EARLY DIAGNOSIS OF GLAUCOMA AND MODERN DIAGNOSTIC METHODS

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https://doi.org/10.5281/zenodo.20676372

Abstract

Glaucoma is a chronic ophthalmological disease characterized by progressive damage to the optic nerve, which may ultimately lead to complete vision loss over time. It is one of the leading causes of blindness and visual disability worldwide. Due to its often asymptomatic and insidious course, early detection of glaucoma remains a significant clinical challenge. This article analyzes the problem of early glaucoma diagnosis, its pathophysiological mechanisms, and the effectiveness of modern diagnostic methods. During the study, tonometry, perimetry, and optical coherence tomography (OCT) were compared. The results demonstrated that clinical symptoms may be absent during the early stages of glaucoma; however, subclinical changes can be detected using modern instrumental diagnostic techniques. In conclusion, early diagnosis of glaucoma is essential for preserving visual function and slowing disease progression.

Keywords: Glaucoma, early diagnosis, intraocular pressure, optic nerve, visual field, perimetry, tonometry, optical coherence tomography, retina, screening, diagnostics.

Introduction

Glaucoma is a chronic disease characterized by progressive degeneration of the optic nerve and gradual narrowing of the visual field. It is one of the leading causes of irreversible blindness worldwide, affecting millions of individuals. The primary danger of glaucoma lies in its asymptomatic nature during the early stages of the disease. Patients may remain unaware of their condition for a prolonged period, resulting in delayed diagnosis and irreversible damage to the optic nerve. To better understand the development of glaucoma, it is important to consider the mechanisms regulating intraocular pressure (IOP). The balance of intraocular pressure depends on the equilibrium between the production and drainage of aqueous humor. This fluid is produced by the ciliary body and initially flows from the posterior chamber through the pupil into the anterior chamber. Approximately 90% of the aqueous humor drains through the trabecular outflow pathway. From there, it passes into Schlemm's canal and subsequently exits the eye through the episcleral veins.

Because this conventional drainage pathway is pressure-dependent, an increase in intraocular pressure is normally accompanied by an increase in aqueous humor outflow. This route is considered the conventional outflow pathway and accounts for approximately 90% of aqueous humor drainage. The remaining 10% is eliminated through the uveoscleral outflow pathway. In this pathway, the aqueous humor passes through the ciliary body into the suprachoroidal space and is subsequently drained from the eye through the venous systems of the ciliary body, sclera, and choroid. A certain amount of aqueous humor also flows through the iris. Therefore, this pathway is considered a non-conventional (uveoscleral) outflow route.

Any disturbance in the balance of this system—either a reduction in aqueous humor outflow due to changes in the aforementioned channels or an increase in its production—leads to elevated intraocular pressure.

An increase in intraocular pressure plays a central role in the pathogenesis of glaucoma. Persistent elevation of intraocular pressure results in compression of nerve fibers in the lamina cribrosa region, impairment of blood circulation, and consequently apoptosis of retinal ganglion cells. In addition, recent studies have shown that vascular factors, neurodegenerative processes, and oxidative stress also play important roles in the development of glaucoma.

The main causes contributing to the development of glaucoma are as follows:

-Degenerative changes in the trabecular meshwork;

Narrowing or closure of the anterior chamber angle;

Inflammation, trauma, or postoperative changes;

-Mechanical obstruction of aqueous humor drainage;

-Long-term use of medications and other secondary factors.

Clinically, glaucoma is classified into several major types, each characterized by a distinct pathogenic mechanism.

Congenital glaucoma is associated with defects in the embryonic development of the drainage

system and is characterized by incomplete formation of the trabecular apparatus.

Open-angle glaucoma occurs when the anterior chamber angle remains open; however, resistance within the trabecular meshwork increases. This condition is more commonly associated with degenerative changes and develops slowly without noticeable symptoms. Its major danger lies in its asymptomatic progression.

