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An Analysis of Serum Triglyceride and Electrolytes Levels among Posterior Subcapsular Cataract Patients Attending a Tertiary Care Teaching Hospital of Tripura, North East India - An Observational Study

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ABSTRACT

Background: Posterior subcapsular cataract (PSC) represents a visually disabling subtype of age-related cataract that is frequently associated with metabolic and biochemical disturbances. Although dyslipidaemia and electrolyte imbalance are implicated in cataractogenesis, there is a lack of regional data from Northeast India.
Aim: To evaluate the clinico-biochemical profile of PSC patients with emphasis on serum triglyceride and electrolyte levels.
Methods: A cross-sectional observational study was conducted among 140 PSC patients aged 50–80 years attending AGMC & GBP Hospital, Tripura. Serum triglycerides, sodium, potassium, and chloride were estimated using standardised enzymatic and ion-selective electrode methods. The chi-square test was used to assess the significance of the association between two or more risk factors, while the student's t-test was applied to evaluate the significance of the difference between two means. A p-value of less than 0.05 was considered statistically significant.
Results: Elevated serum triglycerides & chloride levels are observed in 81.4% (OR = 6.58, $p < 0.001$) and 77.9% (OR = 5.27, $p < 0.001$) of study participants, respectively. Sodium imbalance is also noted in 40% (OR = 2.14, $p = 0.001$) of cases. Age and gender significantly influence triglyceride and chloride levels, with higher levels in older females.
Conclusion: Hypertriglyceridemia and hyperchloremia are strongly associated with PSC, while sodium imbalance also contributes significantly. These findings highlight the importance of integrating biochemical screening into cataract prevention and management strategies in Northeast India.

Keywords: Posterior subcapsular cataract, triglycerides, chloride, sodium, dyslipidaemia, electrolyte imbalance, Tripura

INTRODUCTION

Cataract refers to the development of any opacity in the lens or its capsule, blocking the passage of light to the retina and hence leading to impairment of vision. Cataracts are the leading cause of blindness globally, accounting for approximately half of all cases of visual impairment. Among the different types and subtypes of cataract, posterior subcapsular cataract (PSC) is particularly debilitating because of its location at the back of the lens, directly affecting the visual axis.[1] Patients with PSC often experience glare, colour halos and difficulty with near vision, even in the early stages of disease progression. Age is the most important risk factor, and over 80% of patients involved have age-related cataract. In addition to advancing age, several risk factors contribute to the development of PSC, including dyslipidemia, alcohol consumption, diabetes mellitus, glaucoma, congenital cataract, hypoparathyroidism, ocular inflammation and traumas, exposure to infrared and ionising radiation, myopia, obesity, retinal dystrophies, prolonged use of corticosteroids and ultraviolet (UV) exposure.[2]

The lens is an active tissue that needs a careful balance of lipids, proteins and electrolytes to maintain its transparency. If somehow this balance is disturbed, it leads to oxidative stress, protein clumping, and cloudiness. Recent studies suggest that abnormal levels of triglycerides and electrolytes in the blood might play a role in the development of PSC.[3,4]

Several factors are implicated in the development of cataract, such as a low antioxidant defence capacity, high lipid peroxidation, increased non-enzymatic glycosylation, reduced chaperone function of the alpha-crystallins, and increased permeability of the lens membrane. Hypertriglyceridemia triggers cataractogenesis by promoting oxidative stress and lipid peroxidation. High triglyceride levels contribute to cataract formation by generating reactive oxygen species that disrupt protein integrity and lipid membrane stability, leading to opacification. The Framingham Offspring Eye Study reports that men with fasting triglyceride levels ≥250 mg/dL have a significantly higher risk of developing PSC than those with normal lipid profiles.[5] Similarly, another observational study in India demonstrates that hypertriglyceridemia is an independent risk factor for age-related cataracts, including PSC.[6] These findings suggest that triglycerides play a direct role in cataract development and progression.

