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Impact of Systemic Hypertension Control on Glaucoma Progression.

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ABSTRACT

Background: Glaucoma is one of the most common causes of blindness, with the development of the disease being influenced by factors external to intraocular pressure, as well. Researchers most frequently study blood pressure, as hypertension or high variability in blood pressure reduces perfusion of the optic nerve. This is especially important to understand in patients having both conditions.

Methodology: This retrospective cross-sectional research study reviewed data collected from June 2023 to June 2024 from 72 patients who had been diagnosed with both glaucoma and hypertension and received treatment at Nishter Medical University Multan. Documents records of blood pressure, clinical notes, and blood pressure OCT imaging and visual field readings were recorded and analyzed. Patients were classified into uncontrolled and controlled hypertension categories based on blood pressure recordings. With SPSS 22, and based on their statistical relevance, data were computed and analyzed using t tests and chi-squares tests.

Results: Those with uncontrolled hypertension had higher intraocular pressure, higher pressure fluctuations, thinner RNFL, and more severe visual field loss. Progression was significantly more common in the uncontrolled group, both structurally on OCT and functionally on visual field tests. Ocular perfusion pressure was also lower in these patients, and nocturnal BP dips were more frequently noted.

Conclusion: The findings indicate that unstable or poorly controlled systemic hypertension may contribute to faster glaucoma deterioration. Stable blood pressure control appears to play a supportive role in protecting the optic nerve. Integrating BP management into glaucoma care may help slow disease progression and preserve visual function..

Keywords: Glaucoma, systemic hypertension, ocular perfusion pressure, RNFL thinning, visual field progression, intraocular pressure

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1. INTRODUCTION

One of the many forms of chronic and progressive optic neuropathy which ultimately could result in irreversible vision loss, if left untreated is glaucoma. During the development of this condition, the impact of intraocular pressure was primarily seen as the focal contributing factor. However, there is growing evidence involving a variety of other systemic factors contributing to this condition. One of the other systemic factors is the increasing interest in blood pressure. In many

populations, hypertension is highly prevalent, and in the glaucoma patient population, there is a long standing history of having this condition, yet the individual has had little to no eyecare prior to diagnosis [1-3]

The impact of blood pressure on health of the optic nerve is due to its influence on the ocular perfusion pressure. Poorly managed blood pressure leads to fluctuations which can cut off the supply of blood to the optic nerve head. Over time, this supply disruption can weaken the head of the optic nerve, making it more susceptible to damage from sustained pressure. Some studies suggest that chronic hypertension can damage the microvasculature. Other studies suggest that rapid and aggressive reduction of blood pressure, particularly during the night, can lead to reduced perfusion on the optic nerve, which accelerates the deterioration of visual fields. The relationship is complex, and seems to require a careful equilibrium[4-6].

Given the above concerns, it is essential to invetigate to assess the impact the control of hypertension has on the progression of glaucoma, particularly in areas where the follow-up on patients may be limited and where hypertension is prevalent.. The present study was conducted to explore whether differences in blood pressure control are associated with measurable changes in glaucoma progression, assessed through OCT parameters, visual field indices, and intraocular pressure behaviour. The purpose was to clarify whether better systemic BP control might support the stability of glaucoma and help protect long-term visual outcomes.

2. METHODOLOGY

The research was planned as a one-year-long retrospective cross-sectional analysis starting from June 2023 until June of 2024, and it was conducted at Nishter Medical University Multan. Studied were whether the degree of systemic blood pressure control had an effect, and if so, what was the effect on the structural and functional progression of glaucoma. Since the research was retrospective, no exams were conducted, and information was collected only from hospital archives.

This research sought to explore potential correlations between the degree systemic blood pressure control and the structural and functional progression of glaucoma. Since this investigation was retrospective in nature, there was no direct contact with the patients; all the needed details were acquired from the hospital records.

There were 72 patient files reviewed in total. The patients were all diagnosed with glaucoma and had recorded systemic hypertension. To keep consistency,only patients with a minimum of one year follow-up data with visual field tests and OCT scans were included. Files were excluded if they had information missing, if the diagnosis of glaucoma was unclear, secondary glaucoma was the diagnosis, or records were incomplete with hypertension To ensure the dataset contained valid and comparable clinical data, this was done.

