Journal of the American College of Cardiology
Published by Elsevier Inc.
Vol. 55, No. 21, 2010
ISSN 0735-1097/$36.00
doi:10.1016/j.jacc.2009.10.084

QUARTERLY FOCUS ISSUE: HEART RHYTHM DISORDERS

Epicardial Ventricular Tachycardia Ablation

A Multicenter Safety Study

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Objectives The aim of this study was to perform a systematic evaluation of safety and midterm complications after epicardial ventricular tachycardia (VT) ablation.

Background Epicardial VT ablation is increasingly performed, but there is limited information about its safety and midterm complications.

Methods All patients undergoing VT ablation at 3 tertiary care centers between 2001 and 2007 were included in this study. Of 913 VT ablations, 156 procedures (17%) involved epicardial mapping and/or ablation. These were performed in 134 patients (109 men; mean age 56 ± 15 years) after a previous VT ablation in 115 (86%). The underlying substrates were ischemic cardiomyopathy in 51 patients, nonischemic cardiomyopathy in 39 patients, arrhythmogenic right ventricular cardiomyopathy in 14 patients, and other types of cardiomyopathy in 30 patients.

Results Epicardial access was obtained via percutaneous subxiphoid puncture in 136 procedures, by a surgical subxiphoid approach in 14, and during open-heart surgery in 6. Epicardial ablation (mean radiofrequency duration: 13 ± 12 min; median: 10 min) was performed in 121 of 156 procedures (78%). Twenty patients subsequently required repeat procedures, and the epicardium could be reaccessed in all but 1 patient. A total of 8 (5%) major complications related to pericardial access were observed acutely: 7 epicardial bleeding (>80 cm^3) and 1 coronary stenosis. After a mean follow-up period of 23 ± 21 months, 3 delayed complications related to pericardial access were noted: 1 major pericardial inflammatory reaction, 1 delayed tamponade, and 1 coronary occlusion 2 weeks after the procedure.

Conclusions VT ablation required epicardial ablation in 121 of 913 procedures (13%), with a risk of 5% and 2% of acute and delayed major complications related to epicardial access. (J Am Coll Cardiol 2010;55:2366–72) © 2010 by the American College of Cardiology Foundation

Radiofrequency (RF) catheter ablation of ventricular tachycardia (VT) in patients with structural heart disease remains a challenging task, with reported success rates not exceeding 53% to 67% from multicenter or large series (n > 200) (1–3). One possible limitation of conventional endocardial ablation techniques is that some re-entry circuits may lie deep in the subendocardium or in the epicardium, areas impossible to access with current endocardial ablation techniques. Epicardial substrate seems of particular importance for VT ablation in the setting of nonischemic cardiomyopathy (CMP) (4) or arrhythmogenic right ventricular cardiomyopathy (ARVC) but also in patients with ischemic CMP (2,5).

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Since 1996 (6), many centers have reported their experiences (4,7–10) with epicardial ablation, but safety and midterm complications have not been systematically assessed in clinical practice.

Methods

Population and substrate. All patients undergoing VT ablation at 3 tertiary care electrophysiology centers between

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Manuscript received July 4, 2009; revised manuscript received October 2, 2009, accepted October 18, 2009.

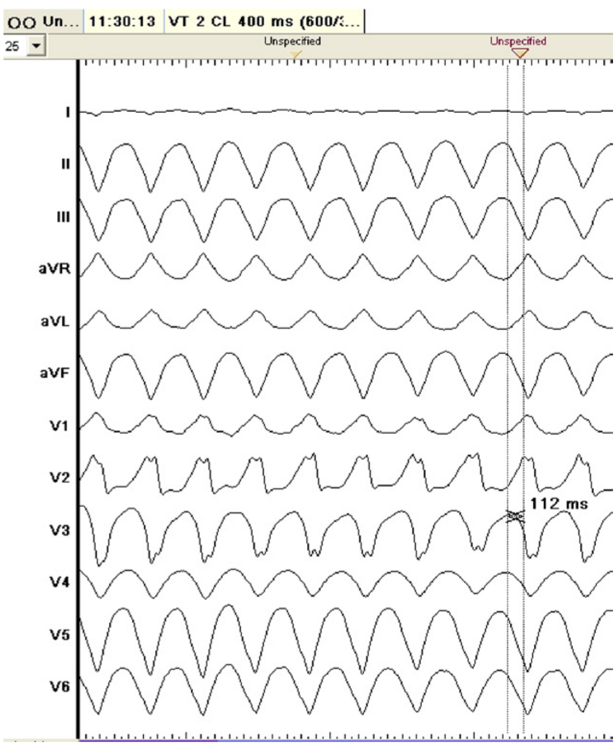

Figure 1 **12-Lead ECG of Epicardial VT in a Patient With a Previous Anteroapical Myocardial Infarction**

Note that the criteria reported by Berruezo et al. (11) are present for this episode of ventricular tachycardia (VT) (pseudo–delta wave, intrinsicoid deflection >85 ms, and shortest RS complex >121 ms). ECG = electrocardiogram.

