Association between ophthalmological hemodynamic parameters and the activity of iris neovascularization in patients with neovascular glaucoma

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Зв'язок між офтальмологічними гемодинамічними параметрами та активністю неоваскуляризації райдужної оболонки у пацієнтів з неоваскулярною глаукомою

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Abstract

Objective. *To evaluate the relationship between ophthalmic hemodynamic parameters, particularly the rheographic coefficient (RQ), and the activity of iris neovascularization in neovascular glaucoma (NVG) of different etiologies, as well as to assess the prognostic value of RQ as a functional indicator of ocular microcirculation.*

Materials and Methods. *A total of 224 eyes (224 patients) were examined: 133 with NVG secondary to proliferative diabetic retinopathy (PDR), 91 after ischemic retinal vein occlusion (RVO), and 34 controls with early cataract. Standard ophthalmic examinations included intraocular pressure (IOP), slit-lamp biomicroscopy, and assessment of iris neovascularization by the Weiss scale (Stages I–IV). Rheoophthalmography was used to determine volumetric ocular blood flow (RQ, ‰).*

Results. *Mean RQ values were 3.02 ± 0.41‰ in PDR (hypovolemic type), 3.76 ± 0.39‰ in RVO (hypervolemic type), and 3.34 ± 0.28‰ in controls (normovolemic type). RQ was significantly associated with the degree of iris rubeosis ($F(1,229)=66.6$; $p<0.001$; $\beta=0.47$; $R^2=0.22$). Severe (Stage III) rubeosis was more frequent in hypervolemic-type eyes (26.7%) compared with hypovolemic-type (2.2%). Abnormal RQ values (<3.0 or >3.7‰) predicted higher neovascularization activity.*

Conclusions. *The RQ is a reliable quantitative measure of ocular microcirculation and an objective predictor of iris neovascularization. Incorporation of RQ into clinical evaluation enables stratification of patients according to hypovolemic and hypervolemic ophthalmic hemodynamic types, thereby supporting personalized treatment planning in NVG.*

Keywords: *Neovascular glaucoma, iris rubeosis, ophthalmic hemodynamics, rheoophthalmography, diabetic retinopathy, retinal vein occlusion, microcirculation, retina, iris.*

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Резюме

Мета. *Оцінити взаємозв'язок між показниками офтальмогемодинаміки, зокрема реоофтальмографічним коефіцієнтом (RQ), та активністю неоваскуляризації райдужки при неоваскулярній глаукомі (НВГ) різної етіології, а також визначити прогностичну цінність RQ як функціонального показника мікроциркуляції ока.*

Матеріали та методи. *Обстежено 224 ока (224 пацієнти): 133 — з НВГ, асоційованою з проліферативною діабетичною ретинопатією (ПДР), 91 — з НВГ після ішемічної оклюзії вен сітківки (ОВС), та 34 — контрольна група (пацієнти з початковою катарактою). Стандартне офтальмологічне обстеження включало вимірювання* *внутрішньоочного тиску (ВОТ), біомікроскопію переднього сегмента та оцінку неоваскуляризації райдужки за шкалою Weiss (I–IV стадії). Об'ємний внутрішньоочний кровообіг оцінювали методом реоофтальмографії з визначенням реографічного коефіцієнта (RQ, ‰). Статистичний аналіз включав непараметричні тести та регресійне моделювання.*

Результати. *Середні значення RQ становили 3,02 ± 0,41‰ у групі ПДР (гіповолемічний тип), 3,76 ± 0,39‰ у групі ОВС (гіперволемічний тип) та 3,34 ± 0,28‰ у контрольній групі (нормоволемічний тип). Виявлено достовірний зв'язок між величиною RQ та ступенем неоваскуляризації райдужки ($F(1,229)=66,6$; $p<0,001$; $\beta=0,47$; $R^2=0,22$). Важка (III стадія) рубеоз райдужки значно частіше спостерігалася при гіперволемічному типі гемодинаміки (26,7%), ніж при гіповолемічному (2,2%). Відхилення RQ від фізіологічного діапазону (<3,0 або >3,7‰) асоціювалося з підвищеною активністю неоваскуляризації.*

