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Association of High-Sensitivity C-Reactive Protein with Cardiovascular Risk Factors, Clinical Features, and Angiographic Findings in Young Adults with Acute Coronary Syndrome: An Analytical Cross-Sectional Study

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Abstract: ***Background: Acute coronary syndrome (ACS) among young adults (≤45 years) is an emerging public health concern, with premature events leading to significant morbidity, mortality, and socioeconomic burden. Inflammation is central to atherosclerosis and plaque instability, with high-sensitivity C-reactive protein (hs-CRP) serving as a reliable biomarker of cardiovascular risk. However, its role in relation to angiographic profile and risk factors in younger ACS patients remains underexplored. Methods: This hospital-based analytical cross-sectional study enrolled 239 consecutive ACS patients aged <45 years at a tertiary care centre in Central India (September 2024–August 2025). Clinical, socio-demographic, and cardiovascular risk factors were recorded. hs-CRP levels were measured using latex turbidimetry and classified as <1 mg/l, 1–3 mg/l, and >3 mg/l. Coronary angiography was performed in eligible patients and categorized as single-vessel disease (SVD), double-vessel disease (DVD), or triple-vessel disease (TVD). Associations between hs-CRP, clinical presentation, and angiographic severity were analysed. Results: Elevated hs-CRP (>3 mg/l) was observed in 56.9% of patients and showed significant associations with smoking, metabolic syndrome, central obesity, periodontitis, dyslipidaemia, and premature coronary artery disease (p<0.05). In contrast, hypertension and diabetes mellitus were not significantly correlated. Patients with STEMI had higher hs-CRP levels compared to those with UA/NSTEMI (p<0.01). Angiographic analysis revealed progressively higher hs-CRP levels in DVD and TVD compared to SVD (p<0.001). Conclusion: hs-CRP is strongly associated with cardiovascular risk factors, STEMI presentation, and angiographic severity in young ACS patients. Routine hs-CRP assessment may enhance early risk stratification and inform targeted therapeutic strategies.***

Keywords: Acute coronary syndrome, young adults, high-sensitivity C-reactive protein, cardiovascular risk factors, coronary angiography, inflammation

1. Introduction

Acute coronary syndrome (ACS) remains one of the leading causes of morbidity and mortality worldwide, with its rising incidence in young adults emerging as a growing public health challenge. Traditionally considered a disease of older age, recent evidence from South Asia and other low- and middle-income countries indicates an increasing prevalence in individuals aged ≤45 years. This trend is primarily attributed to lifestyle-related factors such as smoking, dyslipidaemia, obesity, and clustering of metabolic risks. The implications are particularly serious, as early-onset ACS contributes to premature deaths, reduced workforce productivity, and greater long-term healthcare expenditures [1–3].

Inflammation is central to the pathogenesis of atherosclerosis and plaque rupture. Among inflammatory biomarkers, high-sensitivity C-reactive protein (hs-CRP) has gained prominence as a marker of cardiovascular risk. Elevated hs-CRP levels are known to promote endothelial dysfunction, enhance plaque vulnerability, and contribute to thrombotic events. Clinically, increased hs-CRP concentrations have been linked with larger infarcts, recurrent ischemic events, and worse prognosis in ACS patients [4,5].

Previous investigations have also explored the association of hs-CRP with angiographic severity of coronary artery disease (CAD). Higher values have been correlated with multivessel involvement, greater lesion complexity, and elevated SYNTAX scores, suggesting that hs-CRP reflects both systemic inflammation and the anatomical burden of atherosclerosis [6,7]. However, much of this evidence is derived from older populations, while data on younger patients—who often present with single-vessel disease or thrombotic lesions—remain limited [8].

Although the prognostic role of hs-CRP in ACS is well established, its independent significance in young adults is still uncertain. Younger individuals with ACS may differ in clinical characteristics, inflammatory status, and angiographic

patterns compared to older cohorts. Clarifying these associations is essential for improving risk stratification and guiding tailored interventions in this subgroup [9,10].

Against this background, the present analytical cross-sectional study was designed to assess the relationship between hs-CRP, cardiovascular risk factors, clinical manifestations, and angiographic findings among young adults with ACS. The study aims to provide insights into whether hs-CRP can serve as a reliable marker of disease severity and clinical outcomes in this vulnerable age group.