2001 and 2007 were included in this study. Of 913 VT ablations, 156 (17%) involved epicardial mapping and/or ablation. They were performed in 134 patients (109 men; mean age 56 ± 15 years), after previous failed VT ablation in 115 (86%) or because the epicardium was thought to be a likely source on the basis of the characteristics of VT in the remaining patients (Figs. 1 and 2) (11). The underlying substrates were ischemic CMP in 51 patients (38%), nonischemic CMP in 39 (29%), ARVC in 14 (10%), and other types of CMP (valvular, sarcoidosis, noncompaction of the left ventricle, isolated left ventricular diverticulum) in 13 (10%); 17 patients (13%) had no structural heart disease (Table 1). All patients had failed therapy with 1 or more antiarrhythmic drugs.

Procedure. With patients under conscious sedation, the pericardium was mainly accessed via a percutaneous subxiphoid puncture, as previously described (6), using an epidural needle (Tuohy bevel, 18 gauge, 1.3 × 80 or 150 mm; Braun, Kronberg, Germany) originally developed to perform epidural access. The needle has a smoothly curved distal end, intended to facilitate entry into a potential space, and hopefully decreases the likelihood of a traumatic myocardial puncture. Percutaneous subxiphoid epicardial access was performed before heparin infusion in patients with international normalized ratios <2.0. In cases of previous cardiac surgery or difficult pericardial access, a surgical subxiphoid (9) (Fig. 3) or lateral thoracotomy approach was performed under general anesthesia. When cardiac surgery was indicated for concomitant valvular or ischemic heart disease, ablation was performed during open-chest surgery.

Abbreviations and Acronyms

ARVC = arrhythmogenic right ventricular cardiomyopathy

CMP = cardiomyopathy

RCA = right coronary artery

RF = radiofrequency

RV = right ventricular

The ablation protocols differed among centers and evolved during the course of the study. Different types of ablation catheters were used in the pericardium (4- and 8-mm solid tip, internally and externally irrigated–tip catheters, and cryocatheters). RF ablation parameters used in the pericardium differed depending on the type of catheter and the center. After 2006, externally irrigated–tip catheters (3.5-mm tip, ThermoCool, NaviStar or not; Biosense Webster, Diamond Bar, California) were used at all 3 centers for epicardial RF ablation. Catheter irrigation during epicardial mapping was set at 0 or 1 ml/min. During epicardial ablation, power ranged from 20 to 50 W, with irrigation of 10 to 30 ml/min. Intrapericardial fluid was drained by aspiration from the access sheath periodically after RF ablation lesions or continuously with a vacuum system connected to the epicardial sheath, which was 0.5- to 1-F larger than the ablation catheter.

Before ablation on the left ventricular epicardium, coronary angiography was performed to confirm the absence of a coronary artery at the ablation site. High-output (10 mA or greater) pacing was also performed before ablation on the lateral left ventricular wall to exclude close proximity to the left phrenic nerve (12). From pericardial access to pericardial sheath removal, a catheter or a guidewire was always present, protruding from the sheath, because of concern that the sharp edge of a pericardial sheath might predispose to laceration of adjacent tissue or vessels. The pericardial sheath was removed at the end of the ablation in the absence of pericardial bleeding.

Echocardiography was performed within 24 h after the procedure and/or at discharge to assess pericardial fluid. Use of nonsteroidal anti-inflammatory drugs was left to the physician's discretion.

Data collection. Data were collected from a centralized system containing complete records of all patients treated and followed at the different centers. These records provided detailed histories and diagnoses for all patients, ablation reports, emergency department visits and outpatient visits, as well as data recorded during inpatient care. Patients local to the hospital were followed up in the ablation center. For the other patients, referring cardiologists were contacted for clinical follow-up and echocardiographic data of their patients. Mortality was assessed from the Social Security Death Index for American patients or by direct phone calls to referring physicians for European patients.