Висновки. *Реоофтальмографічний коефіцієнт (RQ) є надійним кількісним показником офтальмогемодинаміки та незалежним предиктором активності неоваскуляризації райдужки при неоваскулярній глаукомі. Використання RQ у клінічній практиці дозволяє стратифікувати пацієнтів за типом гемодинамічних порушень, прогнозувати перебіг захворювання та оптимізувати персоналізовані підходи до лікування НВГ ішемічного та застійно-ішемічного походження.*

Ключові слова: *неоваскулярна глаукома, рубеоз райдужки, офтальмогемодинаміка, реоофтальмографія, діабетична ретинопатія, оклюзія вен сітківки, мікроциркуляція, сітківка, райдужка*

Introduction

Neovascular glaucoma (NVG) is a severe secondary form of glaucoma that develops as a consequence of ischemic damage to the retina and anterior segment of the eye. The most common etiological factors are proliferative diabetic retinopathy (PDR) and retinal vein occlusion (RVO) [1]. Ischemic retinal changes lead to excessive expression of vascular endothelial growth factor (VEGF) and other pro-inflammatory cytokines, which stimulate the development of iris neovascularization and formation of fibrovascular membranes in the iridocorneal angle, thereby impairing aqueous humor outflow [2, 3].

Iris/iridocorneal angle neovascularization is a reliable clinical marker of ocular ischemia, and its progression is accompanied by trabecular meshwork fibrosis, synechiae, and persistent ocular hypertension [4–6].

According to contemporary clinical research, patients with PDR predominantly demonstrate microcirculatory impairment associated with reduced perfusion of the ciliary body and choroid as a consequence of diabetic microangiopathy. Such changes may be interpreted as a hypovolemic (previously termed hypoperfusion) hemodynamic pattern, reflecting diminished volumetric blood filling of the anterior uveal tract [2].

In contrast, RVO is typically associated with venous congestion, increased vascular permeability, and impaired venous outflow, leading to secondary ischemia of the anterior segment. Such hemodynamic alterations may be interpreted as venous congestion accompanied by secondary ischemic stress. Chronic ocular ischemia is considered a major trigger of ocular neovascularization in ischemic eye diseases, including neovascular glaucoma [5]. Retinal ischemia represents the principal pathogenic stimulus for intraocular neovascularization and plays a central role in the development of neovascular glaucoma, irrespective of the underlying vascular etiology [7].

Assessment of ophthalmic hemodynamics is a critical component in understanding glaucoma pathogenesis. Various non-invasive techniques are used for this purpose, including color Doppler imaging, laser speckle flowgraphy, optical coherence tomography angiography, pulsatile ocular blood flow analysis, and rheoophthalmography (ROG) [8, 9]. ROG, in particular, enables quantitative evaluation of volumetric blood filling of the uveal tract and anterior segment, which is especially informative in cases of ischemia, iris neovascularization, and secondary angle changes.

Ocular perfusion pressure is regarded as a key factor in maintaining ocular microcirculation: its reduction produces hypoperfusion of the optic nerve head and ciliary body. Impairment of vascular autoregulation leads to imbalance between systemic arterial pressure and local blood flow, causing the ischemia to worsen [7]. Mathematical modeling confirms that even a slight increase in intraocular pressure (IOP) can significantly reduce blood flow in the central retinal artery [10].

