The European Research Journal 2021;7(2):159-169 Original Article

DOI: 10.18621/eurj.775245 *Cardiology*

Features of patients with premature ventricular complex ablation: a tertiary referral center experince

Ahmet Tütüncü[1], Erhan Yılmaz[2]

[1]Department of Cardiology, University of Health Sciences, Bursa Yüksek İhtisas Training and Research Hospital, Bursa, Turkey
[2]Department of Cardiology, Bursa Orhangazi State Hospital, Bursa, Turkey

ABSTRACT

Objectives: In patients who do not respond to medical treatment with idiopathic premature ventricular complex (PVC), catheter ablation is performed using the electroanatomic mapping (3D EAM) system for ablation. The aim of this study is to evaluate the acute and long-term success of patients and the procedural features and complication results associated with PVC localization in patients who underwent catheter ablation in our center.

Methods: Two hundred seventeen patients who underwent activation mapping and ablation using 3D EAM for PVC were included in the study. Patients were followed up for acute procedure success, periprocedural complications, and six-month long-term recurrence. In addition, these parameters, PVC's were evaluated in three groups as right ventricular outflow tract (RVOT), coronary cusp and rare localized origin, and clinical outcomes and interventional variables related to the success of the PVC's location were compared.

Results: In our study, the mean age of the patients was 43 ± 12.1 years and the female gender ratio was 37.8%. When catheter ablated PVC foci were evaluated, it is seen that 81 (37.3%) were from RVOT and 56 (25.8%) were from coronary cusp. In addition, 6 (2.8%) were aortomitral continuity, 22 (10.1%) were left ventricular summit/epicardial, 17 (7.8%) were parahisian, and total 80 (36.8%) were rare localized PVCs. Acute procedure success was 92.6% and long-term procedure success was 83% in all cases. When the patients in our study were analyzed according to their PVC locations and procedure successes, those with rare localization compared to those with RVOT and coronary cusp origin were 66 (87.5%), 79 (96.3%), and 53 (94.6%); respectively (p = 0.03) and long-term successes were 58 (72.5%), 73 (90.1%), and 49 (87.5%); respectively (p <0.05). Long-term transaction success was lower.

Conclusions: Frequent PVCs can be treated with electroanatomic mapping and radiofrequency ablation with high success rate and low complication rate. Patients with RVOT and coronary cusp-derived PVC had a high acute and long-term success rate, while success rates were lower in rare localized PVCs from epicardial/summit, papillary muscle, parahisian and tricuspid-mitral anulus.

Keywords: premature ventricular complexes, catheter ablation, electroanatomic mapping

Ventricular ectopic beats or premature ventricular complexes (PVCs) are caused by early depolarizations originating from ventricular myocardial cells. While most PVC originates from the ventricular myocardium, the bifurcation distal conduction tissue of the His bundle, such as bundle branches, fascicles or Purkinje fibers, are also potential source sites for these arrhythmias.

Received: *August 1, 2020;* ***Accepted:*** *September 30, 2020;* ***Published Online:*** *February 8, 2021*

How to cite this article: *Tütüncü A, Yılmaz E. Features of patients with premature ventricular complex ablation: single center case series. Eur Res J 2021;7(2):159-169. DOI: 10.18621/eurj.775245*

Address for correspondence: *Ahmet Tütüncü, MD., University of Health Sciences, Bursa Yüksek İhtisas Training and Research Hospital, Department of Cardiology, Bursa, Turkey. E-mail: tutuncuahm@yahoo.com*

e-ISSN: 2149-3189

PVCs are common in clinical practiceIt is mainly seen in structural heart diseases such as ischemic heart disease (IHD) [1], heart valve disease [2], cardiomyopathy [3] and ventricular hypertrophy [4]. In patients with a normal heart angiographically and echocardiographically, more than 100 PVCs are seen daily in 4% [5].

PVCs are associated with poor prognosis in those with structural heart disease. The presence of frequent or complex PVCs after myocardial infarction increases cardiovascular mortality of 3-5 years [1]. Similarly, in those with left ventricular hypertrophy, PVCs are associated with an increase in all-cause mortality [4].

Current studies have shown that the possible negative effects of frequent PVCs and the development and reversibility of PVC-induced cardiomyopathy (CMP) in patients with a structurally normal heart [6, 7]. It has been suggested that the highest sensitivity and specificity (100% and 87%, area under the curve 0.96 respectively) in predicting PVC-induced CMP formation is more than 16% PVC load [7]. However, there are patients who have high PVC load but do not develop CMPOther situations that cause the development of PVC-related CMP; PVC QRS duration is over 140 ms, presence of interpolated PVC, PVC coupling interval < 300 ms, being asymptomatic and being epicardial origin PVC [8-10]. Singh *et al*. [9] stated that frequent PVC is one of the reversible causes of dilated cardiomyopathy (DCM) and showed an improvement in left ventricular (LV) function after suppression of PVCs with idiopathic DCM patients.

Today, catheter ablation is considered as a first-line treatment for patients with PVC-induced CPM. Recent publications have shown that catheter ablation of outflow-induced PVC is more effective than pharmacotherapy, in addition, catheter ablation provides a higher LVEF normalization compared to antiarrhythmic drug (AAD) [9, 11]. Indications for catheter ablation are PVCs that cause ventricular dysfunction [12] and the presence of serious symptoms and AADs are not desired by the patient, have side effects, or are not effective [13]. In PVC ablation, the complication rate is acceptable and the major complication rate is approximately 2.4% [14]. The success rate in experienced centers is more than 90%, and the complication rate is 1%.