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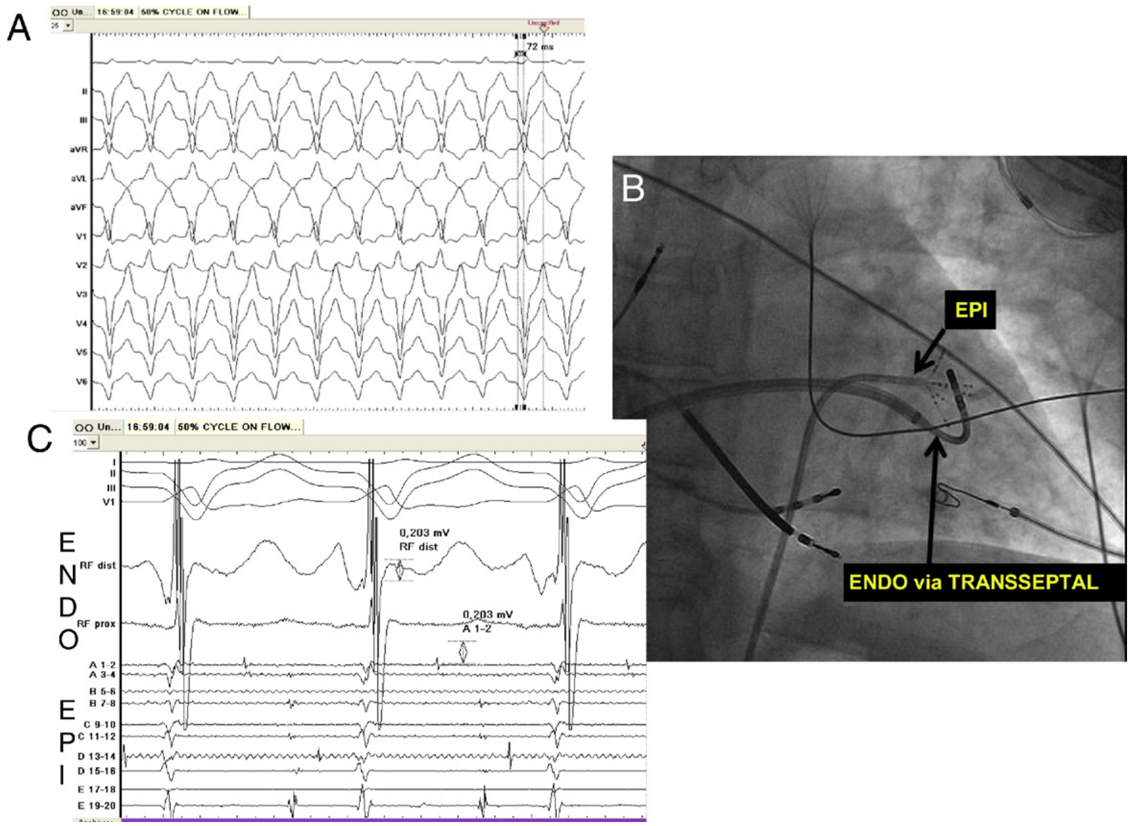

Figure 2 VT in a 61-Year-Old Man With Mild Ischemic Cardiomyopathy (LVEF: 50%)

(A) Twelve-lead electrocardiographic morphology of ventricular tachycardia (VT), which does not appear epicardial (EPI) in origin (relatively short QRS complex, no pseudo–delta wave, intrinsicoid deflection in lead V_2 <85 ms). However, no optimal spot could be found in the endocardium (normal endocardial voltage). **(B)** Fluoroscopy (postero-anterior view) of the catheter's position in **C**. Ablation catheter is in the endocardium while the PentaRay catheter (Biosense Webster) is on the epicardial side of the same area. **(C)** Endocardial (ENDO) and epicardial mapping demonstrates that the critical portion of the circuit is epicardial (50% of the VT cycle length is recorded on the PentaRay catheter, whereas electrograms recorded on the ablation catheter [using the same amplification], at the corresponding endocardial spot, are normal). LVEF = left ventricular ejection fraction.

Statistical analysis. Continuous variables are expressed as mean ± SD or medians when indicated. Complication and right ventricular (RV) puncture rates of the first 78 procedures compared with the following 78 were compared using Fisher exact tests. A p value <0.05 was considered statistically significant.

Results

Procedure. A total of 115 patients underwent only 1 effective epicardial access (percutaneous, surgical, or via thoracotomy). Sixteen patients had 2 epicardial procedures and 3 patients had 3 epicardial procedures with successful percutaneous subxiphoid access. However, in 1 other patient, repeat access failed 3 months after the initial epicardial procedure, but she had experienced a dramatic pericardial reaction after the initial procedure.

