Atrial fibrillation resulting from superior vena cava drivers addressed with cryoballoon ablation: Late reconnection at the site of phrenic nerve pacing catheter

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Introduction

Cryoballoon ablation is now an established approach for achieving pulmonary vein (PV) isolation, as part of the management of drug-refractory symptomatic atrial fibrillation (AF).[1] More recently, the technique has been utilized for successful isolation of the superior vena cava (SVC).[2–4] We present a case highlighting a potential pitfall affecting the durability of SVC isolation using the cryoballoon.

Case report

A 74-year-old man was referred for a PV isolation procedure for the management of paroxysmal AF. A Reveal XT (Medtronic, Minneapolis, MN) implantable cardiac monitor (ICM) had been inserted previously for investigation of syncope. Interrogation of this device showed episodes of AF (Figure 1A) and pauses of 4 seconds following AF termination, corresponding to episodes of presyncope. Echocardiography demonstrated a structurally normal heart.

A 28 mm Arctic Front Advance cryoballoon (Medtronic) and 20 mm Achieve mapping catheter (Medtronic) were used. The patient was in AF at baseline. Two 240-second cryoenergy applications were made to each of the 4 pulmonary veins, with electrical isolation confirmed using the Achieve catheter. Throughout this process, the AF appeared to organize, terminate, and then recommence following a period of atrial ectopy. Far-field signals with conduction into the atrium were observed with the Achieve catheter in the right superior pulmonary vein (RSPV), even following confirmation of RSPV isolation (Figure 2A).

KEYWORDS Atrial fibrillation; Catheter ablation; Cryoablation; Cryoballoon; Non–pulmonary vein foci; Superior vena cava
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Mapping showed that the initiating atrial ectopy originated within the SVC. A strategy of SVC isolation with the cryoballoon was therefore undertaken. An SVC venogram was performed prior to ablation. Phrenic nerve (PN) pacing was performed during cryoenergy applications, using a quadripolar catheter passed into the innominate vein from the femoral vein, with manual palpation of abdominal movement.

Three applications of cryoenergy were made at the SVC–right atrial (RA) junction (Figure 3A and B). The first application was made with intentional partial obstruction of SVC blood flow. This application was terminated at 57 seconds owing to a lack of efficacy. The following 2 applications were made with complete occlusion and were terminated at 84 and 142 seconds, respectively, using a "double stop" forced balloon deflation strategy, because of decreased diaphragmatic excursion, with prompt recovery of normal diaphragmatic contraction. Following these applications, SVC–RA entry and exit block was confirmed with pacing, and further, spontaneous independent electrical activity was noted within the SVC, not perturbing sinus rhythm (Figure 2B and C). An SVC venogram following these ablations showed no stenosis.

The patient was arrhythmia-free, as documented by the ICM, for 8 months postprocedure and had no further pauses or presyncope. However, the patient subsequently re-presented with recurrent paroxysmal AF (Figure 1A), and a repeat procedure was undertaken.

Three-dimensional electroanatomical mapping was performed using the CARTO 3 system (Biosense Webster, Diamond Bar, CA). A venogram revealed no stenosis of the SVC or SVC–RA junction. All 4 pulmonary veins remained isolated from the index procedure. The SVC had reconnected, with voltage and activation mapping tracing the site of reconnection to the anteromedial aspect of the SVC–RA junction (Figure 3C and D). This site appeared to correspond with the site of the quadripolar catheter utilized for phrenic pacing, which presumably prevented apposition between the

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KEY TEACHING POINTS

- Atrial fibrillation can occur solely driven by a superior vena cava driver, even when pulmonary vein isolation is present.
- Isolation of the superior vena cava with a standard 28 mm cryoballoon is safe and feasible as an adjunctive strategy to pulmonary vein isolation when it is identified as a source of drivers.
- Circumferential occlusion of the superior vena cava with the cryoballoon may be hindered by the presence of the pacing catheter used to monitor phrenic nerve function, and may confound the durability of superior vena cava isolation.

cryoballoon and SVC during the initial procedure. Ablation performed at this site led to reisolation of the SVC.

The patient had no documented recurrence of AF on the ICM (Figure 1B) and has clinically remained well.

Discussion

This case highlights the following features:

(1) a demonstration of AF solely driven by an SVC driver, without contribution of the pulmonary veins (demonstrated at the patient's second procedure);
(2) the safe use of a cryoballoon ablation method to achieve isolation of the SVC; and
(3) reconnection of SVC conduction at the site of the pacing catheter used for PN stimulation.

