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Case Report

Unidirectional block on the mitral isthmus during radiofrequency application for perimitral atrial tachycardia

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ABSTRACT

We present the case of a patient who developed regular, narrow QRS tachycardia after ablation for long-standing persistent atrial fibrillation. During the electrophysiological study, this tachycardia was diagnosed as macroreentrant atrial tachycardia circulating around the mitral annulus. Catheter ablation was performed to treat the tachycardia by targeting the linear region between the annulus and the left inferior pulmonary vein. Although linear radiofrequency application along the mitral isthmus (MI) line resulted in the termination of this tachycardia, a unidirectional conduction block was observed through the MI. Bidirectional conduction block was subsequently achieved by delivering supplemental radiofrequency energies at the gap on the MI.

1. Introduction

Post-ablation atrial tachycardia (AT) is observed in 2.9%–31% of patients undergoing catheter ablation for atrial fibrillation (AF) [1,2]. The most common macroreentrant tachycardia circulates around the mitral annulus, which is observed in 10%–61% cases of ATs in the left atrium (LA) following ablation for AF [1–4]. This type of AT can be treated by catheter ablation therapy through which a bidirectional conduction block is established through the mitral isthmus (MI) between the left inferior pulmonary vein (PV) and the mitral annulus.

In patients with typical atrial flutter circulating around the tricuspid valve, the verification of a bidirectional conduction block is recommended for cavotricuspid isthmus (CTI) ablation, because a unidirectional conduction block at the CTI has been previously reported to cause recurrence of atrial flutter [5]. Linear ablations in the LA, including that in the “roof line” that joins the left and right superior PVs and that in the “MI line,” have been developed to treat AF patients. The endpoint of the linear ablation in the LA region should also be the completion of the bidirectional block to prevent any subsequent recurrence of the tachycardia [6]. We herein report a case of a unidirectional conduction block during linear ablation at the mitral isthmus.

2. Case report

A 46-year-old man who was experiencing palpitations for 6 months after undergoing catheter ablation for persistent AF was admitted to our hospital for treatment of recurrent arrhythmia. During the initial ablation procedure, the PVs were individually isolated from the LA and electrogram-based ablation was performed in all aspects of the LA, including the LA appendage and coronary sinus (CS). No linear ablation was performed in the LA during the initial procedure. A surface electrocardiogram during palpitation showed the presence of a regular, narrow QRS tachycardia, with a heart rate of 125 bpm (Fig. 1A). This tachycardia was resistant to oral bepridil antiarrhythmic therapy. The intravenous administration of adenosine triphosphate (20 mg) did not terminate the tachycardia, but it revealed the morphology of positive P-waves in leads II, III, and aVF and negative P-waves in I, aVL, and V1-6 (Fig. 1B). A chest radiograph showed no cardiomegaly (cardiothoracic ratio: 50%), and echocardiography revealed normal left ventricular function with an ejection fraction of 61% and mild LA dilatation with a dimension of 42 mm.

The electrophysiological study and catheter ablation were performed after informed consent was obtained from the patient. The anti-arrhythmic medication was discontinued for 7 days before the procedure. A decapolar electrode catheter was positioned in the CS via the right subclavian vein. Following transseptal access, all four PVs were visualized using selective venography and did not reveal any PV stenosis, and selective

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venography was used during the procedure to show venous anatomy and the location of the LA–PV junction. A steerable 20-polar circular mapping catheter was introduced into the LA. An 8-mm-tip ablation catheter (Fantasista, Japan Lifeline, Japan) was used for mapping and ablation. The bipolar and unipolar electrograms were filtered at 30–400 Hz and 0.05–400 Hz, respectively.

Tachycardia with an atrial cycle length (CL) of 245 ms demonstrated an atrial activation sequence from the septal to the lateral areas of the posterior LA (Fig. 2A). Entrainment mapping was first performed to distinguish reentrant ATs in the right atrium (RA). The post-pacing interval (PPI) at the CTI and the lateral RA were both longer than the tachycardia CL (300 and 410 ms, respectively). Activation mapping in the LA revealed that both the posterior and anterior left atria were activated from the low to high direction, whereas the activation of the anterior LA was propagated from the lateral region to the septum. These findings were compatible with the macroreentrant AT circulating around the mitral annulus (perimitral AT), and 100% of the circuit could

