Remote entrainment pacing from multiple distant areas to identify a slow conduction isthmus of a reentrant circuit in scar-related atrial tachycardia

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Introduction

Scar-related atrial tachycardias (ATs) often develop during catheter ablation of atrial fibrillation (AF) in patients with severely remodeled atrium. Although the optimal ablation target of a reentrant scar-related AT is a critical isthmus, usually within the scar area, identification of the critical isthmus is often challenging owing to reduced myocardial viability, represented by small electrogram amplitude. In particular, entrainment pacing within such a scar area is challenging owing to difficulty in pacing capture at injured myocardium with an elevated pacing threshold.

KEY TEACHING POINTS

- The entire tachycardia circuit may not be visualized on the activation map owing to low voltage in scar-related atrial tachycardia.
- Pacing study on the tachycardia circuit is sometimes difficult because of high pacing threshold at the diseased myocardium.
- Remote entrainment pacing is useful for the identification of a concealed isthmus upstream of the earliest activation site.

Case report

A 78-year-old male patient with hypertension, diabetes mellitus, and persistent AF was referred for AF ablation. Preprocedural echocardiography showed a left atrial volume of 72 mL with mild mitral regurgitation and preserved left ventricular ejection fraction. After pulmonary vein isolation, atrial programed stimuli induced an AT with a cycle length of 264 ms. High-resolution mapping using an Octaray catheter on CARTO 3 (Biosense Webster, Diamond Bar, CA) was performed. Local activation time annotation was performed automatically by the CARTO system, which uses the maximum negative slope of the unipolar distal signal to set the timing of the mapping annotation. The activation map showed a possible reentrant circuit within the left atrial anterior wall (Figure 1, Supplemental Video 1). However, propagation continuity was missing at the possible slow conduction isthmus (SCI) upstream of the earliest activation site (EAS). The color bar graph also showed a missing time zone corresponding to the possible SCI. Pacing stimuli using bipolar electrodes of a 3.5-mm-tip ablation catheter (THERMOCOOL SMARTTOUCH SF; Biosense Webster) with fixed output (5 mA at 1.0 ms pulse width) failed to capture the myocardium at the EAS and the estimated SCI. In this situation, a focal mechanism cannot be ruled out, and the estimated SCI could not be confirmed as the critical channel of the macroreentrant AT circuit.

Subsequent entrainment pacing at areas distant to the EAS revealed manifest entrainment by pacing at the great cardiac vein and left atrial appendage with orthodromic capture of the EAS (Figure 2). On the other hand, pacing at the left atrial septum, lateral tricuspid annulus, and left atrial roof captured the EAS antidromically. These findings suggested that the AT had a macroreentrant circuit and that propagation approaching the EAS came from the 2-o'clock direction in Figure 2, supporting the idea that SCI existed at the estimated area. Radiofrequency application at the SCI terminated the AT immediately (Figure 3), and no further atrial tachyarrhythmias were induced. The patient has remained free from atrial tachyarrhythmia during the 9 months since ablation.

Discussion

This case report demonstrates the utility of remote entrainment pacing from surrounding distant areas of the EAS in the identification of concealed SCI that cannot be visualized

