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Original Research Article

ANALYSIS OF OXIDATIVE STRESS MARKERS AND ELECTROLYTE IMBALANCE IN PATIENTS WITH DIABETIC CATARACT

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Abstract

Background: Diabetic cataract is a major complication of diabetes, potentially linked to oxidative stress and electrolyte imbalances. This study aimed to investigate the role of plasma Superoxide Dismutase (SOD) and serum sodium (Na+) levels in diabetic cataract patients. **Material & Methods:** This observational study, approved by the Institutional Ethics Committee, was conducted at Gandhi Hospital and Sarojini Devi Eye Hospital over 18 months (March 2015 - October 2016). It included 100 participants, divided into 25 diabetic cataract patients (cases) and 75 healthy controls. Inclusion criteria were cataract patients aged 35-65 years with a known history of diabetes mellitus. Exclusion criteria included hypertension, history of eye trauma or surgery, and high urea or creatinine levels. Blood samples were analyzed for plasma SOD, serum Na+, glucose, creatinine, and urea using standard biochemical methods. **Results:** The study found significantly decreased plasma SOD levels in diabetic cataract patients (Mean ± SD: 156.04 ± 18.29 U/ml) compared to controls (Mean ± SD: 183.33 ± 17.58 U/ml, $p<0.01$). Serum Na+ levels were significantly higher in cataract patients (Mean ± SD: 144.5 ± 5.6 mEq/l) than controls (Mean ± SD: 141.4 ± 5.0 mEq/l, $p<0.05$). Blood glucose levels were also significantly higher in cases, while serum creatinine and blood urea showed no significant differences. **Conclusion:** The study demonstrates a significant association between decreased plasma SOD levels and elevated serum Na+ levels with diabetic cataract, suggesting a potential role of oxidative stress and electrolyte imbalance in its pathogenesis. These findings could contribute to better understanding and management of diabetic cataract.

INTRODUCTION

Cataract and Diabetes Mellitus: Cataract, characterized by the clouding of the eye's lens, remains a leading cause of blindness globally. In the diabetic population, cataract develops at an earlier age and progresses more rapidly than in the non-diabetic population.[1,2] This subtype, known as diabetic cataract, is a notable manifestation of chronic diabetes mellitus, underscoring the intricate relationship between systemic metabolic conditions and ocular health.[3,4]

Oxidative Stress in Diabetes: Oxidative stress, marked by excessive production of reactive oxygen species (ROS) and a concurrent decline in antioxidant defense, is a fundamental feature of diabetes.[5] The pathophysiology of diabetes involves hyperglycemia-induced generation of free radicals, which in turn leads to various microvascular and macrovascular complications. In the context of ocular health, oxidative stress damages the delicate lens fibers, accelerating the process of cataractogenesis.[6,7] Superoxide Dismutase (SOD), an enzyme that scavenges superoxide radicals, emerges as a critical defensive biomarker in this oxidative milieu. The plasma levels of SOD are reflective not only of the body's antioxidant capacity but also of the severity and progression of diabetic complications, including cataract.[8]

Electrolyte Imbalance and Lens Opacity: Electrolyte imbalance, especially alterations in sodium (Na+) levels, has a direct impact on the homeostasis of the ocular lens. In diabetes, fluctuating serum Na+ levels can disrupt the osmotic equilibrium, leading to changes in lens hydration and transparency. Elevated Na+ levels may cause osmotic stress and consequent opacification of the lens fibers, contributing to the development of cataract.[9,10]

Study Rationale: This study focuses on plasma SOD and serum Na+ levels in diabetic cataract patients to elucidate their roles in the onset and progression of this condition. Given the established links between oxidative stress, electrolyte imbalance, and diabetic complications, these markers are hypothesized to provide valuable insights into the specific pathophysiological processes at play in diabetic cataract.

This study aims to investigate the relationship between oxidative stress markers and electrolyte imbalance in the pathogenesis of diabetic cataract. It focuses on analyzing the levels of plasma Superoxide Dismutase (SOD) and serum sodium (Na+) in patients with diabetic cataract in comparison to healthy controls.

Objectives

To measure and compare the plasma levels of SOD in diabetic cataract patients and healthy controls, thereby evaluating the extent of oxidative stress in these groups.

To assess and contrast serum Na+ levels in both groups to understand the role of electrolyte imbalance in diabetic cataract.

To explore the potential correlation between oxidative stress and electrolyte imbalance with the development and progression of diabetic cataract.

MATERIALS AND METHODS

Study Design and Setting

This observational, cross-sectional study was carried out at two major healthcare facilities: Gandhi General Hospital, Secunderabad, and Sarojini Devi Eye Hospital, Hyderabad. Spanning from March 2015 to October 2016, this research received ethical clearance from the Institutional Ethics Committee of Gandhi Hospital, Secunderabad, ensuring adherence to ethical standards in medical research.

