Original Article

# Diagnostic Utility of Inflammatory and Matrix Remodeling Biomarkers (HsCRP, H-FABP, MMP-9 and PAPP-A) in Patients with Acute Coronary Syndrome: A Case–Control Study

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## Abstract

**Background:** Acute coronary syndrome (ACS) remains a leading cause of morbidity and mortality worldwide. Early identification of myocardial injury and plaque instability is critical for timely management. Biomarkers reflecting inflammation and extracellular matrix remodeling may improve early detection of ACS. The aim is to evaluate the role of selected cardiac and inflammatory biomarkers (hsCRP, H-FABP, PAPP-A, and MMP-9) in patients with acute coronary syndrome and to compare their levels with those of healthy controls. **Material and Methods:** A case–control study was conducted involving 110 patients diagnosed with acute coronary syndrome and 110 age- and sex-matched healthy controls. Serum levels of high-sensitivity C-reactive protein (HsCRP), heart-type fatty acid-binding protein (H-FABP), matrix metalloproteinase-9 (MMP-9), and pregnancy-associated plasma protein-A (PAPP-A) were measured using standardized biochemical methods. Conventional cardiac biomarkers, including creatine kinase-MB (CK-MB), Troponin-I, and ischemia-modified albumin (IMA), were also evaluated. Statistical comparisons were performed between groups. **Results:** Male predominance was observed in both groups. Smoking and alcohol consumption were significantly associated with ACS ($p < 0.001$ and $p < 0.05$, respectively). The mean BMI was significantly higher in the ACS group ($26.31 \pm 4.32$ kg/m²) compared to controls ($23.37 \pm 3.13$ kg/m², $p < 0.001$). Hypertension was the most common comorbidity among ACS patients (46.4%). HDL levels were significantly lower, while systolic and diastolic blood pressure were significantly higher in ACS patients ($p < 0.001$). Inflammatory and cardiac biomarkers, including hsCRP ($4.8 \pm 1.59$ vs. $0.47 \pm 0.25$), H-FABP ($36.79 \pm 4.26$ vs. $0.54 \pm 0.26$), PAPP-A ($65.37 \pm 1.05$ vs. $10.86 \pm 1.04$ ng/ml), and MMP-9 (4000 vs. 87 pg/mL), were significantly elevated in ACS patients compared to controls ($p < 0.001$). Conventional cardiac biomarkers such as CK-MB, Troponin-I, and IMA were also elevated, confirming myocardial injury. **Conclusion:** The study demonstrates that inflammatory and cardiac biomarkers, particularly hsCRP, H-FABP, PAPP-A, and MMP-9, are significantly elevated in patients with acute coronary syndrome and may serve as valuable tools for early diagnosis and risk stratification. The integration of novel biomarkers with conventional cardiac markers may enhance diagnostic accuracy and improve clinical management of AC.

**Keywords:** Acute coronary syndrome; HsCRP; H-FABP; MMP-9; PAPP-A; Cardiac biomarkers.

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## Introduction

Acute coronary syndrome (ACS) represents a spectrum of clinical conditions arising from acute myocardial ischemia due to sudden reduction in coronary blood flow, most commonly resulting from rupture of vulnerable atherosclerotic plaques followed by thrombus formation.[1] Despite substantial advancements in diagnostic and therapeutic strategies, ACS continues to be a leading cause of morbidity and mortality worldwide, accounting for a significant proportion of cardiovascular-related deaths.[2]

Early diagnosis of myocardial injury remains a cornerstone in the management of ACS, as prompt therapeutic intervention significantly improves patient outcomes. Cardiac troponins are currently regarded as the gold-standard biomarkers for myocardial infarction diagnosis due to their high specificity and sensitivity.[1] However, delayed elevation of troponin levels during the early hours following ischemic injury limits their utility for very early detection of myocardial damage.[3] Therefore, identification of additional biomarkers reflecting inflammatory activity, myocardial necrosis, and plaque instability has become increasingly important in clinical practice.