The aim of this study is to report the baseline demographic and echocardiographic features of 217 patients with frequent PVC, in which we performed catheter ablation in our 3-year period, clinical results related to the success of the ventricular extra beats, and complication rates with interventional variables.

METHODS

Patient Selection

In our study; 217 patients who were successfully treated with PVC ablation between January 2016 and January 2019 at Bursa Yüksek İhtisas Training and Research Hospital were examined. Informed consent form was obtained from all patients before the procedure. At least once 24-hour ECG Holter monitoring was performed before catheter ablation. Patients with low (< 50%) LVEF were evaluated as PVC-CMP. According to Framingham coronary artery risk classification, coronary angiography was performed through femoral artery in addition to patients who were found to be moderate and high. Whether patients were diabetic, hypertensive or hyperlipidemic was recorded. The results from the routine blood sample taken from the antecubital vein were recorded. In routine echocardiographic evaluation (Vivid-7, GE Wingmed sound Horten, Norway); left atrial diameter (LAD), left ventricular systolic and diastolic diameters, left ventricular wall thickness and ejection fraction were calculated. Interventional variables such as the clinical results and complication rates, and the duration of the procedure and fluoroscopy were recorded according to the PVC locations.

The study was approved by the Bursa Yüksek İhtisas Training and Research Hospital Ethics Committee. Written consent was obtained from all patients before participating in the study, and this study was conducted according to the Helsinki Declaration.

Electrophysiological Study and Catheter Ablation

Patients were allowed to stop AADs five half-lives before planned ablation procedures. Electrophysiological study was performed under local anesthesia in a fasted state. Sedation was not applied to the patients before the procedure to avoid the risk of suppressing automaticity. If clinical PVCs were not initially available, isoproterenol infusion and electrical stimulation techniques were used to induce arrhythmia. Intra-

venous isoproterenol 1-5 µg/min infusion was given to provide at least 20% heart rate increase. Electrical stimulation was performed using the right ventricular apex or right ventricular outflow tract (RVOT) using burst pacing and triple extra stimuli pacing.

Electroanatomical mapping was done with EnsiteTM Precision (Abbott, Chicago, IL, USA) or CARTO3 (Biosense Webster, USA) (Fig. 1). Using fluoroscopic guidance, a decapolar diagnostic catheter was inserted through the right femoral vein into the coronary sinus. Ablation catheter 8F quadripolar irrigation ablation catheters used for mapping and ablation Thermocool Smarttouch CF (Biosense Webster Inc., Diamond Bar, California, USA) and FlexAbility (Endosense / Abbott, St) with 3.5 mm tip and 2-5-2 mm electrode range. Paul, MN, USA) was used. For left-sided access, a transaortic retrograde pathway or trans-septal puncture was performed, and an additional intravenous unfractionated heparin intravenously was given to provide an active clotting time of 300-350 seconds.

