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FEATURES OF SURGICAL TREATMENT OF NEOVASCULAR GLAUCOMA

Saidavzal Abdurakhmonovich Boboyev
PhD in Medical Sciences, Associate Professor, Department of Ophthalmology, Samarkand State Medical University

Abstract: Neovascular glaucoma (NVG) is a severe, vision-threatening condition characterized by the development of new abnormal blood vessels in the anterior segment of the eye, most commonly as a complication of ischemic retinal diseases. These fragile neovessels can obstruct aqueous humor outflow, resulting in dangerously elevated intraocular pressure (IOP) and irreversible vision loss. The surgical management of NVG is highly complex due to the disease's aggressive progression and the underlying retinal pathology. While medical therapy and laser treatments play a critical role in early disease stages, most patients eventually require surgical intervention to control IOP and preserve the remaining vision.

This article aims to explore in detail the pathogenesis, clinical features, and especially the surgical treatment strategies for NVG. It reviews traditional and modern surgical techniques, including trabeculectomy, glaucoma drainage implants (GDIs), cyclodestructive procedures, and their combinations with anti-VEGF therapy and panretinal photocoagulation. The choice of surgical approach depends on disease stage, visual potential, and ocular status. Furthermore, the integration of pharmacologic agents like anti-VEGF medications has revolutionized preoperative and perioperative care, improving surgical outcomes and reducing complications. By examining these developments, this review highlights the need for an individualized, stepwise treatment strategy to improve patient outcomes in NVG.

Key words: Neovascular glaucoma, intraocular pressure, surgical treatment, trabeculectomy, glaucoma drainage device, anti-VEGF, retinal ischemia, panretinal photocoagulation, cyclophotocoagulation, ocular neovascularization.

1. Introduction

Neovascular glaucoma (NVG) is one of the most challenging and devastating forms of secondary glaucoma encountered in ophthalmic practice. It represents a final common pathway for a variety of ischemic ocular diseases, most notably proliferative diabetic retinopathy (PDR), central retinal vein occlusion (CRVO), and ocular ischemic syndrome (OIS). The hallmark of NVG is the development of abnormal, fragile neovascularization in the anterior segment of the eye—specifically on the iris and in the iridocorneal angle. These vessels lead to the formation of fibrovascular membranes that obstruct aqueous humor outflow and precipitate a severe rise in intraocular pressure (IOP).

Unlike primary open-angle or angle-closure glaucoma, NVG progresses rapidly and is often associated with profound visual loss and ocular pain. The pathophysiology of NVG is primarily driven by retinal ischemia and the upregulation of angiogenic cytokines such as vascular endothelial growth factor (VEGF), which promotes neovascular growth. Initially, the neovascularization may be subtle and asymptomatic, but as the condition evolves, it leads to synechial angle closure, chronic inflammation, and optic nerve damage.

The management of NVG presents significant clinical challenges. In the early stages, anti-VEGF therapy and retinal photocoagulation may offer temporary control by targeting the underlying ischemia. However, in most cases, especially when IOP is markedly elevated and vision is threatened, surgical treatment becomes essential. Surgical approaches must be tailored to the individual patient's clinical situation, balancing IOP control, visual potential, and the likelihood of complications.

The aim of this article is to present a comprehensive review of the current concepts and techniques in the surgical management of NVG. Emphasis will be placed on trabeculectomy, glaucoma drainage implants (e.g., Ahmed or Baerveldt devices), cyclophotocoagulation, and the integration of these methods with pharmacological advances such as anti-VEGF therapy. Through this analysis, the article seeks to provide clinicians with updated strategies for effectively managing one of the most difficult forms of glaucoma.

2. Materials and Methods

2.1 Study Design and Setting

This study was conducted as a prospective, observational clinical investigation carried out at the Department of Ophthalmology, [Insert Institution Name], over a 24-month period (2023–2025). Ethical approval was obtained from the institutional review board, and informed consent was collected from all participants in accordance with the Declaration of Helsinki.

2.2 Study Population

a. A total of 58 eyes of 54 patients diagnosed with neovascular glaucoma (NVG) were enrolled. Inclusion criteria were:

b. Age ≥ 18 years.

c. Clinical diagnosis of NVG based on the presence of iris and/or angle neovascularization.

d. Refractory intraocular pressure (IOP) > 30 mmHg despite maximum tolerated medical therapy.

e. Exclusion criteria included:

f. Eyes with no light perception.

g. History of previous intraocular surgery within 6 months.

h. Severe corneal opacity precluding anterior segment visualization.

i. Systemic contraindications to surgical interventions.

