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Original Article

Efficacy of ablation at the anteroseptal line for the treatment of perimitral flutter

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ABSTRACT

Background: Left atrial flutter following atrial fibrillation (AF) ablation is increasingly common and difficult to treat. We evaluated the safety and efficacy of ablation of the anteroseptal line connecting the right superior pulmonary vein (RSPV) to the anteroseptal mitral annulus (MA) for the treatment of perimitral flutter (PMF).

Methods: We systematically studied patients who were previously treated with AF ablation and who presented to the electrophysiology laboratory with atrial tachyarrhythmias between January 2000 and July 2010. The diagnosis of PMF was confirmed by activation mapping and/or entrainment. After re-isolation of any recovered pulmonary vein, a linear radiofrequency (RF) ablation was performed on the line that connected the RSPV to the anteroseptal MA. In this analysis, we included only patients who were treated with an anteroseptal line for their PMF.

Results: Ablation was performed at the anteroseptal line in 27 PMF patients (63 ± 13 years; 9 women) who had undergone prior ablation for paroxysmal ($n=3$) or persistent ($n=24$) AF, using electroanatomic activation mapping (70% CARTO, 30% NavX). The anteroseptal ablation line was effective in 22/27 (81.5%) patients in the acute-care setting. Termination of AF to sinus rhythm occurred in 15/22 (68.2%) patients, and 7/22 (31.8%) patients' AF converted to another right or left atrial flutter. At the 6-month follow-up, 20% of patients demonstrated recurrent left atrial tachyarrhythmia. Only one patient required repeat ablation, and the remaining patients' condition was controlled with antiarrhythmic medications. No major procedural complications or heart block occurred.

Conclusion: Ablation at the left atrial anteroseptal line is safe and efficacious for the treatment of PMF. Unlike ablation at the traditional mitral isthmus line, ablation at the left atrial anteroseptal line does not require ablation in the coronary sinus.

1. Introduction

Atrial fibrillation (AF) is the most common sustained arrhythmia, and as the average age of the population increases, the incidence of AF will continue to rise [1,2]. The past decade has seen the steady advance of catheter-based approaches to the management of AF.

Fortunately, serious complications arising from AF ablation have declined as collective experience has increased and techniques have improved. Pulmonary vein stenosis, atrial-esophageal fistula, cerebral vascular accidents, and coronary artery injury are now uncommon complications [3]. Despite these advances, the prevalence of late-onset postprocedural left atrial (LA) flutter remains as high as 10% [4]. Presumably, in LA flutter, the conversion of AF to a more organized reentrant circuit results in the development of macro-reentrant atrial tachycardias. These tachycardias possibly result from "proarrhythmic" lesion sets that create areas of slow conduction, predisposing the circuit to reentry [5].

Perimitral flutter (PMF) is responsible for a considerable percentage of cases of macroreentrant LA flutter, especially in the setting of AF ablation [6]. Despite recent technological

Abbreviations: AAD, Antiarrhythmic drug; AF, Atrial fibrillation; CS, Coronary sinus; CTI, Cavotricuspid isthmus; ICE, Intracardiac echocardiography; LA, Left atrium; LAA, Left atrial appendage; MA, Mitral annulus; PMF, Perimitral flutter; PVI, Pulmonary vein isolation; RF, Radiofrequency; RSVP, Right superior pulmonary vein

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Table 1
Baseline characteristics of the perimitral flutter study population ($n=27$).

Patient characteristics	
Age (years)	63 ± 13
Women	33.33%
Ejection fraction	52% (23%–65%)
Structural heart disease	
No heart disease	11/27
Ischemic heart disease	2/27
Valvular heart disease	4/27
Medications	
Beta blockers	11/27
Calcium-channel blockers	8/27
Digoxin	3/27
Amiodarone	1/27
Dofetilide	3/27
Sotalol	3/27
Class IC antiarrhythmics	8/27

advances and a better understanding of the anatomy, mitral isthmus ablation remains technically challenging, often requiring substantial ablation (> 15 min of radiofrequency [RF] energy), high ablation powers (≤ 50 W), and epicardial ablation within the coronary sinus (CS) in approximately 70% of patients. Even so, success rates for mitral isthmus ablation in the acute setting are only moderately high [7].

