Textbooks on Clinical Medicine
for International Students

OPHTHALMOLOGY

XI'AN JIAOTONG UNIVERSITY

Chief Editor
Zhang Lin

Dean's Office of Xi'an Jiaotong University
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Foreword

Since our university first admitted international students in 1995, we have fostered many qualified medical workers for the neighboring countries. At the same time, we have developed an outstanding teaching team, who take the lead in teaching foreign students medicine all in English at home.

Although we are among the first to accept international students and have formed our own particular educational system, we have noticed that we should make improvements in the teaching materials. For many years, we have been using original edition of foreign textbooks combined with individual teaching materials of the lecturers. We have long thought of compiling a complete set of textbooks of our own.

To our pleasure, in the celebration of the tenth year of commencing medical education for international students, with the painstaking efforts of the Dean's Office, and active participation of our staff, the English textbooks on clinical medicine for international students in our university are finally printed.

There are 15 textbooks in the set, all of which are compiled according to the characteristics of clinical education and the demand of develop of the subjects, and by teachers who are engaged in the clinical education of international students. The textbooks are students – centered, and the materials accord with the requirements for the medical students.

This set of textbooks is especially for the use of medical international students in our university. It can also be used by the students of the long – schooling and five – year schooling.

In the process of compiling the textbooks, we have been encouraged and supported by the president of the First Hospital of Xi'an Jiaotong University, Li Xu, and the vice president, He Dalin; the section chief and vice section chief of the Office of International Communication, Feng Zhenping, and Song Yuxia; and the teachers in the Teaching Department of the First Hospital. We'd like to take this chance to express our sincere gratitude for those who take part in the great task.

It's the first time we did such work. We are most appreciative of your advice.

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Chapter 1 Anatomy of Eye

Anatomy of Eye and Orbit

The eye and its associated structures can be divided into six separate anatomical divisions: (1) adenexa, consisting of the eyelids and lacrimal apparatus; (2) anterior segment, composed of the conjunctiva, cornea, and anterior chamber; (3) iris and lens; (4) posterior segment, consisting of the vitreous, retina, choroid, and sclera; (5) extraocular muscles; and (6) orbit. Each segment contains a number of structures that are both anatomically and functionally related.

Adnexa

Eyelids The eyelids serve to protect the eyes from the environmental injury and trauma and to keep the ocular surface moist by both preventing evaporative drying of the conjunctiva and cornea and helping to spread tears produced by the lacrimal glands. The eyelids consist of five layers of tissue, from superficial to deep: the skin, a muscular layer (orbicularis oculi muscles), a layer of loose areolar connective tissue, a fibrous layer (the tarsus), and an internal mucous membrane (the conjunctiva). When open, the elliptical space between the lid margins is referred to as the palpebral fissure and extends from the lateral canthus on the temporal side of the eye, to the medial canthus on the nasal side of eye. Adjacent to the medial canthus is the caruncle, a small yellowish structure that consists of modified sweat and sebaceous glands and the plica semilunaris, a vestigial remnant of the third eyelid formed by a folding of the conjunctiva.

Located in the margin of the eyelid between the fibrous layer and internal mucous membrane are the meibomian glands, which secrete sebum into the tear fluid. Also located along the eyelid margin are the hair follicles of the eyelashes. The sebaceous glands of Zeis and the sweat glands of Moll are adjacent to the hair follicles.

The lids receive blood from branches of both the lacrimal and ophthalmic arteries, and drain to the ophthalmic veins and the veins draining the forehead. Lymphatic drainage from the medial aspect of the lids goes to the submandibular nodes, while that from the lateral aspect drains to the preauricular and parotid nodes. The upper eyelid is innervated by CN V_1 and the lower eyelid by CN V_2.

Lacrimal apparatus The lacrimal apparatus consists of the lacrimal glands located in the anterior superior temporal segment of the orbit, punctae, canaliculi, Lacrimal sac, and nasolacrimal duct, all located in the medial canthus. Tears are produced in the palpebral and orbital portions of the lacrimal gland and secreted onto the conjunctiva via ten secretory ducts. The tears are spread and distributed by capillary action and the blinking motion of the eyelids. Tears drain to the superior and inferior puncta. These two small openings are located on their respective eyelid margin on the lateral border of the medial canthus. Fluid entering the punctae drains through the inferior and superior canaliculi to the common canaliculus, lacrimal sac, and finally, through the nasolacrimal duct into the inferior meatus of the nose.

