Predictors Of Successful Radiofrequency Catheter Ablation Of Premature Ventricular Complexes

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Abstract

Introduction Cases with an elevated burden of premature ventricular complexes PVC can benefit from catheter ablation, which was proven to be an efficient as well as therapeutic strategy to improve symptoms while simultaneouslyreducingPVC burden.

Aim: The objective of this research is to determine the predictors of successful radiofrequency catheter ablation of premature ventricular complexes.

Participants &Methods: A group of 100 subjects with a burden PVCs greater than 15%, who were scheduled for a conventional or 3D ablation at electrophysiology unit of Ain Shams University between 2018 and 2020, have been recruited in the current study. Success has been identified as acute elimination of PVCs in Cath-lab with a 30 minutes waiting period and PVCs burden <3% on follow up Holter recording.

Results: The success rate was 83% among 100 patients (mean age 41.31 ± 17.69 years, 52% female patients), with 68% of the patients undergoing conventional ablations. Success was predicted by age (<58 years), outflow tract (OT) origin of PVCs, and the existence of a pre-QRS signal on the ablation catheter> 33msec (P- value < 0.001). No statistical difference between conventional ablation as well as 3D ablation was detected in this study regarding predictors of success.

Conclusion: Age, Origin of PVCs and pre-QRS signal are predictors of success of PVCs ablation.

Keywords: Radiofrequency catheter ablation; premature ventricular complexes; conventional ablation; 3D ablation.

Abbreviations: LVEF = left ventricular ejection fraction; ECG = electrocardiogram; LVOT = left ventricular outflow tract; RFCA = radiofrequency catheter ablation; PVC = premature ventricular contraction; RV = right ventricular/ventricle; OT = Outflow tract; RVOT = right ventricular outflow tract.

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INTRODUCTION

Premature ventricular complexes (PVCs) are considered to be a frequent arrhythmias in clinical practice pervasiveness estimated of 1-4% on a standard 12-lead electrocardiography (ECG) and 40-75% of subjects on 24- to 48-h Holter monitoring. They are commonly a benign case of the structurally naturalistic heart; however, they can indicate elevated risks of sudden deaths in structurally heart disease (SHD). In addition, they can be indicators for underlying pathology. The occurrence of PVCs as well their complication are elevated in the majority of heart diseases, as high as 90 percent in both ischemic as well as nonischemic cardiomyopathy **(Gorenek et al., 2020).**

In elevated PVC burden cases, ablation by catheterization represents an efficient as well as therapeutic strategy in order to ameliorate symptoms, along with reducing the burden of PVC. Based on the origin of the PVC, ablation by catheterization maybe the first treatment in PVCs arising from the RVOT or it can be taken into account in cases if treatment is not successful or is undesirable (such as LVOT, non-outflow tract PVCs). Ablation by catheterization is usually performed due to the symptoms related to the elevated burden of PVC. Ablation is not regarded as an indicator for asymptomatic PVCs with a decreased burden (<10%) **(Baman et al., 2010).**

OBJECTIVES

The main objective of the current study is to determine the predictors of successful Radiofrequency catheter ablation of premature ventricular complexes.

PATIENTS AND METHODS

Type of Study: This was a prospective observational study**.**

Study Setting: Electrophysiology at Ain Shams University Hospitals

Study Period: From October 2018 till December 2020

Study Population: This study was conducted on 100 cases with recurrent PVCs referred for electrophysiology study and radiofrequency catheter ablation at the Electrophysiology Unit of Ain Shams University.

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Inclusion Criteria: This study recruited one hundred subjects with premature ventricular depolarizations > or equal 15% on 24 hour Holter, PVCs induced LV dysfunction or symptomatic PVCs not responding to medical treatment **(Cronin et al, 2019).**

Exclusion Criteria: The exclusion criteria were applied as follows:

1. Cases that have major clinical illness as liver cell failure, chronic pulmonary disease and renal failure.
2. Congenital heart disease.
3. Rheumatic heart disease
4. Patients with prosthetic valve
5. PVCs burden less than 15 %
6. Patients with proven ongoing ischemia
7. Patients who refused ablation and on medical treatment.

Sampling Method: random sampling**.**

Sample Size: 100 patients (52 females and 48 males)

Ethical Considerations: Written informed consents were obtained from all participants for clinical evaluation. The approval of Ain Shams University Ethical Committee was obtained as informed to the ethical guidelines of the 1975 declaration of Helsiniki as amended in 2008.

