Vascular Health and Risk Management

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Effectiveness and Safety of Radiofrequency Catheter Ablation Using Three-Dimensional Electroanatomic Mapping Systems in Treating Ventricular Arrhythmias: A Single-Center Prospective Cohort Study in Vietnam

Le Uyen Phuong Tran[1], Ngoc Dung Kieu[1], Cao Dat Tran[1], Tri-Thuc Nguyen[1], Van Sy Hoang[2], Truc Thanh Thai[3]

[1]Department of Arrhythmology, Cho Ray Hospital, Ho Chi Minh City, Vietnam; [2]Department of Internal Medicine, University of Medicine and Pharmacy at Ho Chi Minh City, Ho Chi Minh City, Vietnam; [3]Department of Medical Statistics and Informatics, University of Medicine and Pharmacy at Ho Chi Minh City, Ho Chi Minh City, Vietnam

Correspondence: Truc Thanh Thai, Department of Medical Statistics and Informatics, University of Medicine and Pharmacy at Ho Chi Minh City, 217 Hong Bang Street, Ward 11, District 5, Ho Chi Minh City, 700000, Vietnam, Tel +84 908381266, Email thaithanhtruc@ump.edu.vn

Purpose: Advanced catheter ablation using three-dimensional electroanatomic mapping (EAM) has shown favorable outcomes in high-income countries, but real-world evidence from low- and middle-income settings is scarce. This study aimed to assess the clinical characteristics, procedural features, and outcomes of radiofrequency ablation using EAM in patients with ventricular tachycardia (VT) or premature ventricular contractions (PVCs) at a tertiary cardiac center in Vietnam.

Methods: We analyzed 233 patients who underwent VT and PVC ablation at Cho Ray Hospital from March 2021 to December 2023. Patients were categorized into two groups based on left ventricular ejection fraction (LVEF) with the cut-off value of 50%: reduced (LVEF < 50%, n = 39) and preserved (LVEF ≥ 50%, n = 194). Data on demographics, arrhythmia burden, ablation protocol, and follow-up outcomes were collected and compared.

Results: Patients with reduced LVEF more frequently presented with ventricular tachycardia (23.1% vs 6.7%, p < 0.001), ischemic heart disease (23.1% vs 7.7%, p = 0.008), and were more likely to require irrigated catheters (46.2% vs 20.1%, p = 0.001). The PVC burden prior to ablation was significantly different between groups (36.3% ± 17.2 vs 27.8% ± 12.2, p = 0.014) and patients with reduced LVEF exhibited remarkable recovery after ablation, with LVEF improving from 33.7 ± 8.1 to 55.2 ± 9.1 ($p < 0.001$). The acute ablation success rate was 100% in both groups. The procedure demonstrated high levels of safety, with a non-severe complication rate of 4.7% (n = 11) and low radiation exposure (median 16 mGy [inter-quartile range: 11–26]).

Conclusion: Catheter ablation is highly effective and safe in treating ventricular arrhythmias across different LVEF, especially in ventricular arrhythmia-induced cardiomyopathy group, leading to rapid recovery of left ventricular function and reduction in arrhythmia burden. These findings provide important real-world evidence from a resource limited setting, providing multiple use of catheters and skin patches.

Keywords: safety, effectiveness, ventricular arrhythmias induced cardiomyopathy, radiofrequency catheter ablation, heart failure

Introduction

Premature ventricular contractions (PVCs) are one of the most frequently encountered arrhythmias in both healthy individuals and patients with structural heart disease.[1] Although traditionally considered as benign, particularly in the absence of overt cardiac pathology, frequent PVCs and and monomorphic ventricular tachycardia (VT) have increasingly been associated with the development of a distinct and potentially reversible form of left ventricular (LV) dysfunction

Received: 26 June 2025
Accepted: 5 September 2025
Published: 8 September 2025

known as ventricular arrhythmias induced cardiomyopathy (VAICM).[2,3] This subtype of heart failure is characterized by impaired LV function that is temporally and causally related to PVC and VT burden, and it has garnered growing recognition due to its reversibility with effective VA treatment.

The pathophysiology of VAICM is believed to involve several mechanisms, including mechanical dys-synchrony, abnormal calcium handling, and progressive adverse ventricular remodeling.[4] While a high PVC burden, commonly defined as more than 10% of total heartbeats, is considered a major risk factor, not all patients with frequent PVCs develop LV dysfunction.[5] These observations highlight the complexity of the disease and the need to better understand the clinical and electrophysiological factors that predispose certain individuals to developing VAICM. Suppression of ventricular arrhythmias (VA) has been shown to improve LV function and B-type natriuretic peptide (BNP) levels in VAICM, either through antiarrhythmic drugs or catheter ablation.[6] While antiarrhythmics have a discontinuation rate of 10% due to short- and long-term side effects and potentially decrease efficacy overtime, catheter ablation is not a risk-free invasive procedure for all types of patients, with complication rates reported between 5% to 8%, in addition to limited accessibility in resource-restricted areas.[7,8] Despite these insights, most evidence has been derived from high-income countries, and data from low- and middle-income settings remain scarce, leaving an important gap in understanding the applicability and outcomes of ablation in such contexts.

Catheter ablation has emerged as an effective treatment strategy for managing frequent PVCs and VT, particularly when pharmacological therapy is insufficient or poorly tolerated.[9] Ablation has demonstrated substantial improvements in left ventricular ejection fraction (LVEF), symptom burden, and long-term outcomes in appropriately selected patients.[10] However, differences in patient profiles, healthcare infrastructure, operator experience, and resource availability may influence both procedural success and clinical outcomes. Patients referred for ablation usually had experienced failure of previous longterm medical treatment while electrophysiologists constitute a minority. The cost procedure reduction solution including re-sterilization of catheters and multiple use of 3D skin patches in developing countries would affect the results, safety and outcomes. Therefore, generating context-specific evidence is essential to validate the generalizability of global guidelines and optimize care. However, whether similar improvements in LV function and arrhythmia control can be achieved in low-resource settings using advanced electroanatomic mapping systems remains unclear.

In Vietnam, radiofrequency catheter ablation for VA has become increasingly available in major cardiac centers, yet published data remain scarce. Limited access to three-dimensional mapping systems and variability in clinical practice underscore the need for real-world evidence to inform decision-making in this setting. This study aimed to evaluate the effectiveness and safety of radiofrequency catheter ablation using three-dimensional electroanatomic mapping systems in patients with ventricular arrhythmias, including those with and without LV dysfunction. By analyzing procedural parameters, VA burden, and changes in cardiac function following ablation, this single-center cohort study contributes real-world data from Vietnam and may help guide the management of VAICM in similar clinical settings.

