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Original Research Article

SENILE CATARACT AND ITS CORRELATION WITH ALTERED SERUM SODIUM LEVELS: A CASE-CONTROL STUDY

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ABSTRACT

Background: Senile cataract is a leading cause of age-related visual impairment. Recent evidence suggests that electrolyte imbalances, particularly in serum sodium and potassium levels, may play a role in cataractogenesis. This study aims to evaluate the association between serum sodium and potassium levels in patients with senile cataracts compared to healthy controls. **Methods:** A case-control study was conducted with 300 participants, including 150 cataract patients and 150 age- and gender-matched controls. Serum sodium and potassium levels were measured using the flame photometry method. The mean values were compared between groups, and statistical significance was assessed. **Results:** The mean serum sodium level in the cataract group (145.08 ± 2.51 meq/L) was significantly higher than in the control group (140.21 ± 3.28 meq/L) ($P < 0.05$). However, the mean serum potassium level showed no statistically significant difference (4.40 ± 0.12 meq/L in cases vs. 4.18 ± 0.15 meq/L in controls, $P > 0.05$). **Conclusion:** The study suggests that elevated serum sodium levels may contribute to cataract development, while potassium levels do not appear to play a significant role. Managing sodium intake and electrolyte balance could be considered as a preventive approach against cataract progression. Future research should focus on longitudinal studies to establish a causal relationship and explore possible clinical interventions.

Keywords: Senile Cataract,Serum Sodium, Serum Potassium,Electrolyte Imbalance, Osmotic Stress, Cataractogenesis, clipless surgery, harmonic scalpel, gallstone disease, bile duct injury, surgical outcomes.

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INTRODUCTION

Senile cataract is a leading cause of reversible blindness worldwide, particularly in the elderly population. It is characterized by the progressive opacification of the crystalline lens due to aging-related changes, leading to impaired vision and, in advanced cases, total blindness **(1).** The exact etiology of senile cataract is multifactorial, involving oxidative stress, protein aggregation, metabolic dysfunction, and environmental influences such as ultraviolet radiation exposure and smoking **(2).** However, emerging evidence suggests that electrolyte imbalances, particularly altered serum sodium levels, may play a critical role in cataractogenesis **(3).**

The human lens maintains transparency through a delicate balance of water and electrolytes, which is regulated by active ion transport mechanisms. Sodium (Na^+) is a key component in this process, ensuring proper hydration and homeostasis within the lens fibers **(4).** Any disturbance in serum sodium levels, such as hyponatremia (low sodium levels) or hypernatremia (high sodium levels), can disrupt this delicate equilibrium, leading to osmotic stress and lens opacification **(5).** In addition, fluctuations in sodium levels can impair the function of Na^+/K^+-ATPase pumps in lens epithelial cells, which are crucial for maintaining intracellular ionic stability and preventing lens protein aggregation **(6).**

Several studies have suggested a potential correlation between serum sodium abnormalities and cataract formation, but findings remain inconclusive.**(7)** Some researchers have reported a higher prevalence of senile cataracts in individuals with chronic hyponatremia, likely due to prolonged exposure to hypotonic stress, which results in intracellular swelling and oxidative damage **(8).** On the other hand, hypernatremia has been linked to dehydration-induced oxidative stress, which accelerates protein denaturation and lens opacity formation **(9).** Understanding these associations is critical for identifying potential preventive strategies and optimizing electrolyte management in aging individuals.

This case-control study aims to investigate the correlation between altered serum sodium levels and the development of senile cataracts. By comparing serum sodium concentrations in cataract patients and age-matched controls without cataracts, this study seeks to determine whether dysnatremia serves as a risk factor for cataractogenesis. The findings may provide new insights into the role of electrolyte homeostasis in ocular health and pave the way for preventive strategies to delay cataract progression in the elderly population**.**

MATERIALS AND METHODS

Study Design and Setting: This case-control study was conducted in the Ophthalmology Department of our a tertiary care hospital. Ethical approval was obtained from the Institutional Ethics Committee before commencing the study. Written informed consent was obtained from all participants prior to their enrollment.

Study Population: The study included two groups:

1. Cases: Patients diagnosed with senile cataract, confirmed through a comprehensive ophthalmological examination.

2. Controls: Age- and gender-matched individuals without any signs of cataract, selected from routine outpatient visits or hospital staff volunteers.

Patients with secondary cataracts (e.g., traumatic, metabolic, congenital, or steroid-induced cataracts) and those with systemic diseases affecting electrolyte balance, such as chronic kidney disease, uncontrolled diabetes mellitus, liver disorders, or recent hospitalizations for fluid-electrolyte disturbances, were excluded from the study.