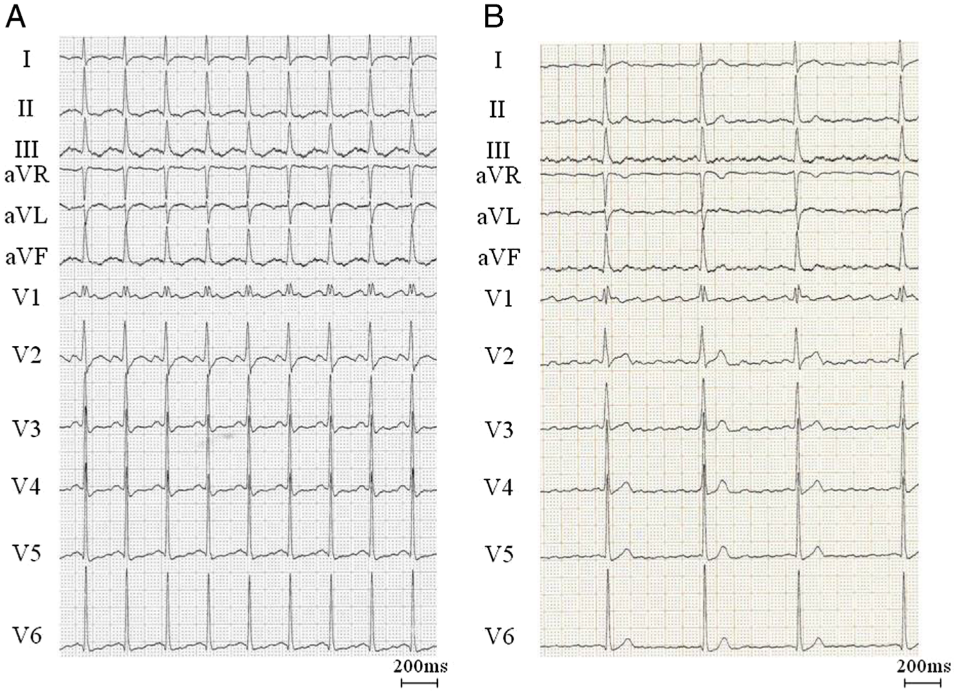

Fig. 1. (A) A surface 12-lead electrocardiogram (ECG) during tachycardia with a heart rate of 125 bpm. (B) A surface 12-lead ECG during administration of 20 mg adenosine triphosphate. Negative P-waves in the I, aVL, and V1–6 leads and positive P-waves in the II, III, and aVF leads are observed.

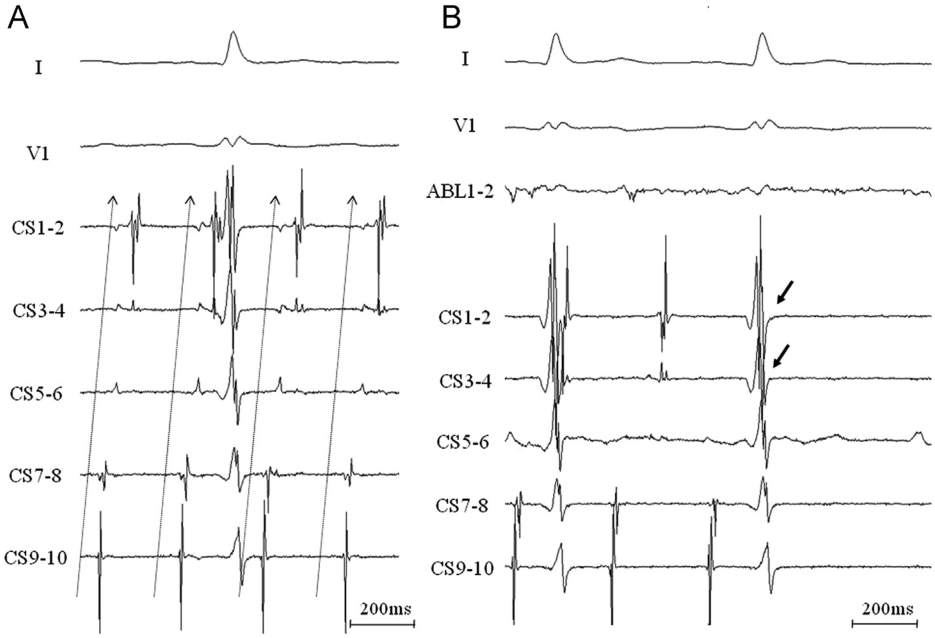

Fig. 2. (A) Intracardiac electrograms (ECGs) during tachycardia with a cycle length of 245 ms. The ECG of the CS catheter demonstrating a septal (CS 9–10) to lateral activation sequence (CS 1–2) (dotted line arrow). (B) Atrial tachycardia (AT) terminated during radiofrequency application between the CS 5–6 and CS 7–8 electrodes on the mitral isthmus with the atrial conduction block. Atrial potentials at the CS 1–2 and 3–4 have disappeared at the AT termination (arrow). I, V1: 12-lead surface ECG; CS: coronary sinus; ABL: ablation catheter.

