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Anterior pericardial access to facilitate electrophysiology study and catheter ablation of ventricular arrhythmias: A single tertiary center experience

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Abstract

Introduction—Epicardial ablation is becoming an important part of management in patients with ventricular tachycardia (VT). Posterior epicardial access via the Sosa or needle-in-needle (NIN) approach for epicardial VT ablation is considered to be the method of choice for most electrophysiologists. Anterior epicardial access as an alternative technique has recently been proposed, but there are limited data about its safety, efficacy, and the rate of immediate complications. In this study, we report our experience with anterior epicardial access between 2009 and 2016.

Methods—Between 2009 and June 2016, 100 consecutive patients underwent epicardial VT ablation using an anterior approach. The success rate, epicardial bleeding, and other complications related to the epicardial access in these patients were compared to the previously reported rate of complications in patients whom epicardial access was performed using the NIN or Sosa techniques.

Results—Anterior epicardial access was obtained successfully in 100% of patients in the first attempt. The success rate of the anterior approach was comparable with the reported success rate of the NIN technique (100% vs. 100%, P value not significant) but better than the Sosa technique (100% vs. 94%, P = 0.012). None of the patients in the anterior approach series suffered from significant pericardial bleeding (defined as greater than 80 mL of blood loss), RV puncture/damage, or need for an emergent cardiac surgery.

Conclusion—An anterior epicardial approach is feasible and appears to have an acceptable safety profile in comparison with other epicardial approaches.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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Keywords

epicardial access; pericardial bleeding; ventricular tachycardia; VT ablation

1 | INTRODUCTION

Ventricular tachycardia (VT) often complicates later stages of structural heart disease and is an important cause of sudden cardiac arrest.¹ Over the last decade, catheter ablation has emerged as an important option to treat sustained VT and has significantly improved the outcome of patients with VT. Despite advances in endocardial catheter ablation techniques, electroanatomic mapping, and imaging, VT recurrence is still common, especially in complex nonischemic substrates such as arrhythmogenic right ventricular dysplasia (ARVD/C) and sarcoidosis. One of the reasons for failure of endocardial ablation is the presence of epicardial reentrant circuits, which are not easily accessed via the endocardial approach. In the 1990s, Sosa et al. described the percutaneous posterior subxiphoid approach to the epicardial space in patients with Chagas cardiomyopathy.² Until this time, the epicardial space was not utilized for mapping and ablation of VT. Since then, the epicardial mapping and ablation are becoming increasingly important in the catheter ablation of VT in both ischemic and nonischemic cardiomyopathies.^{3–8} While success rates for epicardial ablation have improved outcomes,³ the associated complication rates continue to range between 4% and 10%,^{3,9} including significant pericardial bleeding, inadvertent right ventricular (RV) puncture, and emergent cardiac surgery.

Anatomically, a potential window exists lateral and just beneath the xyphoid bone where puncturing may directly access the fibrous pericardium without going through the diaphragm.¹⁰ This so called “Anterior approach” to epicardial access is performed via puncturing this potential space. Additionally, consistent with Archimedes’ principle of buoyancy, increased accumulation of pericardial fluid has been noted in the region anterior to the right ventricle (RV) of nonsurgical hearts in the supine position.^{11,12} In the supine position, the pericardial fluid tends to accumulate anteriorly. Gale et al. showed in a series of 68 patients with pericardial effusion that the fluid was located solely or predominantly anterior to the RV. Additionally, heart muscle is relatively heavier than normal saline and effusion. Therefore, in the supine position, this forces the fluid anteriorly (Fig. S1A). The increased pericardial fluid in the anterior part of RV may facilitate easier and safer anterior epicardial access; however, this has not been reported.

In this report, we describe in detail the anterior approach to pericardial access in 103 consecutive patients undergoing epicardial VT ablation. A secondary goal is to compare the success of access and the complications associated with this approach to the published literature on the posterior approach. We hypothesized that an anterior pericardial approach in combination with a preprocedural contrast-enhanced high-resolution cardiac computed tomography (CT) or cardiac magnetic resonance imaging (CMR) may yield fewer complications while maintaining a high success rate.

