Perimitral atrial flutter associated with a protected coronary sinus after a Maze IV procedure and concomitant mitral annulus repair

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Introduction

The Maze IV procedure during cardiac surgery is an established treatment for patients with atrial fibrillation (AF) concomitant with a mitral valve repair or replacement. Recurrent atrial tachyarrhythmias are mainly left atrial (LA) flutter, which is associated with gaps on previous surgical lesions. Herein, we report a case in which a 3-dimensional mapping system could demonstrate a typical perimitral atrial flutter but radiofrequency (RF) ablation of a gap on a previous lesion could not terminate the tachycardia.

Case report

A 50-year-old man with palpitations was referred to our center for a mitral valve repair concomitant with a Maze IV procedure because of drug-refractory mitral regurgitation and AF. The right and left lesion sets for the Maze IV procedure were as follows.[1] The LA lesion set was performed under cardioplegic arrest. The LA appendage was amputated, and a bipolar clamp was used to isolate both the left superior and inferior pulmonary veins (PVs). A left atriotomy was performed, and the remaining ablation lines were created with the bipolar clamp. Cryoablation was used to connect the isthmus ablation line to the mitral annulus (MA). Hence, these lesion sets resulted in a large isolated area including the entire posterior LA with all PVs and mitral isthmus block. At 2 years after cardiac surgery involving the Maze IV procedure, a symptomatic atrial tachycardia (AT) recurred, and therefore RF catheter ablation was indicated. The recurrent AT was documented with a tachycardia cycle length (TCL) of 250–270 ms and 2:1 atrioventricular conduction. The P-wave polarity indicated that the AT was a clockwise perimitral AT because of positive P waves in leads V_1, I, and aVL and negative P waves in the inferior leads.[2,3] The intracardiac recordings from the ring catheter within the PVs demonstrated reconduction at the anterior portion of both the left superior and left inferior PVs (Figure 1A). In contrast, the LA posterior wall was completely isolated and the isolated potentials were documented (not shown in the figure). The electrode catheter placed in the coronary sinus (CS) documented the activation propagating from a distal to a proximal site (Figure 1A). Subsequently, an activation map recorded using the CARTO 3 system (Biosense Webster, Inc, Diamond Bar, CA) and pacing maneuvers from a septal site near the MA suggested that the AT appeared to be a clockwise perimitral macroreentrant atrial tachycardia (MRT) (Figure 1A). However, RF application for a previous lesion between the MA and the surgical line in the posterior LA using the bipolar clamp, where dull fractionated potentials were recorded, could not terminate the MRT (not shown in the figure). RF application in the CS where a relatively sharp potential was recorded, opposite

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ABBREVIATIONS AF = atrial fibrillation; **AT** = atrial tachycardia; **CS** = coronary sinus; **LA** = left atrium/atrial; **MA** = mitral annulus; **MRT** = macroreentrant atrial tachycardia; **PPI** = postpacing interval; **PV** = pulmonary vein; **RF** = radiofrequency; **TCL** = tachycardia cycle length

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KEY TEACHING POINTS

- The electroanatomic mapping system could not identify the critical isthmus for the ongoing macroreentrant atrial tachycardia.
- Distinguishing the local coronary sinus musculature potentials from far-field left atrial potentials was essential. Of note, tiny dull potentials were visible in the recording with the distal electrodes of the coronary sinus catheter.
- Pacing maneuvers including measurement of the postpacing interval and entrainment and assessment of the P-wave morphology and Stimulus-P wave interval were necessary to detect the critical channel of this unusual macroreentrant atrial tachycardia.

to the epicardial site, could not terminate the MRT. The postpacing interval (PPI) at both endocardial and epicardial sites equaled the TCL (Figures 1A and 1B). After reviewing intracardiac electrograms in the CS, double potentials (a small dull potential and a single sharp potential) in the distal CS were documented (Figure 1B, right panel, and Figure 1C). Detailed mapping in the distal CS demonstrated double potentials with a fractionated electrogram between them (Figure 1C). A single RF application at that site could immediately terminate the MRT with conduction block between the double potentials (Figure 2A).[4] Finally, during sinus rhythm, pacing maneuvers could demonstrate complete bidirectional block of LA-CS conduction (Figure 2B). There has been no recurrence of the MRT as of the last available follow-up (2 years) information.

