at baseline to guide the procedure and ensure proper catheter contact. The voltage map demonstrated no voltage along the CT and SVC. Activation mapping demonstrated the earliest sinus activation at the superior anterior aspect of the SVC and RA junction at the expected location of SN activity. However, high output pacing at the earliest sinus activation site captured the phrenic nerve.

ICE demonstrated a prominent AR (Figure 1), and further activation mapping revealed the earliest activation (–20 ms pre–p wave with QS unipolar) at the expected SN location (Figure 2) and immediately adjacent to the previously ablated/no voltage area observed from the IST hybrid ablation (Figure 3). However, phrenic capture was present at this location. On ICE, the catheter tip was on the SVC side, at the base of the AR, where phrenic capture was observed. Further mapping was performed with early activation still present on the RA appendage side of the AR at –12 ms pre–p wave, still with QS unipolar. No phrenic capture was demonstrated on the RA appendage side of the AR and to the tip of it, favoring the SVC side. This location was ablated at 40 W with an immediate increase in HR to 150 beats/min, then decreased to 60 beats/min. The RA appendage side of the AR was then further ablated while preserving phrenic nerve and SN activity.

After the procedure, her HR stayed between 70 and 80 beats/min, and symptoms immediately resolved on the day of the procedure. Four months later, she remains free of symptoms, exercises multiple times per week, and has average HR trends remaining in the 60s and 70s (Figure 4).

Discussion

IST remains a challenging and likely underdiagnosed disorder for which an SN sparing hybrid ablation is increasingly offered to avoid PPM implantation. We report one of the first cases of persistent IST following SN sparing hybrid ablation in which the AR was identified as the trigger for IST following the use of ICE.

Treatment for IST varies—medical treatment may be suboptimal and the 2015 Heart Rhythm Consensus recommended ablation only for refractory cases.[1] Even then, the optimal approach to ablation is unclear. Many groups have described SN modification, but there is still high recurrence and complications, such as phrenic nerve injury or the need for PPM.[2] SN sparing hybrid ablation was proposed as a novel approach that addressed these issues. A hybrid ablation approach minimizes complications by displacing the phrenic nerve. Video-assisted thoracoscopy with an RF bipolar clamp isolates the superior vena

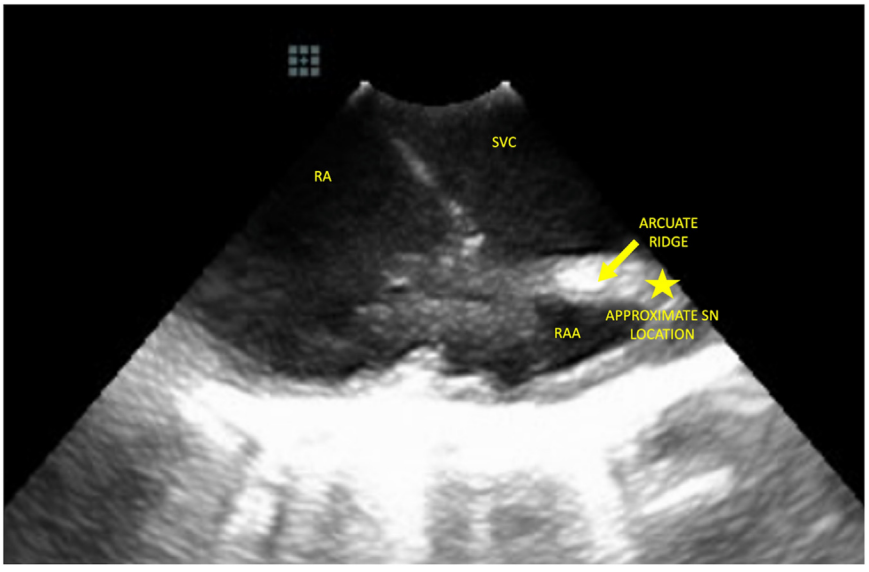

Figure 1 Intracardiac echocardiogram and location of arcuate ridge. The arcuate ridge lies just adjacent to the superior vena cava (SVC)–right atrium (RA) junction. It is often better visualized with intracardiac echocardiography, compared with fluoroscopy or electroanatomic mapping alone. RAA = right atrial appendage; SN = sinus node.