Materials and Methods

Study Settings and Participants

This prospective cohort study included patients who underwent catheter ablation for PVCs and VT at Cho Ray Hospital, one of the largest tertiary referral centers in Vietnam, between March 2021 and December 2023. As a high-volume national hospital with a dedicated arrhythmia unit and access to advanced electrophysiological technologies, Cho Ray Hospital serves a diverse population from both urban and rural regions, providing a representative setting for real-world cardiac arrhythmia management. Eligible patients were those presenting with symptomatic PVCs/ VT or suspected VA-induced cardiomyopathy, defined by a high PVC burden documented on a 24-hour ambulatory Holter electrocardiogram prior to the procedure.[11] All participants underwent a comprehensive pre-procedural evaluation, including transthoracic echocardiography and coronary angiography, to exclude significant structural or ischemic heart disease. Patients with contraindications to catheter ablation were excluded. In cases where coronary artery lesions were detected, optimal revascularization and medical therapy was instituted before considering ablation.

Study Procedure

The catheter ablation procedures were conducted using the Ensite Precision™ electroanatomic mapping system (Abbott, St. Paul, MN, USA) which facilitated precise mapping of arrhythmogenic sites within the ventricles even with re-sterilized catheters and multiple use of 3D patches. To ensure accurate identification of PVC and VT foci, antiarrhythmic medications were discontinued for at least five half-lives prior to the procedure. Antiplatelet therapy was not interrupted while anticoagulants were withheld on the procedure day only. Mapping was performed directly using the ablation catheter, enabling real-time localization of arrhythmogenic areas. High-density mapping catheters HD-Grid (Abbott, St. Paul, MN, USA) were used only for substrate definition in patients with ischemic heart disease. Due to socio-economic constraint, catheters were re-sterilized up to 2 times and each 3D skin patches kit were used by 2–3 patients to reduce the cost and increase treatment access. The number of collected mapping points was carefully documented to ensure comprehensive coverage and accurate identification of the arrhythmic foci. Activation mapping was utilized for patients presenting PVCs and VT. The earliest activation location was targeted for focal VA and the whole critical isthmus was targeted for reentrant VA to effectively interrupt the arrhythmia.

Catheter ablation was performed using either irrigated-tip or non-irrigated-tip catheters, depending on the location of the arrhythmogenic foci, tissue characteristics. Ablation settings, including power and duration of energy delivery, were determined at the discretion of the operator, considering the nature of the arrhythmia and the patient's cardiac anatomy.[12,13] The primary procedural goal was the complete elimination of VA without causing injury to surrounding cardiac structures. Acute procedural success was defined as the absence of spontaneous or inducible clinical VA during 30 minutes post-ablation monitoring and pacing maneuvers.[14,15]

For patients who did not exhibit spontaneous PVCs or VT during the procedure, adrenaline (10–30 microgram) was administered to induce arrhythmias and facilitate accurate mapping (isoproterenol was not available in Vietnam). The same adrenaline protocol was also used post-ablation in all patients to test procedural efficacy, ensuring that PVCs or VT could no longer be provoked following ablation.

Follow-Up

Patients were scheduled for follow-up visits at 1 week, 1 month, and 3 months after the procedure. Clinical evaluations included assessment of arrhythmia-related symptoms and signs of heart failure. Echocardiography was performed at 3 months to evaluate left ventricular function, while 24-hour Holter ECG monitoring was repeated at 1 week and 3 months to quantify PVC burden and detect arrhythmia recurrence.

Measurement

The main outcomes of this study were the reduction in premature VA burden, improvement in LVEF, and the acute procedural success rate following radiofrequency catheter ablation. VA burden was assessed using a 24-hour ambulatory Holter electrocardiogram (ECG), while LVEF was evaluated through transthoracic echocardiography. Acute success was defined as the complete elimination of spontaneous or inducible PVCs or VT at the conclusion of the ablation procedure, as confirmed by pacing maneuvers and pharmacologic provocation. Other outcomes included changes in left ventricular end-diastolic and end-systolic dimensions. Outcomes were compared between patients with reduced versus preserved ejection fraction to explore differences in baseline characteristics and post-procedural responses.

Data Analysis

All statistical analyses were performed using Stata version 17.0. Continuous variables were expressed as mean ± standard deviation (SD) if normally distributed, or median with interquartile range (IQR) if not. Comparisons between two independent groups (patients with reduced vs preserved ejection fraction) were conducted using the independent *t*-test for normally distributed variables and the Wilcoxon rank-sum test for non-normally distributed variables. Categorical variables were expressed as frequencies and percentages and compared using the Chi-square test or Fisher's exact test where appropriate. Paired t-tests were used to compare data before and after ablation within the same group. A p-value of < 0.05 was considered statistically significant.

Results

The effectiveness of radiofrequency catheter ablation using three-dimensional electroanatomic mapping systems in reducing the burden of ventricular tachycardia and premature ventricular complexes, as well as improving left ventricular function, was demonstrated in our study. Despite multiple uses of 3D skin patches and re-sterilization of catheters, the safety of the procedure was confirmed. Detailed findings are presented in the following sections.

Baseline Patient Characteristics

Among 371 patients undergoing catheter ablation for PVCs and VT at the study hospital during the study period, 233 patients had 3D electroanatomic mapping and were included in data analysis (Figure 1). Of these, the mean age was 50.0 ± 13.7 years, with a predominance of females (67.4%). The median duration of VA-related symptoms prior to ablation was 12.0 (inter-quartile range (IQR) = 5.0–24.0) months. Common presenting symptoms included palpitations (70.4%), dyspnea (33.0%), and exertional dyspnea (24.5%), while 18.5% reported presyncope and 10.7% had experienced syncope. Notably, 36.1% of patients had hypertension, 25.8% had dyslipidemia, and 6.9% had diabetes mellitus. Structural heart disease was present in a small proportion of patients, including ischemic heart disease (10.3%), cardiomyopathy (5.6%), and congenital heart disease (2.1%). Most patients (95.7%) had no prior device implantation (Table 1).

