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The Prevalence of Cardiac Arrhythmias in COVID-19 Patients Undergoing CRRT During the First 24 Hours of ICU Admission

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Abstract

Background: This study aimed to determine the prevalence of cardiac arrhythmias in COVID-19 patients undergoing Continuous Renal Replacement Therapy (CRRT) during the first 24 hours of ICU admission.

Methods: This cross-sectional study was conducted to assess the prevalence of cardiac arrhythmias among 78 COVID-19 patients undergoing CRRT hemoperfusion during the first 24 hours of hospitalization in the ICU of Kowsar Hospital, Semnan, in 2020. Data were collected using a checklist that included demographic characteristics, underlying diseases, and types of cardiac arrhythmias, extracted from patients' medical records in the hospital's medical records department. Data analysis was performed using SPSS software, version 26.

Results: The mean (± SD) age of the patients was 54.68 ± 1.61 years. The proportions of males and females were 41% and 59%, respectively. The overall prevalence of cardiac arrhythmia was 21.8%, with bradycardia being the most common type (7.7%). The prevalence rates of heart disease, hypertension, diabetes, and hyperlipidemia were 48.7%, 39.7%, 28.2%, and 26.9%, respectively. Additionally, 20.5% of patients had a history of cardiovascular disease. No statistically significant associations were found between cardiac arrhythmia and age, gender, or underlying conditions such as heart disease, hypertension, diabetes, and hyperlipidemia (P>0.05). However, the prevalence of supraventricular arrhythmia (100%) and ventricular arrhythmia (66.7%) was significantly higher among patients with a history of cardiovascular disease (P<0.001).

Conclusion: Our study demonstrated a substantial prevalence of cardiac arrhythmia in COVID-19 patients undergoing CRRT within the first 24 hours of ICU admission. The findings emphasize the importance of recognizing this vulnerable period for arrhythmia development and highlight the need for proactive measures to mitigate risks in this high-risk population.

Keywords: Cardiac Arrhythmias, COVID-19, CRRT hemoperfusion, ICU

Conflicts of Interest: *None declared*
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Introduction

The COVID-19 pandemic, caused by the novel corona-virus SARS-CoV-2, has emerged as a global health crisis, affecting millions of individuals worldwide (1). While the respiratory manifestations of COVID-19 are well-documented, growing evidence indicates that this viral infection also significantly impacts the cardiovascular

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↑What is "already known" in this topic:
COVID-19 patients are at high risk of developing cardiac arrhythmias as a result of severe infection and systemic inflammation. In addition, therapeutic interventions such as continuous renal replacement therapy (CRRT) may influence cardiovascular function. However, the prevalence and types of cardiac arrhythmias in patients undergoing CRRT during the first 24 hours of ICU admission remain unclear.

→What this article adds:
Our study demonstrated a significant prevalence of cardiac arrhythmias in COVID-19 patients undergoing CRRT within the first 24 hours of ICU admission. These findings contribute to a better understanding of the clinical effects of CRRT on cardiac function in COVID-19 patients and provide valuable insights for physicians and healthcare professionals to optimize patient care and reduce the risk of arrhythmia.

system. Among the various cardiovascular complications associated with COVID-19, cardiac arrhythmias have attracted particular attention due to their potential to exacerbate morbidity and mortality in affected patients (2-4).

ardiac arrhythmias are defined as irregular heartbeats that may present as tachycardia, bradycardia, or other abnormal cardiac rhythms. They can arise from several factors, including electrolyte imbalances, myocardial injury, and heightened sympathetic activity, all of which may be intensified by COVID-19 (5, 6). The systemic inflammation induced by the virus can lead to myocarditis and other forms of cardiac injury, further increasing the risk of arrhythmias in these patients (7).

Patients with severe COVID-19 often require admission to intensive care units (ICUs) for close monitoring and advanced supportive care. One such intervention is Continuous Renal Replacement Therapy (CRRT), which is employed in patients experiencing acute kidney injury (AKI) or fluid overload (8, 9).

CRRT is a form of dialysis that provides continuous blood filtration and is particularly advantageous for critically ill patients who may not tolerate conventional intermittent hemodialysis. However, the use of CRRT introduces additional complexities in patient management, including alterations in electrolyte balance and hemodynamic stability, both of which can contribute to the development of cardiac arrhythmias (10, 11). The prevalence of cardiac arrhythmias in COVID-19 patients undergoing CRRT remains an area of ongoing investigation. Studies have reported that arrhythmias occur in a considerable proportion of critically ill COVID-19 patients, with incidence rates ranging from 10% to 40% (12, 13). Factors such as pre-existing cardiovascular disease, the severity of COVID-19, and the acute effects of CRRT on fluid and electrolyte balance may all contribute to this increased incidence. Moreover, the first 24 hours following ICU admission represent a critical period during which rapid changes in clinical status can occur, underscoring the importance of close arrhythmia monitoring during this time (14, 15).

