Ridge-related reentry despite apparent bidirectional mitral isthmus block

Chen-Xi Jiang, MD, Jian-Zeng Dong, MD, De-Yong Long, MD, Rong-Hui Yu, MD, Ri-Bo Tang, MD, Cai-Hua Sang, MD, Man Ning, MD, Song-Nan Li, MD, Xue-Yuan Guo, MD, Xin Du, MD, Rong Bai, MD, FHRS, Nian Liu, MD, Jia-Hui Wu, MD, Chang-Sheng Ma, MD, FHRS

From the Department of Cardiology/Atrial Fibrillation Center, Beijing Anzhen Hospital, Capital Medical University, Beijing, China.

BACKGROUND Verification of bidirectional block is important for mitral isthmus (MI) ablation. However, recurrent perimitral reentry exists despite apparently MI block.

OBJECTIVE The purpose of this study was to identify and investigate the characteristics of the ridge breakthrough despite apparent bidirectional MI block and related reentry.

METHODS In 60 patients undergoing MI ablation and achieving the criteria of bidirectional block when assessed on the line, the pattern under differential pacing was reassessed at the ridge away from the line to check whether a breakthrough existed. Also, activation and entrainment mapping was performed in 7 patients with ridge-related reentry (RRR) to investigate its possible mechanism.

RESULTS A ridge breakthrough was found in 7 of 60 patients (11.7%) apparently fulfilling the criteria of bidirectional block. The delay from pacing artifact during distal coronary sinus pacing was shorter at the ridge than on the line (95.6 ± 11.7 ms vs 130.9 ± 15.3 ms; $P < .001$). In 7 patients with RRR, the left atrial endocardial activation time accounted for 58.5% ± 3.2% of the tachycardia cycle length (TCL) and wide double potential could be recorded on the line. The post-pacing interval (PPI) − TCL after entrainment at the ridge was shorter than that on the line (11.4 ± 3.9 ms vs 34.3 ± 6.6 ms; $P < .001$), and in 2 patients in whom entrainment from the coronary sinus was possible, the PPI − TCL was 15 and 18 ms, respectively.

CONCLUSION Apparent bidirectional MI block despite a ridge breakthrough is not uncommon and may lead to RRR, while the line is not part of the reentry.

KEYWORDS Atrial fibrillation; Ablation; Atrial tachycardia; Mitral isthmus; Lateral ridge

(Heart Rhythm 2016;13:1845–1851) © 2016 Published by Elsevier Inc. on behalf of Heart Rhythm Society.

Introduction

Mitral isthmus (MI) is often targeted for catheter ablation of atrial fibrillation (AF). Linear ablation across MI is useful for substrate modification by compartmentalization of the left atrium (LA), as well as prevention of perimitral macroreentry, which may contribute for a higher ablation success rate.[1] The most commonly used approach includes ablation from the mitral annulus to the ostium of the left inferior pulmonary vein (PV), and differential pacing from the coronary sinus (CS) and a mapping catheter put at the contralateral side on the line is well established as the protocol to assess bidirectional block.[2] However, incomplete block of MI is reported to be a common cause of iatrogenic atrial tachycardia (AT).[1] While achieving complete block is technically challenging, such a "proarrhythmic effect" remains a great concern for MI intervention.

In addition, the protocol for assessing bidirectional block of MI needs to be performed carefully and the criteria followed rigorously. Perimitral AT could recur after apparently successful block of MI.[3] First, because of an inappropriate catheter location, pacing output, or misjudgment of the near-field and far-field electrograms, approximately 20% of the procedures assessing MI block have been reported to encounter pitfalls classified into 6 types.[4] Second, some variants of breakthroughs can escape the verification of differential pacing and mimic bidirectional block. Among these, the unique anatomical characteristics of the ridge between the left atrial appendage (LAA) and left PVs make it a common hiding place for a breakthrough. This study aimed at identifying and exploring the characteristics of the breakthrough located at the ridge after MI ablation and subsequent ATs.

Methods

Study population

Sixty consecutive patients undergoing MI ablation and fulfilling the criteria of bidirectional block during catheter ablation of AF were included in this study. In addition, 82

Dr Jiang and Dr Dong are co-first authors. This work was supported by the National Natural Science Foundation of China (grant no. 81300145). **Address reprint requests and correspondence:** Dr Chang-Sheng Ma, Department of Cardiology/Atrial Fibrillation Center, Beijing An Zhen Hospital, Capital Medical University, Beijing, China 100029. E-mail address: chshma@vip.sina.com.

1547-5271/$-see front matter © 2016 Published by Elsevier Inc. on behalf of Heart Rhythm Society. http://dx.doi.org/10.1016/j.hrthm.2016.06.018

redo cases presenting with organized ATs in whom the criteria of bidirectional block of MI were fulfilled at the end of their previous procedure were investigated for ridge-related reentry (RRR). The study complied with the Declaration of Helsinki, and the protocol was approved by the institutional review boards at Beijing Anzhen Hospital. Each participant provided their written informed consent form.

