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Full Length Research

Role of oxidase and antioxidant enzymes in neutrophils and blood circulation in patients with acute coronary syndrome

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ABSTRACT: Acute coronary syndrome (ACS), a subcategory of cardiovascular diseases, has become a major cause of mortality and morbidity worldwide. Oxidative stress resulting from increased production of reactive oxygen species and decreased antioxidants plays a major role in the pathophysiology of ACS. This study evaluated the activities of certain oxidase and antioxidant enzymes in circulation and neutrophils to determine their roles in increased oxidative stress in patients with ACS. A total of 52 patients with ACS admitted in the coronary care unit of two tertiary hospitals and 52 healthy controls were enrolled. Blood samples were collected from all subjects, and various oxidase and antioxidant enzymes in neutrophils and circulation were assayed. The patients had significantly higher white blood cell and neutrophil counts than the controls. In patients, the mean (±SD) serum activities of nicotinamide adenine dinucleotide phosphate (NADPH) oxidase (12.83±6.6 U/L) and superoxidase dismutase (4.34±1.41 U/mL) were significantly higher than in the control group (4.88±3.03 U/L and 3.02±1.7 U/mL, respectively) while the catalase had significantly lower activities (33.36±13.16 U/mL vs. 63.98±31.86 U/mL). In neutrophils, the activities of myeloperoxidase, NADPH oxidase and catalase were significantly higher in ACS patients, while superoxidase dismutase was significantly lower. Further, significant positive correlations were found between activities of myeloperoxidase and catalase, and NADPH oxidase and superoxidase dismutase in neutrophils of ACS patients. These findings revealed that higher activities of myeloperoxidase and NADPH oxidase, both in serum and neutrophils, lead to increased oxidative stress and form the inflammatory basis of ACS, and the antioxidant enzymes combat the events.

Keywords: Acute coronary syndrome, catalase, neutrophils, myeloperoxidase, NADPH oxidase, superoxidase dismutase.

INTRODUCTION

Cardiovascular diseases (CVDs) are major public health problems and the number one cause of morbidity and mortality throughout the world (Ritchie and Roser, 2018). CVDs refer to various types of problems associated with the heart and blood vessels. Coronary artery disease (CAD) refers to the narrowing, blocking or damaging of coronary arteries by atherosclerosis, is the most common cause of CVD (Parizadeh *et al*., 2018), which can be asymptomatic (Sanchis-Gomar *et al*., 2016). Acute coronary syndrome (ACS) is characterized by severe reduction or complete occlusion of blood supply through coronary arteries. ACS is a subcategory of CAD and almost always presents with a symptom. The spectrum of the ACS ranges from unstable angina (UA) to non-ST segment elevation myocardial infarction (NSTEMI) and ST segment elevation myocardial infarction (STEMI).

ACS has a number of causes, but the most prevalent is atherosclerosis, which can lead to thrombosis and the cessation of coronary blood flow if plaques are ruptured (Kurup, 2017). Atherosclerosis is caused by a phenomenon called oxidative stress (Munnur *et al*., 2014), which is a general term used to characterize a significant

imbalance between reactive oxygen species (ROS) generation and the antioxidant defense mechanism in body leading to a potential danger situation. The overproduction of ROS has been proposed as a key mediator of cardiac tissue damage. These species are toxic to all cellular components and may cause biological damage (Becker, 2004). This happens when there is an oversupply of ROS on one hand and a deficiency of antioxidant systems on the other (Lefer and Granger, 2000).

The white blood cells (WBCs) specially neutrophils play crucial roles toward adverse clinical outcomes in ACS as these cells secrete a variety of enzymes that modulate the oxidative stress in body. In particular, upon stimulation neutrophils activate their NADPH oxidase (NOX) to generate large quantities of superoxide, which serves as a precursor of hydrogen peroxide and other ROS; as a result, oxidative stress is increased by loss of redox balance (Winterbourn *et al*., 2016). Neutrophils play a critical role in redox signaling, and ROS generated during ischemia play important role in both myocardial healing and activation of neuroprotective pathways. However, exaggerated activation of the redox signaling system can cause adverse consequences including cell apoptosis and extracellular matrix degradation (Carbone *et al*., 2019).