Demographic attributes including age, sex, and preliminary medical history were acquired from the first registered appointment. Pertinent information regarding hypertension included the duration of high blood pressure, medications used, and blood pressure readings taken during the follow-up study period. According to the average readings documented in the patients' files, they were categorized into two groups: hypertension that was controlled, and hypertension that was uncontrolled.

Clinical records are documented in detail to ensure completeness and chronological order. Measurements and variables from clinical entries I reviewed included, the intraocular pressure, number of medications taken, type of glaucoma the patient has, visual field results, and the OCT findings.. Additionally, I documented average retinal nerve fibre layer thickness and noted whether there was evidence of any thinning over time in the OCT. Mean deviation values and reports of progression were also noted from the visual field reports.

The estimation of ocular perfusion pressure was determined via the standard calculation from the SBP, DBP, and IOP, and was calculated from the medical notes, and where relevant, the nocturnal blood pressure dipping records.

SPSS (Statistical Package for the Social Sciences) version 22 was the software used to enter the data for analyses. Continuous variables were measured using the average and standard deviation. Categorical variables were measured using counts and percentages. Group comparison was done using an independent t-test for continuous variables and chi-square test for categorical variables for controlled and uncontrolled hypertension groups. A statistically significant measure was taken as 0.05 and below.

3. RESULTS

The participants in this study included 72 patients diagnosed with glaucoma and with systemic hypertension. Comparatively, patients with controlled blood pressure were in their younger age cohort, however, this difference was statistically negligible. Males and females were reportedly evenly allocated in both groups. A striking hypertension pattern and a higher number of used antihypertensives were documented in the cohort with uncontrolled blood pressure. This cohort was documented to have lived with hypertension longer and were on a higher number of antihypertensive medications. Diabetes and history of smoking was documented in both groups, however, this showed statistically irrelevant differences. Overall, the demographics of the groups were similar, with the differences primarily in medications.

Table 1. Baseline Demographic and Systemic Characteristics of Participants (n = 72)

Variable	Controlled Hypertension (n = 38)	Uncontrolled Hypertension (n = 34)	p-value
Age (years), mean ± SD	57.4 ± 8.6	59.1 ± 7.9	0.34
Sex (Male), n (%)	20 (52.6%)	19 (55.9%)	0.78
BMI (kg/m²), mean ± SD	26.7 ± 3.4	27.9 ± 3.8	0.21
Duration of hypertension (years)	7.8 ± 3.1	9.2 ± 3.5	0.07
Diabetes mellitus, n (%)	9 (23.7%)	12 (35.3%)	0.28
Smoking history, n (%)	7 (18.4%)	8 (23.5%)	0.58
Number of antihypertensive drugs	1.6 ± 0.7	2.1 ± 0.9	0.01*

*Significant at $p < 0.05$

There was a stark contrast when comparing the eye findings of the two groupsAll glaucoma types were nearly proportionally distributed across all groups, however, patients with uncontrolled hypertension presented with higher baseline and follow-up intraocular pressure and had increased aggravated pressure. Its consider thar more significant shifts in pressure are correlated with greater damage to the optic nerve. People with uncontrolled hypertension also had greater glaucoma medication requirements, indicating that there was more destabilization of the disease. Patients with uncontrolled hypertension are likely to have a comparably larger burden of disease to other groups.

Table 2. Ophthalmic Characteristics of Study Participants

Variable	Controlled BP (n = 38)	Uncontrolled BP (n = 34)	p-value
Type of Glaucoma			
– Primary Open-Angle Glaucoma	26 (68.4%)	23 (67.6%)	0.93
– Normal-Tension Glaucoma	7 (18.4%)	4 (11.8%)	0.42
– Primary Angle-Closure Glaucoma	5 (13.2%)	7 (20.6%)	0.39
Baseline IOP (mmHg), mean ± SD	16.3 ± 3.2	18.1 ± 3.8	0.02*
Mean IOP during follow-up (mmHg)	15.1 ± 2.9	17.8 ± 3.4	0.001*
IOP fluctuation (mmHg)	2.8 ± 1.1	4.2 ± 1.6	<0.001*
Number of anti-glaucoma medications	1.8 ± 0.9	2.4 ± 1.1	0.01*

There was evidence of clear divergence in observed features related to the structure and the function. Mean values for RNFL were markedly reduced for the group with out of control hypertension, indicative of greater loss of nerve fibers. Patients had a higher incidence of progressive thinning of their retinal nerve fiber layer (RNFL) in this population group. This was mirrored with scored visual field analysis by these individuals having uncontrolled hypertension, who experienced greater mean deviation deficits in their results with resulting in more rapid yearly deterioration. The results indicate that a larger percentage of participants exhibited confirmed visual field loss. Having taken these results into consideration, it may be that inadequately managed hypertension may be a factor in more rapid and/or extreme declines in glaucoma.