Discussion

The peri-CS musculature is considered an arrhythmogenic substrate for maintaining MRTs and AF. Thus, catheter intervention for the CS musculature is critical to eliminating these complex atrial arrhythmias.[5]

Considering the MRT after surgical AF ablation and cardiac surgery, the main mechanism is a gap on a previous lesion. The reentry circuit is localized perimitrally or around the PVs in most cases.[6] Recently, Miyazaki et al[7] reported a recurrent perimitral tachycardia using an epicardial CS connection to bypass endocardial conduction block at the mitral isthmus. For an accurate diagnosis, distinguishing the local CS musculature (epicardial) potentials from far-field LA (endocardial) potentials is essential. However, variable conduction block between the LA and the CS resulting from the surgical procedure and inflammation after that can make the assessment of complete block more difficult. Thus, electrophysiological maneuvers including entrainment and a detailed assessment of electrograms are essential. In this case, the recognition of wide double potentials recorded by the CS catheter was also critical to clarifying the reentry circuit. Of note, both the first and second potentials recorded by the ablation catheter corresponded to the first dull and second sharp signals recorded by the CS catheter, respectively. Pacing from that site demonstrated that the PPI equaled the TCL, and concealed entrainment was observed. The P-wave morphology during pacing was identical to that during the MRT (Figure 1C). The interval between the pacing spike and the sharp potential in the distal CS was relatively short (100 ms), which indicated that pacing could directly capture the sharp potential, and then, any signals recorded by any of the electrode catheters were orthodromically activated. In contrast, pacing from both the LA near the MA and a proximal CS site activated the dull potential recorded at the distal CS site and then orthodromically activated the rest of the signals. The dull potential and the sharp potential were considered the LA and the CS musculature potential, respectively. The P-wave morphology during pacing was identical to that during the MRT. Furthermore, the interval between the pacing artifact and the P wave were measured as 270 and 300 ms in the LA near the MA and a proximal CS site, respectively, which indicated that there was no direct conduction from the LA to the RA, and the breakthrough site, which formed the P wave, was located between the LA near the MA and the proximal CS site. Considering the electrophysiological findings, the greater portion of the CS, other than the distal site and the proximal site, was electrically protected from the LA. The distal site of the CS connected to the LA with abnormal electrical properties and served as a narrow channel for the MRT. In contrast to the distal CS site the proximal CS site had substantial connections to both the LA and the RA. Therefore, the first ablation application at the proximal CS site could not terminate the MRT. Figure 3 summarizes the electrophysiological properties and shows the possible mechanism of the MRT. The possible reentry circuit of the MRT was as follows: (1) the activation propagated clockwise around the MA; (2) when the impulse reached a lateral site around the MA, it bifurcated into 2 wavefronts. One component conducted slowly to the epicardium, propagated along the CS, and finally reentered into the LA in the proximal CS site. The other component propagated endocardially around the MA and terminated at the previous mitral isthmus line created by the bipolar clamp (Figure 3). We concluded that the complete endocardial linear block resulting from the previous surgical procedure was present during the ongoing MRT. Conduction block between the LA and the CS with a single RF application could terminate the MRT, and no further RA activation could be documented. This finding is consistent with the presence of endocardial isthmus

