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Evaluation of oxidative stress Parameters among Cataracts Patients in Khartoum state

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ABSTRACT

Background: Epidemiological studies have consistently shown that oxidative stress plays a pivotal role in the pathogenesis of various types of diseases includingCataracts, a common eye condition characterized by the clouding of the lens, leading to decreased vision.

Objective: The aim of the present study is to compare the plasma levels of Total Antioxidant Capacity (TAC), Malondialdehyde (MDA), Catalase (CAT), Superoxide Dismutase (SOD), Glutathione peroxidase (GPx),and Glutathione reductase (GRx) activities in Cataracts patients and controls in Khartoum state.

Materials and Methods: This study was carried out in hospitals across Khartoum state, from January to April 2023. The study included a total of 100 participants, categorized into 50 Cataracts patients as the case group and 50 healthy subjects as the control group. Data was collected through structured questionnaires and blood sample analyzed. Plasma antioxidant parameters were measured using atomic absorption spectrophotometry methods. Data analysis were performed using SPSS version 27.

Results: The levels of plasma MDA, CAT, and SOD enzymes were found to be significantly increased in the case group compared to controls.However, the TAC, GPx, and GRx enzyme levels did not show significant differences between cases and controls. There was no correlation found between the study parameters and the age and duration of disease in patients.

Conclusion: Cataracts could be linked to elevated levels of MDA, an indicator of oxidative stress. Additionally, in patients with Cataracts, the enzymes CAT and SOD might increase as a compensatory response to oxidative stress.

Key words: Catalase, Superoxide dismutase, Malnodialdyde, Cataracts, Antioxidants.

I. INTRODUCTION:

Oxidative stress is recognized for its role in contributing to a wide array of pathologic conditions[1]. This condition occurs due to an imbalance between the production of reactive oxygen species (ROS) and the body's capacity to neutralize their detrimental effects with antioxidants. Reactive oxygen species, while essential in small quantities for processes like cell signaling and fighting pathogens, become harmful when their levels exceed the body's antioxidant defense capabilities[2]. This imbalance leads to oxidative stress, which can damage cells, proteins, and DNA, playing key roles in aging as well as the onset of various diseases, such as cataracts[3].

The relationship between oxidative stress and disease underscores the importance of maintaining a balance between ROS and antioxidants. The body's endogenous antioxidant defenses include enzymes such as superoxide dismutase (SOD), Catalase, and glutathione peroxidase, which detoxify ROS. Additionally, the consumption of exogenous antioxidants through a diet rich in fruits, vegetables, and other sources of antioxidants can help counteract the harmful effects of oxidative stress[2, 4]. Studies persist in investigating the impact of oxidative stress on diseases. and the benefits of antioxidant defense in management of many pathologic scenarios.

Cataracts, the leading cause of blindness in middle-income and low-income countries[5], develop when protein in the lens builds up, preventing light from passing clearly through the lens, causing some loss of vision[6]. It is often related to aging but can also result from genetic factors, other diseases, or injuries.The relationship between oxidative stress and Cataracts was studied in previous works and reflects a critical area of research within ophthalmology and biochemistry concerning the development of Cataracts, which is considered as the primary cause of blindness around the globe[5-7]. Cataracts are characterized by the clouding of the eye's natural lens, leading to a decline in vision. This condition primarily affects the elderly, but certain risk factors, including diabetes, smoking, and prolonged exposure to UV light, can prompt its earlier onset[8].

Previous research has found that the lens is particularly susceptible to oxidative stress due to its high concentration of proteins and its exposure to light, which can generate ROS[9]. Moreover, the lens's antioxidant defense mechanisms, which include enzymes like superoxide dismutase, Catalase, and glutathione peroxidase, as well as non-enzymatic antioxidants such as vitamin C, vitamin E, and glutathione, may become overwhelmed or less efficient with age or under pathological conditions, leading to an accumulation of oxidative damage[10].

Notably, studies have demonstrated that oxidative damage occur in the proteins of the lens, especially crystallins, is a critical factor in Cataracts formation[11]. These proteins play a vital role in maintaining lens transparency and refractive ability. Their modification or aggregation under oxidative stress conditions contributes to the cloudiness characteristic of Cataracts.

In summary, the relationship between oxidative stress and Cataracts is well-established in scientific literature, highlighting the importance of maintaining a balance of oxidative and antioxidative forces within the lens to protect against Cataractogenesis. Further research in this area may pave the way for novel preventative strategies or treatments that could help mitigate the risk or progression of Cataracts through the modulation of oxidative stress or enhancement of the lens's antioxidant capacity.The current study aims to evaluate individual antioxidant enzymes and the overall antioxidant defense in patients with Cataracts compared to normal subjects. Furthermore, it extends the investigation to assess Malondialdehyde (MDA) as an indicator of lipid peroxidation in those suffering from Cataracts.