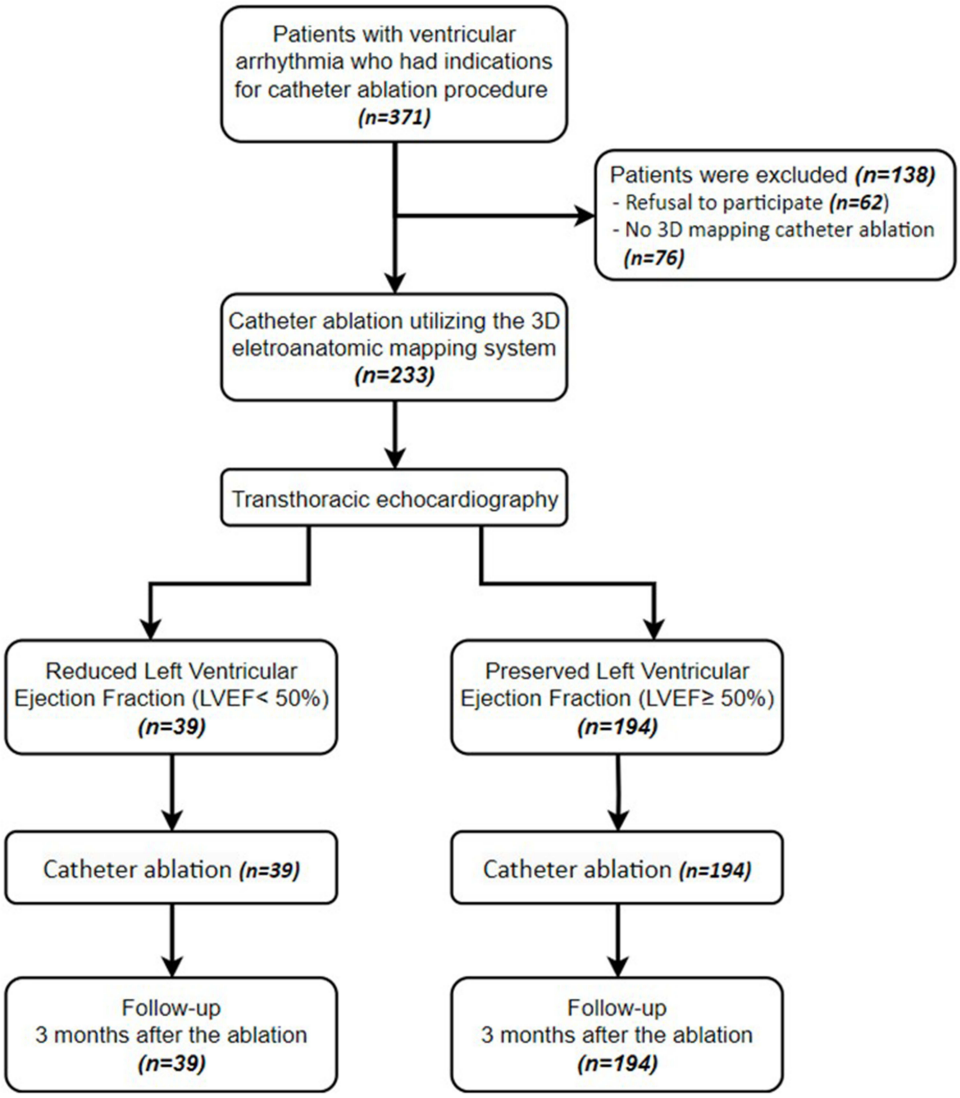

Figure 1 Flowchart of study recruitment and follow up.

Table 1 Baseline Clinical Characteristics of Patients Undergoing Catheter Ablation, Stratified by Left Ventricular Ejection Fraction (LVEF)

Patient Characteristics	Total (n=233)	Reduced LVEF (n=39)	Preserved LVEF (n=194)	p-value
Age (year), mean (SD)	50.0 (13.7)	50.4 (14.8)	49.9 (13.5)	0.829
Female, n (%)	157 (67.4)	21 (53.8)	136 (70.1)	**0.048**
Disease duration (month), median (IQR)	12.0 (5.0–24.0)	12.0 (4.0–24.0)	12.0 (5.0–24.0)	0.385
Symptoms, n (%)				
Palpitation	164 (70.4)	30 (76.9)	134 (69.1)	0.327
Dyspnea	77 (33.0)	16 (41.0)	61 (31.4)	0.246
Exertional dyspnea	57 (24.5)	16 (41.0)	41 (21.1)	**0.008**
Chest discomfort	43 (18.5)	12 (30.8)	31 (16.0)	**0.030**
Presyncope	25 (10.7)	8 (20.5)	17 (8.8)	**0.044**
Syncope	25 (10.7)	8 (20.5)	17 (8.8)	**0.044**
Hypertension, n (%)	84 (36.1)	16 (41.0)	68 (35.1)	0.478
Diabetes mellitus, n (%)	16 (6.9)	8 (20.5)	8 (4.1)	**0.001**
Dyslipidemia, n (%)	60 (25.8)	19 (48.7)	41 (21.1)	**<0.001**
Prior ablation, n (%)	9 (3.9)	2 (5.1)	7 (3.6)	0.648
Ischemic heart disease, n (%)	24 (10.3)	9 (23.1)	15 (7.7)	**0.008**
Coronary stenting, n (%)	24 (10.3)	9 (23.1)	15 (7.7)	**0.008**
Valvular heart disease, n (%)	2 (0.9)	0 (0)	2 (1.0)	0.999
Cardiomyopathy, n (%)	13 (5.6)	13 (33.3)	0 (0)	**<0.001**
Congenital heart disease, n (%)	5 (2.1)	1 (2.6)	4 (2.1)	0.999
Device implantation, n (%)				
None	223 (95.7)	33 (84.6)	190 (97.9)	**0.003**
Pacemaker	4 (1.7)	2 (5.1)	2 (1.0)	
ICD	6 (2.6)	4 (10.3)	2 (1.0)	

Note: Bold values indicate statistical significance at $p < 0.05$.
Abbreviations: SD, Standard Deviation; IQR, Interquartile Range; ICD, Implantable cardioverter–defibrillator; LVEF, Left Ventricular Ejection Fraction.

Patients were categorized into two groups: those with reduced LVEF (n = 39) and those with preserved LVEF (n = 194). Although both groups had similar ages (50.4 ± 14.8 vs 49.9 ± 13.5 years, p = 0.829), the reduced LVEF group had fewer female patients (53.8% vs 70.1%, p = 0.048). Cardiovascular risk factors such as diabetes (20.5% vs 4.1%, p = 0.001) and dyslipidemia (48.7% vs 21.1%, p < 0.001) were more prevalent in the reduced LVEF group. Cardiomyopathy was present exclusively in this group (33.3%, p < 0.001), as was a higher prevalence of ischemic heart disease (23.1% vs 7.7%, p = 0.008). Additionally, patients with reduced LVEF are more frequently presented with heart failure symptoms such as chest discomfort, presyncope, and syncope (all p < 0.05).

