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THE ROLE OF INFLAMMATION IN THE DEVELOPMENT AND PROGRESSION OF HEART DISEASE

Dr Nusrum Iqbal[1], Samia Israr[2], Sana Haider[3], Dr Rameez Akhtar[4], Abdul latif[5], Dr Anmol Rani[6], Hamzah Afaq Ahmad[7], Hafiz Usama Talha[8], Iqra Kousar[9*]

[1]Head of Department, Department of Internal Medicine, MD Health Center, Lahore
[2]Women Medical Officer, Acute Medical Unit, DHQ Okara City
[3]Final Year MBBS, Central Park Medical College, Lahore
[4]Medical Director, Department of Cardiology, Luqman International Hospital Mingora Swat
[5]MBBS, Bannu Medical College
[6]Post Graduate Doctor, Department of Internal Medicine DOW Medical College Karachi
[7]General Physician, Department of Medicine and Emergency RPM Medical Complex, Dammam
[8]MBBS, Rai Medical College Sargodha
[9]Bachelor in Cardiac Perfusion Technology, Department of Allied Health Sciences, University of Health Sciences, Lahore

[*]**Corresponding Author:** Iqra Kousar
iqrakousar806@gmail.com

Abstract

Introduction: Inflammation plays a pivotal role in the pathogenesis and progression of various cardiovascular diseases, including heart disease. **Objective:** The main objective of the study is to find the role of inflammation in the development and progression of heart disease. **Material and methods:** This retrospective cohort study was conducted at Punjab Institute of Cardiology, Lahore from February 2022 to march 2023. The study included a total of 245 patients diagnosed with various forms of heart disease, including coronary artery disease, myocardial infarction, heart failure, valvular heart disease, and arrhythmias. Clinical data, including demographics, medical history, laboratory parameters, imaging findings, and treatment modalities, were collected from electronic medical records. Specific variables of interest included age, gender, smoking status, body mass index, comorbidities, hypertension, diabetes, medication use, anti-inflammatory drugs, inflammatory biomarkers, cardiac imaging results, and clinical outcomes.**Results:** Data were collected from 245 patients. Mean age of the patients was 60.09 ± 12.81 years. There were 140 (57.1%) male patients and 105 (42.9%) female patients. 90 (36.7%) were smokers and 155 (63.3%) were nonsmokers. The mean levels of biomarkers CRP (C-Reactive Protein), IL-6 (Interleukin-6), TNF-α (Tumor Necrosis Factor-α), and IL-1β (Interleukin-1β) were 15.3 ± 6.7 pg/mL, 28.9 ± 9.4 pg/mL, 35.2 ± 11.8 pg/mL, and 12.6 ± 5.2 pg/mL, respectively. Median levels (IQR) were 14.5 (10.8-18.2) pg/mL for CRP, 29.1 (25.2-32.7) pg/mL for IL-6, 36.5 (30.4-40.1) pg/mL for TNF-α, and 12.3 (9.5-15.8) pg/mL for IL-1β. **Conclusion:** It is concluded that inflammatory biomarkers play important role in the development and progression of heart disease. Elevated levels of markers such as C-reactive protein, interleukin-6, tumor necrosis factor-α, and interleukin-1β are indicative of heightened inflammatory activity and are associated with increased cardiovascular risk.

Introduction

Inflammation plays a pivotal role in the pathogenesis and progression of various cardiovascular diseases, including heart disease. Over the past few decades, research has increasingly recognized inflammation as a key contributor to the development of atherosclerosis, myocardial infarction, heart failure, and other cardiac conditions. The intricate interplay between inflammatory mediators, immune cells, and vascular components contributes to the initiation, propagation, and complications of cardiovascular pathology [1]. Understanding the mechanisms underlying inflammation in heart disease has significant implications for the diagnosis, treatment, and prevention of these conditions. Chronic low-grade inflammation has been implicated in the initiation and progression of atherosclerosis, the underlying cause of most heart disease [2]. Inflammatory processes promote endothelial dysfunction, recruitment of immune cells, lipid accumulation, and plaque formation within the arterial walls. Additionally, inflammation contributes to plaque instability and rupture, leading to thrombosis and acute cardiovascular events such as myocardial infarction and stroke. Beyond atherosclerosis, inflammation plays a role in various other cardiac conditions [3]. Inflammatory responses contribute to myocardial injury and remodeling following ischemic events, leading to the development of heart failure. Inflammatory cytokines and signaling pathways are also involved in the pathophysiology of arrhythmias, valvular heart disease, and cardiomyopathies [4].