Study Tools

Study Procedures and Study Interventions:

Baseline evaluation

Organic heart disease was excluded by physical examination, chest radiography, and echocardiography.

Electrocardiographic measurements (ECG)

The individual 12 lead surface electrogram (ECG) and Holter monitoring scores have been manually reviewed. The origin of PVC was identified via 12- lead ECG (Figure 1) **(Tada et al, 2019).**

The origin of PVCs has been described as the origin site (Yamada et al, 2017):

1. Right ventricular outflow tract (RVOT): left bundle branch block morphology, with inferior axis, long R waves in inferior leads, negative (QS) complexes in avR and avL, all-negative QS or small r wave in lead V1, as well as R transitionin lead V3 or lead V4 (Figure 2).
2. Left ventricular out flow tract (LVOT): right bundle branch block morphology, with inferior axis, long R waves in inferior leads, as well as negative (QS) complexes in the avL as well as the avR; or left bundle branch block morphology with longer R wave amplitude and period in lead V1, in addition to early R transition in lead V1 or V2 (Figure 3).
3. RV non-OT: left bundle branch block morphology, without the typical inferior axis or RVOT features (Figure 4).
4. LV non-OT: right bundle branch block morphology, without LVOT features (Figure 5).

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Echocardiography Assessment (Lang et al, 2015)

Two-dimensional echocardiography was conducted at baseline via a system that can be commercially obtained. The left vetricular ejection fraction was evaluated according to two consecutive beats of sinus rhythm by Simpson's formula. In case of persistent hypertrophy, the average ejection fraction will be calculated to multiply the sinus rhythm with the PVC ejection fraction. The dimensions of LV systolic and diastolic were estimated according to echocardiography in M mode in the parasternal long axis view. Cases that were subjected to ablation by catheterization, baseline echocardiography was re done three months before the procedure. Baselines, which are LV, LVEF end-systolic dimension (LVESd), and LV end-diastolic dimension (LVEDd) were measured.

24 hour Holter monitoring

Holter monitoring has been conducted at baseline in order to evaluate the burden of PVC. Moreover, the burden of PVC is identified as the proportion of overall beats that are PVCs. The burden of PVC was defined as the proportion of PVCs related to the overall QRS complex number. The cases that have a PVC burden ≥15% have been recruited in the present study.

The procedures of electrophysiology and ablation

Informed written consents have been obtained from participants, and then 12 lead surface ECG was done before the start of the electrophysiological procedure to ensure the presence of the PVCs.

The investigation of participants was performed with no sedation in a fasting state. Antiarrhythmic drugs have been stopped for at least five half-lives prior to the procedure.

Under local anesthesia, using 2% lidocaine, two femoral vein punctures have been made (6F and 7F sheathes) into the femoral vein, one decapolar catheter was placed at the CS position through the 6F sheath and a 7F (4mm or irrigated tip) ablation catheter was placed through the 7F sheath to map the RVOT.

If the PVCs are expected to be of LVOT in origin (coronary angiography was done to locate the sites of coronaries), retrograde approach through femoral artery.

Transeptal technique was done if the approach of the PVCs was difficult by retrograde one (LV PVCs) and the PVC is located within the LV inflow.

Mapping of the PVCs were done (activation mapping targeting the earliest activation 30 msec before the beginning of the QRS on the surface ECG) and the procedure was done either conventionally or by 3D electroanatomical mappingusing CARTO® , Biosense Webester or NavX® , Abbott (Kim et, al 2019) (Figure 6).

The procedure endpoint was the total removal of clinical PVCs and no stimulation after a 30-minute waiting period or announcement of failure.

Follow-up

Participants were asked to return for follow-up 6 nmonths after the procedure.

The clinical symptoms have been revised. The physical examination, reiterating the standard 12 lead surface ECG, 24 hours Holter recording after 6 months of ablation or earlier in symptomatic patients, and echocardiography were performed.

