Role of the left atrial appendage “stump” in persistent atrial fibrillation

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Introduction

The left atrial appendage (LAA) is an important source of localized ectopic triggers and reentrant atrial tachycardias in patients with atrial fibrillation (AF), particularly nonparoxysmal AF.[1] The arrhythmogenic role of the LAA “stump” after surgical LAA ligation has been increasingly explored. Herein, we report the role of catheter ablation in a patient with recurrent long-standing persistent AF (LSPAF) after LAA surgical ligation.

Case report

Our patient is an 80-year-old man with a history of severe coronary artery disease with surgical revascularization and multiple percutaneous coronary interventions, dilated ischemic cardiomyopathy (left ventricular ejection fraction of 30%, left ventricular end-diastolic diameter 5.8 cm), severe functional mitral regurgitation, and LSPAF with multiple failed electrical cardioversions. He received a dual-chamber implantable cardioverter-defibrillator for primary prevention of sudden cardiac death in 2010. In 2011, he underwent multivessel coronary artery bypass and mitral valve repair, at the same time a CryoMaze procedure (posterior wall and pulmonary vein isolation with mitral isthmus line and LAA ligation) was performed using staplers. Though he has a history of a gastrointestinal bleed related to an arteriovenous malformation, he has tolerated rivaroxaban for stroke risk reduction (CHA_2DS_2-Vasc score was 5, indicating a 7.2% stroke risk per year, with a HAS-BLED score of 3). He has had multiple prior admissions for decompensated heart failure in the setting of AF with rapid ventricular response, often requiring inotropic support along with external electrical cardioversions on each admission, albeit with very short-lasting sinus rhythm.

Despite aggressive guideline-directed medical therapy for heart failure, including high-dose beta-blockade, and amiodarone (for 3 years) for rhythm control, he now presented with progressive dyspnea and clinical hypervolemia in the setting of AF with rapid ventricular response. He underwent right heart catheterization, which showed significantly elevated right-side filling pressures as well as low cardiac output. He was aggressively diuresed via inotropic assistance with milrinone and eventually was stabilized. Subsequently, he was deemed an appropriate candidate for catheter ablation with the intention to minimize heart failure–related morbidity secondary to his AF.

The patient was brought to the electrophysiology laboratory. A 7F multielectrode catheter was looped along the crista terminalis and into the coronary sinus for pacing and recording. A 10F, 10 mHz SoundStar catheter (Biosense Webster, Irvine, CA) was placed in the right atrium through the left femoral vein for intracardiac echocardiography (ICE) guidance. Two transseptal atrial punctures were performed using fluoroscopic and ICE guidance. A multielectrode (PentaRay, Biosense Webster, Irvine, CA) catheter was advanced into the left atrium through an SL0 sheath. A 3-dimensional shell representing the left atrium and pulmonary veins was constructed using the CartoSound and electroanatomic mapping system. Voltage mapping of the left and right atria revealed diffuse low voltage, consistent with advanced and diffuse fibrosis, with reconnection of the left superior pulmonary vein (LSPV) and signals in the LAA stump. Left atrial ablation was performed in the posterior wall of the LSPV antrum (Figure 1). Both entrance and exit block were demonstrated via the PentaRay mapping catheter. The remaining pulmonary veins remained isolated from the prior maze procedure. Subsequently, the LAA stump was targeted for ablation. Because the LAA has a very thin wall and may be prone to perforation, LAA electrical isolation (LAAEI) is currently performed by delivering

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KEY TEACHING POINTS

- The left atrial appendage (LAA) is an important source of localized ectopic triggers and reentrant atrial tachycardias in patients with atrial fibrillation (AF).
- Preclinical models and surgical studies postulated that the LAA could potentially be electrically isolated by surgical epicardial clipping occlusion.
- The LAA "stump" has been shown to be a possible site of initiation of AF.
- Catheter ablation of the LAA stump after LAA surgical occlusion may be necessary to achieve freedom from AF.
- Ablation of the LAA stump appears to be feasible and safe despite the need for prolonged radiofrequency application.

radiofrequency (RF) energy at the level of the LAA ostium, which is considerably thicker. LAAEI was guided by ICE and 3-dimensional mapping systems using a PentaRay mapping catheter. To obtain electrical isolation in this structure, 18 minutes of high-power RF ablation were required. The RF settings during LAAEI included power up to 43 W while maintaining a catheter tip temperature of 42°C for a maximum of 30 seconds per ablation site. While we were isolating the LAA, AF terminated with restoration of sinus rhythm (Figure 2A, B). Complete LAA isolation was successfully achieved (Figure 2C–F). Both LAA entrance and exit block were demonstrated. Adenosine was administered with no evidence of dormant conduction in the LSPV or the LAA.

