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Utilization of Coronary Venous Ethanol Ablation for Intramural Ventricular Arrhythmias in Two Different Scenarios: A How-To Approach

İki Farklı Senaryoda İntramural Ventriküler Taşikardiler için Koroner Venöz Etanol Ablasyonunun Kullanımı: Nasıl Yaklaşalım?

HOW TO?
NASIL YAPALIM?

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Ventricular arrhythmias (VAs) present a significant challenge in clinical practice, often requiring catheter-based interventions for effective management.[1] While radiofrequency (RF) ablation is a well-established treatment modality, its efficacy may be limited by anatomical constraints and intramural locations where RF energy penetration is inadequate. In such cases, alternative approaches are essential to achieve successful ablation and improve patient outcomes.[2,3]

How to Approach Intramural/Epicardial Outflow Tract Ventricular Arrhythmia (VA) Ablation?

Identification of the intramural substrate is one of the critical steps in managing these arrhythmias. Pre-procedural imaging may provide clues about the localization of the arrhythmic focus based on gadolinium enhancement observed on cardiac magnetic resonance imaging.[4] Further clues can be derived from surface electrocardiograms[5,6] (Table 1). In cases of outflow tract VAs, the inability to find adequate precocity on endocardial map is not uncommon. Nevertheless, first-line endocardial unipolar ablation, including ablation with half-normal saline and a "waiting-period" for potential late elimination, are generally preferred for intramural or epicardial outflow tract VAs. Auxiliary techniques, such as venous ethanol ablation and bipolar ablation, are reserved as rescue options.[7]

Ethanol ablation has emerged as a promising alternative for treating refractory ventricular arrhythmias, particularly those arising from challenging anatomical sites or intramural locations.[8–10] By directly infusing ethanol into the target tissue, this technique creates transmural lesions and effectively disrupts arrhythmogenic foci. The following are two cases illustrating different clinical scenarios in which venous ethanol ablation was successfully performed.

Case Report

Case 1: Ethanol Ablation of Annular Vein for Intramural Ventricular Tachycardia (VT)
A 49-year-old female presented with recurrent episodes of premature ventricular complexes (PVCs) and ventricular tachycardia (VT) refractory to antiarrhythmic medication. The daily burden was 55,000 ventricular beats, with fast VT episodes (180–200

Table 1. Clues Suggesting an Intramural/Epicardial Origin of Outflow Tract Ventricular Arrhythmias (VAs)

Electrocardiogram (ECG) criteria: Pseudo-delta wave >56 ms Maximum deflection index >0.55 Shortest RS complex duration >157 ms V2 pattern break Abrupt R-wave transition in V3
Pre-procedural cardiac magnetic resonance imaging revealing an intramural or epicardial focus
Absence of adequate precocity on endocardial mapping for focal VAs, or absence of a diastolic component in the reentrant circuit
Recordings from coronary veins indicating an intramural source of origin