Table 3. OCT and Visual Field Parameters

Outcome	Controlled BP (n = 38)	Uncontrolled BP (n = 34)	p-value
RNFL average thickness (µm)	84.7 ± 9.8	78.1 ± 10.6	0.004*
RNFL progressive thinning, n (%)	9 (23.7%)	18 (52.9%)	0.007*

Visual Field Mean Deviation (MD, dB)	–5.4 ± 2.8	–7.1 ± 3.4	0.01*
Rate of MD decline (dB/year)	–0.32 ± 0.14	–0.48 ± 0.21	0.002*
Visual field progression, n (%)	11 (28.9%)	20 (58.8%)	0.008*

Based on the analysis of the structural and functional progression in the cohort of the study, a significant relationship between the two variables was established. Almost three-quarters of the participants who suffered from uncontrolled hypertension- experienced progression, in contrast to a little above one-third of the participants who had their blood pressure controlled. The difference was still quite clear in regard to structural OCT progression versus functional decline in visual fields. A small proportion exhibited concurrent progression of both types, which was also more prevalent in the uncontrolled cohort. This pattern shows how critical the regulation of systemic blood pressure may be for the preservation of the optic nerve.

Table 4. Association Between Hypertension Control and Glaucoma Progression

Variable	**Controlled BP (n = 38)**	**Uncontrolled BP (n = 34)**	**p-value**
Overall glaucoma progression, n (%)	14 (36.8%)	26 (76.5%)	<0.001*
Structural progression (OCT), n (%)	6 (15.8%)	12 (35.3%)	0.04*
Functional progression (VF), n (%)	8 (21.1%)	14 (41.2%)	0.05
Combined structural + functional progression, n (%)	4 (10.5%)	9 (26.5%)	0.09

Increased systemic blood pressure causes even more ocular perfusion pressure, but overall is still within a control blood pressure range. Patients with uncontrolled blood pressure have hypoperfused in the systolic, diastolic, and mean, which may lower the thresholds of the optic nerve's vulnerability. Moreover a greater percentage of the uncontrolled hypertension cohort showed significant nocturnal dipping of blood pressure. These drops are known to compromise the blood supply to the optic nerve during sleep. Such a combination of reduced supply pressures coupled with extreme overnight drops could help to explain the higher progression rates seen among these patients.

Table 5. Ocular Perfusion and Blood Pressure-Related Variables

Variable	**Controlled BP**	**Uncontrolled BP**	**p-value**
Systolic OPP (mmHg)	52.7 ± 5.3	47.1 ± 6.1	<0.001*
Diastolic OPP (mmHg)	43.8 ± 4.6	39.2 ± 5.8	0.002*
Mean OPP (mmHg)	46.4 ± 4.9	41.7 ± 5.5	0.001*
Nocturnal BP dip >20%, n (%)	5 (13.2%)	14 (41.2%)	0.006*