Electrolyte homeostasis is essential for lens transparency. The lens maintains osmotic balance through sodium, potassium, and chloride ions by Na^+ -K^+ ATPase pump and Na^+ K^+2Cl^- cotransporter in the lens, thereby regulating hydration and minimising protein aggregation. Elevated serum chloride levels are observed in patients with cataracts.[7] Chloride imbalance exacerbates lens fibre swelling and posterior lens opacification, and disruption of chloride transport mechanisms alters lens hydration, leading to osmotic stress and development of posterior subcapsular changes.[8]

The dual impact of high triglycerides and electrolyte imbalance drives PSC formation through several biological processes:

- **Oxidative stress**: Increased level of serum triglycerides promotes lipid peroxidation, which damages lens proteins and membranes.[9]
- **Osmotic imbalance**: An increase in serum sodium & chloride concentration disturbs ionic imbalance, resulting in dehydration, fibre swelling and posterior lens clouding.[10]
- **Metabolic dysregulation**: Both factors are closely associated with poor glycemic control, which predisposes patients to PSC.[11]

Since cataracts increase with age, they remain one of the leading causes of blindness worldwide. So, it is justifiable to attempt to identify the modifiable risk factors for cataract. Studying the relationship between triglycerides &

electrolytes and PSC is important for patient's eye care and public health. Hence, evaluation of serum triglyceride, sodium & chloride levels help to identify people at higher risk of developing PSC. Early intervention to manage hypertriglyceridemia and hyperchloremia lowers the risk of PSC. Also, combining detailed ocular examination with metabolic health check-ups improve patient care. Furthermore, this study is conducted in Tripura to address the high burden of cataract-related blindness in the region and the rising prevalence of hypertriglyceridemia and electrolyte imbalances, both of which are strongly linked to PSC. Limited published data from Northeast India further justify the choice, as findings from Tripura help to fill this regional gap and provide evidence relevant for public health awareness and preventive strategies.

MATERIALS AND METHODS

Study Design

The present study was a cross-sectional, hospital-based observational study with data collection spanning over one and a half years. This study was conducted in the Department of Biochemistry of AGMC & GBP Hospital, in collaboration with the Department of Ophthalmology, AGMC & GBP Hospital.

Study Population and Sample Size

The study included patients aged 50 to 80 years having posterior subcapsular cataract who visited the Department of Ophthalmology at AGMC & GBP Hospital. In total, 140 patients with posterior subcapsular cataracts were chosen. The sample size was calculated using the following formula:

$N = Z(1 - \alpha/2)^2 \times SD^2 \div d^2$; where N= sample size, Z = 1.96 at 95% confidence interval, SD=26.87, and d=5 as allowable precision.[12]

Data Collection

To achieve the required sample size of 140 subjects, participants were recruited via consecutive sampling from patients attending the Ophthalmology Outpatient Department at AGMC & GBP Hospital, using predefined inclusion and exclusion criteria.

Inclusion Criteria

- The patients who were clinically diagnosed with posterior subcapsular cataract attending the Ophthalmology Department of AGMC & GBP Hospital.
- Between 50 and 80 years of age.
- Provided consent to participate in the study.

Exclusion Criteria

- Patients with a history of cataract surgery (pseudophakia or surgical aphakia).
- Patients with acute or chronic renal failure, acute or chronic diarrhoea, diabetes mellitus, hypertension or any major systemic illness and malignancy.
- Patients with pre-existing ocular diseases such as glaucoma, uveitis, or corneal opacity.
- Patients who declined to participate in the study.

Ethical approval and informed consent

The study protocol was submitted to the Institutional Ethics Committee of AGMC and GBPH for review and approval. The research commenced only after obtaining formal clearance from the committee (Ref. No. F.4(6-13)/AGMC/Medical Education/ IEC Approval/2022/6075). All data were kept confidential and used solely for research purposes. Eligible patients were informed about the study objectives and procedures, and written informed consent was obtained. Each participant underwent detailed history-taking, general and systemic examinations and ocular evaluation with findings recorded on a structured case record form.

Sample collection

For biochemical analysis, 5 ml of venous blood was collected under aseptic conditions, preferably from the antecubital vein, using

sterile equipment. Samples were placed in fluoride and clot-activator containers, allowed to clot at room temperature, and then centrifuged to separate serum. Proper labelling and coding were performed, and analyses were carried out as soon as possible. In the event of a delay, aliquots were stored at 2–8°C until testing.

Parameters Studied

Routine biochemical parameters were assessed, specifically serum triglyceride and serum chloride levels**.**

Estimation of Serum Triglycerides

Serum triglyceride levels were estimated using the GPO-Trinder enzymatic method in the XL-640 fully automated autoanalyser.[13]

Estimation of Serum Na+, K+ and Cl-:

Serum sodium, potassium and chloride levels were measured using an ion-selective electrode (ISE)–based Easy Lyte Electrolyte Autoanalyser.[14]

Data Analysis

Data entry and analysis were performed using SPSS (version 29). The chi-square test was used to assess the significance of the association between two or more risk factors, while the student's t-test was applied to evaluate the significance of the difference between two means. A p-value of less than 0.05 was considered statistically significant.