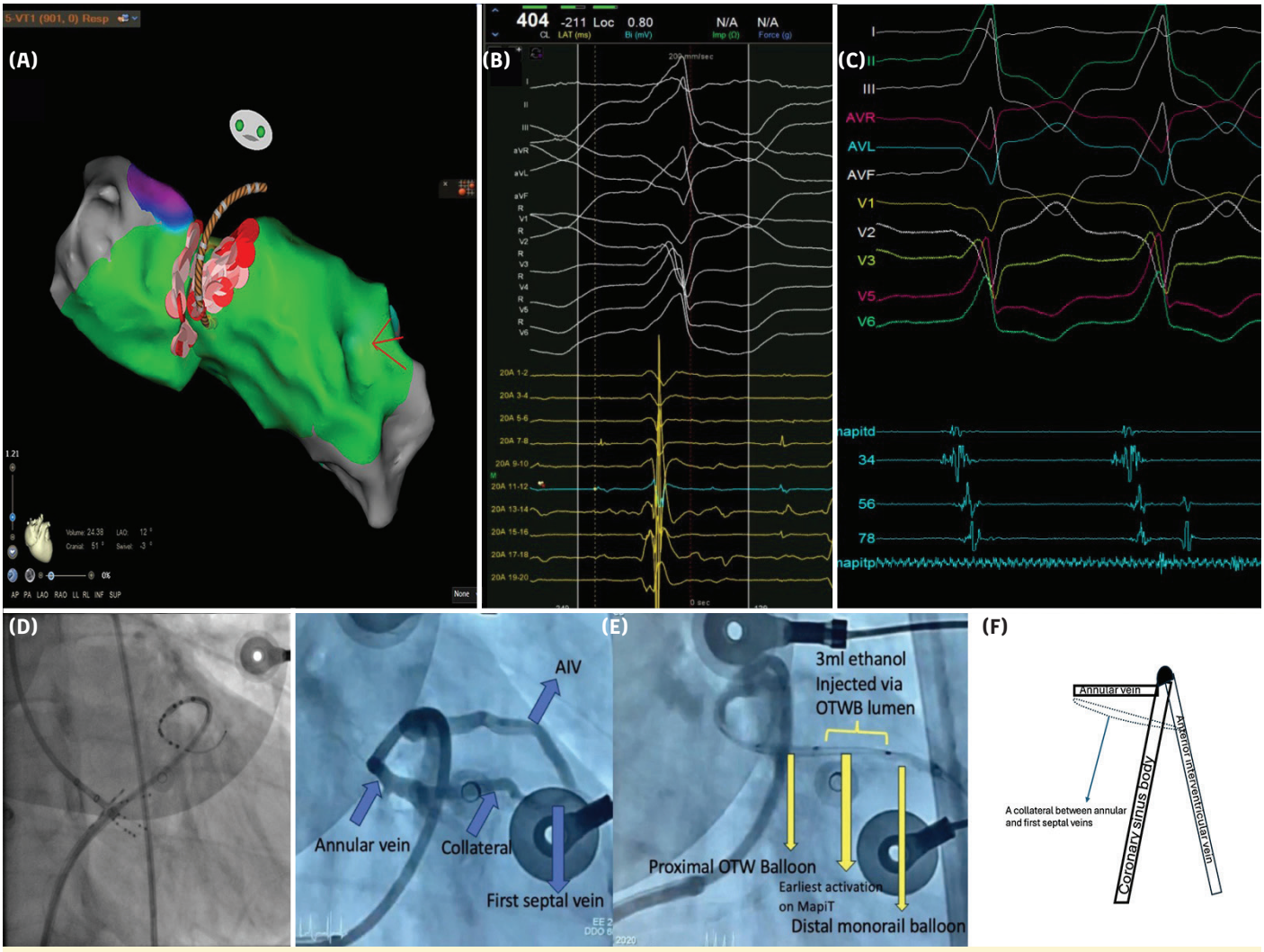

Figure 1. (A) Endocardial activation map of the supravalvular and subvalvular left ventricular outflow tract (LVOT) using the Carto 3 electroanatomic mapping system (Biosense-Webster, CA, USA). (B) The earliest endocardial signal identified was a far-field signal. Extensive ablation at that site did not suppress the arrhythmia. (C) The Map-iT catheter (placed inside the annular and the collateral vein towards first septal vein) demonstrated 50 ms of precocity (electrodes 3-4) within the collateral vein (D) Fluoroscopic image of Map-iT catheter inside the collateral vein. (E) Using a double-balloon technique, with a monorail balloon placed distally, 3 mL of ethanol was injected through the lumen of a proximally placed over-the-wire balloon. Complete elimination of the arrhythmias was observed within 10 minutes. (F) Schematic depiction of coronary venous system.

bpm) lasting up to five minutes. During the initial presentation, the patient underwent anatomical ablation with long-duration RF lesions, but this was unsuccessful. The patient was monitored for one month to observe possible late elimination, which did not occur. Subsequently, a second procedure was scheduled. Electroanatomical mapping using the Carto 3 system (Biosense-Webster, CA, USA) and Pentaray (Biosense-Webster, CA, USA) and SmartTouch SF catheters (Biosense-Webster, CA, USA) identified the origin of VT within the intramural outflow tract (Figure 1A). The earliest activation, at 30 milliseconds, appeared as a far-field signal below the left ventricular outflow tract (LVOT) near the interleaftlet triangle (ILT) (Figure 1B). Long-duration RF ablation (35–40 watts for at least 60 seconds with > 10% impedance drop) of this and adjacent tissue was performed again but was unsuccessful. Given the anatomical constraints, the decision was made to proceed with ethanol ablation via the annular vein.