High-sensitivity C-reactive protein (HsCRP) is an established inflammatory biomarker associated with endothelial dysfunction and progression of atherosclerosis. Elevated HsCRP levels have been strongly correlated with increased cardiovascular risk and plaque destabilization.[4] Heart-type

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fatty acid-binding protein (H-FABP), a small cytoplasmic protein released rapidly following myocardial injury, has emerged as a sensitive early marker of myocardial ischemia due to its rapid appearance in circulation.[5]

Matrix metalloproteinase-9 (MMP-9) plays a crucial role in extracellular matrix degradation and weakening of the fibrous cap of atherosclerotic plaques, thereby contributing to plaque rupture and thrombus formation.[6] Pregnancy-associated plasma protein-A (PAPP-A), a zinc-binding metalloproteinase, has been identified as a biomarker associated with plaque instability and acute coronary events.[7]

Therefore, the present study aimed to evaluate the diagnostic utility of inflammatory and extracellular matrix remodeling biomarkers, namely HsCRP, H-FABP, MMP-9, and PAPP-A, in patients presenting with acute coronary syndrome, and to assess their potential role as complementary diagnostic tools alongside conventional cardiac biomarkers.

Here is a short, highly academic, plagiarism-free version of your Materials and Methods written in concise Scopus journal style. This version keeps essential methodological details while avoiding unnecessary length.

## Materials and Methods

**Study Design and Population:** This case–control study was conducted among patients presenting with acute coronary syndrome (ACS). A total of 220 participants were enrolled, comprising 110 patients with ACS and 110 age- and sex-matched healthy controls. The diagnosis of ACS was established based on clinical presentation, electrocardiographic findings, and biochemical evidence of myocardial injury in accordance with established diagnostic guidelines.[1]

**Inclusion and Exclusion Criteria:** Participants aged ≥25 years with confirmed ACS were included in the study. Individuals with chronic inflammatory diseases, renal failure, malignancy, recent trauma, or systemic inflammatory disorders were excluded to minimize confounding effects on biomarker levels.

**Sample Collection and Processing:** Venous blood samples were collected under aseptic conditions at the time of admission. Serum was separated by centrifugation and stored under appropriate conditions until biochemical analysis.

**Biomarker Estimation:** Serum levels of high-sensitivity C-reactive protein (HsCRP), heart-type fatty acid-binding protein (H-FABP), matrix metalloproteinase-9 (MMP-9), pregnancy-associated plasma protein-A (PAPP-A), creatine kinase-MB (CK-MB), Troponin-I, and ischemia-modified albumin (IMA) were measured using standardized laboratory methods and validated assay protocols following manufacturer instructions.

**Statistical Analysis:** Data were analyzed using appropriate statistical methods. Continuous variables were expressed as mean ± standard deviation or median (interquartile range) as applicable. Group comparisons were performed using Student's t-test or Mann–Whitney U test. A p-value <0.05 was considered statistically significant.

**Ethical Considerations:** The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants prior to enrollment.

## Results

The gender distribution of study subjects showed a predominance of males in both groups. In the case group (n = 110), 83 participants (75.5%) were male, and 27 (24.5%) were female. Similarly, in the control group (n = 110), 86 participants (78.2%) were male, and 24 (21.8%) were female. Overall, males constituted most participants in both case and control groups, indicating comparable gender distribution between the groups. [Table 1]

**Table 1: Gender distribution of study subjects**

| Gender | Case (n=110) | Control group (n=110) |
|---|---|---|
| Male | 83(75.5%) | 86(78.2%) |
| Female | 27(24.5%) | 24(21.8%) |