Tear fluid forms a layer that ranges from 4 to 9 μm thick and serves to protect and lubricate the surface of the cornea and conjuctiva , to provide nutrition and oxygenation to the cornea, and to flatten any minor irregularities in the surface of the cornea, providing a uniform optical surface. The tear fluid consists of a lipid layer secreted from the meibomian glands of the eyelids, and aqueous layer produced by the lacrimal apparatus, and a mucous layer produced by the conjunctival goblet cells. Tear fluid has a pH between 7.1 and 8.6 and also contains small quantities of albumin, lysozyme, IgG, IgA, urea, inorganic salts, lactate, and cellular debris.

The blood supply of the lacrimal glands is from a branch of the lacrimal artery and drains into the ophthalmic vein. Lymphatic drainage travels to the preauricular nodes. The lacrimal gland receives sensory innervation from the lacrimal branch of CN V1, parasympathetic secretory innervation from the superior salivary nucleus via the greater superficial petrosal nerve, and sympathetic innervation from nerve fibers traveling with the lacrimal artery and nerve.

Anterior segment

Conjunctiva The conjunctiva is a thin mucous membrane that covers the posterior surface of the eyelids and the anterior surface of the eyeball itself. The palpebral conjunctiva begins at the eyelid margins and covers the entire surface of the inner eyelid to the fornix, where it is firmly attached to the underlying fibrous tissue, before being reflected back to cover the globe as the bulbar conjunctiva. At the point at which the conjunctiva is reflected back over sclera, the conjunctiva has numerous folds that allow the eye to move freely.

Cornea The cornea is a thin, clear, avascular structure that makes up the anterior wall of the globe and functions to refract light toward the pupil and lens. The transition from the cornea to the sclera is the limbus and contains the epithelial stem cells that are the source of the corneal epithelium. The cornea is normally completely avascular. The cornea derives its nourishment from the diffusion of nutrients from the tear fluid anteriorly and aqueous humor posteriorly. Additionally, the superficial layers of the cornea can obtain oxygen from the atmosphere by direct diffusion. The cornea is richly innervated from branches of CN V1, and even the smallest abrasion results in significant pain.

The cornea itself is divided into five layers: the epithelium, Bowman's layer, the stroma, Descemet's membrane, and the endothelium. The epithelium is a stratified squamous cell layer that is approximately five cells thick and continuous with the conjunctiva. The epithelium is rapidly proliferating, with actively mitotic cells located at the limbus. Full turnover of the epithelium occurs every seven days. Adjacent to the basement membrane of the epithelium is Bowman's layer, which primarily consists of a layer of compacted collagen fibrils. Underneath Bowman's layer is the stroma, composed of parallel lamellae of collagen fibers held together by a mucopolysaccharide matrix. The stroma forms the bulk of the cornea. Descemet's membrane, located beneath the stroma, is tightly associated with the underlying endothelium. The endothelium is one cell thick and lacks any substantial proliferative capacity. The endothelium functions to remove fluid from the stroma to help maintain corneal clarity.

Anterior chamber The anterior chamber is a semispherical space bounded anteriorly and laterally by the cornea and posteriorly by the iris. The anterior chamber is optically clear and is filled with aqueous humor. Aqueous humor is a cell-free, low-protein, electrolyte-rich fluid produced by ultrafiltration of the serum by the ciliary body. The aqueous flows from the ciliary body through the pupillary opening toward the periphery, where it is filtered through a trabecular meshwork and drained via the canal of Schlem into the scleral sinus and anterior ciliary veins.

Iris and lens The iris is a thickened flat disk of tissue containing a central opening, the pupil. As the anterior extension of the ciliary body, the iris serves as the dividing mark between the anterior and posterior chambers. It is surrounded both anteriorly and posteriorly by aqueous and sits directly in front of the lens. Within the iris lie the sphincter and dilator muscles of the pupil that serve to adjust the amount of light reaching the retina. The posterior surface of the iris is lined with a double layer of thickened, pigmented epithelial cells. The density of the iris stroma just anterior to this layer is responsible for eye color. The circumferential margin of the iris is attached to the ciliary body.

Directly behind the iris is the lens, which is an avascular, biconvex disk approximately 4 mm thick and 9 mm in diameter. It contains no nerve fibers or lymphatics. The lens focuses the incoming light from the pupil onto the retina. Radiating from the equatorial plane of the lens are zonular fibers that connect to muscles in the ciliary body. Alteration of the tension of the fibers through ciliary muscle contraction and relaxation changes the shape of the lens. This allows for accommodation and the focusing on both near and far objects.