Electrophysiology study and catheter ablation

Before the procedure, all antiarrhythmic drugs except amiodarone were discontinued for at least 5 half-lives, while oral anticoagulation was continued, and LA thrombus was excluded by transesophageal echocardiography. Informed consent was obtained from all patients.

The procedure was performed under conscious sedation with fentanyl and midazolam. A deflectable decapolar catheter was positioned in the CS. After a single transseptal puncture, the 3.5-mm open-irrigated mapping catheter (NaviStar ThermoCool, Biosense Webster Inc., Diamond Bar, CA) was advanced into the LA. In patients with AF, circumferential pulmonary vein isolation (CPVI) was performed under the guidance of the CARTO system (Biosense Webster Inc., Diamond Bar, CA), and additional sites such as MI was ablated only if AF persisted after CPVI; whereas in patients with persistent AF, a fixed approach including CPVI as well as LA roof, MI, and cavotricuspid isthmus ablation was adopted. Ablation targeting superior vena cava and other non-PV AF initiators was performed if they existed. In the redo procedure, conduction recovery across PV, MI, and all other lines was checked and any gaps were attempted to close.

Radiofrequency energy was delivered with a maximum temperature of 43°C, a power up to 35 W, and a flow rate of 17 mL/min. When ablation was applied inside the CS, the maximum power was decreased to 25 W while the flow rate was increased to 30 mL/min. At each site, the ablation time was restricted to 30–60 seconds but no more than 30 seconds when ablating the LA posterior wall and inside the CS.

MI ablation

An MI line was drawn from the lateral side of the mitral annulus to the ostium of the left inferior PV. When sinus rhythm was restored, either by ablation or by cardioversion, residual gaps along the line was identified and closed during distal CS (CSd) pacing. If bidirectional block was unable to achieve by endocardial ablation, further ablation inside the CS was attempted. The differential pacing technique and related criteria reported by Jais et al[2] were used to assess MI linear block. The CS and mapping catheter were positioned on the lateral and the septal side of the ablation line, respectively (Figure 1, also see Figure 2A). The line was considered bidirectional block if the delay from the pacing artifact recorded by the mapping catheter was longer during CSd pacing as compared with proximal CS pacing, and when pacing at the mapping catheter, the proximal CS was activated ahead of the CSd. These criteria should be checked along the line from the PV side (site A in Figure 1 and Figure 2A) to the annulus side (site B in Figure 1 and Figure 2A).

Identification of the ridge breakthrough

When the criteria of complete bidirectional block were fulfilled, the mapping catheter was repositioned to the high lateral ridge between the LAA and left PVs away from the ablation line (site C in Figure 1 and Figure 2A), and delay from the pacing artifact was checked during CSd pacing again. If it was shorter than that recorded on the ablation line and, when pacing at this site, the CS activation was not the block pattern, a high ridge breakthrough was considered to exist. After the breakthrough was ablated, complete bidirectional block was reevaluated.

Investigation of RRR

To further understand the characteristics of the ridge breakthrough, RRR was investigated in redo cases with MI block criteria fulfilled during prior ablation. An organized AT was considered to be RRR on the basis of the following: (1) Activation mapping indicated perimitral macroreentry and the post-pacing interval (PPI) after entrainment pacing minus tachycardia cycle length (TCL) was no more than 20 ms around the mitral annulus. (2) The PPI − TCL was no more than 20 ms at the high lateral ridge. (3) For counterclockwise reentry, the time interval between the CSd and local activation was shorter at the high lateral ridge than on the ablation line. (4) The AT was able to be terminated by ablation at the high lateral ridge. Once the diagnosis of RRR was established, detailed endocardial activation and entrainment mapping was performed at the ridge, on the line, and inside the CS.

Antiarrhythmic drugs were given for 3 months after the procedure, and oral anticoagulation was administered according to the current guidelines. All patients were followed up by 48-hour Holter monitoring every month for the first 6 months. An office or telephone interview was scheduled every month thereafter until at least 12 months after the procedure. *Arrhythmia recurrence* was defined as any documented AF or organized AT episode lasting for more than 30 seconds after the blanking period.

Statistical analysis

All continuous variables are presented as mean ± SD or number(percentage) if not normally distributed. Continuous data were compared using the Student *t* test if normally distributed or using the nonparametric Mann-Whitney *U* test if not normally distributed. Categorical variables were compared using the χ^2 or Fisher exact test, as appropriate. A *P* value of $< .05$ was considered statistically significant. All statistical analyses were performed with SPSS 13.0 (SPSS Inc., Chicago, IL).