2. Research Methodology

Study design and setting
This analytical cross-sectional investigation was carried out at a tertiary care teaching hospital in Central India over a 12-month period (September 2024–August 2025). All consecutive patients younger than 45 years presenting with acute coronary syndrome (ACS) were recruited after written informed consent. Eligibility and diagnosis were verified by the principal investigator, a consultant cardiologist. Approval was obtained from the Institutional Ethics Committee prior to initiation of the study.

Study population
Participants included individuals presenting to the outpatient clinics, inpatient wards, or emergency services with ACS, comprising unstable angina (UA), non-ST elevation myocardial infarction (NSTEMI), and ST elevation myocardial infarction (STEMI). UA was defined as angina at rest for ≥20 minutes, recent (<1 month) or worsening angina with ischemic changes on electrocardiogram. NSTEMI was diagnosed when troponin T was elevated without ST-segment elevation, while STEMI required ≥30 minutes of ischemic chest pain with diagnostic ST elevation or new-onset left bundle branch block (LBBB). Patients with ongoing infections, febrile illness, or chronic inflammatory disorders were excluded.

Sample size
Sample size estimation was based on data from Gupta et al., who reported elevated hs-CRP (>1 mg/L) in 80.8% of young Indian patients with premature coronary artery disease. Using this prevalence, with 95% confidence level and 5% absolute precision, the calculated sample size was 239 ($n = Z^2p[1–p]/d^2$). Allowing for 10% attrition, the final sample target was 264 participants [11].

Clinical and laboratory evaluation
Each participant underwent detailed evaluation of presenting symptoms, cardiovascular (CV) risk factors, socioeconomic status (SES), and family history. Physical examination included anthropometry, blood pressure measurement, body mass index (BMI), and waist–hip ratio (WHR). Central obesity was defined as WHR >0.9 in men and >0.8 in women. Oral examination for periodontal disease was performed by a trained dentist using standardized indices (plaque index, gingival index, bleeding index, attachment loss, probing pocket depth). Laboratory tests comprised complete blood count, renal profile, serum electrolytes, fasting glucose, fasting lipid profile, and high-sensitivity C-reactive protein (hs-CRP). Lipids were measured using enzymatic kits; low-density lipoprotein (LDL) was calculated with the Friedewald formula. hs-CRP was quantified using latex turbidimetry (QUANTA, Tulip Diagnostics, USA) and categorized as <1 mg/L (low risk), 1–3 mg/L (intermediate risk), and >3 mg/L (high risk).

Coronary angiography
Coronary angiography was performed in consenting patients following standard ACS protocols. Significant coronary artery disease (CAD) was defined as ≥70% luminal narrowing in a major epicardial artery (left anterior descending [LAD], left circumflex [LCx], right coronary artery [RCA]) or ≥50% in the left main coronary artery (LMCA). CAD was categorized as single-, double-, or triple-vessel disease; LMCA involvement was grouped with double-vessel disease.

Definitions of risk factors
Diabetes mellitus was defined as fasting plasma glucose ≥126 mg/dL or ongoing treatment for diabetes. Hypertension was defined as blood pressure ≥140/90 mmHg on at least two readings or current antihypertensive use. Dyslipidaemia was defined as LDL ≥130 mg/dL, triglycerides ≥150 mg/dL, or reduced HDL (<40 mg/dL in men, <50 mg/dL in women). Smoking included current use or cessation within the previous year. Family history was recorded if CAD occurred in a first-degree relative before 55 years (men) or 65 years (women). Metabolic syndrome was defined using NCEP-ATP III criteria (≥3 of the following: waist circumference >102 cm in men/>88 cm in women, triglycerides ≥150 mg/dL, low HDL, blood pressure ≥130/85 mmHg or on therapy, fasting glucose ≥110 mg/dL). SES was determined using the modified Kuppuswamy scale.

Statistical analysis
Data analysis was performed using SPSS version 15.0. Continuous variables were presented as mean ± standard deviation (SD), and categorical variables as percentages. Group comparisons were carried out with Student's t-test for continuous variables and chi-square test for categorical variables. A p-value <0.05 was considered statistically significant.

3. Results & Discussion

We studied 239 subjects including 102 (40.2%) males and 137 (59.8%) females, with a statistically significant number of females (p=0.0371). The mean age of the participants was 37.3 ± 5.4 years. Most of them 141 (64.3%) were hailing from urban areas. The table 1 describes the corelation of socio-demographic factors with hs-CRP levels. The hs-CRP levels were significantly higher for females and those belonging to the lower socio-economic status.