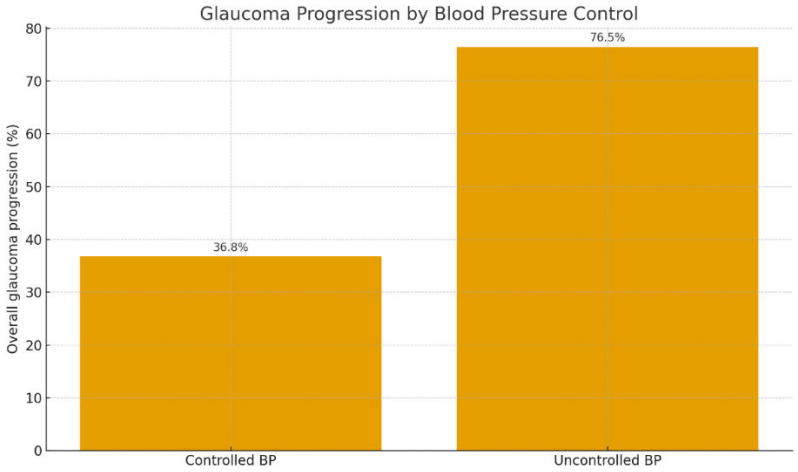

Figure 1: Glaucoma progression by blood pressure control

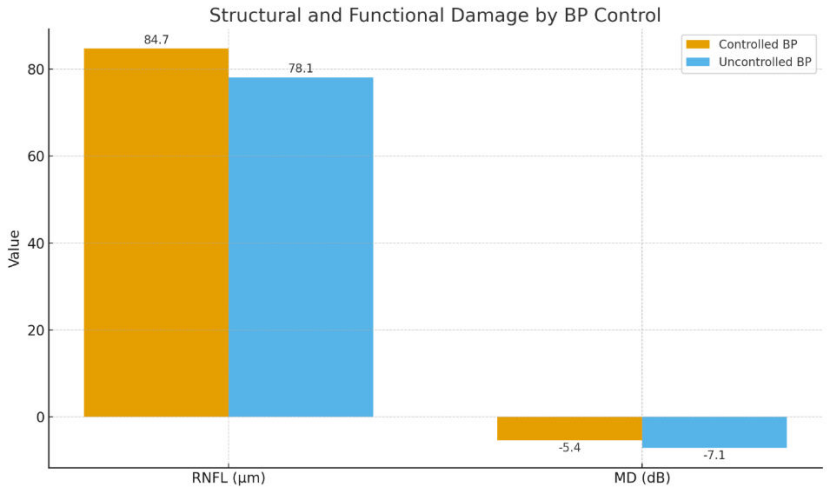

Figure 2: Comparison of RNFL thickness and mean deviation between groups

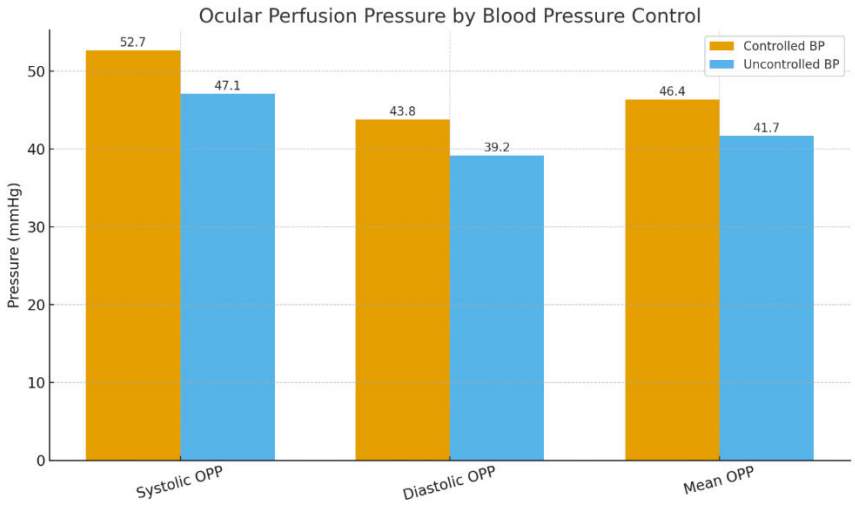

Figure 3: Ocular perfusion pressure in controlled and uncontrolled hypertensive glaucoma patients.

4. DISCUSSION

The current research determined that patients suffering from glaucoma and also having poorly managed systemic hypertension had much worse outcomes in comparison with other patients. Such outcomes included greater thinning of the retinal nerve fiber layer (RNFL), advanced deterioration of the visual field (VF) in conjunction with more eye pressure measured at higher levels (IOP), greater and more fluctuating rates of ocular hypertension and elevated rates of advanced ocular disease with both structural and functional progression. Those whose blood pressure was better controlled tended to have less progression and better ocular perfusion parameters. This suggests that underlying poorly controlled blood pressure may be driving the accelerated deterioration of glaucoma [7, 8].