Comparison was done between successful cases and failed cases to determine predictors of procedure success. Success is determined as disappearance of PVCs by RF ablation and PVC burden of <3% at follow up Holter monitoring after 6 months (**Cronin et al, 2019).**

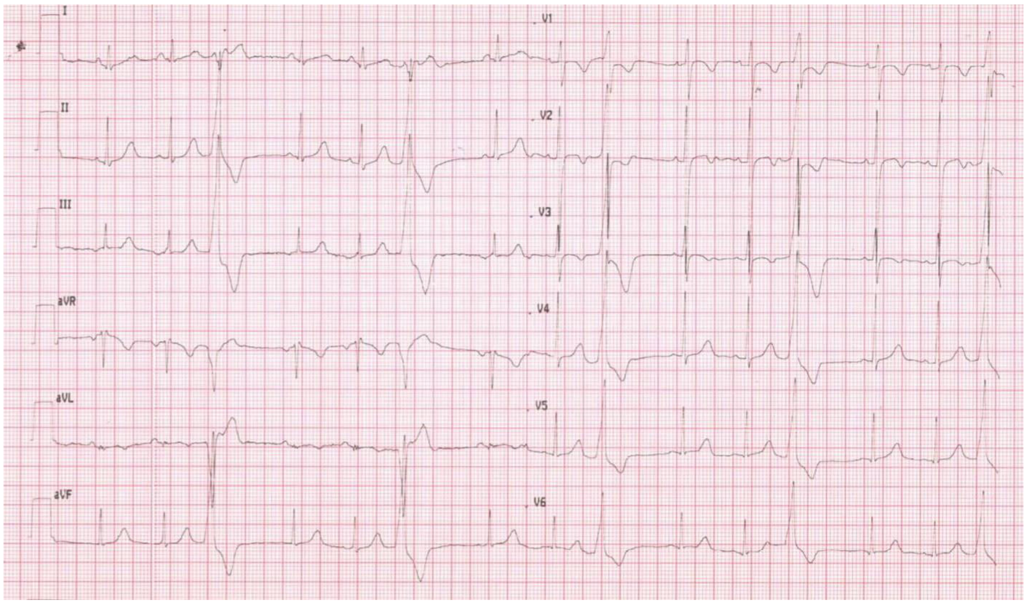

Figure 1: ECG showing PVCs (originating from LVOT).

