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Glaucoma

Glaucoma is a complicated disease in which damage to the optic nerve leads to progressive, irreversible vision loss. Glaucoma is the second leading cause of blindness.

Glaucoma is a multi-factorial, complex eye disease with specific characteristics such as optic nerve damage and visual field loss. While increased pressure inside the eye (called intraocular pressure or IOP) is usually present, even patients with normal range IOP can develop glaucoma.

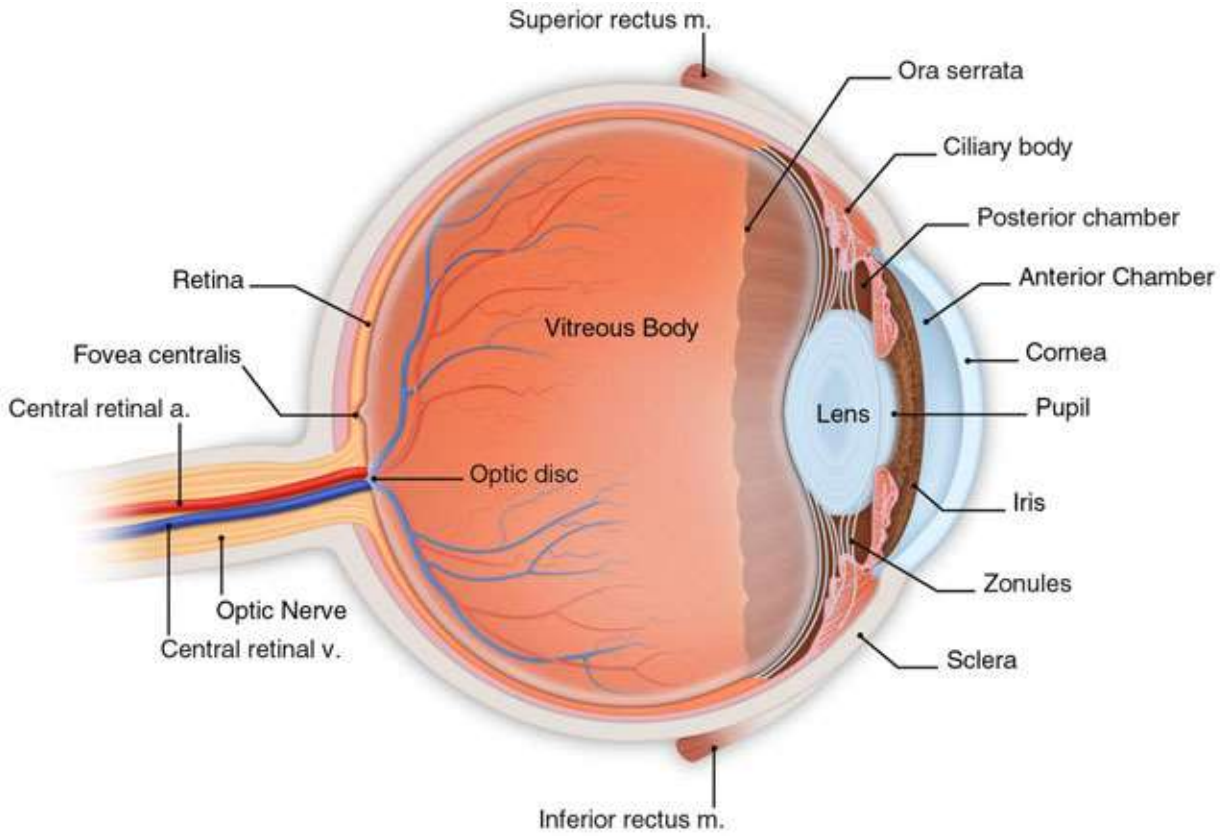
There is no specific level of elevated eye pressure that definitely leads to glaucoma; conversely, there is no lower level of IOP that will absolutely eliminate a person's risk of developing glaucoma. That is why early diagnosis and treatment of glaucoma is the key to preventing vision loss.

Measuring Eye Pressure

Eye pressure is measured in millimeters of mercury (mm Hg). Normal eye pressure ranges from 12-22 mm Hg, and eye pressure of greater than 22 mm Hg is considered higher than normal. When the IOP is higher than normal but the person does not show signs of glaucoma, this is referred to as ocular hypertension.