Sample Size and Sampling Method: The sample size was calculated based on previous literature and pilot study data. A total of 150 cases and 150 controls were recruited using a consecutive sampling method until the desired sample size was achieved.

Ophthalmological Examination:A detailed ophthalmological assessment was performed, including:

- Best corrected visual acuity (BCVA) measurement using a Snellen chart.

- Slit-lamp biomicroscopy to assess lens opacity.

- Grading of cataract severity using the Lens Opacities Classification System III (LOCS III).

- Fundus examination using indirect ophthalmoscopy after pupil dilation (if media clarity allowed).

Serum Sodium Measurement: Venous blood samples were collected from all participants under fasting conditions. Serum sodium levels were measured using an automated electrolyte analyzer based on ion-selective electrode (ISE) technology. The normal reference range for serum sodium was considered 135–145 mEq/L. Participants were categorized into three groups based on sodium levels:

- Hyponatremia: Serum sodium <135 mEq/L
- Normonatremia: Serum sodium 135–145 mEq/L
- Hypernatremia: Serum sodium >145 mEq/L

Statistical Analysis: All data were entered into a statistical software program (e.g., SPSS v.26 or GraphPad Prism) and analyzed as follows:

- Descriptive statistics (mean ± standard deviation for continuous variables, frequency, and percentage for categorical variables).
- Comparative Analysis: An independent t-test was used to compare mean serum sodium levels between cases and controls.
- Correlation Analysis: Pearson's correlation coefficient was applied to assess the relationship between serum sodium levels and cataract severity.
- Logistic Regression: Adjusted odds ratios (OR) with 95% confidence intervals (CI) were calculated to determine whether altered sodium levels were independent risk factors for senile cataract, controlling for age, gender, and other confounders.

Ethical Considerations: The study was conducted following the principles outlined in the Declaration of Helsinki. All participants were informed about the purpose, risks, and benefits of the study, and confidentiality was strictly maintained.

RESULTS

The study included a total of 300 participants, divided equally into 150 cases (patients with senile cataracts) and 150 controls (healthy individuals without cataracts). The age range of participants in the case group was 45 to 75 years. The mean age of the case group was 66.2 ± 5.6 years, while the mean age of the control group was 64.1 ± 5.2 years.

In the case group, 93 out of 150 participants (62%) were males, while 57 (38%) were females. Similarly, in the control group, 89 participants (59%) were males, and 61 (41%) were females.

Table 1: Distribution of Study Participants According to Age and Gender

Study Groups	Sample Size (n)	Mean Age (Years)
Case Group	150	66.2 ± 5.6
Control Group	150	64.1 ± 5.2

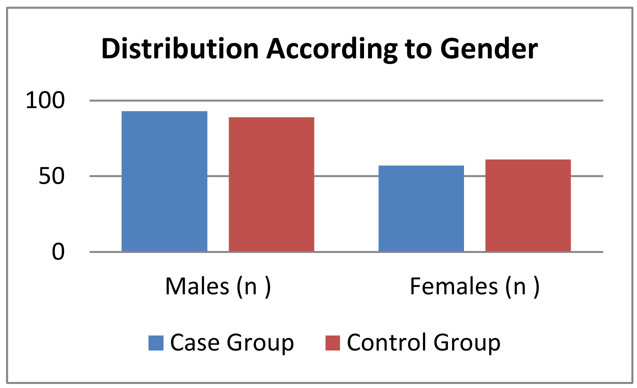

Figure 1. Distribution of Study Participants According to Gender

In this study, a total of 300 participants were enrolled, with 150 patients diagnosed with nuclear, cortical, or posterior subcapsular cataracts (case group) and 150 healthy individuals (control group). All participants underwent serum sodium and potassium level estimation using the flame photometry method to assess possible electrolyte imbalances.

The results indicated that the mean serum sodium level in the cataract group was 145.08 ± 2.51 meq/L, whereas in the control group, it was 140.21 ± 3.28 meq/L. This difference was found to be statistically significant (P-value < 0.05), suggesting a potential association between elevated serum sodium levels and cataract development.

On the other hand, the mean serum potassium level in the cataract group was 4.40 ± 0.12 meq/L, while in the control group, it was 4.18 ± 0.15 meq/L. The difference in potassium levels between the two groups was statistically non-significant (P-value > 0.05), indicating that serum potassium variations may not play a major role in cataractogenesis.

