ELECTROPHYSIOLOGY

Successful Percutaneous Epicardial Access in Challenging Scenarios

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Background: *This case-series highlights strategies used for successful epicardial access in challenging cases. Percutaneous epicardial access has become a valuable tool for mapping and ablating arrhythmias. However, this technique can be especially difficult in certain circumstances and is frequently avoided.*

Methods: *All cases of epicardial access for ablation from our institution were reviewed searching for exceptionally difficult cases in patients with complex pericardial and thoracic anatomy. The successful strategies are characterized in this report.*

Results: *Among 144 patients who underwent an epicardial ablation procedure between January 2004 and June 2013, four required unconventional approaches for epicardial access for ventricular tachycardia ablation. Two patients (one with previous cardiac surgery and one with prior pericardial effusion) had substantial fibrous pericardial adhesions with no virtual pericardial space and required adhesiolysis. One patient, status postpartial colectomy, underwent computed tomography-guided intercostal epicardial access due to the presence of bowel throughout the subdiaphragmatic space in the upper abdomen. The fourth patient had partial congenital absence of the pericardium and underwent epicardial access through the creation of a subxiphoid window. All epicardial accesses were successful and performed without major complication.*

Conclusions: *With precise procedural planning and cardiac imaging, percutaneous epicardial access is feasible even in patients with significant anatomical challenges. (PACE 2015; 38:84–90)*

epicardial access, ablation, percutaneous, challenging, ventricular tachycardia

Introduction

Ventricular tachyarrhythmias (VT) are predominately found in patients with structural heart disease and are associated with increased morbidity and mortality.[1,2] In some patients, medical treatment and endocardial radiofrequency (RF) ablation of VT fail to prevent VT recurrence, and epicardial ablation should be considered.[3,4] This location of pathology is most commonly seen in patients with arrhythmogenic ventricular cardiomyopathy and dilated cardiomyopathy (DCM),[5] and percutaneous epicardial access, mapping, and ablation are increasingly used.[6] In contrast to standard catheter access, which depends on intact vascular structures, percutaneous epicardial access requires passage of needle and sheath through numerous extracardiac tissues, and can result in atypical complications and procedural challenges. The presence of adhesions from previous cardiac surgery, disturbance of the pericardial anatomy, as well as anatomical variation render the technical approach to epicardial access complex and associated with a higher risk to the patient of bleeding and injury to adjacent structures.[7–9] The objective of this study was to review our single-center experience with percutaneous epicardial access to identify strategies that permitted successful access in the context of unusual circumstances.

Materials and Methods

The standard procedure for epicardial access has been well described elsewhere.[9,10] Briefly, a 2-mm left para-xiphoid space incision is made after application of local anesthesia. A blunt-tipped epidural needle is directed toward the cardiac silhouette under fluoroscopic guidance in the

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right anterior oblique (RAO), left anterior oblique (LAO), anterior-posterior, or straight lateral views. For anterior puncture, an angle of 15–30° from the horizontal is used, whereas for posterior access, the angle is around 45°. As the needle penetrates through the fibrous pericardium, a palpable “give” is appreciated and a puff of contrast demonstrates layering within the pericardial space. A guidewire is advanced into the pericardial space, and RAO/LAO views are used to confirm guidewire position before advancing a sheath over the wire.

For this series, we defined a case as particularly challenging if it required significant deviation from usual practice in order to obtain epicardial access.

We reviewed the Mayo Clinic database of epicardial access for ablation and among 144 patients who underwent a percutaneous epicardial ablation procedure from January 2004 to June 2013, we identified four patients who met the criteria. The records of these patients were reviewed to identify strategies that permitted successful access.

Results

#1 Prior Cardiac Surgery

A 57-year-old man presented with recurrent VT in the context of an ischemic cardiomyopathy (left ventricular ejection fraction; 20-25%) and two prior coronary bypass graft (CABG) surgeries. He also had a history of two prior endocardial VT ablation procedures performed elsewhere, including an unsuccessful attempt at epicardial access.

An inferior subxiphoid approach was difficult and complicated by right ventricular puncture despite the use of standard technique and intracardiac echocardiography. At this point, the angulation of the needle was changed and increased from approximately 40° to 70° from the horizontal plane, allowing access toward the base of the heart. A heavy-duty Amplatz wire was successfully deployed. Due to the presence of firm, fibrous adhesions from previous cardiac surgery, the wire immediately curled at its entrance site into the pericardial space, thus hampering sheath placement. While it still maintained access to the pericardial space, it was too short to allow any exchange maneuvers. Therefore, under fluoroscopic guidance, another needle was placed adjacent to the wire into the pericardial space along the same tract permitting access to the space. Both wires were eventually removed with traction and a ThermoCool DF ablation catheter (Biosense Webster, Diamond Bar, CA, USA) entered the pericardial space successfully.