The present study sought to evaluate the feasibility, safety, and efficacy of ablation at the LA anteroseptal line connecting the right superior pulmonary vein (RSPV) to the anteroseptal mitral annulus (MA) for the treatment of PMF.

2. Material and methods

2.1. Study population and follow-up

We retrospectively analyzed patients who were treated for PMF with catheter ablation for atrial tachyarrhythmias, at the anteroseptal line connecting the RSPV to the anteroseptal MA. The study was approved by the Institutional Review Board of the Cleveland Clinic Foundation.

From June 2000 to July 2010, ablation at the anteroseptal line was performed in 27 patients with PMF that was either the presenting arrhythmia or an organized intermediate rhythm during AF ablation. All patients provided written informed consent. The baseline characteristics of the study population are presented in Table 1.

During the first 3 months after ablation, patients used an event recorder to monitor for arrhythmias and recorded them on a weekly basis and whenever they were symptomatic. Additional event recorder monitoring was obtained beyond the 3-month period if patients either had atrial tachyarrhythmia within the first 3 months or had symptoms consistent with arrhythmia. Patients underwent 24-h Holter ECG at 3 months, 6 months, and every 6 months thereafter. Follow-up visits were scheduled at 3, 6, and 12 months after ablation and yearly thereafter when possible. More frequent follow-up was scheduled for patients who had symptoms, arrhythmia recurrence, or complications from the procedure. All patients underwent transthoracic echocardiography within 3 months before ablation, echocardiography, and cardiac computed tomography to assesses for possible pulmonary vein (PV) stenosis at 3 months after ablation.

Arrhythmia recurrence was identified when patients reported symptoms consistent with arrhythmia and/or when an atrial tachyarrhythmia lasting 30 s was captured on a 12-lead ECG, event recording, or Holter monitor recording. Without such documentation, patients were considered arrhythmia-free. Antiarrhythmic drugs (AADs) were used during the first 2 months after ablation and were then stopped unless continued arrhythmia indicated their use, in which case patients were considered to have arrhythmia recurrence.

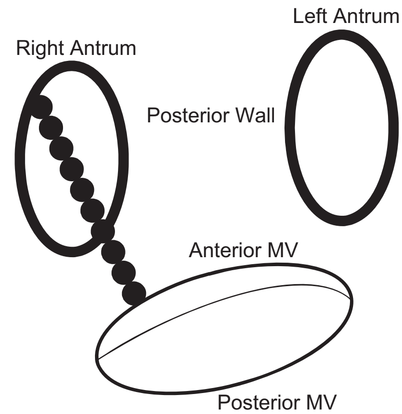

Fig. 1. Schematic representation of the anteroseptal line joining the right superior antrum with the anteroseptal mitral annulus.

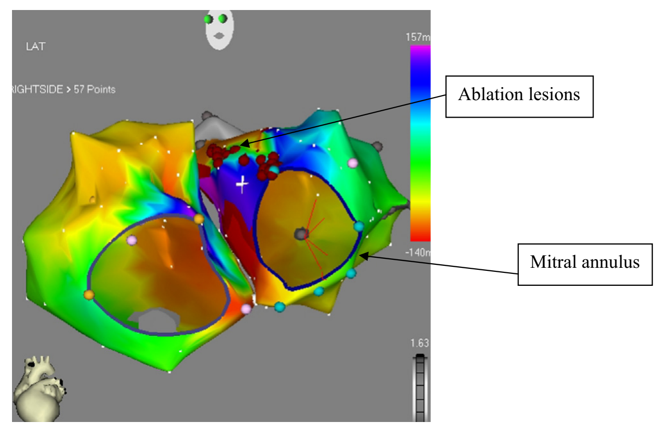

Fig. 2. Electroanatomic map of the right and the left atrial chambers of a patient with perimitral flutter with RF ablation line from the RSPV to the anteroseptal MA.