These findings align with emerging evidence that systemic blood pressure (BP) and not just intraocular pressure plays a crucial role in glaucoma progression. According to a review by He et al., vascular factors including BP and ocular perfusion pressure (OPP) are important contributors to glaucomatous optic neuropathy, beyond just IOP elevations. In that view, changes in BP (too high or poorly regulated) may impair autoregulation of optic nerve head blood flow, making the optic nerve more vulnerable to damage [9].

Similarly, a recent large review concluded that systemic BP levels correlate with glaucomatous damage: both hypertension and hypotension (or excessive BP fluctuations) have been implicated [10]. In our study, the uncontrolled hypertension group not only had higher IOP but also lower OPP and more frequent nocturnal blood-pressure dips, which likely contributed to optic nerve ischemia and faster progression. This supports the “vascular hypothesis” of glaucoma that inadequate perfusion and dysregulated blood flow, rather than IOP alone, may drive damage[11-13].

In particular, the studies reported that low BP (especially low mean arterial pressure) combined with higher baseline IOP predicted faster RNFL thinning in glaucoma patients. That aligns with our observations: patients with poorly controlled systemic hypertension who are likely to endure BP variability experienced having a thinner RNFL and a higher rate of progression. This suggests that fluctuations in blood pressure (rather than consistently elevated blood pressure) may be particularly harmful [14, 15].

Conversely, epidemiological data continues to be inconsistent/uncertain. Take for instance, an examination of the population of the Blue Mountain Eye Study which demonstrated the positive correlation between hypertension and primary open-angle glaucoma [16]. There are reports suggesting that younger individuals or those with early disease may experience elevated BP that could temporarily enhance eye perfusion and confer some protective effects [17]. These conflicting findings reflect the complex, and perhaps U-shaped, nature of the effects of BP on glaucomatous damage. Both chronic poorly controlled hypertension and low BP/ hypotension (or excessive nocturnal dips) can be detrimental [15].

Data from animals lend support to the need for caution: A study of chronically hypertensive rodents found that even with increased ocular perfusion pressure, hypertension did not preserve the retinal architecture or the optic nerve fibers when the intraocular pressure was elevated, likely due to long-term hypertension disrupting vascular autoregulation and vessel remodeling. [18] This means: Having control of blood pressure along with increased perfusion pressure do not ensure that chronic blood vessel damage will be prevented.

Further, the treatment of hypertension, in itself, has the potential to impact the risk of glaucoma. One study reported that the use of systemic antihypertensive medications was associated with the increased progression of glaucoma, which the authors suggest might be due to the rapid reduction of blood pressure which in turn decreases ocular perfusion pressure and ultimately decreases the blood flow to the optic nerve. In our setting, some patients on several antihypertensive agents, especially, may have fluctuating BP, which may partly explain why uncontrolled hypertension correlates with worse outcomes of glaucoma [19, 20].

Along with data obtained from clinical studies, epidemiology, and testing, there is much proof to suggest that stable, well-controlled BP (without erratic fluctuations or dips at night) would likely provide more protection to glaucomatous eyes than potentially more dangerous conditions such as erratically controlled or unregulated hypertension Glaucoma patients' systemic BP and ocular perfusion should be considered alongside IOP when monitoring glaucoma patients.

The significance of collaboration between ophthalmologists and general practitioners, when dealing with glaucoma patients with hypertension. In respect of practical experience of blood pressure measurement, intentional control of excess nighttime blood pressure lowering, and stability of blood pressure, might contribute to the slowing of glaucoma progression. This becomes even more important in areas (like ours) with a high prevalence and inconstant follow-up.

Some limitations must be considered. First, the retrospective cross-sectional design places restrictions on causation inference. While the 72 (n = 72) is enough to be able to find meaningful differences, it is still modest, especially comparing it to the 72 n = 72 sample sizes. Nocturnal BP data is also based on the records. Not complete 24-hour ambulatory BP monitoring data records may be lacking and is likely to BP fluctuations. There are variations in confounding treatment regimens in patients and other potential confounders (like adherence and lifestyle). However, the consistent pattern across the measures (OCT) and (visual field) function strengthens the confidence in the findings.

Future research efforts focusing on planned prospective studies should monitor larger multi-institutional samples, incorporate standardized protocols for 24-hour ambulatory BP monitoring, and implement standardized protocols to test

the impact of individual classes of antihypertensive medications. This would provide greater clarity on the impact of stable versus volatile control of BP and the impact of different BP control target values to estimate the risks of and timing of medications to control the BP to circumvent nocturnal over-dipping on the glaucoma progression risk.