Table 1: Corelation of hs-CRP with sociodemographic factors (n=239)

Socio-demographic factors	Hs-CRP categories			p value
	<1 mg/l n = 49	>1- 3 mg/l n = 54	> 3 mg/l n = 136	
Mean Age (years)	38.6 ± 2.4	41.6 ± 6.3	42.6 ± 3.7	0.529
Gender				
Male	21 (42.8)	19 (35.2)	62 (45.6)	0.0371
Female	28 (57.2)	35 (64.8)	74 (54.4)	
Residence				
Urban	31 (63.2)	33 (61.1)	77 (56.7)	0.0745

Rural	14 (36.8)	21 (38.9)	59 (43.3)	
Socio-economic status*				
Upper	6 (12.3)	7 (13.0)	13 (9.5)	<0.0001
Upper middle	11 (22.4)	14 (26.0)	38 (28.0)	
Middle	9 (18.3)	6 (11.1)	26 (19.1)	
Upper lower	9 (18.3)	7 (13.0)	22 (16.2)	
Lower	14 (28.7)	20 (36.9)	37 (27.2)	

***Modified Kuppuswamy scale**

Overall, 49 (20.5%), 54 (22.6%) and 136 (56.9%) patients had hs-CRP levels <1 mg/l, 1–3 mg/l, and >3 mg/l, respectively. Table 1 presents the distribution of hs-CRP across different socio-demographic factors.

The mean age was comparable across groups, being 38.6 ± 2.4 years in the <1 mg/l category, 41.6 ± 6.3 years in the 1–3 mg/l group, and 42.6 ± 3.7 years in the >3 mg/l group (p = 0.529). A significant gender difference was observed, with higher hs-CRP levels (>3 mg/l) found in 54.4% of females compared to 45.6% of males (p = 0.0371).

With respect to residence, 43.3% of rural participants and 56.7% of urban participants had hs-CRP >3 mg/l, though this difference was not statistically significant (p = 0.0745).

Socio-economic status showed a strong association with hs-CRP levels (p < 0.0001). Among participants from the lower SES, 27.2% had hs-CRP >3 mg/l, compared to 9.5% in the upper SES group. The prevalence of elevated hs-CRP was progressively higher in lower strata, indicating a significant social gradient in inflammation markers.

Table 2 shows values of hs-CRP according to the different CV risk factors. The smokers were found to have a significantly higher proportion of patients with higher CRP (55.3% with >3 mg/l as compared to 18.8% with <1 mg/l, p ¼ 0.03 for comparison with non-smokers). Similarly, the patients with MS, central obesity, and periodontitis were also found to have a greater prevalence of elevated hs-CRP levels. In contrast, no statistically significant association was seen between hs-CRP levels and HTN, DM and dyslipidemia.

Table 2: Distribution of cases of ACS according to cardio-vascular risk factors (n=239)

Cardio-vascular risk factors	Hs-CRP categories			p value
	<1 mg/l n = 49	>1- 3 mg/l n = 54	> 3 mg/l n = 136	
Smoking (n=86)	24 (28.0)	15 (17.4)	47 (54.6)	0.0137
Metabolic syndrome (n=99)	17 (17.1)	28 (28.3)	54 (54.6)	0.0164
Hypertension (n=112)	29 (25.9)	37 (33.0)	46 (41.1)	0.482
Diabetes Miletus (n=132)	34 (25.8)	41 (31.0)	57 (43.2)	0.0792
Central Obesity (n=79)	20 (25.3)	17 (21.5)	42 (53.2)	0.0253
Periodontitis (n=102)	33 (32.3)	16 (15.7)	53 (52.0)	0.0428
Dyslipidaemia (n=148)	29 (19.6)	34 (23.0)	85 (57.4)	<0.001
Premature CAD (n=58)	11 (19.0)	16 (27.5)	31 (53.5)	<0.001

Table 2 shows the association of hs-CRP levels with various cardiovascular risk factors among ACS patients. Overall, the majority of cases with smoking, metabolic syndrome, central obesity, periodontitis, dyslipidaemia, and premature CAD had hs-CRP >3 mg/l, and these associations were statistically significant.