In the posterior wall we used low irrigation settings (2 mL/min) and temperature control mode (temperature 55°C and max power 25 W). Lesions performed on the posterior wall were delivered for up to 15 seconds. In the LAA, high-output pacing was performed prior to ablation to identify areas of phrenic nerve capture, which were avoided during ablation. The superior vena cava was noted to be silent. Given the strong desire for sinus rhythm maintenance owing to his recurrent heart failure, epicardial coronary sinus isolation was also performed.

After ablation, no AF or atrial flutter was inducible with atrial stimulation without isoproterenol infusion. No complications were encountered. Only a small portion of his right atrial wall had atrial activity before ablation and it is probably what is maintaining sinus rhythm (Figure 3A–C). The patient was diuresed an additional 20 pounds of water weight while maintaining sinus rhythm and was discharged home. He has remained euvolemic in sinus rhythm for 6 months, without hospitalization for decompensated heart failure.

Discussion

The LAA deserves special consideration when mapping and ablating patients with persistent AF and LSPAF. The arrhythmogenic role of the LAA was not well known until 2010, when our group initially reported on the prevalence of triggers firing from the LAA and the optimal strategy to eliminate these foci to increase the procedural success rate. Nine hundred eighty-seven consecutive patients underwent redo catheter ablation for AF (29% paroxysmal, 71% nonparoxysmal) in that study. All patients had demonstrated isolated pulmonary veins (PVs) after the initial ablation. The study revealed not only that 27% of patients had electrical firing from the LAA, but also that the LAA was the only source of arrhythmia in patients with no PV reconnection or other extra-PV trigger site (in 8.7%). More importantly, complete electrical isolation of the LAA showed an arrhythmia recurrence of only 15% at 12-month follow-up compared to 68% and 74% when focal ablation of LAA triggers or no ablation was performed, respectively.[1]

The results of the effect of empirical LAAEI on long-term procedural outcomes in patients with LSPAF undergoing catheter ablation (ie, the BELIEF trial) have been recently published.[2] This randomized controlled trial (RCT) study compared the ablation outcome in patients with LSPAF undergoing LAAEI in addition to our standard approach

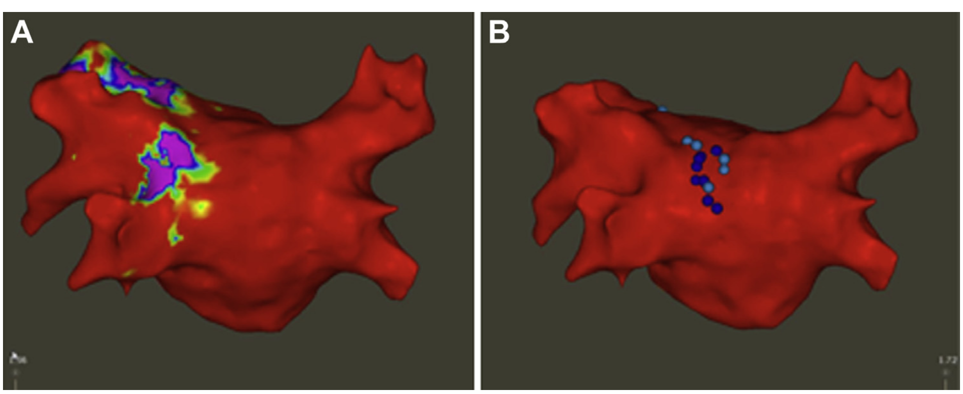

Figure 1 Electroanatomic voltage map of the left atrium. **A:** Bipolar map in posteroanterior view of the scar in the left atrium prior to isolation of the left superior pulmonary vein. **B:** Bipolar map in posteroanterior view of the scar in the left atrium after the left superior pulmonary vein was isolated.

