Association Between Preoperative Systemic Inflammatory Indices and Visual Outcomes After Cataract Surgery

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AIM: To evaluate the association between preoperative systemic inflammatory indices (systemic immune-inflammation index [SII], systemic inflammation response index [SIRI], and aggregate index of systemic inflammation [AISI]) and poor visual outcomes following cataract surgery.

METHODS: This retrospective study included 240 patients who underwent cataract surgery between April 2022 and June 2025. SII, SIRI, and AISI were calculated from complete blood counts obtained within 7 days preoperatively. Poor visual outcome at 4 weeks postoperatively was analyzed using multivariable logistic regression and restricted cubic spline models, with adjustment for potential confounders.

RESULTS: The mean age was 69 years, and 67.1% of participants were female. SII demonstrated a nonlinear association with poor postoperative visual outcomes (p for nonlinearity = 0.029), with increased odds observed at SII values of 500–1000 and at extremely low levels. Compared with the lowest tertile, the highest SII tertile was associated with a significantly increased risk (adjusted odds ratio [OR] 2.790, 95% confidence interval [CI] 1.209–6.615; p = 0.018). After adjustment for sex, body mass index (BMI), and intraocular pressure, SIRI (tertile 3 vs. tertile 1: OR 2.019, 95% CI 1.035–3.997; p = 0.041) and AISI (tertile 2 vs. tertile 1: OR 1.977, 95% CI 1.017–3.898; p = 0.046) were also associated with poor visual outcomes. In multivariable analyses, SII and AISI remained independently associated with poor postoperative vision (OR 2.790, 95% CI 1.209–6.615; p = 0.018; OR 2.104, 95% CI 1.016–4.432; p = 0.047).

CONCLUSIONS: Preoperative SII, SIRI, and AISI were significantly associated with worse short-term visual outcomes after cataract surgery. These indices, particularly SII and AISI, may provide clinically useful information for perioperative risk stratification. Further prospective validation studies and investigation of targeted anti-inflammatory strategies are warranted.

Keywords: cataract surgery; postoperative visual outcomes; systemic inflammatory indices; retrospective study

Introduction

Cataract remains the leading cause of reversible blindness worldwide, accounting for approximately 51% of global blindness cases, with cataract surgery representing the definitive treatment for visual restoration [1]. Despite advances in surgical techniques and postoperative care, approximately 10–15% of patients experience suboptimal visual recovery, often due to postoperative inflammation, cystoid macular edema, or delayed healing, which can significantly impair quality of life [2]. Early identification of individuals at increased risk for poor visual outcomes is therefore essential to optimize perioperative management and improve prognostic accuracy.

Systemic inflammation has been increasingly recognized as a key factor influencing outcomes in various ophthalmic conditions and postoperative recovery processes [3]. An elevated systemic inflammatory burden may exacerbate ocular tissue damage and impair postoperative healing following cataract surgery. Postoperative complications such as cystoid macular edema, reported in 4–10% of cases [4], are known to adversely affect visual acuity. However, reliable, readily accessible biomarkers to quantify preoperative systemic inflammation and predict postoperative visual prognosis remain limited. Recently, hematological inflammatory indices, including the systemic immune-inflammation index (SII), systemic inflammation response index (SIRI), and aggregate index of systemic inflammation (AISI), have emerged as promising indicators [5]. These composite indices integrate neutrophil, lymphocyte, monocyte, and

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platelet counts to provide a more comprehensive assessment of systemic inflammatory status. Compared with traditional single-parameter markers, these composite indices may offer improved prognostic performance.

Elevated levels of SII, SIRI, and AISI have been associated with adverse outcomes in cardiovascular diseases, malignancies, and, increasingly, ocular disorders such as diabetic retinopathy and age-related macular degeneration [6]. For example, higher SII levels have been correlated with disease severity and visual impairment in diabetic retinopathy, while increased SIRI and AISI levels have been linked to poorer outcomes in patients undergoing vitrectomy for proliferative diabetic retinopathy and retinal vein occlusion [7,8]. In the context of cataract, however, existing research has primarily focused on local ocular inflammatory mechanisms or on cross-sectional associations between systemic inflammatory indices and cataract prevalence, rather than on postoperative visual recovery.

To date, evidence evaluating the relationship between preoperative systemic inflammatory profiles and postoperative visual outcomes following ocular surgery remains limited. In particular, the prognostic value of readily available composite hematological inflammatory indices in real-world surgical settings has not been fully established. Given the potential role of systemic inflammation in postoperative healing and visual recovery, the present study aimed to investigate the association between preoperative SII, SIRI, and AISI and poor visual outcomes after cataract surgery. By addressing this knowledge gap, the findings may facilitate early identification of patients at higher risk of suboptimal visual prognosis and support more individualized perioperative management strategies.

Methods

Study Design and Participants

This was a single-center, retrospective observational cohort study conducted at the Department of Ophthalmology, The First People's Hospital of Zunyi, Guizhou, China. The study included newly diagnosed patients with age-related cataract (ARC) admitted between April 2022 and June 2025. The study protocol was approved by the Ethics Committee of The First People's Hospital of Zunyi (IRB Number: 2025-1-662) and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all patients prior to inclusion in the study.

Patients were eligible if they met the following inclusion criteria: age $\geq$50 years; newly diagnosed ARC based on slit-lamp examination and Lens Opacities Classification System (LOCS) III classification; scheduled for cataract surgery at our hospital; availability of complete medical records; and provision of informed consent. Exclusion criteria were as follows: history of other ocular diseases affecting visual prognosis, including autoimmune disease, malignancy, thyroid dysfunction, systemic infections, hepatic or renal disease, or chronic inflammatory conditions; intraoperative or pre-existing ocular conditions such as high myopia, uveitis, glaucoma, ocular trauma, or prior eye surgery; systemic inflammatory or autoimmune disorders; cognitive or psychiatric disorders; and incomplete clinical data.