2.2. Ablation strategy

We have previously described our pulmonary vein isolation (PVI) and periprocedural anticoagulation protocols in detail [8,9]. Briefly, all AADs were stopped 4–5 half-lives before ablation, with the exception of amiodarone, which was discontinued ≥ 4–5 months before the procedure. A transesophageal echocardiogram was obtained for patients presenting with AF if they had a subtherapeutic international normalized ratio ≤ 3 weeks before ablation. A 10-Fr phased-array intravascular ultrasound catheter (Siemens AG Inc., Malvern, PA, USA) was placed in the right atrium to assist with performing transseptal punctures, to guide catheter location and manipulation within the LA, and to monitor for cardiac complications during ablation. In all patients, all PV antra were re-isolated under intracardiac echocardiographic (ICE) guidance.

After completion of the re-isolation of the PV antra, the PMF was mapped using the NavX or CARTO 3-dimensional (3D) electroanatomic system and then confirmed by entrainment from the proximal, distal coronary sinus and the anterior mitral annulus.

2.3. Ablation at the anteroseptal line and verification of block across the line

The anteroseptal line was created between the anterior/anteromedial aspect of the mitral annulus and the ostium of the RSPV (Fig. 1). The ablation catheter was advanced through the transseptal sheath to the anterior/anteromedial mitral annulus, and delivery of

