SURGERY
OF THE INFANT EYE

edited by

Marvin L. Kwitko

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Marvin L. Kwitko, M.D., F.A.A.O., F.A.C.S., F.R.C.S.(C)
Attending Ophthalmologist, St. Mary's Hospital and Sir Mortimer Davis General Hospital; Project Director (Ophthalmology), Lady Davis Institute for Medical Research; Consultant in Ophthalmic Pathology, St. Mary's Hospital, Montreal, Quebec, Canada

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CONTRIBUTORS

ROBERT J. BROCKHURST, B.S., M.D.
Associate Clinical Professor of Ophthalmology, Harvard Medical School; Surgeon, Massachusetts Eye and Ear Infirmary; Clinical Senior Scientist, Retina Foundation, Boston, Massachusetts

STUART I. BROWN, M.D.
Professor and Chairman, Department of Ophthalmology, The University of Pittsburgh School of Medicine and the Eye and Ear Hospital, Pittsburgh, Pennsylvania

ANDREA BUNKE, M.D.
Resident, Division of Ophthalmology, Department of Surgery, State University of New York, Downstate Medical Center, Brooklyn, New York

ROBERT C. DELLA ROCCA, M.D.
Attending Ophthalmologist, Oculoplastic Service, New York Eye and Ear Infirmary; Chief, Oculoplastic Service, St. Luke's Hospital Center, New York, New York

NICHOLAS G. DOUVAS, M.D.
Director, Port Huron Eye Clinic, Port Huron, Michigan

AUSTIN I. FINK, M.D.
Professor, Division of Ophthalmology, Department of Surgery, State University of New York, Downstate Medical Center; Director, Department of Ophthalmology, The Long Island College Hospital, Brooklyn, New York

CARMEN GUBERINA, M.D.
Assistant Attending, St. Vincent's Hospital and Medical Center; Associate Attending, Columbus Hospital; Assistant Attending, New York Eye and Ear Infirmary, New York, New York

ROBISON D. HARLEY, M.D.
Professor Emeritus of Ophthalmology, Temple University Health Science Center; Clinical Professor of Ophthalmology, Jefferson Medical College of Thomas Jefferson University; Professor in Pediatrics, St. Christopher's Hospital for Children, Philadelphia, Pennsylvania

DAVID A. HILES, M.D.
Clinical Associate Professor of Ophthalmology, The University of Pittsburgh School of Medicine; Chief of Ophthalmology, Children's Hospital of Pittsburgh; Director, Fight for Sight Children's Eye Clinic, Eye and Ear Hospital, Pittsburgh, Pennsylvania

NORMAN S. JAFFE, M.D.
Clinical Professor of Ophthalmology, Bascom Palmer Eye Institute, University of Miami School of Medicine, Miami, Florida

FREDERICK A. JAKOBIEC, M.D.
Associate Professor of Clinical Ophthalmology and Pathology, College of Physicians and Surgeons, Columbia University; Director, Algernon B. Reese Laboratory of Ophthalmic Pathology, Edward S. Harkness Eye Institute, New York

CHARLES D. KELMAN, M.D.
Attending Surgeon, Manhattan Eye, Ear and Throat Hospital; Chief of Ophthalmology, Lydia E. Hall Hospital, New York; Visiting Professor, Hahnemann Medical School, Philadelphia, Pennsylvania

MARVIN L. KWITKO, M.D.
Attending Ophthalmologist, St. Mary's Hospital and Sir Mortimer Davis General Hospital; Project Director (Ophthalmology), Lady Davis Institute for Medical Research; Consultant in Ophthalmic Pathology, St. Mary's Hospital, Montreal, Quebec, Canada

PETER R. LAIBSON, M.D.
Cornea Service, Wills Eye Hospital, Professor of Ophthalmology, Thomas Jefferson School of Medicine, Philadelphia, Pennsylvania

HOBART A. LERNER, M.D.
Clinical Associate Professor of Ophthalmology, University of Rochester School of Medicine and Dentistry; Chief of Ophthalmology, Genesee Hospital, Rochester, New York

OTTO LIPPMANN, M.D.
Chairman, Committee on Child Health and Development, American Association of Ophthalmology, Austin, Texas

MELVIN I. MARKS, M.D.
Associate Professor of Pediatrics, McGill University; Director of Infectious Diseases, Montreal Children's Hospital, Montreal, Quebec, Canada

MALCOLM L. MAZOW, M.D.
Clinical Associate Professor of Ophthalmology, University of Texas Medical School at Houston, Houston, Texas

RICHARD S. MUCHNICK, M.D.
Assistant Attending Surgeon, Manhattan Eye, Ear and Throat Hospital; Assistant Attending Ophthalmologist, The New York Hospital; Clinical Assistant Professor of Ophthalmology, Cornell University Medical College, New York, New York