Surgery Procedures

All procedures were performed by the same experienced ophthalmologist, using a standardized phacoemulsification technique under local anesthesia. A clear corneal incision was created, followed by continuous curvilinear capsulorhexis, hydrodissection, and phacoemulsification of the lens nucleus. A foldable intraocular lens (IOL) was subsequently implanted into the capsular bag.

Postoperative care consisted of a standardized regimen: topical tobramycin-dexamethasone eye drops six times daily, tobramycin-dexamethasone ointment once nightly, pranoprofen eye drops four times daily, and sodium hyaluronate eye drops four times daily. Patients were re-evaluated two weeks postoperatively, and treatment was adjusted individually based on clinical response.

Outcomes Measurement

The primary outcome was poor postoperative visual recovery, defined as an uncorrected visual acuity (UCVA) worse than 20/40 (logMAR $\geq$ 0.3; MAR, minimum angle of resolution) at 1 month after surgery. This is a commonly used threshold for functional visual impairment. UCVA was assessed by trained ophthalmologists using a standardized Snellen chart and converted to logMAR units for statistical analysis.

In this retrospective study, UCVA was selected as the primary endpoint to reflect real-world functional visual recovery and patient satisfaction. Furthermore, UCVA provided a more complete and consistent dataset, as it was more uniformly recorded in the clinical database compared with best-corrected visual acuity (BCVA).

Measurement of Inflammatory Biomarkers

Peripheral venous blood samples were collected within 7 days prior to cataract surgery as part of routine preoperative evaluation. All samples were processed according to standardized clinical laboratory protocols, and hematologic parameters, including neutrophil, lymphocyte, monocyte, and platelet counts, were measured using automated blood analyzers.

Systemic inflammatory biomarkers were calculated to reflect different dimensions of the host immune-inflammatory response. SII was calculated as platelet count $\times$ neutrophil count/lymphocyte count. The SIRI was calculated as neutrophil count $\times$ monocyte count/lymphocyte count. The AISI was calculated as neutrophil count $\times$ monocyte count $\times$ platelet count/lymphocyte count.

All biomarkers were derived from absolute cell counts and analyzed as continuous and categorical (tertiles) variables

Table 1. Baseline characteristics of patients stratified by visual outcomes at 4 weeks postoperatively.

Characteristics	Total (n = 240)	Poor vision (logMAR ≥0.30) (n = 104)	Good vision (logMAR <0.30) (n = 136)	*p*-value
Gender, n (%)				0.948
Male	79 (32.9)	34 (32.7)	45 (33.1)	
Female	161 (67.1)	70 (67.3)	91 (66.9)	
Age, year, median [IQR]	69.00 [60.75–74.00]	72.00 [65.00–78.25]	67.00 [60.00–72.00]	<0.001
BMI, kg/m^2, mean ± SD	23.22 (3.08)	22.46 (2.95)	23.81 (3.06)	0.001
WBC, $\times 10^9$/L, median [IQR]	5.60 [4.90–6.82]	5.75 [4.88–6.80]	5.50 [4.90–6.90]	0.951
Platelet, $\times 10^9$/L, median [IQR]	203.50 [168.75–250.50]	207.00 [169.00–247.50]	201.50 [168.75–261.50]	0.834
Lymphocyte, $\times 10^9$/L, median [IQR]	1.60 [1.20–1.90]	1.50 [1.20–1.90]	1.60 [1.30–2.00]	0.030
Neutrophil, $\times 10^9$/L, median [IQR]	3.55 [2.80–4.40]	3.70 [2.90–4.43]	3.40 [2.70–4.30]	0.335
Monocyte, $\times 10^9$/L, median [IQR]	0.40 [0.30–0.50]	0.39 [0.30–0.50]	0.40 [0.30–0.48]	0.642
Hemoglobin, g/L, median [IQR]	134.00 [125.00–145.00]	131.00 [124.75–142.25]	136.00 [126.00–146.00]	0.078
Creatinine[a], μmol/L, median [IQR]	68.20 [60.32–77.90]	69.10 [60.60–79.90]	68.10 [59.70–76.60]	0.371
Fasting glucose[b], mmol/L, median [IQR]	5.20 [4.70–5.80]	5.20 [4.70–5.80]	5.20 [4.70–5.80]	0.960
Temperature, °C, median [IQR]	36.50 [36.30–36.60]	36.50 [36.30–36.60]	36.50 [36.30–36.60]	0.799
Pulse, beats/min, mean ± SD	76.47 (10.26)	76.72 (9.75)	76.28 (10.66)	0.742
Respiratory rate, breaths/min, median [IQR]	20.00 [19.00–20.00]	20.00 [19.00–20.00]	20.00 [19.00–20.00]	0.199
SBP, mmHg, median [IQR]	131.00 [120.00–147.00]	132.00 [115.75–148.00]	131.00 [123.50–143.00]	0.742
DBP, mmHg, mean ± SD	79.58 (10.73)	77.77 (11.40)	80.96 (10.01)	0.022
SII, $\times 10^9$/L, median [IQR]	458.26 [318.69–649.78]	490.83 [327.66–713.30]	434.75 [301.93–571.39]	0.091
SIRI, $\times 10^9$/L, median [IQR]	0.86 [0.58–1.27]	0.89 [0.62–1.38]	0.84 [0.56–1.19]	0.196
AISI, $\times 10^9$/L, median [IQR]	170.78 [114.34–275.37]	184.13 [130.89–301.16]	158.20 [109.46–269.02]	0.271
NLR, median [IQR]	2.27 [1.68–2.91]	2.48 [1.72–3.11]	2.09 [1.61–2.70]	0.025
PLR, median [IQR]	131.12 [100.00–165.17]	134.00 [105.32–165.17]	126.88 [97.02–164.79]	0.156
Eye laterality, n (%)				0.549
Right eye	123 (51.3)	51 (49.0)	72 (52.9)	
Left eye	117 (48.8)	53 (51.0)	64 (47.1)	
Preoperative UCVA (logMAR), median [IQR]	0.82 [0.52–1.30]	0.92 [0.60–1.30]	0.76 [0.52–1.00]	0.002
Intraocular pressure, mmHg, median [IQR]	15.00 [14.00–17.00]	15.00 [13.00–16.00]	15.00 [14.00–18.00]	0.020
Axis length[c] (IOLMaster), mm, median [IQR]	23.29 [22.82–23.88]	23.22 [22.81–23.83]	23.42 [22.85–23.93]	0.223
Axial length[d] (A-scan), mm, median [IQR]	23.35 [22.84–24.00]	23.26 [22.63–23.94]	23.41 [22.94–24.01]	0.242
Lens nuclear hardness grade, n (%)				0.016
II	45 (18.8)	12 (11.5)	33 (24.3)	
III	153 (63.8)	68 (65.4)	85 (62.5)	
IV	36 (15.0)	19 (18.3)	17 (12.5)	
V	6 (2.5)	5 (4.8)	1 (0.7)	