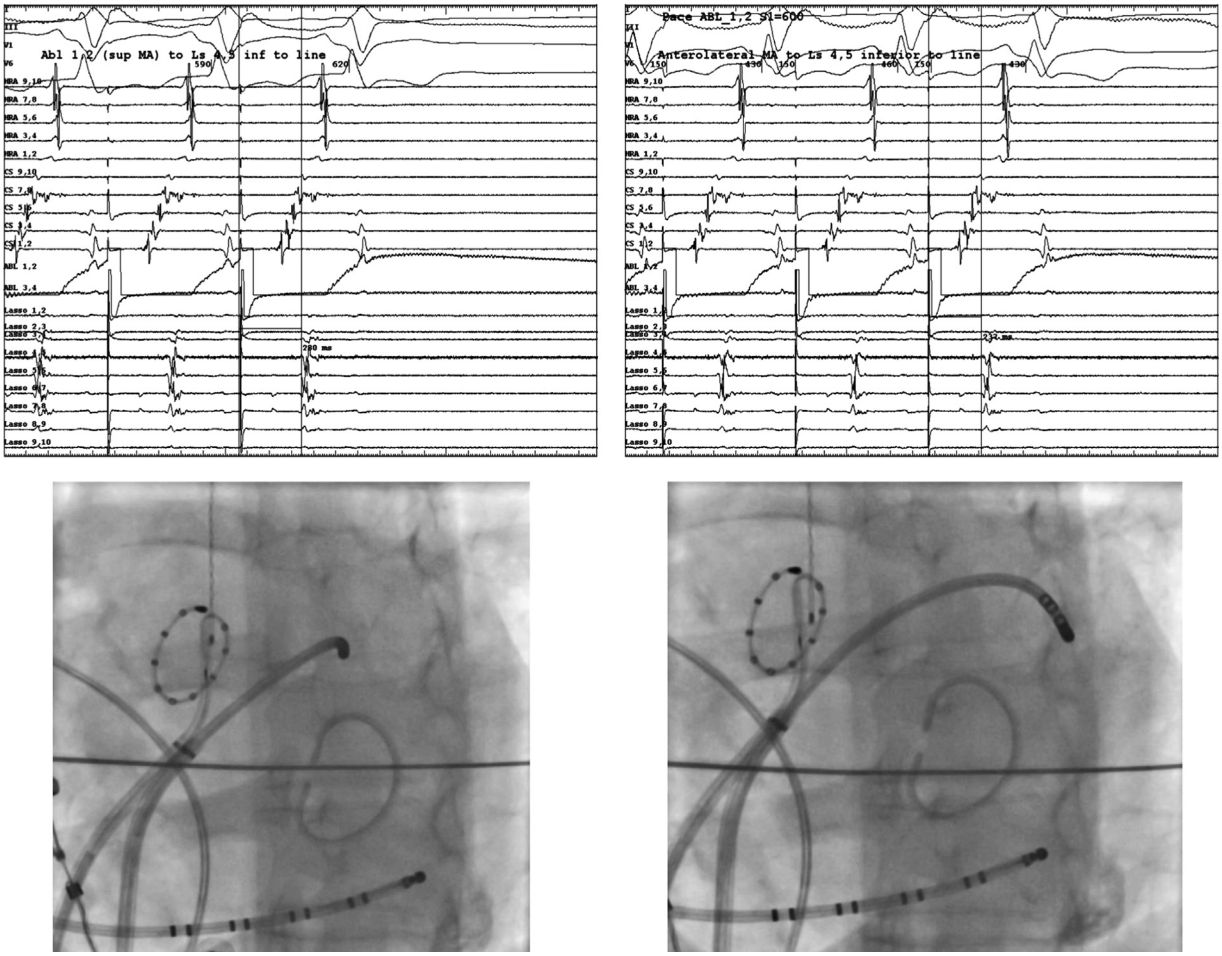

Fig. 3. This a left anterior oblique view of the left atrium with the circular mapping catheter placed over the septum of the left atrium. Pacing with the ablation catheter from the superior MA position (12 o'clock) to inferior to the line (circular mapping) 280 ms compared to pacing from anterolateral MA (2 o'clock) to circular mapping inferior to the line is 237 ms (note in the both images CS activation is distal to proximal).

radiofrequency lesions was started when the atrioventricular voltage ratio was 1:2. The ablation was performed using 3D electroanatomic mapping guidance by rotating the catheter counterclockwise until it reached the scar of the RSPV (Fig. 2). The transseptal sheath is typically positioned at the level of the interatrial septum, so during ablation of the roof of the RSPV, extra caution was taken by applying gentle pressure to the ablation catheter.

While pulling back, RF energy was applied at each point for 30–60 s until a significant reduction or elimination of the local potential was reached. To achieve the desired power delivery, irrigated RF energy was delivered at a power of 30–35 W using irrigation rates of 30 mL/min. Temperature was limited to 40 °C.

A complete block was achieved along the ablation line and documented after restoring sinus rhythm. Sinus rhythm was restored using one of the following methods: (1) evaluation of the coronary sinus activation pattern during pacing just laterally and medially to the line with the ablation catheter (the translinear pacing maneuver); with this method, a complete linear block was confirmed if pacing laterally to the line resulted in a distal-to-proximal CS activation pattern and if after pulling back the catheter to the septal side of the line, CS was activated from proximal to distal; or (2) differential pacing maneuvers (Fig. 3).

3. Results

Ablation at the anteroseptal line was performed in 27 PMF patients (aged 63 ± 13 years; 9 female) with prior ablation for paroxysmal ($n = 3$) or persistent ($n = 24$) AF using electroanatomic activation mapping (70% CARTO, 30% NavX). All patients had previously been treated with ≥ 1 AF ablation procedure. After re-isolation of any recovered PV, a linear RF ablation was performed connecting the RSPV to the anteroseptal MA.

3.1. Acute procedural success

The line was acutely effective in 22/27 (81.5%) patients. AF termination to sinus rhythm occurred in 15/22 (68.2%) patients, and 7/22 (31.8%) patients' arrhythmia converted to another right or left atrial flutter. These secondary flutters were mapped and ablated as well. All patients left the electrophysiology lab with restored sinus rhythm.

3.2. Follow-up

At 6-month follow-up, 20% of patients demonstrated recurrent LA tachyarrhythmia. Only one patient required repeat ablation, and the remaining patients' arrhythmias were controlled with AADs. The patient who required repeat ablation had recovery of the conduction across the successfully ablated line and had no documented arrhythmia recurrence at follow-up visits.

3.3. Complications and safety issues

No major procedural complications or heart block occurred. No patients experienced steam pop, cardiac tamponade, or thromboembolic events.

4. Discussion

This retrospective analysis provided information on the feasibility, efficacy, and safety of performing ablation at the anteroseptal line for the treatment of PMF. It described a technique for terminating PMF, which was achieved in 81.5% of patients and resulted in 96% of patients being free of arrhythmia.

