Mechanisms of postoperative atrial tachycardia following biatrial surgical ablation of atrial fibrillation in relation to the surgical lesion sets

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BACKGROUND Atrial tachycardia (AT) may develop after biatrial surgical ablation of atrial fibrillation. However, the mechanism has not been determined in detail.

OBJECTIVE We aimed to determine the mechanism and treatment of postoperative AT following biatrial surgical ablation in relation to the design and durability of the surgical lesion sets.

METHODS An electrophysiologic study and radiofrequency ablation were performed in 34 consecutive patients (23 male, mean age of 63 ± 9.4 years) who were referred for AT that developed late after biatrial surgical ablation.

RESULTS The mechanism of a total of 53 ATs was macroreentry in 30, a focal mechanism in 20, and localized reentry in 1, and could not be determined in 2. The cause of the macroreentrant AT was residual conduction across a surgical lesion, most of which was located at the annular end of the mitral (n = 18) or tricuspid isthmus incision (n = 7), where cryoablation was applied during the surgery. We did not find any gaps across the cut-and-sew lesions. Radiofrequency (RF) applications to the gap, or an alternative site to transect the circuit, or the earliest activation site of the focus was effective for 48 ATs (91%). After a total of 1.3 ± 0.6 RF sessions, 27 patients (79%) were free of AT (n = 2) or AF (n = 5) during a follow-up period of 50 ± 49 months.

CONCLUSIONS Macroreentry due to a gap in a surgical lesion and focal AT were the major mechanisms of AT in patients after biatrial surgical ablation. Radiofrequency ablation of those ATs is feasible.

KEYWORDS Radiofrequency ablation; Atrial fibrillation; Cut and sew; Macroreentry; Cryoablation

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Introduction

Atrial fibrillation (AF) is a common cardiac arrhythmia and is associated with a high morbidity and mortality rate.[1,2] Biatrial surgical ablation procedures are effective in restoring and maintaining sinus rhythm in patients with AF.[3] Biatrial surgical ablation procedures consists of the isolation of all 4 pulmonary veins (PVs) to prevent propagation of repetitive activations and multiple incisions on the right and left atria to block the reentrant activation.[4] During the past decade, surgical cut-and-sew lesions have been replaced by a number of alternative energy sources such as cryothermia or radiofrequency (RF) energy to make a complete conduction block.

Although they are effective in restoring sinus rhythm and preventing thromboembolisms, the biatrial surgical ablation procedures in previous studies have been reported to cause the emergence of atrial tachycardia (AT)[5–11] and have been shown to be effective in the catheter ablation to eliminate such postoperative ATs. However, the detailed mechanism is unclear, and especially the relationship between the surgical lesion sets and mechanisms of the ATs has not been elucidated. Further, the long-term outcome after RF ablation is unclear.

The aim of our study was to describe the electrophysiologic characteristics of postoperative AT after a biatrial surgical ablation, and to determine the mechanism in relation to the surgical lesion sets. Furthermore, we aimed to evaluate the feasibility, safety, and acute and long-term outcomes of catheter ablation of AT in patients after biatrial surgical ablation.

Methods

Patients

Between July 1999 and June 2015, 34 patients (23 male) with a mean age of 63 ± 9.4 years, who were referred to our laboratories, underwent catheter ablation of ATs that emerged late (>1 month) after a biatrial surgical ablation of AF. The institutional ethics review committee approved this study protocol. Table 1 shows the clinical characteristics of this consecutive series. Three patients underwent a standalone surgical ablation for lone AF. Thirty-one patients

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underwent a concomitant surgical procedure. Twenty-eight patients had preoperative persistent AF and 6 had paroxysmal AF. The AT emerged within 1 year after the biatrial surgical ablation in 21 patients, and later than 1 year in 13, with a mean duration of 31 ± 45 months after the surgery.

Surgical procedure

All patients had undergone 1 of the following 3 surgical ablation procedures: Cox-Maze III (n = 3), radial procedure (n = 15), or modified maze (n = 16) for AF (Figure 1). The details of those procedures are described elsewhere.[12–14] In brief, the Cox-Maze III procedure consisted of a box isolation of all 4 PVs, excision of both atrial appendages, and multiple incisions on the right and left atria. Incisions extending to the mitral or tricuspid annulus were complemented with cryoablation to their annular ends.[12] The radial procedure is a modified procedure of the Cox-Maze III, where a box isolation of the PVs was replaced by cryoablation of each PV orifice, and an incision between the excised left atrial appendage and anterior mitral annulus was added to prevent macroreentry around the left PVs (LPV).[13] The modified maze procedure consisted of a bilateral PV isolation using a bipolar RF device (AtriCure Inc, West Chester, OH), a right-sided left atriotomy to expose the mitral valve, and a left atrial appendage excision;[14] the atriotomy was extended down to the posterior mitral valve annulus between the middle and posterior scallops and the annulus and coronary sinus (CS) were cryoablated.