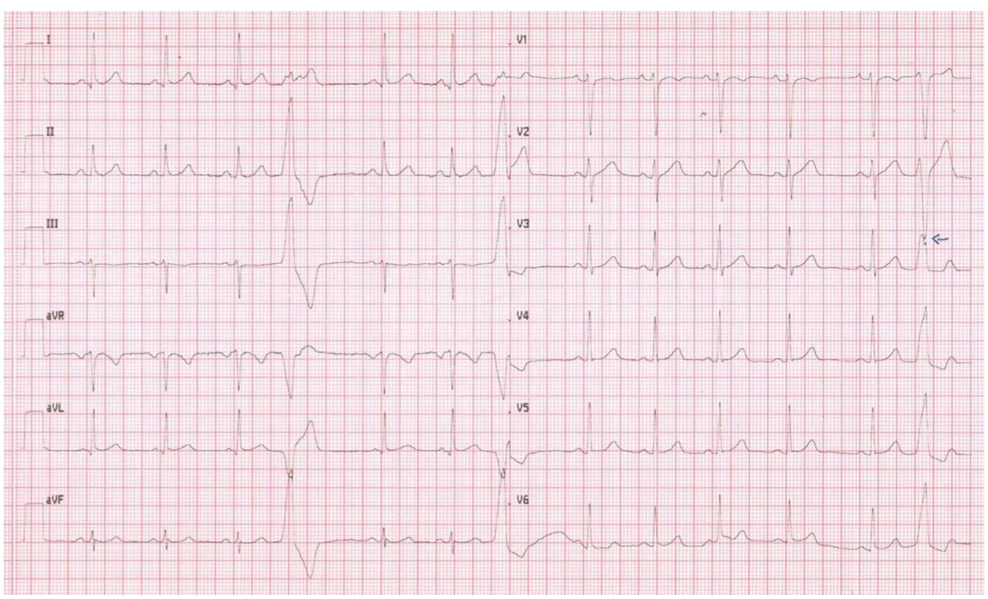

Figure 2: ECG with PVCs originating from the RVOT

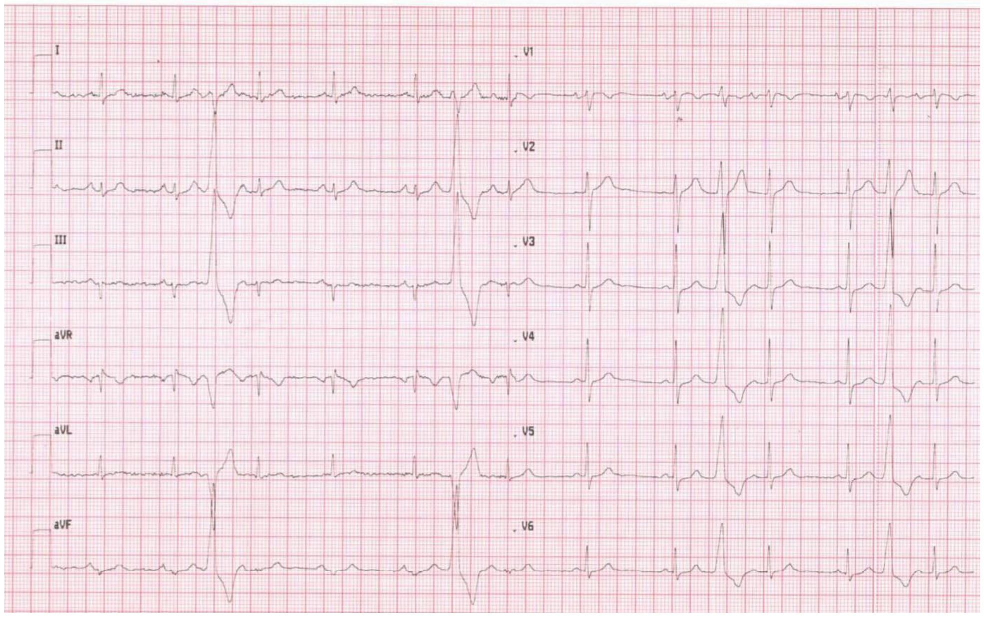

Figure 3: Showing ECG with PVCs originating from the LVOT.

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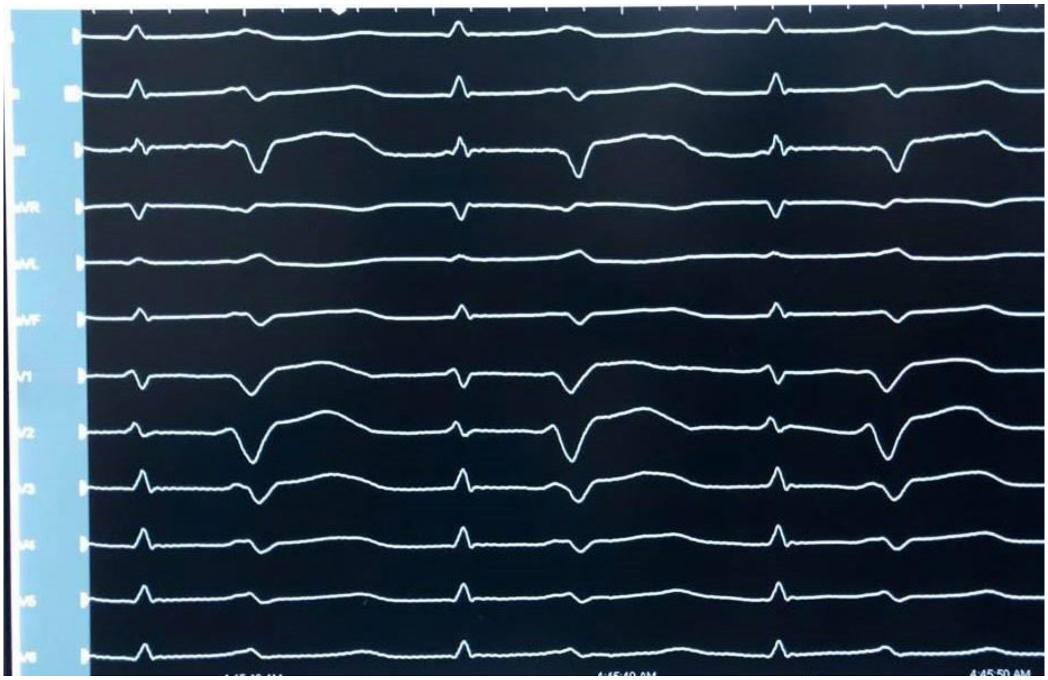

Figure 4: ECG with PVCs originating from the RV (non-OT)