Inflammation is the most basic process for tissue regeneration following an injury. It is made up of a series of cellular and microvascular reactions that help to eliminate damaged tissue and regenerate new tissue (Schmid-Schönbein, 2006). Inflammation is increasingly becoming found to be crucial in the onset and progression of atherosclerosis (Hansson *et al*., 2006). Inflammatory cytokines have been linked to the risk and severity of CAD, and a growing body of evidence revealed the presence of different immune cells in atherosclerotic plaques and neutrophils becoming a significant player in the athero-inflammation process (Kurup, 2017). Therefore, assessment of neutrophil enzymes is crucial in understanding the pathophysiology of ACS.

NOX are trans-membrane proteins which are originally detected in neutrophils and in order to reduce oxygen to a superoxide radical, transfer an electron from the NADPH substrate to flavin adenine dinucleotide across biological membranes (Kleniewska *et al*., 2012). It has been shown that NOX activity deregulation contributes to high production of ROS which eventually leads to CVDs (Cave *et al*., 2005). A member of the peroxidase family, myeloperoxidase (MPO), is a crucial component of the innate immune system that is primarily secreted by neutrophils to provide protection against invading pathogens which has emerged as a key player in the initiation and progression of atherosclerotic CVD (Kamanna *et al*., 2013). When neutrophils are activated, lysosomes fuse with phagosome and release MPO, while a NOX complex is formed on the internal membrane surface, generating superoxide anions (O_2•), which quickly dismutate to generate hydrogen peroxide (H_2O_2). The latter reacts with chloride ions to generate hypochlorous acid, which is catalyzed by MPO (Davies and Hawkins, 2020). Systemic levels of MPO are considered a marker of plaque vulnerability and predict prognosis in patients with ACS (Ferrante *et al.*, 2010).

Aerobic organisms have integrated antioxidant systems, which include enzymatic and non-enzymatic antioxidants that are usually effective in blocking harmful effects of ROS (Birben *et al*., 2012). Superoxide dismutase (SOD) is the only antioxidant enzyme that scavenges the O_2• by converting this free radical to oxygen and H_2O_2. SODs are a group of metalloenzymes that work in the front line of defense against ROS-mediated injury (Asmat *et al*., 2016), and can play a preventive role in the development of atherosclerosis. On the other hand, decreased activity of this enzyme could contribute to oxidative stress-induced cellular component damage (Ninić *et al*., 2019). Catalase is considered to be a key component of the first line of enzymatic antioxidant defense which efficiently decomposes H_2O_2 in peroxisomes to produce water and molecular oxygen and protects cells against an excess formation of ROS (Pham-Huy *et al*., 2008).

The pathophysiology of ACS is based on the formation of atherosclerotic plaque as a result of oxidative stress. The general objective of the present study is to determine the effect of oxidative stress in blood circulation and at the cellular level in patients with ACS. The specific objectives include evaluation of the activities of certain oxidase and antioxidant enzymes in circulation and neutrophils and impact of these enzymes on each other following the development of ACS. It is hoped that assessment of these enzymes in neutrophils and blood circulation, and their role on oxidative stress, may provide some insight into the development, and possible treatment of ACS.

MATERIALS AND METHODS

Study subjects and location

This cross-sectional study comprised of 104 individuals of which 52 were patients (experimental group) suffering from acute coronary syndrome (ACS), admitted in the coronary care unit (CCU) of Dhaka Medical College Hospital, and Sir Salimullah Medical College Hospital. The diagnosis of ACS was made by expert physicians through the characteristic electrocardiogram and elevated level of Troponin I. Any patient suffering from diabetes mellitus, impaired renal or liver functions, autoimmune disease, or any other chronic inflammatory disease was excluded from the study. A group of 52 healthy subjects who were employees of the local offices were enrolled as the control group who did not have any prior history of CVD or diabetes mellitus. All experiments described in this study were carried out at the Immunology, Non-communicable Diseases and Environmental Toxicology Laboratory of the Department of Biochemistry and Molecular Biology, University of Dhaka, Bangladesh.

Data and blood sample collection

A questionnaire was prepared to obtain the demographic and baseline characteristics of the participants. About 10 mL of peripheral venous blood was drawn from each subject which was divided equally in a purple-capped tube containing dipotassium EDTA for plasma collection and a screw capped glass tube for serum collection. The plasma and serum were collected in small aliquots and stored at -20°C until analyzed.