Mapping was performed in the patient’s clinical VT. Two large epicardial scar zones extended from midventricle to apex and from approximately 2 cm away from the mitral annulus to the annulus itself at the inferoseptal/inferolateral level of the left ventricle. Linear ablation on the inferior surface of the left ventricle terminated the clinical VT. There was no evidence of coronary vessel injury on coronary angiography. A small apical pericardial effusion as well as a pleural effusion were noticed at the end of the case, which resolved during subsequent follow-up. At 4.5-year follow-up, the patient remains free of VT.

#2 Dense Fibrous Pericardial Adhesions

A 54-year-old man with idiopathic nonischemic cardiomyopathy and recurrent VT with multiple implantable cardioverter defibrillator (ICD) shocks presented to our institution for a VT ablation. A previous endocardial ablation procedure attempt had been abandoned because of pericardial tamponade. The clinical VT was mapped endocardially, and findings suggested perhaps an epicardial circuit and exit. Epicardial access was therefore undertaken. The access wire could only be advanced around 2 cm due to a heavily scarred and fibrosed pericardial space, presumably from the patient’s prior pericardial hemorrhagic effusion. Injection of dye into this space showed that it would only pass over the inferior wall (Fig. 1). With the use of a 6-French pericardial pigtail catheter, the adhesions were lysed, opening up approximately one-third of the space along the inferior and inferolateral aspects of the left ventricle and posterior septal aspect of the right ventricle. At these points, multiple areas of epicardial scar were found. RF energy was delivered at the best pace-mapping site, along the posterolateral midleft ventricular wall, and VT could not be reinduced. There was no significant pericardial effusion at the end of the case.

#3 Computed Tomography-Guided Epicardial Access

A 74-year-old man with dilated ischemic cardiomyopathy and bowel cancer status postpartial colectomy with colostomy was referred to our institution with an electrical storm. Five months prior, he had undergone an endocardial VT ablation attempt elsewhere complicated by cardiac perforation and tamponade. Six VT morphologies were identified, one of which demonstrated a pseudo-delta wave suggestive of epicardial exit (Fig. 2E). Epicardial access was not initially undertaken as physical examination and fluoroscopy revealed the presence of the bowel throughout the subdiaphragmatic space in the upper abdomen. This was confirmed with computed tomography (CT) scanning, which showed no access from the subxiphoid area except through the bowel. Endocardial-only ablation at the left

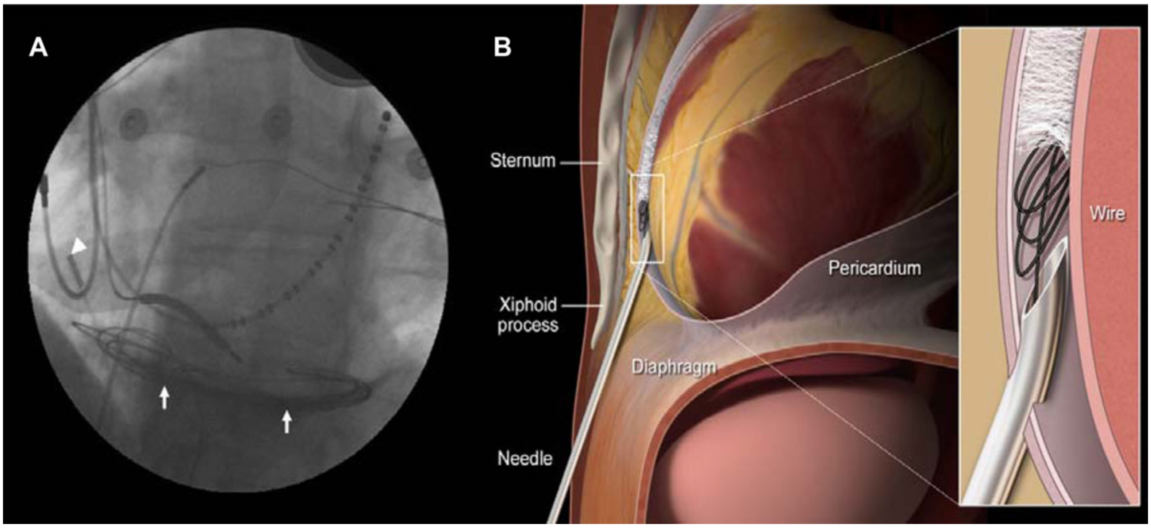

Figure 1. *(A) Left anterior oblique fluoroscopic image showing significant coiling of the epicardial guidewire due to extensive pericardial adhesions (arrows); of note, intracardiac ultrasound was also used (arrowhead). (B) Illustration showing adhesions in the pericardial space broken up using a stiff wire and progressive advancement of the sheath.*