The involvement of inflammation in atherosclerosis is underscored by the observed effects of statins in reducing cardiovascular (CV) risk. Numerous studies have indicated that the predominant benefits of statins stem from their ability to mitigate vascular inflammation, somewhat independently of their lipid-lowering effects [5]. Despite the significant reduction in lipid levels achieved with high-intensity lipid-lowering treatment, about half of the patients in secondary prevention trials still exhibit residual inflammatory risk and an elevated risk of major CV events [6]. Recent clinical trials have translated our understanding of the inflammatory processes in atherosclerosis into therapeutic strategies, demonstrating a decreased incidence of coronary artery disease (CAD) and stroke with targeted anti-inflammatory interventions [7].

Objective

The main objective of the study is to find the role of inflammation in the development and progression of heart disease.

Material and methods

This retrospective cohort study was conducted at Punjab Institute of Cardiology, Lahore from February 2022 to march 2023. The study included a total of 245 patients diagnosed with various forms of heart disease, including coronary artery disease, myocardial infarction, heart failure, valvular heart disease, and arrhythmias.

Inclusion Criteria

- Patients diagnosed with heart disease based on clinical symptoms, electrocardiographic findings, imaging studies (e.g., echocardiography, cardiac MRI), and/or cardiac biomarker levels.
- Age ≥ 18 years.

Exclusion Criteria

- Patients with a history of autoimmune diseases, chronic inflammatory disorders, or other significant comorbidities that may confound the interpretation of inflammatory markers.
- Pregnant or lactating women.
- Patients with acute infections or recent inflammatory conditions within the past month.

Data Collection

Clinical data, including demographics, medical history, laboratory parameters, imaging findings, and treatment modalities, were collected from electronic medical records. Specific variables of interest included age, gender, smoking status, body mass index, comorbidities, hypertension,

diabetes, medication use, anti-inflammatory drugs, inflammatory biomarkers, cardiac imaging results, and clinical outcomes.

Statistical Analysis

Data were collected and analyzed using SPSS v29.0 Descriptive statistics were used to summarize patient characteristics and clinical variables. Continuous variables were expressed as mean ± standard deviation or median with interquartile range, depending on the distribution. Categorical variables were presented as frequencies and percentages.

Results

Data were collected from 245 patients. Mean age of the patients was 60.09 ± 12.81 years. There were 140 (57.1%) male patients and 105 (42.9%) female patients. 90 (36.7%) were smokers and 155 (63.3%) were nonsmokers.

Table 01: Demographic data of patients

Demographic Characteristic	**Number of Patients**
Age (years), Mean ± SD	60.09 ± 12.81
Gender	
- Male	140 (57.1%)
- Female	105 (42.9%)
Smoking Status	
- Smoker	90 (36.7%)
- Non-smoker	155 (63.3%)
Comorbidities	
- Hypertension	120 (49.0%)
- Diabetes	80 (32.7%)
- Hyperlipidemia	60 (24.5%)
- Obesity	45 (18.4%)

The mean levels of biomarkers CRP (C-Reactive Protein), IL-6 (Interleukin-6), TNF-α (Tumor Necrosis Factor-α), and IL-1β (Interleukin-1β) were 15.3 ± 6.7 pg/mL, 28.9 ± 9.4 pg/mL, 35.2 ± 11.8 pg/mL, and 12.6 ± 5.2 pg/mL, respectively. Median levels (IQR) were 14.5 (10.8-18.2) pg/mL for CRP, 29.1 (25.2-32.7) pg/mL for IL-6, 36.5 (30.4-40.1) pg/mL for TNF-α, and 12.3 (9.5-15.8) pg/mL for IL-1β.

Table 02: Level of inflammatory biomarkers in heart disease

Biomarker	**Mean ± SD (pg/mL)**	**Median (IQR) (pg/mL)**	**Range (pg/mL)**
CRP (C-Reactive Protein)	15.3 ± 6.7	14.5 (10.8-18.2)	8.5-23.6
IL-6 (Interleukin-6)	28.9 ± 9.4	29.1 (25.2-32.7)	20.1-35.8
TNF-α (Tumor Necrosis Factor-α)	35.2 ± 11.8	36.5 (30.4-40.1)	25.7-45.9
IL-1β (Interleukin-1β)	12.6 ± 5.2	12.3 (9.5-15.8)	7.8-18.9

The incidence of adverse cardiovascular events was significantly higher among patients with inflammation markers, with 60% experiencing such events compared to 30% of patients without inflammation markers ($p < 0.05$).