The detailed distribution of serum sodium and potassium levels among study participants is presented in Table 2 below.

Table 2: Distribution of Study Participants According to Mean Serum Sodium and Potassium Levels

Serum Levels	Case Group (n=150)	Control Group (n=150)	P-value
Serum Sodium (meq/L)	145.08 ± 2.51	140.21 ± 3.28	< 0.05 (Significant)
Serum Potassium (meq/L)	4.40 ± 0.12	4.18 ± 0.15	> 0.05 (Non-Significant)

DISCUSSION

The present study investigated the correlation between serum sodium and potassium levels in patients with senile cataracts and healthy controls. The findings revealed a statistically significant difference in serum sodium levels between the cataract and control groups, whereas serum potassium levels did not show a significant difference. These results highlight the potential role of sodium homeostasis in cataractogenesis.

Our study found that the mean serum sodium level in the cataract group (145.08 ± 2.51 meq/L) was significantly higher than in the control group (140.21 ± 3.28 meq/L) (P < 0.05). This suggests that elevated sodium levels may contribute to the development of cataracts. Several studies have indicated that increased sodium levels can disrupt the delicate ionic balance in the lens, leading to osmotic stress and protein aggregation, both of which contribute to lens opacification **(10)**.

Previous research supports the role of sodium dysregulation in cataractogenesis. A study by Thomas et al. (2017) observed that patients with senile cataracts exhibited significantly higher serum sodium levels compared to age-matched controls, reinforcing the idea that hypernatremia may accelerate lens damage **(11).** The increased sodium concentration may impair the function of Na^+/K^+-ATPase pumps, leading to intracellular accumulation of sodium and a corresponding loss of potassium and calcium balance, which is crucial for maintaining lens transparency **(12).**

Moreover, excessive sodium influx into the lens fibers can cause increased water retention within the lens, leading to swelling and metabolic dysfunction. This process ultimately results in lens fiber degeneration and opacification, a hallmark of cataract formation **(13).** Therefore, sodium imbalance may act as a modifiable risk factor for cataractogenesis, and strategies aimed at regulating serum sodium levels could help delay cataract progression.

Unlike sodium, our study found no significant difference in serum potassium levels between the cataract group (4.40 ± 0.12 meq/L) and the control group (4.18 ± 0.15 meq/L) (P > 0.05). This suggests that potassium homeostasis may not play a major role in cataract development.

This finding aligns with earlier studies, such as the investigation by Han et al. (2017), which concluded that potassium levels in cataract patients were within the normal range and did not significantly differ from those in healthy individuals **(14).** The stability of potassium levels may be attributed to the compensatory mechanisms of the lens, which actively regulate intracellular potassium despite changes in sodium levels **(15)**.

However, some research suggests that severe potassium depletion could exacerbate oxidative stress, leading to lens damage in extreme cases. While potassium fluctuations alone may not directly induce cataract formation, their interaction with other electrolyte imbalances, such as sodium excess, warrants further exploration **(16)**.

The findings of this study emphasize the importance of maintaining electrolyte balance, particularly sodium regulation, in preventing or delaying cataractogenesis. Further research should explore whether dietary modifications or pharmacological interventions aimed at sodium balance can serve as preventive strategies against cataract progression.

Additionally, future studies should investigate the mechanisms underlying sodium-induced oxidative stress and protein aggregation in the lens, using larger sample sizes and longitudinal study designs. Identifying specific thresholds of sodium dysregulation that predispose individuals to cataracts could also aid in early screening and prevention.

Despite its significant findings, this study has several limitations. First, the sample size, though adequate, was limited to a single center, reducing generalizability to broader populations. Second, the study design was cross-sectional, preventing the establishment of a causal relationship between serum sodium levels and cataract formation. Third, confounding factors such as dietary sodium intake, hydration status, and systemic conditions that could influence electrolyte balance were not extensively evaluated. Additionally, the study relied on single-point serum sodium and potassium measurements, which may not fully capture long-term electrolyte variations. Future studies with larger, multi-center cohorts and longitudinal follow-up are recommended.

CONCLUSION

This study highlights a significant association between elevated serum sodium levels and senile cataracts, while serum potassium levels did not show a substantial impact. The findings suggest that sodium imbalance may contribute to cataractogenesis, possibly through osmotic stress and metabolic disturbances in the lens. Given the increasing burden of cataracts in aging populations, monitoring and managing sodium levels may serve as a potential preventive strategy. However, further longitudinal and interventional studies are necessary to confirm these findings and explore targeted approaches for electrolyte regulation in cataract prevention and management.

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