The percutaneous subxiphoid approach was successful in accessing the pericardial space in 136 procedures and failed in 15 (10%). The reasons for these 15 failures (in 15 different

Table 1 Baseline Characteristics of the Population Depending on the Substrate

	Ischemic CMP (n = 51)	Idiopathic Dilated CMP (n = 39)	ARVC (n = 14)	No CMP (n = 17)	Other CMP (n = 13)	All Patients (n = 134)
Percentage of epicardial access compared with the global population of VT ablation (n = 722)	16%	35%	41%	6%	18%	19%
Age (yrs)	63 ± 11	59 ± 15	42 ± 13	48 ± 14	53 ± 13	56 ± 15
Men	48 (94%)	32 (82%)	9 (64%)	10 (59%)	10 (77%)	109 (81%)
Left ventricular ejection fraction (%)	31 ± 11	33 ± 12	59 ± 9	61 ± 9	44 ± 11	40 ± 17
Patients with previous endocardial VT ablation	46 (90%)	33 (85%)	9 (64%)	15 (88%)	12 (92%)	115 (86%)
Patients with epicardial mapping and ablation	42 (82%)	36 (92%)	14 (100%)	12 (71%)	9 (69%)	113 (84%)

ARVC = arrhythmogenic right ventricular cardiomyopathy; CMP = cardiomyopathy; VT = ventricular tachycardia.

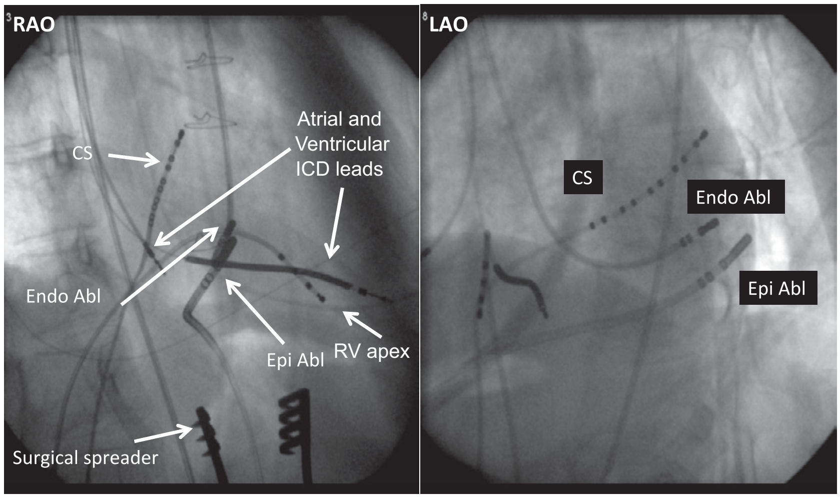

Figure 3 **Fluoroscopic View During VT Ablation With Surgical Subxiphoid Access**

(Left) Right anterior oblique (RAO) view with an ablation catheter on the site of interest on the endocardial side (Endo Abl) via a retrograde aortic approach. Another catheter (Epi Abl) is placed on the epicardial side of the same spot and has been introduced via surgical approach. Note the surgical spreader **(bottom)**. **(Right)** Left anterior oblique (LAO) view of the same site. CS = coronary sinus catheter; ICD = implantable cardioverter-defibrillator; RV apex = catheter placed at the apex of the right ventricle; VT = ventricular tachycardia.

patients) were histories of cardiac surgery in 11 patients, an implantable cardioverter-defibrillator epicardial patch in 1 patient, and histories of pericarditis in 2 patients (including the patient with a failed repeat procedure). For the remaining procedure, the patient had experienced a myocardial infarction several years before the procedure, and no clear reason for pericardial adhesions or failed access was identified.

Concerning the 15 patients from these procedures (with failed percutaneous epicardial access), the surgical subxiphoid approach was then performed successfully in 9 patients. No further epicardial attempt was performed in 5 patients, who were not counted further in the study (although no complications were noted during follow-up, they did experience VT recurrence). The remaining patient with failed access had previously successful percutaneous subxiphoid pericardial access and was included in this group for her first procedure but not counted for her second (failed) procedure.

A total of 14 surgical subxiphoid pericardial windows and 6 thoracotomy procedures were performed for access. Epicardial RF or cryoablation was delivered in 121 of 156 procedures (78%) (Table 1). Cryoablation was used in 11 procedures (7%) because of adjacent coronary arteries (n = 5) or during open-chest surgery (n = 6). In the 35 remaining procedures, no energy was delivered to the epicardium. In 33 procedures, the endocardium was finally thought to be a better target than the epicardium. In the last 2 procedures, no ablation was performed, because of the closeness of the proximal part of the left anterior descending coronary artery.