KEYWORDS Entrainment pacing; Atrial tachycardia; Slow conduction isthmus; Ablation; Mapping
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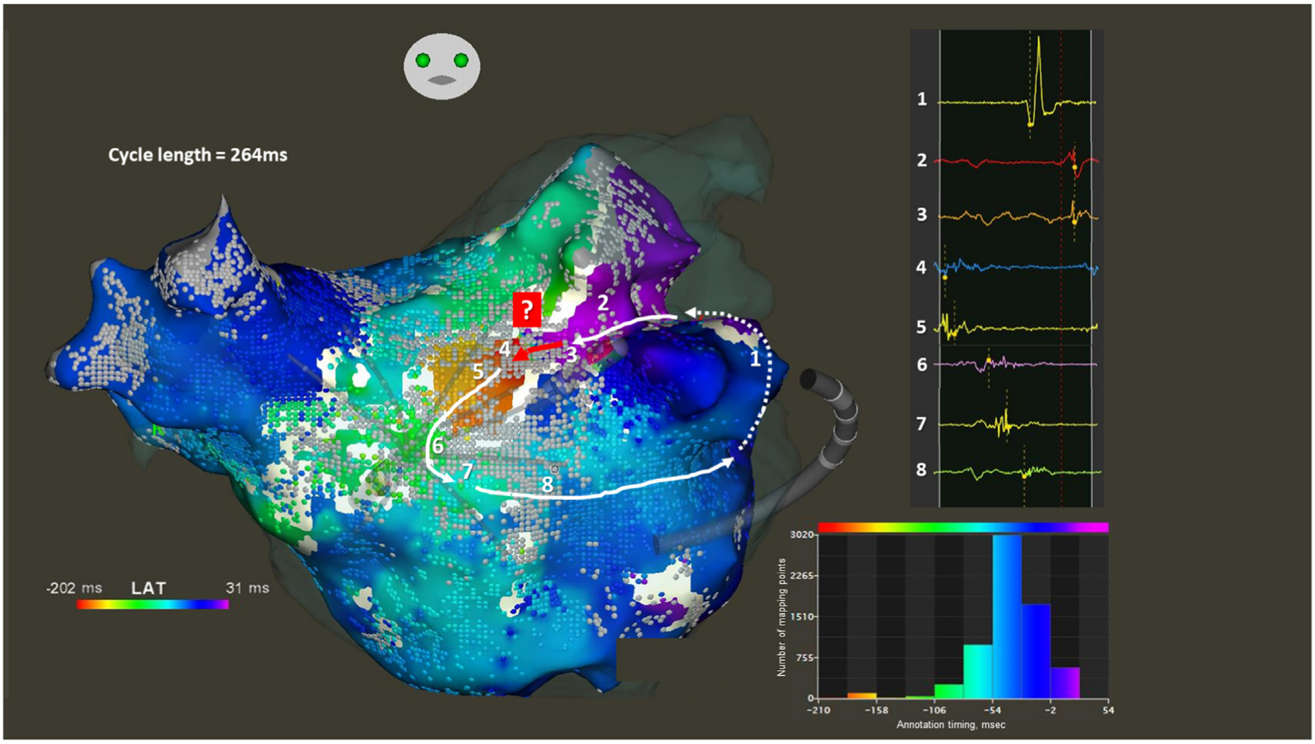

Figure 1 Atrial tachycardia (AT) circuit. Activation map of AT with a tachycardia cycle length of 264 ms. The AT propagation demonstrated counter-clockwise rotation (*white arrow*), possibly with a slow-conducting anterior isthmus (*red arrow*). Electrograms recorded at specific portions (numbers 1–8) and the local activation histogram are presented. Bipolar noise level was set at 0.03 mV, and bipolar signal amplitude at the possible slow conduction isthmus (SCI) was below the noise level. Lower and upper threshold of the early-meets-late module was set at 18% and 90%, respectively. The possible SCI (*red arrow*) had a very low signal amplitude without timing annotation. The local activation histogram showed a lack of mapping points annotated within the activation time interval between purple and red. However, electrograms (#3 and #4) recorded tiny signals possibly connecting a missing time zone between the purple and red areas.

