The Role of Serum Sodium and Potassium Levels in Patients with Ocular Tumors at Prof. Dr. Chairuddin Panusunan Lubis Hospital, Universitas Sumatera Utara

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Abstract

Sodium (Na^+) and potassium (K^+) are essential electrolytes involved in various biological processes, including tumor cell proliferation, migration, and metabolism. However, the role of serum sodium and potassium levels in patients with ocular tumors remains unclear. This analytical observational study employed a cross-sectional design involving 60 subjects, consisting of 30 patients with ocular tumors and 30 healthy controls. Serum sodium and potassium levels were measured using the Ion Selective Electrode (ISE) method. Differences between groups were analyzed using the Mann-Whitney test with a significance level of $p<0.05$. Most ocular tumors were benign, with squamous papilloma being the most common histopathological diagnosis (16.7%). The mean serum sodium level was higher in the ocular tumor group than in the control group (146 ± 8.42 mmol/L vs 143.13 ± 2.97 mmol/L); however, the difference was not statistically significant ($p=0.061$). Mean serum potassium levels were comparable between the ocular tumor and control groups (4.22 ± 0.53 mmol/L vs 4.30 ± 0.64 mmol/L), with no statistically significant difference ($p=0.700$). Although a trend toward higher serum sodium levels was observed in the ocular tumor group, serum sodium and potassium levels cannot currently be considered diagnostic biomarkers for ocular tumors.

Keywords: Ocular tumor; serum sodium; serum potassium; electrolytes; biomarker

Introduction

A tumor is a mass formed due to abnormal cell growth that can be benign or malignant. An ocular tumor is a tumor that can occur in various parts of the eye. Tumors can occur in the adnexa of the eye, such as the eyelids and the lacrimal system. Tumors can also occur in the cornea, conjunctiva, iris, retina, and optic nerve. Ocular tumors can affect the patient's facial appearance; in severe cases, they can cause facial deformities. Vision impairment may also occur in some cases of ocular tumors (Tatyana, Hans, and Gabrielle, 2023).

According to the American Cancer Society, the prevalence of ocular tumors in 2025 will be 3,140, with melanoma being the most common type. The incidence rate (new cases) is 1 per 100,000 people, and the prevalence (total cases) is approximately 12 per 100,000 people. The Hyderabad Eye Research Foundation in India reported a prevalence of 9,633 ocular tumors, with the most common types being retinoblastoma (12%), ocular surface squamous neoplasia (OSSN) (10%), and conjunctival nevus (9%) (Shangkun, Yuan, and Zhang, 2024).

Cases of ocular cancer or tumors in Indonesia are rarely reported in detail and are limited to specific regions across the country. According to a report by Mansur at Dr. Wahidin Sudirohusodo General Hospital in Makassar, 70 cases of ocular tumors were identified in 2023. The types of ocular tumors identified were intraocular tumors (58.6%), extraocular tumors (40%), and retrobulbar tumors (1.4%). In East Java, Soebagjo et al. reported 44 patients with retinoblastoma at Dr. Soetomo Regional General Hospital. Patient characteristics included 61.36% males and 38.64% females, with an average age of 3.72 years (Soebagjo et al, 2020).

The diagnosis of an ocular tumor can be confirmed through various imaging studies and histopathological examination. Imaging studies include ultrasound, fluorescein angiography, computed tomography (CT), and magnetic resonance imaging (MRI) to determine the tumor's overall dimensions, configuration, location, presence of extraocular extension, and related features. Histopathological examination can be performed using various methods, such as fine-needle aspiration biopsy and frozen section analysis, to determine the type of tumor (Harsh and Mohan, 2020) (Vikram, Natario, and Mandeep, 2025).

Electrolytes are minerals dissolved in body fluids, water, and the bloodstream. Electrolytes are essential for basic life functions, such as maintaining electrical neutrality within cells and generating and transmitting action potentials in nerves and muscles. Electrolyte levels can become imbalanced, resulting in either high or low levels. High or low electrolyte levels can disrupt normal bodily functions. Important electrolytes include sodium, potassium, chloride, magnesium, calcium, phosphate, and bicarbonate (Anand, 2025).