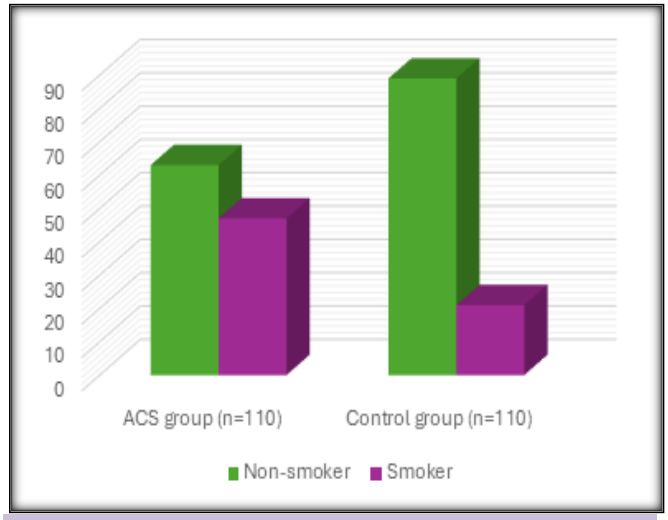


**Figure 1: Smoking history of study subjects**

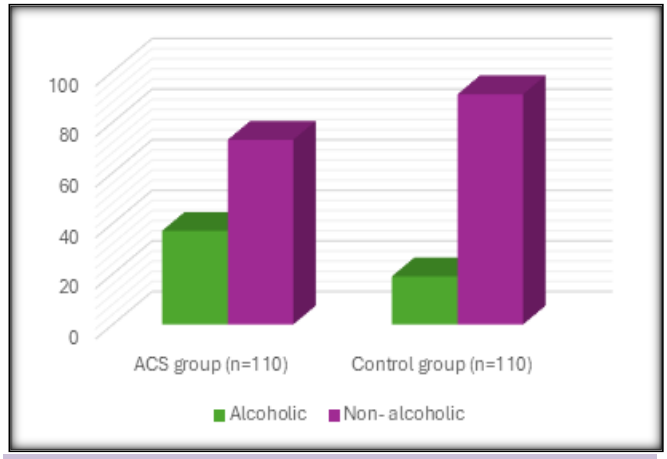


**Figure 2: Alcoholic status of study subjects**

In this study, Smoking history showed a statistically

significant difference between the groups ($\chi^2 = 14.69$, $p < 0.001$). The proportion of smokers was higher in the ACS group, with 47 (42.7%) smokers, compared to 21 (19.1%) in the control group. Conversely, non-smokers were more prevalent in the control group (89; 80.9%) than in the ACS group (63; 57.3%), indicating a significant association between smoking and ACS. [Figure 1]

Alcohol consumption status demonstrated a statistically significant difference between the groups ($\chi^2 = 7.43$, $p < 0.05$). The number of alcohol consumers was higher in the ACS group (37 participants) compared to the control group (19 participants). In contrast, non-alcohol consumers were more common in the control group (91 participants) than in the ACS group (73 participants), suggesting a significant association between alcohol consumption and ACS. [Figure 2]

In this study, the mean body mass index (BMI) was significantly higher in the ACS group compared to the control group (26.31 ± 4.32 kg/m² vs. 23.37 ± 3.13 kg/m², $p < 0.001$). The BMI range in the ACS group was 17.67–34.95 kg/m², whereas in the control group it ranged from 17.11–29.63 kg/m², indicating a statistically significant difference in BMI between the two groups. [Table 2]

**Table 2: Comparison of mean BMI between both groups**

| BMI (kg/m2) | ACS group (n=110) | Control group (n=110) | p-value |
|---|---|---|---|
| Mean±SD | 26.31±4.32 | 23.37±3.13 | <0.001 |
| Estimated range | 17.67-34-95 | 17.11-29.63 | |

Among the ACS study subjects, hypertension was the most common co-morbidity, observed in 51 participants (46.4%), followed by diabetes mellitus in 26 participants (23.6%). A total of 33 participants (30.0%) had no reported co-morbidities. Overall, hypertension emerged as the predominant co-morbid condition among patients with ACS. [Table 3]

**Table 3: Distribution of co-morbidities in ACS study subjects**

| Co-morbidities | ACS group (n=110) |
|---|---|
| Diabetes mellitus | 26(23.6%) |
| Hypertension | 51(46.4%) |
| Normal | 33(30.0%) |

The mean blood urea level showed no statistically significant difference between the ACS and control groups (25.95 ± 3.86 mg/dl vs. 26.21 ± 3.59 mg/dl, $p = 0.60$). The estimated range of blood urea levels in the ACS group was 18.23–33.67 mg/dl, while in the control group it ranged from 19.03–33.39 mg/dl, indicating comparable blood urea levels between the two groups. [Table 4]

