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ORIGINAL ARTICLE

Assessment of Oxidative Stress, Cardiac Biomarkers, and Platelet Indices in Acute Myocardial Infarction: A Case-Control Study

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KEYWORDS

Acute Myocardial Infarction;
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Malondialdehyde (MDA)

ABSTRACT: Acute myocardial infarction (AMI) is a pathological condition primarily affecting the coronary arteries. The future risk of cardiac events is closely linked to abnormalities in heart biomarkers. The generation of free radicals due to oxidative stress leads to the oxidation of low-density lipoprotein (LDL), which subsequently contributes to the formation of atherosclerosis. In cases where necrosis occurs as a result of coronary artery occlusion, there is a notable increase in CK-MB levels. This study aimed to evaluate the levels of CK-MB, high-sensitivity C-reactive protein (hs-CRP), platelet indices, and malondialdehyde (MDA) in patients with acute myocardial infarction. A total of 19 patients with AMI who consulted outpatient clinics and were referred to the Al-Rabea Cardiac Center for further management were included in the study, along with 19 healthy controls. Blood samples (5 ml) were collected from each participant through venipuncture. After centrifugation, serum was separated and analyzed for lipid parameters (triglycerides, total cholesterol, LDL, high-density lipoprotein (HDL), and very low-density lipoprotein (VLDL)), cardiac biomarkers (hs-CRP and CK-MB), and oxidative stress markers (malondialdehyde, MDA). The results indicated a significant increase in MDA, heart biomarkers, and lipid parameters in the AMI group compared to the control group, with the exception of HDL, which was found to be significantly decreased. Lipid peroxidation, as indicated by elevated MDA levels, was found to be closely associated with AMI. Furthermore, CK-MB, hs-CRP, and platelet parameters (PDW, platelet count, and MPV) could serve as valuable biomarkers for the diagnosis and understanding of the pathogenesis of AMI.

INTRODUCTION

Cardiovascular diseases (CVDs) remain the leading cause of mortality worldwide, with acute myocardial infarction (AMI) representing one of the most critical emergencies in this category [1]. AMI typically results

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from the sudden occlusion of a coronary artery, leading to irreversible myocardial damage. Timely diagnosis and intervention are essential in reducing mortality rates and improving patient outcomes [2]. Consequently, extensive research has focused on identifying biochemical, inflammatory, and platelet-related biomarkers associated with AMI to enhance diagnostic accuracy and prognostic evaluation [2].

Oxidative stress plays a crucial role in the pathogenesis and progression of cardiovascular diseases by promoting excessive free radical production, leading to the oxidation of low-density lipoproteins (LDL) and accelerating atherosclerosis [3]. Among oxidative stress markers, malondialdehyde (MDA) is a significant byproduct of lipid peroxidation and serves as a reliable indicator of oxidative damage in acute myocardial infarction (AMI) patients [3]. Additionally, systemic inflammation increases in AMI, making high-sensitivity C-reactive protein (hs-CRP) a valuable biomarker for assessing inflammatory responses in these patients [4]. Therefore, both MDA and hs-CRP increase in inflammatory and chronic diseases, helping to assess overall health and the risk of developing chronic conditions [4].

Platelets also play a pivotal role in thrombotic events, and alterations in platelet indices may provide essential insights into the coagulation status of AMI patients [5]. Parameters such as platelet distribution width (PDW), platelet count, and mean platelet volume (MPV) serve as critical indicators of platelet activity and thrombotic risk [6, 7]. Therefore, a comprehensive evaluation of cardiac biomarkers, oxidative stress markers, and platelet indices can offer deeper insights into the underlying mechanisms of AMI and contribute to improved diagnostic and therapeutic strategies.

MATERIALS AND METHODS

Patients

A total of 38 cases were included in this study: 19 patients with Acute Myocardial Infarction (AMI) who visited outpatient clinics and were referred to the Al-Rabea Cardiac Center in Nassirryia for further management, and 19 apparently healthy controls. The study assessed various biomarkers, including Hs-CRP (measured by the ELISA method from Wiesbaden, Germany), CK-MB (measured by the photometric UV test method from DGKC, Germany), oxidative stress marker MDA (measured according to the method of Buege and Aust, 1978), and platelet indices (Platelet count, MPV, and PDW), using an automated hematology analysis system, comparing the results between patients and controls.