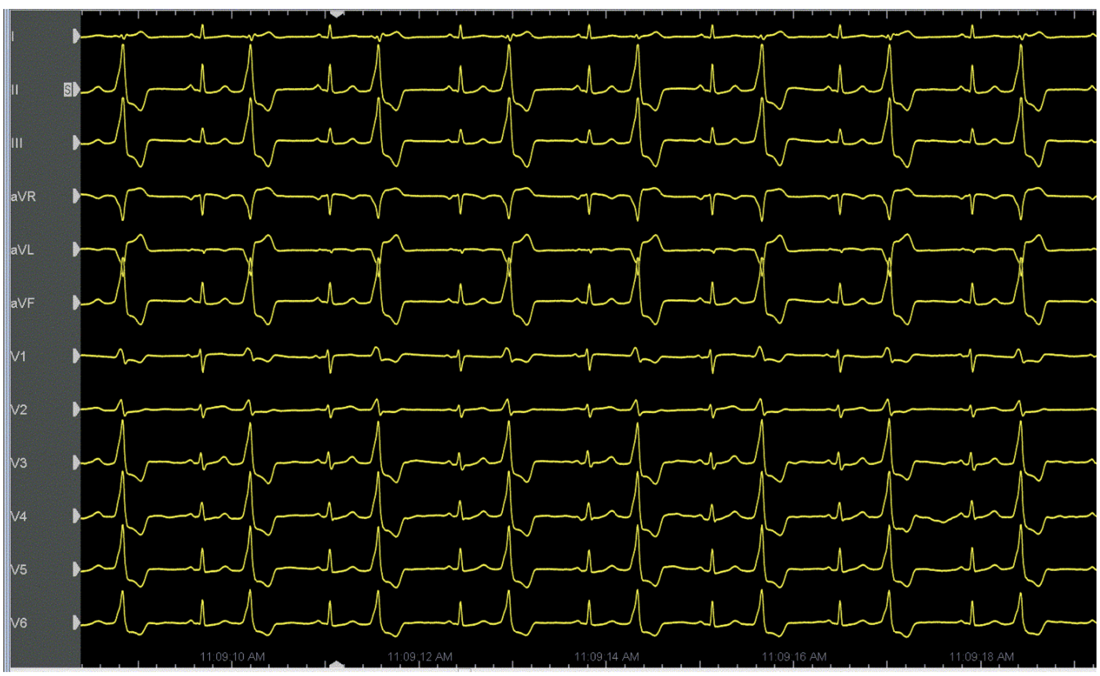

Figure 5: ECG showing VT/PVCs arising from the LV (anterior Mitral annulus) (non-OT)

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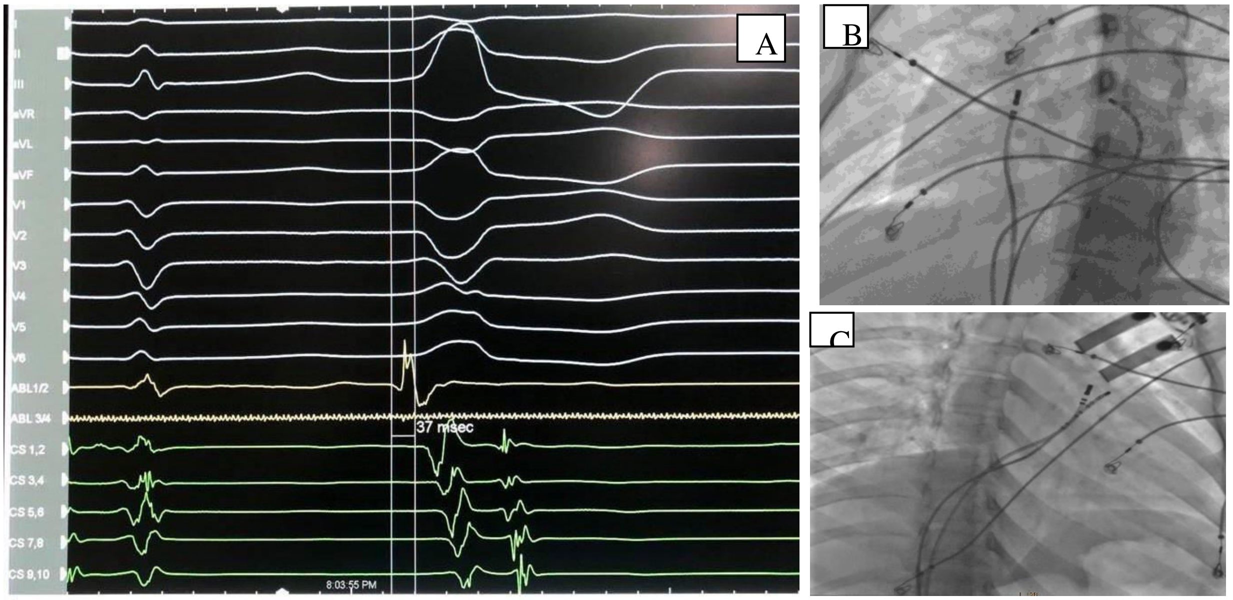

Figure 6: Pre-QRS signal during conventional ablation (A). Lao view showing ablation catheter in RVOT (B). Rao view showing ablation catheter in the RVOT (C).