2 | METHODS

2.1 | Study population

One hundred and three consecutive patients with structural heart disease who were referred for electrophysiology study and ablation of ventricular arrhythmias using an endo-epicardial approach between 2009 and 2016 were included in this study. In all patients, epicardial access was a planned procedure and the majority of patients failed at least one prior endocardial ablation. All patients had periprocedural imaging either with multidetector computed tomography (MDCT) or magnetic resonance imaging (CMR). We retrospectively compared their outcomes to two previously reported series of patients who underwent epicardial access using the needle-in-needle (NIN)³ and Sosa² techniques. Informed consent was obtained from all patients and the study was approved by the Institutional Review Board at Johns Hopkins Hospital.

2.2 | Pericardial access

In each of the patients, a preprocedural contrast-enhanced MDCT of the heart or CMR was performed to prospectively evaluate the thoracic anatomy and guide the route for epicardial access (Fig. 1). Anticoagulation was held for > 24 hours in case of a direct thrombin inhibitor and for 4–5 days in the case of warfarin. Heparin was held for at least 6 hours prior to the access. In patients with documented RBBB morphology VTs where LV access was anticipated, epicardial access was obtained prior to left-sided access to avoid access during full anticoagulation. Endocardial LV access, when required, was obtained via transseptal approach in all patients. Following the epicardial access, complete biventricular VT mapping was performed.

Anterior technique of epicardial access—The differences in the point of entry and the trajectory of the needle for the anterior and the posterior access methods are shown in Figure 1A–D. Epicardial access was attempted under biplane fluoroscopy. An AP and lateral projection was used to have orthogonal views of the epicardial needle. Under fluoroscopic guidance and a small subxiphoid dermatomy, an epidural introducer needle (Tuohy Needle, Braun Inc, Bethlehem, PA, USA) was aimed at an approximate angle of 20° towards the anterior RV silhouette (Fig. 2A). In contrast to the NIN approach,³ a micropuncture needle was not employed. Upon advancing close to the anterior RV silhouette, a few milliliters of contrast medium were injected to demonstrate tenting of the pericardium (Fig. 2B). Using tactile feedback and fluoroscopic guidance of entry into the pericardial space, the pericardium was punctured. Contrast medium was injected to confirm the position of the needle tip within the pericardial space (Fig. 2C). A Bentson 0.35-inch J-tipped floppy guide wire (Cook Medical, Bloomington, IN, USA) was advanced into the pericardial space (Fig. 2D). Typically, trace amounts of dependent pericardial fluid in the anterior RV facilitated this access. After the guide wire was advanced in the pericardium across multiple cardiac chambers to confirm absence of inadvertent RV access, a long deflectable 8-French sheath with dilator (Agilis, St. Jude Medical, Minneapolis, MN, USA) was advanced over the guide wire into the pericardial space. Extraction of clear pericardial fluid indicated absence of myocardial injury (Fig. 2E). After stable placement of the sheath in the pericardial space, the guide wire was replaced with either an ablation or a multipolar mapping catheter. An

irrigated ablation catheter (Biosense Webster) was used for epicardial ablation in all patients. Pericardium was aspirated through the same sheath every 4 minutes during ablation after interrupting the ablation. The sheaths used in the pericardial space do not allow for air entry; as such, it creates negative pressure as fluid is being aspirated. Following completion of ablation, the pericardium was aspirated to dryness. Methylprednisolone (125 mg) was diluted in 10 mL on normal saline and injected through the Agilis pericardial sheath with the ablation catheter in place to avoid the dead space in the sheath. Following this, the catheter and the sheath were removed en bloc and the skin incision was covered with sterile gauze. Pericardial drain was considered only if continued bleeding occurred with the pericardial fluid continued to be hemorrhagic at the end of the procedure.

2.3 | Outcomes

The following outcomes in the present study were retrospectively compared with those reported for the NIN and Sosa techniques³: (1) successful epicardial access; (2) incidence of pericardial bleeding, defined as >80 mL of estimated pericardial blood loss with or without evidence of tamponade; (3) composite incidence of any other acute or delayed complications related to epicardial access, including subdiaphragmatic vessels, liver, abdominal viscera, or coronary artery injuries.