Firstly, an activation map was applied using the

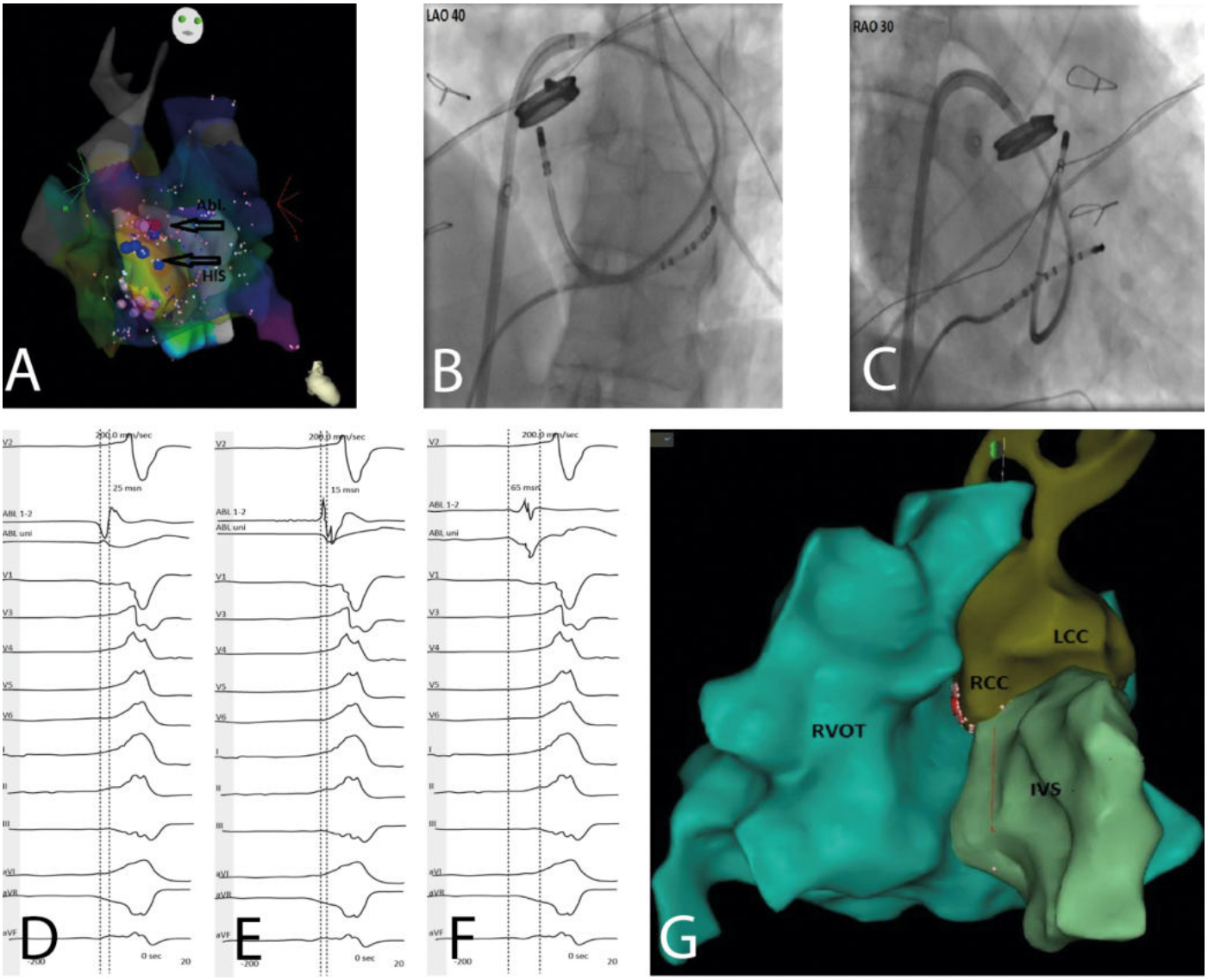

Fig. 1. 3D Electro anatomical mapping (EAM) and catheter ablation of Parahisian PVC with Carto system. (A) The earliest activation in the mapping is seen in the interventricular septum and the parahisian region. The red dot is a successful ablation site. Blue dots his sensation zone. (B-C) Fluoroscopic images of ablated areas. (D-E-F) Respectively, unipolar and bipolar recordings of RVOT, coronary cusp and interventricular septum. The earliest recording is seen in IVS, which received a signal 65 ms ahead. (G) Carto 3D EAM image. RVOT = Right ventricular outflow tract, LCC = left coronary cusp, RCC = right coronary cusp, IVS = interventricular septum.

mapping catheter. The PVC focus was evaluated by bipolar recordings, with the earliest local activation timing detected, and the presence of the QS complex formed in the case of radial spreading away from the PVC focus with unipolar electrograms. The purpose of the activation mapping was to identify the region that was recorded 30 ms or earlier from the start of the reference surface PVC QRS. In addition, the pace mapping technique was used to determine the source of the PVCs and the most suitable ablation site. The aim of pace mapping was to provide similarity in at least 11 of the 12 ECG morphologies. Irrigation ablation was performed in a 30-35 W power controlled mode in the appropriate ablation zone and a 10 Ω impedance drop was targeted. After ablation, electrophysiological study with or without isoproterenol was repeated and programmed electrical stimulation (PES) was performed. When tachycardia or PVCs with the same morphology were not induced after 30 minutes of waiting time after ablation, ablation was considered successful.

Statistical Analysis

Statistical study was done using SPSS 17 (SPSS Inc., Chicago, IL, United States) package computer program. Variables with normal distribution were expressed as mean ± standard deviation, and variables without normal distribution were expressed as median (interquartile range: IQR). Categorical variables were given as frequency and percentage (%). Student's t test was used to compare normally distributed numeric variables in two different groups, while Mann Whitney U test was used for non-normally distributed numeric variables. Chi-square or Fisher's exact tests were used to compare nominal data. In our study, Bonferroni multiple comparison test was used to determine the difference between the three groups. A p value < 0.05 was considered significant.

RESULTS

In our study, the mean age of the patients was 43 ± 12.1 yeras and the female gender ratio was 37.8%. The study population was found to have hypertension (n = 45, 20.7%), hyperlipidemia (n = 45, 20.7%), diabetes mellitus (n = 31, 14.3.7%) and smoking (n = 60, 27.6%). In echocardiographic evaluation of patients, LVEF was 45.9 % ± 8.2%. VEB load was determined as 22.4% in 24-hour Holter monitoring. Demographic, laboratory, electrocardiographic and echocardiographic features of the study population are shown in Table 1.

Considering the characteristics of the catheter ablation procedure of the patients included in the study population; When catheter ablated PVC foci were evaluated, it was seen that 81 (37.3%) originated from right ventricular outlet (RVOT), 56 (25.8%) originated from coronary cusp. In addition, a total of 80 (36.8%), 6 (2.8%) aortomitral continuity, 22 (10.1%) left ventricular summit/epicardial, 17 (7.8%) parahisian, are of rare localization. In addition, 6 (2.8%) of the cases were due to multiple foci.