Total and differential WBC counts and preparation of neutrophil lysate

The total and differential WBCs were counted from fresh blood samples using the standard procedures, as described elsewhere (Choudhury *et al*., 2019). To separate neutrophils from the blood samples, dextran sedimentation was done followed by centrifugation on Ficoll-Hypaque. Neutrophils formed pellet at the bottom of the tube which was resuspended and washed with normal saline. The cells were counted, centrifuged, and finally 0.5 mL leukocyte lysis buffer (Boston BioProducts) was added to the neutrophil pellet and mixed well. The lysed cells were then centrifuged, supernatant was collected and analyzed immediately.

Assay of oxidase and antioxidant enzymes in serum and neutrophil lysate

The NOX activity was measured by the method of Reusch and Burger (1974), as detailed previously (Ferdausi *et al*., 2020). The SOD activity was measured by following the method established by Marklund and Marklund (1974) as detailed in a recent study (Radeen *et al*., 2021). MPO activity can be measured by a colorimetric assay method (Bradley *et al*., 1982). In brief, a volume of 100 µL of 0.015% H_2O_2 was added to 2.9 mL of 0.167 mg/mL O-dianisidine solution in phosphate buffer. An aliquot of 100 µL of serum/neutrophil lysate was added to start the reaction. The rest of the procedure was described elsewhere (Choudhury *et al.*, 2019). The catalase activity was assayed according to the method described by Góth (1991) with a slight modification, as described previously *(Radeen et al*., 2021). A sample of 50 µL serum/neutrophil lysate was incubated with 0.25 mL of 65 µmol H_2O_2 in 1 mL of 60 mM phosphate buffer at 37°C.

Statistical analyses

Statistical analysis of the data was carried out using GraphPad PRISM (version 8.0.1 for Windows, GraphPad software, California, USA) and Statistical Package for Social Sciences (version 20.0 for Windows, SPSS Inc., USA). The normality assessment of continuous variables was made by descriptive statistical analyses and presented as mean and standard deviation. The discrete data were presented as absolute numbers and percentages. For comparison of the continuous (all wet-lab experimental data) and categorical variables (shown in Table 1) between the ACS patients and control subjects, the independent samples *t*-test and chi-square test were used, respectively. The correlation analyses were done to determine relationship between different parameters within a group. The results were considered significant at $p<0.05$. Graphical presentation was done using GraphPad PRISM and Microsoft Excel (version 2010 for Windows, Microsoft Corporation, USA).

Ethics committee approval

This study was conducted in accordance with the Declaration of Helsinki. The study protocol was reviewed and approved by the Ethical Review Committee of the Faculty of Biological Sciences (Ref. 56 /Biol. Sci./ 2017-2018), University of Dhaka, Bangladesh.

RESULTS

Among the 52 ACS patients, 37 (71%) were diagnosed with STEMI, 14 (27%) with NSTEMI and one subject (2%) was suffering from UA. The age of the patient and control groups varied from 30 to 70 years with a median of 51 years in both groups. The mean Troponin I value of the patients on admission was 13.55 ng/mL. The baseline health characteristics including age, body mass index (BMI), systolic blood pressure (SBP), diastolic blood pressure (DBP), smoking status, hypertension, family history of CVD, and breathlessness have been summarized and compared in Table 1. It was found that the age, SBP, DBP, and BMI were not significantly different between the studied groups. On the other hand, smoking status, family history of CVD, breathlessness, and hypertension appeared to be significant risk factors for the progression of ACS.

The mean ± SD total WBC count in the control group was 7.96 ± 1.74 million cells/mL compared to 9.85 ± 2.59 million cells/mL in the ACS patient group ($p<0.0001$). The differential WBC count showed the percentages of neutrophils varied widely, from 50.0 to 90.1% in the patient group. There were significantly higher neutrophil, basophil, and monocyte counts in the patient group than in the controls, while significantly lower lymphocyte counts were found in ACS patients but the eosinophil counts did not differ significantly between the two groups as shown in Table 1.

Correlation analysis was done between the total WBC count and the duration of chest pain (DCP) from onset to

Table 1. Comparison of demographic, baseline, WBC data and risk factors of the studied subjects.