Modern treatment strategies for neovascular glaucoma aim to control intraocular pressure while addressing the ischemic and angiogenic components of the disease. Transscleral laser cyclophotocoagulation (TS-CPC) remains one of the earliest and most widely used methods for pressure control in NVG, particularly in eyes with poor visual prognosis or severe systemic comorbidities. Recent clinical studies have demonstrated that TS-CPC performed using slow-coagulation and micropulse techniques provides effective and sustained IOP reduction with a more favorable safety profile compared to traditional continuous-wave protocols. In addition to its hypotensive effect, TS-CPC may contribute to partial stabilization of ocular hemodynamics by reducing ciliary body metabolic demand and improving the balance between aqueous humor production and ocular perfusion [11,12].

Despite significant progress, the issue of standardized evaluation of ophthalmic hemodynamics remains unresolved. Current clinical protocols focus primarily on IOP reduction and angiogenesis blockade, whereas anterior-segment hemodynamic changes — which directly influence disease progression, prognosis, and therapeutic efficacy — are often not quantified.

The use of the RQ as a quantitative indicator of intraocular volumetric blood flow provides new opportunities for stratifying patients by type of microcirculatory impairment, predicting iris neovascularization activity, and determining optimal treatment strategies.

Objective. To determine the relationship between ophthalmic hemodynamic parameters, particularly the rheographic coefficient (RQ), and the activity of iris neovascularization in neovascular glaucoma of different etiologies, as well as to evaluate the prognostic significance of RQ as a functional marker of microcirculatory status in these patients.

Materials and Methods

The study was conducted in accordance with the principles of the Declaration of Helsinki (2013). All patients provided informed consent for participation. The study protocol (№4, 2024) was approved by the Bioethics Committee of the SI "The Filatov Institute of Eye Diseases and Tissue Therapy of NAMS of Ukraine".

A total of 224 eyes (224 patients) were included in the study. All patients received treatment and follow-up at the Division of Laser Microsurgery of Eye Diseases, SI "The Filatov Institute of Eye Diseases and Tissue Therapy of the NAMS of Ukraine".

Based on the underlying etiology, all patients were divided into three groups:

Group I (n = 133): NVG secondary to PDR;

Group II (n = 91): NVG following RVO;

Group III (Control, n = 34): Patients with early-stage cataract, matched for age and sex.

Inclusion criteria: Adults (≥18 years) with a confirmed diagnosis of secondary neovascular glaucoma associated with proliferative diabetic retinopathy or retinal vein occlusion, the presence of clinically detectable iris and/or iridocorneal angle neovascularization, and the ability and willingness to complete all scheduled follow-up examinations.

Exclusion criteria: History of intraocular surgery within 12 months prior to enrollment; ocular trauma; uveitic glaucoma or glaucoma of other etiologies; stage IV iris or angle neovascularization according to the Weiss classification [4]; active intraocular inflammation at the time of enrollment; and severe or uncontrolled systemic disease that could interfere with ophthalmic assessment or study follow-up.

All patients underwent a standard ophthalmic examination, including measurement of best-corrected visual acuity (BCVA), IOP using a Goldmann applanation tonometer, and slit-lamp biomicroscopy of the anterior segment with assessment of iris neovascularization. In selected cases, anterior segment optical coherence tomography and/or slit-lamp photography were used to confirm the clinical assessment of iris and iridocorneal angle neovascularization.

To assess volumetric intraocular blood flow (rheographic coefficient RQ, ‰), rheoophthalmography (ROG) was performed using the "Reocom" computer rheographic complex (Ukraine, Kharkiv) according to a standard protocol [13].

The degree of iris neovascularization was graded using the classical Weiss scale (1971), which includes four stages: Stage I – scattered neovascular vessels located near the pupillary margin; Stage II – neovascular proliferation extending to the mid-peripheral iris; Stage III – a vascular network associated with anterior synechiae and incomplete angle closure; Stage IV – a dense neovascular network with anterior synechiae and complete iridocorneal angle closure [4].

To ensure sample comparability, the study groups were stratified by age, sex, duration of the underlying disease, level of glycated hemoglobin (HbA1c), previous ophthalmic interventions (panretinal photocoagulation (PRP), anti-VEGF therapy), as well as additional risk factors such as smoking status, pseudophakia, or presence of cataract.