Ablation at the classical mitral isthmus line, extending from the left inferior PV to the lateral mitral annulus, is far from the ideal approach to ablation in PMF. Several studies have made it clear that the anatomy of the mitral isthmus is not uniform and exhibits significant variation. In their series of 100 consecutive patients, Jais et al. required >30 min of RF delivery in 20% of patients to achieve complete block [6]. In postmortem studies, the distance between the left inferior PV and the lateral mitral annulus averaged 35 mm length and approximately 4 mm depth: longer than the cavotricuspid isthmus with similar myocardial thickness. Certain anatomic features have been suggested as possible obstacles to successful mitral isthmus ablation [10–13]: myocardial depth >5 mm; convective cooling by local blood vessels, such as the CS and circumflex artery, that act as a heat sink; a myocardial sleeve around the CS and continuities with the atrial myocardium that may bridge the lesion line; crevices in the isthmus area that may hinder safe and efficient RF energy delivery; continuation of atrial myocardium onto the atrial aspect of the mitral valve leaflet; and epicardial connections (e.g., the ligament of Marshall) across the mitral isthmus line.

Several cases of injury to the circumflex artery owing to ablation of the lateral mitral isthmus and inside the CS have been reported. The circumflex artery and the CS share a close relationship. Takahashi et al. reported the first case of acute circumflex artery occlusion during CS ablation, which was performed to achieve mitral isthmus block [14]. Hasdemir et al. found that the circumflex artery was <2 mm from the CS catheter at the lateral and anterolateral mitral annulus in 24% of patients [15]. Wittkampf et al. postulated that the risk of damaging the circumflex artery increased along with more distal ablation because the relationship between the circumflex artery and the CS might be even closer at a more distal, “anterior” position, while myocardial thickness increases at a more posteromedial mitral isthmus position [11].

Other potential barriers to successful mitral isthmus ablation are lack of stability of the ablation catheter and poor tissue contact. Matsuo et al. demonstrated that the use of Steerable sheaths significantly improved the efficacy of ablation at the mitral isthmus by improving navigation and stability [16].

Recent studies have suggested that mitral isthmus ablation may be proarrhythmic if bidirectional block across the line is not achieved or in the case of conduction recovery [7,17]. Tzeis et al. reported on the safety and feasibility of an alternative line: the modified anterior line, extending from the anterior/anterolateral mitral annulus to the orifice of the left superior PV, just medial to the LAA [18]. However, with this technique, a high incidence of inadvertent isolation of the left atrial appendage (LAA) and delayed activation of the LAA were potential drawbacks.

The line from the right inferior pulmonary vein to the mitral annulus can be substituted with the lateral mitral isthmus line for ablation. However, it was found to have a less favorable anatomy, i.e., a longer isthmus and greater percentage of ridges [13].

In our patients, ablation at the LA anteroseptal mitral line proved to be straightforward. Although this line was usually anatomically longer than the traditional lateral mitral isthmus line, the atrial wall was relatively thin, it was far from the LAA, and ablation in the CS was not required, which is desirable in view of the complications associated with CS ablation.

All our patients had re-isolation of any recovered PV prior to mapping and ablation of their PMF. We believe that re-isolating the veins is a cornerstone of successful, long-term treatment of atrial flutters. This idea was confirmed by the PROPOSE study, in which targeting the possible triggers of atrial flutter appeared to result in higher freedom from arrhythmia than did targeting the flutter only [19].

5. Study limitations

This study has several limitations. First, we retrospectively studied a small cohort of patients in whom ablation was performed at the anteroseptal line instead of that at the usual mitral isthmus line, based on the operator's preference. Therefore, a randomized control trial comparing the 2 lines of ablation would be of great benefit. Second, details about the procedures were lacking. Unless such data are collected prospectively, it is difficult to retrieve information about procedure time and fluoroscopy time when ablation at this line is done in conjunction with PV isolation. Third, we did not confirm earliest LA activation time during the intrinsic rhythm, which is done to avoid any unintentional ablation to the Bachmann's bundle region.

6. Conclusion

Ablation at the LA anteroseptal line is a safe and efficacious treatment for PMF. Unlike ablation at the traditional mitral isthmus line, ablation at the LA anteroseptal line does not require ablation in the coronary sinus. A randomized trial will be required to further compare results after ablation at the LA anteroseptal line with those after ablation at the traditional mitral isthmus line.