Notes: Data are presented as mean ± standard deviation (SD) or median (interquartile range [IQR]), as appropriate. Normality was assessed using the Shapiro-Wilk test. Group comparisons were performed using Student's *t*-test or the Mann-Whitney *U* test for continuous variables, and the chi-square (χ^2) test for categorical variables.

[a] n = 218; [b] n = 230; [c] n = 222; [d] n = 239.

MAR, minimum angle of resolution; BMI, body mass index; WBC, white blood cell; SBP, systolic blood pressure; DBP, diastolic blood pressure; SII, systemic immune-inflammation index; SIRI, systemic inflammation response index; AISI, aggregate index of systemic inflammation; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; UCVA, uncorrected visual acuity.

for regression analyses. The definitions and formulas for the biomarkers are provided in **Supplementary Table 1**.

Confounding Factors

Potential confounding factors were extracted from medical records and included age, sex, body mass index (BMI), hypertension, diabetes mellitus, smoking status, preoperative uncorrected visual acuity, axial length, and intraocular pressure. Axial length was measured using both the IOLMaster 500 and A-scan ultrasound for all participants. However, measurements were not obtainable in patients with dense subcapsular or nuclear cataracts. These variables were selected in advance of the study based on evidence from their potential clinical relevance to postoperative visual outcomes.

Statistical Analysis

Continuous variables were assessed for normality by using the Shapiro-Wilk test. Baseline characteristics were presented as mean ± standard deviation (SD) or median (interquartile range [IQR]) for continuous variables and as counts (percentages, n [%]) for categorical variables. Normally distributed variables were compared using the Student's *t*-test, while non-normally distributed variables were compared using appropriate nonparametric tests. Categorical variables were compared using the chi-square test.

Participants were categorized into three groups based on their tertiles of SII, SIRI, and AISI levels. Accordingly, both continuous and categorical forms of these indices were evaluated in separate logistic regression models. The associations between each inflammatory index and poor visual outcome were assessed using logistic regression models, and odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. Four models were constructed: Model 1, unadjusted; Model 2, adjusted for sex, BMI, and intraocular pressure; Model 3, fully adjusted for all potential confounders (age, sex, BMI, intraocular pressure, platelet count, baseline visual acuity, and nuclear hardness); and Model 4, adjusted for age, sex, BMI, intraocular pressure, baseline visual acuity, and nuclear hardness.

In the multivariable logistic regression analyses, there were 104 cases of poor vision. With seven independent variables included in the final model, the events-per-variable ratio was 14.9. Covariates were selected *a priori* based on clinical relevance to account for potential confounding factors that may influence postoperative visual outcomes.

Restricted cubic spline models (crude model) with four knots placed at the 5th, 35th, 65th, and 95th percentiles were applied to evaluate potential nonlinear relationships. The Wald chi-square test was used to evaluate nonlinearity. Subgroup analyses stratified by age, BMI, and intraocular pressure were conducted to evaluate the robustness of the findings. Subgroup cutoffs were determined based on the distribution of the characteristics of the study population. BMI (23.30 kg/m^2) and baseline intraocular pressure (15.00 mmHg) were dichotomized at the median values, while age was stratified at 70 years as a clinically interpretable cutoff close to the median. Interaction *p*-values were calculated by using the likelihood ratio test.

All analyses were conducted using a complete-cases approach. Statistical analyses were performed using R software (version 4.5.1; R Foundation for Statistical Computing, Vienna, Austria). All tests were two-sided, and *p*-values < 0.05 were considered statistically significant.

Results

A total of 240 patients were included in this study. Among them, 104 (43.33%) exhibited poor postoperative visual outcomes (logMAR $\geq$0.30) at 4 weeks postoperatively based on UCVA assessment. The median age in the poor vision group was 72 years (IQR: 65.00–78.25 years), compared with 67 years (IQR: 60.00–72.00 years) in the good vision group ($p < 0.001$) (Table 1). The proportion of females was comparable between groups, accounting for 67.3% (n = 70) in the poor vision group and 66.9% (n = 91) in the good vision group ($p = 0.948$). Compared with patients with good postoperative vision, those with poor vision had significantly lower BMI, diastolic blood pressure (DBP), and lymphocyte count, as well as higher neutrophil-to-lymphocyte ratio (NLR) values (all *p*-values < 0.05). Baseline visual acuity was also significantly worse in the poor vision group (median logMAR: 0.92, IQR: 0.60–1.30) compared with the good vision group (median logMAR: 0.76, IQR: 0.52–1.00, $p = 0.002$). There was a significant difference in the distribution of lens nucleus hardness grades between the two groups ($p = 0.016$). Additionally, intraocular pressure was slightly lower in patients with poor postoperative vision ($p = 0.020$).