Statistical analysis was performed using JASP software (version 0.18.3). The normality of quantitative data distribution was assessed using the Shapiro-Wilk test. For non-normally distributed variables, results were presented as median (Me) and interquartile range [Q_1–Q_3]. Comparisons between three independent groups were performed using the Kruskal–Wallis test, while pairwise comparisons were carried out using the Mann-Whitney U test. The relationship between the RQ and the degree of iris neovascularization was evaluated using logistic regression analysis with calculation of β coefficient, F-statistic, and coefficient of determination (R^2). The Pearson χ^2 test was used to assess the distribution of categorical variables. Differences were considered statistically significant at $p < 0.05$.

Results

A total of 224 eyes (224 patients) were included in the study, of which 133 had NVG secondary to PDR, 91 had NVG following RVO, and 34 constituted a control group without ophthalmic pathology (Table 1).

Patients with NVG associated with PDR and RVO demonstrated similar demographic characteristics (mean age 64.2 ± 6.1 years); however, statistically significant intergroup differences were identified in HbA1c, IOP, and the RQ.

In the control group (n = 34), values of IOP and RQ remained within physiological ranges.

The majority of patients with NVG had a prolonged duration of the underlying systemic disease (more than 10 years in PDR, and 9-11 years in RVO), as well as markedly elevated IOP values (>34 mmHg).

Based on rheoophthalmography, the mean RQ value was lower in the PDR group (3.32 [2.8–4.0] ‰), consistent with a hypovolemic type of ophthalmic hemodynamics, whereas higher RQ values were observed in the RVO group (3.9 [3.4–4.2] ‰), compatible with a hypervolemic type.

Table 1. Clinical Characteristics of Patients with Neovascular Glaucoma

Parameter	NVG in PDR (n = 133)	NVG after RVO (n = 91)	Control (n = 34)	p-value
	Me [Q_1-Q_3], n (%)			
Age, years	65 [62–68]	63 [61–66]	63.5 [60–66]	0.284
Sex, m/f, n (%)	62 / 71 (46.6 / 53.4)	50 / 41 (54.9 / 45.1)	13 / 21 (38.2 / 61.8)	–
BCVA	0.02 [0.03–0.04]	0.02 [0.03–0.06]	0.9 [0.7–1.0]	< 0.001
RQ (‰)	2.8 [2.2–3.71]	4.0 [3.59–4.8]	3.3 [3.3–3.4]	< 0.001
Intraocular pressure, mmHg	36 [33–39]	34 [33–40]	15 [14–17]	< 0.001
Duration of underlying disease, months	132 [84–168]	15 [12–18]	–	0.672
HbA1c, %	7.4 [6.9–8.8]	4.3 [3.8–4.7]	4.4 [4.0–4.8]	< 0.001
PRP / anti-VEGF, n (%)	39 (29.3)	30 (32.9)	–	0.514
Smoking, n (%)	34 (25.6)	24 (26.4)	9 (26.5)	0.992
Cataract / pseudophakia, n (%)	60 (45.1)	41 (45.1)	15 (44.1)	0.986

Note: Continuous variables were compared using the Kruskal–Wallis test; categorical variables using Pearson's χ^2-test. Data are presented as median (Me) and interquartile range (Q_1–Q_3), as most variables did not follow normal distribution (Shapiro–Wilk test, $p < 0.05$).
Abbreviations: NVG – neovascular glaucoma; PDR – proliferative diabetic retinopathy; RVO – retinal vein occlusion; RQ – rheographic coefficient (according to reoophthalmography); HbA1c – glycated hemoglobin; PRP – panretinal photocoagulation.