5. CONCLUSION

This study demonstrates that poor systemic hypertension control is associated with increased glaucomatous progression evidenced by greater RNFL thinning, worse visual field loss, higher IOP, and lower ocular perfusion. The findings support the view that maintaining stable and well-controlled blood pressure may be important in slowing glaucoma damage. These results call for integration of systemic BP management and ocular follow-up in hypertensive glaucoma patients to preserve optic nerve health and prevent vision loss.

REFERENCES

[1] Jammal, A.A., et al., Blood pressure and glaucomatous progression in a large clinical population. 2022. 129(2): p. 161-170.

[2] Lee, K., et al., Risk factors associated with structural progression in normal-tension glaucoma: intraocular pressure, systemic blood pressure, and myopia. 2020. 61(8): p. 35-35.

[3] Bogdanova, I.L.J.J.o.M.S., THE EFFECT OF CERTAIN SYSTEMIC DISEASES ON THE OCCURENCE AND PROGRESSION OF GLAUCOMA. 2020. 3(3): p. 13-22.

[4] Shukla, A.G., R. Razeghinejad, and J.S.J.E.o.o.p. Myers, Balancing treatments for patients with systemic hypertension and glaucoma. 2020. 21(18): p. 2225-2230.

[5] Cui, Y.-k., et al., Mechanistic links between systemic hypertension and open angle glaucoma. 2022. 105(4): p. 362-371.

[6] Garcia-Villanueva, C., et al., Impact of systemic comorbidities on ocular hypertension and open-angle glaucoma, in a population from Spain and Portugal. 2022. 11(19): p. 5649.

[7] Chang, A.Y., et al., The role of intraocular pressure and systemic hypertension in the progression of glaucomatous damage to the macula. 2022. 31(5): p. 317-321.

[8] Marshall, H., et al., Cardiovascular disease predicts structural and functional progression in early glaucoma. 2021. 128(1): p. 58-69.

[9] He, Z., et al., The role of blood pressure in glaucoma. Clinical & experimental optometry : journal of the Australian Optometrical Association, 2011. 94: p. 133-49 DOI: 10.1111/j.1444-0938.2010.00564.x.

[10] Nislawati, R., et al., Role of hypertension as a risk factor for open-angle glaucoma: a systematic review and meta-analysis. 2021. 6(1).

[11] Funk, R.O., et al., Multiple systemic vascular risk factors are associated with low-tension glaucoma. 2022. 31(1): p. 15-22.

[12] Dada, T., et al., Ocular and systemic factors associated with glaucoma. 2022. 16(3): p. 179.

[13] Wu, A., et al., A review of systemic medications that may modulate the risk of glaucoma. 2020. 34(1): p. 12-28.

[14] Park, C.K., et al., Effect of systemic blood pressure on optical coherence tomography angiography in glaucoma patients. 2021. 35(7): p. 1967-1976.

[15] Vinokurtseva, A., et al., Impact of inhaled and intranasal corticosteroids exposure on the risk of ocular hypertension and glaucoma: a systematic review and meta-analysis. 2022: p. 1675-1695.

[16] Kuang, T.-M., et al., Association of Systemic Hypertension With Primary Open-angle Glaucoma: A Population-based Case-Control Study. American Journal of Ophthalmology, 2020. 218: p. 99-104 DOI: https://doi.org/10.1016/j.ajo.2020.04.020.

[17] Nislawati, R., et al., Role of hypertension as a risk factor for open-angle glaucoma: a systematic review and meta-analysis. BMJ Open Ophthalmol, 2021. 6(1): p. e000798 DOI: 10.1136/bmjophth-2021-000798.

[18] van Koeverden, A.K., et al., Systemic hypertension is not protective against chronic intraocular pressure elevation in a rodent model. Scientific Reports, 2018. 8(1): p. 7107 DOI: 10.1038/s41598-018-25264-4.

[19] Ma, T., et al., High rate of conversion from ocular hypertension to glaucoma in subjects with uveitis. 2022. 106(11): p. 1520-1523.

[20] Lee, J.S., et al., Systemic arterial stiffness is associated with structural progression in early open-angle glaucoma. 2022. 63(3): p. 28-28.