Table 1. Demographic and echocardiographic features of patients

	All patients (n = 217)
Age (year)	43 ± 12.1
Female gender, n (%)	82 (37.8)
Tobacco, n (%)	60 (27.6)
Hypertension, n (%)	45(20.7)
Hyperlipidemia, n (%)	45 (20.7)
Diyabetes mellitus, n (%)	31 (14.3)
LVEF (%)	45.9 ± 8.2
Septal thickness (mm)	0.92 ± 0.21
Posterior wall thickness (mm)	0.90 ± 0.24
Left ventricular diastolic diameter (mm)	50 ± 5.4
Left ventricular systolic diameter (mm)	36 ± 3.5
Left atrial diameter (mm)	37 ± 5.1
LDL (mg/dL)	139 ± 49
HDL (mg/dL)	44 ± 12
Triglycerides (mg/dL)	171 ± 72
Glucose (mg/dL)	110 ± 34
Creatinine (mg/dL)	1.18 ± 0.61
Sodium (mg/dL)	137 ± 3.9
Potassium (mg/dL)	4.0 ± 2.2
Hemoglobin (g/dL)	12.7 ± 1.6
WBC ($\times 10^9$/L)	7.1 ± 1.9
Thyroid stimulating hormone (mU/L)	1.75 ± 1.7

LVEF = Left ventricular ejection fraction, LDL = Low density lipoprotein, HDL = High density lipoprotein

Table 2. Procedural features and complications

	All patients ((n = 217))
Ventricular extra beat distribution, n (%)	
Right ventricular outflow tract VEA	81(37.3)
Coronary cuspıs VEA	56(25.8)
Rare localized VEA, n (%)	80 (36.8)
Aorto-mitral continuity	6 (2.8)
Parahisian	17 (7.8)
Left ventricular summit/ Epicardial	22 (10.1)
Papillary muscle	10 (4.6)
Tricuspi annulus	7 (3.2)
Mitral annulus	8 (3.7)
Fascicles	4 (1.8)
Multiple focus	6 (2.8)
The presence of concomitant cardiomyopathy, n (%)	
Yes	77 (35.5)
No	140 (64.5)
Anti arrhythmic drug use (%)	208 (95.9)
VEA burden (%)	22.4
VEA QRS duration (ms)	135± 37
VEA coupling interval, msn	17 (7.8)
Interpolated VEA, n (%)	22 (10.1)
Asymptomatic, n (%)	355± 115
Coronary angio intervention, n (%)	80 (36.9)
Mapping and ablation 3D-Electroanatomic mapping system	
CARTO, n (%)	121 (55.8)
EnSite Precision, n (%)	83 (38.2)
Columbus, n (%)	13 (6)
Irrigated ablation catheter, n (%)	210 (96.8)
Acute procedure success, n (%)	201 (92.6)
Long-term procedure success, n (%)	180 (83)
Procedure time (min)	81 ± 31
Ablation time (s)	466 ± 117
Fluoroscopy time (min)	19 ± 8.7
Death, n (%)	0(0)
Vascular access hematoma, n (%)	9 (4.1)
AV Complete block, n (%)	1(0.4)
Tamponade, n (%)	2 (0.9)

VEA = Ventricular extra beat

Radiofrequency (RF) catheter ablation procedure time, scope duration and RF application time of the patients included in the study population are 81 ± 31 minutes, 19 ± 8.7 minutes and 466 ± 117 seconds, respectively. It was observed that procedure success was 92.6% in the acute period and 83% of long-term procedure success. Coronary angiography was performed in 36.9% of the patients in the study. In addition, when the complication rates were examined, the most common complication site was hematoma 9 (4.1%). In addition, AV block was observed in 1 (0.4%) patient with Parahisian origin and tamponade was observed in 2 (0.9%) patients, but no procedure-related death occurred. Considering the PVC localizations of patients with tamponade, the first was RVOT free wall and the second was LV summit-induced and was observed during the ablation procedure through the coronary sinus. The procedural features and complications of the study population are shown in Table 2.

When the patients in our study were analyzed according to their PVC locations and procedure successes, those with rare localization compared to those with RVOT and coronary cusp origin were 66 (87.5%), 79 (96.3%), and 53 (94.6%); respectively (p = 0.03) and long-term successes were 58 (72.5%), 73 (90.1%), and 49 (87.5%); respectively (p <0.05). Long-term transaction success was lower. In addition, it was observed that the procedure, fluoroscopy and RF ablation times (101 ± 32.7 minutes, 27.2 ± 7.9 minutes, and 812 ± 96 seconds, respectively) were longer in those with rare localization. Interventional variables according to the clinical results related to ventricular extra beat locations and process successes of the study population are shown in Table 3.

DISCUSSION

With this study, we determined the demographic characteristics of the patients undergoing PVC ablation and the success and complication rates of the catheter ablation procedure in a high-volume center where catheter ablation was performed. Most of our patients were under 50 years old and 37.8% were females. This rate is Nakagawa *et al*. [15] compared to his study, it is seen that he has similar age and gender ratios. In addition, 85.2% of our patients were non-diabetic and 72.4% were non-smokers. When analyzed by PVC foci, most of the study population was non-RVOT (62.7%) originated group. Acute and long-term success rates of patients with PVC ablation were 92.6% and 83%, respectively. When the PVC foci were examined in detail, it was seen that the patients with rare localized PVC had low acute and long-term success rates, and longer procedure, fluoroscopy and RF ablation times.