High eye pressure alone does not cause glaucoma. However, it is a significant risk factor. Individuals diagnosed with high eye pressure should have regular comprehensive eye examinations by an eyecare professional to check for signs of the onset of glaucoma.

Anatomy of the eye



A tough white covering called the sclera protects the eye. Part of the white sclera can be seen in the front of the eye. A clear, delicate membrane called the conjunctiva covers the sclera.

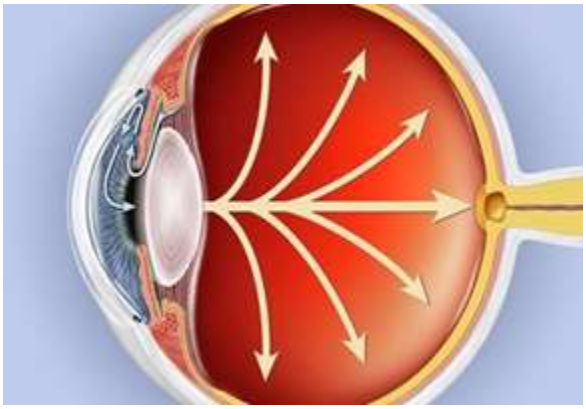
At the front of the eye is the cornea. The cornea is the clear part of the eye's protective covering. It allows light to enter the eye. The iris is the colored part of the eye that shrinks and expands so the pupil can let just the right amount of light into the eye. The light is directed by the pupil to the lens. The lens focuses the light onto the retina (inside the lining of the eye). Nerve fibers in the retina carry images to the brain through the optic nerve.

Healthy Drainage

The front part of the eye is filled with a clear fluid called intraocular fluid or aqueous humor, made by the ciliary body. The fluid flows out through the pupil. It is then absorbed into the bloodstream through the eye's drainage system.

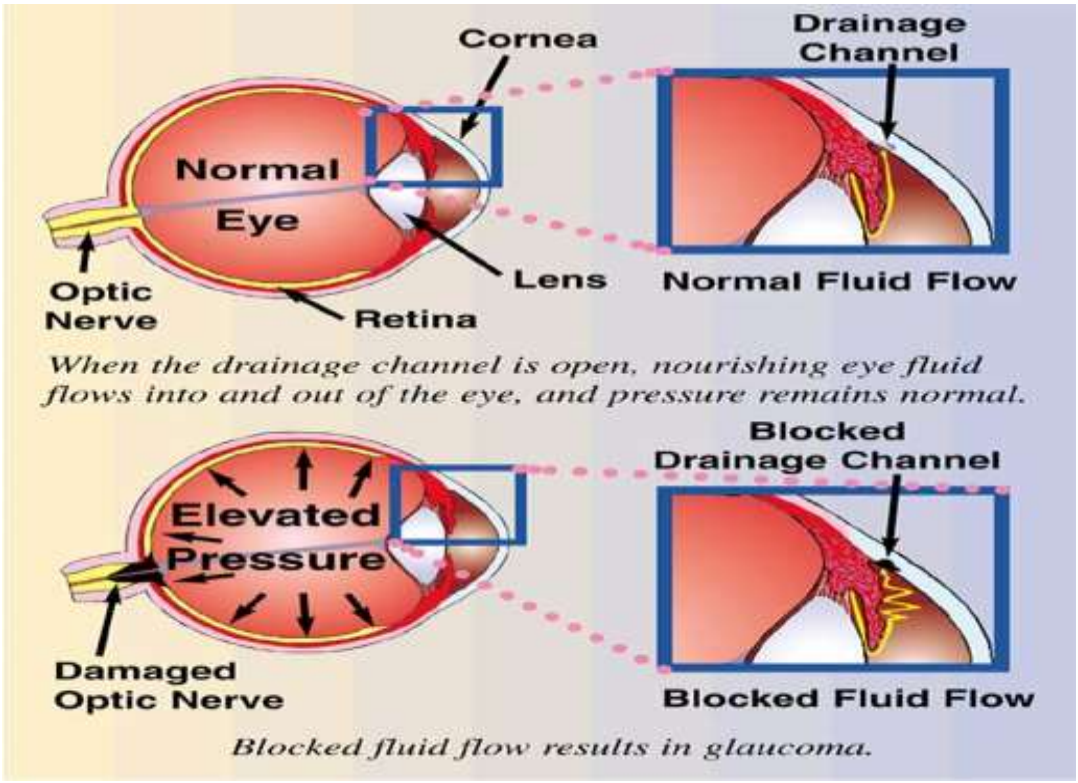
This drainage system is a meshwork of drainage canals around the outer edge of the iris. Proper drainage helps keep eye pressure at a normal level. The production, flow, and drainage of this fluid is an active continuous process that is needed for the health of the eye.