be mapped around the mitral annulus. Subsequent entrainment mapping at two different sites on the mitral annulus confirmed that this tachycardia was a perimitral AT circulating around the mitral annulus in a counterclockwise direction.

Linear ablation at the MI line from the lateral mitral annulus to the ostium of the left inferior PV was then performed to eliminate the tachycardia. Radiofrequency (RF) energy was delivered with a target temperature of 50 °C and a power limit of 35 W. The tachycardia was terminated during the fifth RF application near the CS 5–6 electrodes on the MI (Figs. 2B and 3). An atrial pacing maneuver was then attempted to verify the completion of the MI block. During pacing at the most distal CS electrodes (CS 1–2), both the prolonged activation time to the proximal CS electrodes and the septal to lateral activation sequence (CS 9–10 to CS 7–8) suggested the absence of conduction in a clockwise direction (Fig. 3A).

However, during pacing at the most proximal CS electrodes (CS 9–10), although the conduction time to the CS 1–2 was prolonged, the septal to lateral activation sequence (CS 5–6 to CS 3–4 to CS 1–2) indicated the presence of residual conduction on the MI line (Fig. 3B). Detailed mapping on the MI line performed to localize a gap during pacing from the proximal CS (CS 7–8) revealed a fragmented potential between the CS 5–6 and CS 7–8 electrodes, demonstrating delayed conduction through the MI line. Supplemental RF application at this site resulted in a sudden change of the activation sequence on the CS catheter. The conduction time from the proximal CS (CS 7–8) to the distal CS (CS 1–2) was then prolonged from 160 to 215 ms, and separated double potentials could be recorded on the mapping catheter positioned along the MI line (Fig. 4A). Finally, the differential pacing maneuver confirmed the establishment of the bidirectional block on the MI line.

During pacing from CS 7–8, the delay from the pacing artifact to the atrial potential on the ablation catheter was 215 ms (Fig. 4A). Changing the pacing site to the proximal CS (CS 9–10) resulted in a shorter perimitral activation time (Fig. 4B), thus suggesting the establishment of a complete bidirectional conduction block on the MI line. The activation time from CS 1–2 to CS 9–10 during pacing from CS 1–2 remained 180 ms, as during the unidirectional conduction block. The LA–PV reconnection was detected in three PVs (the left and right superior PVs and the right inferior PV), which were successfully re-isolated. Following these procedures, no atrial arrhythmia could be induced by atrial pacing. The patient had no recurrence of AT during the subsequent 6-month observation period.

3. Discussion

Ablation along the MI line, that is, from the left inferior PV to the mitral annulus has been performed to treat patients with persistent AF and perimitral AT. The endpoint of this procedure was defined as the establishment of a bidirectional block on the line [6]. For CTI ablation, the fundamental methods of assessing