Participants

The study cohort consisted of 100 individuals, divided into two groups: 25 diabetic cataract patients (cases) and 75 healthy controls. The inclusion criteria were:

Diagnosed cataract patients aged between 35-65 years.

A confirmed history of diabetes mellitus.

The exclusion criteria were designed to eliminate potential confounding variables:

Age below 35 or above 65 years.

A history of hypertension.

Previous trauma or infections affecting the eye.

Past ocular surgeries.

Elevated urea and creatinine levels (greater than 1.3).

Sample Collection and Analysis

Blood samples were meticulously collected from all participants under standardized conditions. The collection procedure involved the following steps:

Venipuncture performed by trained medical professionals using aseptic techniques.

Immediate labelling and processing of blood samples to ensure integrity.

Centrifugation to separate serum and plasma, followed by proper storage at 2-8°C until analysis.

The analysis of collected samples involved several biochemical assays conducted at the clinical chemistry laboratory of Gandhi Hospital:

Superoxide Dismutase (SOD): Assessed using the Xanthine Oxidase method, this test quantifies SOD activity, an indicator of oxidative stress.

Serum Na+ levels: Measured using the Ion exchange electrode method to evaluate electrolyte balance.

Blood Glucose: Determined via the Glucose Oxidase-Peroxidase (GOD-POD) method, crucial for confirming the diabetic status of patients.

Serum Creatinine: Analyzed using the Creatinase method, providing insights into kidney function.

Blood Urea: Assessed by the Urease method, complementing the evaluation of renal health.

Statistical Analysis

Data obtained from these assays were subjected to rigorous statistical analysis. This included: Descriptive statistics (mean, standard deviation) for continuous variables like SOD levels and serum Na+. Inferential statistics to compare means between cases and controls, using t-tests or ANOVA as appropriate. Correlation analysis to explore relationships between oxidative stress markers, electrolyte levels, and diabetic cataract severity. $p<0.05$ considered as statistically significant

Ethical Considerations

The study was approved by Institutional Ethics Committee, Gandhi Medical College, Secunderabad, Telangana. In line with ethical guidelines, informed consent was obtained from all participants. The study ensured confidentiality and anonymity of patient data, and participants were informed about their right to withdraw from the study at any point without any consequences to their medical care.

RESULTS

Demographic Distribution and Age Comparison

The study enrolled 100 subjects, including 25 diabetic cataract cases and 75 controls. The demographic distribution across different age groups

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was as follows: in the age group of 35-45 years, there were 4 cases (16%) and 20 controls (27%), totaling 24 participants. In the 46-55 years category, 11 cases (44%) and 32 controls (42%) were recorded, making up 43 participants. The 56-65 years age group comprised 10 cases (40%) and 23 controls (31%), totaling 33 individuals. The mean age ± standard deviation (SD) for the cases was 52.12 ± 7.80 years, and for the controls, it was 50.65 ± 7.79 years. The comparison of mean ages between cases and controls was not statistically significant ($p > 0.05$) (Table 1).

Plasma SOD (Superoxide Dismutase) Levels and Comparison

Regarding Plasma Superoxide Dismutase (SOD) levels, 20% of the cases had normal SOD levels, compared to 88% of controls. Conversely, decreased SOD levels were observed in 80% of the cases and 12% of the controls. The mean SOD ± SD was significantly lower in cases (156.04 ± 18.29 U/ml) compared to controls (183.33 ± 17.58 U/ml), with a p-value of < 0.01, indicating a statistically significant difference (Table 2).

Blood Glucose Levels Analysis

All the diabetic cataract cases had elevated blood glucose levels with a mean ± SD of 215.72 ± 51.85 mg/dl. In contrast, the controls, who were non-diabetic, showed a mean ± SD of 107.76 ± 13.82 mg/dl. The difference in blood glucose levels between the two groups was statistically significant ($p < 0.01$) (Table 3).

Serum Sodium (Na+) Levels Distribution

In the assessment of serum sodium levels, 44% of the cases were within the normal range, compared to 80% of the controls. Elevated serum Na+ levels were observed in 56% of the cases and 20% of the controls. The mean serum Na+ ± SD was slightly higher in cases (144.5 ± 5.6 mEq/l) than in controls (141.4 ± 5.0 mEq/l), with this difference being statistically significant ($p < 0.05$) (Table 4).

Renal Function Tests (Blood Urea and Serum Creatinine)

The renal function, assessed through blood urea and serum creatinine levels, showed no significant difference between the cases and controls. The mean blood urea for cases was 26.72 ± 4.8 mg/dl and for controls was 26.42 ± 3.9 mg/dl. Similarly, the mean serum creatinine for cases was 0.896 ± 0.16 mg/dl, and for controls, it was 0.893 ± 0.11 mg/dl. Both parameters showed no statistical significance ($p > 0.05$), indicating normal renal function in both groups (Table 5).