Understanding the incidence and types of arrhythmias occurring in COVID-19 patients receiving CRRT can provide valuable insights into their clinical management. Early recognition and prompt treatment of these arrhythmias are essential to improving patient outcomes and reducing the risk of adverse events such as sudden cardiac death. Furthermore, identifying specific risk factors associated with arrhythmias in this population may assist clinicians in developing targeted strategies to mitigate these risks (13, 16). In light of these considerations, the present study aimed to determine the prevalence of cardiac arrhythmias in COVID-19 patients undergoing CRRT during the first 24 hours of ICU admission.

Methods

Study Design and Subjects

This cross-sectional study was conducted to determine the prevalence of cardiac arrhythmias in 78 patients with COVID-19 who underwent hemoperfusion with continuous renal replacement therapy (CRRT) during the first 24 hours of hospitalization in the intensive care unit (ICU) of Kowsar Hospital, Semnan, in 2020.

The inclusion criteria were: age ≥18 years; confirmed diagnosis of COVID-19 (verified by PCR or antigen test); ICU admission; receipt of CRRT; and assessment within 24 hours of ICU admission. Exclusion criteria included the presence of cardiac arrhythmia on ECG prior to hemoperfusion, death within the first 24 hours of ICU admission, incomplete or illegible medical records, and any change in the patient's treatment protocol.

Data collection

In the present study, data were collected using a checklist that included demographic variables (age and gender), underlying diseases (hypertension, diabetes, heart disease, and hyperlipidemia), history of cardiovascular disease, and type of cardiac arrhythmia (supraventricular arrhythmia, ventricular arrhythmia, bradycardia, atrial fibrillation, atrial flutter, and premature ventricular contractions [PVC]). These data were extracted from the patients' medical records by reviewing files in the hospital's medical records department.

Statistical analysis

Data were analyzed using SPSS software, version 26. For descriptive analyses, the mean, standard deviation (SD), and number (percentage) were reported. The chi-square test, independent samples t-test, and one-way ANOVA were used to examine relationships between the study variables. All key variables in this study were complete, with no missing data; therefore, no imputation or other methods for handling missing data were required. Formal adjustments for multiple comparisons were not applied, as the analyses were limited and aligned with the pre-specified study objectives. A *P*-value <0.05 was considered statistically significant.

Ethics considerations

This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Deputy of Research and the Ethics Committee of Semnan University of Medical Sciences, Iran (IR.SEMUMS.REC.1401.155).

Results

In the present study, a total of 78 patients with COVID-19 who underwent hemoperfusion with CRRT were included. Table 1 presents the demographic and clinical characteristics of patients. The mean (±SD) age of the patients was 54.68±1.61 years.

The proportions of male and female patients were 41% and 59%, respectively. Based on electrocardiography results, the overall prevalence of cardiac arrhythmia was 21.8%, with bradycardia being the most common type (7.7%).

The prevalence rates of heart disease, hypertension, diabetes, and hyperlipidemia were 48.7%, 39.7%, 28.2%, and 26.9%, respectively. Additionally, 20.5% of patients had a history of cardiovascular disease.

There was no statistically significant difference between

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Table 1. Demographic and clinical characteristics of 78 patients

Variables			Number (%)
Sex	Male		32 (41)
	Female		46 (59)
Cardiac arrhythmia	Yes	Supraventricular arrhythmia	2 (2.5)
		Ventricular arrhythmia	3 (3.8)
		Bradycardia	6 (7.7)
		Atrial fibrillation	1 (1.3)
		Flutter	1 (1.3)
		PVC	1 (1.3)
		Ventricular fibrillation	2 (2.5)
	No		61 (78.2)
Heart disease	Yes		38 (48.7)
	No		40 (51.3)
Hypertension	Yes		31 (39.7)
	No		47 (60.3)
Diabetes	Yes		22 (28.2)
	No		56 (71.8)
Hyperlipidemia	Yes		21 (26.9)
	No		57 (73.1)
History of cardiovascular disease	Yes		16 (20.5)
	No		62 (79.5)

Table 2. Association of age and sex with cardiac arrhythmia status and type

Variable		Mean	SD	*P* Value
Sex	Male	51.66	14.56	0.125*
	Female	56.78	13.79	
Cardiac arrhythmia	Supraventricular arrhythmia	75.50	2.19	0.182**
	Ventricular arrhythmia	55.00	20.07	
	Bradycardia	50.33	10.67	
	No arrhythmia	54.43	14.13	

Variable		Sex		*P* Value
		Male (%)	Female (%)	
Cardiac arrhythmia	Supraventricular arrhythmia	1 (50)	1 (50)	0.083***
	Ventricular arrhythmia	0 (0)	3 (100)	
	Bradycardia	5 (83.3)	1 (16.7)	
	No arrhythmia	26 (38.8)	41 (61.2)	

*: Independent sample t-test
**: One way ANOVA
***: Chi-square

male and female patients in terms of mean age (P=0.125).