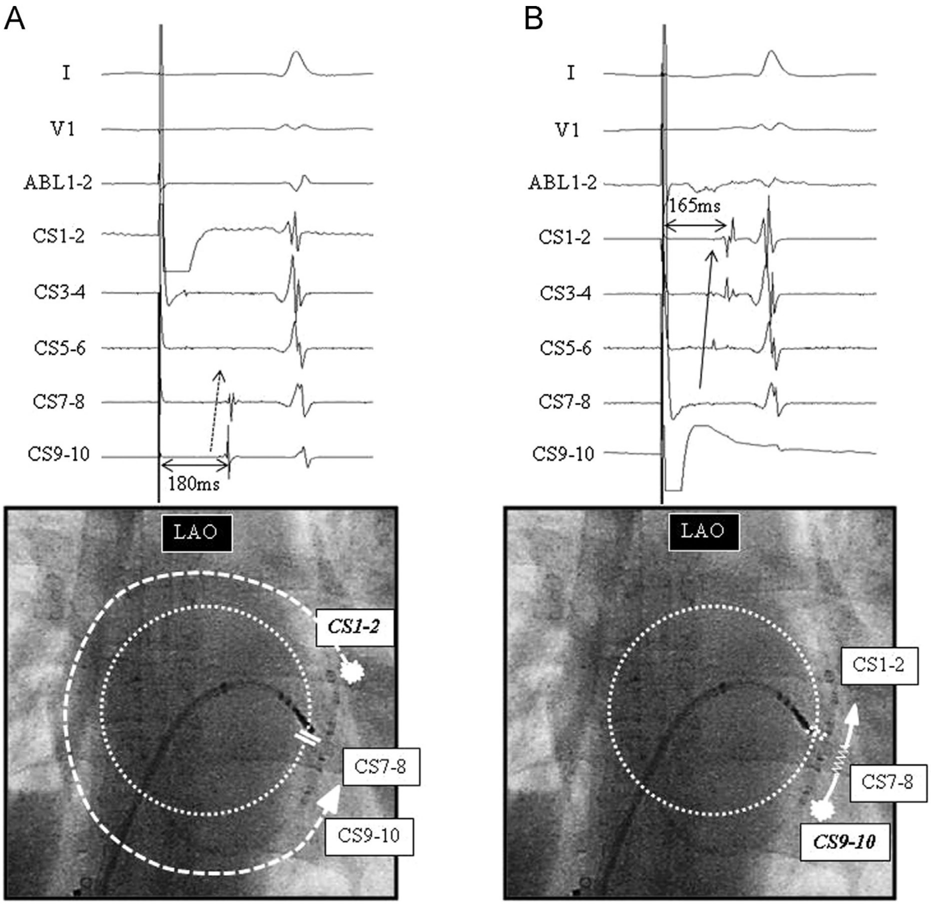

Fig. 3. Demonstration of a unidirectional conduction block on the mitral isthmus (MI). (A) Pacing performed on the lateral side (CS 1–2) of the ablation line resulted in septal to lateral activation at the septal side of the ablation line (dotted line arrow) with a conduction time of 180 ms, while the atrial activation at the lateral side of the ablation line was conducted from the lateral to septal direction. (B) Pacing at the septal side (CS 9–10) of the ablation line demonstrates septal to lateral activation at the lateral side of the ablation line (arrow) with a conduction time of 165 ms. These findings suggest that conduction remained in the septal to lateral direction (counterclockwise) on the ablation line. The dotted line represents the mitral annulus. LAO: left anterior oblique; the other abbreviations are the same as those used in Fig. 2.