Ventricular Arrhythmias Characteristics

Most patients (85.4%) exhibited VAs with a right bundle branch block morphology, suggesting a left ventricular origin in most cases (Table 2). The average QRS complex duration was 142.1 ± 18.7 ms. Regarding arrhythmia presentation, 63.9% of patients experienced both PVCs and VT, while 26.6% presented with isolated PVCs and 9.4% with isolated VT. The mean VA burden was 29.1% ± 13.3%, corresponding to an average of approximately 29,968 VA beats over 24 hours.

Patients with reduced LVEF exhibited significantly more complex arrhythmia presentations. Specifically, the prevalence of VT-only presentation was higher (23.1% vs 6.7%), while PVC-only presentation was lower (5.1% vs 30.9%, p < 0.001). The PVC burden, as measured by 24-hour Holter monitoring, was significantly greater in the reduced LVEF group (41,804 ± 22,021 vs 28,039 ± 13,973 PVCs/day, p = 0.003; PVC burden: 36.3% ± 17.2 vs 27.8% ± 12.2, p = 0.014). QRS duration was longer in the heart failure group (149.0 ± 20.7 ms vs 140.8 ± 18.0 ms, p = 0.011).

Table 2 Characteristics and Burden of Premature Ventricular Complexes and Ventricular Tachycardia, Stratified by Left Ventricular Ejection Fraction (LVEF)

Patient Characteristics	Total (n=233)	Reduced LVEF (n=39)	Preserved LVEF (n=194)	p-value
Right bundle branch block, n (%)	199 (85.4)	29 (74.4)	170 (87.6)	**0.032**
QRS duration (ms), mean (SD)	142.1 (18.7)	149.0 (20.7)	140.8 (18.0)	**0.011**
PVC and VT presentation, n (%)				
Only PVC	62 (26.6)	2 (5.1)	60 (30.9)	**<0.001**
Only VT	22 (9.4)	9 (23.1)	13 (6.7)	
Both VT and PVC	149 (63.9)	28 (71.8)	121 (62.4)	
PVC Burden/Holter 24 hours prior to ablation (%), mean (SD)	29.1 (13.3)	36.3 (17.2)	27.8 (12.2)	**0.014**
Number of PVC/Holter 24 hours, mean (SD)	29968.0 (15,885.0)	41,804.2 (22,021.6)	28,039.6 (13,793.7)	**0.003**

Note: Bold values indicate statistical significance at $p < 0.05$.
Abbreviations: SD, Standard Deviation; LVEF, Left Ventricular Ejection Fraction; PVC, premature ventricular contraction; VT, ventricular tachycardia.

Procedural Characteristics

The overall mean procedure duration was 86.8 ± 33.3 minutes. Non-irrigated catheters were used in the majority of cases (75.5%), while irrigated catheters were employed in 24.5% of procedures. Acute procedural success was achieved in 100% of patients. The most frequent site of successful ablation was the right ventricular outflow tract (RVOT) in 71.2% of cases, followed by the left ventricular outflow tract (15.0%) and left ventricle (5.2%). Advanced sheaths, including fixed-curve and deflectable types, were used in 12.0% and 18.5% of procedures, respectively (Table 3).

Table 3 Procedural Characteristics of Catheter Ablation, Stratified by Left Ventricular Ejection Fraction (LVEF)

Patient Characteristics	Total (n=233)	Reduced LVEF (n=39)	Preserved LVEF (n=194)	p-value
Baseline sinus cycle length (ms), mean (SD)	680.8 (188.8)	654.6 (163.3)	686.6 (193.4)	0.343
AH interval (ms), mean (SD)	85.2 (16.0)	87.3 (20.3)	84.7 (15.0)	0.461
HV interval (ms), mean (SD)	45.5 (5.6)	46.5 (7.6)	45.3 (5.1)	0.372
Pace map score (%), mean (SD)	96.0 (4.3)	95.0 (7.9)	96.2 (3.1)	0.360
Earliest activation signal (ms), mean (SD)	37.0 (8.8)	36.7 (9.0)	37.1 (8.8)	0.793
Catheter, n (%)				
Non-irrigated	176 (75.5)	21 (53.8)	155 (79.9)	**0.001**
Irrigated	57 (24.5)	18 (46.2)	39 (20.1)	
Reentry VT, n (%)	11 (4.7)	3 (7.7)	8 (4.1)	0.400
Successful location, n (%)				
RVOT	166 (71.2)	21 (53.8)	145 (74.7)	**0.009**
RV	9 (3.9)	5 (12.8)	4 (2.1)	**0.008**
LVOT	35 (15.0)	5 (12.8)	30 (15.5)	0.673
LV	12 (5.2)	6 (15.4)	6 (3.1)	**0.007**
Papillary muscle	2 (0.9)	2 (5.1)	0 (0)	**0.027**
Left posterior fascicle	12 (5.2)	1 (2.6)	11 (5.7)	0.696
Sheath type used, n (%)				
Non-deflectable sheath	71 (30.5)	17 (43.6)	54 (27.8)	0.051
Fixed-curve sheath	28 (12.0)	5 (12.8)	23 (11.9)	0.792
Deflectable sheath	43 (18.5)	12 (30.8)	31 (16.0)	**0.030**

Note: Bold values indicate statistical significance at $p < 0.05$.
Abbreviations: SD, Standard Deviation; RVOT, Right Ventricular Outflow Tract; RV, Right Ventricle; LVOT, Left Ventricular Outflow Tract; LV, Left Ventricle; LVEF, Left Ventricular Ejection Fraction; VT, ventricular tachycardia.