The mean age of patients without cardiac arrhythmia was 54.43±14.16 years, while the highest mean age among those with cardiac arrhythmia was observed in patients with supraventricular arrhythmia (75.50 ± 2.19 years). The majority of ventricular tachycardia cases occurred in women (100%), whereas bradycardia was more common in men (83.3%). However, no statistically significant relationship was found between cardiac arrhythmia status and either age or gender (P>0.05) (Table 2).

Table 3 shows the relationship between underlying diseases and cardiac arrhythmia status. No statistically significant associations were found between cardiac arrhythmia status and the presence of heart disease, hypertension, diabetes, or hyperlipidemia (P>0.05).

However, a significant association was observed between a history of cardiovascular disease and cardiac arrhythmia status: the frequencies of supraventricular arrhythmia (100%) and ventricular arrhythmia (66.7%) were significantly higher among patients with a history of cardiovascular disease (P<0.001).

Discussion

The COVID-19 pandemic has presented unprecedented challenges to healthcare systems worldwide, with cardiovascular complications emerging as major concerns among affected patients. One of the notable complications observed in COVID-19 patients is cardiac arrhythmia, particularly among those requiring intensive care (16, 17). In this study, 78 COVID-19 patients who underwent hemoperfusion with CRRT were evaluated. The results showed that the mean (±SD) age of patients was 54.68 ± 1.61 years. The proportions of male and female patients were 41% and 59%, respectively. The overall prevalence of cardiac arrhythmia was 21.8%, with bradycardia being the most common type (7.7%). The prevalence rates of heart disease, hypertension, diabetes, and hyperlipidemia were 48.7%, 39.7%, 28.2%, and 26.9%, respectively. Additionally, 20.5% of patients had a history of cardiovascular disease.

No statistically significant relationships were observed between cardiac arrhythmia status and age, gender, or underlying conditions such as heart disease, hypertension, diabetes, and hyperlipidemia (P>0.05). However, the prevalence of supraventricular arrhythmia (100%) and ventricular arrhythmia (66.7%) was significantly high-

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Table 3. The relationship between underlying diseases with cardiac arrhythmia

		Diabetes		*P-Value
		Yes (%)	No (%)	
Cardiac arrhythmia	Supraventricular arrhythmia	1 (50)	1 (50)	0.823
	Ventricular arrhythmia	1 (33.3)	2 (66.7)	
	Bradycardia	1 (16.7)	5 (83.3)	
	No arrhythmia	19 (28.4)	48 (71.4)	
		Hypertension		*P*-Value
		Yes (%)	No (%)	
Cardiac arrhythmia	Supraventricular arrhythmia	2 (100)	0 (0)	0.208
	Ventricular arrhythmia	2 (66.7)	1 (33.3)	
	Bradycardia	3 (50)	3 (50)	
	No arrhythmia	24 (35.8)	43 (64.2)	
		Heart disease		*P*-Value
		Yes (%)	No (%)	
Cardiac arrhythmia	Supraventricular arrhythmia	2 (100)	0 (0)	0.129
	Ventricular arrhythmia	3 (100)	0 (0)	
	Bradycardia	3 (50)	3 (50)	
	No arrhythmia	30 (44.8)	37 (55.2)	
		Hyperlipidemia		*P*-Value
		Yes (%)	No (%)	
Cardiac arrhythmia	Supraventricular arrhythmia	1 (50)	1 (50)	0.331
	Ventricular arrhythmia	2 (66.7)	1 (33.3)	
	Bradycardia	2 (33.3)	4 (66.7)	
	No arrhythmia	16 (23.9)	51 (76.1)	
		History of cardiovascular disease		*P*-Value
		Yes (%)	No (%)	
Cardiac arrhythmia	Supraventricular arrhythmia	2 (100)	0 (0)	<0.001
	Ventricular arrhythmia	2 (66.7)	1 (33.3)	
	Bradycardia	1 (16.7)	5 (83.3)	
	No arrhythmia	11 (16.4)	56 (86.3)	

*: Chi-squared test

er among patients with a history of cardiovascular disease (P<0.001).