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STATISTICAL ANALYSIS

Data were collected and revised, then coded and entered into the computer using the Statistical Package for Social Science (IBM SPSS) version 23. Quantitative data were expressed in the form of mean, ±standard deviations and ranges at inter-quartile (IQR), median, and parametric range when non-parametric data were found. Furthermore, qualitative variables were expressed in the form of percentages as well as numbers.

Intergroup comparison with respect to qualitative data has been performed according to **Fisher exact test** or **Chi-square test** when the anticipated cell count is lower than five. While, intergroup comparison with regard to parametric distribution as well as quantitative data, has been performed based on **Independent t-test.** Whereas the nonparametric distribution has been performed by **Mann-Whitney test.**

The confidence interval was determined at 95%, whereas and the error margin was acceptable at 5%. Therefore, the p-value was regarded significant as follows:

Non-significant when p-value is > 0.05.

Significant when p-value is < 0.05.

Highly significant when p-value is < 0.01.

RESULTS

- **Baseline characteristics**

The studied patients were one hundred, 52 were females (52%) and their mean age was estimated of 41.31± 17.69, whereas their mean weight was 71.88±20.03. 38 patients had hypertension (38%) and 25 patients had Diabetes (25%) (table:1).

The mean Burden of PVCs during baseline 24-h Holter monitoring was 26.37 ± 9.34. There were no marked differences between the two groups with regard to ejection fraction or PVCs burden by Holter monitoring (Table: 2).

- **Procedural characteristics**

Conventional ablation was performed in 68% of patients while 32% of patients had ablation using 3D system (CARTO n=24, NAvX n=8).

The mean ablation time was 192.35 ± 66.17 seconds and the mean fluoroscopic time was 24 (20 – 61.5) minutes which was identical between the conventional and 3D groups (Table 3), (Figure 7).

- **Electrophysiologic characteristics**

The origin of the PVCs was from RVOT in 48 patients, from LVOT in 23 patients, from the LV in 20 patients (9 summit , 8 Aorto-Mitral continuity, 3 anterolateral LV), from the epicardium in 7 patients, and from the RV in 2 patients (postero-lateral RV) (table 4).

Patients were considered to have outflow tract PVCs (OT) (n=71), if their PVCs originated from the RVOT or the LVOT, and non-outflow tract PVCs (Non-OT) (n=29) in patients who had PVCs from other origins.

The onset of bipolar electrogram on the ablation catheter pre-QRS was significantly different in successful ablation patients (>33msec, P<0.001). The PVCs origin was significantly related to successful ablation (OT, P<0.001) (table: 5).

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Clinical outcome

Post ablation Holter with a median of 1 % of PVCs with a success rate of 83% in ablation of the PVCs. In unadjusted analysis, the advanced age as well as HTN were correlated with failure. OT origin and pre-QRS signal were associated with success (table: 6). Logistic regression analysis using (Backward: Wald) showed that a pre-QRS signal of >33 msec, non-OT PVCs and age <58 years were all predictors of success (table 7

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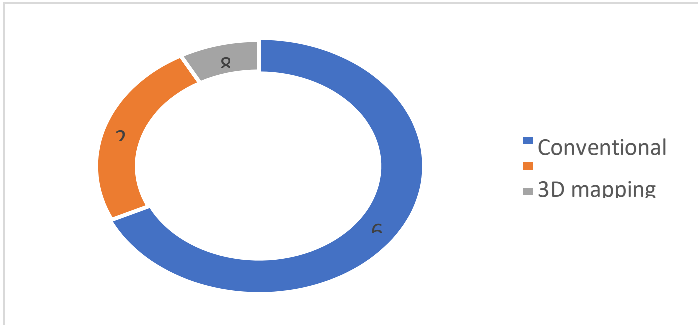

Figure (7): Types of ablation procedures in the present study.

Table (1): Baseline demographic characteristics

		Total no. = 100
Gender	Female	52 (52.0%)
	Male	48 (48.0%)
Age (years)	Median (IQR)	42 (30 – 56)
	Mean ± SD	41.31 ± 17.69
	Range	9 – 77
Weight (Kilograms)	Mean ± SD	71.88 ± 20.03
	Range	27 – 110
HTN	No	62 (62.0%)
	Yes	38 (38.0%)
DM	No	75 (75.0%)
	Yes	25 (25.0%)

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Table (2): Baseline echocardiography and Holter characteristics.