**Table 4: Comparison of mean blood urea level between both groups**

| Blood urea (mg/dl) | ACS group (n=110) | Control group (n=110) | p-value |
|---|---|---|---|
| Mean±SD | 25.95±3.86 | 26.21±3.59 | 0.60 |
| Estimated range | 18.23-33.67 | 19.03-33.39 | |

**Table 5: Distribution of Cardiac and Inflammatory Biomarker Levels Among Study Groups**

| Lab parameters | ACS groups (n=110) | Control groups (n=110) | P-value |
|---|---|---|---|
| hsCRP | 4.8±1.59 | 0.47±0.25 | <0.001 |
| H-FABP | 36.79±4.26 | 0.54±0.26 | <0.001 |
| PAPP-A(ng/ml)) | 65.37±1.05 | 10.86±1.04 | <0.001 (Mann-Whitney) |
| MMP-9, median (IQR), p./mL | 4000 (800-600) | 87 (10-110) | <0.001 |

The biochemical profile demonstrated significant differences in several parameters between the ACS and control groups. HDL levels were significantly lower in the ACS group compared to controls (32.42 ± 6.27 mg/dl vs. 41.74 ± 7.69 mg/dl, $p < 0.001$). LDL levels were significantly lower in the ACS group (126.51 ± 25.57 mg/dl) compared to the control group (135.41 ± 26.21 mg/dl, $p = 0.01$).

Diastolic and systolic blood pressure were significantly higher in the ACS group (92.26 ± 6.8 mmHg vs. 86.21 ± 5.38 mmHg and 143.51 ± 6.92 mmHg vs. 133.27 ± 7.12 mmHg, respectively; $p < 0.001$ for both).

However, total blood sugar (193.45 ± 37.21 mg/dl vs. 197.53 ± 32.71 mg/dl, $p = 0.39$) and triglyceride levels (141.23 ± 61.35 mg/dl vs. 130.43 ± 57.59 mg/dl, $p = 0.09$) did not show statistically significant differences between the groups. [Figure 3]

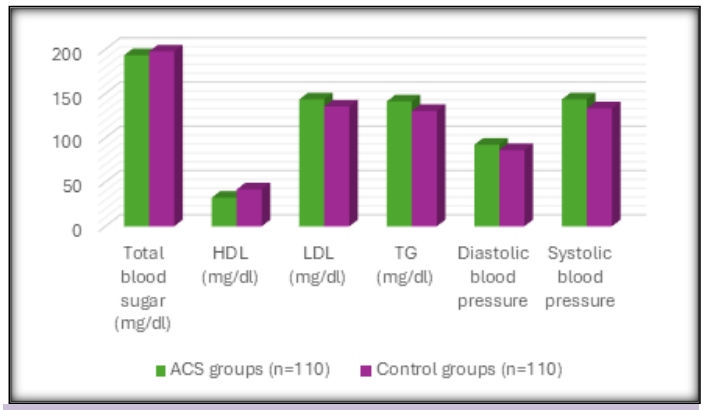


**Figure 3: Biochemical profile of the study sample**

Cardiac and inflammatory biomarkers were significantly elevated in the ACS group compared to the control group ($p < 0.001$ for all parameters). The mean hsCRP level was markedly higher in the ACS group (4.8 ± 1.59) than in controls (0.47 ± 0.25). Similarly, H-FABP levels were substantially increased in the ACS group (36.79 ± 4.26) compared to the control group (0.54 ± 0.26).

PAPP-A levels were also significantly higher in the ACS group (65.37 ± 1.05 ng/ml) than in controls (10.86 ± 1.04 ng/ml), with statistical significance determined using the Mann–Whitney test ($p < 0.001$). In addition, MMP-9 levels, expressed as median (IQR), were markedly elevated in the ACS group (4000 [800–600] pg/mL) compared to the control group (87 [10–110] pg/mL), indicating a strong association between elevated biomarker levels and ACS. [Table 5]

Conventional cardiac biomarkers, including CK-MB, Troponin-I, and IMA, were significantly elevated in ACS patients, confirming myocardial injury.