Univariable logistic regression analysis showed that older age, lower BMI, higher lens nuclear hardness grade, lower diastolic blood pressure (DBP), lower lymphocyte count, lower intraocular pressure, and higher levels of SII and SIRI were significantly associated with increased odds of poor postoperative vision (all $p < 0.05$; Table 2). Compared with patients in the lowest tertile of SII, those in the highest tertile exhibited significantly higher odds of poor postoperative vision (OR = 1.937, 95% CI: 1.035–3.666; $p = 0.040$). Similarly, patients in the highest tertile of SIRI showed an increased odds of poor postoperative vision (OR = 1.885, 95% CI: 1.007–3.568; $p = 0.049$). In contrast, AISI levels were not significantly associated with poor postoperative vision in either continuous or categorical analyses (both $p > 0.05$). After adjustment for sex, BMI, and intraocular pressure, higher levels of SIRI (tertile 3) and AISI (tertile 2) were significantly associated with poor postoperative vision (OR = 2.019, 95% CI: 1.035–3.997; $p = 0.041$; and OR = 1.977, 95% CI: 1.017–3.898; $p = 0.046$, respectively).

After further adjustment for age, platelet count, baseline preoperative vision, and lens nuclear hardness grade (Model 3), tertile 3 of SII and tertile 2 of AISI remained significantly associated with poor postoperative vision (both $p < 0.05$). However, SII lost statistical significance after adjustment in Model 2 (highest tertile: OR = 1.784, 95% CI: 0.929–3.454; $p = 0.083$; Table 3), suggesting potential confounding or collinearity effects.

Restricted cubic spline analysis indicated a statistically significant nonlinear (approximately S-shaped) relationship between SII and the odds of poor postoperative vision (*p* for nonlinearity = 0.029; Fig. 1A–C). Specifically, lower odds were observed at SII levels below 500, although extremely low SII values were also associated with increased risk of poor vision. The odds of poor vision increased progressively as SII rose from 500 to 1000, followed by a modest decline, although remaining elevated relative to the lower ranges.

Table 2. Univariable logistic regression analysis of risk factors of poor visual outcome at 4 weeks postoperatively.

Variable	OR (95% CI)	*p*-value
Gender		
Female	Ref.	
Male	0.982 (0.568–1.689)	0.948
Age, years		
Continuous variable	1.079 (1.045–1.116)	<0.001
<70	Ref.	
≥70	2.667 (1.584–4.541)	<0.001
BMI, kg/m^2	0.861 (0.786–0.940)	0.001
WBC, $\times 10^9$/L	0.951 (0.820–1.099)	0.500
Platelet, $\times 10^9$/L	0.998 (0.995–1.002)	0.328
Lymphocyte, $\times 10^9$/L	0.572 (0.341–0.941)	0.030
Neutrophil, $\times 10^9$/L	1.000 (0.845–1.179)	0.999
Monocyte, $\times 10^9$/L	0.617 (0.126–1.345)	0.429
Hemoglobin, g/L	0.987 (0.971–1.002)	0.091
Creatinine[a], μmol/L	1.012 (0.996–1.028)	0.145
Fasting glucose[b], mmol/L	1.041 (0.858–1.263)	0.677
SBP, mmHg	0.999 (0.986–1.014)	0.940
DBP, mmHg	0.972 (0.947–0.996)	0.024
SII, $\times 10^9$/L		
Continuous variable (per 15-unit increase)	1.000 (0.993–1.006)	0.892
Tertile 1	Ref.	
Tertile 2	1.054 (0.556–2.000)	0.871
Tertile 3	1.937 (1.035–3.666)	0.040
SIRI, $\times 10^9$/L		
Continuous variable (per 15-unit increase)	2.550 (0.052–134.863)	0.630
Tertile 1	Ref.	
Tertile 2	1.355 (0.718–2.570)	0.350
Tertile 3	1.885 (1.007–3.568)	0.049
AISI, $\times 10^9$/L		
Continuous variable (per 15-unit increase)	0.998 (0.986–1.008)	0.677
Tertile 1	Ref.	
Tertile 2	1.673 (0.892–3.168)	0.111
Tertile 3	1.439 (0.765–2.725)	0.261
NLR, $\times 10^9$/L	1.114 (0.952–1.320)	0.187
PLR, $\times 10^9$/L	1.001 (0.997–1.005)	0.598
Intraocular pressure, mmHg	0.893 (0.811–0.979)	0.018
Axis length[c] (IOLMaster), mm	1.036 (0.826–1.298)	0.753
Axial length[d] (A-scan), mm	1.058 (0.873–1.288)	0.559
Lens nuclear hardness grade		
II	Ref.	
III	2.200 (1.080–4.735)	0.035
IV	3.074 (1.230–7.979)	0.018
V	13.750 (1.962–278.138)	0.022

Notes: OR, odds ratio; CI, confidence interval. Continuous variables are modeled per-unit increases unless otherwise specified.

[a] n = 218; [b] n = 230; [c] n = 222; [d] n = 239.

In a subsequent model adjusting for additional confounders including age, platelet count, and baseline vision, only SII remained independently associated with poor postoperative vision (highest tertile: OR = 2.704, 95% CI: 1.186–6.321; $p = 0.019$), while the association for AISI (tertile 2) was of borderline statistical significance (OR = 2.036, 95% CI: 0.988–4.264; $p = 0.056$). Notably, exclusion of platelet count from the model resulted in loss of statistical significance for all associations. The only borderline finding was observed for continuous AISI and poor vision ($p = 0.099$), which may reach statistical significance in a larger sample.

Table 3. Multivariable associations of SII, SIRI, and AISI with poor postoperative vision after cataract surgery.