Sodium (Na^+) and potassium (K^+) are among the most abundant cationic electrolytes in the body's extracellular fluid. Na^+ also plays a role in tumorigenesis through several mechanisms, such as membrane potential depolarization, pH regulation, and metabolic activity. Tumor progression is also influenced by Na^+ and K^+ levels through the processes of cell proliferation, migration, and invasion. A study conducted by Raghnhild in 2020 found that high levels of potassium and sodium can increase the risk of cancer, with the highest prevalence observed in prostate and nasopharyngeal cancers. A study conducted by Teymoori in 2024 found that a high potassium intake can reduce the risk of breast cancer (Dominik, Chan, and Shang, 2024) (Dominik, Chan, and Shang, 2021)

Based on the explanation above, sodium and potassium levels have been shown to influence carcinogenesis and tumor cell development in various organs. However, there have been no further studies on the relationship between sodium and potassium levels and the incidence of ocular tumors. This has prompted researchers to investigate further the relationship between sodium and potassium levels in the blood of patients with ocular tumors.

Method

This study is a cross-sectional study in which data were collected at a single point in time, with a research design aimed at determining the relationship between sodium and potassium levels and patients with ocular tumors at Prof Dr. Chairuddin P. Lubis USU Hospital and affiliated hospitals.

The study was conducted at the Eye Clinic of the Division of Oculoplastic Reconstruction and Oncology at Prof. Dr. Chairuddin P. Lubis USU Hospital and its affiliated hospitals, as well as at the USU Hospital Laboratory in Medan, after receiving approval from the Universitas Sumatera Utara Health Research Ethics Committee. The study period ran from January 2026 until the required sample size was reached.

The study population consisted of all patients with ocular tumors receiving treatment at the Eye Clinic of the Division of Oculoplastic Reconstruction and Oncology at Prof. Dr. Chairuddin P. Lubis USU Hospital and its affiliated hospitals. The control population (non-tumor) in this study consisted of all subjects with normal eyes within the Universitas Sumatera Utara Hospital system.

The sample size can be calculated using the formula for comparative numerical analysis. The sample of case population consisted of patients visiting the ophthalmology outpatient clinic at Prof. Dr. Chairuddin P. Lubis USU Hospital and affiliated hospitals with a diagnosis of an ocular tumor; patients with no history of tumor surgery previously. The sample of control population consisted of patients without ocular tumors or tumors in other organs; patients who are in good health and are not dehydrated. Exclusion criteria in this study

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were patients with heart disease who are taking antiarrhythmic medications; patients undergoing hemodialysis; patients taking diuretics; patients with gastroenteritis who are taking medications for diarrhea.

Blood potassium and sodium levels are measured by drawing a 3 mL venous blood sample from each patient. The sample is placed in a Biolyte Analyzer, which uses Ion-Selective Electrode (ISE) technology to detect potassium and sodium ions via selective electrodes. The potassium and sodium levels are recorded in mmol/L.

The collected data were analyzed in two stages: univariate analysis, which examined one variable at a time, and bivariate analysis, which assessed the relationship between two variables using an independent samples t-test if the data were normally distributed. If the data are not normally distributed, the Mann-Whitney test is used at a significance level of <0.05.

Result

This study involved 60 participants divided into two groups. The first group, consisting of 30 participants, comprised patients with ocular tumors receiving treatment at the Eye Clinic of the Division of Oculoplastic Reconstruction and Oncology at Prof Dr. Chairuddin P. Lubis USU Hospital and its affiliated hospitals. The second group consisted of 30 subjects with normal eyes from the surrounding community of the Universitas Sumatera Utara Hospital.

The demographic characteristics of the study participants, including gender and age, are presented in Table 1.

Table 1. Characteristics of the research subjects

Demographic Characteristics	Ocular Tumor (n=30)	Control (n=30)	p
Gender, n (%)			
Male	17 (56.7)	16 (53.3)	0.765
Female	13 (43.3)	14 (46.7)	
Age, years			
Average ± SD	41.23 ± 18.19	34.97 ± 17.07	0.219
Median (min – max)	44.5 (8–75)	28.5 (12–68)	

Based on Table 1, the gender distribution in the ocular tumor group was dominated by males, with 17 participants (56.7%), while females numbered 13 (43.3%). In the control group, there were 16 males (53.3%) and 14 females (46.7%). The median age in the eye tumor group was 44.5 years (range 8-75 years), higher than that of the control group, which was 28.5 years (range 12-68 years). However, statistical analysis showed no significant differences between the two groups based on either gender (p=0.765) or age (p=-0.219). Therefore, the two groups can be considered homogeneous and comparable, and demographic characteristics were nor confounding factors in this study.