Conflict of interest

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

References

[1] Feinberg WM, Blackshear JL, Laupacis A, et al. Prevalence, age distribution, and gender of patients with atrial fibrillation. Analysis and implications. Arch Intern Med 1995;155:469–73.
[2] Miyasaka Y, Barnes ME, Gersh BJ, et al. Secular trends in incidence of atrial fibrillation in Olmsted County, Minnesota, 1980 to 2000, and implications on the projections for future prevalence. Circulation 2006;114:119–25.
[3] Hoyt H, Bhonsale A, Chilukuri K, et al. Complications arising from catheter ablation of atrial fibrillation: temporal trends and predictors. Heart Rhythm 2011;8:1869–74.
[4] Chae S, Oral H, Good E, et al. Atrial tachycardia after circumferential pulmonary vein ablation of atrial fibrillation: mechanistic insights, results of catheter ablation, and risk factors for recurrence. J Am Coll Cardiol 2007;50:1781–7.
[5] Shah D, Sunthorn H, Burri H, et al. Narrow, slow-conducting isthmus dependent left atrial reentry developing after ablation for atrial fibrillation: ECG characterization and elimination by focal RF ablation. J Cardiovasc Electrophysiol 2006;17:508–15.
[6] Jais P, Hocini M, Hsu LF, et al. Technique and results of linear ablation at the mitral isthmus. Circulation 2004;110:2996–3002.
[7] Matsuo S, Wright M, Knecht S, et al. Peri-mitral atrial flutter in patients with atrial fibrillation ablation. Heart Rhythm 2010;7:2–8.
[8] Hussein AA, Martin DO, Saliba W, et al. Radiofrequency ablation of atrial fibrillation under therapeutic international normalized ratio: a safe and efficacious periprocedural anticoagulation strategy. Heart Rhythm 2009;6:1425–9.
[9] Kanj MH, Wazni OM, Natale A. How to do circular mapping catheter guided pulmonary vein antrum isolation: the Cleveland Clinic approach. Heart Rhythm 2006;3:866–9.

[10] Becker AE. Left atrial isthmus: anatomic aspects relevant for linear catheter ablation procedures in humans. J Cardiovasc Electrophysiol 2004;15:809–12.
[11] Wittkampf FH, van Oosterhout MF, Loh P, et al. Where to draw the mitral isthmus line in catheter ablation of atrial fibrillation: histological analysis. Eur Heart J 2005;2:689–95.
[12] West JJ, Norton PT, Kramer CM, et al. Characterization of the mitral isthmus for atrial fibrillation ablation using intracardiac ultrasound from within the coronary sinus. Heart Rhythm 2008;5:19–27.
[13] Chiang SJ, Tsao HM, Wu MH, et al. Anatomic characteristics of the left atrial isthmus in patients with atrial fibrillation: lessons from computed tomographic images. J Cardiovasc Electrophysiol 2006;17:1274–8.
[14] Takahashi Y, Jais P, Hocini M, et al. Acute occlusion of the left circumflex coronary artery during mitral isthmus linear ablation. J Cardiovasc Electrophysiol 2005;16:1104–7.
[15] Hasdemir C, Yavuzgil O, Payzin S, et al. Angiographic analysis of the anatomic relation of coronary arteries to mitral and tricuspid annulus and implications for radiofrequency ablation. Am J Cardiol 2007;100:666–71.
[16] Matsuo S, Yamane T, Date T, et al. Completion of mitral isthmus ablation using a steerable sheath: prospective randomized comparison with a nonsteerable sheath. J Cardiovasc Electrophysiol 2011;22:1331–8.
[17] Sawhney N, Anand K, Robertson CE, et al. Recovery of mitral isthmus conduction leads to the development of macro-reentrant tachycardia after left atrial linear ablation for atrial fibrillation. Circ Arrhythm Electrophysiol 2011;4:832–7.
[18] Tzeis S, Luik A, Jilek C, et al. The modified anterior line: an alternative linear lesion in perimitral flutter. J Cardiovasc Electrophysiol 2010;21:665–70.
[19] Bai R, Di Biase L, Mohanty P, et al. Ablation of perimitral flutter following catheter ablation of atrial fibrillation: impact on outcomes from a randomized study (PROPOSE). J Cardiovasc Electrophysiol 2012;23:137–44.