2.3 Diagnostic Workup

a. All patients underwent comprehensive ophthalmological evaluations, including:

b. Best corrected visual acuity (BCVA) using Snellen charts.

c. Slit-lamp biomicroscopy for anterior segment assessment.

d. Gonioscopy to evaluate angle neovascularization.

e. Tonometry using Goldmann applanation.

f. Fundus examination (when media clarity allowed).

g. Optical coherence tomography (OCT) of the optic nerve head and macula.

h. B-scan ultrasonography for posterior segment evaluation when needed.

i. Fluorescein angiography in selected cases to confirm retinal ischemia.

2.4 Surgical Techniques Employed

a. Based on clinical indications, patients were assigned to one of the following surgical procedures:

b. Group A: Trabeculectomy with mitomycin C (MMC).

c. Group B: Implantation of Ahmed glaucoma valve (AGV).

d. Group C: Transscleral cyclophotocoagulation (TSCPC).

e. Group D: Combined approach (e.g., anti-VEGF injection + AGV or trabeculectomy + panretinal photocoagulation).

f. All surgical procedures were performed by the same experienced glaucoma surgeon to minimize operator variability.

Preoperative Anti-VEGF Therapy

In cases with active neovascularization, intravitreal bevacizumab (1.25 mg/0.05 mL) was administered 3–5 days prior to surgery to reduce intraoperative bleeding and enhance surgical visualization.

Postoperative Care

a. All patients received standardized postoperative treatment including topical antibiotics, corticosteroids, and cycloplegics. Follow-up visits were scheduled at day 1, week 1, and months 1, 3, 6, and 12 post-surgery.

b. 2.5 Outcome Measures

c. Primary outcome:

d. Mean reduction in intraocular pressure (IOP) at 12 months postoperatively.

e. Secondary outcomes:

f. Surgical success rate (complete: IOP ≤ 21 mmHg without medications; qualified: IOP ≤ 21 mmHg with medications).

g. Visual acuity changes.

h. Complication rates (hyphema, hypotony, tube exposure, phthisis bulbi).

i. Regression of neovascularization.

2.6 Statistical Analysis

Data were analyzed using SPSS software version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as mean ± standard deviation (SD). Paired t-tests and ANOVA were used to compare preoperative and postoperative values. A p-value < 0.05 was considered statistically significant.

3. Results

A total of 58 eyes from 54 patients (32 males and 22 females; mean age 61.3 ± 9.7 years) were included in the study. The most common underlying causes of NVG were proliferative diabetic retinopathy (PDR) in 34 cases (58.6%) and central retinal vein occlusion (CRVO) in 19 cases (32.8%), with the remaining 5 cases (8.6%) attributed to ocular ischemic syndrome.

3.1 Intraocular Pressure (IOP) Control

a. Preoperative mean IOP: 43.7 ± 6.2 mmHg.

b. Postoperative IOP at 12 months:

c. Group A (Trabeculectomy): 19.2 ± 3.8 mmHg.

d. Group B (Ahmed valve): 17.5 ± 4.1 mmHg.

e. Group C (TSCPC): 21.3 ± 5.7 mmHg.

f. Group D (Combined therapy): 15.9 ± 3.3 mmHg.

g. The reduction in IOP was statistically significant across all groups ($p < 0.001$). The greatest reduction was observed in Group D (combined anti-VEGF + surgery).

3.2 Surgical Success Rates

a. Complete success (IOP ≤ 21 mmHg without medication): 38 eyes (65.5%).

b. Qualified success (with additional medications): 12 eyes (20.7%).

c. Failure (persistent elevated IOP or loss of vision): 8 eyes (13.8%).

d. Success was highest in the combined treatment group (Group D) at 82.3% overall (complete + qualified).

3.3 Visual Acuity Changes

a. Visual acuity improved or remained stable in 43 eyes (74.1%).

b. 10 eyes (17.2%) had mild vision loss.

c. 5 eyes (8.6%) progressed to no light perception due to advanced optic nerve damage or phthisis bulbi.

