Necessary equipment and techniques

Balloon protection of the left phrenic nerve during epicardial catheter ablation of ventricular tachycardia

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Summary

During epicardial radiofrequency ablation procedures for ventricular tachycardia the proximity to the left phrenic nerve may limit or even prohibit ablation of the arrhythmia, especially in the lateral segments of the left ventricle. We report a case of successful epicardial ventricular tachycardia ablation with balloon-protection of the phrenic nerve and discuss necessary equipment and techniques.

Clinical case

A 47-year-old male patient with non-ischaemic dilated cardiomyopathy – presumably post-myocarditis – and a left ventricular ejection fraction of 35% had recurrent monomorphic ventricular tachycardia (VT) prompting adequate implantable cardioverter defibrillator (ICD) shocks. He underwent an acutely successful endocardial radiofrequency ablation via a transseptal approach. Two years later, the patient presented with electrical storm and multiple adequate shocks. Emergent endo- and epicardial ablation was performed. A 3D electroanatomical map (CARTO 3, Biosense Webster, Diamond Barr CA, USA) of the epicardium was acquired and showed extensive patchy epicardial scaring in several segments. VT circuits could be located over the lateral wall of the left ventricle. The course of the left phrenic nerve was tracked by high-output pacing from the ablation catheter (10V/2ms) and marked on the 3D electroanatomical map. As shown in figure 1, the phrenic nerve was running through the scar. Nerve sparing

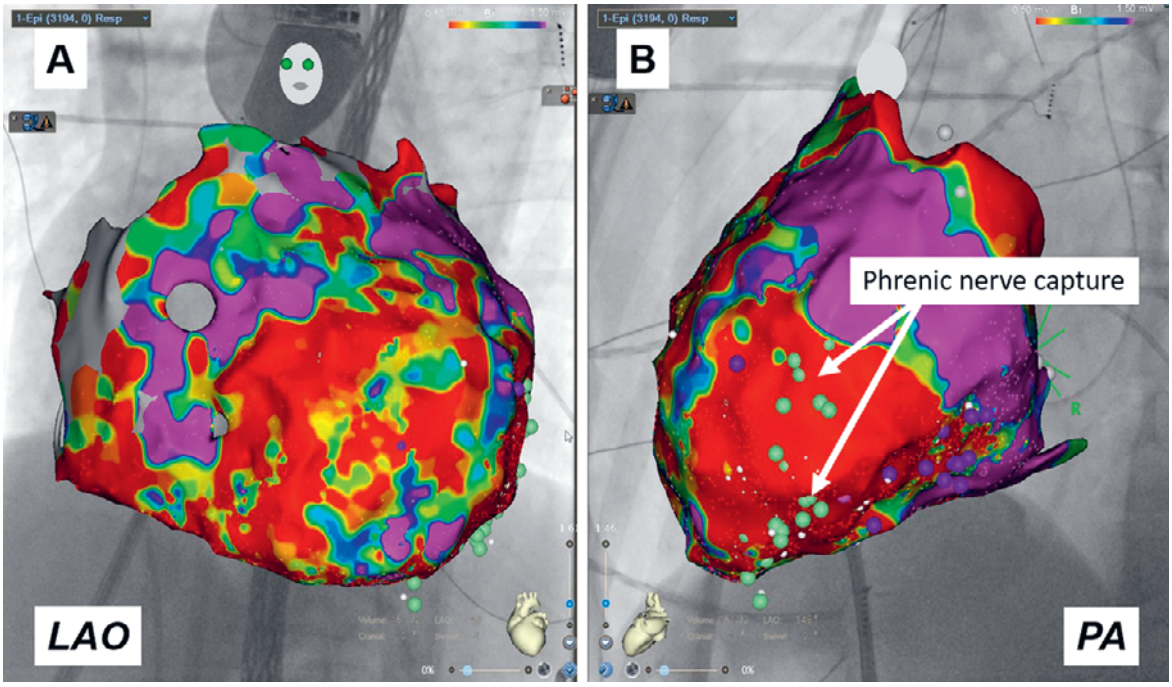

Figure 1: Panel **A** shows a left anterior-oblique view and panel **B** shows a posterior-anterior view of the 3D electroanatomical voltage map of the epicardium. Bipolar voltage is colour-coded with purple indicating normal voltage (>1.5 mV) and red indicating dense scar (<0.5 mV). The green dots represent areas of phrenic nerve capture by high-output pacing from the epicardial ablation catheter.