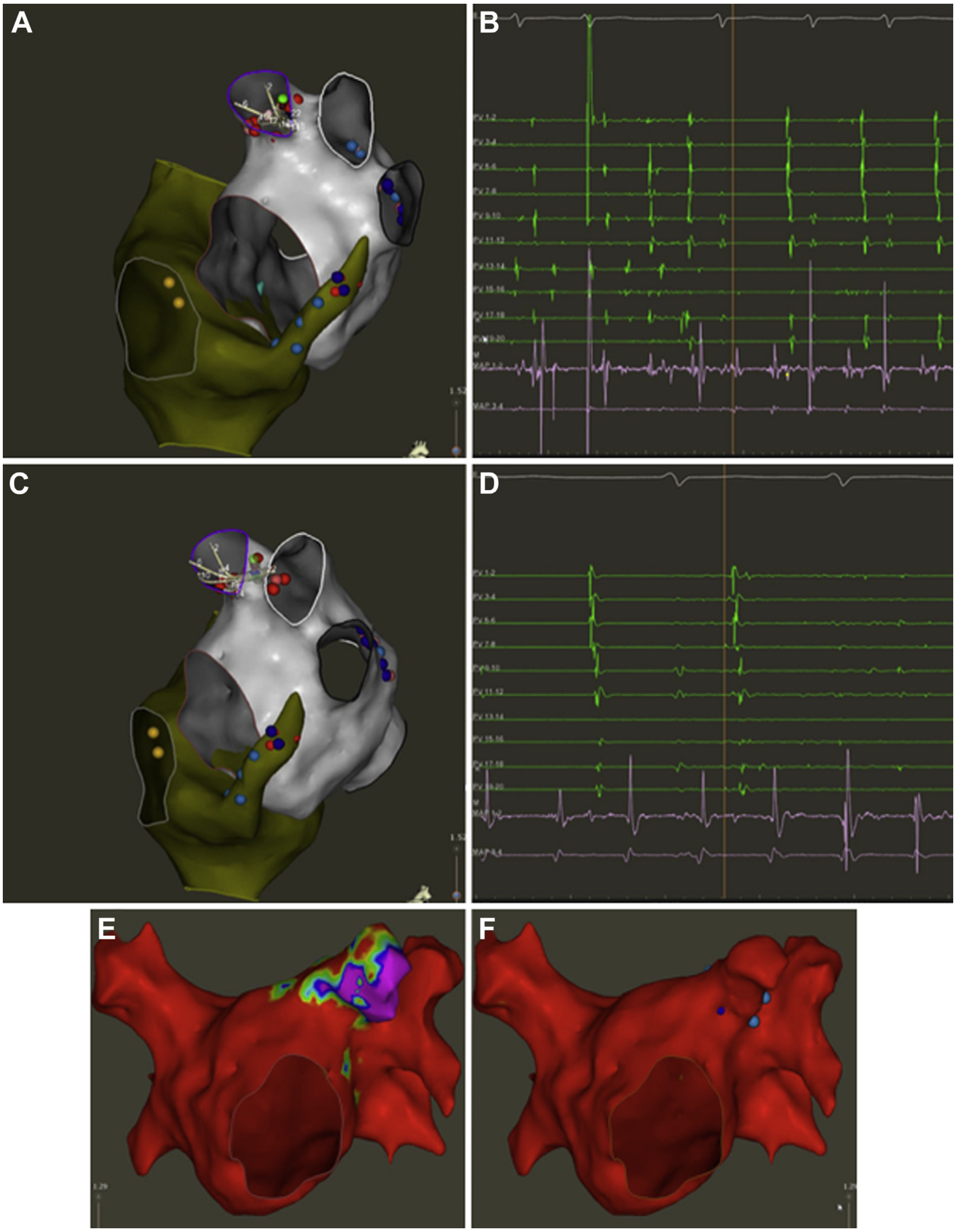

Figure 2 **A:** Electroanatomic mapping illustrating the right atrium superimposed to the left atrium showing the left atrial appendage (LAA). **B:** Radiofrequency application to the LAA "stump" achieving LAA isolation with subsequent atrial fibrillation termination and restoration of sinus rhythm. **C**, **D:** Electroanatomic mapping illustrating the right atrium superimposed to the left atrium illustrating complete LAA isolation. **E:** Bipolar map in anteroposterior view of the scar in the left atrium prior to isolation of the LAA. **F:** Bipolar map in anteroposterior view of the scar in the left atrium after successful LAA isolation.