ventricular posterior wall was performed. In view of this, a week later, a second ablation procedure was subsequently scheduled with CT-guided thoracic access. With this CT-guided approach, a lead grid was applied to the xiphisternal region and the skin marked at the time of CT scanning (Figs. 2A and 2B). This approach was able to guide puncture sites at the time of the procedure (Fig. 2D), and to correlate underlying structures with the grid visible in the CT images (Fig. 2C). A 2- to 3-cm "window" in the left parasternal area, at approximately the fifth intercostal space, was deemed suitable for epicardial access and was performed in the electrophysiologic (EP) laboratory. With the initial attempt at access, the pleural space was inadvertently punctured. After pulling the wire back and further advancing the needle about 0.3 cm, access to the pericardium was achieved. Using a DF curve ThermoCool bidirectional saline-irrigated-tip RF catheter (Biosense Webster), left ventricular and right ventricular epicardial geometries were rendered and mapped using the CARTO system (Biosense Webster) (Figs. 2F–H). Effective ablation was based on the presence of epicardial scar, since induction of VT was unsuccessful. Following ablation, a small left-sided pleural effusion was noticed on chest radiography and completely resolved during follow-up; however, no pericardial effusion was evident.

#4 Congenital Absence of the Pericardium

A 65-year-old man with partial congenital absence of the pericardium and DCM presented for consideration of repeat ablation for persistent VT despite two previous endocardial ablations 2 months prior. In addition, epicardial access had also been attempted unsuccessfully. A CT scan of the chest performed prior to the ablation procedure showed partial absence of the pericardium, with pericardium presence over the right atrium, the right ventricular free wall, and the origin of the left pulmonary artery (Fig. 3). The clinical VT was characterized by a right bundle branch block morphology and inferior axis, with QRS complexes being biphasic in lead I and negative in aVL. Pace-mapping from the distal coronary sinus and concealed entrainment, from the left ventricular outflow tract next to the mitral annulus, with a very long stimulus to QRS time suggested a very localized, possibly intramyocardial, circuit. Electroanatomic reconstruction of the aortic cusps and of the left ventricle was performed. Despite ablation at the left coronary cusp hinge point as well as just inside the left ventricle, under the aortic valve, the tachycardia persisted. As such, he underwent epicardial access under general anesthesia. A surgical subxiphoid window was created in the EP lab, through which a wire and sheath were advanced. Predominantly using epicardial pace-mapping, epicardial ablation was performed opposite the site of the endocardial lesion set, preceded and followed by coronary angiography. After ablation, VT was noninducible.

No complications occurred. A modest fluid collection inferolaterally adjacent to the left ventricle and a tiny fluid collection anteriorly over the