Variables	ACS patients (n=52)	Control subjects (n=52)	p-value
Demographic and baseline characteristics			
Male Gender, n (%)	38 (73.1)	42 (80.77)	0.35*
Age (years)	51.78 ± 11.33	47.29 ± 10.96	0.07**
BMI (kg/m^2)	24.00 ± 3.16	25.65 ± 3.14	0.08**
SBP (mmHg)	128.06 ± 13.69	120.00 ± 16.14	0.06**
DBP (mmHg)	82.95 ± 11.47	79.42 ± 9.17	0.29**
White blood cells (WBC) count			
Total WBC (10^6 cells/mL)	9.85 ± 2.59	7.96 ± 1.74	<0.0001**
Neutrophil (%)	67.16 ± 9.85	59.12 ± 7.07	<0.001**
Lymphocyte (%)	28.47 ± 9.11	37.41 ± 7.03	<0.001**
Monocyte (%)	2.92 ± 1.30	2.25 ± 0.94	<0.01**
Eosinophil (%)	0.98 ± 1.24	0.98 ± 0.85	0.999**
Basophil (%)	0.49 ± 0.55	0.16 ±.23	<0.001**
Additional risk factors			
Current smokers/ Ex-smokers/ Non-smoker (%)	47.0/19.6/33.4	23.9/10.9/65.2	< 0.001*
Hypertension, n (%)	20 (38.46)	5 (9.62)	< 0.001*
Breathlessness, n (%)	17 (32.69)	3 (5.77)	< 0.001*
Family history of CVD, n (%)	11 (21.15)	4 (7.8)	< 0.05*

WBC: White blood cells; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; BMI: Body mass index; *: chi-square test; **: *t*-test.

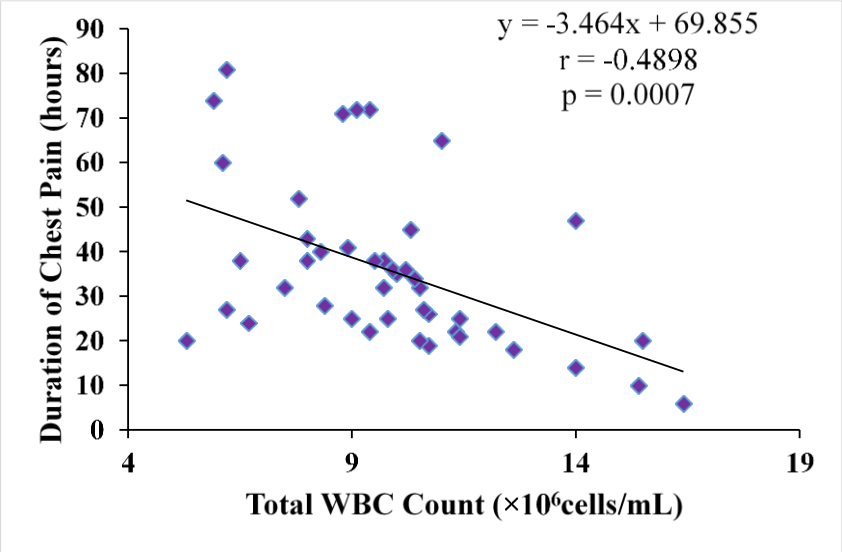

Figure 1. A significant negative correlation was found between the total white blood cell (WBC) count and duration of chest pain with an r value of -0.49 (p<0.001). Data were analyzed by the Pearson's correlation test.

hospitalization of the ACS patients. A significant (p<0.001) negative correlation was found between the total WBC count and the DCP with a Pearson correlation coefficient, r = -0.49. This finding revealed that the number of total WBCs were higher when the blood samples were collected immediately after the onset of chest pain. The scatter plot has been shown in Figure 1.

The mean NOX activity in serum of the control subjects was 4.88 ± 3.03 U/L and the values were within the range of 1.08 to 12.3 U/L. On the other hand, the mean serum NOX activity in the ACS patients was 12.83 ± 6.6 U/L and the values fell within the range of 2.5 to 25.1 U/L. The serum NOX activity in ACS patients was significantly higher than in control subjects (p<0.0001, Figure 2). Similarly, the mean NOX activity in neutrophil lysate of control subjects (n=25) was 316.9 ± 86.89 × 10^{-3} mU/million cells and that in the ACS patients (n=25) was 638.4 ± 266.3 ×10^{-3} mU/million cells (p<0.001, Figure 2).