Table 3. Clinical results and interventional variables related to the success of the procedure according to the locations of ventricular extra beats

Variables	RVOT (n = 81)	Coronary cuspıs (n = 56)	Rare Localization (n = 80)	*p* value
Age (year)	42.8 ± 16.8	41.6 ± 15.1	45.2 ± 13.9	0.58
Sex (female)	36.9%	39.8%	37.2%	0.77
Hypertension	20.4%	20.1%	15.1%	0.87
Diyabetes mellitus	14.4%	12.6%	15.4%	0.80
Acute procedure success	79 (96.3%)[b]	53 (94.6%)[b]	66 (87.5%)[a]	**0.03**
Long-term procedure success	73 (90.1%)[b]	49 (87.5%)[b]	58 (72.5%)[a]	**< 0.05**
Procedure time (minute)	71 ± 13.4[b]	64 ± 11.9[b]	101 ± 32.7[a]	**< 0.05**
Fluoroscopy time (minute)	15.8 ± 12.7[b]	16,7 ± 11.7[b]	27,2 ±7.9[a]	**< 0.05**
Total ablation time (second)	407 ± 76[b]	391 ± 48[b]	812 ± 96[a]	**< 0.05**
Total complication rate	3.7%	3.6%	5%	0.18

Data are shown as mean±standard deviation or n (%) or %. [a,b,c] the same letters show no significant difference between groups based on Bonferroni multiple comparison tests. RVOT = Right ventricular outflow tract. $p < 0.05$ was considered statistically significant.

The incidence of PVC in healthy subjects was examined by various researchers and PVC was detected in 1-4% of healthy people without asymptomatic and structural heart disease in standard twelve-lead ECG recordings. This rate increased to 39-67% when subjects were monitored for 24 hours with Holter monitoring [16]. The first step in the treatment of patients with PVC with mild symptoms without structural heart disease is the education of the benign nature of this arrhythmia. Beta-blockers or non-dihydropyridine calcium channel blockers may be considered in patients whose symptoms cannot be managed effectively, but these agents are effective only in a very limited proportion of 10-15% of patients [17, 18]. Although membrane active anti-arrhythmic drugs are more effective in PVC suppression, risk-benefit rates have not been carefully evaluated in those without structural heart disease. In patients with severe structural heart disease, these drugs (except amiodarone) should be used carefully in PVC suppression due to increasing mortality [17-19]. Although suppression can be achieved with pharmacological agents, a prospective study has shown that the effectiveness of drugs alone is poor in PVC suppression. Although the goal of medical therapy is to improve symptoms with a decrease in PVC load, catheter ablation is potentially curative by directly targeting abnormal cells where clinical PVCs appear. In a randomized study involving 330 patients with RVOT PVC, the 1-year recurrence rate of PVCs (defined as > 300 beats/day) was significantly lower in patients undergoing radiofrequency ablation (RFA) than medically treated with propafenone or metoprolol (19.4 vs 88.6%, $p < 0.001$) [20]. Similarly, in a retrospective study of 510 patients by Zhong *et al*. [21], catheter ablation showed a greater reduction in PVC load compared to class I/III antiarrhythmic drugs (93% vs 82%, $p = 0.04$). As a result, catheter ablation is an important option in the management of these patients.

Premature ventricular complexes are considered benign when there is no structural heart disease. There is a clear relationship between frequent premature ventricular contractions and cardiomyopathy and is reversible with catheter ablation in selected patients [22-24]. In our study, we evaluated those with LVEF < 50% as PVC related cardiomyopathy. The number of patients with PVC-related cardiomyopathy in our study was 77 (35.5%). The number of PVCs /24h associated with impaired LV function is usually reported at loads above 15-25% of total cardiac beats, but this rate may even be below 10% [6, 25, 26]. Many studies have reported PVC burden as an important predictor of the development of left ventricular (LV) systolic dysfunction. However, no exact cut-off value related to this load was found [27, 28]. Baman *et al*. [25] showed that more than 24% PVC load was associated with PVC-induced cardiomyopathy in 24-hour Holter monitoring. When the results of our study are evaluated, it is seen that the PVC load is 22.4% and the rate of PVC-related cardiomyopathy is 35.5%. In addition, PVC morphology, origin and PVC duration are other factors associated with cardiomyopathy [29].

Idiopathic PVCs generally originate from the exit path of the right and left ventricles, mitral and tricuspid annulus, His-Purkinje system, left ventricular summit and papillary muscles [30]. In our study, the majority of PVC localizations constitute 81 (37.3%) PVCs originating from RVOT. In addition, as a rare localized source of PVC, aorta-mitral continuity 6 (2.8%), parahisian 17 (7.8%), left ventricular summit/epicardial 22 (10.1%), papillary muscle 10 (4.6%), tricuspid 7 (3.2%) and mitral. annulus 8 (3.7%), fascicular 4 (1.8%) and multiple focus 6 (2.8%) were detected. In addition, the rate of PVC from coronary cusp is 56 (25.8%). In Lee *et al*.'s study [31], catheter ablation was performed in 152 patients, 54 of whom had CMP. In this study, those with and without CMP were 6 (11%) - 15 (15%) and those with papillary muscle were 9 (17%) -7 (7%), respectively. In a study by Tada *et al*. [32], catheter ablation was applied to 454 patients in total. According to this study, the majority of the patients were 223 (49%) patients with RVOT. Again, in this study, the rare localizations of PVC are mitral 24 (5%) and tricuspid 38 (8%) annulus and LV epicardial 93 (21%) origin [35]. Latchamsetty *et al*. [14] were included 1185 idiopathic PVC patients who underwent ablation therapy in their study, and 45% of the cases were shown to be RVOT, 15% were coronary cube and 40% were other rare origin PVCs. When the single central case series we have published is compared with other studies, it is seen that the rate of RVOT-induced PVC is lower and the rate of PVC with coronary cuspis is higher.