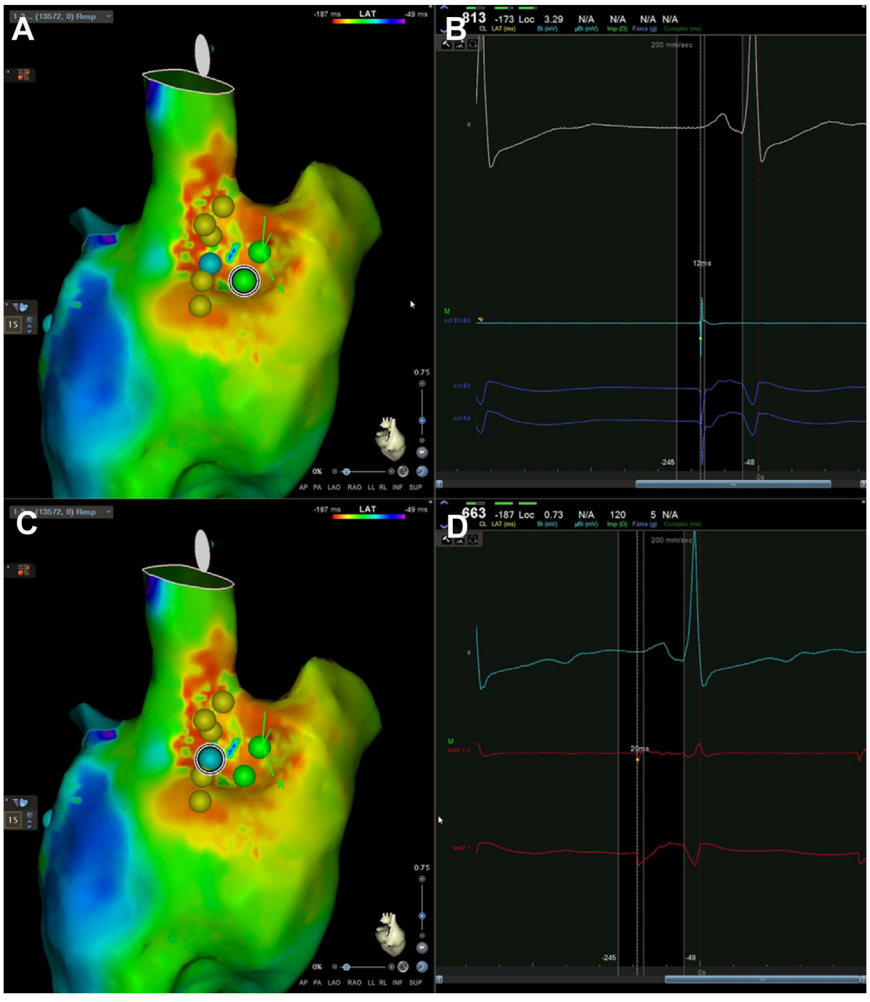

Figure 2 Electroanatomic mapping and intracardiac electrograms of the arcuate ridge. The arcuate ridge was mapped from the right atrial appendage (**A, B**) and the superior vena cava (**C, D**). However, phrenic capture was not present at the latter.

cava, inferior vena cava, and crista terminalis—key sites of postganglionic sympathetic fiber innervation—after endocardial identification of the SN. Initial data suggested up to a 30% decrease in HR immediately intraprocedurally.[3] Recent data suggested a high freedom from redo procedures and PPM implantation.[4] However, this case revealed that an SN sparing hybrid ablation may not be sufficient for certain patients—particularly for AR-associated IST—compared with epicardial and standard endocardial ablation.

In these patients, there may be other conduction pathways responsible for tachycardia. It is well known that IST is a diagnosis of exclusion and may coexist with, or be confused with, other supraventricular tachycardias.[5] The tachycardias—often atrial or SN re-entrant tachycardia—frequently originate around the SVC and SVC–RA junction and may coincide with SN activation.[6] Thus, the SVC–RA junction is a complex yet small anatomic region with many electrophysiologic essential structures. Adjacent to the SVC–RA junction is the AR, a band of myocardium extending from the CT to the superior limbus of the fossa ovalis on the interatrial septum. It varies in size and is difficult to appreciate with fluoroscopy and electroanatomic mapping alone. Subsequently, ICE allows adequate visualization and characterization. Furthermore, epicardial ablation will avoid the endocardial AR, as clamping and ablation are performed above the SN.

The literature describing this phenomenon has been limited, although it is growing. The first reported case of IST originating from the AR was first described by Killu et al[7] in 2007. The authors identified the earliest activation site on a prominent AR in a patient who had undergone multiple prior endocardial ablations in the high RA.[7] Like our case, the ablation site was identified by ICE. Following ablation along the entire AR, tachycardia was no longer inducible with isoproterenol. Recently, Cabrera et al[8] reported 6 patients who underwent ICE-guided ablation of the AR. They demonstrated a 25% HR reduction by extending the lesion set along the entire AR and that ablation of only the earliest