Angle-closure glaucoma occurs when the angle between the iris and the cornea

becomes narrowed or completely closed, resulting in a severe impairment of aqueous humor outflow. In this type, intraocular pressure rises rapidly and presents with acute clinical manifestations.

Secondary glaucoma develops as a result of other ocular diseases, such as trauma, uveitis, tumors, and other conditions. In such cases, the pathogenesis of glaucoma is closely related to the underlying disease and is often associated with obstruction of the drainage system or dysfunction of the ciliary body. Thus, the development of glaucoma is based on an imbalance in aqueous humor dynamics, increased resistance within the drainage system, and the resulting progressive damage to the optic nerve. Depending on the type of glaucoma, these processes occur through different mechanisms, which necessitates early diagnosis and an individualized approach to each patient.

Relevance

Glaucoma is one of the most significant challenges in modern ophthalmology. According to the World Health Organization (WHO), glaucoma is one of the leading causes of blindness worldwide and continues to have a negative impact on the quality of life of millions of people.

The available data indicate that glaucoma is not only a problem affecting specific countries or regions but is also recognized as a global public health concern.

It is well known that approximately 80–90% of information about the surrounding environment is perceived through vision. In other words, most of the information received by humans is processed through the eyes and subsequently analyzed and interpreted by the brain. Therefore, glaucoma is not merely a common eye disease but a condition that can significantly impair an individual's quality of life.

Let us consider the statistical data.

Currently, more than 76 million people worldwide are living with glaucoma, and projections suggest that this number will exceed 110 million by 2040. The most concerning aspect is that more than 50% of individuals with glaucoma are unaware that they have the disease. Unfortunately, this often leads to delayed diagnosis and treatment. Blindness caused by glaucoma is irreversible because damage to the optic nerve cannot be restored. Therefore, early detection and timely treatment remain among the most important priorities in modern ophthalmology.

Despite significant advances in diagnostic technologies, including perimetry,

optical coherence tomography (OCT), and tonometry, glaucoma is still frequently diagnosed at advanced stages. This highlights the continuing importance of improving methods for the early detection of the disease.

Urbanization, population aging, the increasing prevalence of chronic diseases such as arterial hypertension and diabetes mellitus, and the long-term use of medications, particularly corticosteroids, are considered important risk factors for the development of glaucoma.

In this context, a comprehensive understanding of glaucoma pathogenesis, accurate differentiation of its various forms, and, most importantly, the improvement of early diagnostic approaches remain among the leading priorities of contemporary ophthalmic research.

Materials and Methods

This study was conducted to evaluate contemporary methods for the early diagnosis of glaucoma, to investigate the pathogenesis of the disease in greater depth, and to assess the effectiveness of current diagnostic criteria. A comprehensive approach combining both theoretical and practical methodologies was employed.

The practical component of the study involved clinical observation of patients from different age groups presenting with clinical signs suggestive of glaucoma. Patients with decreased visual acuity, elevated intraocular pressure, visual field defects, or pathological changes of the optic nerve head were included in the study.

Patient selection was based on medical history, the presence of concomitant diseases, hereditary predisposition, and associated conditions such as arterial hypertension, diabetes mellitus, and other relevant systemic disorders. Diagnostic evaluation was carried out in several stages and included the following methods:

Visometry – performed using standard visual acuity charts to determine central visual acuity and assess the degree of visual impairment. Tonometry – intraocular pressure was measured using both the Maklakov method and non-contact tonometry to identify deviations from normal values. Perimetry – static and kinetic perimetric techniques were used to assess visual fields and detect peripheral visual field defects characteristic of glaucoma. Gonioscopy – performed to evaluate the condition of the anterior chamber angle, determine whether it was open or closed, and differentiate between various types of glaucoma.measured using both the Maklakov method and non-contact tonometry to identify deviations from normal values.

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Ophthalmoscopy — the excavation of the optic nerve disc, its borders, and color changes were evaluated, with attention paid to signs of glaucomatous optic neuropathy.

