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Impact of Chronic PVC Burden on Left Ventricular Function and Cardiovascular Outcomes

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ABSTRACT

Objective: To evaluate the impact of chronic premature ventricular complex (PVC) burden on left ventricular (LV) function and cardiovascular outcomes, and to assess the role of pharmacological treatment in improving clinical outcomes. **Methodology:** This retrospective study was conducted at the Department of Cardiac Electrophysiology, Hayatabad Medical Complex, Peshawar, from September 2023 to July 2024. A total of 250 patients were included, divided into high PVC burden (>20%) and low PVC burden (≤20%) groups, with 125 patients in each group. Data on PVC burden, LV ejection fraction (LVEF), left atrial volume index (LAVI), and follow-up outcomes were collected. Statistical analysis included chi-square and t-tests, with significance set at $p < 0.05$. **Results:** The high PVC burden group showed significantly lower mean LVEF (42%) compared to the low PVC burden group (56%) ($p < 0.001$). LAVI was markedly higher in the high-burden group (34.5 mL/m² vs. 24.3 mL/m², $p < 0.05$). Follow-up outcomes were significantly associated with medication use; 68% of patients on medication improved, compared to 40% without medication ($p < 0.05$). A chi-square test revealed significant association between medication use and follow-up outcomes ($p = 0.02$). **Conclusion:** Chronic PVC burden adversely affects LV function and cardiovascular outcomes. Pharmacological treatment significantly improves clinical outcomes, underscoring the need for structured management strategies. Future research should focus on prospective studies and randomized trials to validate these findings.

INTODUCTION

Premature ventricular complexes (PVCs), defined as early depolarizations originating from the ventricles, are commonly encountered in clinical practice and have significant implications for cardiac function and patient outcomes. While PVCs have traditionally been considered benign, emerging evidence suggests that a high burden of PVCs may lead to left ventricular (LV) dysfunction and contribute to the development of cardiomyopathy.[1] This concern becomes particularly relevant in populations with structurally normal hearts, where the long-term hemodynamic consequences of frequent PVCs remain an area of active investigation.[2]

Recent studies have demonstrated that a high PVC burden is associated with progressive LV dilation, reduced ejection fraction, and functional impairment.[3] Furthermore, frequent PVCs can exacerbate myocardial dyssynchrony, leading to remodeling and increased risks of arrhythmia and heart failure in both diseased and non-diseased hearts.[4] The burden threshold of >20% has been identified as critical, with negative outcomes becoming significantly more pronounced beyond this limit.[5]

Frequent PVCs have been identified as significant predictors of long-term left ventricular dysfunction, emphasizing early intervention in patients with high PVC burdens.[6] The left atrial (LA) dysfunction caused by high PVC burdens demonstrates significant associations with reduced global LA peak strain and increased LA stiffness, highlighting the hemodynamic impact.[2]

Analysis of Holter monitoring has shown a strong correlation between high PVC burdens (>10%) and reduced LV ejection fractions, supporting its predictive role in adverse cardiac outcomes.[7] Patients with left-sided PVCs have higher risks of adverse outcomes,

including heart failure and reduced survival, compared to right-sided PVC origins.[8]

A meta-analysis has identified non-sustained ventricular tachycardia and epicardial PVC origins as key risk factors for the development of PVC-induced cardiomyopathy.[9] Deep learning algorithms trained on ECG data demonstrate high accuracy in predicting LV dysfunction in patients with frequent PVCs, offering novel diagnostic pathways.[10] High PVC burdens (>5%) are common even in treated heart failure patients and are associated with significantly worse outcomes, including increased mortality.[11] Female patients with high PVC burdens are at increased risk of left ventricular enlargement, which is reversible with catheter ablation.[12] Ablation of low-burden PVCs (<10%) significantly improves quality of life and symptom burden, indicating benefits even in less severe cases.[13]

In Pakistan, the study of PVC-related cardiomyopathies is gaining traction due to the increasing prevalence of arrhythmias in the general population. Data from local tertiary hospitals highlight the need for more robust evaluation methods, including Holter monitoring and advanced imaging, to assess the long-term effects of PVCs on cardiovascular outcomes.[14] Early detection and management remain pivotal in mitigating adverse outcomes in these patients.