RESULTS

In the present study, Table 1 shows the distribution of study participants according to gender and age. The study includes 140 participants, of which 86 are female and 54 are male, indicating a predominance of female participants. The majority of participants are 60–70 years old (63.6%). A slightly higher proportion is found in females (65.1%) than in males (61.1%). The 70–80-year age group comprises 23.6% of the study participants, again with a larger proportion of females (23.3%) than males (24.1%). In this study, the smallest group is found in the 50–60 age group, representing only 12.9%, with 11.6% female and 14.8% male. This distribution indicates that the study population is largely concentrated in the 60–70-year age group with a balanced representation across genders.

Table 1: Distribution of study participants according to age and gender

Age Group (Years)	Female n (%)	Male n (%)	Total n (%)
50–60	10 (11.6%)	8 (14.8%)	18 (12.9%)
60–70	56 (65.1%)	33 (61.1%)	89 (63.6%)
70–80	20 (23.3%)	13 (24.1%)	33 (23.6%)
Total	86 (100%)	54 (100%)	140 (100%)

Table 2 shows a predominance of abnormal biochemical values among the study participants. Serum triglyceride levels are elevated in nearly two-thirds of the group (67.1%), indicating a high burden of dyslipidemia. Electrolyte imbalances are also evident, with hypernatremia present in 40% and hyperkalemia in only 16% of individuals. Most strikingly, serum chloride is elevated in 77.9% of cases.

Table 2: Distribution of Serum Triglyceride and Serum Electrolytes

Parameters	Mean ± SD	Normal n (%)	High n (%)
Serum Triglyceride	206.12 ± 62.49	46 (32.9)	94 (67.1)
Serum Sodium	143.65 ± 6.64	84 (60.0)	56 (40.0)
Serum Potassium	5.40 ± 0.88	117 (84.0)	23 (16.0)
Serum Chloride	107.69 ± 9.39	31 (22.1)	109 (77.9)

The mean serum triglyceride levels increase progressively with advancing age. Participants in the 50–60-year age group have the lowest mean TG level (148.2 ± 34.5 mg/dL), while those in the 60–70-year age group show slightly higher values (165.7 ±

39.2 mg/dL). The levels continue to rise in the 70–80-year age group (178.4 ± 42.1 mg/dL) and peak in participants aged over 80 years (182.6 ± 45.3 mg/dL). The p-value of 0.002 indicates that this upward trend is statistically significant (Figure 1).

