Video-assisted thoracoscopic surgery to displace the phrenic nerve during endocardial ablation of right atrial tachycardia

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Introduction

Catheter ablation is an effective treatment for symptomatic focal atrial tachycardia (AT).[1] Owing to its proximity to the anterolateral junction between the superior vena cava and right atrium (RA), collateral injury to the phrenic nerve is a rare but potential complication associated with ablation targeting this area. Collateral damage is most often seen during cryoballoon ablation of atrial fibrillation (AF) (3%–6%) but has also been reported during AT radiofrequency ablation (~1%).[2] Epicardial catheter manipulation and balloon inflation have been used to displace the phrenic nerve, but high complication rates have been reported.[3] Here we report a 44-year-old woman with intractable palpitations owing to AT located directly over the right phrenic nerve, in whom video-assisted thoracoscopy to displace the phrenic nerve during ablation enabled curative therapy with no significant complications.

Case report

A 44-year-old woman with a family history of sudden cardiac death attributable to hypertrophic cardiomyopathy, a personal history of cardiomyopathy, nonsustained ventricular tachycardia, subcutaneous implantable cardioverter-defibrillator for primary prevention of sudden death, and double aortic arch was referred for catheter ablation of recurrent AT causing frequent palpitations, dizziness, and near-syncope despite antiarrhythmic drug therapy with sotalol. Her electrocardiogram showed sinus rhythm with frequent premature atrial complexes (PACs) (Figure 1). Patch monitoring showed a 15% PAC burden and 5133 episodes of AT over a period of nearly 13 days. The longest episode was 27 seconds and correlated with her symptoms. Echocardiogram showed normal left ventricular wall thickness but a mildly reduced ejection fraction (51%) with diffuse hypokinesis. Stress echocardiogram showed no evidence of ischemia.

First electrophysiological study

A duodecapolar catheter was advanced transvenously to the distal coronary sinus with proximal poles in the mid/high RA, and a quadripolar catheter was placed in the His position. No sustained AT was observed spontaneously or by pacing. Spontaneous PACs were frequent, however. Activation mapping revealed that the most frequent morphology was located in the posteriorlateral RA. High output pacing at this region caused phrenic nerve stimulation. Less frequent PAC morphologies were also noted to be very close to the phrenic nerve outline (Figure 2). Therefore, ablation was deferred at the time.

Novel hybrid procedure for phrenic nerve displacement

A repeat endomyocardial catheter ablation attempt was performed 12 weeks later, combined with a video-assisted thoracic surgery (VATS) approach under general anesthesia. The patient had a relatively anteriorly displaced phrenic nerve that was densely adherent to the RA. An initial 10-mm incision was made in the fourth intercostal space along the anterior axillary line. Blunt dissection was carried down the chest wall and the chest was entered bluntly with a digit. Digital sweep revealed no adherent lung. A 12-mm trocar was then placed into this incision and the thoracoscopic camera was inserted to verify appropriate placement. The lung was then insufflated with carbon dioxide. A second 12-mm trocar was placed in the sixth intercostal space along the anterior axillary line. A 5-mm trocar was placed in the midclavicular line along the second intercostal space. The pericardium was then lifted and a pericardiotomy was made 2 cm anterior to the phrenic nerve. This was extended inferiorly and superiorly with Bovie cautery (Figure 3A). A silk suture was then placed in the midpoint of the pericardium and externalized through the chest wall. Gentle traction on the suture was able to displace the lateral pericardial wall (Figure 3B).

The lung was again insufflated and the suture was released to allow us to perform activation mapping, after which we

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KEY TEACHING POINTS

- Pacing prior to ablation in the atrium for atrial tachycardia can identify areas of phrenic nerve stimulation that require alternative ablation strategies.
- Existing methods to displace the phrenic nerve carry high rates of complications.
- Video-assisted thoracic surgery–guided phrenic nerve displacement is a feasible method to safely perform ablation when there is phrenic nerve stimulation at the arrhythmia focus.

confirmed the absence of stimulation of the phrenic nerve with high output pacing.

The patient remained in sinus rhythm during the electrophysiological study, with no inducible sustained tachycardia. Activation mapping of the frequent monomorphic PACs again revealed the site of earliest activation in the low posterior-lateral RA. After deflation of the right lung and placing of traction on the sutures, absence of phrenic nerve stimulation with high output pacing was confirmed at the site of earliest right atrial activation (Supplemental Movie 1). Radiofrequency ablation using an irrigated-tip catheter with a 60-second lesion at 40 watts was delivered at the site of earliest activation. After the first lesion and for the remainder of the case, no further PACs were observed. Additional lesions were delivered in a rosette surrounding the earliest site in the posterior-lateral RA (Supplemental Figure 1). Following completion of the atrial ablation, the pericardium was reapproximated with interrupted silk sutures and a 24 French Blake drain was placed through the inferior trocar.

The patient tolerated the procedure well, with no complications during or after intervention. Pain was controlled with oral medication. She was discharged 48 hours after the procedure and remained symptom free, off antiarrhythmic medications, on a 3-month follow-up assessment.

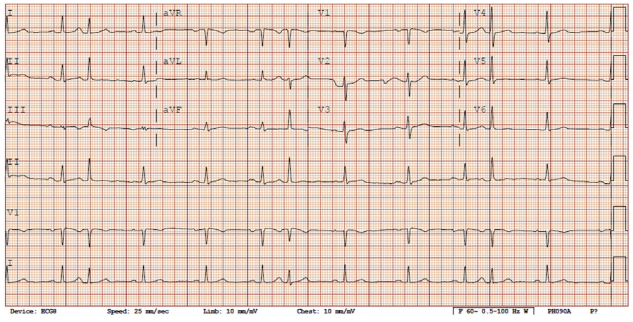

Figure 1 Electrocardiogram showing normal sinus rhythm with an average ventricular rate of 63 beats per minute. Multiple premature atrial complexes were observed.