Total endocardial and epicardial RF ablation time was 22 ± 16 min. In the 110 procedures with epicardial RF ablation, mean epicardial RF duration was 13 ± 12 min (median 10 min). Maximal power varied from 20 to 50 W (median 30 W). Externally irrigated–tip catheters were used for epicardial ablation in 99 of 156 procedures (63%).

Complications. Major complications (Table 2) were observed acutely or before discharge in 14 of 156 procedures (9%). Eight were related to epicardial approach (5%): 7 epicardial bleeding (>80 cm^3) because of RV puncture in 4 cases (bleeding stopped spontaneously or after reversal of heparin anticoagulation; no patient required blood transfusion or surgery) and 1 asymptomatic coronary stenosis in a procedure with cryoablation close to a posterolateral ventricular branch of the right coronary artery (RCA). At this ablation site, cryoablation was attempted because of proximity to the coronary artery. Angiography performed after the 4-min cryoapplication showed a 50% to 60% stenosis. Follow-up stress testing with single photon-emission computed tomographic perfusion imaging showed that scar presumably existed before the ablation and was unrelated to the coronary stenosis.

Six complications were related to endocardial ablation: pulmonary embolism in 2 patients (in patients with both venous and arterial femoral access in addition to pericardial puncture), an audible steam pop with pericardial effusion during endocardial ablation in 1 patient (using 35 W with an irrigated-tip catheter in the RV outflow tract in a patient with ARVC), cardiogenic shock in 1 patient, infranodal atrioventricular block in 1 patient (in a patient with idiopathic dilated CMP and epicardial VT as well as multiple VTs from the left Purkinje network), and bilateral groin hematomas requiring blood transfusion in 1 patient (Table 2).

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Table 2 Acute and Delayed Major and Minor Complications Related to Epicardial and Endocardial VT Ablation

	Complications Related to Epicardial Approach		Other Complications	
Major complications				
Acute	Intrapericardial bleeding (>80 cm^3)	7 (4.5%)	Pulmonary embolism	2 (1.3%)
	Coronary artery stenosis	1 (0.6%)	Endocardial pop with pericardial effusion	1 (0.6%)
			Cardiogenic shock	1 (0.6%)
			Infranodal AV block	1 (0.6%)
			Bilateral groin hematoma requiring blood transfusion	1 (0.6%)
Delayed (>48 h)	Major pericardial reaction	1 (0.6%)		
	Delayed tamponade	1 (0.6%)		
	Myocardial infarction	1 (0.6%)		
Total		11 (7%)		6 (4%)
Minor complications				
	RV puncture without consequence	23/136 percutaneous approach (17%)	Femoral dissection	1 (0.6%)
	Pleural catheterization with guidewire	2 /136 (1.5%)		
	Chest pain	Almost all patients		

AV = atrioventricular; RV = right ventricular; VT = ventricular tachycardia.

Minor complications (Table 2) related to epicardial access were also noted: RV puncture without significant bleeding (<80 cm^3) in 23 procedures (17% of percutaneous subxiphoid access), inadvertent entry of the guidewire into the pleural space without pneumothorax or complication in 2 procedures (Fig. 3), and chest pain after almost all procedures (related to pericardial inflammation), usually requiring treatment with nonsteroidal anti-inflammatory drugs. One minor complication related to endocardial procedure was also noted (a femoral artery dissection that did not require therapy).

To evaluate a possible learning-curve effect on the complication rate, the population was divided into 2 groups (group 1: procedures performed during the first half of the study [initial experience or learning curve] vs. group 2: procedures performed during the second half of the study). No difference was found in terms of major complications related or not to pericardial access (3 of 78 during the first period vs. 5 of 78 during the second period, p = NS), but a trend toward more RV punctures (without consequence) during the first part of the study was observed (16 of 68 [24%] vs. 7 of 68 [10%] with percutaneous subxiphoid puncture, p = 0.07).

Follow-up. After a mean follow-up period of 23 ± 21 months, 3 of 134 patients (2%) had undergone heart transplantation, and 118 of 134 (88%) were still alive. Freedom from VT recurrence was achieved in 95 of 134 patients (71%). Three delayed complications (2%) related to pericardial access were noted: 1 major pericardial inflammatory reaction, 1 delayed tamponade 10 days after the procedure in a patient with a supratherapeutic international normalized ratio of 11, and 1 acute inferior myocardial infarction 2 weeks after the procedure. This patient had ARVC with epicardial RV free wall ablation, without preceding coronary angiography, which was not routinely performed before ablation on the RV epicardial free wall. Emergency coronary angiography showed RCA occlusion at the site of the ablation, with an unusual RCA anatomy (the marginal branch of the RCA supplying the posterior descending artery).