(ie, PV isolation, posterior wall isolation, roof and anterior septum ablation, superior vena cava isolation, and non-PV triggers) vs our standard approach alone. At 12 months of follow-up, 56% in the group with LAAEI and 28% of patients in the control group were recurrence free after a single procedure (P = .001). With repeat procedures, cumulative success at 24-month follow-up was reported in 76% of patients who underwent LAAEI and 56% of patients in the control group (P = .003). This RCT demonstrated that after both first and redo procedures in patients with LSPAF, empiric LAAEI improved long-term freedom from atrial arrhythmias without increasing complications.[2]

Our findings in the BELIEF trial showing the critical role of the LAA were corroborated in a recent well-designed study by Yorgum and colleagues[3] using cryoablation (instead of RF) for empiric LAAEI, in which at the 12-month follow-up, 86% of patients in the LAAEI group and 67% of patients in the control group were free of atrial arrhythmias ($P < .001$).

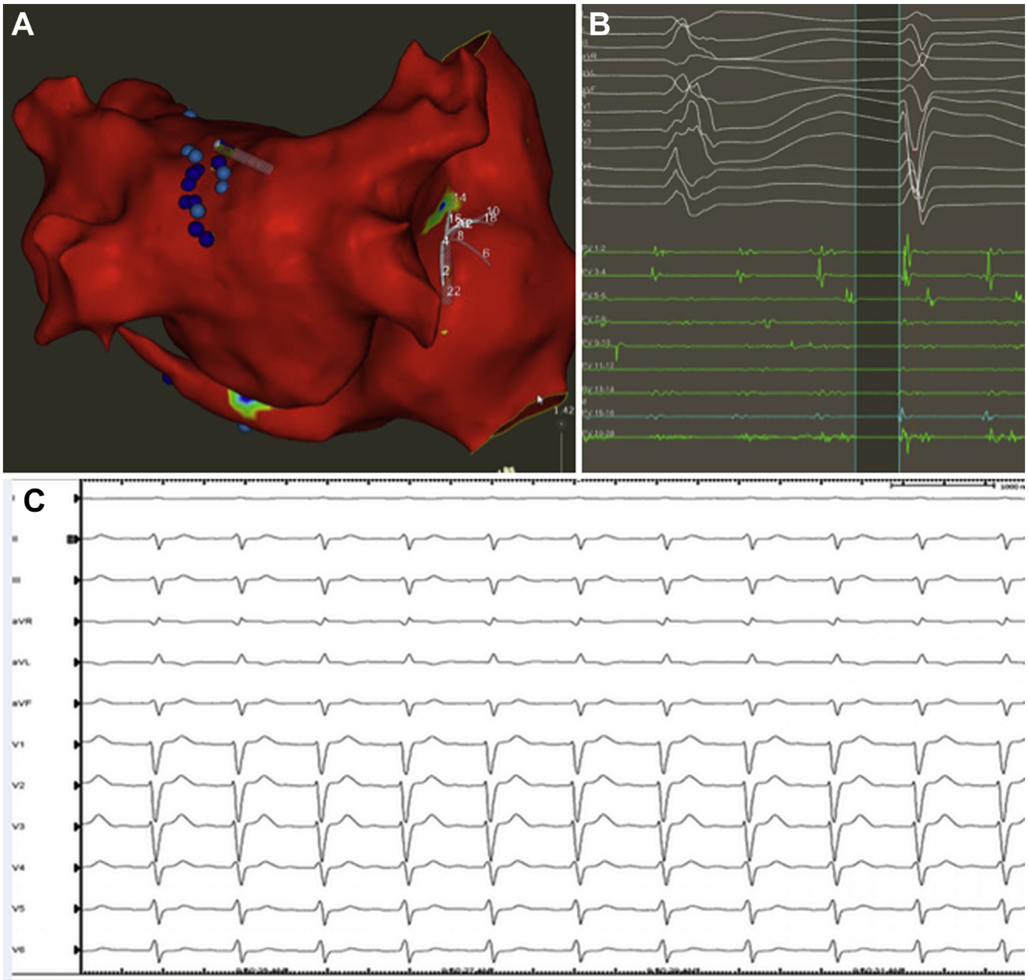

Figure 3 **A:** Electroanatomic mapping illustrating a PentaRay catheter visualized in the posteroanterior orientation on the posterior wall of the right atrium. **B:** Electrogram showing only area of the right atrium with signals maintaining sinus rhythm. **C:** Postprocedure electrocardiogram illustrating sinus rhythm.