Posterior segment

Vitreous The vitreous makes up almost two thirds of the volume of the eye and is responsible for maintaining the shape of the eyeball. It is a thick, gelatinous fluid surrounded by a hyaloid membrane. The vitreous is located behind the lens and is related anteriorly to the posterior capsule of the lens and posteriorly to the retina. The vitreous is optically clear, but may have suspended fibrous strands and debris.

Retina The retina forms the innermost membrane of the posterior segment of the eye. The optic nerve and retinal vessels enter the retina at the optic disk, a yellow depressed circle. Lateral and slightly inferior to the optic disk is the macula. In the center of the macula is the fovea, which contains the highest density of photoreceptors, permitting the greatest visual acuity. The visual field is centered at the fovea.

The retina is neural tissue, the axons of which travel within the optic nerve. It consist of two layers: the inner neurosensory layer and the outer retinal pigment epithelium layer. The neurosensory layer contains the photoreceptor cells and relay circuits for transmitting light received by the photoreceptors to the brain. The retinal pigment epithelium layer consists of epithelial cells that help to support the metabolic and sensory functions of the neurosensory cell layer.

Vascular supply to the anterior layers of the retina comes from the central retinal artery and its branches, which can be easily visualized on funduscopic examination. The posterior one third of the retina is nourished via diffusion of nutrients from the choroid.

Chorid Deep to the retina is the choroid, which provides nutrients to the posterior layers of the retina. The choroid is the most posterior portion of the uveal tract, which also includes the ciliary body and the iris. It is a highly vascularized connective tissue layer located between the retina and sclera.

Sclera The sclera is a thick white fibrous layer that forms the outer posterior wall of the eye, deep to the uveal tract. It is connected circumferentially to the cornea anteriorly and merges within the dura of the optic nerve posteriorly. Approximately 1 mm thick, it is nourished by vessels coursing through the episclera, its outer elastic covering. The sclera provides structural integrity to the eye as well as attachment for the extraocular muscles.

Extraocular muscles The eye has six cardinal directions of movement and is controlled by six extraocular muscles (EOM). The EOM are innervated by CN III, IV, and VI. The superior and inferior recti muscles are the primary controls for vertical eye movement. The medial and lateral recti move the eye in the horizontal plane. The recti muscles are attached to the sclera 5 to 8-mm posterior to the limbus and to a tendinous band in the posterior orbit known as the annulus of Zinn.

The superior oblique muscle originates on the orbital wall near the superior medial border of the annulus, stretches around the pulley-like trochlea located on the superior medial portion of the orbit. The superior oblique moves the eye inward and downward. The inferior oblique is the only muscle not attached near the optical canal. Rather, it runs from the anterior medial portion of the orbit to the posterior lateral portion of the sclera. Contraction of the interior oblique causes outward and upward eye movement.

Orbit The eye sits in the orbital cavity that is formed by bones of the cranium and the face. These bones serve to protect the eye while allowing it to move freely in multiple directions. The following bones contribute to the orbit: maxilla, frontal, sphenoid, zygomatic, palatine, ethmoid, and Lacrimal. The medial and inferior walls of the orbit are the thinnest and are most commonly fractured with trauma to the eye and orbit. Surrounding the globe is loose fatty tissue cushioning the eye against injuries and allowing free movement of the eye.

The orbit contains multiple fossae for accommodating such structures as the lacrimal apparatus, lacrimal sac, and trochlea and foramina which allow the transmission of nerves and veins to the eye.

Chapter 2 Basic Eye Examination of Eye

Checking vision

The first step in the ophthalmic screening examination involves assessing the status of a patient's visual acuity. The examiner assesses vision by using either a standardized visual acuity chart or a near card specially designed for bedside use. If such tools are unavailable, the clinician can attempt to improvise by using such items as a newspaper or food label.

Snellen test

Although many tests have been devised for assessing a patient's vision, the Snellen test serves as the standard examining method. The Snellen chart displays lines of numbers and block letters, with the size of the characters decreasing from top to bottom.

To perform the Snellen test:

1. Position the patient at a distance of 20 feet (or 14 inches for the near card) away from the chart. Whenever possible, visual acuity should be assessed while the patient is wearing the appropriate glasses or corrective lenses. Patients over 40 years old may require reading glasses or bifocals to overcome age-associated presbyopia when using the reading card.