Among smokers (n=86), more than half (54.6%) had hs-CRP >3 mg/l (p = 0.0137). Similarly, patients with metabolic syndrome (54.6%, p = 0.0164), central obesity (53.2%, p = 0.0253), and periodontitis (52.0%, p = 0.0428) showed significantly higher prevalence of elevated hs-CRP. Dyslipidaemia was strongly correlated, with 57.4% having hs-CRP >3 mg/l (p < 0.001). Premature CAD also demonstrated a significant association, with more than half of patients (53.5%) showing hs-CRP >3 mg/l (p < 0.001). In contrast, hypertension and diabetes mellitus did not show significant correlation with hs-CRP levels (p = 0.482 and p = 0.0792, respectively).

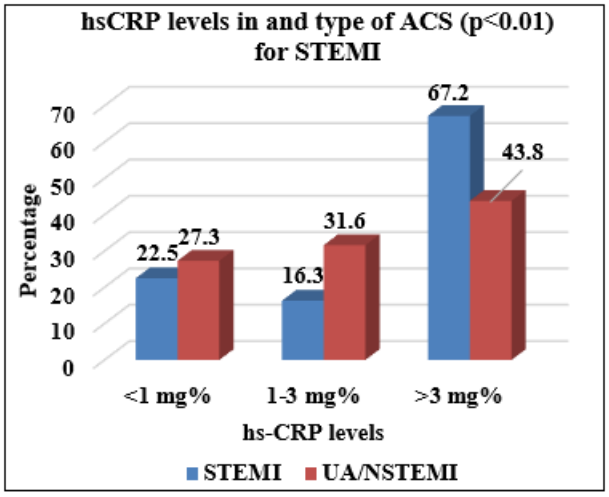

Figure 1: Distribution of cases according to hsCRP levels and type of Acute coronary syndrome (n=239)

Figure 1 demonstrates the distribution of high-sensitivity C-reactive protein (hs-CRP) levels across different types of acute coronary syndrome (ACS). Among patients with ST-elevation myocardial infarction (STEMI), the majority (67.2%) had hs-CRP >3 mg/l, compared to 43.8% of those with unstable angina/non-ST-elevation myocardial infarction (UA/NSTEMI). Conversely, a higher proportion of UA/NSTEMI patients had hs-CRP levels between 1–3 mg/l (31.6%) compared to STEMI patients (16.3%). Patients with hs-CRP <1 mg/l were fewer in both groups (22.5% in STEMI and 27.3% in UA/NSTEMI). The differences were statistically significant (p < 0.01), indicating a strong association between elevated hs-CRP levels and STEMI presentation.

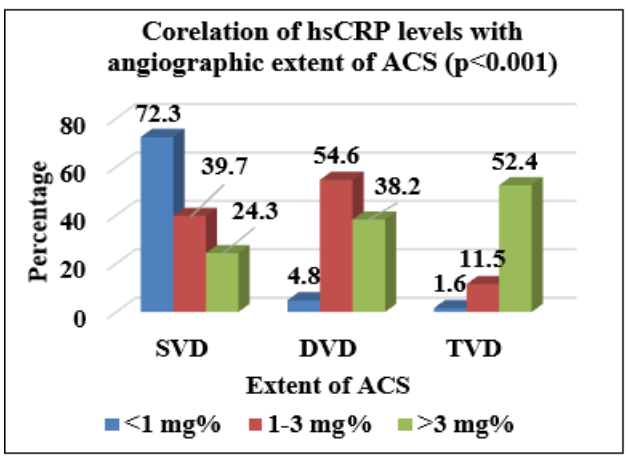

Figure 2: Corelation of hs-CRP levels with extent of involvement of CAD (n=239)

Figure 2 illustrates the correlation of high-sensitivity C-reactive protein (hs-CRP) levels with the angiographic extent of acute coronary syndrome (ACS). Patients with single vessel disease (SVD) predominantly had hs-CRP levels <1 mg/l (72.3%), while those with double vessel disease (DVD) showed higher proportions in the 1–3 mg/l (54.6%) and >3 mg/l (38.2%) categories. In contrast, patients with triple vessel disease (TVD) had the highest prevalence of hs-CRP >3 mg/l (52.4%), indicating a significant association between elevated hs-CRP and more extensive coronary artery involvement ($p < 0.001$).