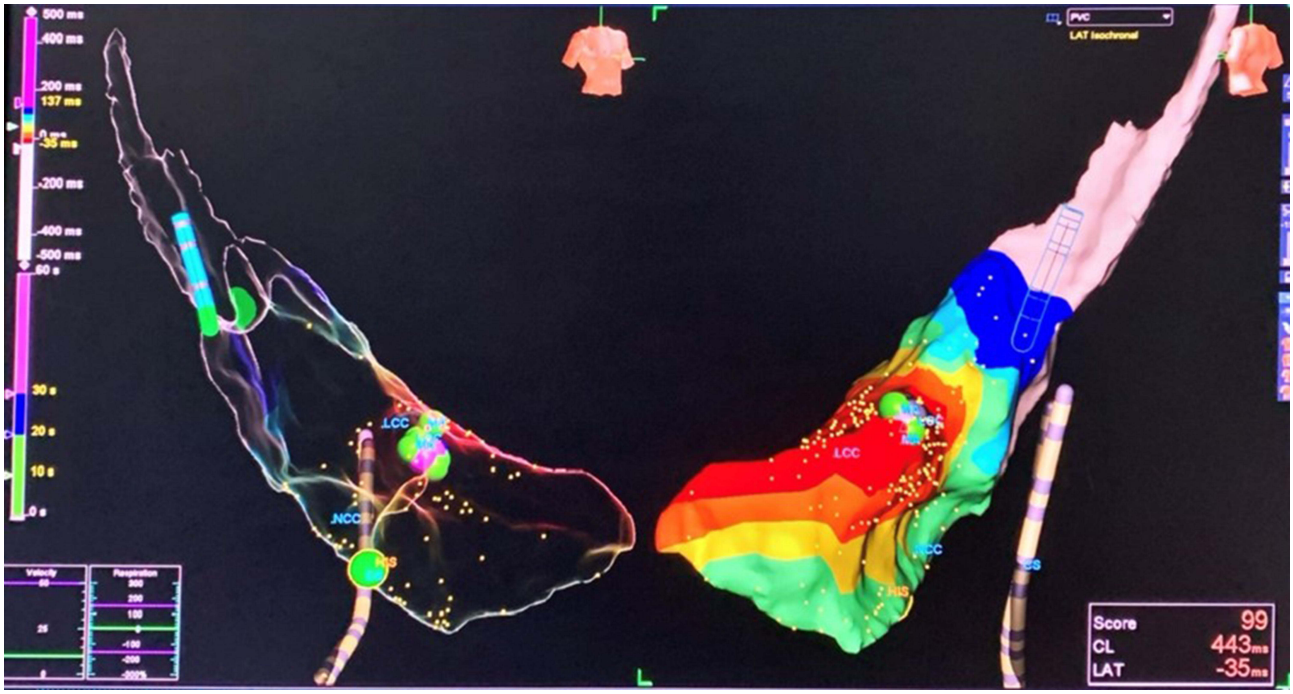

Figure 2 Catheter ablation of the right outflow tract PVC in a patient with PVC-induced cardiomyopathy.

Irrigated catheters were more frequently used in patients with reduced LVEF (46.2% vs 20.1%, $p = 0.001$). Despite differences in catheter type and some procedural parameters (eg, lower mean ablation power and temperature in the reduced LVEF group), 100% acute procedural success was achieved in both groups. Mapping parameters, including pace map score and earliest activation time, were similar between groups. Notably, patients with reduced LVEF were more likely to have VA sources located in the left ventricle (15.4% vs 3.1%, $p = 0.007$) and less frequently in the RVOT (53.8% vs 74.7%, $p = 0.009$). Use of deflectable sheath was also more common in the reduced LVEF group ($p = 0.030$). Representative cases of successful ablation in patients with VA-induced cardiomyopathy are illustrated in Figure 2 (RVOT origin) and Figure 3 (LVOT origin).

Safety and Efficacy

Among all patients, the mean fluoroscopy time was 4.5 ± 2.6 minutes and the median radiation dose was 16.0 (IQR = 11.0–26.0) mGy (Table 4). The acute complication rate was low, with only 11 patients (4.7%), mainly from local hematoma (n = 9, 3.8%) and minority related to lesion creation such as pericardial effusion (n = 1, 0.4%), left ventricular thrombus (n = 1, 0.4%). Compared to patients with preserved LVEF, those with reduced LVEF had similar procedure times (90.3 ± 34.3 vs 86.1 ± 33.2 minutes, p = 0.476), fluoroscopy times (5.2 ± 2.4 vs 4.4 ± 2.6, p = 0.066), and fluoroscopy doses (median = 16, IQR = 11–34 mGy vs median = 16.0, IQR = 11.0–25.0 mGy, p = 0.514). However, in patients with reduced LVEF, the risk of complication was higher than those with preserved LVEF (12.8% vs 3.09%, p = 0.007).

All patients included in this study completed one-week and three-month follow-ups. The time interval to the first follow-up assessment was 7 days (IQR 5.0–8.0) and the interval to three-month-assessment was 89.0 days (IQR 78.0–97.0). The VA burden one week after ablation, a marker for early efficacy and procedural success, decreased significantly in the overall population. Catheter ablation resulted in marked improvements in echocardiographic parameters after 3 months in the overall cohort. The left ventricular end-diastolic diameter decreased from 48.6 ± 6.3 mm to 47.2 ± 4.8 mm ($p < 0.001$), and the end-systolic diameter decreased from 32.3 ± 7.2 mm to 30.3 ± 5.6 mm ($p < 0.001$). Simultaneously, the LVEF improved significantly from 58.1% ± 12.8 to 63.2% ± 7.0 ($p < 0.001$). In subgroup analysis, patients with reduced LVEF experienced more pronounced reverse remodeling. Their LVEF increased markedly from 33.7% ± 8.1 to 55.2% ± 9.1 ($p < 0.001$), alongside significant reductions in both end-diastolic and end-systolic diameters.