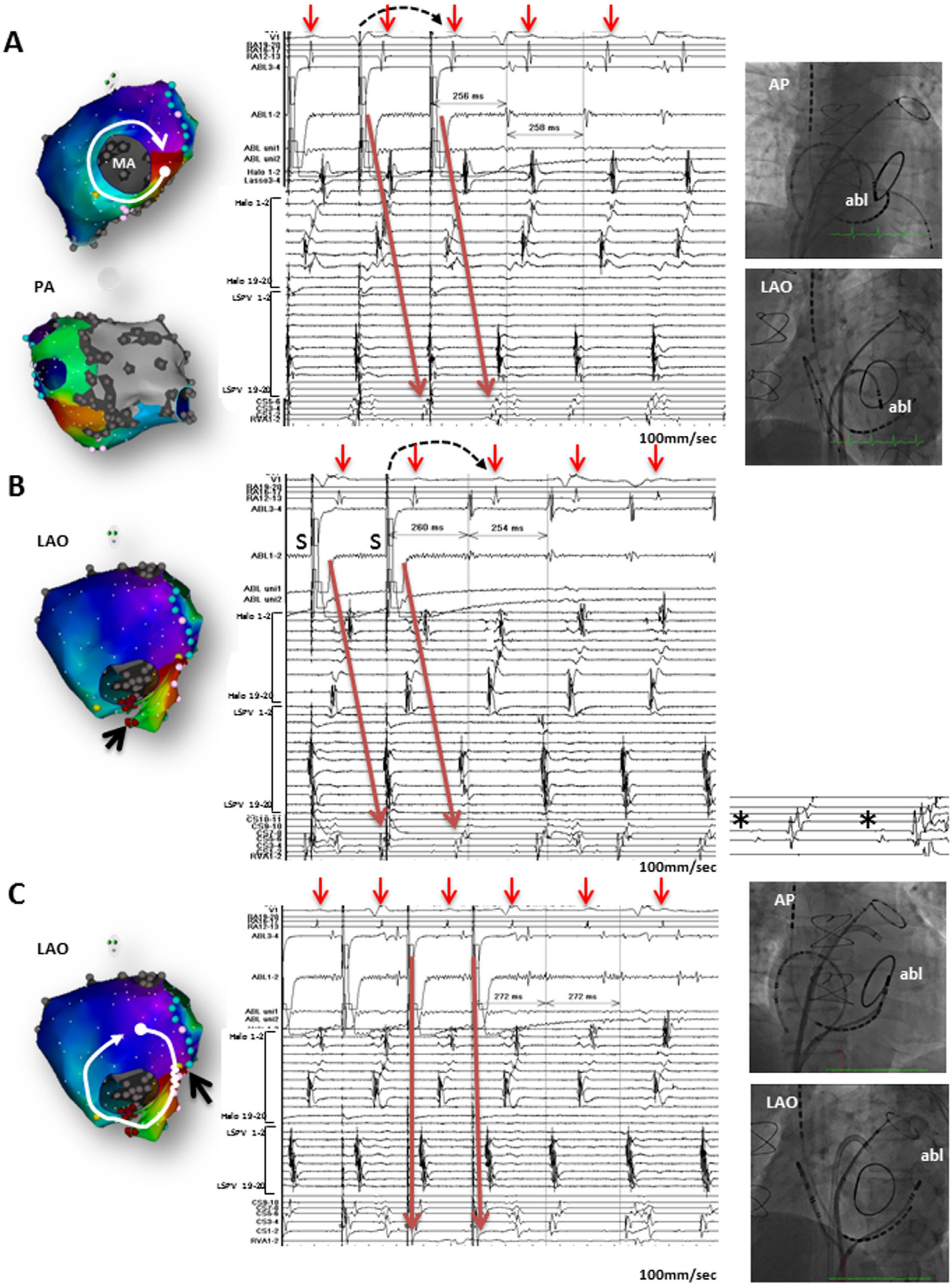

Figure 1 **A:** Activation map of the LA recorded using the CARTO 3 system. The entire posterior wall of the LA is completely isolated. The PPI was measured as 256 ms. The yellow 3D point indicates the pacing site. The ping 3D points indicate the ablation sites from the endocardial LA (left panel). Of note, pacing could capture the dull potential recorded at a distal CS site and demonstrated concealed entrainment (red arrow in the middle panel). The dotted arrow indicates the interval between the pacing spike and the P wave (middle panel). The catheter position in the fluoroscopic image (right panel). **B:** Activation map of the LA and CS recorded using the CARTO 3 system. The black arrow indicates the ablation and pacing sites at the proximal CS site (left panel). Of note, pacing could capture the dull potential recorded at the distal CS site and demonstrated concealed entrainment (red arrow in the middle panel). The dotted arrow indicates the interval between the pacing spike and the P wave (middle panel). The documentation of the tiny dull potential recorded at the distal CS site (right panel). **C:** Detailed electroanatomic mapping within the entire CS using the CARTO 3 system (left panel). The yellow 3D point indicates the pacing site. The PPI is equal to the TCL. Concealed entrainment is demonstrated (lower panel). Of note, pacing could capture the sharp potential recorded at the distal CS site and demonstrated concealed entrainment (red arrow in the middle panel). The dotted arrow indicates the interval between the pacing spike and the P wave (middle panel). 3D = 3-dimensional; abl = ablation catheter; AP = anterior-posterior; CS = coronary sinus; LA = left atrium/atrial; LAO = left anterior oblique; PA = posterior-anterior; PPI = postpacing interval; TCL = tachycardia cycle length.