In this study, higher concentrations of high-sensitivity C-reactive protein (hs-CRP) showed a significant relationship with both cardiovascular risk factors and angiographic severity in patients with acute coronary syndrome (ACS). Individuals with double- and triple-vessel disease (DVD and TVD) most frequently had hs-CRP values >3 mg/L, while lower concentrations were more common in single-vessel disease (SVD). Similarly, ST-elevation myocardial infarction (STEMI) cases exhibited disproportionately elevated hs-CRP levels compared to those presenting with unstable angina (UA) or non-ST elevation myocardial infarction (NSTEMI). These findings reinforce the role of systemic inflammation in the initiation, progression, and clinical manifestation of atherosclerotic plaque instability in ACS [12,13].

Elevated hs-CRP was strongly associated with traditional cardiovascular risk determinants, such as smoking, metabolic syndrome, abdominal obesity, periodontitis, dyslipidaemia, and premature coronary artery disease (CAD), underscoring its relevance as a systemic biomarker of risk. These associations are in line with prior research linking hs-CRP to inflammatory and metabolic pathways that accelerate atherosclerosis [14–17]. In contrast, hypertension and diabetes mellitus did not show significant associations in our cohort, despite previous studies reporting positive correlations [18,19]. This variation may reflect differences in sample characteristics, disease control, or treatment compliance.

The relationship of hs-CRP with angiographic disease extent highlights its prognostic potential. Patients with multivessel CAD demonstrated the highest systemic inflammatory burden, consistent with evidence that hs-CRP levels rise in proportion to plaque load and vascular injury [20,21]. Likewise, the predominance of elevated hs-CRP in STEMI compared with UA/NSTEMI suggests that this biomarker may help differentiate higher-risk presentations [22-24]. Such observations indicate that hs-CRP testing could be a valuable adjunct in risk stratification, particularly in low-resource environments where access to advanced imaging is limited.

From a therapeutic standpoint, hs-CRP may offer insights beyond traditional lipid markers. Persistently high hs-CRP despite adequate lipid control reflects residual inflammatory risk, which has been associated with poorer cardiovascular outcomes [25]. Anti-inflammatory agents such as canakinumab and colchicine have demonstrated event reduction in patients with elevated hs-CRP, further emphasizing the clinical relevance of this marker [10,26]. Based on our findings, incorporating hs-CRP testing into ACS management pathways could help identify patients most likely to benefit from adjunctive anti-inflammatory interventions.

4. Conclusion

Our results demonstrate that elevated hs-CRP is closely associated with cardiovascular risk factors, angiographic complexity, and clinical phenotype in ACS. Incorporating hs-CRP into routine evaluation may strengthen risk stratification and guide tailored management, contributing to a more precision-based approach in cardiovascular care.

5. Future Scope

Future investigations should prioritize longitudinal evaluation of hs-CRP to clarify its predictive role for recurrent cardiovascular events and mortality in younger ACS cohorts. Randomized controlled trials in diverse populations are also warranted to determine whether hs-CRP–guided anti-inflammatory therapy improves long-term outcomes. Furthermore, integrating social determinants and lifestyle-related risk factors into such analyses may refine preventive strategies for vulnerable groups.

References

[1] Peerwani G, Hanif B, Rahim KA, Kashif M, Virani SS, Sheikh S, et al. Presentation, management, and early outcomes of young acute coronary syndrome patients—analysis of 23,560 South Asian patients from 2012 to 2021. *BMC Cardiovasc Disord*. 2024;24:378.

[2] Rallidis LS, Xenogiannis I, Brilakis ES, Bhatt DL. Causes, Angiographic Characteristics, and Management of Premature Myocardial Infarction: JACC State-of-the-Art Review. J Am Coll Cardiol. 2022 Jun 21;79(24):2431-2449.

[3] Khan KA, Khan MN, Kumar R, Shah JA, Batra MK, Kumar D, et al. A surge in prevalence and factors affecting early onset acute coronary syndrome. *Signa Vitae*. 2022;18(2):63–70.

[4] Liu S, Jiang H, Dhuromsingh M, Dai L, Jiang Y, Zeng H. Evaluation of C-reactive protein as predictor of adverse prognosis in acute myocardial infarction after percutaneous coronary intervention: A systematic review and meta-analysis from 18,715 individuals. Front Cardiovasc Med. 2022 Nov 16;9:1013501.