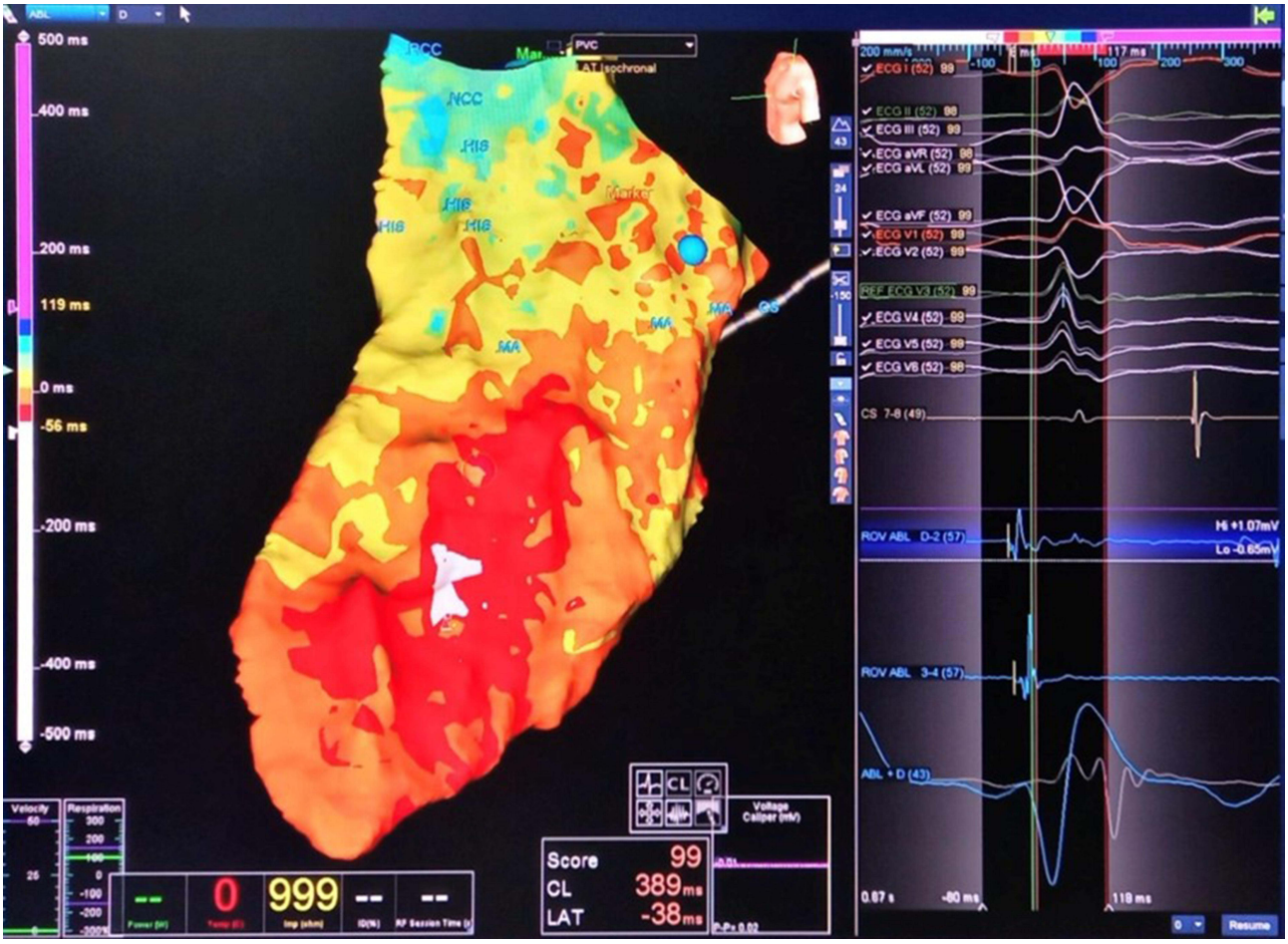

Figure 3 Catheter ablation of the left outflow tract PVC in a patient with PVC-induced cardiomyopathy.

Although patients with preserved LVEF also showed significant improvements (LVEF from 63.1% ± 6.3 to 64.9% ± 5.2, $p < 0.001$), the magnitude of change was greater in the reduced LVEF group, reflecting the potential for functional recovery in VA-induced cardiomyopathy.

Table 4 Safety and Efficacy Outcomes Following Catheter Ablation, Stratified by Left Ventricular Ejection Fraction (LVEF)

Patient Characteristics	**Total (n=233)**	**Reduced LVEF (n=39)**	**Preserved LVEF (n=194)**	**p-value**
Power (watt), mean (SD)	36.4 (7.9)	33.3 (7.1)	37.0 (7.9)	**0.006**
Ablation duration (min), mean (SD)	5.0 (2.5)	4.8 (2.2)	5.0 (2.5)	0.590
Procedure time (min), mean (SD)	86.8 (33.3)	90.3 (34.3)	86.1 (33.2)	0.476
Fluoroscopy time (min), mean (SD)	4.5 (2.6)	5.2 (2.4)	4.4 (2.6)	0.066
Fluoroscopic dosage (mGy), median (IQR)	16.0 (11.0–26.0)	16.0 (11.0–34.0)	16.0 (11.0–25.0)	0.514
PVC Burden/ 24h Holter ECG one week after catheter ablation (%), mean (SD)	0.1 (0.4)	0.2 (0.4)	0.1 (0.3)	0.177
Complication, n (%)	11 (4.7)	5 (12.8)	6 (3.1)	**0.022**
PVC burden/24h Ambulatory Holter ECG (%), mean (SD)				
Before ablation	29.1 (13.3)	36.3 (17.2)	27.8 (12.2)	**0.014**
3 months after ablation	0.5 (1.3)	1.0 (2.0)	0.4 (1.1)	0.082
Within-group p-value	**<0.001**	**<0.001**	**<0.001**	

(*Continued*)

Table 4 (Continued).

Patient Characteristics	Total (n=233)	Reduced LVEF (n=39)	Preserved LVEF (n=194)	p-value
Left ventricular end diastolic dimension (mm), mean (SD)				
Before ablation	48.6 (6.3)	55.7 (9.5)	47.2 (4.3)	**<0.001**
3 months after ablation	47.2 (4.8)	51.5 (6.4)	46.4 (4.0)	**<0.001**
Within-group p-value	**<0.001**	**<0.001**	**0.004**	
Left ventricular end systolic dimension (mm), mean (SD)				
Before ablation	32.3 (7.2)	43.1 (9.6)	30.1 (3.9)	**<0.001**
3 months after ablation	30.3 (5.6)	37.0 (8.4)	29.0 (3.5)	**<0.001**
Within-group p-value	**<0.001**	**<0.001**	**<0.001**	
Left ventricle ejection fraction (%), mean (SD)				
Before ablation	58.1 (12.8)	33.7 (8.1)	63.1 (6.3)	**<0.001**
3 months after ablation	63.2 (7.0)	55.2 (9.1)	64.9 (5.2)	**<0.001**
Within-group p-value	**<0.001**	**<0.001**	**<0.001**	

Note: Bold values indicate statistical significance at $p < 0.05$.
Abbreviations: SD, Standard Deviation; LVEF, Left Ventricular Ejection Fraction; PVC, premature ventricular contraction.

Discussion

This prospective study investigated the effectiveness and safety of catheter ablation for PVCs and VT in a real-world Vietnamese population, with a specific focus on differences between patients with preserved and reduced LVEF. First, patients with reduced LVEF exhibited a significantly higher PVC burden, broader QRS durations, and a greater prevalence of VT presentations and structural heart disease and these patients often require more aggressive approach to ablate including the use of open-irrigated catheter and long sheaths. Second, catheter ablation resulted in the improvement in both groups of patient with reduced EF and preserved EF. The magnitude of recovery, particularly in LVEF and ventricular dimensions, was more pronounced in patients with reduced LVEF, highlighting the reversible nature of PVC-induced cardiomyopathy. Third, the use of three-dimensional electroanatomic mapping in VA ablation was associated with a favorable safety profile, with only minor complications documented in patients with VAICM.