		Total no. = 100
Holter	Mean ± SD	26.37 ± 9.34
	Range	13 – 48
Echocardiography	Mean ± SD	61.10 ± 6.20
	Range	55 – 80
Echocardiography	Normal	100 (100.0%)

Table (3): Comparison of PVCs origin between conventional and 3D groups.

Ablation type	Diagnosis		Test value	P-value	Sig.
	VOT	Non VOT			
	No. = 71	No. = 29			
Conventional	51 (71.8%)	17 (58.6%)	1.651*	0.199	NS
3D mapping	20 (28.2%)	12 (41.4%)			

P-value < 0.05: Significant; P-value > 0.05: Non-significant; P-value < 0.01: Highly-significant
*: Chi-square test

Table (4): Origin of PVCs and success/failure rates

Origin of PVCs	Success n=83	Failure n=17	Total n=100	% Success
RVOT	47	1	48	97.9%
LVOT	22	1	23	95.7%
LV	10	10	20	50%
epicardial	2	5	7	28.6%
RV	2	0	2	100%

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Table (5): Comparison of success predictors between conventional and 3D groups.

		Conventional No. = 58	3D mapping No. = 25	Test value	P-value	Sig.
Diagnosis	VOT	50 (86.2%)	19 (76.0%)	1.298*	0.255	NS
	Non VOT	8 (13.8%)	6 (24.0%)			
Pre QRS signal on ablation by-msec	Mean ± SD	45.52 ± 6.32	44.48 ± 5.55	0.711•	0.479	NS
	Range	24 – 55	34 – 55			
Ablation time in seconds	Mean ± SD	170.19 ± 60.32	200.80 ± 63.20	-2.091•	0.040	S
	Range	78 – 355	100 – 312			
Flouro time in mins	Median (IQR)	23 (18 – 29)	33 (16 – 56)	-0.880≠	0.379	NS
	Range	8 – 121	3 – 99			
Post ablation hoter	Median (IQR)	1 (1 – 1)	1 (1 – 3)	-0.623≠	0.533	NS
	Range	0 – 10	0 – 7			

P-value < 0.05: Significant; P-value > 0.05: Non-significant; P-value < 0.01: Highly-significant
*: Chi-square test

Table (6): Comparison of the procedure and electrophysiologic data between success and failure groups.

		Success No. = 83	Failure No. = 17	Test value	P-value	Sig.
Diagnosis	VOT	69 (83.1%)	2 (11.8%)	34.904*	0.000	HS
	Non VOT	14 (16.9%)	15 (88.2%)			
Pre QRS signal on ablation by-msec	Mean ± SD	45.20 ± 6.08	26.76 ± 6.91	11.126•	0.000	HS
	Range	24 – 55	16 – 44			
Ablation type	Conventional	58 (69.9%)	10 (58.8%)	0.793*	0.373	NS
	3D mapping	25 (30.1%)	7 (41.2%)			
Ablation time in seconds	Mean ± SD	179.41 ± 62.43	255.53 ± 44.80	-4.773•	0.000	HS
	Range	78 – 355	177 – 322			
Flouro time in mins	Median (IQR)	23 (16 – 40)	67 (56 – 88)	-4.533≠	0.000	HS

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	Range	3 – 121	19 – 102			

P-value < 0.05: Significant; P-value > 0.05: Non-significant; P-value < 0.01: Highly-significant
*: Chi-square test

Table (7): Logistic regression analysis using (Backward: Wald) for factors of success

	Univariate				Multivariate			
	P-value	**Odds ratio (OR)**	**95% C.I. for OR**		**P-value**	**Odds ratio (OR)**	**95% C.I. for OR**	
			Lower	**Upper**			**Lower**	**Upper**
Age ≤ 58	**0.001**	8.983	2.513	32.116	–	–	–	–
Diagnosis (OVT)	**0.000**	36.964	7.589	180.056	–	–	–	–
Pre QRS signal on ablation by-msec > 33	**0.000**	316.000	33.100	3016.839	**0.000**	284.894	19.228	4221.146
Ablation time in seconds ≤ 222	**0.000**	18.118	4.668	70.316	–	–	–	–
Flouro time in mins ≤ 47	**0.000**	31.406	6.515	151.409	**0.011**	27.385	2.160	347.221

P-value < 0.05: Significant; P-value > 0.05: Non-significant; P-value < 0.01: Highly-significant

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DISCUSSION

Patients with idiopathic premature ventricular complexes (PVCs) may benefit from radiofrequency catheter ablation, which might ameliorate the function of the heart in the cases of PVC-mediated cardiomyopathy. The method known as "activation mapping" is the most effective method for locating the origin place and guiding effective ablation. Patients receiving RFCA in the modern mapping age had good short-term results, as shown by retrospective, multicenter cohort research that demonstrated a total acute success rate of 84 percent [range 67 – 93 percent] (Latchamsetty, et al. 2015).