Electrophysiologic study and catheter ablation

The AT was documented by 12-lead electrocardiograms (ECGs) in all patients. Electrophysiological studies were performed under deep sedation with midazolam and propofol. Intracardiac electrode catheters were positioned under fluoroscopic guidance. A 6F, 20-pole catheter was placed around the tricuspid annulus. CS recordings were performed from a 7F decapolar catheter. A 7F duodecapolar circular mapping catheter (Lasso; Biosense Webster) and an 8-mm-tip or 4-mm-tip irrigated ablation catheter (Navistar Thermocool; Biosense Webster, or Safire BLU Duo; St Jude Medical, respectively) were inserted into the left atrium (LA). Procedures were guided using an electroanatomic mapping system (CARTO; Biosense Webster, Diamond Bar, CA, USA, or Ensite NavX; St Jude Medical, Saint Paul, MN, USA).

Bipolar endocardial electrograms were monitored continuously and recorded on an EP-WorkMate recording system (EP Med Systems) with a filter setting of 30–500 Hz. RF current was delivered using an RF generator (Stockert J70 RF Generator; Stockert GmbH, Freiburg, Germany, or IBI-1500 RF generator; St Jude Medical) targeting a maximum temperature of 41°C (for Safire BLU Duo) or 43°C (for Navistar Thermocool) and a maximum power of 30 W. In the case of ablation within the CS, the maximum power was limited to 20 W. A manually controlled steerable sheath (Agilis; St Jude Medical) was used as needed.

AT was deemed macroreentry when an activation map exhibited a reentry around a large central obstacle such as

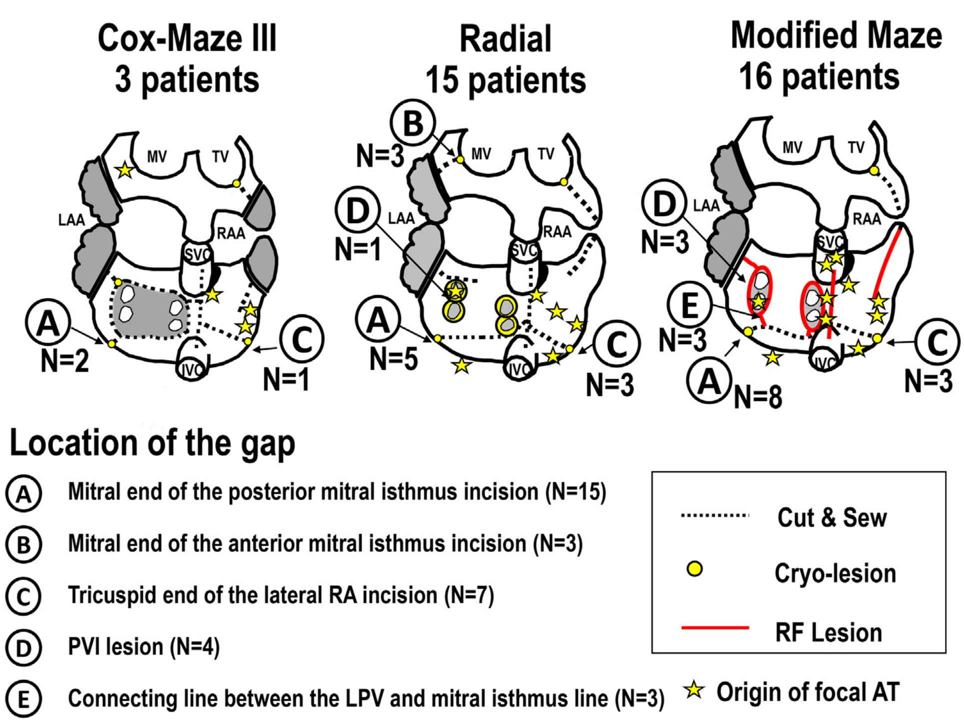

Figure 1 Schematics exhibiting the 3 biatrial surgical ablation procedures performed in the study patients. The dotted lines show the cut-and-sew surgical lesions, the yellow dots and circles show the cryolesions, and the red lines show the RF lesions made during each maze procedure. The letters (A, B, C, D, and E) in the circles show the sites with residual conduction across the surgical lesions responsible for macroreentrant atrial tachycardia (AT). The star shows the origin of a focal AT. LAA = left atrial appendage; RAA = right atrial appendage; MV = mitral valve; TV = tricuspid valve; SVC = superior vena cava; IVC = inferior vena cava.

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