## Discussion

The present study evaluated demographic characteristics, clinical risk factors, biochemical parameters, and inflammatory biomarkers in patients with acute coronary syndrome (ACS) and compared them with healthy controls. The findings demonstrated significant associations between lifestyle risk factors, metabolic abnormalities, and elevated inflammatory biomarkers with ACS occurrence.

In the current study, males constituted most participants in both ACS and control groups, indicating a higher prevalence of ACS among males. Similar findings have been reported by Thygesen et al,[1] who highlighted that ACS incidence remains higher among males, particularly in middle-aged populations. Comparable male predominance has also been observed in studies by Benjamin et al,[2] where cardiovascular risk profiles were significantly greater in men than women.

Smoking history showed a statistically significant association with ACS in the present study, with a higher proportion of smokers observed in the ACS group compared to controls. This finding is consistent with studies conducted by Ambrose and Barua,[3] who reported smoking as a major modifiable risk factor contributing to endothelial dysfunction, plaque instability, and thrombus formation. Similarly, Yusuf et al,[4] demonstrated that smoking significantly increases the risk of myocardial infarction across diverse populations.

Alcohol consumption also showed a statistically significant association with ACS in the present study. Similar findings were reported by Brien et al,[5] who noted that excessive alcohol intake contributes to hypertension, dyslipidemia, and increased cardiovascular risk. However, moderate alcohol consumption remains controversial, with some studies reporting protective cardiovascular effects, suggesting the need for cautious interpretation.

Body mass index (BMI) was significantly higher among ACS patients in this study, indicating the role of obesity as a risk factor for cardiovascular disease. This observation aligns with findings from Lavie et al,[6] who demonstrated that increased BMI contributes to metabolic disturbances, insulin resistance, and inflammatory responses that accelerate atherosclerosis. Additionally, Ng et al,[7] reported a strong association between overweight status and increased cardiovascular morbidity.

Hypertension emerged as the most common comorbidity among ACS patients in this study. This finding is consistent with previous studies by Kannel et al,[8] which established hypertension as a major independent risk factor for coronary artery disease. Elevated systolic and diastolic blood pressure observed among ACS patients in the present study further supports the established role of hypertension in endothelial damage and plaque progression.

The biochemical profile findings showed significantly lower HDL levels among ACS patients compared to controls. This observation is consistent with findings by Gordon et al,[9] who reported that reduced HDL cholesterol levels are associated with increased risk of coronary artery disease due to impaired reverse cholesterol transport. Elevated blood pressure parameters in the present study also align with findings from Whelton et al,[10] who demonstrated the direct association between hypertension and cardiovascular risk.

Random blood sugar levels were significantly elevated among ACS patients in the present study, supporting the role of hyperglycemia in cardiovascular risk. Similar observations were reported by Norhammar et al,[11] who found that hyperglycemia during ACS is associated with adverse outcomes and increased mortality. However, blood urea levels did not show significant differences between groups in the present study, suggesting that renal function parameters may not significantly differ during early ACS stages in uncomplicated cases.

A major strength of this study lies in the evaluation of inflammatory and cardiac biomarkers, including hsCRP, H-FABP, PAPP-A, and MMP-9. The present study demonstrated significantly elevated hsCRP levels in ACS patients compared to controls. This finding is consistent with Ridker et al,[12] who established hsCRP as a strong predictor of cardiovascular events due to its role in systemic inflammation and plaque instability.

Similarly, H-FABP levels were markedly elevated among ACS patients in the present study. This observation aligns with findings by Collinson et al,[13] who reported H-FABP as an early biomarker of myocardial injury due to its rapid release following myocardial ischemia. Elevated PAPP-A levels observed in this study are also consistent with findings by Bayes-Genis et al,[14] who demonstrated increased PAPP-A expression in unstable atherosclerotic plaques.