Statistics

It was used through SPSS application (version 18). Student t was used. $P < 0.05$ was deliberated asl significant statistically.

RESULTS

In comparison to the control group, the study revealed a significant increase in MDA levels, along with elevated cardiac biomarkers and lipid parameters. However, HDL levels were notably decreased. Further details regarding these findings are presented in Figure 1-4.

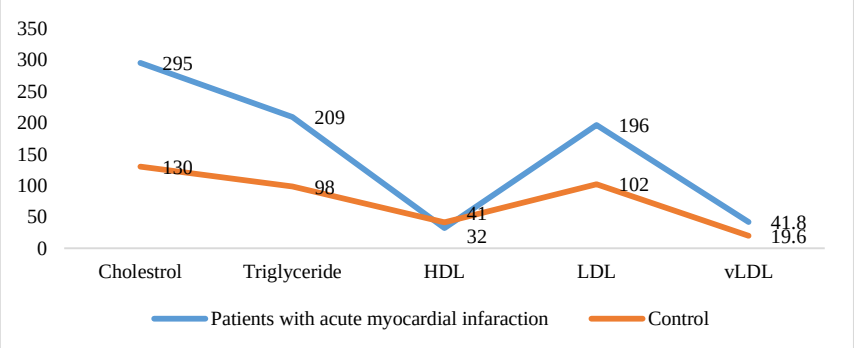

Figure 1. Lipid profile (Chlolestrol, Triglyceride, HDL, LDL and vLDL) among patients in relation to compared to control.

Figure 1 illustrates the lipid profile (Cholesterol, Triglycerides, HDL, LDL, and VLDL) in patients compared to a control group. The results show a significant increase in the lipid profile (Cholesterol,

Triglycerides, LDL, and VLDL) in the Acute Myocardial Infarction (AMI) group compared to the control group (P-value < 0.05). This suggests a direct relationship between elevated lipid levels (Cholesterol, Triglycerides, LDL, and VLDL) and a reduction in HDL levels, indicating an increased risk of atherosclerosis in AMI patients. High levels of atherogenic lipids (Cholesterol, Triglycerides, LDL, and VLDL) contribute to plaque formation in blood vessels, while high levels of HDL (c-HDL) act as a protective factor, reducing the risk of atherosclerosis.

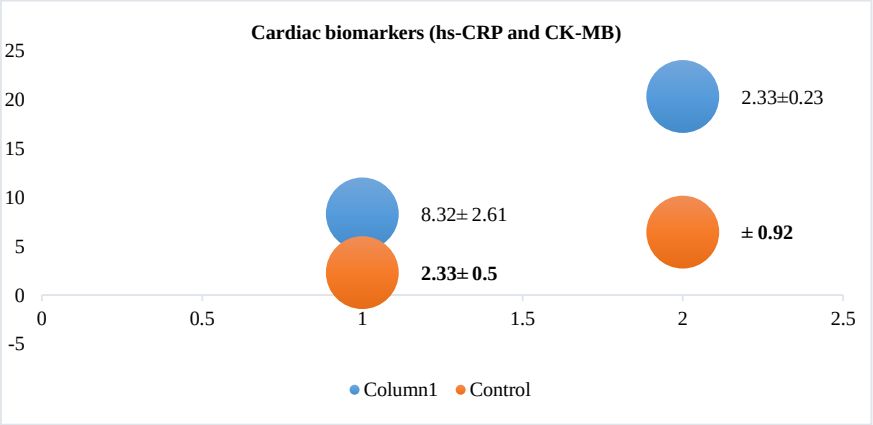

Figure 2. Cardiac biomarkers (hs-CRP and CK-MB) among patients with AMI and control.