The inner pressure of the eye (intraocular pressure or IOP) depends upon the amount of fluid in the eye. If your eye's drainage system is working properly then fluid can drain out and prevent a buildup. Likewise, if your eye's fluid system is working properly, then the right amount of fluid will be produced for a healthy eye. Your IOP can vary at different times of the day, but it normally stays within a range that the eye can handle.



The Eye With Glaucoma

In most types of glaucoma, the eye's drainage system becomes clogged so the intraocular fluid cannot drain. As the fluid builds up, it causes pressure to build within the eye. High pressure damages the sensitive optic nerve and results in vision loss.



The Optic Disc

You have millions of nerve fibers that run from your retina to the optic nerve. These fibers meet at the optic disc. As fluid pressure within your eye increases, it damages these sensitive nerve fibers and they begin to die. As they die, the disc begins to hollow and pushes the optic nerve into a cupped or curved shape. If the pressure remains too high for too long, the extra pressure can damage the optic nerve and result in vision loss.

Is There Another Cause?

It was once thought that high intraocular pressure (IOP) was the main cause of this optic nerve damage. Although IOP is clearly a risk factor, we now know that other factors must be involved because people with "normal" IOP can experience vision loss from glaucoma.

The Fluid Inside

Aqueous humor is the clear, watery fluid that is continually produced inside the eye. It is different from your tears. Tears are produced by glands outside of the eye and moisten the outer surface of the eyeball.

Investigations
Thorough history with special attention to:
nature of any ocular disturbances, e.g., loss of peripheral vision, halos around lights, decreased visual cuity
quality of any pain, e.g., deep orbital, brow or headacheassociated systemic symptoms, e.g., abdominal pain, nausea and vomit

Types of Glaucoma

Glaucoma is actually a group of diseases. The most common type is hereditary.

Primary Open-Angle Glaucoma

This is the most common form of glaucoma, affecting about three million Americans. It happens when the eye's drainage canals become clogged over time.

The inner eye pressure (also called intraocular pressure or IOP) rises because the correct amount of fluid can't drain out of the eye. With open-angle glaucoma, the entrances to the drainage canals are clear and should be working correctly. The clogging problem occurs further inside the drainage canals, similar to a clogged pipe below the drain in a sink.

Most people have no symptoms and no early warning signs. If open-angle glaucoma is not diagnosed and treated, it can cause a gradual loss of vision. This type of glaucoma develops slowly and sometimes without noticeable sight loss for many years. It usually responds well to medication, especially if caught early and treated.

Glaucoma is an eye disease that gradually steals vision. There are typically no early warning signs or painful symptoms of open-angle glaucoma. It develops slowly and sometimes without noticeable sight loss for many years.

Most people who have open-angle glaucoma feel fine and do not notice a change in their vision at first because the initial loss of vision is of side or peripheral vision, and the visual acuity or sharpness of vision is maintained until late in the disease.

Angle-Closure Glaucoma

This type of glaucoma is also known as acute glaucoma or narrow angle glaucoma. It is much more rare and is very different from open-angle glaucoma in that the eye pressure usually rises very quickly.

This happens when the drainage canals get blocked or covered over, like a sink with something covering the drain.

With angle-closure glaucoma, the iris is not as wide and open as it should be. The outer edge of the iris bunches up over the drainage canals, when the pupil enlarges too much or too quickly. This can happen when entering a dark room.

A simple test can be used to see if your angle is normal and wide or abnormal and narrow. Treatment of angle-closure glaucoma usually involves surgery to remove a small portion of the outer edge of the iris. This helps unblock the drainage canals so that the extra fluid can drain. Usually surgery is successful and long lasting. However, you should still receive regular check-ups.