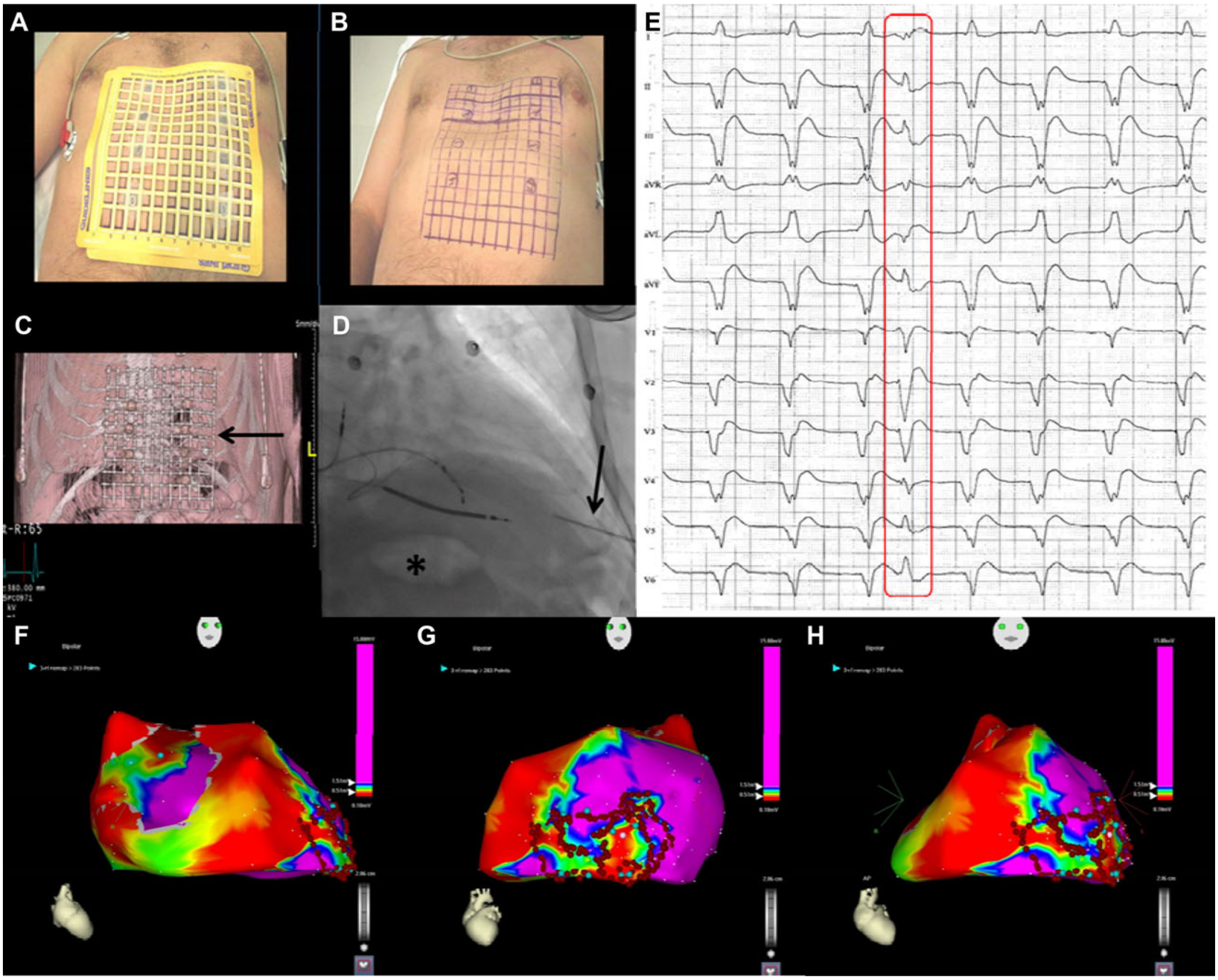

Figure 2. *CT-guided epicardial access: (A) CT grid; (B) skin markings; (C) 3D rendition with representative grid and approximate site of skin puncture (arrow); (D) RAO fluoroscopy image showing Tuohy needle for access (arrow), and prominent epigastric bowel (*); (E) ECG showing a PVC suggestive of epicardial exit—red box; (F–H) electroanatomic reconstruction of the epicardial surface of the right and left ventricles—RAO, LAO, and antero-posterior views, respectively; the red dots represent the ablation sites. CT = computed tomography; ECG = electrocardiogram; LAO = left anterior oblique; PVC = premature ventricular contraction; RAO = right anterior oblique.*

right ventricle were seen, which spontaneously resolved during his hospitalization.

Discussion

Since its first description for the ablation of epicardial VT, percutaneous epicardial access has become a valuable and more frequently utilized tool for mapping and ablating complex arrhythmias.[10] Epicardial mapping and ablation in specialized centers is performed in around 20% of VT ablation procedures,[5] often as a second procedure after a failed endocardial ablation. While early reports suggest it is safe and effective in the majority of the patients,[11,12] anatomical variants of the pertinent extracardiac structures, prior cardiac surgery, or prior pericarditis all provide unusual technical challenges, and at times this approach is avoided. Therefore, imaginative and innovative techniques to access the pericardium are at times required.[7,8] Here we report the techniques that resulted in access to the epicardial space in a selection of the most complex cases at a high-volume VT ablation center (Table I).