While PV isolation remains the mainstay in the invasive management of paroxysmal AF, non-PV foci have been recognized as potential triggers and predictors for recurrences.[5–7] Non-PV foci have been observed in up to 19.4% in a series of patients with paroxysmal AF.[6] Foci locations vary across cohorts, with patient ethnicity, geography, and provocation protocols appearing to influence distribution.[5–8] Identification and elimination of non-PV foci may represent appropriate ablation targets. Our patient had spontaneous ectopy and tachycardia arising from the SVC, established as a driver for his AF. The abolition of and subsequent freedom from AF, monitored on the ICM, correlated with the isolation, reconnection, and reisolation of the SVC.

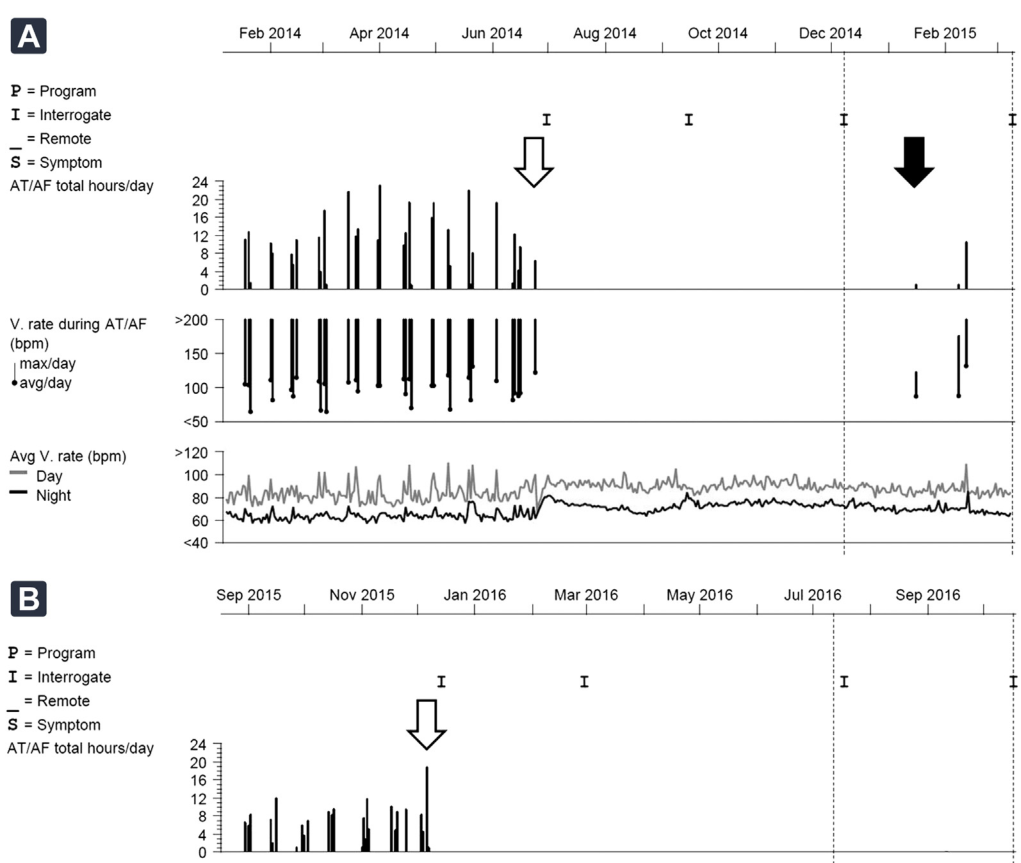

Figure 1 Chronological reports from the implantable cardiac monitor. **A:** Episodes of paroxysmal atrial fibrillation leading into the index procedure (*white arrow*), absence of detected tachyarrhythmias over the following 8 months, and subsequent recurrence of atrial arrhythmias (*black arrow*). **B:** Recurrence in the atrial arrhythmia burden and no further events following reisolation of the superior vena cava (*white arrow*). AT/AF = atrial tachycardia/atrial fibrillation; V. rate = ventricular rate.