Variable	Model 1		Model 2		Model 3		Model 4	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
SII, $\times 10^9$/L								
Continuous (per 15-unit increase)	1.000 (0.993–1.006)	0.892	0.998 (0.991–1.005)	0.554	0.999 (0.988–1.008)	0.830	0.995 (0.987–1.002)	0.210
Tertile 1	Ref.		Ref.		Ref.		Ref.	
Tertile 2	1.054 (0.556–2.000)	0.871	1.117 (0.579–2.163)	0.740	1.218 (0.592–2.512)	0.592	1.025 (0.508–2.067)	0.944
Tertile 3	1.937 (1.035–3.666)	0.040	1.784 (0.929–3.454)	0.083	2.790 (1.209–6.615)	0.018	1.516 (0.749–3.082)	0.247
SIRI, $\times 10^9$/L								
Continuous (per 15-unit increase)	2.550 (0.052–134.863)	0.630	1.569 (0.025–115.32)	0.830	0.416 (0.002–74.057)	0.744	0.100 (0.001–12.478)	0.352
Tertile 1	Ref.		Ref.		Ref.		Ref.	
Tertile 2	1.355 (0.718–2.570)	0.350	1.506 (0.776–2.951)	0.228	1.488 (0.722–3.091)	0.283	1.318 (0.648–2.695)	0.446
Tertile 3	1.885 (1.007–3.568)	0.049	2.019 (1.035–3.997)	0.041	1.502 (0.689–3.292)	0.306	1.256 (0.592–2.658)	0.550
AISI, $\times 10^9$/L								
Continuous (per 15-unit increase)	0.998 (0.986–1.008)	0.677	0.995 (0.984–1.006)	0.395	0.993 (0.975–1.010)	0.454	0.990 (0.976–1.001)	0.099
Tertile 1	Ref.		Ref.		Ref.		Ref.	
Tertile 2	1.673 (0.892–3.168)	0.111	1.977 (1.017–3.898)	0.046	2.104 (1.016–4.432)	0.047	1.805 (0.892–3.700)	0.102
Tertile 3	1.439 (0.765–2.725)	0.261	1.498 (0.769–2.943)	0.237	1.526 (0.656–3.580)	0.372	1.035 (0.496–2.149)	0.927

Model 1: Unadjusted.

Model 2: Adjusted for sex, BMI, and intraocular pressure.

Model 3: Model 2 + age, platelet count, baseline preoperative UCVA, and lens nuclear hardness grade.

Model 4: Model 2 + age, baseline preoperative UCVA, and lens nuclear hardness grade.

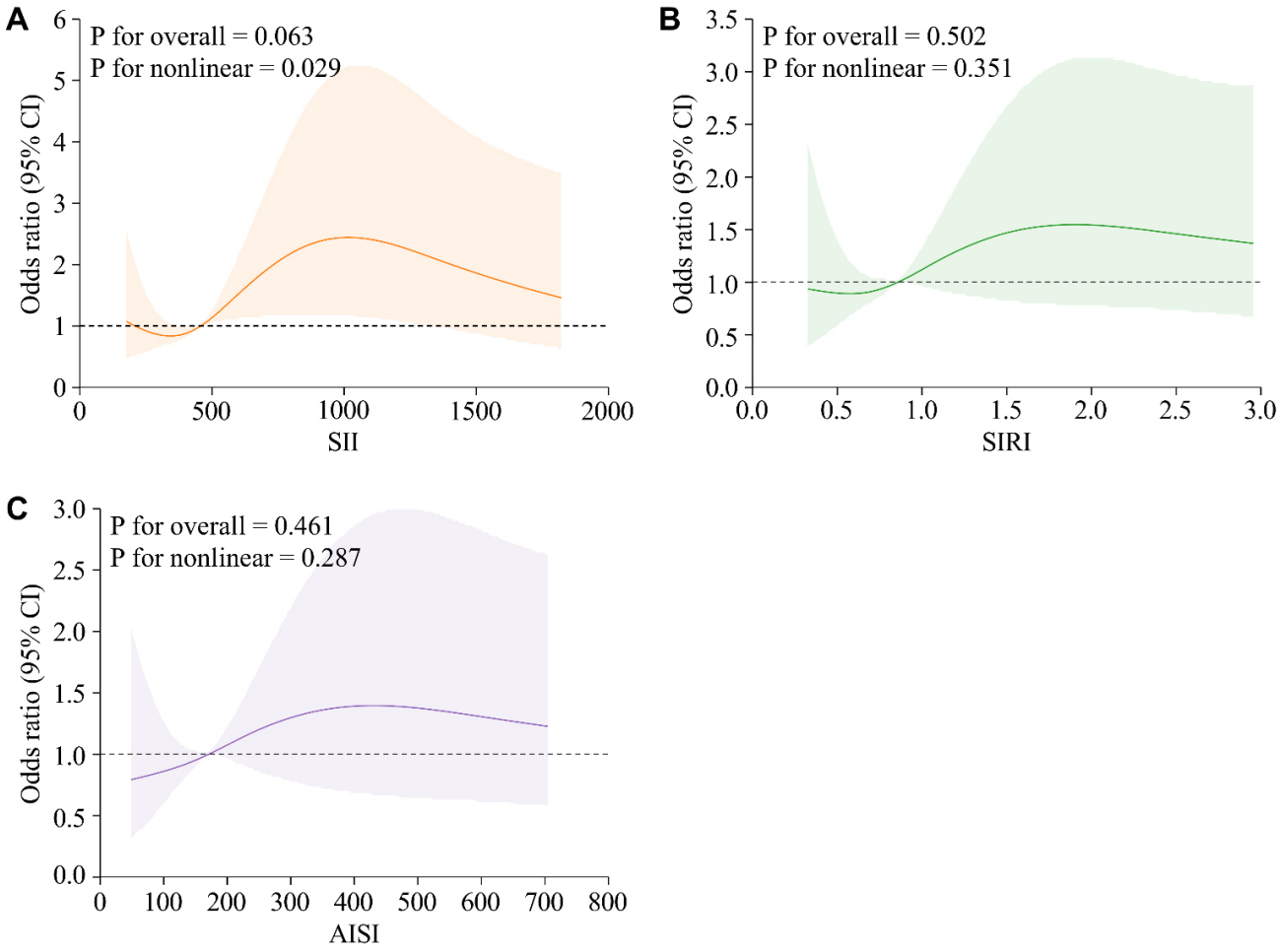

Fig. 1. Association between systemic inflammatory indices and postoperative visual impairment. Restricted cubic spline analyses illustrating the nonlinear relationship between SII (A), SIRI (B), and AISI (C) and the risk of poor postoperative vision. Solid lines represent the estimated odds ratios (ORs), and the shaded areas indicate the 95% confidential intervals (CIs). The horizontal dashed line represents the reference value (OR = 1). *p*-values for nonlinearity were evaluated using the Wald chi-square test. All spline models were unadjusted (crude models).