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epicardial ablation – adjacent to areas where the phrenic nerve was captured – was performed, but the course of the phrenic nerve prohibited ablation in a large area, presumably harbouring relevant arrhythmogenic substrate. At the end of the procedure methylprednisolone 40 mg was infused into the pericardial space to limit the inflammatory response.

Two months later the patient again presented with recurrent monomorphic VT and adequate ICD shocks. A second epicardial ablation procedure was performed. The pericardial space was accessed via subxyphoidal puncture. The access was subsequently double wired to allow for insertion of two 8.5F/40cm steerable sheets (Agilis EPI Steerable Introducer Dual-Reach, Abbott, Chicago IL, USA) into the pericardial space through the same epicardial puncture site. A 3D electroanatomical map of the pericardium was acquired (CARTO 3, BiosenseWebster, DiamondBarr CA, USA). Target areas for ablation were identified. The course of the left phrenic nerve was tracked with high-output pacing (10V/2ms) from the ablation catheter and marked on the 3D mapping system. The course of the left coronary artery was known from the prior procedure and distant from the target area. A vascular balloon (VACS II Valvuloplastiekatheter 20.0/40 mm, Osypka AG, Rheinfelden, Germany) was advanced into the pericardial space over a regular guidewire (EmeraldFD J-Curve, Cordis, Santa Clara CA, USA) through the second steerable sheet and positioned between the ablation catheter and the phrenic nerve. The balloon was inflated with diluted contrast medium (fig. 2).

Before ablation in the vicinity of the phrenic nerve, successful displacement of the nerve by the balloon was confirmed by absent phrenic nerve capture capture when pacing with high output from the ablation catheter at the planned ablation site. Otherwise, the vascular balloon was deflated, replaced and reinflated. With this strategy, radiofrequency ablation of the complete epicardial target area was safely possible. No VT was inducible with programmed stimulation at the end of the procedure.

More than 1year after the ablation, the patient has remained free of VT and ICD interventions.

Discussion

In patients with non-ischaemic dilated cardiomyopathy presenting with VT, the arrhythmogenic substrate is frequently located on the epicardial aspect of the left ventricular myocardium. Epicardial mapping and ablation is therefore often necessary. Typical locations of epicardial VT substrate include the lateral wall of the left ventricle where the left phrenic nerve usually runs from basal superior to apical inferior. An anterior course of the left phrenic nerve is less common [1].

Radiofrequency ablation close to the phrenic nerve may lead to irreversible nerve palsy. The proximity of the left phrenic nerve may therefore limit epicardial