Under fluoroscopic guidance, venography of the coronary sinus was performed to define the venous anatomy. Venography revealed an annular vein with a collateral connection to the first septal vein. A 3.3 F decapolar Map-iT catheter (Access Point Technologies EP, MN, USA), placed via a 6F Judkins Right (JR) guiding catheter, revealed 50 milliseconds of precocity (bipolar electrodes 3–4) (Figure 1C, D). The Map-iT catheter was then removed, and two 0.014-inch coronary guidewires were advanced to the first septal vein and the anterior interventricular vein via the annular vein. Using a double-balloon technique, a 3.0 x 8 mm monorail balloon was placed distally, and 3 mL of ethanol was injected via the lumen of a proximally placed 2.5 x 8 mm over-the-wire balloon (Figure 1E). Within a few seconds, the VT terminated. Occasional PVCs with a similar morphology were observed but disappeared completely within 10 minutes after the infusion. The post-procedural follow-up was uneventful. Two months after the procedure, the patient

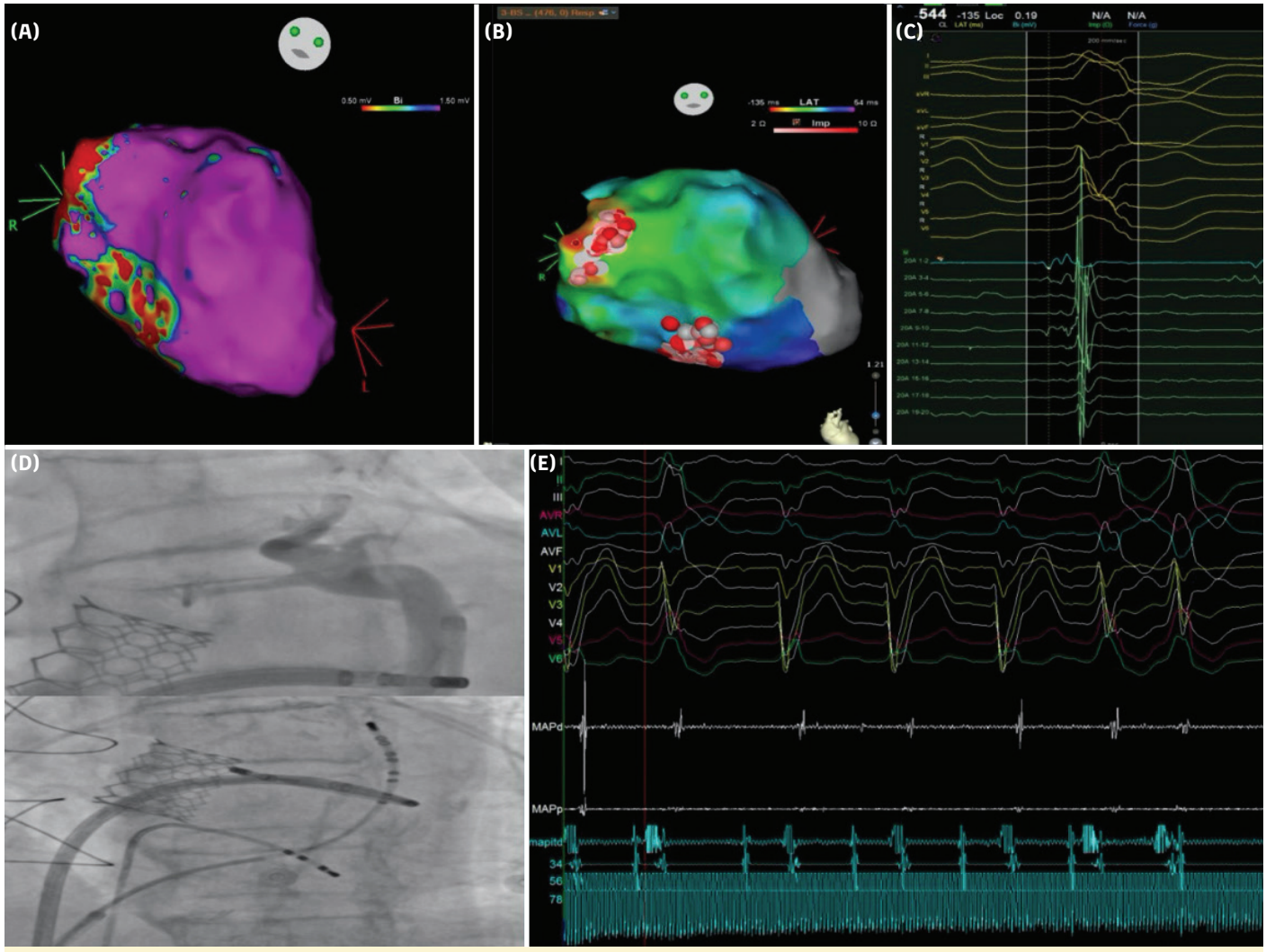

Figure 2. (A) Endocardial bipolar voltage mapping revealed a discrete area of low voltage in the inferior left ventricle (LV), likely related to a previous myocardial infarction. (B) The activation map of the targeted premature ventricular contraction (PVC) showed far-field activation immediately beneath the prosthetic aortic valve. Also shown are the lesions in both the inferior low-voltage area, where scar modification was performed, and the subvalvular LVOT, where early far-field (C) activation was observed. Endocardial ablation failed to suppress the PVC. (D, E) Coronary sinus venography showed an annular vein, which was cannulated using the Map-iT catheter. The distal bipolar signals demonstrated 52 ms of pre-QRS. Injection of 3 mL of ethanol via the lumen of an over-the-wire balloon completely suppressed the arrhythmia.