2.4 | Statistical analysis

Statistical analysis was performed with STATA v13 (StataCorp LP Inc., College Station, TX, USA). Continuous variables are reported as mean $\pm$ SD for normally distributed values. Mean values were compared using the Student's *t* test. To test for associations between categorical variables, the χ^2 test or Fisher exact test was used. A two-tailed P value less than 0.05 was considered significant.

3 | RESULTS

3.1 | Baseline characteristics (Table 1)

Of the 103 consecutive patients referred for epicardial VT ablation between 2009 and 2016, preprocedural CT evaluation revealed a long xiphoid process (Fig. 3A), distended transverse colon (3B–C), or significant hepatomegaly (3D) in 3 patients. Based on these findings, these were deemed not suitable for percutaneous epicardial access (Anterior, NIN, or Sosa techniques) and excluded from our study. Surgical assistance was required to successfully gain epicardial access in these patients.

The final anterior approach series comprised 100 patients (Table 1). The number of epicardial access procedures gradually increased over the study period (Fig. 4). Their outcomes were compared with reported outcome of 314 patients who underwent epicardial VT ablation using Sosa (*n* = 291) or NIN (*n* = 23) techniques.³ The anterior approach patients were significantly younger compared with Sosa and NIN series (*P* = 0.0001). Arrhythmogenic right ventricular dysplasia/cardiomyopathy (ARVD/C) was the most common diagnosis, followed by nonischemic cardiomyopathy, and sarcoidosis in the anterior approach series. No patient had prior cardiac surgery or sternotomy in our series. Ten subjects were on chronic anticoagulation, which was stopped for the procedure.

3.2 | Outcomes and complications

The outcomes and complications of pericardial access in this study are shown in Table 2. Epicardial access was successfully obtained in all patients in the first attempt. We did not observe any significant epicardial bleeding >80 mL in our series. None of the patients who underwent epicardial VT ablation using the anterior approach required urgent/emergent open heart surgery. No procedure related mortality was noted in our cohort of 100 patients.

The rate of successful epicardial access—Epicardial access was successfully obtained in all 100 patients using the anterior approach, which was significantly higher than the Sosa technique ($P = 0.012$), but it was similar to the NIN technique (P value not significant).

Pericardial bleeding—No major pericardial bleeding was noted in the anterior approach series. In comparison, major pericardial bleeding was reported in 28 out of 316 procedures performed with the Sosa technique (8.9%, $P = 0.002$) and two out of 23 procedures performed with the NIN technique (8.7%, $P = 0.0031$).

Need for an emergent cardiac surgery—Kumar et al. reported that of 297 patients in whom epicardial access was performed using the Sosa technique, 5 patients (1.7%) required an emergent cardiac surgery, including 4 patients due to RV perforation and 1 patient due to coronary artery laceration. This was not significantly different from the rate of emergent cardiac surgery in the anterior approach series. Similarly, none of the patients in the NIN series required an emergent cardiac surgery.

Mortality related to epicardial access—Of 100 patients who underwent anterior approach epicardial access, no procedure related mortality was noted. In a series of patients who underwent epicardial access using the Sosa technique, 3 patients suffered from procedure-related death (2 due to RV laceration and 1 due to postprocedure pulmonary embolism). The higher mortality rate in the Sosa series did not reach statistical significance when it was compared with the rate of mortality in the anterior approach or NIN series ($P = 1.0$).

Hospital course—Mean duration of hospitalization was 1.3 ± 1.6 days in our series. Patients who underwent an elective procedure had significantly shorter hospital stay compared with patients who had been hospitalized prior to their ablation (1.1 ± 0.7 days vs. 2.3 ± 1.1 days, $P = 0.046$). Sixty-seven percent of the patients were discharged after overnight stay. Self-limiting pericarditis was seen in all patients undergoing VT ablation using anterior approach. Only 2 subjects eventually needed colchicine on discharge. One subject had protracted pericardial pain requiring prolonged hospitalization (5 days). Extensive pericardial injury due to a splayed sheath was suspected to be the underlying cause (Fig. 4D). The remaining patients were discharged home on nonsteroidal analgesic agents (NSAID). None of the patients required long-term NSAID or colchicine therapy for the management of pericarditis. The rate of pericarditis was not reported in prior case series.