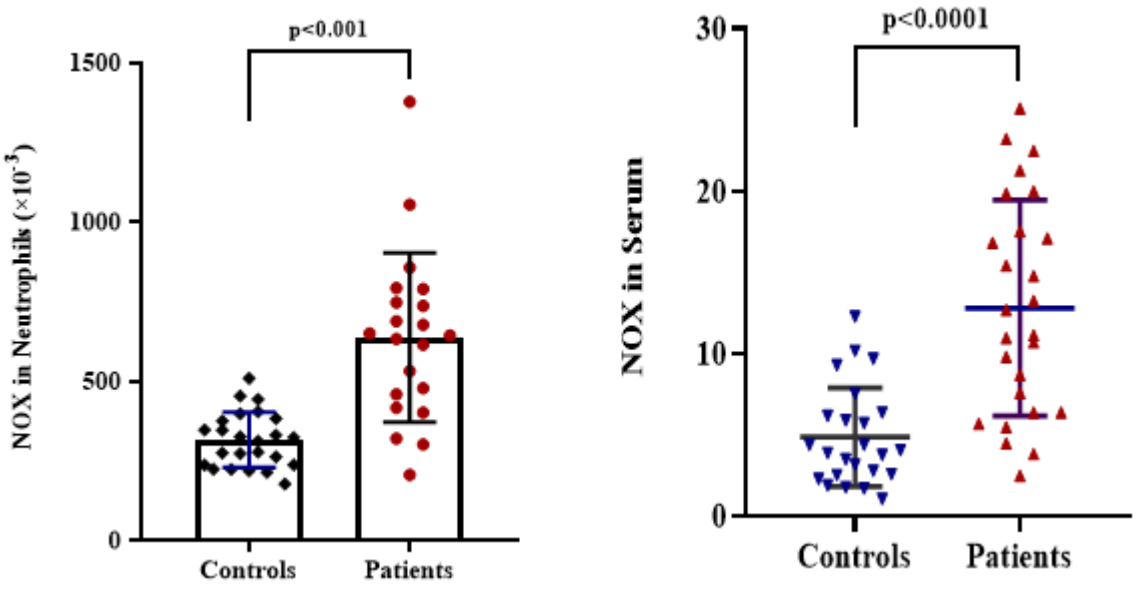

Figure 2. Comparison of NADPH oxidase (NOX) activity in neutrophil lysate (mU/million cells), and serum (U/L) in ACS patients and control subjects. Data were analyzed by the independent samples *t*-test.

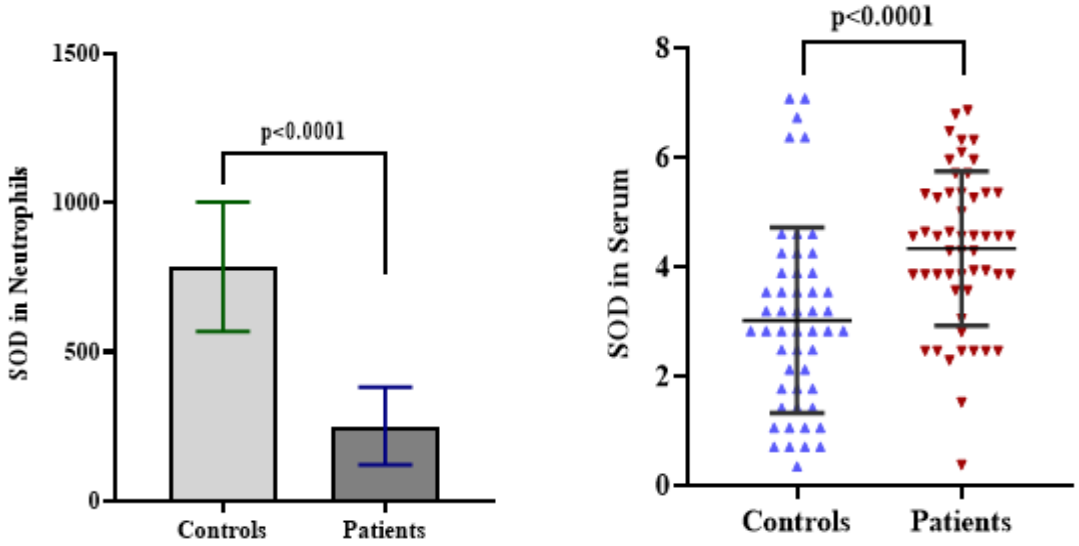

Figure 3. Comparison of superoxide dismutase (SOD) activity in neutrophil lysate (mU/million cells), and serum (U/mL) in ACS patients and control subjects. Data were analyzed by the independent samples *t*-test.