No constrictive pericarditis or phrenic nerve injuries were reported in any patient.

Discussion

In this multicenter study, VT ablation required epicardial ablation in 121 of 913 procedures (13%). The overall risk for acute (5%) and delayed (2%) major complications related to epicardial access and ablation seems justified by the absence of alternative treatments in this population. However, these results must be interpreted in the context of the procedures being performed in selected patients and at experienced centers with acute surgical backup; widespread application of epicardial access and ablation should progress with caution.

Consistent with prior reports, the highest prevalence of epicardial VT substrate was observed in patient groups with diagnoses of ARVC (41%) and nonischemic dilated CMPs (35%), followed by patients with ischemic heart disease (Table 1). Even if these prevalences may be overestimated because of the referral nature of the population (patients with epicardial substrate more often referred by other centers that are not familiar with this technique), the proportion of epicardial VT substrate in ARVC (13) and nonischemic dilated CMPs (4) is higher compared with other substrates.

Although all cardiologists are trained to perform pericardial puncture for tamponade, accessing the pericardium in the absence of pericardial fluid is more challenging. A specific technique has been described by Sosa et al. (6) and adopted with some variation by electrophysiologists performing such procedures. To prevent major complications, some precautions are necessary. First, patient selection is important. Despite a study by Sosa et al. (14) demonstrating that access can be achieved in some patients who have had prior cardiac surgery, adhesions may prevent access or limit mapping, RV puncture may be more likely when a potential pericardial space is not encountered, and coronary artery bypass grafts may be at risk in some cases. In our study, percutaneous subxiphoid pericardial access and/or mapping failed in 11 of 13 patients (85%) with previous cardiac surgery. When access was finally obtained in 2 patients, mapping was limited to the inferior wall.

Second, puncture is facilitated by the use of a Tuohy needle to limit the risk for myocardial injury. Use of contrast medium to confirm entry in the pericardial space and the introduction of a long guidewire, inserted to sufficient length to cross multiple cardiac chambers along the cardiac silhouette and thus exclude the possibility that it has been inserted into a cardiac chamber, are mandatory before introducing the sheath. This ensures that myocardial perforation or laceration with a large sheath does not occur (Fig. 4). In this study, 20% of RV punctures occurred during percutaneous subxiphoid pericardial access, but only 4 (3%) resulted in significant bleeding. One of these 4 patients had received heparin after transseptal access performed before epicardial access, but there was no additional anticoagulation risk noted for the other 3 patients. Concerning the 3 patients with pericardial bleeding but without RV puncture, myocardial injury was thought by the operator to be unlikely. In 1 of these patients, contrast medium injection showed a coronary vein shadow, leading to a suspicion of inadvertent coronary vein puncture. Moreover, to avoid myocardial wall injury by the sharp edges of a sheath, it seems reasonable that intrapericardial sheaths should always contain either a guidewire and dilator or a catheter and should not be left empty in the pericardial space.

The timing of the epicardial procedure relative to the endocardial procedure is also an important issue. It seems reasonable to perform epicardial access before systemic anticoagulation because of the possibility of bleeding complications. Even though in this study, bleeding always stopped spontaneously or after heparin reversal, caution is warranted, and on-site surgical backup is advised.

Initially, solid-tip catheters were used for epicardial ablation, but power delivery was limited because of the absence of cooling from blood flow that is present during endocardial ablation (15). Although externally irrigated–tip catheters were initially avoided at some centers because of the need for intrapericardial fluid infusion, this type of catheter was subsequently used for epicardial ablation in 63% of our procedures, with periodic intrapericardial fluid drainage and careful monitoring of arterial pressure and motion of the cardiac silhouette on fluoroscopy (every 15 to 20 min). At 1 center, fluid was drained continuously with a vacuum system connected to the epicardial sheath during mapping and ablation. These investigators also believed that this approach improved contact between the catheter tip and the myocardium.

Because of the risk for coronary artery lesions in the case of RF application to a vessel, it seemed reasonable to perform coronary angiography before energy delivery to the epicardium. Because coronary vessels are usually absent from the RV free wall, we did not systematically perform coronary artery angiography at this site. However, even in the absence of coronary artery lesions in such cases in our study, it could be useful to perform coronary angiography even at this site, especially when the catheter position is doubtful or close to the septal area.