The data presented in Table 1 illustrate the clinical characteristics of patients with NVG of varying etiology, demonstrating that older patients with elevated IOP and long-standing systemic disease exhibit more pronounced alterations in ophthalmic hemodynamics. The observed differences in RQ values between etiological groups indicate distinct hemodynamic characteristics, potentially reflecting differences in the underlying pathogenic mechanisms in NVG associated with PDR and RVO.

To further clarify and standardize hemodynamic patterns, three primary ophthalmic hemodynamic types were identified based on the RQ index, reflecting the key pathophysiological mechanisms of microcirculatory impairment in NVG (Table 2).

Comparison of the incidence of severe (Stage III) iris rubeosis between groups demonstrated a statistically significant difference ($\chi^2 = 18.47$; $p < 0.001$).

The level of active neovascularization increased proportionally with the degree of hemodynamic imbalance, confirming a close relationship between ophthalmic hemodynamics and angiogenic activity of the anterior segment.

In the group with NVG associated with diabetic retinopathy, the hypovolemic hemodynamic type predominated (62 % of eyes), characterized by reduced volumetric blood filling of the ciliary body and ischemic alterations of the anterior segment. In this subgroup, Stage I–II rubeosis prevailed in 78.3 % of cases, whereas severe (Stage III) rubeosis was observed in 21.7 %, reflecting an ischemic but not congestive microcirculatory pattern.

In NVG secondary to retinal vein occlusion, the hypervolemic type with venous stasis predominated (80 % of eyes), accompanied by increased vascular permeability and secondary ischemia. Severe (Stage III) rubeosis occurred in 30.8 % of cases, which is approximately 1.5 times higher than in the PDR-associated NVG group. Thus, the hypervolemic hemodynamic type is associated with more intense angiogenesis and a more severe clinical course.

In the control group (34 eyes), ophthalmic hemodynamic indices corresponded to the normovolemic type (RQ = 3.1–3.6), with no signs of rubeosis.

Univariate regression analysis confirmed a significant association between the rheographic coefficient (RQ) and the degree of iris rubeosis according to Weiss.

The model was statistically significant: $F(1,229) = 66.595$; $p < 0.00000$; $\beta = 0.47$; $t(229) = 8.16$; $R^2 = 0.22$; standard error = 0.76; Durbin–Watson coefficient d = 1.40, indicating model stability and absence of autocorrelation.

A decrease in RQ below 3.0 ‰ or an increase above 4.0 ‰ was significantly associated with higher frequency of Stage II–III rubeosis ($p < 0.001$).

This confirms that pronounced hemodynamic abnormalities—both hypovolemic and hypervolemic types—stimulate pathological iris neovascularization.

Three hemodynamic types were identified, reflecting distinct mechanisms of microcirculatory disturbance:

- Hypovolemic type (RQ ≤ 3.0) – predominant in NVG associated with DR; characterized by ciliary body hypoperfusion and ischemic microcirculation.
- Hypervolemic type with venous stasis (RQ > 3.7) – typical for NVG after RVO; reflects venous overload, increased vascular permeability, and secondary ischemia.
- Normovolemic type (RQ = 3.1–3.6) – corresponds to physiological ophthalmic hemodynamics and was characteristic of the control group.

Table 2. Types of Ophthalmic Hemodynamics (according to RQ Index) and Frequency of Iris Rubeosis in Neovascular Glaucoma of Different Etiology