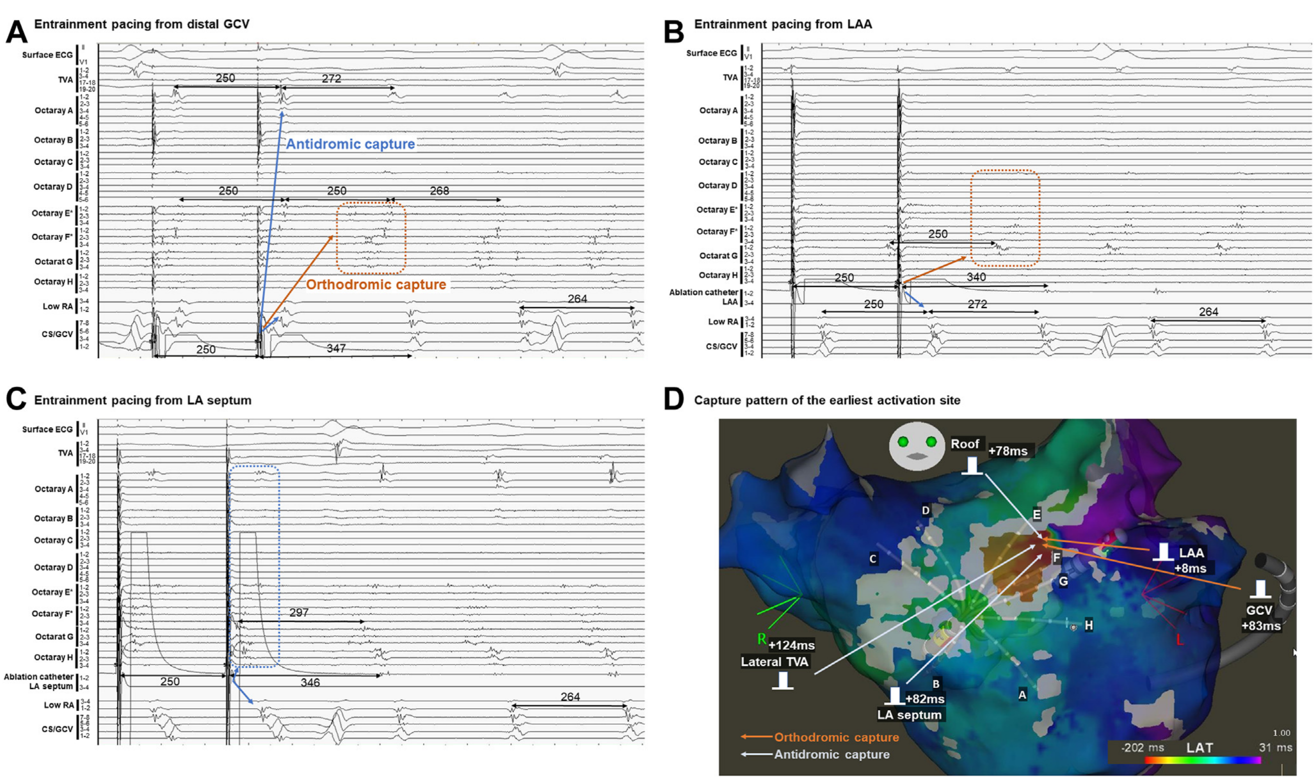

Figure 2 Entrainment pacing from multiple distant areas. Entrainment pacing with a pacing cycle length of 250 ms was performed during atrial tachycardia (AT) with a cycle length of 264 ms from the great cardiac vein (GCV) (**A**), left atrial appendage (LAA) (**B**), left atrial (LA) septum (**C**), lateral tricuspid valvular annulus (TVA), and LA roof. Splines E and F were positioned at the earliest activation site (EAS) of the AT (*). Pacing from GCV and LAA demonstrated manifest entrainment with orthodromic capture of the EAS (*orange arrow*). On the other hand, pacing from the other sites antidromically captured the EAS. Types of pacing capture of the EAS are summarized in the figure. Times beside the pacing sites are postpacing interval – tachycardia cycle length.