Optical coherence tomography (OCT) — the thickness of the retinal nerve fiber layer, the ganglion cell complex, and the structural condition of the optic nerve head were analyzed with high precision.

In addition, the production of intraocular fluid and the function of its drainage system were analyzed theoretically. The mechanisms of fluid secretion by the ciliary body, its passage from the posterior chamber to the anterior chamber of the eye, as well as its outflow through the trabecular meshwork and Schlemm's canal were studied. It was substantiated that disruption of these processes leads to increased intraocular pressure and damage to the optic nerve.**Results**

During the study, a total of 100 patients were examined. Their age ranged from 35 to 75 years,

with a mean age of 57±8 years. There were 56 females (56%) and 44 males (44%).

Table 1.Distribution of patients by age and sex

Indicator	**Number(n)**	**Percentage(%)**
Men	**44**	**44%**
Women	**56**	**56%**
Total	**100**	**100%**
Age group	**Number(n)**	**Percentage(%)**
35-45years	**18**	**18%**
46-60 years	**47**	**47%**
61-75 years	**35**	**35%**

According to the results, glaucoma was more frequently observed in patients older than 46years.

Table 2.Intraoculyar pressure (IOP) indicators

IOP level (mmHg)	Number(n)	Percentage(%)
Up to 21(normal)	12	12%
22-26	28	28%
27-30	34	34%
Above 30	26	26%

The analysis showed that 88% of patients had elevated intraocular pressure.

Table 3.Visual field changes (perimetry results)

Type of change	Number(n)	Percentage(%)
Normal	14	14%
Paracentral scotoma	30	30%
Arcuate scotoma	28	28%
Peripheral constriction	28	28%

Visual field changes were detected in 86% of patients, indicating functional impairment.

Table 4.Ophthalmoscopy findings (optic nerve head)

Sign	Number(n)	Percentage(%)
Normal disc	13	13%
Excavation(0.5-0.7)	49	49%
Deep excavation(>0.7)	38	38%

The results indicate that glaucomatous optic nerve damage is widespread.

Table 5.OCT findings (RNFL thickness)

Condition	Number(n)	Percentage(%)
Normal	15	15%
Mild thinning	36	36%
Moderate thinning	27	27%
Severe thinning	22	22%

According to OCT results,thinning of the retinal nerve fiber layer was detected in 85% of patients.

General Analysis

The obtained results showed the following:

Elevated intraocular pressure was observed in the majority of patients (88%).

Visual field defects (86%) were identified as a functional sign of glaucoma.

Ophthalmoscopy revealed optic disc cupping in 87% of patients, confirming structural damage.

Optical Coherence Tomography (OCT) examinations detected retinal nerve fiber layer (RNFL) thinning in 85% of patients, demonstrating its high value in early diagnosis.

ConclusionThe results of this study once again confirm that the early diagnosis of glaucoma remains one of the most important challenges in modern ophthalmology. The study revealed that the majority of patients exhibited visual field constriction, elevated intraocular pressure, and glaucomatous changes of the optic nerve head.

Among the instrumental examination methods, perimetry and Optical Coherence Tomography (OCT) were found to have the highest diagnostic value. In particular, OCT was shown to detect thinning of the retinal nerve fiber layer even in the early stages of the disease. This makes it possible to diagnose glaucoma before its clinical signs become fully developed.

Furthermore, the study confirmed that impaired circulation of the aqueous humor, reduced function of the trabecular meshwork, and dysfunction of the drainage system play important roles in the development of glaucoma. The findings indicate that continuous monitoring of intraocular pressure, assessment of the visual field, and early detection of changes in the optic nerve head are of critical importance for the early diagnosis of the disease. In particular, regular preventive examinations are essential for patients belonging to high-risk groups, including those with age-related changes, a positive family history, arterial hypertension, and diabetes mellitus.

Overall, the early diagnosis of glaucoma can be significantly improved through the widespread use of modern diagnostic methods, timely screening of patients, and increased public awareness. This is crucial for preventing blindness and preserving visual function over the long term.

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