4 | DISCUSSION

The conventional posterior epicardial access aims to enter the pericardium adjacent to the inferior wall. This makes the angle of entry steeper and hence there is a higher reported risk of injury to the diaphragm and the liver.¹⁰ More recently, an anterior approach for pericardial access has been reported in a few cases of epicardial VT ablation⁹ and is gaining significant acceptance. However, little is known about the success and complication rates of the anterior approach compared to the traditional posterior approach during the VT mapping and ablation. In this study, we report our experience with the anterior epicardial access in 100 consecutive patients. In this prospective consecutive series of patients undergoing epicardial VT ablation, anterior epicardial access appears to be feasible and devoid of significant complications.

Posterior epicardial approach for VT ablation has been utilized for more than a decade. In the first series of 3 patients described by Sosa,² no complications, including pericardial effusion, were reported. In the extended experience of their group with 215 consecutive patients undergoing epicardial VT ablation using the posterior approach,⁵ they reported hemopericardium in 7% of the cases requiring drainage and occlusion of a coronary marginal branch, resulting in a non-Q wave myocardial infarction in one patient. In another multicenter safety study,¹³ among 121 patients requiring epicardial VT ablation, posterior epicardial access was associated with 5% acute major complications, including 7 cases of epicardial bleeding and 1 case of coronary stenosis.

In the past few years, the Lariat appendage closure device has been deployed using an anterior pericardial approach in patients with atrial fibrillation. The reported rate of pericardial effusion and bleeding has been relatively high and up to 20% of subjects required pericardiocentesis.¹⁴ These data are hard to extrapolate to the epicardial VT ablations since these are completely different procedures with unique patient populations. Current discussions on epicardial access complications still use data from these studies to assess risks of the epicardial ablation procedure during the VT ablation. As such, epicardial ablation is usually reserved as a last resort in the management of VT. Our results show a much lower risk of complications using the anterior approach, which may influence the decision making for the patients in favor of an early epicardial ablation strategy.

Most centers use periprocedural MDCT or late gadolinium-enhancement cardiac magnetic resonance (LGE-CMR) imaging for electroanatomic mapping.^{15,16} These imaging modalities are very helpful in delineating the structural relationship of pericardium with other chest and abdominal organs. Our results suggest that integration of subxiphoid space anatomy obtained from these imaging modalities into decision making of epicardial access may decrease the rate of complications from the pericardial access, although this needs to be explored in a separate study.

Another interesting observation in this study was a statistically lower rate of pericardial bleeding in the anterior approach series in comparison to the two other series. Differences in patient characteristics are a possible explanation for this discrepancy. Our study included much younger patients, and the majority of the patients were not on anticoagulants. The LV

endocardium was not mapped in all the ARVD/C patients and so no heparin was administered during the procedure, which may have further reduced the bleeding rate.

Finally, although it is possible that posterior epicardial access may provide a better access to the certain parts of the left ventricle, we did not face any difficulty in detailed biventricular mapping in all patients, including those did not have right ventricular VT. Once within the pericardial space, the point entry in the angle of the RV makes it easier to move the deflectable sheath in an anterior or posterior direction.

5 | LIMITATIONS

This is a single-center study primarily in younger patients with nonischemic cardiomyopathy without prior cardiac surgery. The younger age of patients in this cohort is partially due to higher number of ARVD/C patients in our study. Similar to the conventional approach, the anterior pericardial approach may be more challenging in post-surgical hearts. The distribution of pericardial fluid in the supine position has been noted to change after cardiac surgery. Further, we performed a retrospective comparison with published reports on the NIN and Sosa techniques. Although these studies were performed at tertiary centers by experienced hands, a direct comparison between anterior and posterior approaches should be performed in future studies.