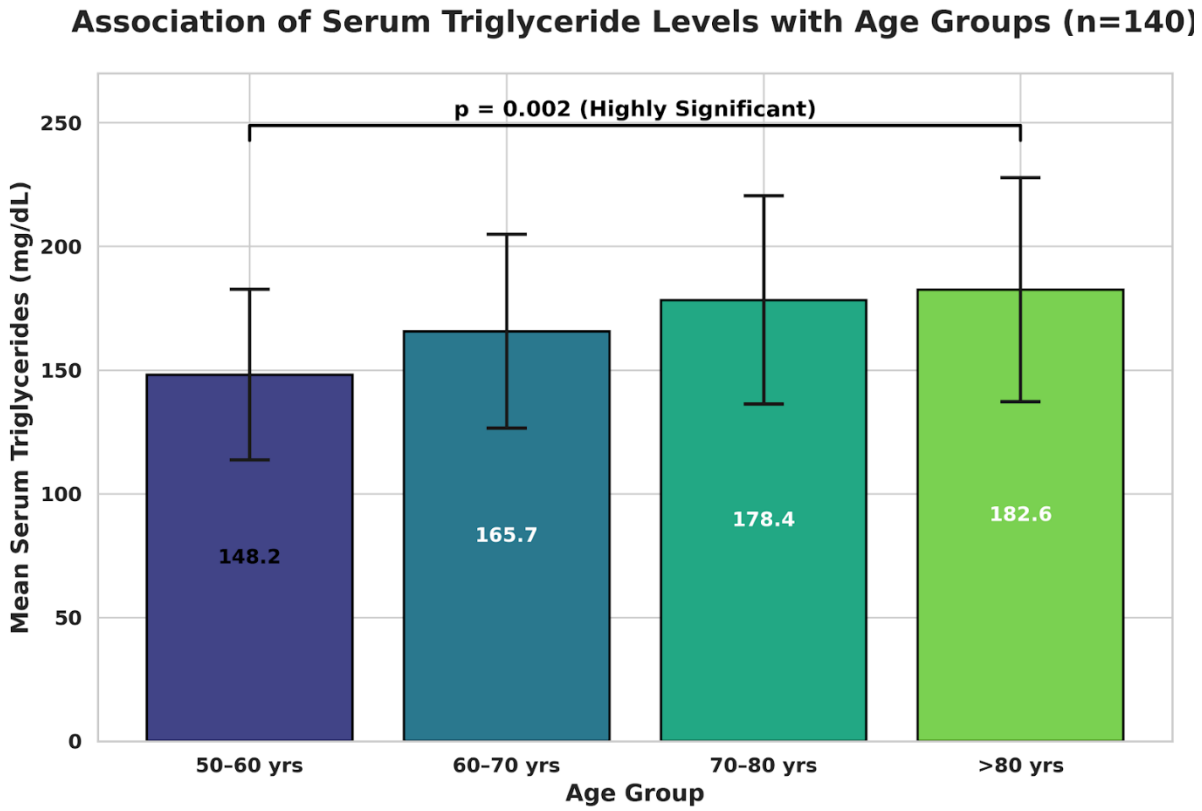

Figure 1: Association of Serum Triglyceride Levels with Age

Figure 2 depicts that the mean serum triglyceride levels are higher in females (174.6 ± 41.2 mg/dL) than in males (158.3 ± 37.6 mg/dL). The difference between the two groups is statistically significant (p = 0.02).

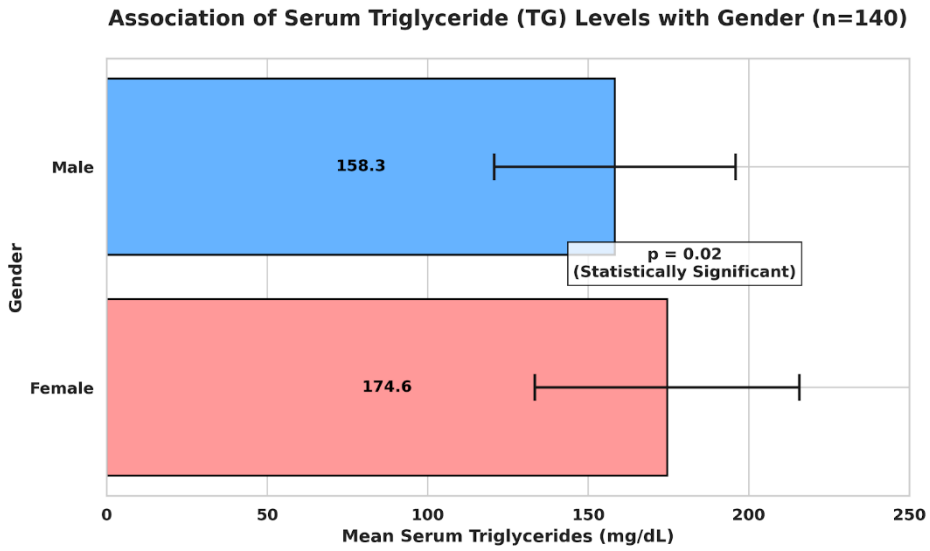

Figure 2: Association of Serum Triglyceride Levels with Gender

Figure 3 illustrates a progressive rise in serum chloride concentrations with advancing age. The mean values increase from 101.2 ± 3.0 mEq/L in individuals aged 50–60 years to 102.8 ± 3.4 mEq/L in those aged 60–70 years, 104.1 ± 3.6 mEq/L in those aged 70–80 years and reach 105.0 ± 3.9 mEq/L among participants older than 80 years. Statistical analysis confirms that this upward trend is significant (p = 0.005).