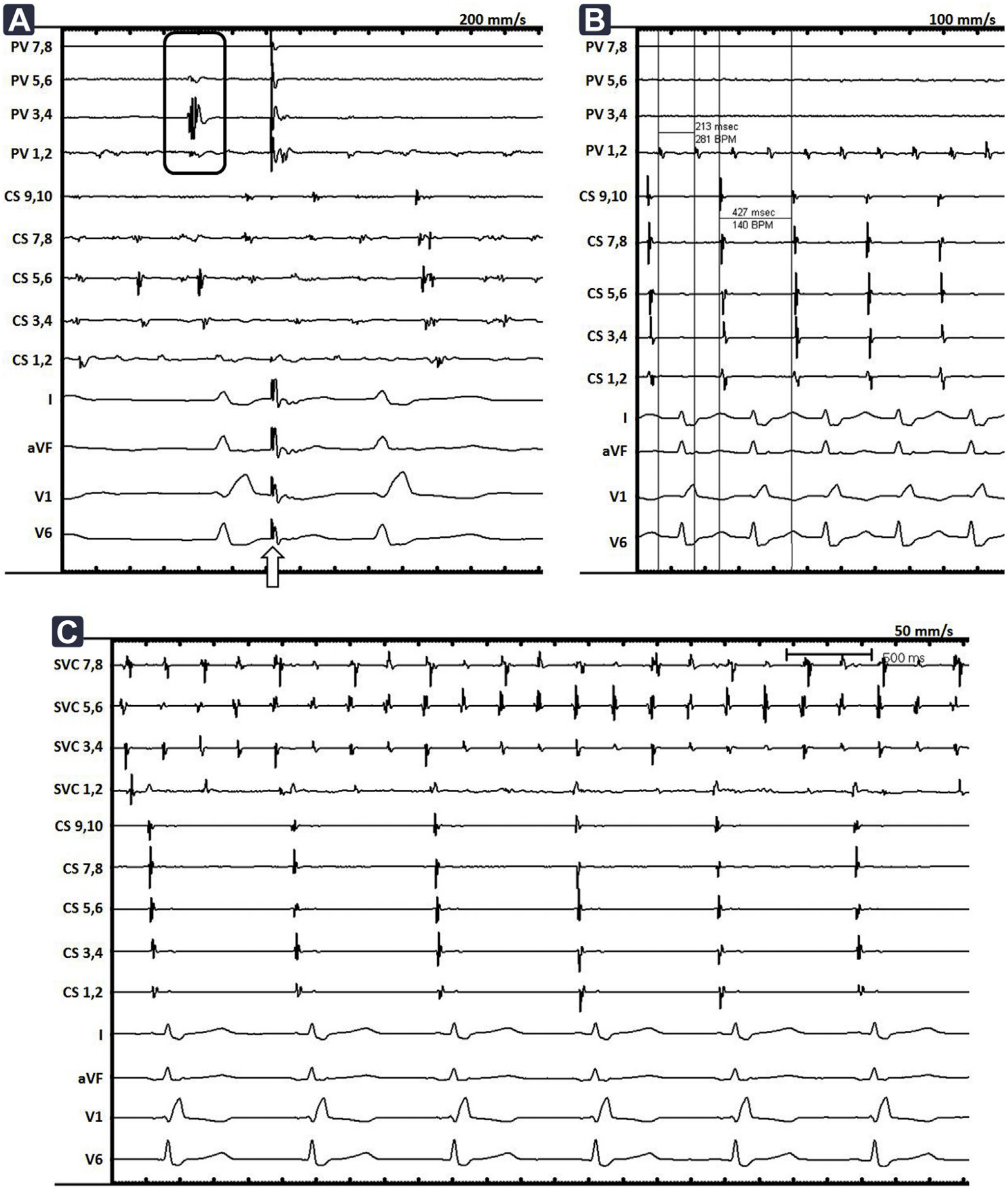

Figure 2 Intracardiac electrograms with the Achieve catheter (labeled PV [pulmonary vein] and SVC [superior vena cava] in the respective panels) and coronary sinus catheter (labeled CS). **A:** The Achieve catheter in the right superior pulmonary vein (RSPV), demonstrating spontaneous activity (*box*) while atrial fibrillation is seen on the CS catheter, reflecting electrical isolation. Low-amplitude activity is observable in the background, most prominently the distal electrodes of the RSPV, reflecting far-field signals from the SVC and appearing to organize at the end. Artefact from phrenic nerve pacing has been marked (*white arrow*). **B:** The Achieve catheter in the RSPV, as the tachycardia became organized, demonstrating apparent 2:1 conduction into the atria, following isolation of the vein. **C:** The Achieve catheter in the SVC postisolation, demonstrating independent rapid activity in the SVC, not perturbing rhythm in the atria or initiating atrial arrhythmias.