The VA burden remains a critical determinant of the risk for developing VA-induced cardiomyopathy.[16] Multiple studies have proposed varying thresholds, ranging from a minimum of 10% of total heartbeats to as high as 24% as predictors of PVC-induced cardiomyopathy development.[17] For instance, Ban et al identified a cut-off of 26% for PVC burden,[18] while Hasdemir et al reported a threshold of 16%, demonstrating high sensitivity and specificity for PVC-induced cardiomyopathy diagnosis.[19] In our study, patients with heart failure exhibited a significantly higher PVC burden than those reported in previous studies.[16,20] Furthermore, heart failure patients also had a higher percentage of arrhythmia over a 24-hour Holter ECG compared to those with preserved ejection fraction, reinforcing the association between higher PVC burdens and the risk of cardiomyopathy. Our study is also in line with the work of Hasdemir as the patient in the group with LV dysfunction would more frequently experience VT and PVC rather than PVC alone.[19] Additionally, the average number of VAs recorded over a 24-hour period was markedly higher in the heart failure group, further highlighting the role of frequent VA burden in promoting or exacerbating cardiac dysfunction. These findings would point to the fact that alone with the high burden of PVC/VT, the manifestation or distribution of these ectopy may also play a role in the progression of the LV dysfunction. Moreover, the difference of VA source in the two group, with a higher rate of non-outflow tract VA in the reduced LVEF group and predominance of outflow tract in the preserved EF group suggests that non-outflow tract source of VA may cause more dys-synchrony in LV activation than outflow tract source of VA and therefore exposed LV more to deteriorate its contraction function. A higher prevalence of underlying heart disease, such as ischemic cardiomyopathy, non-ischemic cardiomyopathy, and prior pacemaker or defibrillator implantation, was observed in the reduced LVEF group. These conditions may make the heart more vulnerable to developing VAICM.

In our study, irrigated catheters were more frequently used in the reduced LVEF group than in the preserved LVEF. In addition, more associated deflectable long sheath in the reduced LVEF group reflects the more complexity of the VA in the non-outflow tract VA and the more intention of operators to cure VA of this group because irrigation catheters could create deeper lesion than non-irrigated catheters. Non-irrigated catheters were more largely used in preserved LVEF group (88.1%) than in reduced LVEF group (11.9%) due to lower cost but the successful result of elimination of predominant RVOT VA in this group reflected the effectiveness of non-irrigation catheters in this region. Although previous studies incorporate open-irrigated catheters for VA ablation with high successful rate and low complication rate,[21,22] our study revealed an economic use of multiple re-sterilized non-irrigation catheters would be create enough depth lesions for elimination RVOT VAs. Our temperature-controlled ablation setting was aimed for a decrease of at least 10% of impedance for efficacy, resulting in an average power of 36.4 ± 7.9 watts and average ablation duration of 5.0 ± 2.5 minutes. The more frequent use of irrigated catheters associated with larger bored deflectable sheaths may be the source of more complication rate in the reduced LVEF group, including pericardial effusion, LV thrombus and groin hematoma.[23] The reduced LVEF group, the more severely-ill and complex patient would expose more risk of complication than the preserved LVEF group. The more frequent use of irrigated catheters and deflectable sheaths in reduced LVEF patients reflects higher procedural complexity. These strategies, while necessary to achieve effective lesion formation in non-outflow tract VAs, may also increase the risk of complications such as pericardial effusion or access-site hematomas. Thus, the higher complication rate in reduced LVEF patients likely reflects both the severity of disease and the technical requirements of ablation in this group.

Regarding LV function recovering time, our study showed that the LVEF improved significantly, especially in the reduced LVEF group who experienced more pronounced reverse remodeling with improvement of LVEF, alongside significant reductions in both end-diastolic and end-systolic diameters. This LV function recovering time is slightly shorter than the reported time in the work of Miki et al in which the authors demonstrated that the majority of the LV function would normalize after 4 months.[24] There were more epicardial origin of VA foci in the study of Miki than us, with longer QRS duration of VA complex compared with our study (170ms vs 148ms), suggesting more extensive remodeling and more dys-synchrony effect on the LV, resulting in longer duration of LV function recovery.

In our study, the overall complication rate of catheter ablation for idiopathic ventricular arrhythmias was 4.7%, primarily consisting of groin hematomas (3.8%), with one case each of pericardial effusion and left ventricular thrombus (0.4%). While this rate is within the globally reported range of 2–5%,[7,21,25] it was notably higher (12.8%) among patients with reduced LVEF. As discussed above, the increased complication rate can be explained by greater arrhythmia complexity, the need for more frequent use of irrigated catheters and deflectable sheaths, and a higher prevalence of non-outflow tract VA origins. These findings are consistent with previous large-scale studies, including Latchamsetty et al, who reported a 5.2% complication rate in idiopathic PVC ablation[7] and Wang et al, who documented a 2.7% rate.[25] Importantly, this study demonstrated that even with economic constraints and equipment reuse, ablation remained safe and effective, supporting prior evidence that PVC-induced cardiomyopathy can be successfully and safely reversed with catheter ablation in appropriately selected patient.

This study has several limitations. First, the sample size was relatively small, which may limit the generalizability of the findings to broader populations. Additionally, our cohort included patients with varying durations of disease, potentially introducing heterogeneity in baseline ventricular function and response to ablation. While we performed comprehensive follow-up within three months post-ablation, longer follow-up periods would be necessary to confirm the sustained benefits of the procedure and assess any delayed effects on ventricular function. Finally, as a single-center study, the findings may be influenced by specific institutional practices in catheter selection and ablation techniques, which may not be applicable to other settings. Further multicenter studies with larger sample sizes are needed to validate our results and refine treatment strategies for VA-induced cardiomyopathy.

Conclusion

Catheter ablation was highly effective in reducing ventricular arrhythmia burden and improving left ventricular function, including rapid reversal of VAICM. This effectiveness was consistently observed even in patients with reduced LVEF, who presented with more complex arrhythmia profiles and required advanced procedural strategies. Overall, the

procedure demonstrated a favorable safety profile, with only minor complications despite resource limitations such as catheter re-sterilization and repeated use of 3D skin patches.

Ethical Approval

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The study protocol was reviewed and approved by the Ethics Committee of Cho Ray Hospital, Ho Chi Minh City, Vietnam (Approval No. 1145/GCN-HDDD, dated 26/03/2021). Written informed consent was obtained from all participants prior to their inclusion in the study.

Acknowledgments

We are grateful to all the patients who participated in this study, and we sincerely thank the Director Board of Cho Ray Hospital for their support throughout the data collection and follow-up period.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This study received no funding.

Disclosure

All authors have no conflicts of interest in the subject of this study.