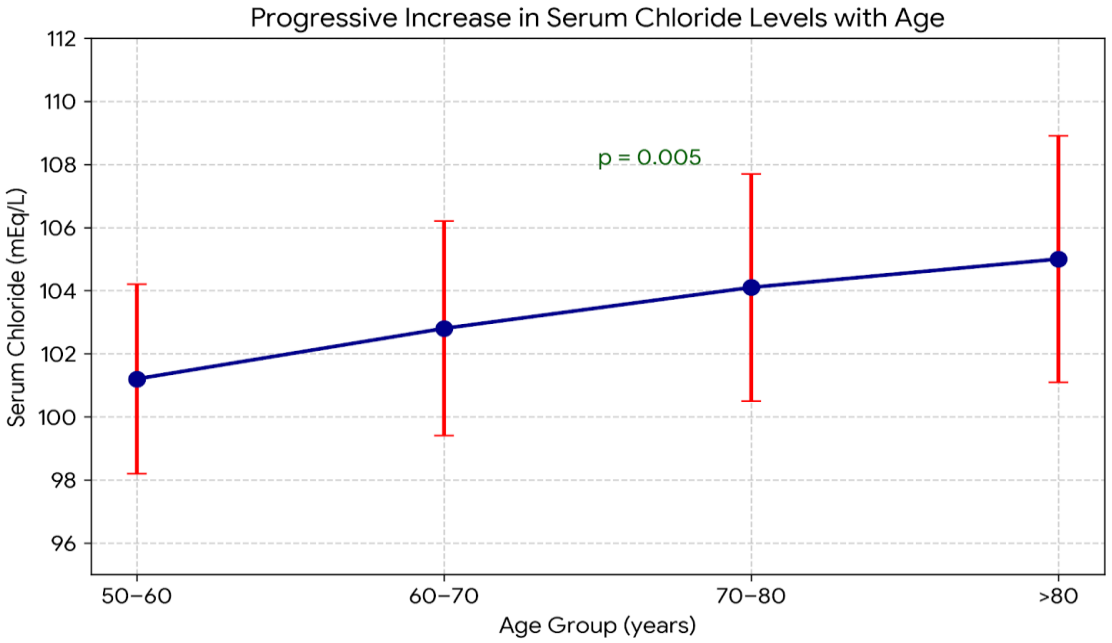

Figure 3: Age-Related Trends in Serum Chloride Levels

Figure 4 demonstrates a significant gender-related variation in serum chloride levels. Female participants have a higher mean concentration (104.0 ± 3.6 mEq/L) than their male counterparts (102.4 ± 3.4 mEq/L). This difference is statistically significant (p = 0.02).

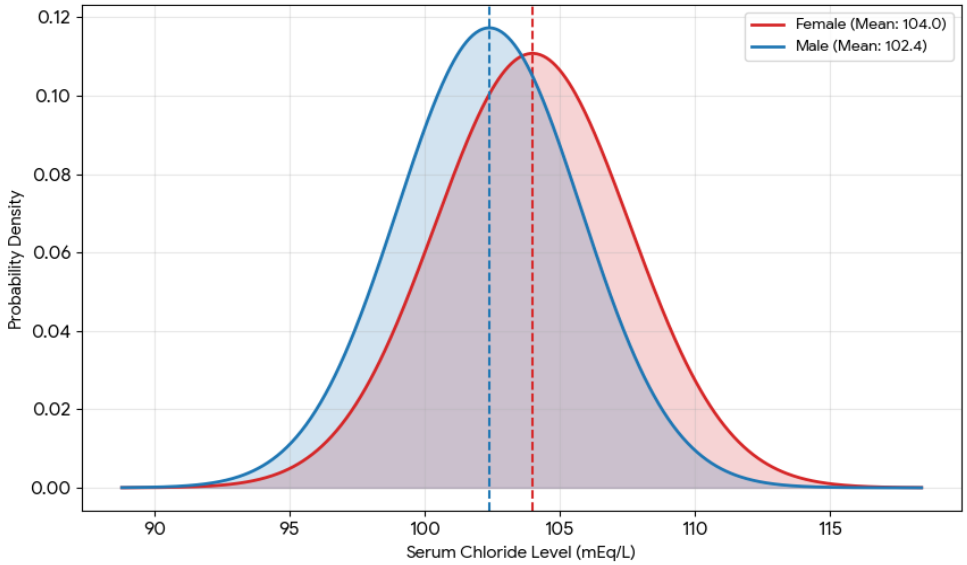

Figure 4: Distribution of Serum Chloride by Gender

The data show that serum sodium levels increase progressively with age. Mean values rise from 138.1 ± 3.4 mEq/L in the 50–60-year group to 139.6 ± 3.8 mEq/L in those aged 60–70 years, 141.2 ± 4.1 mEq/L in the 70–80-year group and reach 142.3 ± 4.4 mEq/L among individuals older than 80 years. The reported p-value of 0.003 indicates that this upward trend is statistically significant (Figure 5)