[5] Li L, Liu S, Zhang Z, Zhou L, Zhang Z, Xiong Y, Hu Z, Yao Y. Prognostic value of high-sensitivity C-reactive protein in patients undergoing percutaneous coronary intervention with different glycemic metabolism status. Cardiovasc Diabetol. 2023 Aug 24;22(1):223.

[6] Faisal AWK, Habib G, Yasmin S, Latif W, Ahmed S. Angiographic patterns of coronary artery disease in young patients presenting at a tertiary cardiac center. Pak J Med Sci. 2022 Nov-Dec;38(8):2107-2111.

[7] Liu Y, Zhang C, Jiang L, et al. Relationship Between High-Sensitivity C-Reactive Protein and Long-Term Outcomes in Elderly Patients With 3-Vessel Disease. *Angiology*. 2021;73(1):60-67.

[8] Lee M, Lee K, Kim DW, Cho JS, Kim TS, Kwon J, Kim CJ, Park CS, Kim HY, Yoo KD, Jeon DS, Chang K, Kim MC, Jeong MH, Ahn Y, Park MW. Relationship of Serial High-Sensitivity C-Reactive Protein Changes to Long-term Clinical Outcomes in Stabilised Patients After Myocardial Infarction. Can J Cardiol. 2022 Jan;38(1):92-101.

[9] Yusuf S, Joseph P, Rangarajan S, Islam S, Mente A, Hystad P, et al. Modifiable risk factors, cardiovascular disease, and mortality in 155,722 individuals from 21 countries: PURE study. *Lancet*. 2020;395:795–808.
[10] Ridker PM, Everett BM, Thuren T, MacFadyen JG, Chang WH, Ballantyne C, et al. Anti-inflammatory therapy with canakinumab for atherosclerotic disease. N Engl J Med. 2017;377(12):1119–31.
[11] Gupta S, Vitull K Gupta, et al. Relationship of high-sensitive C-reactive protein with cardiovascular risk factors, clinical presentation and angiographic profile in patients with acute coronary syndrome: An Indian perspective. Indian Heart J. 2013 May;65(3):359–365.
[12] Ridker PM. A test in context: high-sensitivity C-reactive protein. J Am Coll Cardiol. 2016;67(6):712-23.
[13] Libby P. Inflammation in atherosclerosis. Nature. 2021;592(7855):524-33.
[14] Ridker PM, et al. C-reactive protein and other markers of inflammation in the prediction of cardiovascular disease. N Engl J Med. 2002;347(20):1557-65.
[15] Pradhan AD, et al. Inflammatory biomarkers, hormone therapy, and risk of coronary heart disease in women. JAMA. 2002;288(8):980-7.
[16] Pearson TA, et al. Markers of inflammation and cardiovascular disease: application to clinical and public health practice. Circulation. 2003;107(3):499-511.
[17] DeFina LF, et al. Association of hs-CRP with metabolic syndrome and risk of coronary heart disease. Am J Cardiol. 2011;107(2):166-71.
[18] Schillinger M, et al. Inflammation and metabolic control in diabetes. Diabetes Care. 2003;26(6):1913-7.
[19] Kengne AP, et al. Plasma hs-CRP and risk of diabetes in general populations. Diabetes Care. 2012;35(2):362-7.
[20] Sabatine MS, et al. Association of hs-CRP with angiographic severity of CAD. Circulation. 2007;115(13):1528-36.
[21] Yousuf O, et al. C-reactive protein and cardiovascular disease: a review. J Am Coll Cardiol. 2013;62(6):397-408.
[22] Suleiman M, et al. Early inflammation and risk of long-term outcomes in ACS. Circulation. 2006;114(17):1828-37.
[23] Liuzzo G, et al. The prognostic value of CRP in UA/NSTEMI. N Engl J Med. 1994;331(7):417-24.
[24] Ridker PM, et al. Residual inflammatory risk in statin-treated patients. Eur Heart J. 2018;39(1):36-45.
[25] Bohula EA, et al. Inflammatory biomarkers and outcomes in ACS. Circulation. 2014;129(18):1895-903.
[26] Tardif JC, et al. Colchicine in patients with chronic coronary disease. N Engl J Med. 2019;381(25):2497-505.

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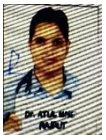

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