2. Testing each eye separately, ask the patient to read progressively smaller lines on the chart and determine the smallest line that he or she can read with greater than 50 percent accuracy.

3. Document the corresponding vision (e. g., 20/20, 20/200) for each eye. The numerator of this fraction represents the distance of the patient from the chart. The denominator represents the distance from which a person with normal visual acuity would read the line with greater than 50 percent accuracy. The abbreviation OD (oculus dexter) represents the right eye and OS (oculus sinister) represents the left eye.

Near vision test

When performance of the standard Snellen test is impractical, The ER physician can elect to use the near vision test to assess vision acuity. This test is similar to the standard Snellen test, with the physician placing the near vision card roughly 14 in. from the eyes of the patients and repeating the steps described previously. Although this test is less precise than the Snellen test, it is often sufficient for a gross assessment of acuity.

If the patient has bifocals or reading glasses, the patient should wear these for the exam.

Low vision testing

For patients with less than 20/400 vision, the examiner may be unable to use the tests described above and should improvise by testing more basic visual functions. In these situations, the clinician may elect to test visual acuity via the more primitive tests described as follows.

Counting fingers. In this test, the clinician determines the distance at which the patient is capable of accurately determining the number of fingers being held up by the examiner. For instance, if the patient is able to count the number of fingers being held up by the clinician from a distance of 3 feet, the results of this test can be recorded as "CF 3 feet" (counting fingers at 3 feet).

Hand movement. If the patient is unable to count fingers from very short distances, the clinician should attempt to determine whether or not the patient can distinguish vertical hand movements from horizontal hand movements when they are performed by the examiner. If the patient is able to perform this function, the clinician can record this as "HM" (hand motions).

Light perception. Finally, if the patient's vision is diminished to the point that he or she cannot appreciate hand movements, the examiner can test for light perception by shining a bright light directly onto the patient's eyes and asking whether or not the patient can appreciate the stimulus. Ask the patient to tell you when the light goes on as you move the light back and forth across the eye. Be sure to adequately cover the opposing eye so that no light can be seen. A positive response is recorded as "LP" (light perception) and a negative response is recorded as "NLP" (no light perception).

Pin hole acuity

If the clinician is attempting to distinguish visual defects resulting from refractive errors (myopia, hyperopia, astigmatism) from pathologic conditions, such as cataracts, optic nerve disease, and so forth, he or she may elect to reevaluate the patient's vision using a pinhole aperture. Such an aperture can be made by punching a hole in a piece of paper with the tip of a pencil. Pinhole testing generally eliminates mild uncorrected refractive errors and so defects in vision detected in pinhole testing can be assumed to result from nonrefractive errors of the eye.

Visual fields testing

Defects in visual field testing can indicate injury at any point along the visual pathway leading from the retina to the occipital lobe. Goldmann and Humphrey visual fields are more formal methods for measuring visual fields, but confrontational fields provide a gross assessment of the periphery.

Confrontational visual fields

To perform a confrontational visual field:

1. Place yourself in front of the patient at arm's length.

2. Ask the patient to cover one eye and to fixate on your nose with the open eye.

3. Ask the patient to report when he or she first sees your fingers as you mover your hands into the field of view from various regions in the periphery. In this manner, map out the patient's visual field and take special note of regions in space that the patient is unable to visually appreciate.

4. Next, with one hand in each of the superior quadrants, simultaneously display fingers on both hands and ask the patient to determine the total number of fingers that are being displayed. Repeat for the inferior quadrants. If the patient is unable to count the total number of fingers displayed simultaneously on both hands, record this as an abnormality, since it may indicate a neglect syndrome.

5. Finally, repeat the steps for the patient's other eye.

Pupillary examination

The pupillary examination is intended to allow the clinician to detect functional deficits in the pupillary reflex arc, the neural circuitry that allows the eye to respond to light via pupillary constriction. Since there is equal bilateral innervation of the pupils, both pupils normally respond in an identical fashion to a light stimulus directed at either eye. The entire examination is summarized in the following steps.

1. Ask the patient to fixate on a distant object in a darkened room.

2. Shine a penlight onto the patient's face being careful not to place the light beam directly onto either pupil.

3. Measure the pupillary diameter in both eyes with a small ruler. Take note of both the absolute size of each pupil and also the relation between the two.