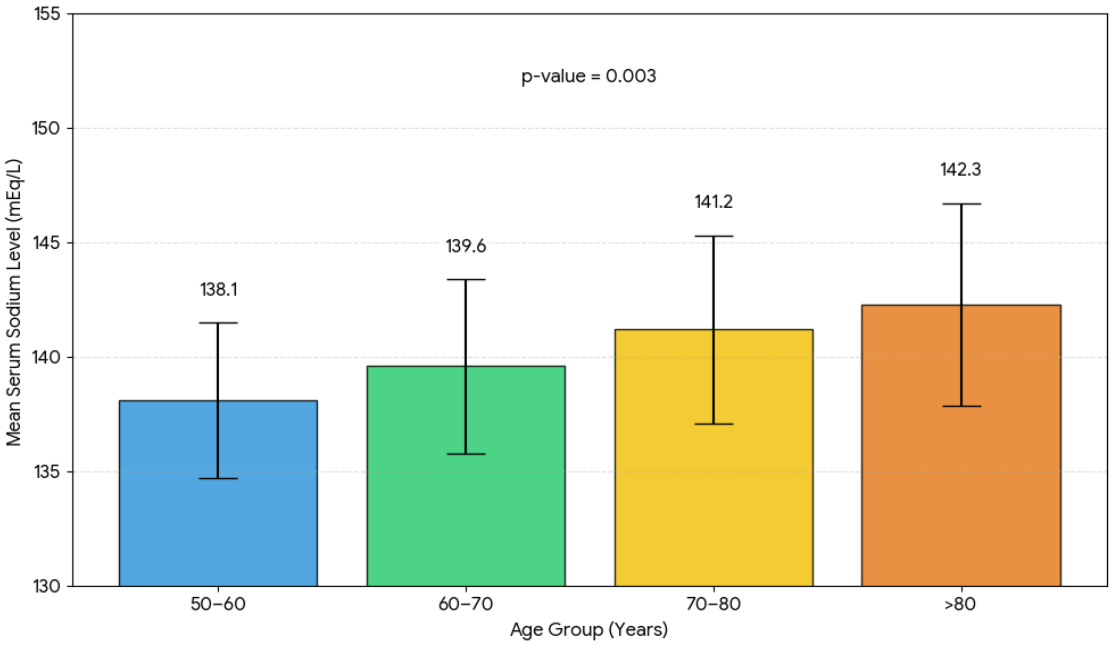

Figure 5: Variation in Serum Sodium Levels Across Different Age Groups

Figure 6 shows a gender-based difference in serum sodium levels. Female participants have a higher mean sodium concentration (141.2 ± 4.1 mEq/L) compared with male participants (139.3 ± 3.8 mEq/L). The p-value of 0.01 confirms that this difference is statistically significant.