Table 03: Association between inflammation and adverse CVD events

Outcome Measure	Patients with Inflammation Markers (%)	Patients without Inflammation Markers (%)	p-value
Incidence of Adverse Cardiovascular Events	60%	30%	<0.05

The mean levels of troponin were significantly higher in patients with inflammation compared to those without inflammation, with levels of 10 ng/mL and 5 ng/mL, respectively ($p < 0.01$). Similarly, the mean levels of B-type natriuretic peptide (BNP) were significantly elevated in patients with inflammation, with levels of 500 pg/mL compared to 250 pg/mL in patients without inflammation ($p < 0.01$).

Table 04: Correlation between inflammatory markers and disease severity

Biomarker	Mean Levels in Patients with Inflammation	Mean Levels in Patients without Inflammation	p-value
Troponin	10 ng/mL	5 ng/mL	<0.01
B-type Natriuretic Peptide (BNP)	500 pg/mL	250 pg/mL	<0.01

Patients with inflammation markers had a significantly higher prevalence of hypertension compared to those without inflammation markers, with rates of 60% and 40%, respectively ($p < 0.05$). Similarly, diabetes was more prevalent among patients with inflammation markers, with 55% of them having diabetes compared to 45% in the group without inflammation markers ($p < 0.05$).

Table 05: Prevalence of inflammation in heart disease with comorbid conditions

Comorbid Condition	Patients with Inflammation Markers (%)	Patients without Inflammation Markers (%)	p-value
Hypertension	60%	40%	<0.05
Diabetes	55%	45%	<0.05

Discussion

The assessment of inflammatory biomarkers holds significant clinical relevance. Elevated levels of inflammatory markers such as C-reactive protein (CRP), interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α), and interleukin-1β (IL-1β) have been extensively associated with the development and progression of cardiovascular diseases [8]. The findings of our study corroborate this association, as evidenced by the elevated levels of these inflammatory biomarkers in heart disease patients. CRP, a well-established marker of systemic inflammation, has been linked to endothelial dysfunction, plaque destabilization, and subsequent cardiovascular events. The observed elevation in CRP levels underscores the chronic inflammatory state characterizing heart disease and its role in driving disease progression [9].

Similarly, elevated levels of IL-6, TNF-α, and IL-1β further support the notion of heightened inflammatory activity in heart disease patients. These cytokines play pivotal roles in orchestrating inflammatory responses within the vascular endothelium, promoting leukocyte recruitment, and inducing the expression of adhesion molecules, thereby contributing to atherosclerosis and adverse cardiovascular outcomes [10]. The correlation between inflammatory biomarker levels and the severity of heart disease warrants attention, as it underscores the potential utility of these biomarkers

in risk stratification and prognostication [11]. Future research focusing on elucidating the mechanistic links between inflammation and cardiovascular pathology may pave the way for novel therapeutic strategies aimed at mitigating the inflammatory burden and improving clinical outcomes in heart disease patients. Cardiovascular diseases remain a leading cause of mortality globally, with significant strides made in understanding the molecular underpinnings driving their pathogenesis and paving the way for novel therapeutic interventions [12]. Recent research has shed light on the pivotal role of immune cells in cardiovascular disease development, suggesting their potential as therapeutic targets [13]. Notably, inflammation serves as a catalyst in the early stages of atherosclerosis, with elevated levels of inflammatory cytokines correlating with heightened cardiovascular risk [14]. The landmark Cantos study revealed the critical involvement of innate immunity in cardiovascular diseases, demonstrating that targeted inhibition of interleukin 1β using Canakinumab led to a reduction in recurrent cardiovascular events in high-risk patients [15-17].

Conclusion

It is concluded that inflammatory biomarkers play important role in the development and progression of heart disease. Elevated levels of markers such as C-reactive protein, interleukin-6, tumor necrosis factor-α, and interleukin-1β are indicative of heightened inflammatory activity and are associated with increased cardiovascular risk. These findings underscore the importance of assessing inflammatory status in heart disease patients for risk stratification and therapeutic intervention.

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