4. Next, shine the penlight directly onto the pupil of one eye. Gauge the degree of pupillary constriction as well as the rapidity of the response. Also note the degree of constriction and rapidity of response for the other eye (consensual reflex). Perform this test for both eyes and record the results. Absence of the pupillary constriction response in a given eye can signal either an afferent or efferent neuronal defect, but the two can be distinguished by the swinging light test.

5. To perform the swinging light test, swing a penlight back and forth between the two pupils. When the light focuses on one eye, its pupil should constrict with consensual constriction of the opposite pupil. When the light reaches the opposite eye, this pupil should now constrict with consensual constriction in the other eye. In the case of an afferent defect, such as optic nerve damage, an eye will be able to constrict consensually but will dilate when the beam of light is swung directly onto it from the opposite side. This is known as a Marcus-Gunn pupil.

6. Finally, test for accommodation by asking the patient to fixate on your finger at a distance of 1 foot. The ability to accommodate is intact if pupillary constriction is evident as you move your finger closes and closes to the patient.

Motility examination

Movement in each eye is controlled by six extraocular muscles (superior, inferior, medial, and lateral recti and superior and inferior obliques). The function and innervation of these muscles in described in following table:

TABLE: ACTION AND INNERVATION OF THE EXTRAOCULAR MUSCLES

Extraocular muscle	Function	Innervation
Lateral rectus	Abduction	CN VI
Superior oblique	Abduction, depression, and intortion	CN IV
Medial rectus	Adduction	CN III
Inferior rectus	Depression	CN III
Superior rectus	Elevation	CN III
Inferior oblique	Abduction, elevation, and intortion	CN III

The motility examination can be performed as follows.

1. Ask the patient to follow your finger with both eyes as you move it in the cardinal fields of gaze.

2. With each movement, note whether the amplitude is normal or abnormal. For instance, when the eyes are moving from right to left or from left to right, the nasal sclera of thee adducting eye should disappear completely with maximum displacement. When the eyes are moving up, half of the cornea should disappear behind the upper eyelid. Finally, when the eyes are moving down, two thirds of the cornea should disappear behind the lower eyelid.

3. If bilateral eye movements are abnormal, perform the test in each eye separately with the other eye covered.

4. Record any sign of nystagmus and the ocular movements that give rise to it.

External examination

External examination entails a careful inspection of both the ocular surface of the eye and surrounding structures. The examiner must inspect the eye thoroughly, everting both the upper and lower eyelids to obtain a clear view of both the cornea and conjunctiva. The examiner should also ask the patient to shift gaze direction to provide a more complete view of eye structures. For a more careful analysis of the eye surface, the examiner may elect to perform corneal staining. The clinician places a wet fluorescein strip in the conjunctival culde-sac of the eye. Green patches on the corneal surface of the eye that do not go away on blinking can be corneal abrasions or defects. Use of a cobalt blue light (of Wood's lamp) will cause areas of fluorescein staining to glow green.

Careful consideration should be given not only to the examination of the globe, but also to its positioning within the eye socket. For instance, exopthalmos (protrusion of the eyeball) can signal underlying Graves' disease, orbital inflammation, or an orbital tumor. Finally, the clinician should note the appearance and position of the eyelid. Ptosis of the eye could result from CN III palsy, Horner's syndrome, or myasthenia gravis.

Slit lamp examination

Examination via a slit lamp biomicroscope allows for an accurate and magnified look at the anatomy of the anterior chamber of the eye. The patient places the chin on the chin rest attached to the biomicroscope and the forehead forward against the forehead rest. The clinician sets the oculars initially at zero and adjusts the width to his or her interpupillary distance. Focusing is controlled by moving the chassis itself for course adjustment or by moving the joystick backward and forward for fine adjustment. Finally, the clinician can control the shape of the light beam itself, which varies from a broad band to a tiny slit. Specific methods of mechanical adjustment depend on the particular model and design of the biomicroscope. Using this apparatus, the clinician can examine the eyelids, conjunctiva, cornea, anterior chamber, iris, lens, and the vitreous of each eye.

Intraocular pressure

Normal values for intraocular pressure (IOP) range from 8 to 21 mm Hg. Abnormal values can range from as low as 0 mm Hg, in cases such as that of a ruptured globe, to 40 mm Hg or higher, observed in certain types of glaucoma. There are many different techniques of measuring intraocular pressure, the most common of which are described as follows.

Applanation tonometry

The applanation tonometer is an easy to use and accurate device that is usually found on most slit lamps. Alternatively, a hand-held applanation device is available to be used with