Angle-closure glaucoma is caused by blocked drainage canals in the eye, resulting in a sudden rise in intraocular pressure. This is a much more rare form of glaucoma, which develops very quickly and demands immediate medical attention.

Symptoms of angle-closure glaucoma may include:

- Hazy or blurred vision
- The appearance of rainbow-colored circles around bright lights
- Severe eye and head pain
- Nausea or vomiting (accompanying severe eye pain)
- Sudden sight loss

In contrast with open-angle glaucoma, symptoms of acute angle-closure glaucoma are very noticeable and damage occurs quickly. If you experience any of these symptoms, seek immediate care from an ophthalmologist.

Normal-Tension Glaucoma

Also called low-tension or normal-pressure glaucoma, in normal-tension glaucoma (NTG) the optic nerve is damaged even though the pressure in the eye is not very high.

Doctors do not know why some people's optic nerves are damaged even though they have almost normal pressure levels.

Those at higher risk for this form of glaucoma are:

- people with a family history of normal-tension glaucoma
- people of Japanese ancestry
- people with a history of systemic heart disease such as irregular heart rhythm.

History of drug use that can cause or worsen glaucoma

corticosteroids (common) . drugs with antimuscarinic activity (rare), e.g., antihistamines, decongestants, antidepressants,antispasmodics

the anticonvulsant topiramate has been associated with acute angle-closure glaucoma

Table 1: Risk Factors for the Development of Glaucoma

Type of Glaucoma	**Open-angle Glaucoma**	**Angle-closure Glaucoma**	
		Acute	**Chronic**
1-Acquired, Primary	Elevated IOP Advanced age[7] Black ethnicity[8] Hispanic ethnicity (Mexican ancestry)[9] Positive family history Myopia[10] Vascular diseases such as migraine,[11] hypertension[12] or nocturnal hypotension[13]	Female gender Advanced age[7] Positive family history Hyperopia White ethnicity	Advanced age[7] Positive family history Hyperopia
2-Acquired, Secondary	Blunt or penetrating trauma Previous intraocular surgery Previous intraocular inflammation Corticosteroid use (ophthalmic, systemic, nasal or inhaled)	Proliferative diabetic retinopathy and central retinal vein occlusion (neovascular angle-closure glaucoma)	
3-congenital	Positive family history		

Table 2: Laser and Surgical Treatment of Glaucoma

Procedure	Indication	Description
Laser Treatment		
Laser trabeculoplasty (argon or selective laser)	Open-angle glaucoma	Laser applications to trabecular meshwork (drainage system). Effect is short term, e.g., 2 y; most suitable for elderly patients.
Laser iridotomy	Angle-closure glaucoma	A neodymium: yttrium-aluminum-garnet (Nd:YAG) laser cuts holes in iris to permit flow of aqueous humor directly from posterior to anterior chamber; can be done without incising eyeball. Simple office procedure.
Laser ciliary body ablation	Advanced refractory glaucomas	Used where other options are limited.
Surgical Treatment		
Filtration procedures (e.g., trabeculectomy, nonpenetrating deep sclerotomy, viscocanalostomy)	Open-angle glaucoma, in cases refractory to medical or laser treatment	A channel is created, allowing aqueous flow from anterior chamber to a subconjunctival space. Healing and surgical success improved with topical use of antiproliferative agents, such as mitomycin C or 5-fluorouracil, during or following procedure.
Iridectomy	Angle-closure glaucoma	Used in affected eye and prophylactically in other eye. Reserved for rare cases refractory to Nd:YAG laser iridotomy.
Drainage tube insertion	Any form of glaucoma, where other surgical procedures have not succeeded	Small tube, inserted into anterior chamber, drains aqueous humor to a plate that is implanted on the sclera, beneath the conjunctiva.

Tests for Glaucoma

Early detection, through regular and complete eye exams, is the key to protecting your vision.