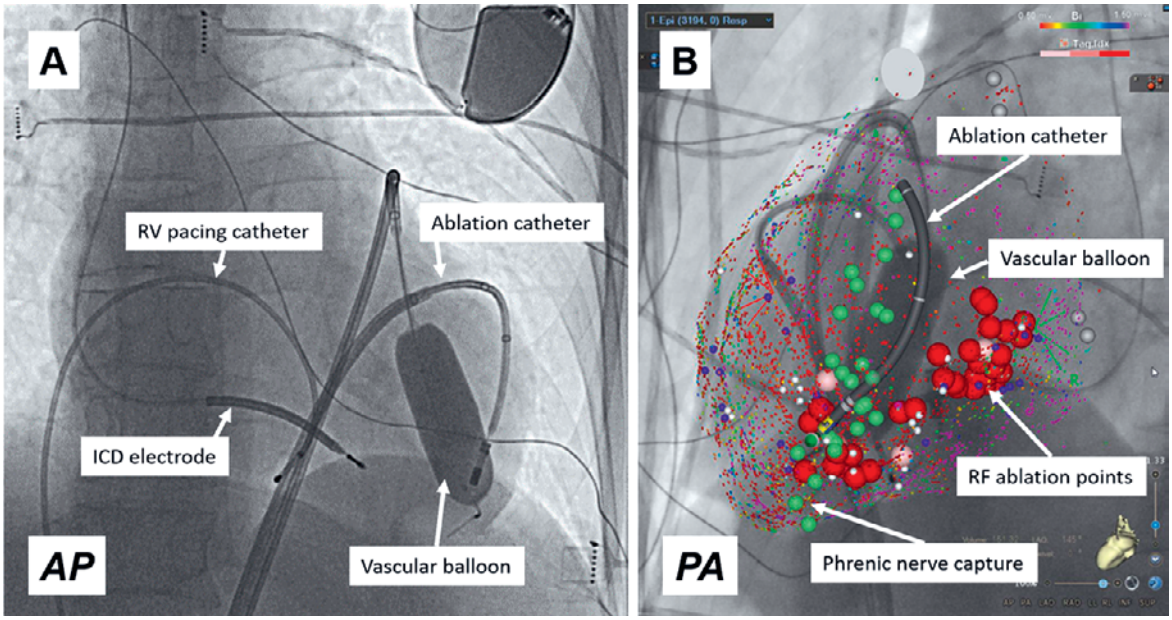

Figure 2: Panel **A** shows a fluoroscopic anterio-posterior view with the vascular balloon positioned in the epicardial space through a steerable sheath. Panel **B** shows electroanatomical mapping points merged with a fluoroscopic posterior-anterior view. The green dots indicate the course of the phrenic nerve. The vascular balloon is positioned parallel to the phrenic nerve. Red dots indicate radiofrequency (RF) ablation points.

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radiofrequency ablation in this area [2]. Several techniques to protect the phrenic nerve have been described and include infusion of saline or air into the pericardial space, surgical ablation and displacement of the nerve with small or large vascular balloons [3–5]. A small study suggested that balloon protection using a large balloon (20 mm) is associated with better short-term results than nerve sparing ablation either without protection or with balloon protection with small balloons (6 mm) [5]. Another small series investigated the introduction of saline, air or a combination of saline and air until phrenic nerve capture is lost or the blood pressure drops. The authors suggest that balloon protection of the left phrenic nerve was less effective than an air/saline combination method. They stated that the placement of a large balloon for left phrenic nerve protection in the appropriate location was challenging. Importantly, the balloon was introduced into the epicardial space via a short, non-steerable sheath in this study [3]. In our case, the use of a second steerable sheath made balloon positioning parallel to the course of the phrenic nerve easy. The use of a large balloon allowed displacement of the phrenic nerve over a relatively large area. The balloon did not need to be positioned exactly between the nerve and the catheter, and radiofreuency ablation could be performed at multiple locations without moving the balloon. Operators must be vigilant for haemodynamic compromise after balloon inflation. In this case we did not observe any relevant haemodynamic response.

Regarding the alternative of air insufflation, there is concern that this may lead to an increase in the defibrillation threshold. Saline infusion, on the other hand, may compromise haemodynamics. Therefore, both methods, in our opinion, are considered less suitable for VT ablation. Prior to each radiofrequency application sufficient separation of the cardiac (visceral) epicardium from the phrenic nerve needs to be verified by high-output pacing from the ablation catheter. Because epicardial ablation procedures are most often performed under general anaesthesia, anaesthesiologists need to be aware of the need for identification of the phrenic nerve by pacing and should therefore avoid pharmacological muscle relaxants during this part of the procedure.

Conclusions

Epicardial VT ablation beneath the left phrenic nerve with nerve protection by a large vascular balloon is feasible and safe. The use of an additional steerable epicardial sheath facilitates balloon positioning.

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Disclosure statement
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