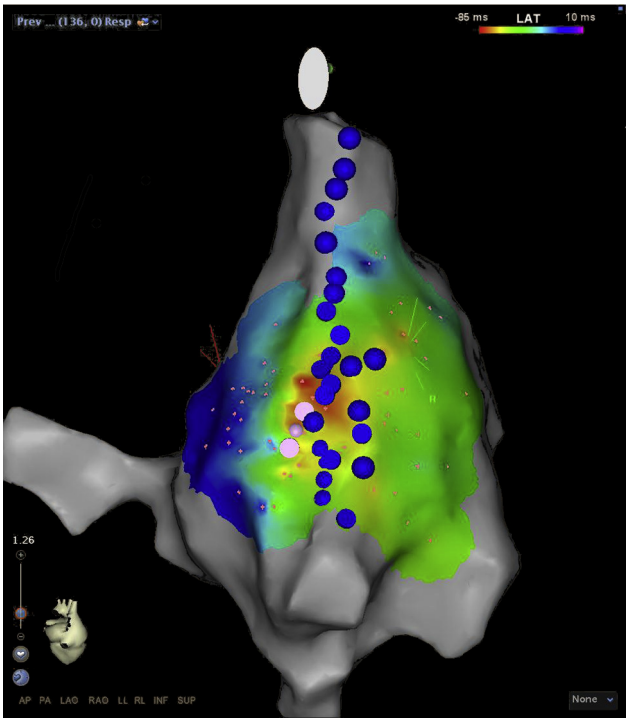

Figure 2 Electroanatomical activation mapping showing the sites of earliest activation during premature atrial contractions. The phrenic nerve capture area is also highlighted (*blue circles*), clearly overlapping the target ablation area.

Repeat patch monitoring showed underlying sinus rhythm with only rare PACs (<1.0%) and no episodes of AT over a 14-day period.

Discussion

Phrenic nerve injury remains a rare complication of right-sided ablation (AT/AF), with the majority of cases resolving within 12 months.[2,4] Nevertheless, phrenic injury may persist in 33% of patients and may be associated with significant morbidity.[3] The reported 7%–19% incidence of phrenic nerve injury with second-generation cryoballoon for the treatment of AF has raised concerns about this issue.[5,6]

When the area targeted for ablation overlaps the zone of phrenic nerve capture, several nonsurgical approaches have been proposed to displace the nerve and allow ablation.[7,8] These include epicardial catheter manipulation and balloon inflation. However, these techniques are limited by a high rate of complications, including pericardial bleeding,[3] and safer approaches are needed.

To the best of our knowledge, this is the first report of a hybrid VATS-guided phrenic nerve displacement procedure combined with an endomyocardial atrial arrhythmia ablation. This novel hybrid approach enabled dynamic movement of the phrenic nerve as the ablation zone was fine-mapped, and enabled successful therapy with no immediate complications. As hybrid surgical and endocardial ablation approaches become more commonly performed, VATS-mediated displacement will become more accessible. Although several studies have shown that a hybrid approach

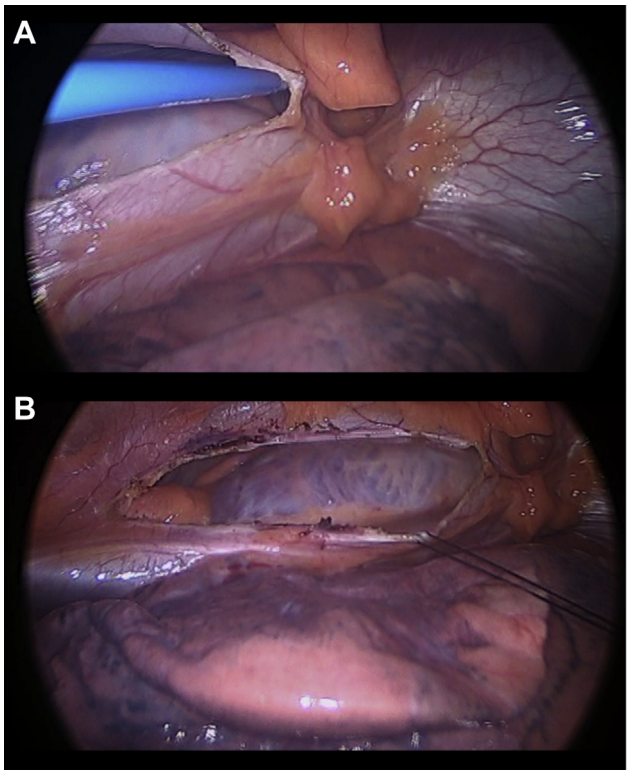

Figure 3 **A:** Pericardiotomy extended inferiorly and superiorly with the Bovie cautery. **B:** Placement of a silk suture in the mid point of the incised pericardium, which was externalized through the chest wall. Gentle traction on the suture was able to retract the lateral pericardial wall.

combining VATS epicardial and catheter endocardial ablation of AF is feasible and improves outcomes[9]—especially for nonparoxysmal patients and those with a dilated left atrium—this combined technique has rarely been reported for the treatment of other arrhythmias.

Furthermore, a left-sided approach can be performed as well. However, the phrenic nerve is significantly more anterior on that side and rarely overlaps the left atrium proper. Typically, the only area where it is close is within the left atrial appendage.

Conclusion

VATS-mediated displacement of the phrenic nerve is a feasible method to displace the right phrenic nerve and enable ablation of nearby cardiac structures.

Appendix

Supplementary Data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2018.03.011.

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