References

1. Amir M, Mappangara I, Setiadji R, Zam SM. Characteristics and prevalence of premature ventricular complex: a telemedicine study. *Cardiol Res*. 2019;10(5):285. doi:10.14740/cr887
2. Cha Y-M, Lee GK, Klarich KW, Grogan M. Premature ventricular contraction-induced cardiomyopathy: a treatable condition. *Circ Arrhythm Electrophysiol*. 2012;5(1):229–236. doi:10.1161/CIRCEP.111.963348
3. Latchamsetty R, Bogun F. Premature ventricular complex–induced cardiomyopathy. *JACC Clin Electrophysiol*. 2019;5(5):537–550. doi:10.1016/j.jacep.2019.03.013
4. Panizo JG, Barra S, Mellor G, Heck P, Agarwal S. Premature ventricular complex-induced cardiomyopathy. *Arrhythmia Electrophysiol Rev*. 2018;7(2):128. doi:10.15420/aer.2018.23.2
5. Zeppenfeld K, Tfelt-Hansen J, de Riva M, et al. 2022 ESC Guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: developed by the task force for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death of the European Society of Cardiology (ESC) Endorsed by the Association for European Paediatric and Congenital Cardiology (AEPC). *Eur Heart J*. 2022;43(40):3997–4126. doi:10.1093/eurheartj/ehac262
6. Huizar JF, Ellenbogen KA, Tan AY, Kaszala K. Arrhythmia-induced cardiomyopathy: JACC state-of-the-art review. *J Am College Cardiol*. 2019;73(18):2328–2344. doi:10.1016/j.jacc.2019.02.045
7. Latchamsetty R, Yokokawa M, Morady F, et al. Multicenter outcomes for catheter ablation of idiopathic premature ventricular complexes. *JACC Clin Electrophysiol*. 2015;1(3):116–123. doi:10.1016/j.jacep.2015.04.005
8. Zhong L, Lee Y-H, Huang X-M, et al. Relative efficacy of catheter ablation vs antiarrhythmic drugs in treating premature ventricular contractions: a single-center retrospective study. *Heart Rhythm*. 2014;11(2):187–193. doi:10.1016/j.hrthm.2013.10.033
9. Sarrazin J-F, Nault I. When to consider ablation for premature ventricular complexes? *Can J Cardiol*. 2022;38(4):540–543. doi:10.1016/j.cjca.2021.12.007
10. Mohanty S, Burkhardt JD, Di Biase L, et al. Best ablation strategy in patients with premature ventricular contractions with multiple morphology: a single-centre experience. *Europace*. 2023;25(5):euad038. doi:10.1093/europace/euad038
11. Prisco AR, Castro JR, Roukoz H, Tholakanahalli VN. Premature ventricular complexes: benign versus malignant–how to approach? *Ind Pacing Electrophysiol J*. 2023;23(6):189–195. doi:10.1016/j.ipej.2023.09.004
12. Choi J-H, Park K-M, Kwon CH, et al. Ablation strategy for idiopathic outflow tract premature ventricular complexes: rationale and design of the ABOUT-PVC study, a prospective multicenter study. *Int J Arrhythmia*. 2024;25(1):16. doi:10.1186/s42444-024-00123-8
13. Lin AN, Shirai Y, Liang JJ, et al. Strategies for catheter ablation of left ventricular papillary muscle arrhythmias: an institutional experience. *Clin Electrophysiol*. 2020;6(11):1381–1392. doi:10.1016/j.jacep.2020.06.026
14. Noheria A, Deshmukh A, Asirvatham SJ. Ablating premature ventricular complexes: justification, techniques, and outcomes. *Methodist DeBakey Cardiovasc J*. 2015;11(2):109. doi:10.14797/mdcj-11-2-109

15. Capulzini L, Vergara P, Mugnai G, et al. Acute and one year outcome of premature ventricular contraction ablation guided by contact force and automated pacemapping software. *J Arrhythmia*. 2019;35(3):542–549. doi:10.1002/joa3.12194
16. Bogun F, Crawford T, Reich S, et al. Radiofrequency ablation of frequent, idiopathic premature ventricular complexes: comparison with a control group without intervention. *Heart Rhythm*. 2007;4(7):863–867. doi:10.1016/j.hrthm.2007.03.003
17. Attachaipanich T, Thiravetyan B, Tribuddharat N, Jaroonpipatkul S, Navaravong L. Premature ventricular contraction-induced cardiomyopathy: contemporary evidence from risk stratification, pathophysiology, and management. *J Clin Med*. 2024;13(9):2635. doi:10.3390/jcm13092635
18. Ban J-E, Park H-C, Park J-S, et al. Electrocardiographic and electrophysiological characteristics of premature ventricular complexes associated with left ventricular dysfunction in patients without structural heart disease. *Europace*. 2013;15(5):735–741. doi:10.1093/europace/eus371
19. Hasdemir C, Ulucan C, Yavuzgil O, et al. Tachycardia-induced cardiomyopathy in patients with idiopathic ventricular arrhythmias: the incidence, clinical and electrophysiologic characteristics, and the predictors. *J Cardiovasc Electrophysiol*. 2011;22(6):663–668. doi:10.1111/j.1540-8167.2010.01986.x
20. Niwano S, Wakisaka Y, Niwano H, et al. Prognostic significance of frequent premature ventricular contractions originating from the ventricular outflow tract in patients with normal left ventricular function. *Heart*. 2009;95(15):1230–1237. doi:10.1136/hrt.2008.159558
21. Gulletta S, Gasperetti A, Schiavone M, et al. Long-term follow-up of catheter ablation for premature ventricular complexes in the modern era: the importance of localization and substrate. *J Clin Med*. 2022;11(21):6583. doi:10.3390/jcm11216583
22. Oomen A, Dekker L, Meijer A. Catheter ablation of symptomatic idiopathic ventricular arrhythmias: a five-year single-centre experience. *Neth Heart J*. 2018;26:210–216. doi:10.1007/s12471-018-1085-5
23. Tabaja C, Hight N, Younis A, et al. Vascular access complications after catheter ablation of ventricular arrhythmias: impact of vascular closure devices. *Heart Rhythm*. 2025;22(3):685–692. doi:10.1016/j.hrthm.2024.09.001
24. Yokokawa M, Good E, Crawford T, et al. Recovery from left ventricular dysfunction after ablation of frequent premature ventricular complexes. *Heart Rhythm*. 2013;10(2):172–175. doi:10.1016/j.hrthm.2012.10.011
25. Wang JS, Shen YG, Yin RP, et al. The safety of catheter ablation for premature ventricular contractions in patients without structural heart disease. *BMC Cardiovasc Disorders*. 2018;18(1):177. doi:10.1186/s12872-018-0913-2