Direct subxiphoid pericardioscopic visualization of epicardial ventricular tachycardia mapping and ablation

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Background
Patients with previously failed endocardial ablation, nonischemic cardiomyopathy such as arrhythmogenic right ventricular cardiomyopathy and healed myocarditis, and limited access to the endocardium often necessitate epicardial mapping. However, prior cardiac surgery frequently limits epicardial mapping owing to the presence of adhesions, necessitating the use of a surgical subxiphoid window for epicardial mapping and ablation. However, complete access and exposure is most often limited and significant complications may arise from blind adhesiolysis.

Hybrid surgical procedures with a combined or sequential endocardial and epicardial ablation procedure have been developed for atrial fibrillation. Via transabdominal and subxiphoid epicardial access, the procedure uses a pericardioscopic cannula and a linear vacuum-assisted unipolar radiofrequency (RF) ablation catheter for ablation on the epicardial surface. A novel use of a pericardioscopic hybrid approach for epicardial mapping and ablation of scar-related ventricular tachycardia (VT) is described in this report.

Methods
The patients described required epicardial access for VT ablation given previous history of cardiac surgery (n = 2) or postinflammatory (n = 1) epicardial adhesions. In collaboration with our cardiac surgical team, a subxiphoid window was created for all patients. A pericardioscopic cannula (Atricure, Mason, Ohio) was used in conjunction with an endoscope to visualize and blunt dissect the epicardial space. Via transabdominal and subxiphoid epicardial access, the procedure uses a pericardioscopic cannula and a linear vacuum-assisted unipolar radiofrequency (RF) ablation catheter for ablation on the epicardial surface. A novel use of a pericardioscopic hybrid approach for epicardial mapping and ablation of scar-related ventricular tachycardia (VT) is described in this report.

Results
Direct visualization of the epicardium within the pericardial space was achieved in 3 patients with high-density electroanatomic mapping (EnSite; Abbott, Abbott Park, IL) of the substrate and VT circuit activation. In all patients, blunt dissection of adhesions was performed successfully, guided by the pericardioscopic cannula and endoscope. Epicardial ablation was not performed using the vacuum-assisted linear ablation tool in 2 cases, owing to (1) focal breakout epicardial activation pattern and (2) proximity to posterior descending artery (PDA) and posterior left ventricular artery. In patient 2, use of the vacuum-assisted linear ablation tool underneath the phrenic nerve resulted in termination within the epicardial isthmus upon application of suction prior to ablation. RF was subsequently applied, and the lesions were confirmed visually in regions of scar using the pericardioscopic cannula and endoscope.

Case 1
A 66-year-old man with history of inferior infarction, 5-vessel coronary artery bypass grafting, ejection fraction (EF) 15%, and VT status post ablation at an outside hospital was presented with recurrent VT and implantable cardioverter-defibrillator shocks. The patient continued to have VT despite amiodarone, sotalol, and mexiletine. He was taken for a combined endocardial/epicardial VT ablation. After a subxiphoid surgical window was created, the epicardium was mapped and accessed with the assistance of a pericardioscopic cannula. Blunt dissection of adhesions was performed under pericardioscopic visualization. Mapping of the patient’s clinical VT demonstrated a focal epicardial breakout pattern. The endocardium of the left ventricle (LV) was mapped, and a total of 8 VTs were targeted. The patient was treated with extensive endocardial and epicardial ablation.
using a standard ablation catheter (FlexAbility; Abbott) on the inferior wall of the LV, which rendered him noninducible.

Case 2
A 72-year-old man with prior inferoapical infarction, 3-vessel coronary artery bypass grafting, EF 25%, VT status post 2 endocardial ablations presented from an outside hospital for implantable cardioverter-defibrillator shocks. A subxiphoid surgical window was created and the epicardial surface was navigated via a pericardioscopic approach. Three VTs were mapped with a linear multielectrode catheter (Livewire, 2-2-2; Abbott). The third VT was induced during high output pacing (10 mA, 2 ms) for phrenic nerve localization from the epicardial surface. It was mapped to a midapical inferior surface of the LV. The vacuum-assisted RF ablation device (Epi-Sense; Atricure) was used to ablate the epicardium with the aid of the distal and proximal sensing electrodes to prevent phrenic nerve injury, as the helical ablation coils face the heart and the side in contact with the pericardium is insulative covering (Figure 1, Supplemental Figure 1). At the initiation of suction from the ablation device for the first RF application, the VT terminated. Ablation was subsequently performed on the epicardial surface (30 W, 90 seconds) overlying the entire mapped epicardial isthmus region (5 applications) and lesions were verified (Figure 1). The other 2 VTs were proven to have a shared isthmus with both epicardial and endocardial components (3-D circuitry) and a midmyocardial exit in the apical inferior wall of the LV. The patient was rendered noninducible at the end of the procedure.