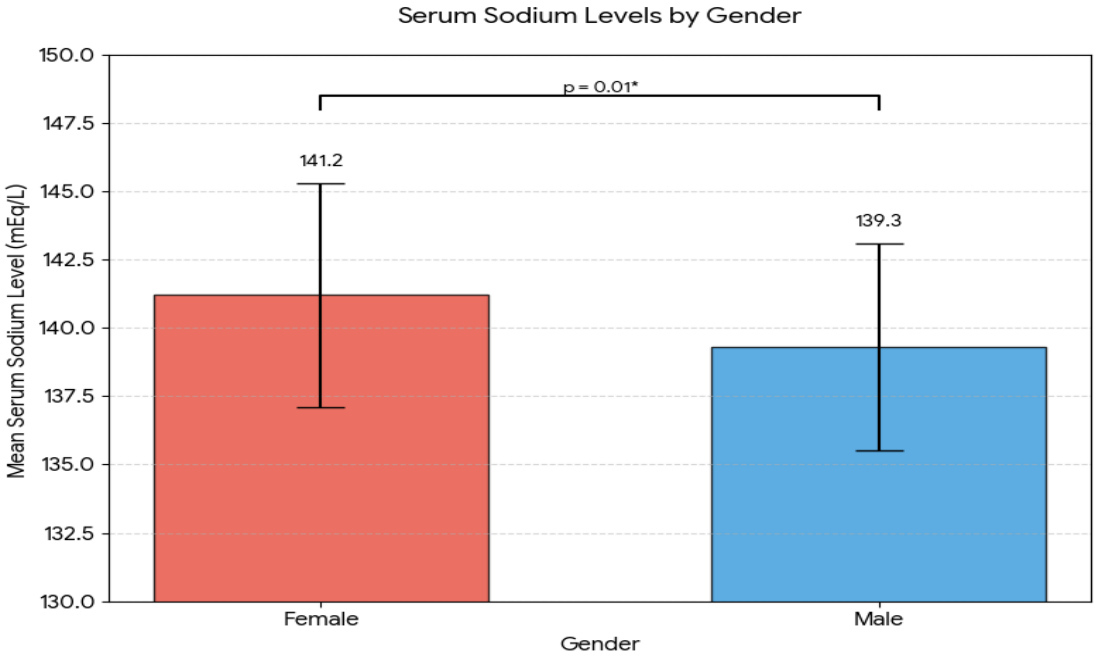

Figure 6: Comparison of serum sodium levels between genders

Table 3 reflects that all three parameters, i.e., serum triglycerides, chloride, and sodium, exhibit significant abnormalities in patients having posterior subcapsular cataract (PSC). Abnormal triglyceride levels are present in 81.4% of participants. The χ^2 value (48.65) and p value (< 0.001) confirm a highly significant association. The odds ratio (OR = 6.58) indicates that patients are more than 6 times as likely to have abnormal triglyceride levels compared with normal values.

Elevated chloride is found in 77.9% of cases. The χ^2 value of 39.90 and $p < 0.001$ confirm strong statistical significance. The odds ratio (OR = 5.27) indicates that patients are over 5 times more likely to present with abnormal chloride levels.

Abnormal sodium levels are observed in 40% of participants. The χ^2 value of 12.47 and p = 0.001 indicate statistical significance, though less pronounced compared to triglycerides and chloride. The odds ratio (OR = 2.14) indicates that patients are about twice as likely to have abnormal sodium levels.

Table 3: Comparative Analysis of metabolic and electrolyte Imbalances among Study Participants

Parameter	Normal (n%)	Abnormal (n%)	χ2	p-value	Odds Ratio (OR)
Serum Triglycerides	26(18.6%)	114 (81.4%)	48.65	p < 0.001	6.58
Serum Chloride	31 (22.1%)	109 (77.9%)	39.90	p < 0.001	5.27
Serum Sodium	84(60.0%)	56 (40.0%)	12.47	0.001	2.14

A higher proportion of subjects show elevated triglyceride levels (67.1%) and abnormal chloride levels (77.9%), indicating a predominance of metabolic and electrolyte imbalances among PSC patients, as shown in Figure 7.

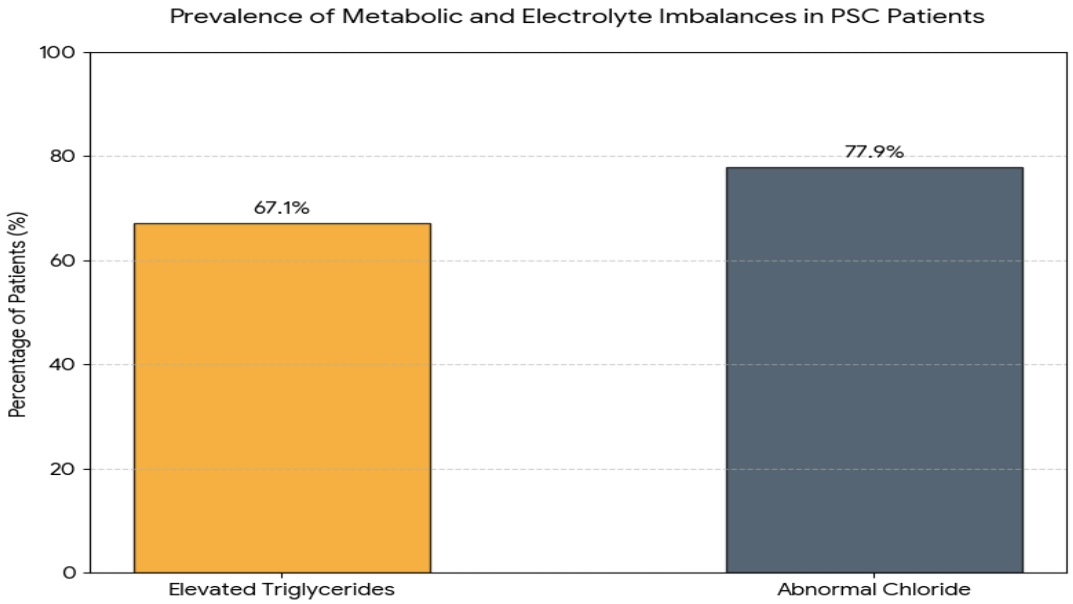

Figure 7: Association of Serum Triglycerides with Chloride Levels among PSC Patients (n = 140)

DISCUSSION

The results of our study highlight that abnormal serum triglycerides, chloride, and sodium are significantly associated with PSC, where triglycerides and chloride show the strongest associations. This supports the growing body of evidence that metabolic dysregulation and electrolyte imbalances contribute to cataractogenesis.