Our findings indicate a concerning prevalence of cardiac arrhythmias in this critically ill population. A considerable proportion of patients experienced various types of arrhythmias, including atrial fibrillation, ventricular tachycardia, and bradyarrhythmias. These findings are consistent with previous studies reporting arrhythmia rates ranging from 10% to 40% in patients with COVID-19 (17–19). The underlying pathophysiological mechanisms are multifactorial and may involve systemic inflammation, myocardial injury, and electrolyte imbalances induced by both the viral infection and therapeutic interventions (6, 20).

The inflammatory response triggered by SARS-CoV-2 infection can lead to myocarditis and direct myocardial injury, rendering patients more susceptible to arrhythmias (7). Additionally, the use of CRRT introduces further complexity, as it can cause significant fluctuations in electrolyte levels—particularly potassium and calcium—which are essential for maintaining normal cardiac rhythm (21). Moreover, hemodynamic instability commonly observed in critically ill patients can exacerbate the risk of arrhythmias, creating a challenging clinical scenario for patient management (22, 23).

Our study highlights the first 24 hours following ICU admission as a particularly vulnerable period for the development of cardiac arrhythmias. During this time, healthcare providers must exercise heightened vigilance in monitoring cardiac rhythms and managing potential risk factors. Early identification and intervention for arrhythmias are crucial, as they can lead to adverse outcomes such as hemodynamic instability and increased mortality (2, 24).

Furthermore, we observed that pre-existing cardiac conditions significantly influenced the likelihood of arrhythmia in our cohort. Consistent with previous research, patients with a history of cardiovascular disease were at elevated risk of developing arrhythmias, underscoring the importance of careful risk assessment in this population (25). The interplay between the cardiac effects of COVID-19, the physiological stresses of severe illness, and the impact of CRRT on electrolyte balance creates a complex clinical picture that necessitates comprehensive management strategies (26).

The implications of our findings extend beyond immediate patient care. Understanding the prevalence and risk factors associated with cardiac arrhythmias in COVID-19 patients undergoing CRRT can inform the development of evidence-based clinical guidelines and protocols aimed at improving patient outcomes. Clinicians should prioritize regular cardiac monitoring and implement proactive strategies for electrolyte management in this high-risk group to mitigate arrhythmia-related complications (14, 27). As the pandemic continues, ongoing research is essential to further elucidate the underlying mechanisms of arrhythmogenesis and to develop targeted interventions to reduce its incidence. Future studies should include larger populations to validate these findings and to explore the long-term outcomes associated with cardiac arrhythmias in COVID-19 patients. Ultimately, enhancing our understanding of these complications will be vital for improving care and outcomes in patients affected by COVID-19.

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Continuous renal replacement therapy (CRRT) in COVID-19 patients admitted to the ICU may contribute to arrhythmogenesis through multiple mechanisms. One of the most important factors is rapid and significant fluctuations in electrolyte levels—particularly potassium, calcium, and magnesium—all of which play key roles in cardiac electrical conduction. Sudden decreases or increases in these electrolytes can lower the threshold for both atrial and ventricular arrhythmias. In addition, CRRT can affect fluid balance and blood pressure. Changes in intravascular volume and hemodynamic instability may alter cardiac preload and afterload, thereby increasing myocardial susceptibility to arrhythmias (28, 29).

Another potential mechanism involves the effects of CRRT on the inflammatory response and cytokine levels. The removal of inflammatory mediators and cytokines may influence autonomic cardiac regulation, potentially affecting cardiac electrophysiology and increasing the likelihood of arrhythmias. Moreover, COVID-19 patients frequently present with underlying myocardial injury or ventricular dysfunction, and CRRT in this setting may impose additional cardiac stress (30, 31).

Overall, the complex interplay among electrolyte imbalances, hemodynamic alterations, inflammatory modulation, and pre-existing cardiac injury provides a plausible mechanistic explanation for the increased incidence of arrhythmias in this population. Nonetheless, the precise impact of CRRT on arrhythmogenesis warrants further investigation through advanced mechanistic and clinical studies.

Conclusion

Our study demonstrated a substantial prevalence of cardiac arrhythmias in COVID-19 patients undergoing CRRT within the first 24 hours of ICU admission. These findings emphasize the importance of recognizing this critical period for arrhythmia development and highlight the need for proactive monitoring and management strategies to mitigate risks in this high-risk population.

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Conflict of Interests

The authors declare that they have no competing interests.

Authors' Contributions

S.M.P. and M.M. conceived the study. A.H.Y. and M.Y. collected the data and performed the statistical analyses. M.M. and S.M.P. participated in the study design, drafted the manuscript, and contributed to data analysis. A.H.Y. and M.Y. assisted in drafting the manuscript and revised it critically for important intellectual content. All authors read and approved of the final manuscript.

Ethical Considerations

This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Deputy of Research and the Ethics Committee of Semnan University of Medical Sciences (IR.SEMUMS.REC.1401.155).

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Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AI Use Statement

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