In our study, we compared the acute and long-term

success rates of RF ablation applied to rare localized foci with RVOT and coronary cusp-derived foci. According to this, acute procedure and long-term success rates of rare localized foci were found to be lower than other foci. Acute procedure success in our study was 92.6%. When evaluated as RVOT, coronary cusp and rare localizations according to PVC origins, this rate was 96.3%, 94.6% and 87.5%, respectively. The detection of PVC load lower than 80% in holter monitoring of the 6th month and 24 hours after catheter ablation treatment was evaluated as a long-term success. In our study, the long-term process success was 83%, when it was evaluated as RVOT, coronary cusp and rare localizations according to PVC origins, this rate was found to be 87.5%, 90.1%, and 72.5%, respectively. It has been observed that these rates overlap with many studies in the literature. In a study by Wang *et al*. [33], when RF ablation success rates were examined, it was seen that the highest rate was RVOT and the lowest rate was epicardially sourced PVCs. Latchamsetty *et al*. [14], in their study, it was observed that the focal points in which RF ablation applied was the highest and the lowest in terms of acute procedure success were RVOT and epicardial, respectively (93% and 67%, respectively). When long term procedure successes were examined, it was determined that the highest and lowest foci were RVOT and papillary muscle. (82% and 60%, respectively).

In another case series evaluating 815 patients who underwent idiopathic PVC/VT ablation, the success of acute procedure ranged from 76% to 100% and the recurrence rate was 0 - 23%. Acute procedure successes vary between 85% and 100% in fascicular and RVOT-induced VTs, and recurrence rates have been shown to range from 0 to 25% in this group of patients. In addition, acute period success was observed in 89 patients in the intracavitary PVC/VT group (96 patients). High recurrence rates such as 0-58% and 40% were found after a single ablation in papillary muscle and moderator band VT, respectively. In PVC / VT (81 patients) originating from tricuspid and mitral rings, the acute success of catheter ablation varies between 66% and 100%, and the lowest success rate in those originating from septal tricuspid rings has been observed [32].

Acute treatment success was achieved in 17 of 22 PVCs with epicardial and summit origin, and 6 of these patients were subxiphoid. Previous studies have reported similar success rates for epicardial regions of PVC origin (via the coronary sinus) even without using an epicardial subxiphoid approach [34, 35]. The subxiphoid approach was further questioned when the additional complication deficit and higher complication rate were considered when compared with the ablation approach of the coronary venous system and surrounding structures (coronary cusp or subcuspus). Unless medical treatment is desired or if there is no cardiomyopathy caused by PVC, medical treatment may be preferred as the first treatment in patients with epicardial PVC [36].

Acute treatment success was achieved in 8 of 10 PVCs of papillary muscle origin in our single center case series, and this number decreased to 7 in the long term. PVCs from papillary muscles also tend to be associated with a lower ablation success rate. Papillary muscle PVCs have a high recurrence rate and require longer procedure times and greater radiofrequency energy delivery [37]. For these arrhythmias, intracardiac echocardiography (ICE) has been shown to assist in guiding the procedure [38]. However, it was performed without using ICE in our cases.

In addition, we found in our study that rare localized PVC foci have longer RF ablation, fluoroscopy and processing times compared to other foci. These relatively long periods of time, Latchamsetty *et al*. [14], in their study, it was observed that rare localized PVC foci overlapped with the length of the procedural duration.

Complications of catheter ablation procedures of idiopathic PVC are rare, and the reported complication rate is 3-5%. The most common is the site of vascular complications. Less common complications include cardiac tamponade/hemopericardium, thromboembolic events, AV block and coronary artery injury [39]. When the complication rates in our study were evaluated, vascular complications were the most common intervention site and percutaneous intervention due to pseudo aneurysm was performed in one patient. Cardiac tamponade was observed in 2 patients and evacuated without surgical need. In addition, in 1 patient with parahisian PVC, AV block was observed 2 days after the procedure. No mortality was observed after the procedure. Comparing the complication rates in all three groups, this rate was higher in those with rare lo-

calization and was not statistically significant. These rates are observed to be compatible with the data of other studies.

Limitations

The primary limitation of our study is that the patients included in our study are from our clinic, a tertiary referral center, and may not reflect other patient populations. Second, the PVC load before and after ablation was assessed by 24-hour rhythm Holter monitoring. Since the frequency of PVCs is variable, one-time rhythm Holter follow-up may not accurately show the true load of PVCs, but in similar studies, the PVC load was also evaluated by a 24-hour Holter [40]. Third, in this study, the sample size was relatively small. Larger sampling sizes are needed to obtain more precise results regarding the parameters we examine after PVC ablation.

CONCLUSION

Frequent PVCs can be treated with electroanatomic mapping and radiofrequency ablation with high success rate and low complication rate. Patients with RVOT and coronary cusp-derived PVC had a high acute and long-term success rate, while success rates were lower in rare localized PVCs from epicardial / summit, papillary muscle, parahisian and tricuspid-mitral anulus. In addition, process, fluoroscopy and RF ablation times were determined longer in rare localized PVCs.

Authors' Contribution

Study Conception: AT; Study Design: AT, EY; Supervision: AT, EY; Funding: AT, EY; Materials: EY; Data Collection and/or Processing: EY; Statistical Analysis and/or Data Interpretation: AT, EY; Literature Review: AT, EY; Manuscript Preparation: AT and Critical Review: AT.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

Financing

The authors disclosed that they did not receive any grant during the conduction or writing of this study.