The presence of postoperative pericardial adhesions was initially thought to be a contraindication to epicardial access since this limits not only the epicardial entry itself, but also catheter maneuverability.[5,13] A subxiphoid

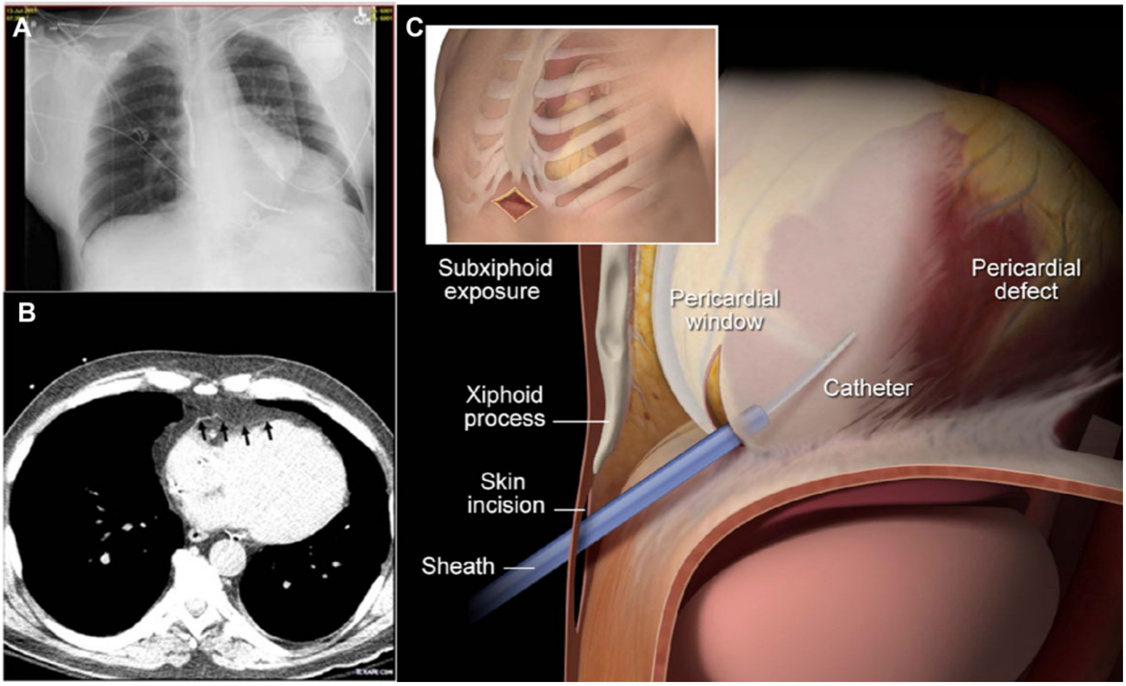

Figure 3. *Partial absence of the pericardium: (A) chest x-ray showing leftward heart displacement; (B) computed tomography scan showing presence of the pericardium only over the right atrium and right ventricle (arrows); there is absence over the left ventricle as seen in this view; (C) illustration of surgical subxiphoid window that permits sheath and catheter advancing and access to the epicardium.*

surgical approach in patients with a history of cardiac surgery was proposed, as an alternative, by Soejima et al.,[7] demonstrating its feasibility and safety. However, other authors have demonstrated that epicardial access is possible to obtain percutaneously in this subset of patients, especially using an inferior approach given the higher density of the adhesions anteriorly, where the pericardial sac is typically opened during cardiac surgery.[14,15] In patient 1 who underwent previous CABG, indeed, percutaneous epicardial access was achieved and forcing the guidewire with caution against the pericardial adhesions provided access for the deflectable ablation catheter. Use of two heavy/stiff wires (such as an Amplatz extra stiff), and significant time (approximately 30 minutes) of continued mechanical motion to break adhesions ultimately permitted entry into the virtual space.

Access to the pericardium can also be challenging due to the potential formation of pericardial adhesions following postprocedural hemorrhagic pericarditis[13] or previous epicardial ablation.[5,16] Based on animal data, it is interesting to note that this process can potentially be limited by the instillation of epicardial steroids to minimize the postepicardial procedure pericarditis, thus limiting adhesion formation.[17] In patient 2, transcatheter mechanical adhesiolysis of heavy and fibrous adherences, derived from prior pericardial tamponade, had been necessary to access the pericardial space. In this situation, progressive lengths of wire were pushed into the fibrosed pericardial space to gradually increase pressure within the space and lyse adhesions. In addition, following this step, a pigtail catheter was repetitively advanced and withdrawn to similarly disrupt adhesions. Use of concomitant imaging with intracardiac echocardiography, transthoracic echocardiography, and/or fluoroscopy is important to confirm access to the appropriate tissue plane and recognition of complications such as pericardial effusion or tamponade.