II. MATERIALS AND METHODS:

The present study is a quantitative method to evaluate Total AntioxidantsCapacity (TAC), Malondialdehyde (MDA), and the enzyme activities of Catalase (CAT), Glutathione Peroxidase (GPx), Glutathione Reductase (GRx), and Superoxide dismutase (SOD) in patients with Cataracts and control subjects.

This analytical, case-control, hospital-based study was conducted in Khartoum state hospitals, from January to April 2023. The study included 100 participants, divided into 50 Cataracts patients as the case group and 50 healthy individuals as the control group. Both age and sex were closely matched between the groups; the average age of the case group was 57.5 ± 10.1 years, whereas it was 54.6 ± 9.8 years in the control group. The length of disease duration among patients varied from 12 to 28 years, average duration was 12.4 ± 7.2 years. In cases, 33% were males while 17% were females,on the other hand in control group, 23% were males while 27% were females.

Inclusion and exclusion criteria: Cataracts patients and healthy volunteersfrom both genders were included. Patients with previous cancer diagnosis, history of cardiovascular disease and/or diabetes. Smokers, alcoholism, chronic kidney, and liver disease were excluded, since these factors are known to alter oxidative stress.

Data Collection and blood sampling: Data were gathered through structured questionnaires, and 5 ml of venous blood was drawn using standard procedures of venipuncture, following the cleansing of the vein puncture site with 70% ethanol. The samples, collected in heparin containers, were then separated by centrifugation at 3000 rpm for 5 minutes, with the plasma being stored until analysis. The analysis of the study parameters were done using Atomic Absorption Spectroscopy.

Ethical Considerations: the study was approved by ethical committee of National University and hospital – Khartoum - Sudan, informed consents were obtained from all participants in the study.

Data analysis: The study's results were presented as the mean ± standard deviation (SD). Following the tabulation of results and the execution of t-tests to compare means between cases and controls, P-values<0.05 were considered statistically significant. Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) version 27.

III. RESULTS:

In the present study, 33% of the individuals in the cases group were male, while 17% were female. Conversely, 23% were male and 27% were female in the control group, as illustrated in Figure 1.

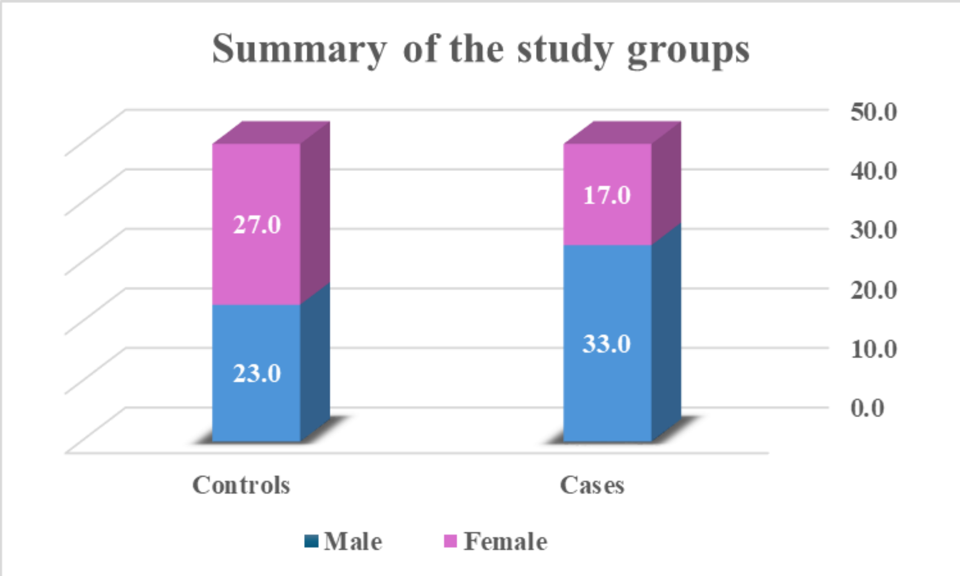

Figure 1: Frequency distribution of gender among study groups

There was asignificantly higher levels of plasma Malnodialdyde (MDA) in Cataractscases compared to controls where it was found to be 1.80 ± 0.36, and 0.95 ± 0.31µMin the two groups respectively ($p<0.001$) as shown in figure 2 and table 1.