The mean SOD activity in neutrophils of the control subjects was 784.8 ± 216.8 mU per million cells and the corresponding value in patients was 251.1 ± 130.1 mU per million cells, which was significantly lower ($p<0.0001$, Figure 3). In contrast, the mean SOD activity in serum of the patient group was 4.34 ± 1.41 U/mL, which was significantly higher ($p<0.0001$) than in the control group, 3.02 ± 1.7 U/mL (Figure 3).

The mean catalase activity in neutrophils of the patient group was 31.59 ± 16.52 U per million cells and the values ranged between 13.25 and 87.92 U per million cells. The mean catalase activity in neutrophils of the control group was 11.68 ± 4.53 U per million cells with the values varying from 4.42 to 22.5 U per million cells. Statistical analysis revealed that ACS patients had significantly higher neutrophil catalase activity than the control subjects ($p<0.0001$, Figure 4). On the other hand, the mean serum catalase activity of the control group was 63.98 ± 31.86 U/mL and that of the patient group was 33.36 ± 13.16 U/mL, which was significantly lower ($p<0.0001$).

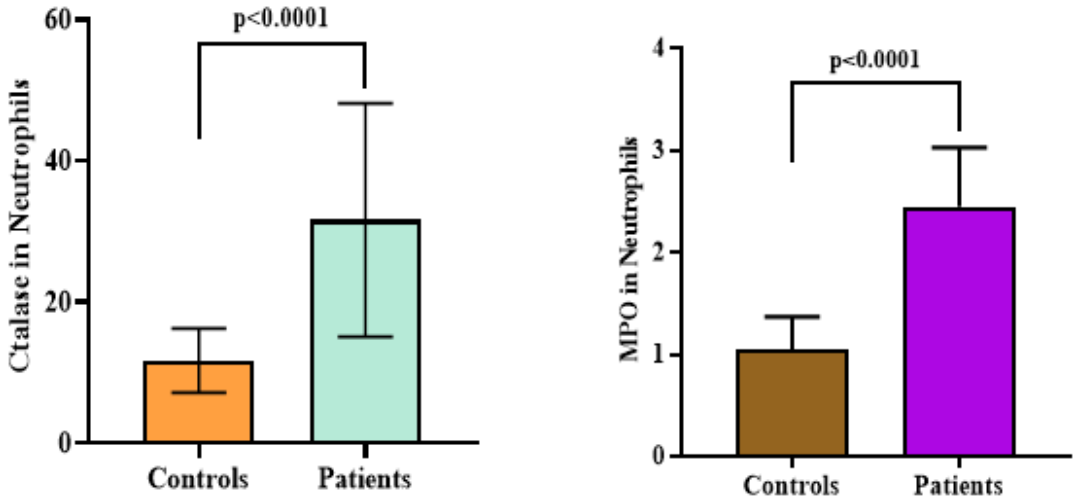

Figure 4: Comparison of catalase activity (U/million cells), and myeloperoxidase (MPO) activity (mU/million cells) in neutrophil lysate in ACS patients and control subjects. Data were analyzed by the independent samples *t*-test.

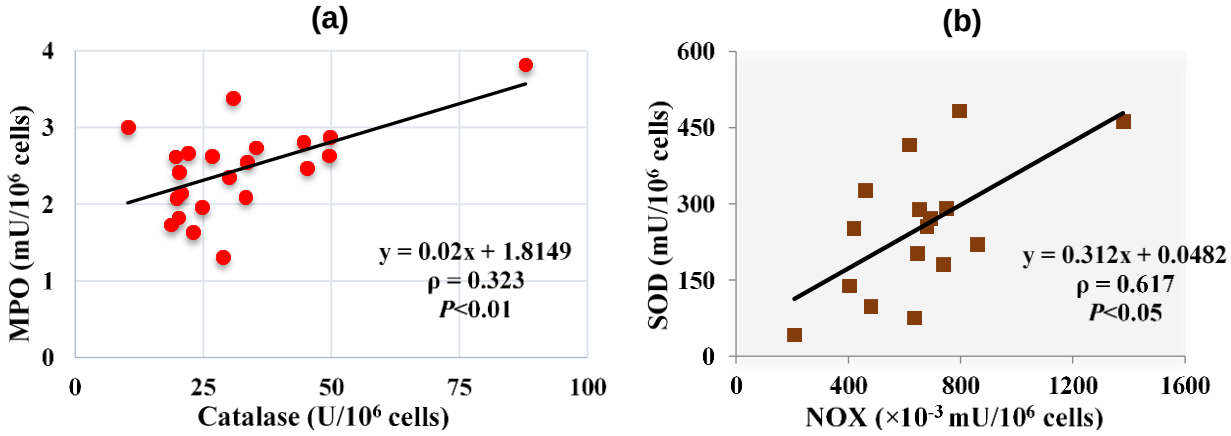

Figure 5. Significant positive correlations between (a) catalase and MPO activities, (b) SOD and NOX activities in neutrophil lysate of ACS patients. Data were analyzed by the Spearman's correlation test.