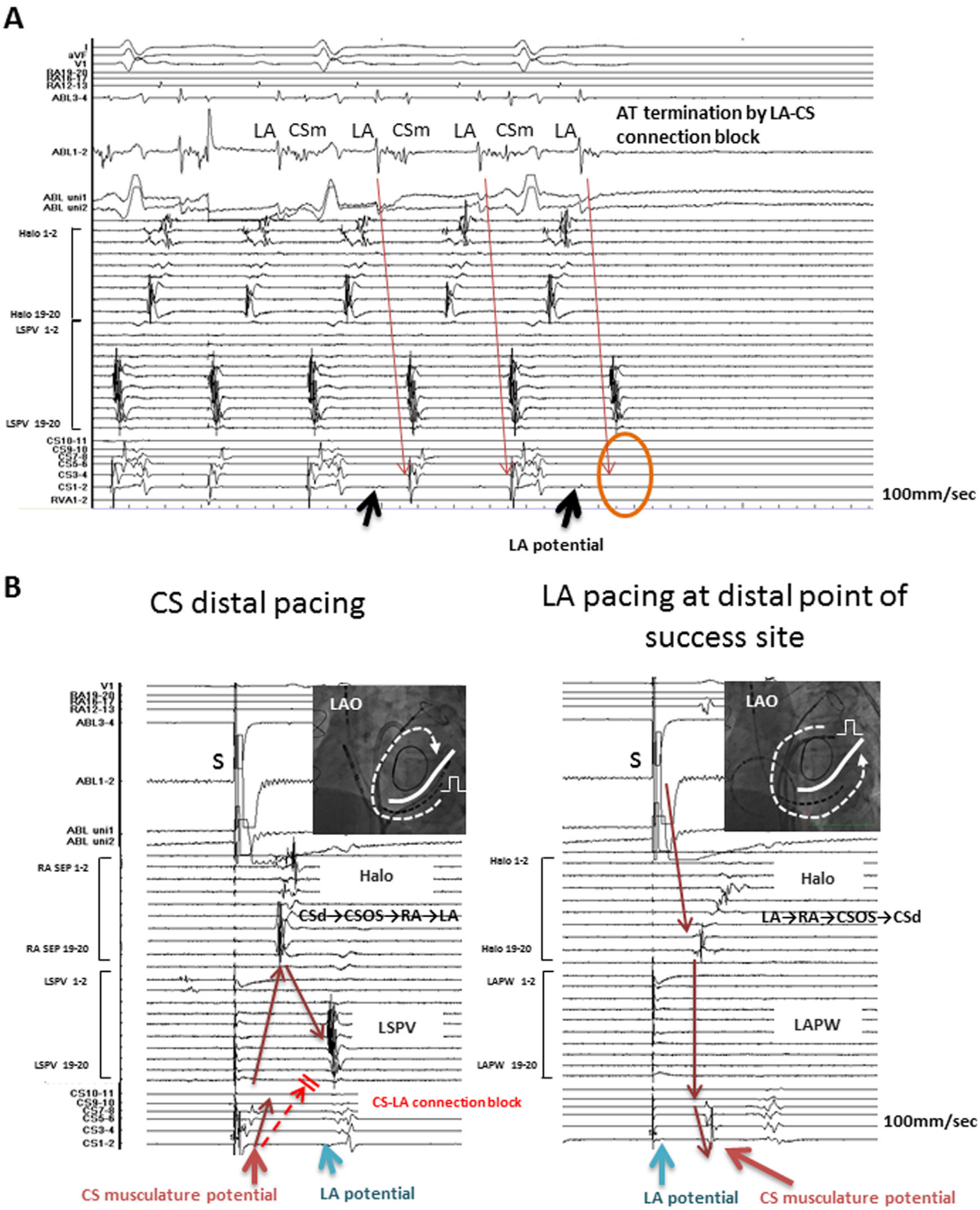

Figure 2 **A:** MRT termination with LA and CS musculature conduction block. Of note, the RA could not be activated after LA-CS conduction block, which indicated that there was no direct conduction from the LA to the RA and that complete isthmus block is present during the ongoing MRT. **B:** Documentation of bidirectional block between the LA and the CS musculature. CS = coronary sinus; CSd = distal portion of coronary sinus; CSm = coronary sinus musculature; CSOS = coronary sinus ostium; LA = left atrium; LAO = left anterior oblique; LAPW = left atrial posterior wall; LSPV = left superior pulmonary vein; MRT = macroreentrant atrial tachycardia; RA = right atrium.

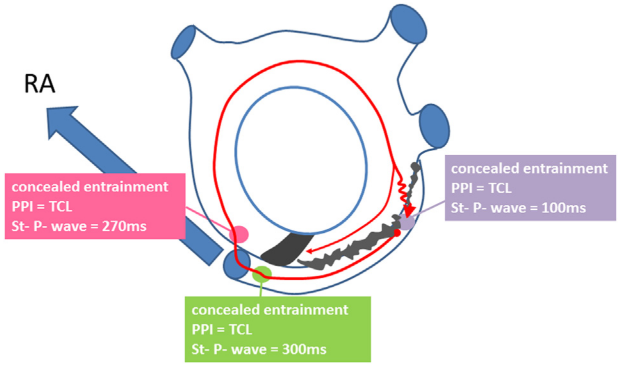

Figure 3 Summary of the electrophysiological findings and possible mechanism of the MRT. Conduction block between the LA and the CS with a single RF application could terminate the MRT. CS = coronary sinus; LA = left atrium; MRT = macroreentrant atrial tachycardia; RA = right atrium; RF = radiofrequency; TCL = tachycardia cycle length.

block and conduction block from the LA to the RA during the ongoing MRT.

This case highlights the association of perimitral MRT with a protected CS. The mechanism is considered to involve complex conduction properties between the LA and the CS musculature caused by both a Maze IV procedure and MA surgery.

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