Despite extensive global research, gaps persist in understanding the specific impact of chronic PVC burden in patients presenting to specialized cardiac electrophysiology units, such as at Hayatabad Medical Complex in Peshawar. This research aims to bridge the knowledge gap by investigating the clinical and structural implications of PVCs on LV function, providing valuable insights for tailored therapeutic interventions.

The objective of this study is to evaluate the impact of chronic PVC burden on left ventricular function and its association with cardiovascular outcomes in a cohort from the Cardiac Electrophysiology Department, Hayatabad Medical Complex, Peshawar.

MATERIALS AND METHODS

Study Setting and Duration

This retrospective study was conducted in the Department of Cardiac Electrophysiology at Hayatabad Medical Complex, Peshawar. The study period extended from September 2023 to July 2024, covering a 10-month data collection and analysis phase.

Study Design and Sample Size

The study included a retrospective review of patients presenting with chronic premature ventricular complex (PVC) burden. Based on a similar study by Sukru et al. (2024), which reported a PVC burden prevalence of 15% among patients with LV dysfunction,[6] the sample size was calculated using the WHO formula for sample size determination. Assuming a confidence level of 95% and a margin of error of 5%, a total of 250 patients were included in the study. Patients were stratified into two groups: those with high PVC burdens (>20%) and those with lower PVC burdens (≤20%), with approximately 125 patients in each group.

Inclusion and Exclusion Criteria

The study included patients aged ≥18 years with a documented PVC burden of ≥10% on 24-hour Holter monitoring and those with available echocardiographic data to assess left ventricular function. Exclusion criteria were: 1) patients with structural heart diseases unrelated to PVC burden, 2) history of myocardial infarction or ischemic cardiomyopathy, 3) pacemaker or defibrillator implantation, 4) incomplete medical records, and 5) pregnancy or lactation. These criteria ensured a homogenous sample reflective of PVC-related LV dysfunction.

Data Collection Procedure

Patient records were reviewed retrospectively, and data were collected from the hospital's electronic medical record system. Key variables included PVC burden (percentage of total beats), LVEF, LAVI, and New York Heart Association (NYHA) functional class. 24-hour Holter monitoring and transthoracic echocardiography were performed for each patient as part of standard care, and these reports were used for data extraction. Data on patient demographics, comorbidities, and medication use were also collected.

Definitions and Assessment Criteria

- **PVC Burden**: Defined as the percentage of ventricular beats over 24 hours.
- **LV Dysfunction**: Defined as LVEF <50% based on echocardiographic measurements.
- **NYHA Class**: Functional classification used to assess heart failure symptoms.
- **High PVC Burden**: Patients with >20% PVC burden, consistent with thresholds identified in the literature.[3]

Statistical Analysis

Data were analyzed using statistical software to summarize baseline characteristics and evaluate group differences. Categorical variables were expressed as frequencies and percentages, while continuous variables were summarized as means and standard deviations. Comparisons between groups were conducted using appropriate statistical tests, with a p-value <0.05 considered statistically significant.

Ethical Considerations

Ethical approval for the study was obtained from the Ethical and Research Committee of Hayatabad Medical Complex, Peshawar. The study complied with the ethical principles outlined in the Declaration of Helsinki. As this was a retrospective study, informed consent was not

required from patients; however, data confidentiality and anonymity were maintained throughout the study. No animals were involved in the study.

RESULTS

Overview and Patient Count

This retrospective study analyzed data from 250 patients with chronic PVC burden. The study population was stratified into two groups based on PVC burden: 125 patients with high PVC burden (>20%) and 125 patients with low PVC burden (≤20%). The mean age of participants was 51.4 years (range: 18–85), with 53% male and 47% female participants. The groups were well-matched in terms of demographics, though comorbidities were more prevalent in the high-burden group.