Table 1: Demographic Distribution and Age Comparison

Description	Cases (n=25)	Controls (n=75)	Total (n=100)
Age Group (35-45 yrs)	4 (16%)	20 (27%)	24
Age Group (46-55 yrs)	11 (44%)	32 (42%)	43
Age Group (56-65 yrs)	10 (40%)	23 (31%)	33
Mean Age ± SD	52.12 ± 7.80	50.65 ± 7.79	-
p-Value (Mean Age)	-	-	>0.05

Table 2: Plasma SOD (Superoxide Dismutase) Levels and Comparison

Parameter	Cases (n=25)	Controls (n=75)	Statistical Significance
Normal SOD Levels (%)	20%	88%	
Decreased SOD Levels (%)	80%	12%	
Mean SOD ± SD (U/ml)	156.04 ± 18.29	183.33 ± 17.58	P < 0.01

Table 3: Blood Glucose Levels Analysis

Group	Mean ± SD (mg/dl)	Statistical Significance
Cases (n=25)	215.72 ± 51.85	P < 0.01
Controls (n=75)	107.76 ± 13.82	

Table 4: Serum Sodium (Na+) Levels Distribution

Serum Na+ (mEq/l)	Cases (n=25)	Controls (n=75)	Statistical Significance
Normal Range	44%	80%	
Elevated Levels	56%	20%	
Mean Na+ ± SD	144.5 ± 5.6	141.4 ± 5.0	P < 0.05

Table 5: Renal Function Tests (Blood Urea and Serum Creatinine)

Parameter	Cases (n=25)	Controls (n=75)	Statistical Significance
Blood Urea (mg/dl)	26.72 ± 4.8	26.42 ± 3.9	>0.05 (NS)
Serum Creatinine (mg/dl)	0.896 ± 0.16	0.893 ± 0.11	>0.05 (NS)

*NS: Not Significant

DISCUSSION

Our study's findings contribute valuable insights into the biochemical changes linked to diabetic cataract, particularly focusing on oxidative stress markers and electrolyte imbalances. This discussion highlights key observations regarding Plasma Superoxide Dismutase (SOD) levels, blood glucose, and serum sodium (Na+) levels in patients with diabetic cataract compared to controls.

Plasma SOD Levels and Oxidative Stress in Diabetic Cataract

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Our observation of significantly lower plasma SOD levels in diabetic cataract cases compared to controls underscores the critical role of oxidative stress in the development of cataracts among diabetic patients. SOD, a vital antioxidant enzyme, mitigates superoxide radicals, and its reduced levels suggest an overwhelmed antioxidant defense in diabetics. This aligns with research indicating a link between oxidative stress and diabetic complications, including cataract formation. For instance, studies have shown increased serum malondialdehyde levels and decreased SOD in cataract patients,[11] and a correlation between lower SOD levels and diabetic cataract.[12]

Blood Glucose Levels and Their Impact on Eye Health

The higher blood glucose levels observed in the diabetic cataract group resonate with established connections between chronic hyperglycaemia and diabetic complications, including cataracts. Hyperglycaemia is implicated in lens protein glycation and polyol pathway activation, leading to osmotic stress and lens opacification. A study supports this, highlighting the association between high blood glucose levels and diabetic cataracts, where internal oxidative damage and protein glycosylation reactions are increased.[13]

Serum Sodium Levels and Electrolyte Imbalance

Our study also noted significant differences in serum Na+ levels between diabetic cataract patients and controls, with a tendency toward elevated levels in the former. This may indicate an electrolyte imbalance in diabetic individuals, potentially related to renal function changes or diabetic nephropathy. Raised serum sodium levels have been implicated in cataract development,[14] and may be a risk factor for age-related cataract formation.[15]

Clinical Implications: These findings highlight the potential for targeting oxidative stress and electrolyte imbalance in the management of diabetic cataract. Antioxidant therapy, aiming to enhance the body's ability to counteract oxidative damage, could emerge as a viable preventive or therapeutic strategy. Furthermore, controlling serum Na+ levels through dietary modifications or pharmacological interventions might help in managing or slowing the progression of cataract in diabetic patients.

Limitations and Future Directions

Our study, while revealing, is not without limitations. The sample size is relatively small, and the cross-sectional design limits the ability to draw causal inferences. Additionally, the study did not account for variables such as duration of diabetes, medication use, and other potential confounders that could affect oxidative stress markers and electrolyte balance. Future studies with larger sample sizes, longitudinal designs, and more comprehensive data collection are needed to validate and expand upon our findings.

CONCLUSION

This study reveals that diabetic cataract patients exhibit significant alterations in oxidative stress markers and electrolyte levels. Specifically, these patients demonstrated substantially lower Plasma Superoxide Dismutase (SOD) levels and higher blood glucose and serum sodium levels compared to controls, suggesting oxidative stress and electrolyte imbalance as contributing factors in diabetic cataract pathogenesis. However, renal function, indicated by blood urea and serum creatinine levels, remained comparable between both groups. These findings highlight the potential importance of managing oxidative stress and electrolyte balance in diabetic cataract patients.

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