- **Five Common Glaucoma Tests**

Examining...	Name of Test
The inner eye pressure	Tonometry
The shape and color of the optic nerve	Ophthalmoscopy (dilated eye exam)
The complete field of vision	Perimetry (visual field test)
The angle in the eye where the iris meets the cornea	Gonioscopy
Thickness of the cornea	Pachymetry

Optic Nerve Imaging

The Importance of Corneal Thickness

Glaucoma Treatments

Goals of Therapy

Prevent, halt or slow progressive visual lossPreserve the structure and function of the optic nerve

Eliminate pain and improve vision in acute forms

- Glaucoma Medications
- Laser Therapies
- Surgery
- Potential Treatments
- Prescription Assistance Programs

Glaucoma Medications

The most common treatments for glaucoma are eye drops and, rarely, pills. There are a number of different categories of eye drops, but all are used to either decrease the amount of fluid (aqueous humor) in the eye or improve its outward flow. Sometimes doctors will prescribe a combination of eye drops. People using these medications should be aware of their purpose and potential side effects, which should be explained by a medical professional. Some side effects can be serious.

Types of Medications

Alpha adrenergic agonistsboth reduce aqueous humor production and increase its outflow. Allergic reactions frequently occur with this class of medication. Side effects may include increased heart rate (tachycardia), irregular heart beat (arrhythmias), elevated blood pressure, headaches, blurry vision, fatigue, dry mouth, and redness in or around the eye.

Examples include:

- apraclonidine
- brimonidine
- epinepherine
- dipivefrin

Beta blockers work to lower eye (intraocular) pressure by reducing the production of aqueous humor and decreasing the rate at which the fluid flows into the eye. Side effects may include a slow or irregular heartbeat, congestive heart failure, chronic obstructive pulmonary disease, depression, impotence, drowsiness, double vision, and breathing problems for patients with asthma or emphysema.

Examples include:

- timolol
- levobunolol
- carteolol
- metipranolol
- betatoxol

Carbonic anhydrase inhibitors are eye drops or pills used to reduce fluid production in the eye. Side effects may include skin rash, eye redness, stinging or irritation, blurred vision, headache, tingling in the hands or feet, nausea or upset stomach, kidney stones, altered taste (especially with carbonated beverages), weight loss, fatigue, and decreased energy.

Examples include:

- dorzolamide
- brinzolamide
- acetazolamide
- methazolamide

Miotics(cholinergic agents) cause the pupil to become much smaller in diameter and help increase the rate of fluid drainage from the eye. Side effects may include red eyes, headache, blurry or cloudy vision, excessive salivation and tearing, sweating, nausea, vomiting, diarrhea, pulmonary edema, and slowed heart beat.

Examples include:

- pilocarpine

Prostaglandin analogs reduce pressure in the eye by increasing the outward flow of fluid from the eye. Side effects may include blurred vision, eye redness or irritation, a change in eye color (mostly in hazel or green eyes), increase in thickness and number of eyelashes, and joint aches or flu-like symptoms.

Examples include:

- tafluprost ophthalmic solution
- latanoprost
- bimatoprost
- travoprost

Combinations of eye drops may also be used to achieve better results. The side effects for these medications are mentioned above.

Examples include:

- dorzolamide and timolol
- latanoprost and timolol
- brimonidine and timolol

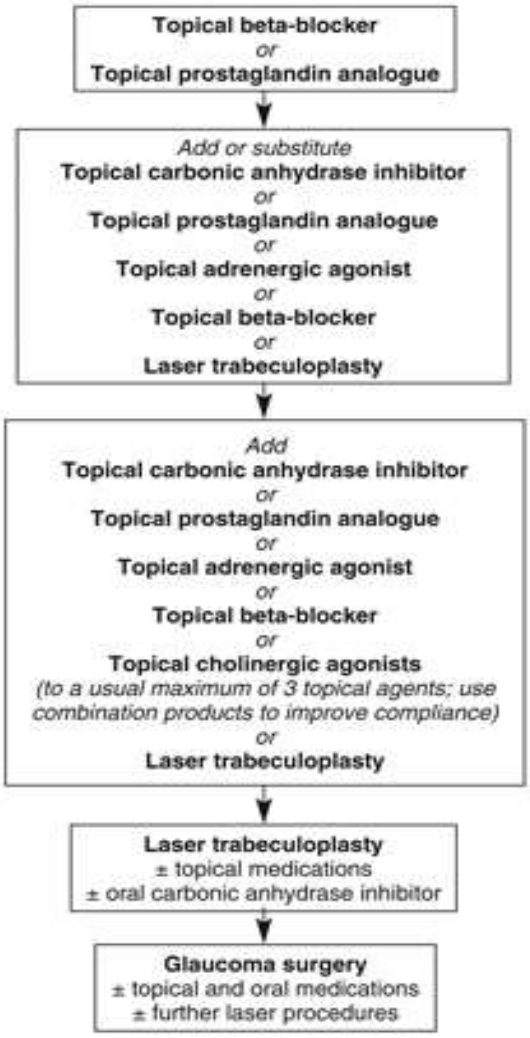
Preservatives

The most commonly used preservative in eyedrops is benzalkonium chloride, which works by denaturing proteins and causing lysis of cytoplasmic membranes. However, as many as 6% of glaucoma patients are allergic to benzalkonium chloride. Prolonged exposure to this preservative can result in superficial damage to the ocular surface, with symptoms such as irritation, dryness, itchiness and burning. To increase tolerability of glaucoma drops, alternative preservatives have been developed. Travoprost is available with an ionic buffer preservative Brimonidine is also

available with a non-benzalkonium chloride preservative called purite. Some ophthalmic drops are available in preservative-free, single-dose units

Management of Open-angle Glaucoma

Treatment is stepped up if optic disc cupping progresses, the visual field deteriorates or intraocular pressure control is inadequate



Class	Drug	Dose	Adverse Effects	Comments	Cost[a]
Beta-adrenergic Antagonists, ophthalmic	*timolol 0.25%, 0.5%* Timoptic, generics	Daily (a.m.) or Q12H	Local adverse effects usually minimal: stinging, dry eyes, rarely conjunctivitis. Systemic effects can include bronchospasm, exacerbation of CHF, bradycardia, syncope, depression, impotence, altered response to hypoglycemia, reduction of high-density lipoproteins.	Avoid in patients with bronchial asthma; caution in patients with a history of syncope or bradycardia.	$
Beta-adrenergic Antagonists, ophthalmic	*timolol gel-forming solution 0.25%, 0.5%* Timoptic-XE, generics	Once daily	Local adverse effects usually minimal: stinging, dry eyes, rarely conjunctivitis. Systemic effects can include bronchospasm, exacerbation of CHF, bradycardia, syncope, depression, impotence, altered response to hypoglycemia, reduction of	Avoid in patients with bronchial asthma; caution in patients with a history of syncope or bradycardia.	$

Class	Drug	Dose	Adverse Effects	Comments	Cost[a]
			high-density lipoproteins.		
Beta-adrenergic Antagonists, ophthalmic	*betaxolol 0.25%* Betoptic S	Daily (a.m.) or Q12H	Local adverse effects usually minimal: stinging, dry eyes, rarely conjunctivitis. Systemic effects can include bronchospasm, exacerbation of CHF, bradycardia, syncope, depression, impotence, altered response to hypoglycemia, reduction of high-density lipoproteins.	Avoid in patients with bronchial asthma; caution in patients with a history of syncope or bradycardia.	$$
Beta-adrenergic Antagonists, ophthalmic	*levobunolol 0.25%, 0.5%* Betagan, generics	Daily (a.m.) or Q12H	Local adverse effects usually minimal: stinging, dry eyes, rarely conjunctivitis. Systemic effects can include bronchospasm, exacerbation of CHF, bradycardia, syncope, depression, impotence, altered response to hypoglycemia, reduction of	Avoid in patients with bronchial asthma; caution in patients with a history of syncope or bradycardia.	$