Case 3
A 65-year-old man with history of nonischemic cardiomyopathy, EF 45%, presented as an outpatient for VT ablation. The patient received 10 shocks after a prior VT ablation and frequent antitachycardia pacing, with VT suspected to be epicardial owing to the focal endocardial breakout pattern observed. He was refractory to amiodarone and an initial attempt at percutaneous access was aborted owing to extensive epicardial adhesions consistent with prior myopericarditis. One month later, a subxiphoid surgical window was obtained and epicardial mapping was guided via pericardioscopic approach. Severe adhesions were confirmed, limiting exposure and movement of the mapping catheter. The combination of the pericardioscopic cannula, endoscope, blunt
dissection with a flexible 22F Yankauer suction instrument (Argyle; Covidien, Mexico), and mapping catheter (Pointwire, 2-2-2) enabled significantly greater exposure beyond a thick adhesion band toward the inferolateral wall up the mitral annulus. One VT was induced and the mapping demonstrated focal breakout from both endocardial and epicardial surfaces, consistent with a midmyocardial VT. A coronary angiogram was performed and demonstrated the vacuum-assisted linear ablation tool (Epi-Sense) was within 5 mm of the posterior left ventricular artery and PDA. This precluded the use of the larger-footprint (3 cm) surgical ablation tool (Figure 2). The VT was terminated from the endocardial surface. Consolidative lesions were made on the epicardial surface with a standard 4-mm-tip irrigated ablation catheter (FlexAbility; Abbott, Abbott Park, IL) in regions 5 mm from the PDA. After ablation, the region was surveyed endoscopically and epicardial RF lesions were visually confirmed. The patient was rendered noninducible as the procedural endpoint.

Discussion
Direct pericardioscopic visualization is feasible during a subxiphoid hybrid approach to VT and facilitates mapping exposure and verification of ablation lesions. In all patients, visualization of a safe dissection plane relative to adhesions was achieved, with estimated blood loss of <75 cc without injury to major epicardial blood vessels within the pericardial space. This enabled improved exposure to the epicardium and more complete mapping of the VT substrate and circuits.

In case 2, an epicardial VT was mapped with the phrenic nerve overlying the isthmus (Figure 1). Historically, percutaneous methods to protect the phrenic nerve include inflation of a balloon or installation of saline, air, or a combination.6 The vacuum-assisted linear RF catheter was designed with a partially insulated surface opposite to the site of ablation, which was a novel application in this case to prevent phrenic nerve injury. Postprocedure chest radiography ruled out elevated hemidiaphragm.

In case 3, efforts to navigate outside the exposed window with a sheath and mapping catheter were obstructed by the presence of dense adhesions. The ability to visualize the plane of dissection with the pericardioscopic technique increased the confidence of the surgeon and electrophysiologist to pursue gradual lysis of adhesions through blunt dissection in deeper areas remote from view. Figure 2 provides the difference in mapping exposure after passing the area of dense adhesion bands with the aid of the pericardioscopic cannula, endoscope, and blunt dissection with a suction device.

Conclusion
A novel pericardioscopic approach may be a useful adjunct during a subxiphoid window approach for epicardial mapping and ablation of scar-related VT. Direct visualization of intrapericardial adhesions may facilitate safer and more
extensive access during dissection and verification of epicardial RF lesions may improve efficacy.

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**Ethics Statement:** This study was conducted according to the Helsinki Declaration guidelines on human research. Maintenance and review of these data was approved by the Institutional Review Board at the University of Chicago Medical Center.

**Appendix**

**Supplementary data**

Supplementary data associated with this article can be found in the online version at [https://doi.org/10.1016/j.hroo.2022.01.001](https://doi.org/10.1016/j.hroo.2022.01.001).

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