Group	n (eyes), %	Iris rubeosis (Weiss classification), n (eyes)	Predominant RQ type, range, ‰	Clinical context	Pathophysiological characteristics
NVG associated with PDR (115 eyes)	71 (62%)	Stage 1 – 27 Stage 2 – 21 Stage 3 – 23	Hypovolemic ≤ 3.0	Hypovolemic type in diabetic retinopathy	Reduced volumetric blood filling of the ciliary body, hypoperfusion, ischemic changes of the anterior segment
	27 (23%)	Stage 1 – 18 Stage 2 – 7 Stage 3 – 2	Hypervolemic > 3.7	Variable hemodynamic responses in diabetic angiopathy	Venous congestion, increased vascular permeability
	17 (15%)	Stage 1 – 17	Normovolemic 3.1–3.6	Controlled perfusion state	Physiological ophthalmic hemodynamics
NVG following RVO (91 eyes)	12 (13%)	Stage 1 – 8 Stage 2 – 1 Stage 3 – 3	Hypovolemic ≤ 3.0	Secondary ischemia after venous occlusion	Reduced perfusion pressure, impaired arterial inflow
	73 (80%)	Stage 1 – 34 Stage 2 – 14 Stage 3 – 25	Hypervolemic > 3.7	Hypervolemic type in RVO	Venous overload, impaired outflow, secondary ischemia
	6 (7%)	Stage 1 – 6	Normovolemic 3.1–3.6	Transitional compensation	Physiological hemodynamics
Control group (34 eyes)	34 (100%)	No rubeosis (0%)	Normovolemic 3.1–3.6	Healthy eyes	Optimal balance between arterial inflow and venous outflow

Abbreviations: NVG – neovascular glaucoma; PDR – proliferative diabetic retinopathy; RVO – retinal vein occlusion; RQ – rheographic coefficient (according to reoophthalmography).

Discussion

The obtained results indicate that the rheographic coefficient reliably reflects the nature of hemodynamic alterations in NVG of different etiologies. In patients with NVG associated with PDR, the mean RQ value was 3.02 ± 0.41 ‰ (median 3.0 [2.8–3.4] ‰), consistent with a hypovolemic type of ophthalmic hemodynamics. In contrast, in patients with NVG following retinal vein occlusion, RQ values were significantly higher and exceeded normative ranges (3.76 ± 0.39 ‰; median 3.8 [3.5–4.0] ‰; $p<0.001$), corresponding to a hypervolemic type of ophthalmic circulation.

Intergroup analysis (Kruskal–Wallis test) revealed a statistically significant difference ($H = 45.28$; $p < 0.001$). According to Dunn's post-hoc test, the RQ in PDR-associated NVG was significantly lower than in controls ($p < 0.001$), while in RVO-associated NVG the RQ was significantly higher compared to both the control and DR groups ($p < 0.001$).

Univariate regression analysis confirmed a statistically significant association between RQ and the degree of iris rubeosis according to Weiss ($F(1,229) = 66.595$; $p<0.00001$; $\beta = 0.47$; $R^2 = 0.22$). The Durbin–Watson coefficient ($d = 1.40$) indicated the absence of residual autocorrelation. The frequency of severe (Stage III) rubeosis was significantly higher in the hypervolemic hemodynamic type (26.7 %) observed in RVO patients, whereas in the hypovolemic type, characteristic of PDR, Stages I–II predominated (97.8 %).

These findings are consistent with pathophysiological models of ischemic disorders [5, 7]. In RVO patients, the predominant congestive-ischemic profile (RQ > 3.7) was associated with a higher incidence of severe rubeosis, likely due to venous overload and secondary hypoxia of the ciliary body. In contrast, in PDR patients, the hypovolemic type (RQ ≤ 3.0) was associated primarily with Stage I–II rubeosis, reflecting an ischemic microcirculatory disturbance. These observations align with the classical descriptions by Weiss (1978), where the degree of rubeosis is interpreted as a clinical indicator of ischemic burden in the anterior segment.

Furthermore, experimental-morphological studies by Tektas & Lütjen-Drecoll (2009) demonstrated that prolonged hemodynamic disturbances induce remodeling of the trabecular meshwork, increased vascular resistance, and sustained elevation of IOP, which corresponds to our findings in both PDR and RVO groups [14].

In our previous study [15], we demonstrated that after diode TS-CPC in NVG patients, the RQ normalized from 2.9 ± 0.4 to 3.3 ± 0.3‰, with a 31% reduction in IOP, confirming the prognostic value of this parameter. A similar trend was reported by Chechin et al. (2018), where improved ophthalmic hemodynamics was associated with long-term IOP stabilization [16].