Additionally, subgroup analyses stratified by age, BMI, and intraocular pressure showed no evidence of effect modification, with no statistically significant interactions observed (all p for interaction > 0.05; Table 4). These findings indicate that the observed associations were consistent across clinically relevant subgroups.

Discussion

In this retrospective study, we identified a significant nonlinear association between SII and early postoperative UCVA following cataract surgery, characterized by a horizontal S-shaped curve. Specifically, the odds of poor postoperative vision increased as SII rose from 500 to 1000, while lower odds were observed below 500. However, extremely low SII values were also associated with increased risk. This pattern suggests that both excessive and insufficient systemic inflammatory responses may adversely influence visual recovery. After adjustment for potential confounders, SII and AISI remained significantly associated with poor visual outcomes, whereas associations for other indices were less consistent, potentially reflecting limited statistical power and residual confounding inherent to this retrospective design.

SII is a composite biomarker reflecting systemic proinflammatory and prothrombotic status driven by elevated neutrophil and platelet counts alongside reduced lymphocyte levels. In the present analysis, higher SII was independently associated with increased odds of poor postoperative vision. This finding is biologically plausible and aligns with previous evidence linking elevated SII to adverse outcomes in inflammatory and vascular conditions. For example, recent evidence demonstrates that an elevated pre-operative SII is a significant predictor for the development of pseudophakic cystoid macular edema, a common cause of suboptimal visual recovery following cataract surgery [9].

Human studies have also indicated that higher SII levels are associated with poorer visual recovery in conditions such as endogenous endophthalmitis, pseudophakic cystoid

Table 4. Subgroup analyses of associations between inflammatory indices and poor postoperative vision.

Inflammatory markers	Subgroup	Model 2	
		OR (95% CI)	*p* for interaction
SII (per 10-unit increase), $\times 10^9$/L	Age		0.630
	<70 years	0.996 (0.985–1.006)	
	≥70 years	0.999 (0.994–1.004)	
	BMI		0.433
	<23.30 kg/m^2	0.998 (0.992–1.003)	
	≥23.30 kg/m^2	1.002 (0.993–1.011)	
	Intraocular pressure		0.382
	<15.00 mmHg	0.998 (0.988–1.004)	
	≥15.00 mmHg	1.002 (0.996–1.007)	
SIRI (per 10-unit increase), $\times 10^9$/L	Age		0.293
	<70 years	0.101 (0.000–10.083)	
	≥70 years	2.627 (0.084–144.85)	
	BMI		0.797
	<23.30 kg/m^2	1.894 (0.072–71.271)	
	≥23.30 kg/m^2	0.926 (0.005–71.688)	
	Intraocular pressure		0.534
	<15.00 mmHg	0.497 (0.002–84.425)	
	≥15.00 mmHg	3.155 (0.153–80.227)	
AISI (per 10-unit increase), $\times 10^9$/L	Age		0.323
	<70 years	0.988 (0.961–1.006)	
	≥70 years	0.998 (0.990–1.006)	
	BMI		0.977
	<23.30 kg/m^2	0.997 (0.989–1.005)	
	≥23.30 kg/m^2	0.997 (0.976–1.014)	
	Intraocular pressure		0.525
	<15.00 mmHg	0.996 (0.982–1.006)	
	≥15.00 mmHg	1.001 (0.991–1.010)	

macular edema, and diabetic retinopathy, with evidence showing that elevated SII correlates with disease progression, increased risk of complications, and reduced postoperative visual acuity [6,9,10]. Our findings are further supported by emerging epidemiological evidence linking systemic inflammatory indices with ocular diseases, particularly cataract-related outcomes. The large population-based study using National Health and Nutrition Examination Survey (NHANES) data has demonstrated that elevated SII is significantly associated with increased cataract prevalence, with nonlinear or threshold effects observed in spline analyses [11]. Similarly, the cross-sectional study has reported that higher SII levels ($>500 \times 10^9$/L) are independently associated with cataract risk, supporting the role of systemic inflammatory burden in lens pathology and visual impairment [12].

Beyond disease occurrence, emerging evidence indicates that systemic inflammatory markers are also associated with postoperative complications following cataract surgery. In pseudophakic systoid macular edema, a key cause of suboptimal visual recovery, inflammatory indices such as SII and SIRI are elevated, and SIRI has demonstrated predictive value for postoperative edema development [13]. Moreover, persistent elevation of intraocular inflammatory cytokines long after cataract surgery further highlights the sustained inflammatory activity within the postoperative ocular microenvironment. Taken together, these findings support a bidirectional interaction between systemic inflammation and local ocular inflammatory processes, which may contribute to variability in early postoperative visual outcomes. However, direct evidence specifically addressing the predictive role of systemic inflammatory indices for visual recovery after cataract surgery remains limited.

The nonlinear relationship observed in this study is also consistent with emerging evidence demonstrating complex, nonlinear associations between systemic inflammatory indices and ocular diseases. Restricted cubic spline analyses have identified U-shaped or threshold-dependent relationships between SII/SIRI and conditions such as age-related macular degeneration and diabetic retinopathy [14]. These findings are consistent with the S-shaped association observed in the present study, reinforcing the concept that an optimal inflammatory balance may be required for physiological recovery, while both hypo-inflammatory and hyper-inflammatory states may be detrimental. Clinically, this

suggests that not only elevated inflammatory states but also abnormally low inflammatory profiles may be associated with suboptimal recovery. Consequently, preoperative risk stratification should not focus exclusively on elevated inflammatory markers; rather, patients at either extreme of the SII distribution may require closer postoperative monitoring or individualized anti-inflammatory strategies to optimize visual outcomes.