REFERENCES

1. Ruberman W, Weinblatt E, Goldberg JD, Frank CW, Shapiro S. Ventricular premature beats and mortality after myocardial infarction. N Eng J Med 1977;297:750-7.
2. DeMaria AN, Amsterdam EA, Vismara LA, Neumann A, Mason DT. Arrhythmias in the mitral valve prolapsed syndrome. Prevalence, nature and frequency. Ann Intern Med 1976;84:656-60.
3. Savage DD, Seides SF, Maron BJ, Myers MJ, Epstein SE. Prevalence of arrhythmias during 24 hour electrocardiographic monitoring and exercise testing in patients with obstructive and nonobstructive hypertrophic cardiomyopathy. Circulation 1979;59:866-75.
4. Bikkina M, Larson MG, Levy D. Asymptomatic ventricular arrhythmias and mortality risk in subjects with left ventricular hypertrophy. J Am Coll Cardiol 1993;22:1111-16.
5. Kostis JB, McCrone K, Moreyra AE, Gotzoyannis S, Aglitz NM, Natarajan N, et al. Premature ventricular complexes in the absence of identifiable heart disease. Circulation 1981;63:1351-6.
6. Hasdemir C, Ulucan C, Yavuzgil O, Yuksel A, Kartal Y, Simsek E, et al. Tachycardia-induced cardiomyopathy in patients with idiopathic ventricular arrhythmias: the incidence, clinical and electrophysiologic characteristics, and the predictors. J Cardiovasc Electrophysiol 2011;22:663-8.
7. Taieb JM, Maury P, Shah D, Duparc A, Galinier M, Delay M, et al. Reversal of dilated cardiomyopathy by the elimination of frequent left or right premature ventricular contractions. J Interv Card Electrophysiol 2007;20:9-13.
8. Latchamsetty R, Bogun F. Premature ventricular complex induced cardiomyopathy. Rev Esp Cardiol (Engl Ed) 2016;69:365-9.
9. Singh SN, Fletcher RD, Fisher SG, Singh BN, Lewis HD, Deedwania PC, et al. Amiodarone in patients with congestive heart failure and asymptomatic ventricular arrhythmia. Survival trial of antiarrhythmic therapy in congestive heart failure. N Engl J Med 1995;333:77-82.
10. Peichl P, Wichterle D, Pavlu L, Cihak R, Aldhoon B, Kautzner J. Complications of catheter ablation of ventricular tachycardia: a single-center experience. Circ Arrhythm Electrophysiol 2014;7:684-90.
11. Go AS, Mozaffarian D, Roger VL, Benjamin EJ, Berry JD, Blaha MJ, et al. Heart disease and stroke statistics -- 2014 update: a report from the American Heart Association. Circulation 2014;129: e28-e292.
12. Aliot EM, Stevenson WG, Almendral-Garrote JM, Bogun F, Calkins CH, Delacretaz E, et al. EHRA/HRS Expert Consensus on Catheter Ablation of Ventricular Arrhythmias: developed in a partnership with the European Heart Rhythm Association (EHRA), a Registered Branch of the European Society of Cardiology (ESC), and the Heart Rhythm Society (HRS); in collaboration with the American College of Cardiology (ACC) and the American Heart Association (AHA). Heart Rhythm 2009;6:886-933.
13. Zipes DP, Camm AJ, Borggrefe M, Buxton AE, Chaitman B, Fromer M, et al. ACC/AHA/ESC 2006 guidelines for manage-