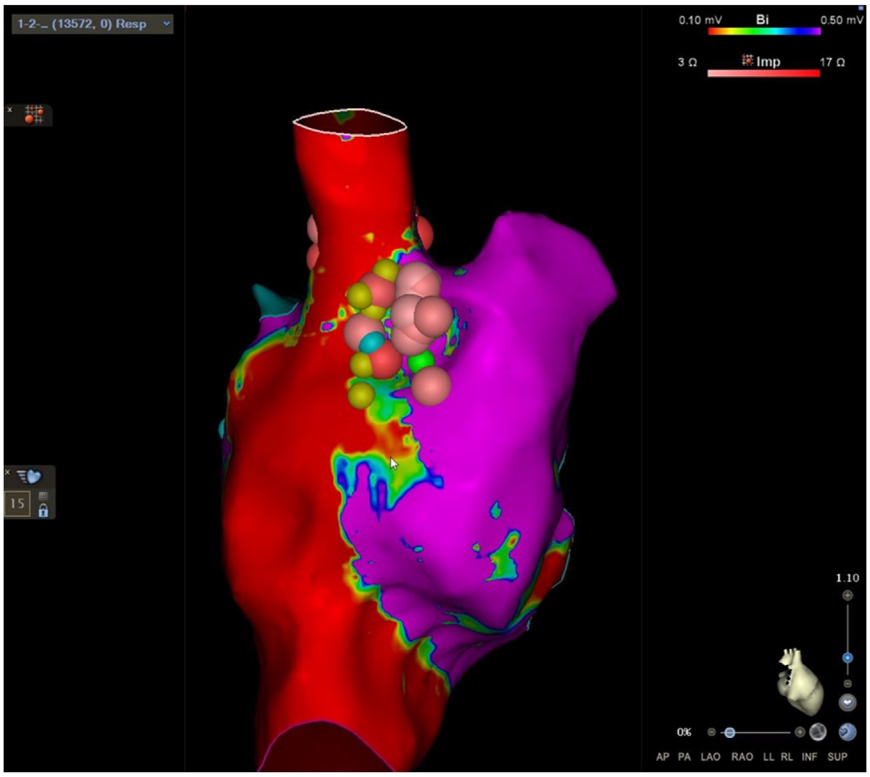

Figure 3 Electroanatomic mapping of the arcuate ridge. No voltage was observed from the previous ablated locations as part of the hybrid ablation.

activation site within the AR was suboptimal. Only 1 patient required reinitiation of ivabradine for symptom control at a mean follow-up of 654 days.[8] Given the growing body of literature suggesting the AR as a source for IST, this advocates for a baseline EP study guided by ICE to perform detailed mapping of the SN and AR. Further studies are needed to identify the incidence of AR triggers and the effectiveness of its ablation.

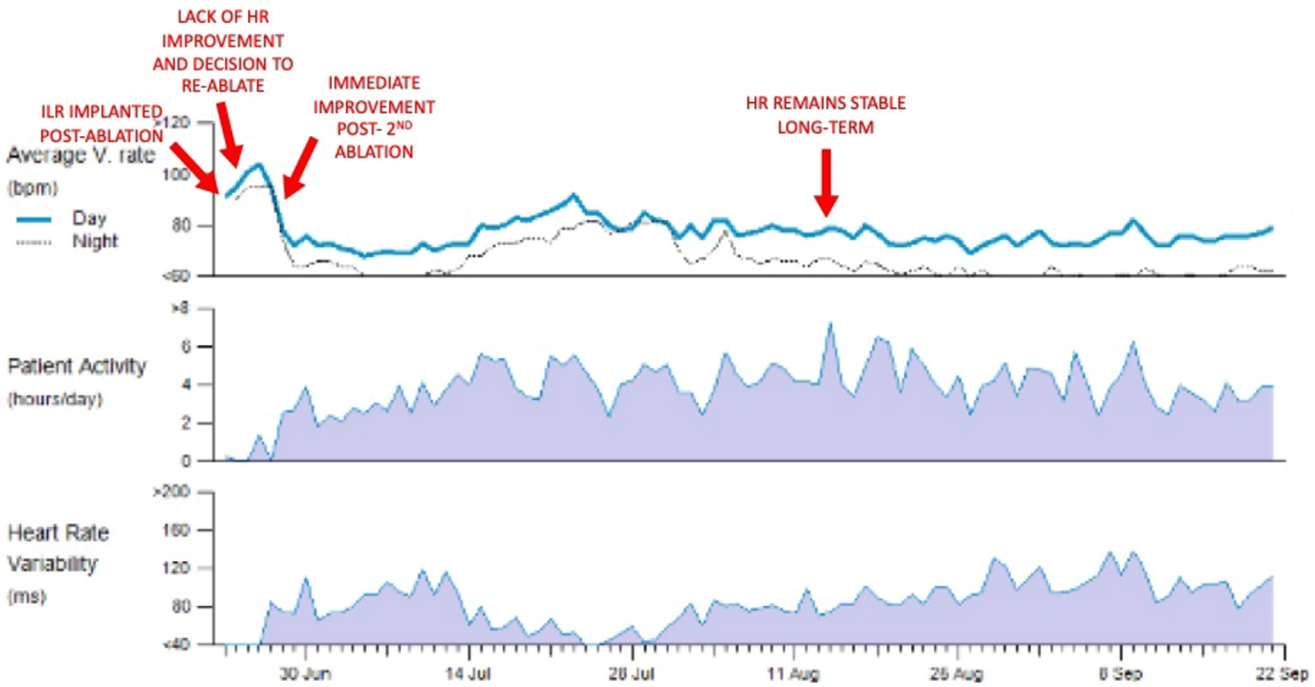

Figure 4 Postprocedural implantable loop recorder with improved heart rate. Heart rate following the initial ablation increased but decreased following immediate re-ablation at the arcuate ridge.

Conclusion

In patients with IST refractory to medication, SN sparing hybrid ablation results in favorable outcomes, while avoiding the need for a PPM. In certain patients, the AR may also be a source of IST. In these patients, a detailed baseline EP study guided by ICE is beneficial in determining SN vs AR activation.

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