The high prevalence of hypertriglyceridemia in this cohort (81.4%) supports previous evidence that dyslipidaemia is a major risk factor for cataract development.[15] Elevated triglycerides increase oxidative stress and lipid peroxidation, resulting in protein denaturation and lens opacification. The

Framingham Offspring Eye Study also finds that individuals with fasting triglycerides of 250 mg/dL or higher have a significantly higher risk of PSC than those with normal lipid profiles.[5] Recent Indian study performed by Gupta M et al has also confirmed that hypertriglyceridemia is an independent risk factor for age-related cataracts.[6] Furthermore, Sahare et al. demonstrate that cataract patients show elevated triglycerides in comparison to controls, which indicates an involvement of lipid metabolism in the pathogenesis of cataracts. Elevated triglyceride levels may contribute to cataract development, potentially through mechanisms involving oxidative stress and inflammation.[16] An earlier study by Park YH et al. also proves that elevated triglyceride levels are associated with an increased rate of cataracts.[17] Another study by Qi Jin et al. also reports that elevated lipid levels, particularly serum triglyceride levels, may contribute to the development and progression of cataract.[18]

In the present study, elevated serum chloride levels are found in 77.9% of PSC patients, supporting earlier findings that chloride imbalance disrupts lens hydration. Chloride ions help regulate lens hydration via $Na^+/K^+/Cl^-$ cotransporters, and when this process is disrupted, it causes fibre swelling and clouding at the back of the lens. A similar observation was reported by Th Rajakannan and Ponmalar, who noted that patients with cataracts had higher chloride levels than controls.[19] Observation in this study was also consistent with a study by Sinatra N et al., who found that high chloride levels might increase oxidative stress and cellular problems, which might also play a role in lens disease.[20]

The present study demonstrates that sodium imbalance is found in 40% of participants, though it is less than imbalances in triglycerides and chloride, and the result is found statistically significant ($p = 0.001$). Sodium is important for keeping the lens clear by supporting Na^+/K^+ ATPase activity. When sodium levels change, they disrupt ionic balance, cause osmotic stress, and damage lens fibres. This result is consistent with the study by Soni PN, who also reported that patients with cataracts had altered serum sodium levels, suggesting that ionic imbalances might contribute to cataract development.[21] Another case-control study in India also found links between cataract and changes in serum sodium.[22] According to Mannangi N et al., changes in serum sodium and chloride levels are used as a marker to determine the risk for the development of cataract.[23] Similar to the present study, Masood T et al. report a significantly elevated serum sodium level, indicating it as a risk factor for developing cataract.[24]

When triglycerides, chloride, and sodium levels are found to be abnormal, they work together to cause disease. Dyslipidaemia leads to oxidative stress, and electrolyte imbalances disrupt osmotic balance. These changes can cause lens proteins to clump, leading to posterior subcapsular cataracts. A study by Wang and Yi, based on a cataract risk prediction model using biochemical markers, shows that metabolic and electrolyte indicators may improve risk assessment.[25] These findings highlight the need to include biochemical screening in cataract prevention, especially in places like Northeast India, where cataracts are common.

Limitations

- The hospital-based nature of the study limits the generalizability of findings to the broader community prevalence of PSC.
- The cross-sectional design restricts the ability to infer causality between biochemical abnormalities and cataract development.
- Potential confounders, including dietary habits, genetic predisposition, and environmental exposures, are not evaluated.
- The study exclusively examines PSC patients, thereby excluding other cataract subtypes.

CONCLUSION

The results of the present study show a strong association among hypertriglyceridemia, hyperchloremia, and PSC along with the importance of sodium imbalance. These metabolic and electrolyte disturbances together point to cataractogenesis having many causes. Adding biochemical screening to regular eye care helps with early detection and prevention. Data from Tripura contribute to national research and highlight the need for coordinated efforts to reduce cataract-related blindness in Northeast India.

- **Screening:** Routine assessment of triglyceride and electrolyte levels should be included in cataract risk evaluations, particularly in regions with high cataract prevalence.
- **Prevention:** Early intervention for dyslipidaemia and electrolyte imbalances reduces the risk and slow progression of PSC.
- **Public Health:** These findings highlight the need to integrate eye care with metabolic health programs in Northeast India, where cataract-related blindness remains a major public health concern.
- **Gender-specific strategies:** Due to the higher prevalence of biochemical abnormalities in females, targeted prevention strategies should be implemented.

Declaration by Authors

Ethical Approval: Approved

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Conflict of Interest: The authors declare no conflict of interest.

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