ment of patients with ventricular arrhythmias and the prevention of sudden cardiac death: a report of the American College of Cardiology/American Heart Association Task Force and the European Society of Cardiology Committee for Practice Guidelines (Writing Committee to Develop Guidelines for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death). J Am Coll Cardiol 2006;48:e247-e346.
14. Latchamsetty R, Yokokawa M, Morady F, Kim HM, Mathew S, Tilz R, et al. Multicenter outcomes for catheter ablation of idiopathic premature ventricular complexes. JACC Clin Electrophysiol 2015;1:116-23.
15. Nakagawa M, Takahashi N, Nobe S, Ichinose M, Ooie T, Yufu F, et al. Gender differences in various types of idiopathic ventricular tachycardia. J Cardiovasc Electrophysiol 2002;13:633-8.
16. Spesific Arrhythmias: Diagnosis and Treatment in Braunwald's Heart Disease A textbook of cardiovascular medicine. 10th Ed.. Philadelphia 2015: p.771-3.
17. Stec S, Sikorska A, Zaborska B, Krynski T, Szymot J, Kulakowski P. Benign symptomatic premature ventricular complexes: short-and long-term efficacy of antiarrhythmic drugs and radiofrequency ablation. Kardiol Pol 2012;70:351-8.
18. Krittayaphong R, Bhuripanyo K, Punlee K, Kangkagate C, Chaithiraphan S. Effect of atenolol on symptomatic ventricular arrhythmia without structural heart disease: a randomized placebo-controlled study. Am Heart J 2002;144:e10.
19. Echt DS, Liebson PR, Mitchell LB, Peters RW, Obias-Manno D, Barker AH, et al. Mortality and morbidity in patients receiving encainide, flecainide, or placebo. The cardiac arrhythmia suppression trial. N Engl J Med 1991;324:781-8.
20. Ling Z, Liu Z, Su L, Zipunnikov V, Wu J, Du H, et al. Radiofrequency ablation versus antiarrhythmic medication for treatment of ventricular premature beats from the right ventricular outflow tract: prospective randomized study. Circ Arrhythm Electrophysiol 2014;7:237-43.
21. Zhong L, Lee YH, Huang XM, Asirvatham SJ, Shen WK, Friedman PA, et al. Relative efficacy of catheter ablation vs antiarrhythmic drugs in treating premature ventricular contractions: a single-center retrospective study. Heart Rhythm 2014;11:187-93.
22. Wang Y, Eltit JM, Kaszala K, Tan A, Jiang M, Zhang M, et al. Cellular mechanism of premature ventricular contraction-induced cardiomyopathy. Heart Rhythm 2014;11:2064-72.
23. Mountantonakis SE, Frankel DS, Gerstenfeld EP, Dixit S, Lin D, Hutchinson MD, et al. Reversal of outflow tract ventricular premature depolarization-induced cardiomyopathy with ablation: effect of residual arrhythmia burden and preexisting cardiomyopathy on outcome. Heart Rhythm 2011;8:1608-14.
24. Ban JE, Park HC, Park JS, Nagamoto Y, Choi JI, Lim HE, et al. Electrocardiographic and electrophysiological characteristics of premature ventricular complexes associated with left ventricular dysfunction in patients without structural heart disease. Europace 2013;15:735-41.
25. Baman TS, Lange DC, Ilg KJ, Gupta SK, Liu TY, Alguire C, et al. Relationship between burden of premature ventricular complexes and left ventricular function. Heart Rhythm 2010;7:865-9.
26. Kanei Y, Friedman M, Ogawa N, Hanon S, Lam P, Schweitzer P. Frequent premature ventricular complexes originating from the right ventricular outflow. Ann Noninvasive Electrocardiol 2008;13:81-5.
27. Sheldon SH, Gard JJ, Asirvatham SJ. Premature ventricular contractions and non-sustained ventricular tachycardia: association with sudden cardiac death, risk stratification, and management strategies. Indian Pacing Electrophysiol J 2010;10:357-71.
28. Duffee DF, Shen WK, Smith HC. Suppression of frequent premature ventricular contractions and improvement of left ventricular function in patients with presumed idiopathic dilated cardiomyopathy. Mayo Clin Proc 1998;73:430-3.
29. Sohn DW, Chai IH, Lee DJ, Kim HC, Kim HS, Oh BH, et al. Assesment of mitral annulus velocity by Doppler tissue imaging in the evalution left ventricular diastolic function. J Am Coll Cardiol 1997;30:474-80.
30. Stevenson WG. Current treatment of ventricular arrhythmias: state of the art. Heart Rhythm 2013;10:1919-26.
31. Lee A, Denman R, Haqqani HM. Ventricular ectopy in the context of left ventricular systolic dysfunction: risk factors and outcomes following catheter ablation. Heart Lung Circ 2019;28:379-88.
32. Tada H, Tadokoro K, Ito S, Naito S, Hashimoto T, Kaseno K, et al. Idiopathic ventricular arrhythmias originating from the tricuspid annulus: prevalence, electrocardiographic characteristics, and results of radiofrequency catheter ablation. Heart Rhythm 2007;4:7-16.
33. Wang JS, Shen YG, Yin RP, Thapa S, Peng YP, Ji KT, et al. The safety of catheter ablation for premature ventricular contractions in patients without structural heart disease. BMC Cardiovasc Disord 2018;18:177.
34. Baman TS, Ilg KJ, Gupta SK, Good E, Chugh A, Jongnarangsin, et al. Mapping and ablation of epicardial idiopathic ventricular arrhythmias from within the coronary venous system. Circ Arrhythm Electrophysiol 2010;3: 274-9.
35. Yokokawa M, Latchamsetty R, Good E, Chugh A, Pelosi F, Jr, Crawford T, et al. Ablation of epicardial ventricular arrhythmias from nonepicardial sites. Heart Rhythm 2011;8:1525-9.
36. Carrigan T, Patel S, Yokokawa M, Swanson S, Morady F, Bogun F. Anatomic relationships between the coronary venous system, surrounding structures, and the site of origin of epicardial ventricular arrhythmias. J Cardiovasc Electrophysiol 2014;25:1336-42.
37. Yokokawa M, Good E, Desjardins B, Crawford T, Jongnarangsin K, Chugh A, et al. Predictors of successful catheter ablation of ventricular arrhythmias arising from the papillary muscles. Heart Rhythm 2010;7:1654-9.
38. Good E, Desjardins B, Jongnarangsin K, Oral H, Chugh A, Ebinger M, et al. Ventricular arrhythmias originating from a papil- lary muscle in patients without prior infarction: a comparison with fascicular arrhythmias. Heart Rhythm 2008;5:1530-7.
39. Peichl P, Wichterle D, Pavlu L, Cihak R, Aldhoon B, Kautzner J. Complications of catheter ablation of ventricular tachycardia: a single-center experience. Circ Arrhythm Electrophysiol 2014;7:684-90.
40. Capucci A, DiPasquale G, Boriani G, Carini G, Balducelli M, Frabetti L, et al. A double-blind cross over comparison of fle-

cainide and slow-release mexiletine in thetreatment of stable premature ventricular complexes. Int J Clin Pharmacol Res 1991;11:23-33.