remained asymptomatic. A 24-hour Holter electrocardiogram (ECG) revealed fewer than 500 PVCs with no ventricular runs, and the patient was not on any antiarrhythmic therapy, including beta-blockers. The patient was informed about the study procedure and provided written consent for the procedure.

Case 2: Ethanol Ablation in the Setting of a Prosthetic Valve

A 77-year-old male with a history of transcatheter aortic valve replacement (TAVR) in 2020, myocardial infarction, and an ejection fraction of 40% presented with symptomatic PVCs. Despite the presence of at least three different PVC morphologies on a three-channel Holter ECG, the 24-hour recording revealed a total of 45,000 ventricular ectopies. The patient was scheduled for catheter ablation. During the procedure, multimorphic PVCs were observed, but a dominant morphology consistent with a left ventricular (LV) summit exit was identified and targeted. Using antegrade access to the LV, an endocardial bipolar voltage map revealed a discrete area of low voltage in the inferior LV, likely due to a prior myocardial infarction. (Figure 2A). Activation mapping of the targeted PVC demonstrated far-field precocity in the ILT, in direct contact with the prosthetic valve. Initial attempts at extensive RF ablation (30–35 watts) using a SmartTouch SF RF catheter were unsuccessful due to the far-field nature of the signals and the proximity to the prosthetic valve (Figure 2B). Given these challenges, ethanol ablation via the annular vein was pursued as an alternative approach.

Following coronary sinus venography to delineate the venous anatomy, a 3.3 F decapolar Map-iT catheter was used to cannulate the vein. Distal bipolar signals were recorded as 52 milliseconds pre-QRS. Using a similar technique, albeit with a single 2.5 x 8 mm over-the-wire balloon placed via a 6F JR guiding catheter, 3