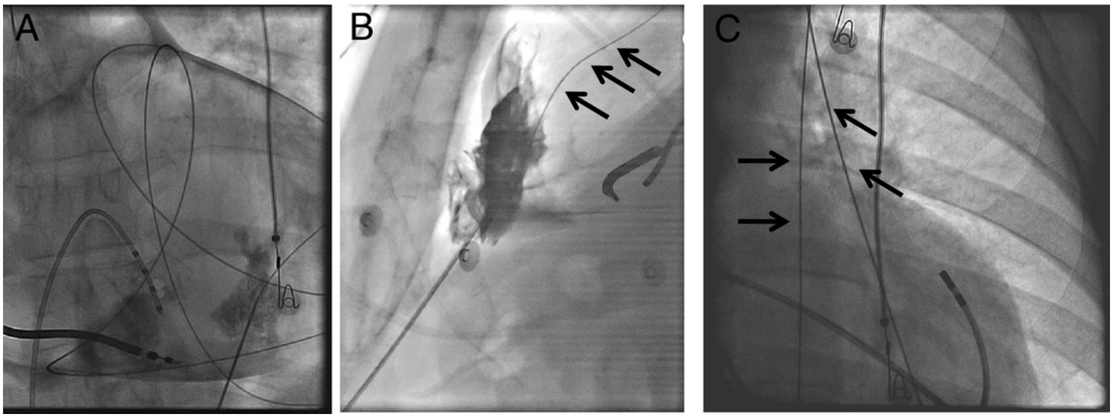

Figure 4 **Pericardial Access and Complications**

(A) Normal pericardial access: posteroanterior view of the heart with a guidewire introduced through percutaneous subxiphoid access into the pericardium. This appearance is typical of a guidewire correctly placed into the pericardial space. **(B)** Right ventricular puncture: lateral projection with the Tuohy needle in the **right bottom corner** with a guidewire **(arrows)** that does not loop into the pericardium but goes into the right ventricle and the pulmonary artery. The contrast staining in the anterior mediastinum indicates that this has been a difficult pericardial catheterization. Furthermore, this compounds the problem by impairing the visualization of the Tuohy needle. **(C)** Pleural puncture: lateral view with the guidewire **(arrows)** in the pleural cavity.

It is not clear whether epicardial ablation may create pericardial adherences, but d'Avila et al. (16) suggested infusing intrapericardial corticosteroids at the end of the procedure to limit this potential risk. In our series, 20 patients had redo epicardial procedures a median of 3 months after the previous epicardial ablation, with no access or mapping issues, except for 1 patient in whom it was impossible to reaccess the pericardium. This patient had experienced a dramatic pericardial reaction after the initial epicardial procedure. No case of constrictive pericarditis was noted after a mean follow-up period of almost 2 years. Whether the follow-up was too short to develop this complication is uncertain, but it would be unlikely that the risk for constrictive pericarditis after epicardial ablation exceeds the risk after cardiac surgery, for which it has been estimated to be 0.2% to 0.3% (17).

Chest pain during the procedure is obviously an issue and requires powerful analgesia such as fentanyl or sufentanyl in the absence of general anesthesia. Residual chest pain is also frequent after the procedure, and nonsteroidal anti-inflammatory drugs are usually prescribed for 1 week.

Our study points out some complications of epicardial mapping and ablation, but other complications have been reported, such as abdominal bleeding after diaphragmatic vessel injury (8), increased defibrillation threshold due to air in the pericardium (18), and phrenic nerve injury (12). Other complications not yet reported may also be anticipated, such as lung or mediastinal lesions.

Study limitations. The study cohort consisted of a highly selected group of patients with a variety of diagnoses and underlying arrhythmia substrates. The majority of the patients had failed prior endocardial ablation attempts. This reflected the nature of the referral practice at these 3 tertiary care electrophysiology centers. It is important to note that these findings may not be applicable to less experienced operators or centers. Percutaneous subxiphoid pericardial access for mapping and/or ablation was started routinely at different times at the different centers (in 2000 at Brigham and Women's Hospital, in 2004 at Bordeaux University Hospital, and in 2005 at Toulouse University Hospital), but the pericardial puncture technique itself remained the same over the years. The numbers of procedures performed at the different centers over the study period differed (104 patients at Brigham and Women's Hospital, 38 patients at Bordeaux University Hospital, and 14 patients at Toulouse University Hospital). Because of the retrospective nature of the study, the exact number of RV punctures may be slightly different from reality (on the basis of the report).

Conclusions

VT ablation required epicardial ablation in 121 of 913 procedures (13%). The risks for acute (5%) and delayed (2%) major complications related to epicardial access seem justified by the absence of a therapeutic alternative for this population.