Thus, the RQ is not merely a "momentary" indicator of perfusion, but a functional marker of microcirculation that reflects long-term structural and functional consequences of impaired blood flow [17, 18]. Deviation of RQ beyond the physiological range (<3.0 or >3.7‰) may serve as an objective predictor of neovascularization activity and treatment effectiveness. Neural network modeling has also shown that baseline hemodynamic parameters, including RQ, may serve as independent predictors of treatment success in NVG patients with diabetes. This study emphasized that microcirculatory status significantly affects long-term therapeutic outcomes, and its quantitative assessment improves the accuracy of NVG prognosis [19].

Thus, the proposed concept of functional monitoring of ophthalmic hemodynamics aligns with current trends in personalized ophthalmology. The results of the present study demonstrate that quantitative assessment of RQ allows stratification of patients according to hemodynamic type, prediction of iris rubeosis severity, and evaluation of treatment efficacy.

The obtained regularities are consistent with fundamental principles of microcirculation, which emphasize that hypoperfusion and venous congestion represent key mechanisms of angiogenesis in ischemic processes [20].

To conclude, NVG results from the interaction of ischemic, angiogenic, and hemodynamic mechanisms that form a pathological feedback loop.

The RQ, obtained by rheoophthalmography in patients with NVG (associated with diabetic retinopathy or retinal vein occlusion), a significant deviation of RQ from the physiological range (3.1–3.6‰) is observed, indicating profound disturbances in the perfusion of the ciliary body.

Based on RQ values, three pathogenetic types of ocular hemodynamics were identified: Hypovolemic type ($RQ \leq 3.0$) – characteristic of NVG associated with proliferative diabetic retinopathy, reflecting ischemic hypoperfusion; Hypervolemic type ($RQ > 3.7$) – typical of NVG following retinal vein occlusion, linked to venous congestion and secondary ischemia; Normovolemic type (RQ 3.1–3.6) – corresponds to physiological ocular blood flow.

These types reflect different mechanisms of neovascularization and explain the variability in the clinical course of NVG.

Critical RQ thresholds (<2.8 or >4.0) were associated with a higher frequency of Stage II–III rubeosis ($\chi^2 = 18.47$; $p < 0.001$). The highest rate of severe rubeosis (45.0%) was observed in the hypervolemic type, whereas in the hypovolemic type, Stage I–II forms predominated (42%).

Univariate regression analysis ($F (1,229) = 66.6$; $p < 0.00001$; $\beta = 0.47$; $R^2 = 0.22$) demonstrated that RQ is an independent predictor of neovascularization activity and the degree of ischemic involvement of the iridocorneal angle. RQ values below 2.8 or above 4.0 ma y be used as objective criteria for stratifying the risk of NVG progression.

Author Contributions

OG and NH – Conceptualization; Methodology; Data curation; Investigation; Formal analysis; Writing – original draft; review & editing. All authors have read and approved the final manuscript and agree to be responsible for all aspects of the work.

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Conflict of Interest

The authors declare that they have no conflicts of interest related to this work.

Ethical approval

The study was approved by the Bioethics Committee of the Filatov Institute of Eye Diseases and Tissue Therapy (Protocol No. 4, 2024). All procedures were conducted in accordance with the Declaration of Helsinki, and written informed consent was obtained from all participants.

Data Availability Statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request. Due to institutional policy and patient confidentiality, raw data are not publicly available.

Abbreviations

ICL – Implantable Collamer Lens; n – number, KC – keratoconus, CXL – corneal cross-linking, UVA – Ultra violet A, IOP – Intraocular pressure, μm – Micron, WTW – white-to-white, ACD – anterior chamber depth, STS – sulcus-to-sulcus, SD – standard deviation, ECC – Endothelial cell count, UCVA and BCVA – Uncorrected and best corrected visual acuity.

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