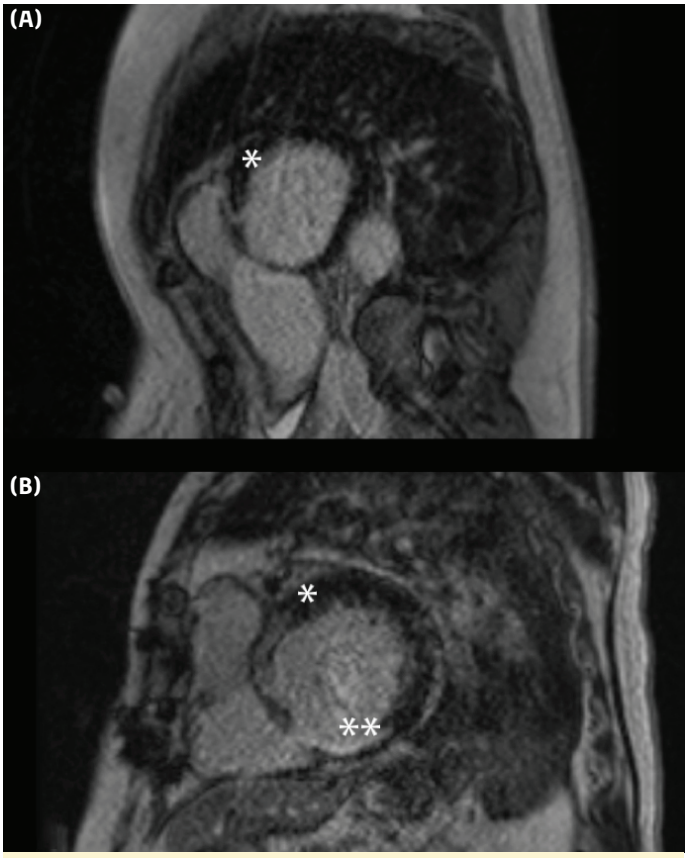

Figure 3. Cardiac magnetic resonance imaging of patients following ethanol ablation. (A) In the first case, minimal gadolinium enhancement was observed in the basal anterior septum, marked by an asterisk (*). (B) In the second case, two discrete areas of late gadolinium enhancement were identified. The first area, marked by a single asterisk (*), showed gadolinium enhancement in the basal anteroseptum. The second area, marked by a double asterisk (*), demonstrated transmural gadolinium enhancement in the inferior wall, attributed to a previous myocardial infarction and subsequent scar homogenization with radiofrequency ablation.

mL of 96% ethanol was infused under pressure monitoring, with careful balloon inflation to deliver ethanol to the arrhythmogenic focus (Figure 2C–E). The targeted PVC morphology was abolished, but PVCs with different morphologies persisted at a low frequency, making activation mapping impossible. As a result, these other morphologies were not targeted. Additionally, the inferior scar from the patient's prior myocardial infarction was homogenized. The follow-up was uneventful. Thirty days after the procedure, there was a significant (>50%) reduction in the burden of ventricular ectopy, with approximately 20,000 ectopies recorded over 24 hours, without any antiarrhythmic therapy other than metoprolol.

Thirty days after the ethanol ablation, cardiac magnetic resonance imaging with gadolinium contrast revealed discrete areas of late enhancement in the periaortic region in both patients, as well as transmural inferior enhancement due to a prior infarction in the second patient (Figure 3). The patient was informed about the study procedure and provided written consent to participate.

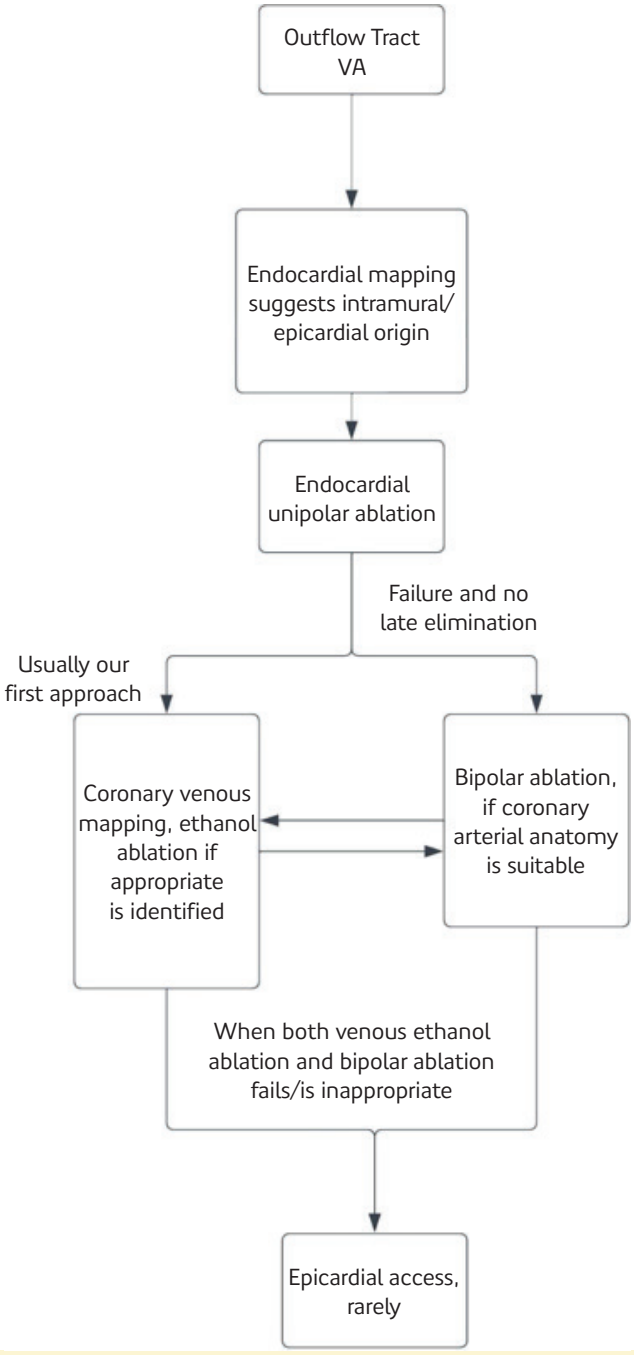

Figure 4. Approach to the management of intramural and epicardial outflow tract ventricular arrhythmias (VAs).