Class	Drug	Dose	Adverse Effects	Comments	Cost[a]
			high-density lipoproteins.		
Carbonic Anhydrase Inhibitors, ophthalmic	*dorzolamide 2%* Trusopt, generics	Q8–12H	Bitter, sour or unusual taste, stinging, local allergic reaction.	Cross-reactivity in patients allergic to sulfonamides.	$
Carbonic Anhydrase Inhibitors, ophthalmic	*dorzolamide 2% preservative-free* Trusopt	Q8–12H	Bitter, sour or unusual taste, stinging, local allergic reaction.	Advantageous for patients with allergies to benzalkonium chloride. Cross-reactivity in patients allergic to sulfonamides.	$$$$$
Carbonic Anhydrase Inhibitors, ophthalmic	*brinzolamide 1%* Azopt	Q12H	Bitter, sour or unusual taste, stinging, local allergic reaction.	Cross-reactivity in patients allergic to sulfonamides; dose can be increased to Q8H after 4 wk if inadequate response.	$$
Prostaglandin Analogues, ophthalmic	*latanoprost 0.005%* Xalatan, generics	Once daily	Foreign body sensation, burning, stinging, itching, increased iris pigmentation, increased eyelash length.	Once-daily dosing should not be exceeded; more frequent administration may reduce effectiveness.	$$
Prostaglandin Analogues, ophthalmic	*travoprost 0.004%* Travatan Z	Once daily	Conjunctival hyperemia, foreign body sensation, burning, stinging, itching, increased iris pigmentation, increased eyelash length.	Once-daily dosing should not be exceeded; more frequent administration may reduce effectiveness. Formulated with a non-benzalkonium chloride preservative.	$$$
Prostaglandin Analogues, ophthalmic	*bimatoprost 0.01%* Lumigan RC	Once daily	Conjunctival hyperemia, foreign body sensation,	Once-daily dosing should not be exceeded; more frequent	$$$$

Class	Drug	Dose	Adverse Effects	Comments	Cost[a]
			burning, stinging, itching, increased iris pigmentation, increased eyelash length.	administration may reduce effectiveness.	
Alpha$_2$-adrenergic Agonists, ophthalmic	*apraclonidine 0.5%, 1%* Iopidine	Q8H	Local allergic reaction, tachycardia, hypotension, headache, tremor.	Contraindicated with MAO inhibitors. Can rarely be used chronically due to more than 40% incidence of marked blepharoconjunctivitis.	$$$
Alpha$_2$-adrenergic Agonists, ophthalmic	*brimonidine0.2%* Alphagan, generics	Q12H	Local allergic reaction, tachycardia, hypotension, headache, tremor.	Contraindicated with MAO inhibitors; not recommended in pediatric patients. Lower incidence of allergy than apraclonidine when used chronically.	$
Alpha$_2$-adrenergic Agonists, ophthalmic	*brimonidine 0.15%* Alphagan P, generics	Q12H	Local allergic reaction, tachycardia, hypotension, headache, tremor.	Contraindicated with MAO inhibitors; not recommended in pediatric patients. Lower incidence of allergy than apraclonidine when used chronically. Contains purite as preservative rather than benzalkonium chloride; may have slightly lower incidence of ocular allergy than	$

Class	Drug	Dose	Adverse Effects	Comments	Cost[a]
				brimonidine 0.2%.	
Cholinergic Agonists, ophthalmic	*pilocarpine 1%, 2%, 4%, 6%* IsoptoCarpine drops, Pilopine HS gel	Drops: QID Gel: QHS	Reduced vision in patients with cataracts, blurred vision due to refractive shift, brow ache, GI upset (rare).	Poorly tolerated in children and younger adults.	Drops: $ Gel: $$
Cholinergic Agonists, ophthalmic	*carbachol* IsoptoCarbachol	Q8H	Reduced vision in patients with cataracts, blurred vision due to refractive shift, brow ache, GI upset (rare).	Poorly tolerated in children and younger adults.	$
Carbonic Anhydrase Inhibitor/Beta-blocker Combinations, ophthalmic	*brinzolamide 1%/timolol 0.5%* Azarga	Q12H	Bitter, sour or unusual taste, stinging, local allergic reaction. Local adverse effects usually minimal: stinging, dry eyes, rarely conjunctivitis. Systemic effects can include bronchospasm, exacerbation of CHF, bradycardia, syncope, depression, impotence, altered	Cross-reactivity in patients allergic to sulfonamides; dose can be increased to Q8H after 4 wk if inadequate response. Avoid in patients with bronchial asthma; caution in patients with a history of syncope or bradycardia.	$$$