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REFERENCES

1. Calkins H, Epstein A, Packer D, et al., Cooled RF Multi Center Investigators Group. Catheter ablation of ventricular tachycardia in patients with structural heart disease using cooled radiofrequency energy: results of a prospective multicenter study. J Am Coll Cardiol 2000;35:1905–14.
2. Sacher F, Tedrow U, Field ME, et al. Ventricular tachycardia ablation: evolution of patients and procedures over 8 years. Circ Arrhythm Electrophysiol 2008;1:153–61.
3. Stevenson WG, Wilber DJ, Natale A, et al., Multicenter ThermoCool VT Ablation Trial Investigators. Irrigated radiofrequency catheter ablation guided by electroanatomic mapping for recurrent ventricular tachycardia after myocardial infarction: the Multicenter ThermoCool Ventricular Tachycardia Ablation trial. Circulation 2008;118:2773–82.
4. Soejima K, Stevenson WG, Sapp JL, Selwyn AP, Couper G, Epstein LM. Endocardial and epicardial radiofrequency ablation of ventricular tachycardia associated with dilated cardiomyopathy: the importance of low-voltage scars. J Am Coll Cardiol 2004;43:1834–42.
5. Sosa E, Scanavacca M, d'Avila A, Oliveira F, Ramires JA. Nonsurgical transthoracic epicardial catheter ablation to treat recurrent ventricular tachycardia occurring late after myocardial infarction. J Am Coll Cardiol 2000;35:1442–9.
6. Sosa E, Scanavacca M, d'Avila A, Pilleggi F. A new technique to perform epicardial mapping in the electrophysiology laboratory. J Cardiovasc Electrophysiol 1996;7:531–6.
7. Brugada J, Berruezo A, Cuesta A, et al. Nonsurgical transthoracic epicardial radiofrequency ablation: an alternative in incessant ventricular tachycardia. J Am Coll Cardiol 2003;41:2036–43.
8. Sosa E, Scanavacca M. Epicardial mapping and ablation techniques to control ventricular tachycardia. J Cardiovasc Electrophysiol 2005;16:449–52.
9. Soejima K, Couper G, Cooper JM, Sapp JL, Epstein LM, Stevenson WG. Subxiphoid surgical approach for epicardial catheter-based mapping and ablation in patients with prior cardiac surgery or difficult pericardial access. Circulation 2004;110:1197–201.
10. Aryana A, d'Avila A, Heist EK, et al. Remote magnetic navigation to guide endocardial and epicardial catheter mapping of scar-related ventricular tachycardia. Circulation 2007;115:1191–200.
11. Berruezo A, Mont L, Nava S, Chueca E, Bartholomay E, Brugada J. Electrocardiographic recognition of the epicardial origin of ventricular tachycardias. Circulation 2004;109:1842–7.
12. Fan R, Cano O, Ho SY, et al. Characterization of the phrenic nerve course within the epicardial substrate of patients with nonischemic cardiomyopathy and ventricular tachycardia. Heart Rhythm 2009;6:59–64.
13. Garcia FC, Bazan V, Zado ES, Ren JF, Marchlinski FE. Epicardial substrate and outcome with epicardial ablation of ventricular tachycardia in arrhythmogenic right ventricular cardiomyopathy/dysplasia. Circulation 2009;120:366–75.
14. Sosa E, Scanavacca M, D'Avila A, Antonio J, Ramires F. Nonsurgical transthoracic epicardial approach in patients with ventricular tachycardia and previous cardiac surgery. J Interv Card Electrophysiol 2004;10:281–8.
15. d'Avila A, Houghtaling C, Gutierrez P, et al. Catheter ablation of ventricular epicardial tissue: a comparison of standard and cooled-tip radiofrequency energy. Circulation 2004;109:2363–9.
16. d'Avila A, Neuzil P, Thiagalingam A, et al. Experimental efficacy of pericardial instillation of anti-inflammatory agents during percutaneous epicardial catheter ablation to prevent postprocedure pericarditis. J Cardiovasc Electrophysiol 2007;18:1178–83.
17. Cimino JJ, Kogan AD. Constrictive pericarditis after cardiac surgery. Am Heart J 1989;118:1292–301.
18. Yamada T, McElderry HT, Platonov M, Doppalapudi H, Kay GN. Aspirated air in the pericardial space during epicardial catheterization may elevate the defibrillation threshold. Int J Cardiol 2009;135:e34–5.

Key Words: epicardial VT ablation ■ safety ■ complications.