Discussion

The presented cases illustrate the utility of venous ethanol ablation using either a double or single balloon system for the management of refractory ventricular arrhythmias in complex anatomical scenarios. Retrograde venous ethanol ablation provides access to intramural sites and challenging anatomical locations that are otherwise inaccessible via conventional endocardial approaches. This technique was first described by Wright et al.[11] in dogs and was later applied to ablation-refractory Vas, with the first report in 2012 documenting two

Table 2. Potential Complications of Coronary Venous Ethanol Ablation and Suggested Management Strategies

Complication	Preventive Measures and Management
Pericardial Effusion/Tamponade	Early or late-onset pericardial effusion or tamponade may occur. Management depends on severity; pericardiocentesis may be necessary in some cases.
Atrioventricular Block	Temporary or permanent atrioventricular block may arise, most likely due to damage to the conduction system. However, the probability of this complication is very low.
Pericarditis	Typically presents as pericardial chest pain following the procedure. Recommended management includes corticosteroids and non-steroidal anti-inflammatory drugs.
Coronary Sinus/Vein Dissection	Usually of no clinical significance but may prevent ethanol infusion.
Ethanol Spillage into Systemic Circulation	Generally of no clinical consequence. To prevent this complication, the operator should ensure proper balloon positioning and confirm that the vein is fully occluded.
Anaphylaxis	A rare but life-threatening condition. It should always be suspected when hypotension occurs without evidence of pericardial effusion. Under general anesthesia, hypotension may be the sole presenting sign. Anaphylaxis should be managed according to established treatment protocols.

cases of intramural VA.[8] The primary factor determining the success of ethanol ablation is the presence of intramural veins at the targeted site and their suitability for cannulation. While the basic technique involves ethanol infusion into a vein via the lumen of an over-the-wire balloon, advanced techniques are required when the targeted vein is large or has collateral branches that could result in systemic dissemination. In the double-balloon technique, ethanol is administered through the lumen of one over-the-wire balloon, while a second balloon is positioned distally to confine the ethanol to the intramural branches located between the balloons and prevent its systemic dissemination. The use of a double-balloon system offers an effective option for managing large veins with collaterals, optimizing the success of the procedure.[12,13] This approach, however, is labor-intensive and requires a high level of technical expertise.

Ethanol ablation provides several advantages over RF ablation, including the ability to achieve deeper tissue penetration and create transmural lesions. Alternatives such as epicardial ablation and bipolar ablation are also viable options. However, epicardial ablation may be limited by the proximity of coronary arteries and the presence of abundant overlying fat tissue. Bipolar ablation, on the other hand, produces deeper lesions compared to unipolar ablation and serves as a valuable alternative technique. However, bipolar ablation is occasionally limited by the proximity to coronary arteries and the inherited risk of complications. In contrast, the ability to deliver ethanol via venous access reduces the risk of collateral damage to adjacent structures by enabling a targeted approach. Nevertheless, careful patient selection and thorough procedural planning are crucial to mitigate the risk of complications, particularly in cases involving critical structures or prosthetic valves. Additionally, the presence of a suitable coronary vein with appropriate signals is essential for the success of any venous ethanol ablation procedure. Figure 4 illustrates our approach to the treatment of intramural or epicardial VAs.

Complications of Venous Ethanol Ablation

Coronary venous ethanol ablation appears to be a relatively safe procedure based on the available data; however, operators must remain vigilant about potentially serious complications.[13,14] These complications and their recommended management strategies are outlined in Table 2.

Conclusion

Venous ethanol ablation using a single or double-balloon system offers a safe and effective alternative for managing refractory ventricular arrhythmias in challenging clinical scenarios. Further studies are needed to clarify the optimal patient selection criteria, procedural techniques, and long-term outcomes associated with this approach.

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