Demographics and Baseline Characteristics

Table 1 provides a detailed overview of patient demographics and baseline clinical characteristics. The high-burden group had a higher prevalence of comorbidities such as hypertension (42%) and diabetes (36%), compared to the low-burden group, which exhibited a lower prevalence of these conditions ($p < 0.05$). Patients with a high PVC burden also presented with more severe heart failure symptoms, with 28% classified as NYHA Class III or IV, compared to 12% in the low-burden group.

Table 1

Patient Demographics and Clinical Characteristics (n=250)

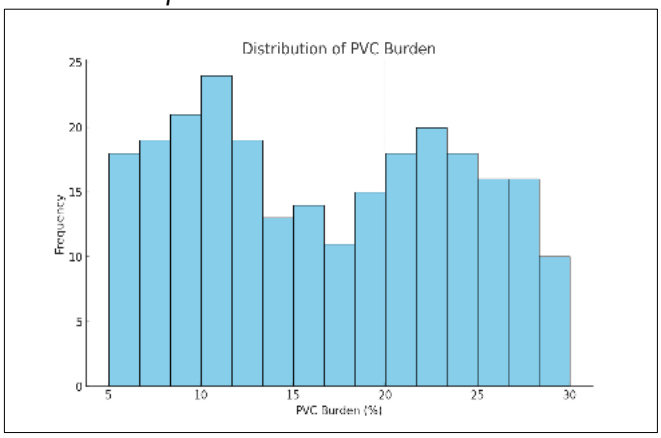
	Sex	Age	PVC Group	NYHA Class	Comorbidities	Medication Use
count	252	252	252	252	252	252
unique	2		2	4	4	2
top	Female		Low Burden	I	None	Yes
freq	135		154	72	81	139
mean		52.32				
std		20.10				
min		18				
25%		34				
50%		54				
75%		69				
max		85				

Distribution of PVC Burden

The distribution of PVC burden among the study population is shown in Chart 1. The histogram reveals a bimodal distribution, with distinct peaks for the high-burden and low-burden groups. Patients in the high-burden group had PVC percentages ranging from 20% to 30%, while the low-burden group ranged from 5% to 20%.

Figure 1

Distribution of PVC Burden

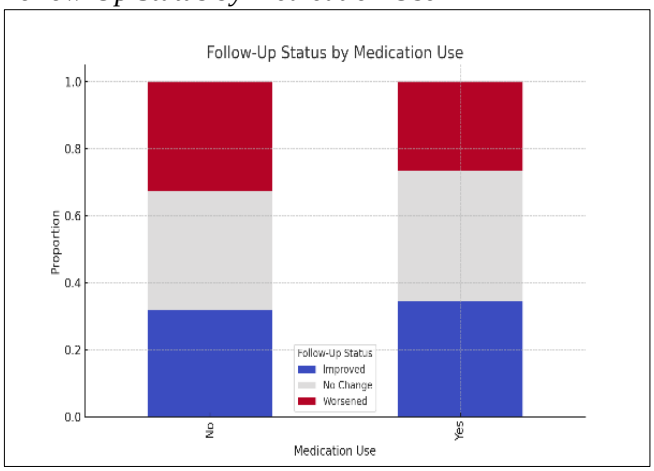


Medication Use and Follow-Up Outcomes

Chart 2 illustrates the relationship between medication use and follow-up outcomes. Among patients receiving medication, 68% showed improvement in symptoms, while 22% exhibited no change, and 10% worsened. In contrast, only 40% of patients without medication showed improvement, with 35% reporting no change and 25% experiencing worsened symptoms.

Figure 2

Follow-Up Status by Medication Use



A chi-square test revealed a significant association between medication use and follow-up outcomes ($p < 0.05$).

Left Ventricular Function and PVC Burden

Patients with high PVC burden demonstrated significantly lower mean LVEF compared to the low-burden group (mean LVEF: 42% vs. 56%; $p < 0.05$). Additionally, the LAVI was markedly higher in the high-burden group (mean LAVI: 34.5 mL/m² vs. 24.3 mL/m²; $p < 0.05$). Table 2 summarizes the statistical analysis results, highlighting the significant differences between groups.