The anatomy of the subxiphoid area is complex and variable, posing a risk of damage to adjacent structures, such as the liver or bowel wall.[18] The preponderance of abdominal complications stem from the inferiorly directed subxiphoid puncture in which a steep entry angle is deployed.[9] In patient 3, a prior partial colectomy had resulted in the extrusion of bowel throughout the subdiaphragmatic space in the upper abdomen. Using CT imaging with an external grid, we were able to identify a safe intercostal approach to enter the dry pericardium in a patient without subxiphoid access. This case

Table I.

General Strategies for Managing Challenging Epicardial Access Cases

Possible Problems Encountered with Epicardial Access	Potential Solutions
Fibrosis/adhesions	Inferior access if post-CABG (to avoid grafts)
	Change needle angle from the horizontal plane
	Attempted adhesiolysis (with mechanical movement of pigtail catheter)
	Use of heavy/stiff wires to mechanically disrupt adhesions
	Use ICE and TTE to confirm tissue plane entering
	Use of postablation intrapericardial steroids (to prevent)
Fibrotic/stiff pericardium, difficult to enter	Trial with micropuncture needle
Anatomical derangements	Preprocedural imaging to identify
• absence of pericardium	CT-guided access to identify intercostal window
• pectus excavatum	• A. CT to mark entry-point
• absent subxiphoid window	• B. CT-guided access to place wire
• transposed bowel wall	Hybrid procedural approach; for example, pericardial window
• large transverse colon	Anterior approach if feasible
Elevated INR/clotting abnormalities	Close monitoring
	Intraprocedural TEE/ICE to allow early detection of effusion
	Leave pericardial drain postablation
Intraprocedural effusion	Aggressively aspirate and maintain suction to use pericardium to apply pressure
	If plan to remove sheath, remove over a wire and observe to confirm no reaccumulation
	Use of cell saver if large hemorrhagic effusion present to autotransfuse
Large body habitus/difficult imaging	Place intracardiac catheters (CS, RVA) for additional anatomical guidance

CABG = coronary artery by-pass graft; CS = coronary sinus; CT = computed tomography; ICE = intracardiac echocardiography; INR = international normalized ratio; RVA = right ventricular apex; TEE = trans-esophageal echocardiography; TTE = trans-thoracic echocardiography.

underlines how precise procedural planning, at times with imaging, can help in patients with suspected challenging epicardial access.

Congenital absence of the pericardium is a rare entity, with less than 400 cases reported in the literature. It can range from small defects to complete absence and it may be isolated or related to other congenital abnormalities. It is usually due to premature atrophy of the left common cardiac vein (duct of Cuvier), resulting in a compromised vascular circulation leading to pericardial agenesis.[19] This theory accounts for the majority of the pericardial defects located on the left side. In fact, pericardial absence is typically left-sided, which may result in herniation of the great vessels or portions of the heart.[20] While right-sided lesions and total defects of the pericardium are extremely rare, complications are more common with partial as opposed to complete absence of the pericardium due to strangulation of the heart into the defect.[21] Patient 4 had partial absence of the pericardium, with pericardium presence over the right atrium, right ventricular free wall, and the origin of the left pulmonary artery, with a left ventricular longitudinal axis displaced laterally, making the epicardial access challenging. Therefore, a hybrid approach utilizing a surgically created window was performed in the EP lab, through which a wire and then a sheath were advanced, enabling epicardial access.

Limitations

It is important to note that the solutions we developed to obtain successful epicardial access in cases with unusual anatomy or pathologic variations were patient specific. Adhesiolysis has been performed in 11 other patients who presented with fibrous and stiff pericardium, and proved to be effective in five of them, giving a success rate of 54% (7/13). However, CT-guided access and subxiphoid window for congenital absence of the pericardium have been unique cases to date. As such, given the small number of patients with challenging epicardial access, our conclusions cannot be extended to the entire population of patients with previous cardiac surgery, distortion of cardiac anatomy, or particular associated conditions. Moreover, other patient-specific physiological variables, such as the extent of lung excursion during respiration or the amount and location of epicardial fat, should be taken into consideration on a case-by-case basis.

Conclusion

In the majority of patients undergoing ablation procedures, percutaneous epicardial access can be readily achieved. Standard epicardial access approaches in patients with unusual anatomy can be especially difficult. However, with precise procedural planning, a multidisciplinary and often nonconventional approach, percutaneous epicardial access is potentially feasible and safe. This series hopefully serves as a platform for further innovation in approaching access in the complex epicardial case.

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