Table 1: Plasma anti-oxidants parameters among study population

Variables	Cases group N=50	Controls group N=50	P value
Age	57.5 ± 10.1	54.6 ± 9.8	NS
Total Antioxidant Capacity (TAC) (mmol/L)	1.12 ± 0.31	1.09 ± 0.32	0.65
Malnodialdyde (MDA) (µM)	1.80 ± 0.36	0.95 ± 0.31	< 0.001
Catalase (CAT) U/L	970.6 ± 162.8	916.8 ± 102.9	< 0.05
Glutathione reductase U/L	57.1 ± 11.3	59.9 ± 9.9	0.18
Superoxide dismutase (SOD) (U/ml)	178.3 ±24.7	159.8 ± 24.9	< 0.001
Glutathione Peroxidase (GPx) (U/ml)	6.5 ± 0.26	2.8 ± 0.60	0.35

Results are expressed as mean ± SD

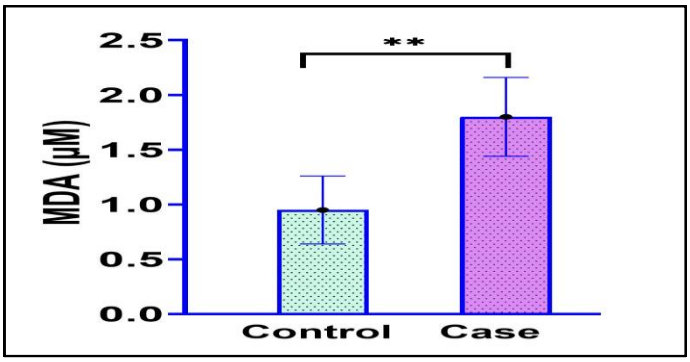

Figure 2: Malondialdehyde (MDA) in the study groups (= p<0.001).**

Although statistically not significant, increased levels of Total Antioxidant Capacity (TAC) were observed in cases of Cataracts1.12 ± 0.31 compared to controls1.09 ± 0.32as shown in figure 3.

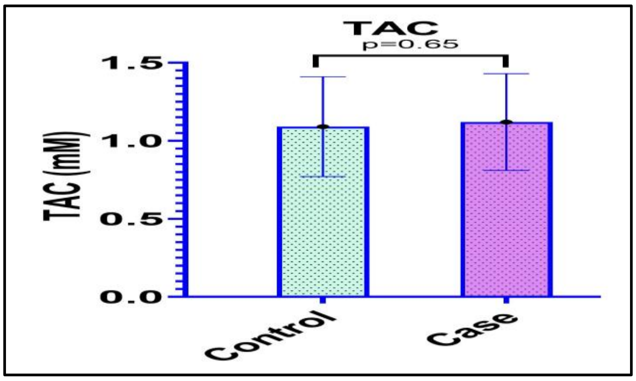

Figure 3: Total Antioxidant Capacity in the study groups.

Antioxidant enzyme Catalase demonstrated a notable increase in subjects with Cataracts compared to controls, where it was 970.6 ± 162.8 and 916.8 ± 102.9 U/L in the two groups respectively ($p<0.05$) as shown in figure 4. Similarly, the levels of Superoxide dismutase was found to be 178.3 ±24.7 U/L in cases of Cataracts compared to 159.8 ± 24.9 U/L in controls ($p<0.001$) as shown in figure 5.

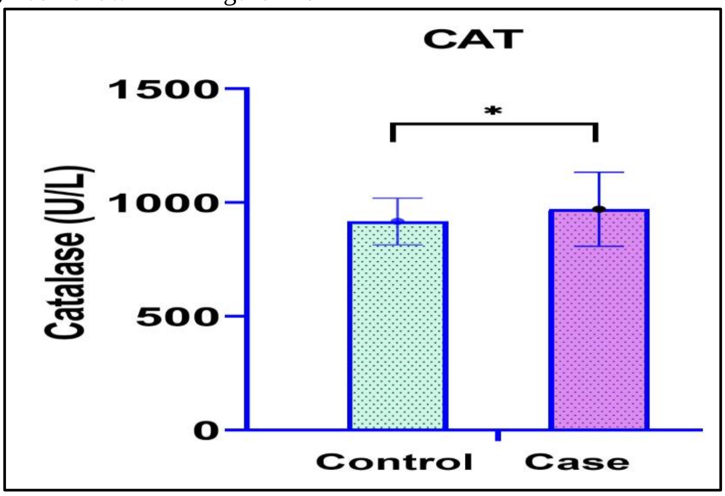

Figure 4: Levels of Catalase in the study groups (* = p<0.05).