The mean MPO activity in neutrophils of the control subjects was 1.04 ± 0.33 mU/million cells, with the values ranging from 0.55 to 2.04 mU/million cells, and the mean activity in neutrophils of ACS patients was 2.45± 0.58 mU/million cells which ranged from 1.31 to 3.82 mU/million cells. A statistical analysis revealed that the MPO activity in neutrophils of the patient group was significantly higher ($p<0.0001$) compared to the controls (Figure 4). Similarly, the mean serum MPO activity in ACS patient group was higher compared to the control group (42.52 ± 13.56 U/L vs. 39.69 ± 6.48 U/L).

Further analyses of the data revealed the activity of MPO and catalase in neutrophils of ACS patients to have a significant ($p<0.01$) positive correlation with the Spearman coefficient rho, ρ, value of 0.323, (Figure 5a). A significant positive correlation ($p<0.05$) was also found between NOX and SOD activities in neutrophils of ACS patients with a Spearman correlation coefficient rho, ρ = 0.617 (Figure 5b), and in control subjects with a Spearman correlation coefficient rho, ρ = 0.488, which was also significant ($p<0.05$).

DISCUSSION

In this study, the activities of several oxidase and antioxidant enzymes were investigated in neutrophil lysate and serum of patients with ACS and the values were compared to those in non-ACS control subjects. In order to avoid false positive results, individuals with diabetes

mellitus, liver or kidney diseases or any other inflammatory conditions that are known to cause oxidative stress have been excluded from this study. Although the mean ± SD age of the ACS patients was slightly higher in this study but not significantly different from the control subjects. This study found tobacco smoking, family history of CVD, and hypertension to be significant risk factors for the development of ACS, as observed previously (Kamruzzaman *et al*., 2019).

In the literature, ROS have been described as key signaling molecules that play important roles in the progression of inflammatory disorders. An enhanced generation of ROS at the site of inflammation by neutrophils causes endothelial dysfunction and tissue injury (Mittal *et al*., 2014). Likewise, oxidative stress causes superoxide anion production in neutrophils which also results in decreased intracellular activity of several antioxidants and increased activity of NOX in neutrophils (Kratnov and Timganova, 2015). In the present study, the activities of NOX in both serum and neutrophil lysate were found to be significantly higher than those in control subjects. Therefore, increased activity of NOX could be associated with the underlying pathogenesis of ACS. These findings support that assessment of NOX in patients with CVD including ACS may be considered a novel parameter for early diagnosis of atherosclerotic complication and to develop a novel anti-atherosclerotic strategy, as suggested previously (Violi and Pignatelli, 2015).

The present study found a significantly lower activity of SOD, the only antioxidant enzyme that removes superoxide anion produced in the body, in neutrophils of the patients compared to the controls. However, serum SOD activity in ACS patients was found to be significantly higher which was consistent with a recent study (Radeen *et al*., 2021). In addition, a previous study found significantly higher activity of SOD in patients with acute myocardial infarction and unstable angina, which had been suggested due to upregulation of the extracellular SOD gene in the vascular wall to compensate for the elevated ROS produced in these patients (Horiuchi *et al*., 2004).

As observed previously by Choudhury *et al*. (2019), this study found significantly higher total WBC and neutrophil counts in the circulation of ACS patients. Therefore, combined use of the total and differential WBC counts could have a greater predictive ability of ACS events. One of the critical findings of the current study is extreme elevation of the total WBC count in which neutrophils is the major contributor whose percentage can rise as high as 90% at the early onset of chest pain of the patients. A significant negative correlation between the total WBC count and the duration of chest pain further indicates the role of neutrophils as inflammatory cells in atherosclerotic plaque erosion which may cause chest pain of the patients due to lack of oxygen and nutrient supply in the damaged cardiac tissues. However, the WBC count returned to normal levels as the chest pain subsided with time.