In contrast to SII, SIRI and AISI showed weaker and less consistent associations with postoperative visual outcomes across multivariable models in this retrospective cohort. Although these indices showed potential associations in univariable analyses, their effects were attenuated after full adjustment. This instability suggests that, in the acute postoperative setting following cataract surgery, neutrophil- and platelet-mediated pathways may play a more dominant role in shaping the ocular inflammatory environment than monocyte-driven pathways, as emphasized by SIRI. Although SIRI has been associated with cataract risk in specific populations, such as patients with cardiometabolic syndrome, these associations appear relatively modest and context-dependent [15]. Similarly, while SIRI has demonstrated some utility in relation to postoperative complications such as Irvine-Gass syndrome, its overall discriminatory performance remains limited [13]. The variability in statistical significance of these markers across models underscores that, while systemic inflammation is a relevant factor, its independent predictive value remains context-dependent and warrants further validation in larger, prospective studies.

AISI reflects a more comprehensive inflammatory profile by integrating multiple leukocyte and platelet parameters. In the present study, AISI was not significantly associated with poor postoperative vision in univariable analysis. However, a significant association was observed in a specific tertile after partial adjustment, with a borderline association in the fully adjusted model, potentially reflecting limited statistical power due to the relatively small sample size. A previous study has reported that AISI is associated with adverse outcomes in systemic conditions such as sepsis, although its application in ophthalmology remains limited [16]. Compared with SII, AISI appears to have lower predictive specificity for vascular-related outcomes, likely due to its broader representation of systemic inflammation [17]. Additionally, AISI-related profiles reflect generalized tissue damage but lack specificity for ocular pathology [18]. Although integration of neutrophil, platelet count, and monocyte mediators captures amplified inflammatory responses, it may not adequately reflect the more targeted impact of neutrophil- or platelet-specific pathways on retinal and ocular tissues [18,19]. These findings suggest that the broad and composite nature of AISI may reduce its utility in predicting localized postoperative outcomes following cataract surgery.

Our findings suggest that preoperative SII serves as a more reliable indicator of early postoperative outcomes than SIRI or AISI, likely because it more accurately reflects neutrophil-mediated pathways involved in the acute ocular inflammatory response. The clinical relevance of the observed nonlinear association is significant, as it suggests that risk stratification should not be limited to hyperinflammatory states. Instead, patients at both extremes of the inflammatory spectrum may require closer monitoring or personalized anti-inflammatory strategies. While the variability of SIRI and AISI across multivariable models suggests that these indices may be more sensitive to specific clinical confounders, the relatively consistent performance of SII underscores its potential as a practical and cost-effective tool for identifying patients at risk of suboptimal functional recovery despite otherwise uncomplicated surgery.

In this study, the 1-month postoperative time point was selected as the primary endpoint because it represents a critical stage at which acute surgical inflammation has largely resolved, and refractive stability is generally achieved. This timeframe is widely accepted in clinical practice for evaluating early surgical outcomes. However, it should be acknowledged that a single 1-month assessment may not capture late-onset inflammatory complications, such as delayed pseudophakic cystoid macular edema or posterior capsular opacification, which emerging evidence suggests may be influenced by persistent intraocular cytokine activity [20]. Therefore, future prospective studies with longitudinal follow-up are warranted to determine whether preoperative systemic inflammatory indices can also predict long-term visual outcomes.

Several limitations inherent to this retrospective study should be acknowledged. First, the retrospective design limits causal inference and introduces potential selection and information biases, which may have influenced the observed associations between systemic inflammatory biomarkers and postoperative visual outcomes. Second, the relatively modest sample size may have limited statistical power, particularly for detecting consistent associations involving SIRI and AISI, and may contribute to the variability observed across adjusted multivariable models. Third, although key clinical and laboratory covariates were included in the analyses, residual confounding cannot be excluded. Unmeasured variables, including genetic predisposition, perioperative pharmacological exposures, or subclinical inflammatory conditions, may have influenced both systemic inflammatory indices and visual recovery outcomes. Fourth, detailed data on preoperative fundus status, interoperative parameters, and surgical complications were unavailable, which may have introduced additional confounding, given their established roles in determining visual recovery. Furthermore, the use of 1-month UCVA rather than BCVA constitutes a methodological limitation. The observed 43.33% rate of poor UCVA at 1 month is clin-

ically plausible, as UCVA at this stage may be influenced by residual refractive error or postoperative astigmatism, and therefore may not fully reflect maximal visual potential. Finally, as a single-center study, the generalizability of these findings to broader cataract surgery populations with differing demographic and clinical characteristics may be limited. Future studies should validate the predictive value of SII in larger cataract surgery cohorts, explore longitudinal changes in SII, SIRI, and AISI, and investigate targeted anti-inflammatory strategies to enhance postoperative visual recovery.

Conclusions

In conclusion, this retrospective study demonstrates that systemic inflammation, as quantified by SII, is associated with early visual outcomes following cataract surgery in a nonlinear manner. These findings highlight the potential value of systemic inflammatory status in perioperative risk stratification. However, given the observational design and associated limitations, prospective, adequately powered studies are required to confirm these associations and to elucidate their clinical relevance.

Availability of Data and Materials

The data used and analysed during the current study are available from the corresponding author on reasonable request.

Author Contributions

GFX: conceptualization, methodology, data curation, formal analysis and writing—original draft; YZ: methodology and writing—review & editing; YY: formal analysis and writing—review & editing; LZ: formal analysis and writing—review & editing; XCW: investigation; XHP: data curation and validation; PHY: data curation and validation. All authors contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study has been approved by the Ethics Committee of The First People's Hospital of Zunyi (IRB Number: 2025-1-662) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all patients prior to inclusion in the study.

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Conflict of Interest

The authors declare no conflict of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.62713/aic.4639.