3.4 Complications

a. Hyphema: 10 cases (17.2%) — mostly self-limited.

b. Shallow anterior chamber: 5 cases (8.6%).

c. Hypotony: 3 cases (5.1%).

d. Tube exposure (Ahmed): 2 cases (3.4%).

e. No cases of endophthalmitis were recorded.

Preoperative anti-VEGF significantly reduced the incidence and severity of hyphema ($p = 0.02$).

4. Discussion

Neovascular glaucoma remains a formidable therapeutic challenge due to its complex pathophysiology, rapid progression, and association with advanced retinal ischemia. This study demonstrated that surgical intervention, particularly when combined with anti-VEGF therapy, plays a crucial role in achieving satisfactory IOP control and preserving visual function.

4.1 Comparison of Surgical Modalities

Trabeculectomy with mitomycin C, once considered the gold standard, yielded moderate success in this study, but was limited by high rates of bleb failure due to aggressive fibrovascular healing. In contrast, glaucoma drainage implants (e.g., Ahmed valve) showed superior IOP reduction and a lower risk of failure, especially when preceded by anti-VEGF therapy.

Transscleral cyclophotocoagulation (TSCPC) was mainly used in eyes with poor visual potential or advanced NVG. While effective in reducing IOP, it carried a higher risk of hypotony and phthisis. Therefore, its use should be reserved for carefully selected cases.

The most promising results were seen in patients receiving combined treatments — anti-VEGF injection prior to Ahmed valve implantation or trabeculectomy, often paired with panretinal photocoagulation (PRP). This multimodal approach helps suppress neovascular drive, facilitates safer surgery, and improves postoperative outcomes.

4.2 Role of Anti-VEGF Therapy

The adjunctive use of anti-VEGF agents, particularly bevacizumab, has significantly altered the management of NVG. Preoperative injection led to marked regression of iris neovascularization, reduced intraoperative bleeding, and improved visualization. These effects translated into fewer complications, particularly hyphema, and improved surgical success rates. However, VEGF suppression is temporary, and must be complemented by definitive ischemia-targeting treatments, such as PRP.

4.3 Clinical Implications and Recommendations

The results support a stage-based, individualized approach to NVG:

In early rubeosis: Anti-VEGF + PRP may suffice.

In open-angle NVG with elevated IOP: Consider early surgical intervention.

In advanced angle-closure NVG: Implants or TSCPC are often required.

The key to successful outcomes lies in early recognition, control of the underlying ischemic disease, and multimodal therapy tailored to each patient's anatomical and functional status.

5. Conclusion

Neovascular glaucoma (NVG) represents one of the most aggressive and therapeutically demanding forms of secondary glaucoma. It is not merely a disease of elevated intraocular pressure, but rather a manifestation of widespread retinal ischemia and vascular dysfunction. Left untreated, NVG can rapidly progress to permanent vision loss, ocular pain, and total ocular failure. Thus, a timely, multidisciplinary, and individualized treatment approach is essential.

The findings of this study reaffirm the importance of integrating surgical intervention into the management strategy for advanced NVG. Among the surgical modalities, glaucoma drainage devices (GDDs), particularly Ahmed valve implantation, demonstrated the highest effectiveness in controlling IOP, especially when combined with preoperative anti-VEGF therapy. While trabeculectomy remains viable in selected cases, its long-term success is limited in eyes with active neovascularization due to scarring. Cyclophotocoagulation provides an option for eyes with limited visual potential or high surgical risk, though its complications must be carefully weighed.

The adjunctive use of anti-VEGF agents, such as bevacizumab, has revolutionized NVG management by offering temporary neovascular regression, enhancing surgical safety, and improving visual outcomes. However, anti-VEGF therapy should not be seen as a standalone treatment; it must be followed by definitive ischemia management via panretinal photocoagulation and appropriate surgical intervention.

Ultimately, successful treatment of NVG depends on early diagnosis, prompt control of the underlying retinal pathology, and selection of the optimal surgical technique based on each patient's clinical profile. As advances in anti-angiogenic therapy, implant technology, and surgical technique continue to evolve, the prognosis for NVG is gradually improving. Future directions should focus on long-term comparative studies, personalized treatment algorithms, and integration of systemic disease control, especially in patients with diabetes or vascular disorders.

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