Figure 2 displays the cardiac biomarkers (hs-CRP and CK-MB) in patients with Acute Myocardial Infarction (AMI) compared to the control group. The results show a significant increase in hs-CRP and CK-MB levels in patients with Acute Coronary Syndrome (ACS) compared to the control group (P-value < 0.05). Elevated CK-MB serves as a biochemical marker of myocyte necrosis, indicating damage to cardiac muscle cells. hs-CRP, an inflammatory marker, further reflects the presence of inflammation associated with AMI and ACS, reinforcing the pathological processes occurring in these patients [8- 10].

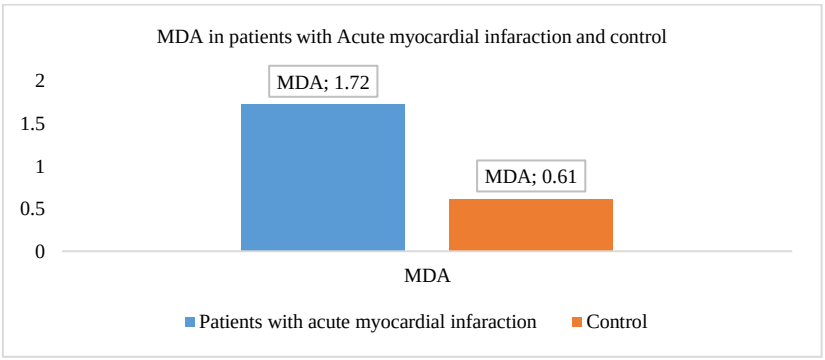

Figure 3. Oxidative stress (MDA) in patient with AMI compared to control group.

Figure 3 presents the level of oxidative stress, measured by Malondialdehyde (MDA), in patients with Acute Myocardial Infarction (AMI) compared to the control group. The results show a significant increase in MDA levels in patients with AMI compared to the control group (P-value < 0.05). Elevated MDA levels indicate increased lipid peroxidation, a process were oxidative stress damages cellular lipids, contributing to the development of atherosclerosis [11]. The imbalance between prooxidant and antioxidant mechanisms contributes to further oxidative damage. In cases of coronary insufficiency, ATP levels are reduced, and ATP is converted to hypoxanthine, which is then metabolized to uric acid by xanthine oxidase upon reperfusion, exacerbating the oxidative stress.

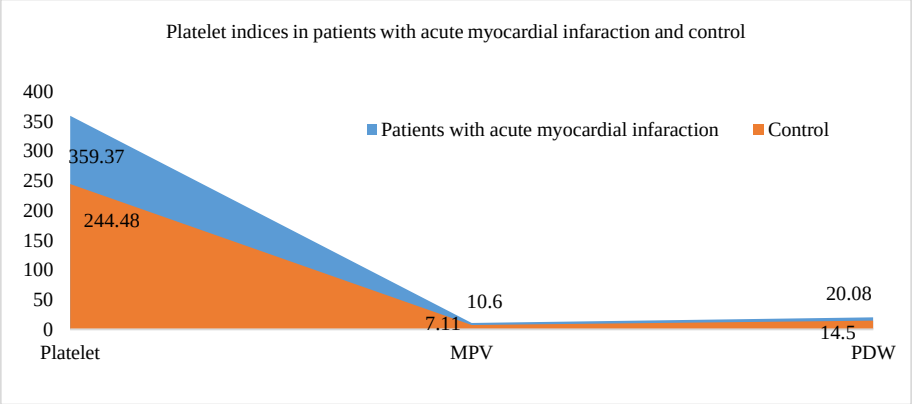

Figure 4. Platelet indices (PDW, MPV, platelet count, and) in patients with AMI and control.

Figure 4 presents the platelet indices (PDW, MPV, platelet count) in patients with Acute Myocardial Infarction (AMI) compared to the control group. The results show a significant increase in platelet count in patients with AMI compared to the control group ($P < 0.05$). Elevated platelet counts and platelet volume, measured after a myocardial infarction (MI), are associated with platelet activation, which plays a critical role in the pathogenesis of thrombosis and atherosclerosis. These findings are consistent with previous studies [12, 13], suggesting that elevated platelet indices may contribute to the risk of cardiovascular events post-MI.