References

[1] Pascolini D, Mariotti SP. Global estimates of visual impairment: 2010. The British Journal of Ophthalmology. 2012; 96: 614–618. https://doi.org/10.1136/bjophthalmol-2011-300539.

[2] Powe NR, Schein OD, Gieser SC, Tielsch JM, Luthra R, Javitt J, *et al*. Synthesis of the literature on visual acuity and complications following cataract extraction with intraocular lens implantation. Cataract Patient Outcome Research Team. Archives of Ophthalmology. 1994; 112: 239–252. https://doi.org/10.1001/archopht.1994.01090140115033.

[3] Semmer AE, Lee MS, Taban M, Smith S, Kosmorsky G. The operation was a success, but the patient cannot see. Survey of Ophthalmology. 2009; 54: 708–713. https://doi.org/10.1016/j.survophthal.2009.06.002.

[4] Flach AJ. The incidence, pathogenesis and treatment of cystoid macular edema following cataract surgery. Transactions of the American Ophthalmological Society. 1998; 96: 557–634.

[5] Weng Y, Zeng T, Huang H, Ren J, Wang J, Yang C, *et al*. Systemic Immune-Inflammation Index Predicts 3-Month Functional Outcome in Acute Ischemic Stroke Patients Treated with Intravenous Thrombolysis. Clinical Interventions in Aging. 2021; 16: 877–886. https://doi.org/10.2147/CIA.S311047.

[6] Wang S, Pan X, Jia B, Chen S. Exploring the Correlation Between the Systemic Immune Inflammation Index (SII), Systemic Inflammatory Response Index (SIRI), and Type 2 Diabetic Retinopathy. Diabetes, Metabolic Syndrome and Obesity. 2023; 16: 3827–3836. https://doi.org/10.2147/DMSO.S437580.

[7] Jia R, Yin Y, Shan H. Systemic inflammatory response index as a novel biomarker for age-related macular degeneration: a cross-sectional study from NHANES (2005-2008). Frontiers in Nutrition. 2025; 12: 1540933. https://doi.org/10.3389/fnut.2025.1540933.

[8] Üçer MB, Cevher S. Assessment of systemic inflammatory response index and other inflammatory indicators in retinal vein occlusion. Medicine. 2023; 102: e36512. https://doi.org/10.1097/MD.0000000000036512.

[9] Kocamış Sİ, Boz AAE, Özdemir İ. Systemic immune-inflammation index could be associated with pseudophakic cystoid macular edema after an uneventful phacoemulsification surgery in patients without risk factors. BMC Ophthalmology. 2022; 22: 378. https://doi.org/10.1186/s12886-022-02606-5.

[10] Niu R, Yan Z, Wang Y, Li Y, Feng W, Liu J, *et al*. Study of clinical traits and systemic immune inflammation index assessments in patients with endogenous endophthalmitis over the last ten years. BMC Ophthalmology. 2024; 24: 11. https://doi.org/10.1186/s12886-023-03266-9.

[11] Li X, Du GL, Wu SN, Sun YQ, Zhang SQ, Zhang ZJ, *et al*. Association between systemic immune inflammation index and cataract incidence from 2005 to 2008. Scientific Reports. 2025; 15: 499. https://doi.org/10.1038/s41598-024-84204-7.

[12] Huang J, Wu H, Yu F, Wu F, Hang C, Zhang X, *et al*. Association between systemic immune-inflammation index and cataract among

outpatient US adults. Frontiers in Medicine. 2024; 11: 1469200. https://doi.org/10.3389/fmed.2024.1469200.

[13] Bilici S, Gültekin Erol T, Küçük N, Uğurbaş SH. Systemic inflammatory response index as a predictive biomarker for Irvine-Gass syndrome. International Ophthalmology. 2025; 45: 315. https://doi.org/10.1007/s10792-025-03680-6.

[14] Wang X, Jiang H, Zhang C. Association of systemic inflammatory biomarkers with ocular disease: a large population-based cross-sectional study. European Journal of Medical Research. 2025; 30: 206. https://doi.org/10.1186/s40001-025-02473-y.

[15] Pan J, Shi W. Association between systemic inflammatory response index and risk of cataract in patients with cardiometabolic syndrome: A cross sectional study based on NHANES. Medicine. 2026; 105: e47398. https://doi.org/10.1097/MD.0000000000047398.

[16] Gurpinar AB, Erdal H, Kalayci HO. Association of SII and AISI in patients with sepsis: A retrospective study. Medicine Science. 2025; 14: 6–9. https://doi.org/10.5455/medscience.2024.10.117.

[17] Bai X, Cheng L, Wang H, Deng Y, Tong X, Wen W, *et al*. The aggregate index of systemic inflammation (AISI) and the risk of all-cause, cardiovascular, and cardio-cerebrovascular mortality in congestive heart failure patients: results from NHANES 1999–2018. Scientific Reports. 2025; 15: 18282. https://doi.org/10.1038/s41598-025-01196-8.

[18] Tarle M, Raguž M, Lukšić I. A Comparative Study of the Aggregate Index of Systemic Inflammation (AISI) and C-Reactive Protein (CRP) in Predicting Odontogenic Abscesses Severity: A Novel Approach to Assessing Immunoinflammatory Response. Diagnostics. 2024; 14: 2163. https://doi.org/10.3390/diagnostics14192163.

[19] Yang H, Reynaud J, Lockwood H, Williams G, Hardin C, Reyes L, *et al*. The connective tissue phenotype of glaucomatous cupping in the monkey eye - Clinical and research implications. Progress in Retinal and Eye Research. 2017; 59: 1–52. https://doi.org/10.1016/j.preteyeres.2017.03.001.

[20] Hao C, Fan E, Wei Z, Radeen KR, Purohit N, Li K, *et al*. Elevated Inflammatory Cytokines Persist in the Aqueous Humor Years After Cataract Surgery. Investigative Ophthalmology & Visual Science. 2025; 66: 12. https://doi.org/10.1167/iovs.66.4.12.