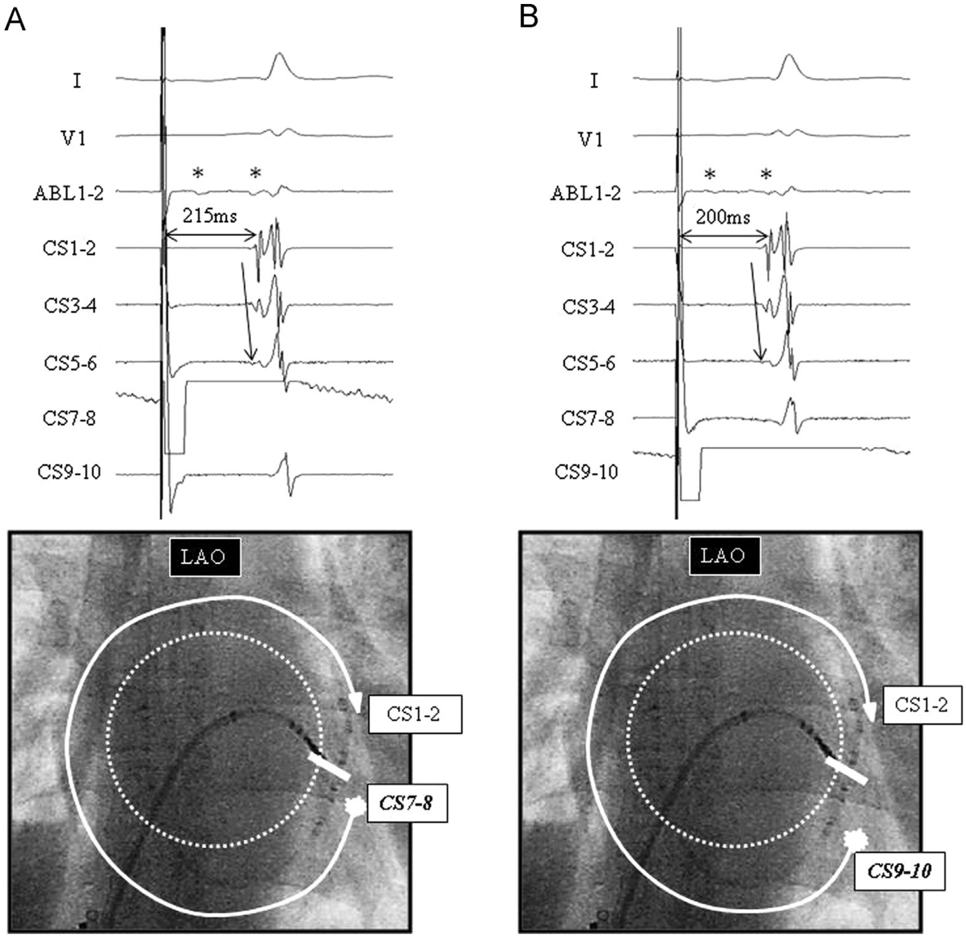

Fig. 4. (A) During the application of radiofrequency at this site, the conduction time from the septal to lateral side was prolonged (160–215 ms), and the activation sequence at the lateral side to the ablation line changed from proximal-to-distal to distal-to-proximal during pacing at the septal side (CS 7–8) of the ablation line (arrow). At the ablation catheter, separated double potentials were recorded on the MI line (asterisk). (A) and (B) Demonstration of the differential pacing technique. The conduction time from the pacing site at the immediately adjacent septal side (CS 7–8) of the MI line to the lateral side (CS 1–2) was longer than that from the pacing site at the septal side (CS 9–10) to the lateral side (CS 1–2) (215 vs. 200 ms). These findings suggest that a counterclockwise conduction block is achieved on the MI line. The abbreviations used were the same as those in Figs. 2 and 3.

bidirectional block have been described in previous reports [5,7]. Shah et al. proposed the criteria for achieving a bidirectional block for CTI as follows: (1) the presence of widely separated local double potentials along the length of the ablation line during CS pacing, (2) mapping the activation detour during pacing from either side of the line, and (3) differential pacing to distinguish slow conduction across the line from complete block [8]. These criteria can also be adapted for confirming a bidirectional block on the MI line [7]. Although a unidirectional conduction block on the CTI during ablation was described in patients with typical atrial flutter [5,6], it was rarely seen on the MI during ablation. Matsuo et al. previously demonstrated a unidirectional conduction block on the MI with unidirectional conduction in a clockwise direction during ablation for perimitral AT [9]. In the present case, we provide the first report of a unidirectional conduction block with residual unidirectional conduction in a counterclockwise direction on the MI.

The mechanisms underlying the unidirectional conduction block in the linear ablation region remain unknown. In patients with typical atrial flutter, Matsushita et al. reported that an abrupt change of fiber orientation in cases of incomplete linear lesion by RF application may result in some degree of conduction disturbance on the line [10]. Cabrera et al. also described how heterogeneities in the refractoriness between fibers with different orientations at the CTI may create a unidirectional conduction block through ablation [11]. Anisotropic wave propagation at the MI in association with different fibers, however, has not been investigated. In the present case, the change of the electrical orientation on the MI line because of prior ablation, including RF application to the PV antrum and the LA around the MI and CS, may have provided a substrate for unidirectional conduction block on the MI line.

Paisey et al. recently proposed a simple technique for recognizing an MI block. In their study, an abrupt change of the CS activation pattern during RF application, under left atrial appendage pacing from a distal-to-proximal to proximal-to-distal direction provided a reliable assessment of MI conduction [12]. Although this technique will never overlook unidirectional conduction in a clockwise direction (such as the case reported by Matsuo et al. [9]), a counterclockwise unidirectional conduction cannot be detected, such as was present in the current case. Schumacher et al. have reported that the rate of recurrence of typical atrial flutter circulating around the tricuspid annulus after linear ablation at the CTI was higher in patients with a unidirectional conduction block than in those with a bidirectional conduction block (54% vs. 9%) [5], which indicates the importance of confirming a bidirectional conduction block in preventing recurrence after linear ablation. Although the prevalence of a unidirectional conduction block on the MI is not yet known, the verification of the “bidirectional” conduction block should be confirmed in the MI ablation, once linear ablation is attempted.

Conflict of interest

None.

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