



Glaucoma: The Silent Thief of Sight and Advances in Management

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DESCRIPTION

Glaucoma, often referred to as the “silent thief of sight,” is a group of progressive optic neuropathies characterized by structural damage to the optic nerve and corresponding visual field loss. It represents the leading cause of irreversible blindness worldwide, affecting more than 76 million people globally, with projections rising to over 110 million by 2040 due to aging populations. What makes glaucoma particularly devastating is its insidious onset; patients may remain asymptomatic until significant vision has already been lost. This gradual progression underscores the importance of early detection, effective monitoring, and innovative therapeutic strategies to mitigate its burden.

The pathogenesis of glaucoma is multifactorial, with elevated Intraocular Pressure (IOP) being the most well-established risk factor. However, not all individuals with high IOP develop glaucoma, and some patients with normal-tension glaucoma experience progressive optic nerve damage despite pressures within the statistically normal range. This complexity highlights the role of other contributing factors, including vascular dysregulation, impaired cerebrospinal fluid dynamics, mitochondrial dysfunction, and genetic predisposition. Emerging evidence suggests that glaucoma is not merely an eye disease but a neurodegenerative disorder with similarities to conditions such as Alzheimer's and Parkinson's disease.

The clinical spectrum of glaucoma includes Primary Open-Angle Glaucoma (POAG), angle-closure glaucoma, congenital glaucoma, and secondary glaucomas caused by trauma, inflammation, or medications. POAG, the most common form, is characterized by gradual loss of peripheral vision due to progressive optic nerve cupping. Angle-closure glaucoma, in contrast, can present acutely with severe pain, halos around lights, headache, and rapid vision loss due to sudden blockage of aqueous humor drainage. Such attacks are ophthalmic emergencies requiring prompt intervention to prevent permanent blindness.

Diagnosis of glaucoma relies on a combination of risk assessment, IOP measurement, optic nerve evaluation, and functional testing. Goldmann applanation tonometry remains the standard for IOP measurement, though newer techniques such as dynamic contour tonometry and rebound tonometry are expanding diagnostic options. Optical Coherence Tomography (OCT) has revolutionized structural assessment by allowing high-resolution imaging of retinal nerve fiber layer and ganglion cell complex thickness. Visual field testing, particularly automated perimetry, remains the gold standard for functional assessment, though its subjective nature presents challenges in early disease detection. Artificial intelligence and deep learning algorithms are increasingly being applied to OCT and visual field data, offering promise in improving early diagnosis and progression monitoring.

Management of glaucoma centers on lowering IOP, the only modifiable risk factor proven to slow disease progression. First-line therapy typically involves topical medications such as prostaglandin analogs, beta-blockers, alpha-adrenergic agonists, and carbonic anhydrase inhibitors. Prostaglandin analogs are particularly effective in enhancing aqueous humor outflow through the uveoscleral pathway, often achieving 25%-30% reductions in IOP. Fixed-combination formulations improve adherence by reducing drop burden, a significant challenge in chronic disease management. Sustained-release drug delivery systems, including punctal plugs, subconjunctival implants, and intracameral injections, are under active development to address adherence issues.

Laser therapies have become increasingly popular in glaucoma management. Selective Laser Trabeculoplasty (SLT), which uses short-pulsed laser energy to target pigmented trabecular meshwork cells, has demonstrated efficacy comparable to medications and can be repeated with minimal risk. In many healthcare systems, SLT is now being considered as a first-line therapy. Argon laser trabeculoplasty, though effective, is less commonly used due to higher rates of scarring. Laser peripheral iridotomy remains essential in the management of angle-closure glaucoma by creating an alternative pathway for aqueous humor flow.

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Surgical options are pursued when medical and laser therapies fail to achieve adequate IOP control. Trabeculectomy, the traditional gold standard, creates a fistula for aqueous humor drainage but carries risks of infection, hypotony, and bleb failure. Glaucoma drainage devices, such as Ahmed and Baerveldt implants, provide alternative pathways for aqueous outflow, offering options for refractory cases. Minimally Invasive Glaucoma Surgeries (MIGS) have emerged as a transformative

advancement, offering safer, less invasive alternatives with faster recovery times. These procedures include trabecular micro-bypass stents, suprachoroidal shunts, and goniotomy techniques, which enhance physiological outflow with fewer complications. Although MIGS generally achieve modest IOP reductions compared to trabeculectomy, their favorable safety profile makes them appealing for earlier intervention and combination with cataract surgery.