Case Report

Marshall bundle reentrant atrial tachycardia after the Cox-Maze IV procedure: The last barrier of the conduction pathway between the coronary sinus and left atrium

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A B S T R A C T

A 74-year-old woman who developed atrial tachycardia following the Cox-Maze IV procedure underwent catheter ablation. The reentrant circuit included the coronary sinus (CS), Marshall bundle (MB), distal MB-left atrial (LA) connection, and anterolateral mitral annulus. The distal MB-LA connection was the last barrier in the conduction pathway between the CS and the left atrium.

1. Case presentation

A 74-year-old woman who had undergone aortic and mitral valve replacement with the Cox-Maze IV procedure (CMP) underwent catheter ablation for atrial tachycardia (AT). Post-pacing interval-tachycardia cycle length (PPI-TCL) was ≤ 10 ms from the coronary sinus (CS) 1–2 to CS 5–6, ridge, and endocardial anterolateral mitral annulus (MA) (Fig. 1A and B). The ridge was defined as the area between the left pulmonary vein (PV) and left atrial appendage, and the anterolateral MA was defined as the endocardial area at the 2 o'clock position of the MA. However, PPI-TCL was > 30 ms at CS 7–8, the anterior wall/posterior wall of the left atrium, and the left atrial appendage resection site (LAAR). We considered that the reentrant circuit included the CS, CS-Marshall bundle (MB) connections, the MB itself, distal MB-left atrial (LA) connections, and the anterolateral MA. CS potentials were captured orthodromically with a long conduction time by entrainment pacing from the ridge, whereas captured orthodromically with a short conduction time by entrainment pacing from the anterolateral MA (Fig. 1A and B). These recordings indicated the presence of a slow conduction pathway between the ridge and anterolateral MA (Fig. 1C). Radiofrequency catheter ablation was applied at the ridge, and was followed by the termination of AT, although abnormal potentials such as fragmented or double potentials were not observed at the point of ablation. These phenomena indicated that the ablation point at the ridge was just proximal to the entrance site of the slow conduction pathway in the reentrant circuit. After that, conduction blocks of the roof line and mitral isthmus line of the previous CMP were confirmed. Additional ablation was performed at the anterolateral MA, and was followed by the disappearance of CS potentials during LAAR pacing, which suggested that only the single conduction pathway from the LAAR to the CS was present at the anterolateral MA (Figs. 1D, 2A and 2B). However, electrical conduction from the CS to the LAAR during CS pacing was present. The conduction time from CS 1–2 to LAAR during CS 1–2 pacing was longer than the conduction time from CS 5–6 to LAAR during CS 5–6 pacing, which was shorter than the conduction time from CS 7–8 to LAAR during CS 7–8 pacing (Fig. 2C). These observations suggested that the wavefronts from the CS pacing sites were unable to propagate via the anterolateral MA and mitral isthmus line between the right PV and MA (Fig. 3A). Furthermore, the activation sequences of LAAR during each CS pacing were identical (Fig. 2C). If the LAAR activation sequence during multiple CS pacing is different, then it could be argued that there are two or more pathways for propagation from the CS to LAAR during CS pacing. Therefore, the conduction pathway from the CS to the LAAR was determined to be
Fig. 1. Intracardiac electrograms of entrainment pacing (A and B), schematic presentation of the conduction pathway during atrial tachycardia (C), and intracardiac electrograms during ablation of the anterolateral mitral annulus (MA) (D). The red arrows indicate the reentrant circuit, while the blue arrows indicate the other wavefronts. The black bands indicate the ablation line caused by the Cox-Maze IV procedure. The yellow dots indicate entrainment pacing sites where the post-pacing interval matched the tachycardia cycle length. ABL, ablation catheter; CS, coronary sinus; LAAR, left atrial appendage resection site; LIPV, left inferior pulmonary vein; LSPV, left superior pulmonary vein; MB, Marshall bundle; RFA, radiofrequency catheter ablation.

Fig. 2. Catheter positions during ablation of the anterolateral mitral annulus (MA) (A), schematic presentation after ablation of the anterolateral MA (B), and intracardiac electrograms during coronary sinus (CS) pacing at a paced cycle length of 600 ms after anterolateral MA ablation (C). The ridge ablation site causing atrial tachycardia (AT) termination is indicated by the green star. The anterolateral MA ablation site is indicated by the blue star. LAO, left anterior oblique projection; PPI, post-pacing interval; TCL, tachycardia cycle length. The arrows, bands, and other abbreviations are as they are in Fig. 1.
the single pathway in the present case [1]. Thus, because the conduction block in the LA roof line had been confirmed, we considered that the wavefronts from the CS pacing sites propagated via the MB (Fig. 3A), and performed additional ridge ablation during CS pacing, which was followed by the disappearance of LAAR potentials (Fig. 3B and C). This phenomenon suggested that the distal MB-LA connection was the last barrier in the conduction pathway between the CS and left atrium. Additionally, these observations demonstrated the presence of a unidirectional conduction block in the distal MB-LA connections prior to the last ridge ablation.

2. Discussion

Several macroreentrant ATs using the MB have been reported; these ATs were treated by ablation, which often leads to the MB conduction block [2,3]. Four methods of creating the MB conduction block have been reported: ridge ablation for disconnecting the distal MB-LA connections [1,2], ablation inside the vein of Marshall [4], CS ablation for disconnecting the CS-MB connections [5], and ethanol infusion [3]. In this case, the MB conduction block was created by the ridge ablation.

Yamamoto et al. reported a case of AT after PV isolation that involved a reentrant circuit including the MB, LA roof, and posterior wall [6]. In addition, several cases of peri-mitral AT using the MB after PV isolation and/or lateral mitral isthmus ablation were reported; these used the MB epicardial connections bypassing the lateral mitral isthmus, as a reentrant circuit [2,3]. Regarding AT after the Maze procedure, previous reports suggested that macroreentry was the leading mechanism, and that peri-mitral AT was the most common [7,8]. In this case, the reported instances of AT were not observed because the complete roofline and mitral isthmus line between the right PV and MA were both created by the previous CMP. Therefore, MB reentrant AT, as shown in this case, may be specific to AT after the CMP with a complete ablation line.

3. Limitations

Notably, in this case, we could not directly demonstrate the MB reentrant circuit because the 2-Fr octapolar electrode catheter (EPstar, Japan Lifeline Corp., Tokyo, Japan) could not be inserted into the vein of Marshall.

Conflict of interest

All authors declare no conflict of interest related to this study.
Acknowledgments

None.

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