The objective of this study is to identify factors that influence the effectiveness of radiofrequency ablation by catheterization of premature ventricular complexes. PVC ablation was performed on 100 patients, the majority of whom (68 patients) were traditionally ablated without employing a 3D-mapping system (whether Navix or Carto systems), with the remaining 32 patients underwent radiofrequency ablation based on a 3D-mapping system. Additionally, success was judged by the full elimination of PVCs within the Cath lab and the presence of less than 3% of PVCs on the Holter monitor during follow-up.

Theindings of the present research show that an age less than 58 years, as determined by multivariable regression analysis, was a predictor of the success of PVC ablation.

According to Güneş et al., (2018), the mean age was substantially different between the PVC recurrence and non-recurrence groups, which is consistent with the findings of Demir et al.

Tanaka et al., (2011) investigated the variations in gender and age between patients with PVCs/VT ablation and those without PVCs/VT ablation. They discovered that younger age was a good predictor of the success of RF ablation. They attributed this to the difference in age in patients with LVOT VT and patients with RVOT VT in their research, since patients' average age with LVOT VT was significantly greater compared with the mean age of patients with RVOT VT.

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Via multivariate analysis, this research found that female gender was not linked to long-term success rate, which was in contrast to the findings of Im et al., (2021) in their prospective study. Further research into this difference is necessary.

Choi et al., (2021) showed that using EAM that early signal on the bipolar ablation catheter distal electrode before the PVC QRS on the ECG indicated successful ablation by retrospectively evaluating 158 patients. They suggested a cut-off of 30 milliseconds. Furthermore, the findings of the present study are compatible with those of Choi et al., who also demonstrated the feasibility of defining a sufficient pre-QRS signal utilizing standard ablation techniques. Similarly, a pre-QRS signal with duration of more than 33 msec is a predictor of successful PVC ablation.

Di Biase and colleagues investigated the use of a pre-QRS cutoff of 30msec as a predictor for single origin of PVCs/VT. The study found that the cutoff was effective in 98 percent of acute success cases, and in 95 percent of cases during follow up. In particular, the authors stated that a pre-QRS signal of less than 30 msec is indicative of multiple activation sites that need ablation at all sites in order to completely remove the PVCs/VT. This may account for the significant failure rate seen in this study in individuals with a pre-QRS of less than 33 msec (Di Biase et al (2019).

Both the German ablation registry Fichtner, et al (2017), and a retrospective study by (Latchamsetty, et al (2015) found that the acute success rate for RVOT PVC excision was significantly higher than the success rate for PVCs from other sources. This is congruent with the findings in this study that demonstrated a 100 percent success rate in the ablation of RVOT PVCs.

A pre-QRS signal of more than 33 has been shown to be a predictor of success in the ablation of PVCs in this research. In a study Im et al., the cutoff value for predicting failure was 15 milliseconds (Im, et al. 2021). A possible explanation for this discrepancy can be attributed to the fact that in the current study, conventional ablation rather than ablation using a 3D system was performed in a wide range of cases (68 percent), and therefore a higher value must be met in order to eliminate the PVCs.

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According to the results of this study, patients with failure of PVCs ablation had a longer fluoroscopic time and a longer total ablation time. This aligns with a previous research by Im et al (2021), who demonstrated that longer flurscopic and ablation times were associated with late PVCs recurrence.

According to the findings of a multicenter study conducted by Lanchmasetty et al, (2015), patients with RVOT origin of the PVCs had the shortest fluoroscopic time and ablation time, while patients with epicardial origin had the longest. Their results also demonstrate that successful ablation was most frequently associated with RVOT origin and failure rates were most frequently associated with epicardial origin, which indicates that their findings are consistent with those of this study.

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Conclusion

Age < 58 years, pre-QRS signal>33 msec and OT origin of PVCs were associated with success of ablation. The findings of the current study indicate that the same indicators for success/failure apply to conventional and 3D ablation of PVCs.

Limitations of the Study

Several limitations may have influenced our results. The study sample size and a 6-months follow-up period may be insufficient to judge the long-term success rate of PVCs ablation.

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