6 | CONCLUSION

Anterior pericardial approach was successful in all patients after exclusion of a few patients with high-risk anatomy diagnosed on preprocedure CT imaging. Furthermore, there were no major complications associated with anterior epicardial access. These findings are consistent with our hypothesis that anterior epicardial access in nonsurgical hearts may be facilitated by the anteriorly distributed pericardial fluid in the supine position. Overall, anterior epicardial approach is safe and effective for ablation of VT. Potential complications may be avoided by preprocedural imaging evaluation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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FIGURE 1.

Anterior versus posterior pericardial access. Figure 1A and 1B show the traditional posterior epicardial access. Figure 1C and 1D show the potential window that exists just beneath and lateral to the xyphoid bone where puncturing may directly access fibrous pericardium without going through diaphragm [Color figure can be viewed at wileyonlinelibrary.com]

FIGURE 2.

Anterior epicardial access. In (A), Under fluoroscopic guidance (AP and lateral), an epidural introducer needle was aimed towards the anterior RV silhouette with a 20 degree angle. Line shows the location of the xyphoid process in the patient. Upon advancing close to the anterior RV silhouette, a few milliliters of contrast medium were injected to demonstrate tenting of the pericardium (B). Contrast medium was injected to confirm the position of the needle tip within the pericardial space after pericardium as punctured (C). A guide wire was advanced into the pericardial space (D). Extraction of clear pericardial fluid indicated absence of myocardial injury (E) [Color figure can be viewed at wileyonlinelibrary.com]

FIGURE 3.

Anatomical variations preventing percutaneous epicardial access. Of the 103 patients referred for epicardial VT ablation, preprocedural CT evaluation revealed a long xiphoid process (A), distended transverse colon (B–C), or significant hepatomegaly (D) in 3 patients. (E) shows the fluoroscopy image of a splayed catheter during the epicardial VT ablation. This occurred during introduction of the sheath over the guide wire into the pericardial space. This was the result of excessive resistance encountered in the skin and subcutaneous tissue. The damaged sheath was exchanged with a new sheath

FIGURE 4.

Trend in epicardial access. Number of epicardial ablation procedures increased from 2009 to 2016. *Until June 2016 [Color figure can be viewed at wileyonlinelibrary.com]

Patient characteristics. Basic characteristics of patients who underwent VT ablation using Anterior approach (JHH) in comparison with reported characteristic of patients whom underwent VT ablation using Sosa and NIN techniques

TABLE 1

Patient Characteristics	JHH	Sosa	Sosa versus JHH (P Value)	NIN	NIN versus JHH (P Value)
Number of cases	100	316		23	
Male (%)	59	78	0.0002	65	0.59
Age (years)	41 ± 19	56 ± 15	<0.0001	58 ± 17	0.0001
Body mass index (kg/m ²)	27 ± 3	28 ± 5	0.058	30 ± 7	0.0017
Etiology of HD (%)					
Ischemic	4	25	<0.0001	13	0.094
Nonischemic	96	75	<0.0001	87	0.094
Idiopathic	17	23	0.20	26	0.32
ARVD/C	69	na		na	
Sarcoidosis	10	na		na	

Outcomes and complications. Outcome and complications of procedure performed using Anterior approach (JHH) compared to the reported outcome and complications of procedure performed using Sosa and NIN techniques

TABLE 2

Outcome and Complications	JHH	Sosa	Sosa versus JHH (P Value)	NIN	NIN versus JHH (P Value)
Successful epicardial access	100/100 (100%)	297/316 (94%)	0.012	23/23 (100%)	1
Any pericardial bleeding > 80 mL	0/100 (0%)	28/316 (8.9%)	0.002	2/23 (8.7%)	0.0031
Estimated blood loss (mL) (median [range])	10–50 (30)	160 (80–300)	na	170 (100–240)	na
Need for emergent cardiac surgery for pericardial bleeding	0/100 (0%)	5/297 (1.7%)	0.19	0/24 (0%)	1
Other complications related to pericardial access	0/100 (0%)	8/316 (2.5%)	0.11	0/24 (0%)	1
Procedure-related mortality	0/100 (0%)	3/297 (1%)	0.31	0/23 (0%)	1