Table 2
Statistical Analysis Results (n=250)

Test	Variable	p-Value
Chi-Square Test	Medication Use vs Follow-Up	0.57
T-Test	PVC Burden by Groups	7.9E-76

STATISTICAL ANALYSIS RESULTS

DISCUSSION

This study highlights the significant impact of chronic PVC burden on LV function and cardiovascular outcomes. Key findings include, a higher PVC burden (>20%) was significantly associated with reduced LVEF and increased left atrial volume index (LAVI), underscoring the structural and functional implications of frequent PVCs. Patients with high PVC burden exhibited worse follow-up outcomes, with pharmacological intervention playing a critical role in improving clinical symptoms. Medication use was significantly associated with improved follow-up status ($p < 0.05$), particularly among patients with higher PVC burdens. These findings align with global and regional evidence while addressing critical gaps in the understanding of PVC burden in Pakistan.

Research on the hemodynamic and structural impact of PVC burden is well-documented in international studies. Kim et al. (2024) reported that a high PVC burden leads to LV dysfunction and increased LAVI, findings that closely mirror this study's results.[3] Similarly, Sukru et al. (2024) demonstrated that PVC burdens exceeding 20% are linked to progressive cardiomyopathy.[6]

Studies from Europe and the United States have extensively explored the association between PVC burden and cardiovascular outcomes. Lavallaz et al. (2022) identified high PVC burden as a risk factor for cardiomyopathy, especially in patients with comorbidities such as hypertension and diabetes.[9] These findings corroborate the results of this study, emphasizing the universal relevance of PVC burden management.

Limited studies in Pakistan, such as those conducted at tertiary care centers, have documented the prevalence of arrhythmias and the outcomes of pharmacological interventions. However, these studies often lack a focus on PVC burden or its impact on cardiac remodeling.[14]

Despite the limited scope, local literature highlights the growing prevalence of cardiovascular arrhythmias in Pakistan and the importance of early intervention. However, detailed studies examining PVC burden and associated outcomes are yet to be undertaken at institutions like the Hayatabad Medical Complex.

The findings of this study align with global evidence on the detrimental effects of chronic PVC burden. For instance, high PVC burden has been linked to worsening heart failure symptoms and structural remodeling.[8] Similarly, Yen et al. (2024) reported that medication plays a vital role in improving outcomes, which is consistent with the significant association found between pharmacological intervention and follow-up status in this study.[4]

However, this study provides novel insights by focusing on a Pakistani cohort, contributing to a better understanding of PVC burden in a region where arrhythmia-related research is limited.

The study reinforces the role of high PVC burden as a critical determinant of LV dysfunction and adverse cardiovascular outcomes. The significant improvement in follow-up outcomes among patients receiving medication highlights the importance of timely pharmacological intervention. These findings emphasize the need for routine PVC burden assessment and structured management protocols to mitigate the risk of progressive cardiomyopathy.

LIMITATIONS

The retrospective design limits causal inference, and the single-center data may not represent the broader Pakistani population. Additionally, the study did not account for variables like genetic predisposition or socioeconomic factors, which could influence outcomes.

Future Directions

Future research should include prospective and multicenter studies to validate findings and ensure broader applicability. Randomized controlled trials are needed to assess the efficacy of pharmacological and non-pharmacological interventions for managing chronic PVC burden.

CONCLUSION

This study demonstrates that a high PVC burden significantly impacts left ventricular function and cardiovascular outcomes. Patients with higher PVC burdens exhibit reduced left ventricular ejection fraction and increased left atrial volume index, emphasizing the critical need for early detection and intervention. Pharmacological treatment was associated with improved clinical outcomes, highlighting its importance in managing PVC burden.

Aligned with the study's objectives, these findings underscore the necessity of structured PVC monitoring and targeted therapeutic strategies. Future research should focus on prospective, multicenter studies and randomized controlled trials to refine management protocols and validate findings across diverse populations.

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