The results of histopathological examinations of 30 ocular tumor specimens revealed various types of tumors with varying frequency distributions, as shown in Table 2.

Table 2. Distribution of Ocular Tumor Based on Histopathological Diagnosis

Type of Tumor	Frequency (n)	Percentage (%)
Squamous papilloma	5	16.7
Epidermal cyst	4	13.3
Squamous cell carcinoma	3	10.0
Basal cell carcinoma	2	6.7
Compound nevi	2	6.7
Conjunctival intraepithelial neoplasia	2	6.7
Myolipoma	2	6.7
Pyogenic granuloma	2	6.7
Veruca vulgaris	2	6.7
Benign lesion (papilloma impression)	1	3.3
Hemangioma dd glomangioma	1	3.3
Intradermal nevus	1	3.3
Nodular basal	1	3.3
Papilloma	1	3.3
Simple benign cyst	1	3.3
Total	30	100.0

Based on Table 2, among the 30 subjects in the ocular tumor group, various types of tumors with diverse histopathological characteristics were identified. The most common tumor type was squamous papilloma, found in 5 subjects (16.7%), followed by epidermal cysts in 4 subjects (13.3%) and squamous cell carcinoma in 3 subjects (10.0%). Several other tumor types were found in 2 subjects (6.7%) or 1 subject (3.3%), respectively. In general, benign tumors dominated this study, although several malignant tumors were also found, such as squamous cell carcinoma, basal cell carcinoma, conjunctival intraepithelial neoplasia, and nodular basal cell carcinoma, indicating a diverse spectrum of oculoplastic neoplasms in the study population.

The difference in serum sodium levels between the ocular tumor group and the control group was analyzed using the Mann-Whitney test, with the results presented in Table 3.

Table 3. Differences in Sodium Levels Between the Ocular Tumor and Control Groups

Variable	Ocular Tumor (n=30)	Control (n=30)	p
Sodium, mmol/L			
Average ± SD	146 ± 8.42	143.13 ± 2.97	0.061
Median (min – max)	144.5 (139-187)	142 (138-148)	

Based on Table 3, the ocular tumor group had descriptive statistics showing higher and more variable serum sodium levels than the control group, with mean values of 146 ± 8.42 mmol/L and 143.13 ± 2.97 mmol/L, respectively. However, the results of the Mann-Whitney test showed no statistically significant difference between the two groups ($p=0.061$; $p>0.05$), although the p-value approaching the significance threshold indicates a trend toward higher sodium levels in patients with ocular tumors, which requires further study with a larger sample size.

The difference in serum potassium levels between the ocular tumor group and the control group was analyzed using the Mann-Whitney test, with the results presented in Table 4.

Table 4. Differences in Potassium Levels Between the Ocular Tumor and Control Groups

Variable	Ocular Tumor (n=30)	Control (n=30)	p
Potassium, mmol/L			
Average ± SD	4.22 ± 0.53	4.3 ± 0.64	0.700
Median (min – max)	4.17 (3.5-5.58)	4.22 (3.6-5.58)	

Based on Table 4, serum potassium levels in the ocular tumor group and the control group showed nearly identical means, at 4.22 ± 0.53 mmol/L and 4.30 ± 0.64 mmol/L, respectively, with values still within the normal range. The results of the Mann-Whitney test showed no statistically significant difference between the two groups (p=0.700; p>0.05). Thus, serum potassium levels were considered homogeneous and did not indicate any dysregulation related to the ocular tumor condition.

DISCUSSION

The gender distribution in the ocular tumor and control groups was relatively comparable, with a slight predominance of males in both groups (56.7% vs 53.3%), and there was no statistically significant difference (p=0.765). This suggests that gender is not a major distinguishing factor in the analysis of serum sodium and potassium levels. These findings are partly consistent with the study by Lin et al., which reported a male predominance in malignant ocular and orbital tumors, although the difference in distribution in this study was likely influenced by the predominance of benign tumors and variations in tumor type and location (Lin et al, 2023).