Preclinical models and surgical studies postulated that the LAA could potentially be electrically isolated by surgical epicardial clipping occlusion. One group demonstrated complete electrical isolation of the LAA in 10 AF patients who underwent off-pump coronary artery bypass surgery with bilateral PVI and LAA clip occlusion.[4] Han and colleagues[5] studied 68 patients who underwent LAA ligation with the LARIAT (percutaneous epicardial LAA occlusion via a premade suture), with 94% of these patients achieving a reduction in LAA voltage and a third of these having complete elimination of LAA voltage.

Whether or not LAA ligation might play an important role in decreasing the AF burden was evaluated by the LAALA-AF registry.[6] Lakkireddy and colleagues[6] conducted a prospective observational study to estimate the benefit of concomitant LARIAT procedure when added to conventional ablation of persistent AF. After 1 ablation procedure, the primary outcome of freedom from AF at 1 year off antiarrhythmic therapy was higher in the LARIAT group (65% vs 39%; $P = .002$). More patients in the ablation-only group underwent repeat ablation because of AF recurrence (33% vs 16%; $P = .018$). The benefit of the LARIAT placement in addition to pulmonary vein isolation vs PVI alone is currently under investigation in the multicenter randomized aMAZE trial (LAA Ligation Adjunctive to PVI for Persistent or Longstanding Persistent Atrial Fibrillation; NCT02513797).

In our case, given that the patient underwent LAA ligation at the time of his coronary artery bypass surgery/mitral valve repair and maze procedure, one would expect that the ligated LAA would not be critical in the initiation and maintenance of AF. However, the reported evidence may suggest otherwise. Surgical LAA occlusion or excision has been performed as an alternative treatment option to prevent embolic strokes in patients undergoing cardiac surgery. In 1949 Madden achieved the first LAA excision in 2 patients with AF and rheumatic mitral valve disease. Thereafter, a randomized trial, the LAA occlusion study (LAAOS), was conducted in 77 patients to evaluate the safety and efficacy of occlusion at the time of elective coronary bypass graft surgery using sutures and staples. Complete occlusion was achieved overall in only 66% of the patients, with staples having a higher efficacy than sutures (72% vs 45%).[7] A meta-analysis of clinical trials demonstrated that most studies showed a mere 55%–66% occlusion rate using a variety of methods including stapling, ligation, and amputation. These studies demonstrate a significant limitation of the surgical approach for anatomic LAA occlusion, therefore a poor electrical isolation method. A prospective study in 2008 evaluated the success of several surgical LAA closure techniques by transesophageal echocardiography. In general, there was a high rate of failure (60%), with LAA excision being the most effective of the different techniques (73% success rate out of the successful LAA closures). Success rate for suture and stapler exclusion was 23% and 0%, respectively.[8]

In 2010, the Food and Drug Administration approved the AtriClip for stroke prevention in patients with AF undergoing open heart surgery. Yet, data on this device are scarce. Most of these patients are left with an LAA stump, which remains arrhythmogenic and may require endocardial electrical isolation.[9] Our case illustrates a patient with persistent AF with triggers originating at the stump of a previously ligated LAA. In 2010, our group published a small series suggesting that the LAA stump was a possible site of initiation of AF. Oftentimes, and particularly in patients with persistent AF and LSPAF undergoing a surgical maze, the LAA is excised or ligated with the creation of an LAA stump. The aim of our study was to report the prevalence of AF firing from the stump and the safety and feasibility of LAA stump ablation.[9] Fourteen patients underwent redo ablation for AF after a failed surgical ablation. Ablation of the LAA stump was performed if electrical firing was noted. Out of the 14 patients with previous LAA ligation, 11 demonstrated firing from the LAA stump (79%). The mean RF time for LAA stump ablation was 29 $\pm$ 7 minutes. At 12 months follow-up, 10 of the 11 patients with LAA stump ablation were in sinus rhythm on or off antiarrhythmic drugs.[9]

Conclusion

Catheter ablation of the LAA stump after LAA surgical occlusion may be necessary to achieve freedom from AF. Ablation of the LAA stump appears to be feasible and safe despite the need for prolonged RF applications. Randomized clinical studies evaluating the efficacy and the safety of AtriClip for this purpose are eagerly awaited.

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