This case adds to the expanding literature supporting the safety and feasibility of the standard cryoballoon as an alternative to radiofrequency ablation for SVC isolation, when it is identified as a source of non-PV foci,[2–4] but also highlights a potential pitfall. PN injury has been reported as the most frequent complication of cryoballoon PV isolation,[9] and the risk is presumably greater when cryoenergy is delivered to the SVC, given its closer proximity to the right PN. PN pacing is hence of paramount importance if SVC isolation is attempted, and is performed using a catheter located in the right subclavian or innominate vein, usually via the femoral vein. Irrespective of modality chosen, close continuous monitoring of PN function should be employed to permit early detection of injury and immediate cessation of ablation if decreased diaphragmatic movement is detected. The technique of rapid cryoballoon deflation,[10] previously described at the PVs, was utilized to good effect, with preservation of PN function.

Although the pacing catheter is necessary as a safety measure, the presence of the pacing catheter itself ultimately appeared to hinder circumferential lesion formation around

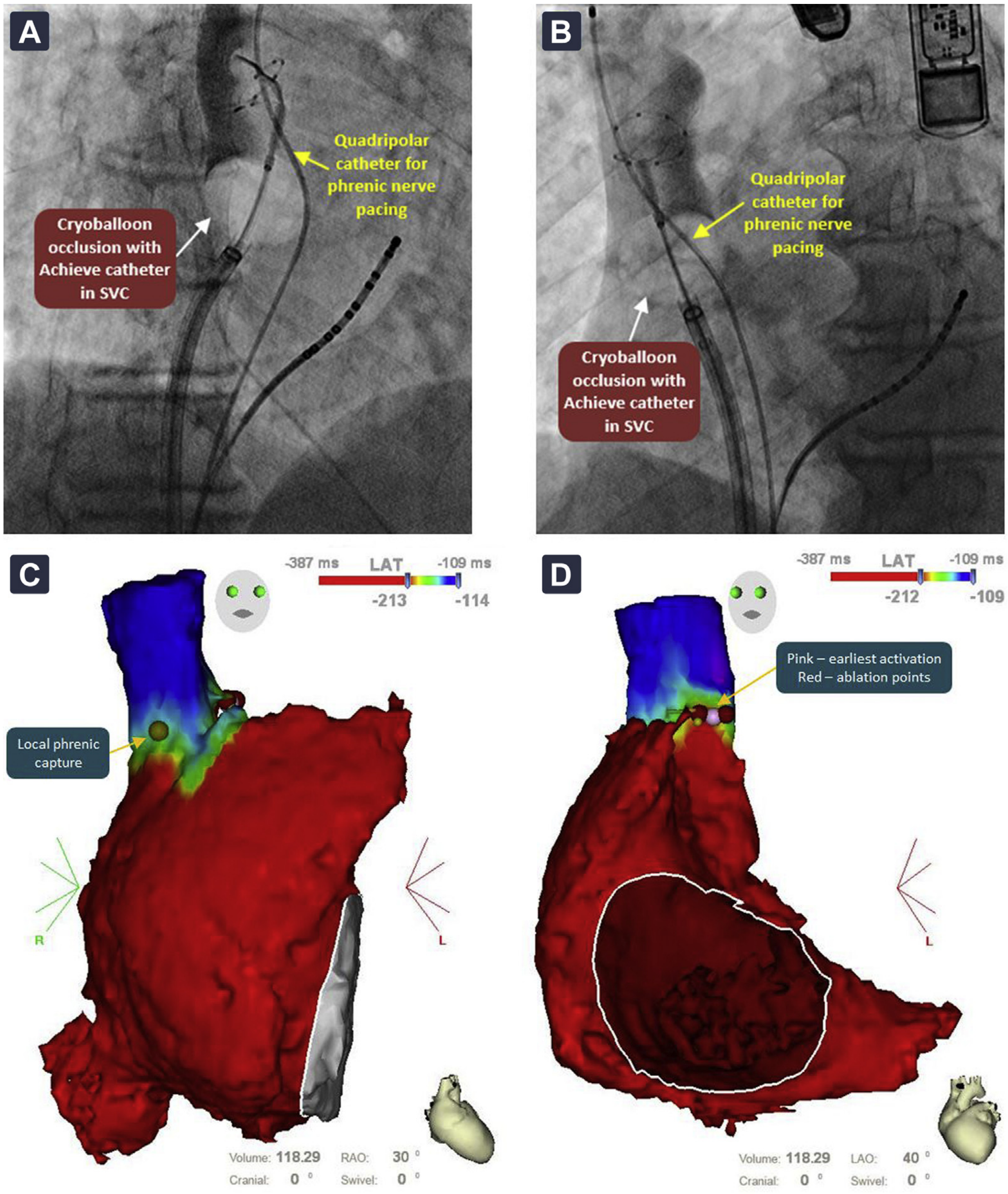

Figure 3 Fluoroscopic views demonstrating superior vena cava (SVC) occlusion and catheter positions: **A:** Right anterior oblique. **B:** Left anterior oblique. **C, D:** Corresponding views of CARTO 3 activation maps of the right atrium, with annotation of the sites of earliest activation (*white*), ablation (*red*), and phrenic capture (*yellow*): **C:** right anterior oblique; **D:** left anterior oblique.

the SVC–RA junction, with the reconnection site mapped during the second study matching the location of the pacing catheter at the index procedure. Potential approaches to circumvent this would include shifting the catheter position between freezes, if more than 1 is performed, or pacing from a superior point of access, such as the internal jugular vein.

Conclusion

Isolation of the SVC using the standard 28 mm cryoballoon is feasible and may be safely performed with vigilant monitoring of PN function, when SVC ectopy or tachycardia is identified as a trigger for AF. Durable SVC isolation may need incorporation of strategies to remove PN pacing catheter–related “malapposition” of the cryoballoon.