Sharma et al. (2025) reported different findings in patients with ocular adnexal lesions: women outnumbered men, with women accounting for 56% and men for 43.8%. In that study, the majority of the lesions were also benign. Shrestha and Sayami (2021)also reported that eyelid lesions were more common in women, 57.8% in women and 42.2% in men, with benign lesions constituting the largest group.

The gender distribution in ocular tumors may vary across studies due to differences in lesion location, the proportion of benign and malignant tumors, geographic factors, environmental exposure, referral patterns, and sample size. In this study, there were no significant differences based on gender between the ocular tumor and control groups; therefore, gender is unlikely to be a major confounding factor in the comparison of serum sodium and potassium levels (Lin et al, 2023) (Sharma et al, 2025) (Shrestha and Sayami, 2021).

The ocular tumor group had a higher mean age than the control group (41.23 ± 18.19 vs 34.97 ± 17.07 years), but the difference was not statistically significant (p=0.219), indicating that the two groups were relatively homogeneous in terms of age. This finding is consistent with the study by Lin et al., which reported that the average age of patients with ocular surface and orbital tumors was around the fourth decade of life, with a higher age observed in malignant tumors compared to benign tumors. This consistency is likely influenced by the predominance of benign tumors, particularly squamous papillomas, in this study (Lin et al, 2023).

The findings of this study are consistent with those of Sharma et al., who reported a wide age range and a predominance of benign lesions in patients with ocular adnexal lesions. The difference in gender distribution, with Sharma et al. finding a predominance of females, is likely due to variations in the population, lesion location, predominant tumor type, and subject recruitment methods (Sharma et al, 2025).

Shimizu et al. reported a higher mean age for patients with ocular and orbital tumors than in this study, namely 62.9 ± 18.3 years. This difference is likely due to the higher proportion of malignant tumors in that study. In general, malignant ocular tumors are more common in older patients than benign tumors. Thus, the age distribution in this study is consistent with the range observed in previous studies, particularly since the tumor composition in this study was dominated by benign tumors (Lin et al, 2023) (Sharma et al, 2025) (Shimizu et al, 2021).

Histopathological examination of 30 subjects with ocular tumors revealed a wide variety of tumor types, with squamous papilloma being the most common (16.7%), followed by epidermal cysts (13.3%) and squamous cell carcinoma (10.0%). Overall, this study was dominated by benign tumors, while malignant tumors and premalignant lesions were found in smaller numbers. These findings are consistent with the study by Lin et al., which reported that the majority of ocular surface and orbital tumors are benign lesions, although the distribution of histopathological types may vary across populations and anatomical tumor locations (Lin et al, 2023).

Sharma et al. reported that epidermal cysts are the most common lesions of the ocular adnexa, accounting for 22.3%, followed by dermoid cysts. In this study, epidermal cysts ranked second in frequency after squamous papillomas. This similarity indicates that cystic lesions are one of the most frequently encountered histopathological groups among ocular and adnexal tumors or masses.

Shrestha and Sayami reported that benign eyelid lesions are more common than premalignant and malignant lesions. Commonly diagnosed benign lesions include melanocytic nevus, epidermal cyst, hemangioma, dermoid cyst, chalazion, and squamous papilloma. These findings support the results of this study, as several of the same diagnoses were also identified, namely epidermal cysts, hemangiomas, nevi, and squamous papillomas.

The predominance of benign tumors in this study should be taken into account when interpreting the serum sodium and potassium levels, as benign tumors are generally localized, grow slowly, and rarely cause systemic metabolic changes. Therefore, the changes in serum sodium and potassium levels observed in this study are unlikely to be significant enough to cause clinically meaningful electrolyte disturbances (Lin et al, 2023) (Sharma et al, 2025) (Shrestha and Sayami, 2021).

In this study, serum sodium levels in the ocular tumor group were descriptively higher than those in the control group. However, the difference was not statistically significant ($p=0.061$). Nevertheless, there was a trend toward increased sodium levels in the ocular tumor group. This finding is consistent with the study by Abdulaziz and Almehmadi, who reported higher serum sodium levels in cancer patients compared to healthy controls, thus supporting the possibility of electrolyte changes associated with the neoplastic process, even though this study did not reach statistical significance.