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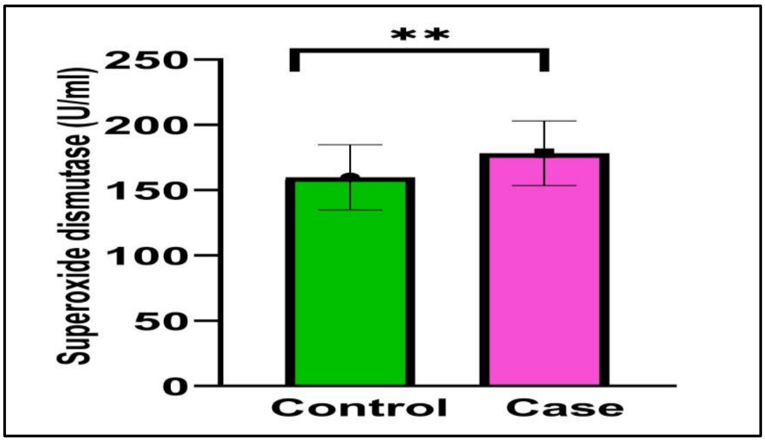

Figure 5: Levels of Superoxide dismutase in the study groups (= p<0.001).**

IV. DISCUSSION:

Recently, the investigation of oxidative stress parameters across various pathological scenarios has garnered increasing interest[1]. In the present study, the increased levels of Malondialdehyde (MDA) in cases of Cataracts suggest that lipid peroxidation may be associated with the disease, (figure 1). This finding is consistent with the findings of Elsa and colleagues, who reported that abnormal redox status plays a significant role in the pathophysiology of several ocular diseases affecting both the anterior and posterior segments of the eye[7].Malondialdehyde (MDA) serves as an indicator of oxidative stress and lipid peroxidation, which involves the detrimental interaction of free radicals with lipids present in cell membranes, ultimately resulting in cellular damage. Lower levels of MDA in patients with Cataracts might initially seem counterintuitive since oxidative stress is associated with the formation of Cataracts. However, the findings in the present study could imply that there is an adaptive response in individuals with Cataracts to minimize lipid peroxidation, or alternatively, it might reflect differences in the metabolism or clearance of MDA among individuals with Cataracts.This becomes evident through the observed increase in antioxidant enzymes such as Catalase and Superoxide dismutase, as demonstrated in this study, (figures 4-5).

Both Catalase and superoxide dismutase are antioxidant enzymes that play critical roles in protecting cells from oxidative damage[12]. Catalase converts hydrogen peroxide, a potentially harmful oxidizing agent, into water and oxygen[13], thereby reducing oxidative stress. Superoxide dismutase catalyzes the process of dismutation of superoxide free radicals into oxygen and hydrogen peroxide, which is then further reduced by Catalase[14]. Higher levels of these enzymes in patients with Cataracts suggest a heightened response to oxidative stress, possibly as a protective or reactive mechanism to counteract the damage.

The Total Antioxidant Capacity (TAC), is an important marker against lipid peroxidation [15, 16],the findings of this study indicate that there is no significant difference observed between TAC levels in the two groups. However, increased levels were observed in Cataracts cases compared to controls, (figure 2). This finding could support the notion of a compensatory mechanism against oxidative stress in patients with Cataracts.In prior research, Ashok and his team found that a disparity between oxidants and antioxidants can cause lipid peroxidation within the lens. Additionally, increased glucose levels in diabetic cataracts contribute to the auto-oxidation of glucose and a glycation in the proteins of the lens which is non-enzymatic. Consequently, The aggregation of proteins with high molecular weight is the outcome of this particular process in the cataract[17].

These findings suggest a complex interplay between oxidants/antioxidant defense system in the development and progression of Cataracts. The increased activity of antioxidant enzymes could be a compensatory response to oxidative stress in the lens, attempting to mitigate damage. Nevertheless, even with the observed rise in antioxidant activity, it is important to recognize that oxidative stress could potentially have an influence on the formation and advancement of Cataracts, indicating that the balance between oxidative damage and antioxidant defense mechanisms is crucial. Further research could delve into whether enhancing the antioxidant defense

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system in individuals could slow the progression or reduce the risk of Cataracts.

V. CONCLUSION:

The findings of this study investigate the biochemical changes associated with Cataracts, a prevalent eye condition, defined by the lens's clouding which results in diminished vision. The study highlights the relationship between oxidative stress markers and the presence of Cataracts.Elevated Malondialdehyde (MDA), Superoxide dismutase (SOD), and Catalase (CAT)levels were observed in patients with Cataracts compared to controls. These finding may suggest an association between Cataracts and oxidative stress.

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