DISCUSSION

The present discussion highlights that oxidative stress, cardiac biomarkers, and platelet indices not only play a critical role in the pathophysiology of acute myocardial infarction (AMI) but can also serve as valuable diagnostic and prognostic tools for assessing the severity of the disease and its outcomes [8].

One important aspect related to oxidative stress is its ability to directly and indirectly impact the chemical and physical changes in cardiac tissues. Oxidative stress is associated with the production of free radicals in the body, which can damage cellular membranes, proteins, and DNA. This damage leads to the destruction of cardiac cells and triggers inflammatory processes, ultimately resulting in the onset of myocardial infarction. Furthermore, oxidative stress and the increase in malondialdehyde (MDA) appear to play a major role not only in the process of atherosclerosis but also in the onset of heart attacks [9].

Regarding cardiac biomarkers, particularly high-sensitivity C-reactive protein (hs-CRP) and creatine kinase-MB (CK-MB), it is essential to note that these biomarkers increase significantly in inflammatory conditions and myocardial injury. hs-CRP, recognized as a systemic inflammatory marker, is not only helpful in diagnosing AMI but also plays a significant role in predicting complications following heart attacks, such as heart failure and stroke [10]. On the other hand, CK-MB, one of the key markers for myocardial injury in the early stages of a heart attack, remains one of the most reliable tools for quick and accurate AMI diagnosis. Therefore, these biomarkers are crucial in determining the extent of myocardial damage and guiding the clinical management of AMI patients [10].

Concerning platelet indices, various studies have demonstrated that platelets play a pivotal role in the thrombotic process and clot formation in cardiovascular diseases. Alterations in platelet parameters, such as mean platelet volume (MPV) and platelet distribution width (PDW), are significantly associated with disease severity and thrombotic risk. These parameters reflect changes in the size and dynamics of platelets, indicating an excessive activation of the platelet system in response to myocardial injury. In this context, elevated MPV could serve as an early marker for thrombus detection and an indicator of the risk of AMI complications [11].

Additionally, the correlation between platelet indices and thrombotic risk further strengthens the role of these indices in predicting complications like stroke and coronary artery occlusion. Moreover, incorporating these platelet parameters alongside other biochemical tests can assist physicians in identifying high-risk patients and

prescribing more targeted and effective treatments. Therefore, the assessment of these indices, together with cardiac biomarkers such as hs-CRP and CK-MB, may pave the way for more accurate diagnosis and better prediction of AMI prognosis [12, 13].

Ultimately, based on these findings, it can be concluded that the combined evaluation of oxidative stress, cardiac biomarkers, and platelet indices represents a comprehensive approach in the clinical management of AMI patients. These evaluations not only facilitate quicker and more accurate diagnoses but also provide a more precise prediction of disease severity and the likelihood of subsequent complications. Furthermore, continued research in this area can contribute to the development of novel therapeutic methods and improved treatment outcomes for AMI patients.

Oxidative stress plays a crucial role in the development of chronic cardiovascular diseases. The increased production of free radicals leads to the oxidation of low-density lipoprotein (LDL) and the formation of atherosclerotic plaques, ultimately contributing to myocardial infarction and other heart disorders. Scientific evidence shows a direct link between oxidative stress and heart diseases, especially when associated with elevated biochemical markers such as CK-MB and hs-CRP.

CONCLUSIONS

This study underscores the complex interaction between oxidative stress, inflammation, and platelet activation in acute myocardial infarction (AMI). The results indicate that markers such as MDA, hs-CRP, CK-MB, and platelet indices may serve as useful biomarkers for early detection, risk evaluation, and monitoring of treatment in AMI patients. Further research involving larger sample sizes and extended follow-up periods is essential to confirm the validity of these biomarkers and examine their prognostic significance.

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Conflict of interest

The authors declare no conflicts of interest that could influence the objectivity of the reported research.

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Author Contributions

AMB, HSS. conducted the experiments. GJA, ATT. conceived the study, designed the experiments, and wrote the manuscript. RFA, HSS, ATT. analyzed the data. GJA, ATT, RFA. contributed reagents, materials, and analysis tools.

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