The differences in results compared with previous studies are likely due to the smaller sample size, the predominance of benign and localized ocular tumors, and the lower incidence of systemic metabolic disorders compared with systemic cancers. In addition, Falk et al. reported that potassium levels, but not sodium levels, were associated with an increased long-term risk of cancer.

Sodium is the primary cation in extracellular fluid and is tightly regulated to maintain fluid balance and physiological function. Therefore, changes in sodium levels within tumor tissue may not necessarily be reflected in changes in serum sodium levels, even though sodium continues to play a role in biological processes at the cellular level. A study by Leslie and Brackenbury explains that some epithelial tumors may have high sodium concentrations, which are associated with the activity of sodium channels and transporters, changes in pH, membrane depolarization, energy consumption, and the processes of tumor cell proliferation, migration, and invasion.

James et al. also demonstrated that sodium accumulation in breast cancer tissue may be associated with the degree of malignancy and response to therapy. Thus, sodium appears to better reflect local changes in tumor tissue than changes in peripheral serum.

Soll et al. demonstrated that sodium in the tumor microenvironment plays a role in enhancing the antitumor immune response. Therefore, the absence of differences in serum sodium levels in this study does not rule out the possibility of local sodium changes in tumor tissue. Thus, peripheral serum sodium may not be sensitive enough to reflect such changes.

The wider range of sodium levels in the ocular tumor group, with a maximum value of 187 mmol/L, indicates the presence of extreme values making the median a more representative measure than the mean. High sodium levels are likely influenced by various clinical and nonclinical factors, as electrolyte disturbances in cancer patients are multifactorial in nature (Berardi et al, 2019).

Thus, the sodium results in this study can be interpreted in two ways. In terms of direction of the change, this study is consistent with Abdulaziz and Almehmadi, as the sodium levels in the ocular tumor group were descriptively higher than those in the control group.

In this study, serum potassium levels in the ocular tumor and control groups were relatively similar, with no statistically significant difference (p=0.700). In contrast to the study by Abdulaziz and Almehmadi, which reported elevated potassium levels in cancer patients, this difference in results is likely due to the predominance of benign and localized ocular tumors, resulting in minimal systemic metabolic changes.

Falk et al. reported that serum potassium levels are associated with an increased long-term risk of cancer, which is likely related to potassium's role in cell proliferation. However, because their study used a prospective cohort design, the results cannot be directly compared with those of this study, which used a cross-sectional design.

Potassium is the primary intracellular cation and is tightly regulated. Therefore, changes in potassium levels in tumor tissue may not necessarily be reflected in serum levels. Nevertheless, potassium channels are known to play a role in the proliferation, migration, apoptosis, and immune response of tumor cells, making them potential targets for cancer therapy (Serrano-Novillo et al, 2019).

You et al. found that sodium and potassium intake were associated with lung cancer risk in large cohorts from the Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial and the Women's Health Initiative. Ahmadirad et al. also reported that a higher total potassium intake is associated with a reduced risk of breast cancer. This study shows that serum potassium levels do not play a significant role in the occurrence of ocular tumors. This is thought to be influenced by the predominance of benign tumors, the localized nature of the tumors, the strict regulation of serum potassium, and the possibility that changes in potassium levels occur more frequently in tumor tissue than in serum. Therefore, tissue-based assessment is more appropriate for evaluating the role of potassium in ocular tumors.

The limitations of this study include the small sample size and the imbalance in the number of patients with benign and malignant tumors, which may affect the mean sodium and potassium levels. The results indicate that serum sodium and potassium levels cannot yet be used as sole diagnostic biomarkers to distinguish patients with eye tumors from controls. However, testing for both remains important for assessing patients' general condition, particularly before surgery or other therapies, as electrolyte imbalances can increase clinical risk.

Conclusion

The mean serum sodium level in the tumor group was higher than in the control group (146 ± 8.42), but the difference was not statistically significant (p=0.061), so it cannot yet be used as a biomarker for ocular tumors. Serum potassium levels in both groups were also within the normal range and did not differ significantly (p=0.700), indicating no potassium dysregulation associated with the occurrence of ocular tumors in this study.

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