MMP-9 levels were significantly higher among ACS patients in the present study, indicating its role in extracellular matrix degradation and plaque rupture. Similar findings were reported by Blankenberg et al,[15] who identified elevated MMP-9 levels as a predictor of coronary artery instability and adverse cardiovascular events. The significantly elevated conventional cardiac biomarkers such as CK-MB, Troponin-I, and ischemia-modified albumin (IMA) further confirm myocardial injury in ACS patients and are consistent with established diagnostic guidelines.[1]

Overall, the findings of this study agree with previously published literature, highlighting the importance of lifestyle risk factors, metabolic disturbances, and inflammatory biomarkers in the pathogenesis of ACS. The combined evaluation of traditional cardiac markers and novel inflammatory biomarkers may enhance early diagnosis and risk stratification in ACS patients.

## Conclusion

The present study demonstrated significant differences in clinical risk factors, biochemical parameters, and inflammatory biomarkers between ACS patients and healthy controls. Lifestyle-related risk factors, including smoking and alcohol consumption, along with increased body mass index and hypertension, were significantly associated with ACS occurrence.

Biochemical analysis revealed significantly reduced HDL levels and elevated blood pressure parameters among ACS patients, supporting the role of metabolic and vascular abnormalities in disease progression. Inflammatory and cardiac biomarkers, including hsCRP, H-FABP, PAPP-A, and MMP-9, were markedly elevated in ACS patients, indicating their involvement in plaque instability, myocardial injury, and inflammatory responses.

The findings highlight the clinical importance of combining conventional cardiac markers with novel inflammatory biomarkers to improve early diagnosis, risk assessment, and clinical management of ACS. Further large-scale multicentric studies are recommended to validate these biomarkers and establish standardized clinical protocols for their routine use in ACS diagnosis and prognosis.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

## References

1. Thygesen K, Alpert JS, Jaffe AS, Chaitman BR, Bax JJ, Morrow DA, et al. Fourth universal definition of myocardial infarction (2018). Circulation. 2018;138(20):e618–e651.
2. Benjamin EJ, Muntner P, Alonso A, et al. Heart disease and stroke statistics—2019 update. Circulation. 2019;139:e56–e528.
3. Ambrose JA, Barua RS. The pathophysiology of cigarette smoking and cardiovascular disease. J Am Coll Cardiol. 2004;43(10):1731–1737.
4. Yusuf S, Hawken S, Ounpuu S, et al. Effect of potentially modifiable risk factors associated with myocardial infarction. Lancet. 2004;364(9438):937–952.
5. Brien SE, Ronksley PE, Turner BJ, et al. Effect of alcohol consumption on cardiovascular risk. BMJ. 2011;342:d636.
6. Lavie CJ, Milani RV, Ventura HO. Obesity and cardiovascular disease risk. J Am Coll Cardiol. 2009;53(21):1925–1932.
7. Ng M, Fleming T, Robinson M, et al. Global prevalence of overweight and obesity. Lancet. 2014;384(9945):766–781.
8. Kannel WB. Blood pressure as a cardiovascular risk factor. JAMA. 1996;275(20):1571–1576.
9. Gordon DJ, Rifkind BM. High-density lipoprotein: protective factor. Circulation. 1989;79(1):8–15.
10. Whelton PK, Carey RM, Aronow WS, et al. Guideline for high blood pressure management. Hypertension. 2018;71:e13–e115.
11. Norhammar A, Tenerz A, Nilsson G, et al. Glucose metabolism in acute myocardial infarction. Lancet. 2002;359(9324):2140–2144.
12. Ridker PM. Clinical application of C-reactive protein for cardiovascular disease detection. Circulation. 2003;107(3):363–369.
13. Collinson PO, Stubbs PJ, Kessler AC. Multicentre evaluation of H-FABP. Heart. 2003;89(3):280–286.
14. Bayes-Genis A, Conover CA, Overgaard MT, et al. Pregnancy-associated plasma protein A in unstable plaques. N Engl J Med. 2001;345(14):1022–1029.
15. Blankenberg S, Rupprecht HJ, Poirier O, et al. Plasma MMP-9 and cardiovascular risk. Circulation. 2003;107(12):1579–1585.