References

1. Kuck KH, Brugada J, Fürnkranz A, Metzner A, Ouyang F, Chun KJ, Elvan A, Arentz T, Bestehorn K, Pocock SJ, Albenque JP; FIRE AND ICE Investigators. Cryoballoon or radiofrequency ablation for paroxysmal atrial fibrillation. N Engl J Med 2016;374:2235–2245.
2. Sucu M, Aytemir K, Yorgun H. Innappropriate sinus tachycardia after superior vena cava isolation in addition to pulmonary veins isolatin of paroxysmal atrial fibrillation cryoballoon ablation. J Atr Fibrillation 2015;8:1270.
3. Gonna H, Domenichini G, Conti S, Gomes J, Raju H, Gallagher MM. Cryoballoon isolation of the superior vena cava. JACC Clin Electrophysiol 2016;2:529–531.
4. Canpolat U, Evranos B, Koçyiğit D, Yorgun H, Aytemir K. Electrical isolation of superior vena cava besides pulmonary vein isolation by cryoballoon technique in a young patient with persistent atrial fibrillation. Turk Kardiyol Dern Ars 2017;45:208.

5. Hayashi K, An Y, Nagashima M, Hiroshima K, Ohe M, Makihara Y, Yamashita K, Yamazato S, Fukunaga M, Sonoda K, Ando K. Importance of nonpulmonary vein foci in catheter ablation for paroxysmal atrial fibrillation. Heart Rhythm 2015;12:1918–1924.
6. Santangeli P, Marchlinski FE. Techniques for the provocation, localization, and ablation of non–pulmonary vein triggers for atrial fibrillation. Heart Rhythm 2017;14:1087–1096.
7. Hojo R, Fukamizu S, Kitamura T, Aomyama Y, Nishizaki M, Kobayashi Y, Sakurada H, Hiraoka M. Development of nonpulmonary vein foci increases risk of atrial fibrillation recurrence after pulmonary vein isolation. JACC Clin Electrophysiol 2017;3:547–555.
8. Elayi CS, Biase L, Bai R, Burkhardt JD, Mohanty P, Santangeli P, Sanchez J, Hongo R, Gallinghouse GJ, Horton R, Bailey S. Administration of isoproterenol and adenosine to guide supplemental ablation after pulmonary vein antrum isolation. J Cardiovasc Electrophysiol 2013;24:1199–1206.
9. Guhl EN, Siddoway D, Adelstein E, Bazaz R, Mendenhall GS, Nemec J, Saba S, Schwartzman D, Voigt A, Wang NC, Jain SK. Incidence and predictors of complications during cryoballoon pulmonary vein isolation for atrial fibrillation. J Am Heart Assoc 2016;5:e003724.
10. Ghosh J, Sepahpour A, Chan KH, Singarayar S, McGuire MA. Immediate balloon deflation for prevention of persistent phrenic nerve palsy during pulmonary vein isolation by balloon cryoablation. Heart Rhythm 2013;10:646–652.