Class	Drug	Dose	Adverse Effects	Comments	Cost[a]
			response to hypoglycemia, reduction of high-density lipoproteins.		
Carbonic Anhydrase Inhibitor/Beta-blocker Combinations, ophthalmic	*dorzolamide 2%/timolol 0.5%* Cosopt, generics	Q12H	Bitter, sour or unusual taste, stinging, local allergic reaction. Local adverse effects usually minimal: stinging, dry eyes, rarely conjunctivitis. Systemic effects can include bronchospasm, exacerbation of CHF, bradycardia, syncope, depression, impotence, altered response to hypoglycemia, reduction of high-density lipoproteins.	Cross-reactivity in patients allergic to sulfonamides.	$$$
Carbonic Anhydrase Inhibitor/Beta-blocker Combinations, ophthalmic	*dorzolamide 2%/ timolol 0.5%, preservative-free* Preservative-freeCosopt	Q12H	Bitter, sour or unusual taste, stinging, local allergic reaction. Local adverse	Advantageous for patients with allergies to benzalkonium chloride. Cross-reactivity in patients allergic to sulfonamides.	$$$

Class	Drug	Dose	Adverse Effects	Comments	Cost[a]
			effects usually minimal: stinging, dry eyes, rarely conjunctivitis. Systemic effects can include bronchospasm, exacerbation of CHF, bradycardia, syncope, depression, impotence, altered response to hypoglycemia, reduction of high-density lipoproteins.		
Prostaglandin Analogue/Beta-blocker Combinations, ophthalmic	*latanoprost 0.005%/ timolol 0.5%* Xalacom	Once daily	Foreign body sensation, burning, stinging, itching, increased iris pigmentation, increased eyelash length. Local adverse effects usually minimal: stinging, dry eyes, rarely conjunctivitis. Systemic effects can include bronchospasm, exacerbation	Once-daily dosing should not be exceeded; more frequent administration may reduce effectiveness. Avoid in patients with bronchial asthma; caution in patients with a history of syncope or bradycardia.	$$$$

Class	Drug	Dose	Adverse Effects	Comments	Cost[a]
			of CHF, bradycardia, syncope, depression, impotence, altered response to hypoglycemia, reduction of high-density lipoproteins.		
Prostaglandin Analogue/Beta-blocker Combinations, ophthalmic	*travoprost 0.004%/timolol 0.5%* DuoTrav	Once daily	Conjunctival hyperemia, foreign body sensation, burning, stinging, itching, increased iris pigmentation, increased eyelash length. Local adverse effects usually minimal: stinging, dry eyes, rarely conjunctivitis. Systemic effects can include bronchospasm, exacerbation of CHF, bradycardia, syncope, depression, impotence, altered response to hypoglycemia,	Once-daily dosing should not be exceeded; more frequent administration may reduce effectiveness. Formulated with a non-benzalkonium chloride preservative. Avoid in patients with bronchial asthma; caution in patients with a history of syncope or bradycardia.	$$$$

Class	Drug	Dose	Adverse Effects	Comments	Cost[a]
			reduction of high-density lipoproteins.		
Alpha$_2$-adrenergic Agonist/Beta-blocker Combinations, ophthalmic	*brimonidine 0.2%/ timolol 0.5%* Combigan	Q12H	Local allergic reaction, tachycardia, hypotension, headache, tremor. Local adverse effects usually minimal: stinging, dry eyes, rarely conjunctivitis. Systemic effects can include bronchospasm, exacerbation of CHF, bradycardia, syncope, depression, impotence, altered response to hypoglycemia, reduction of high-density lipoproteins.	Contraindicated with MAO inhibitors; not recommended in pediatric patients. Lower incidence of allergy than apraclonidine when used chronically. Avoid in patients with bronchial asthma; caution in patients with a history of syncope or bradycardia.	$$$$$
Carbonic Anhydrase Inhibitors, oral	*acetazolamide* generics	250 mg up to QID	Paresthesias of the extremities, metabolic acidosis, hypokalemia, GI upset, urolithiasis, lethargy and	Cross-reactivity in patients allergic to sulfonamides.	$$

Class	Drug	Dose	Adverse Effects	Comments	Cost[a]
			depression, aplastic anemia (rare), Stevens-Johnson syndrome (rare).		
Carbonic Anhydrase Inhibitors, oral	*methazolamide* generics	50–100 mg BID-TID	Paresthesias of the extremities, metabolic acidosis, hypokalemia, GI upset, urolithiasis, lethargy and depression, aplastic anemia (rare), Stevens-Johnson syndrome (rare). Side effects are less severe than with acetazolamide.	Cross-reactivity in patients allergic to sulfonamides.	