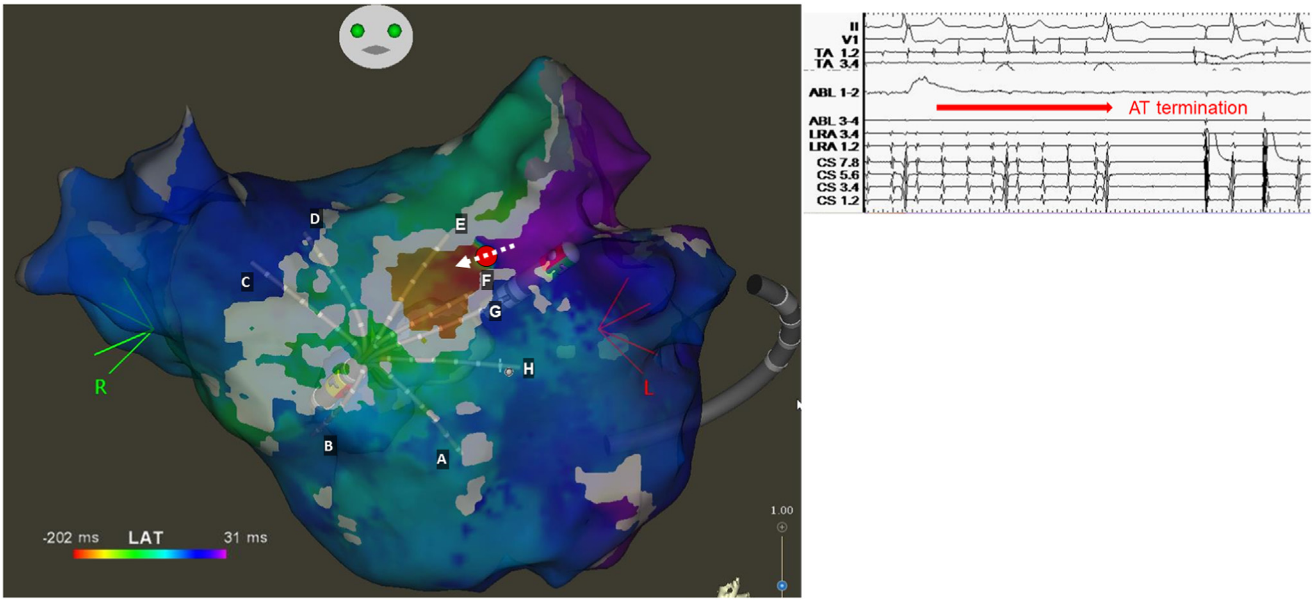

Figure 3 Ablation at the estimated slow conduction isthmus upstream of the earliest activation site (EAS). Radiofrequency ablation (*red circle*) at the estimated slow conduction isthmus upstream of the EAS (*white dashed arrow*) directly terminated the atrial tachycardia (AT). Intracardiac electrocardiogram showed AT termination 2 seconds after the start of ablation delivery with preceding cycle length prolongation.

on the activation map or subject to on-site entrainment pacing.

Recent mapping catheters have an improved shape that is optimized for left atrial mapping, with a greater number of electrodes and a smaller electrode size.[1] Under the current mapping system, this increased signal quality and mapping point density, together with an improved algorithm for signal annotation, produces high-resolution maps that visualize AT circuits in greater detail. Although an AT-critical isthmus within a scar area can often be visualized, entrainment pacing study is still helpful to understanding the AT circuit in some cases, particularly when some portion of the AT circuit cannot be visualized. However, pacing study at such scar areas is challenging owing to the difficulty in pacing capture at injured myocardium with an elevated pacing threshold.

In the present case, the estimated SCI upstream of the EAS could not be visualized owing to low voltage, suggesting the possibility that the isthmus was on the epicardial side. Antidromic or orthodromic capture pattern of the EAS during entrainment pacing at distant multiple areas enables the identification of an SCI that is upstream of the EAS. This method is an application of a method reported by Yamabe and colleagues,[2] namely a multiple-site entrainment pacing method to identify SCI entrance of a reentrant AT demonstrating a centrifugal propagation pattern with the EAS in the vicinity of the atrioventricular node.

Conclusion

Remote entrainment pacing from multiple distant areas surrounding the EAS in scar-related AT enabled identification of an SCI upstream of the EAS. This method will be useful when on-site entrainment pacing is not possible owing to a high pacing threshold.

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Appendix

Supplementary Data

Supplementary data associated with this article can be found in the online version at 10.1016/j.hrcr.2023.09.010.

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