In the literature, Voetman and Roos (1980) reports that endogenous catalase protects human neutrophils against oxidative damage by extracellularly generated hydrogen peroxide. The current study found significantly higher catalase activity in neutrophils of ACS patients compared to controls. In ACS, neutrophils continuously undergo high oxidative stress (Kurup, 2017). Neutrophil catalase helps to prevent this endogenous oxidative damage to cope with the situation. Inflammatory neutrophils also participate in plaque rupture by releasing matrix metalloproteinase, elastase and gelatinase (Bonaventura and Montecucco, 2019). Therefore, it can be hypothesized that the catalase activity in neutrophils may increase in ACS patients to control inflammation by maintaining a lower intracellular H_2O_2 level so that the neutrophils can be in an anti-inflammatory state.

In contrast to neutrophil lysate, the catalase activity in serum of ACS patients was significantly lower. This finding corroborated previous reports in patients with ACS (Radeen *et al*., 2021) and CAD (Serdar *et al*., 2006). It has been hypothesized that lower catalase activity in ACS patients could not compensate the elevated ROS production which resulted in atherosclerotic oxidative stress (Lubrano and Balzan, 2015). An interesting result of the current study has been higher MPO activity in both serum and neutrophils of ACS patients. This finding was in agreement with another study conducted in neutrophils under oxidative stress situation in obese people (Kratnov and Timganova, 2015). However, a previous study observed that MPO played a role in the development, propagation, and consequences of atherosclerotic plaques by participating in inflammation, LDL oxidation, and nitric oxide consumption, all of which led to endothelial dysfunction (Zhang *et al*., 2001).

An important finding of the present study has been a significant positive correlation between neutrophil catalase and MPO activity in ACS patients which suggested that as the MPO activity increased, the catalase activity also increased to decompose the newly generated H_2O_2 in order to control inflammation and oxidative damage. In addition, similar significant positive correlations were also found between the activities of NADPH oxidase and the antioxidant enzyme SOD in neutrophils of both ACS patients and control subjects. It has been suggested that ROS is produced in the lumen of a vesicular compartment by intracellular NOX complexes, and SOD has a key mechanism for precise spatial control of ROS homeostasis and maintenance (Wang *et al*., 2018). As a result, NOX produces more ROS, and SOD becomes more active in the detoxification process.

Finally, the findings of this study imply that the antioxidant enzymes SOD and catalase show tremendous potentials to be used in controlling ROS production by MPO and NOX. Therefore, further studies are needed on therapeutic applications of antioxidant enzymes for cardioprotection and treatment of CVD, as suggested by Maksimenko and Vavaev (2012).

Limitations of the study

This study has some limitations including going through strict health guidelines during COVID-19 pandemic in collecting blood samples, and also for the study not being funded. First of all, the sample size was small and probably insufficient to illustrate the complete picture of a population. Secondly, the number of samples used for assays from neutrophil lysate was smaller. In this study, neutrophils were isolated from freshly collected blood samples to perform the tests, therefore it was not possible to enroll a huge number of participants in a single day. Lastly, for these analyses fully age-matched control subjects could not be collected which could have some impact on the results, although the age of the experimental and control groups did not vary significantly. Despite these limitations, the findings of this study would help understand the inflammatory basis and possible treatment of ACS in future studies with larger sample size.

Conclusion

The relationship between the generation of ROS by oxidase enzymes and their neutralization by antioxidant enzymes in patients with acute coronary syndrome is highlighted in this study. NADPH oxidase and myeloperoxidase assays from neutrophil lysate unveiled a new aspect to find the status of redox balance of neutrophils in the studied subjects. A significantly lower serum catalase activity suggested a weaker antioxidant status in ACS patients, whereas the impelled mechanism to resolve oxidative stress by antioxidant forces was indicated by significantly higher SOD activity in the circulation. In conclusion, the concept of the imbalance produced between oxidants and antioxidants resulted in enhanced oxidative condition was supported by statistical correlations and this oxidative stress progresses to ACS.

Recommendations

Assessment of NOX in patients with CVD including ACS may be considered a novel parameter for early diagnosis of atherosclerotic complication. As a measure to control inflammation, the catalase activity in neutrophils of ACS patients increase to maintain a lower intracellular H_2O_2 level to control oxidative damage of neutrophils, cellular organelles and tissues; therefore, regular monitoring of the neutrophil catalase activity may be recommended.

CONFLICT OF INTEREST

The authors declare no conflicts of interest in publishing this article.

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