GUNTER K. VON NOORDEN, M.D.
Professor of Ophthalmology, Baylor College of Medicine; Director of Ophthalmology, Texas Children's and St. Luke's Episcopal Hospitals, Houston, Texas

ABRAHAM SCHLOSSMAN, M.D.
Attending Surgeon and Director of Ocular Motility Service, Manhattan Eye, Ear and Throat Hospital, New York, New York; Associate Clinical Professor of Ophthalmology State University of New York Downstate Medical Center College of Medicine, Brooklyn, New York; Associate Clinical Professor, Department of Ophthalmology, Mt. Sinai School of Medicine of The City of New York, New York, New York

BYRON C. SMITH, M.D.
Clinical Professor of Ophthalmology, New York Medical College; Consultant, Oculoplastic Surgical Department, New York Eye and Ear Infirmary; Consultant, Department of Ophthalmology Manhattan Eye, Ear and Throat Hospital; Formerly Surgeon Director and Chairman, Department of Ophthalmology, Manhattan Eye, Ear and Throat Hospital, New York, New York

ORKAN GEORGE STASIOR, M.D., M.Sc.
Clinical Professor of Ophthalmology, Albany Medical College of Union University; Director, Ophthalmic Plastic and Reconstructive Surgery Clinic, Albany Medical Center; Chairman, Department of Ophthalmology, The Child's Hospital and Memorial Hospital, Albany, New York

RICHARD C. TROUTMAN, M.D.
Professor and Head, Department of Ophthalmology, State University of New York, Downstate Medical Center College of Medicine, Brooklyn, New York; Surgeon Director, Manhattan Eye, Ear and Throat Hospital, New York, New York

GEORGE O. WARING III, M.D.
Assistant Professor of Ophthalmology, School of Medicine, University of California, Davis, California

PREFACE

In many fields of the human sciences, modern technology permits us to perform tasks that not so long ago were considered impossible. And so it is with the treatment of eye conditions that occur in the infant and very young child. Various forms of blindness commence in the uterus or very shortly after birth. Now, because of advances in anesthesia, improvement in medical technology and educational advances in paramedical personal, we are able to initiate treatment even days after the infant's first cry is heard.

It has been my good fortune to have been joined by some of the outstanding scientists in various fields of ophthalmology. Their surgical experience, love for teaching, and ability to put their thoughts down clearly in writing has given the medical student, ophthalmic resident, and practicing ophthalmologist a handy reference work. For although the infant condition has often been tacked onto works devoted to a specific surgical technique, it has not until now had the proper emphasis.

In *Surgery of the Infant Eye* the stress falls primarily on the particular behavior of the nonadult eye. The young child's eye is a structure whose anatomy, physical properties, reactions to the trauma of surgery are particular to it. Therefore it must be stressed that the young patient's welfare depends on special training, special vigilance, and an unending attention to detail. The ophthalmologist peering through the oculars of the zoom microscope now has the goods to do the job. The purpose of this book has been to gather the facts and details he will require.

The author wishes to indicate his great appreciation to Dr. Miles A. Galin, Dr. M.I.H. Kaufmann, and Mr. Nathan Feifer for their earnest support in the preparation of this book. I would also like to thank my son Geoffrey for his assistance in performing many of the technical tasks I would have otherwise had to do myself.

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THE INFANT EYE

MARVIN L. KWITKO

The eye of the newborn does not in every particular resemble that of the adult; slow development continues throughout the whole of life. There is a distinct parallel between postnatal growth of the eye and that of the brain: from birth to adulthood the eye grows 3.25 times and the brain 3.76 times, whereas body volume and weight increase 21.36 times. The eye's rate of growth is rapid during the first three years of life and markedly slower from that time until puberty.

The characteristic appearance of the neonatal eye owes to the fact that the palpebral aperture is almost as long at birth as in adulthood, while the vertical lid opening is only half the width. Therefore less of the sclera is visible than in the adult. Other differences include the small pupil and the uniform texture of the iris stroma as compared with that of an adult. The conjunctiva is thin and there is no subepithelial adenoid tissue until some weeks after birth. The lacrimal gland is quite small and does not function fully for about six weeks, so that the newborn infant cannot weep.

Perhaps the most striking feature of the newborn infant's eye is one that is readily appreciated without any detailed knowledge of ophthalmology: the baby appears as if he cannot see. Two main factors combine to produce this somewhat "vacant stare" of the newborn: (1) the development of the macula is not completed until several months after birth and (2) the infant has not yet gained those cumulative postural and tactile experiences that contribute so largely to the expression of sensations perceived by the unsophisticated observer as purely visual experiences. Persisting beyond the first few weeks of life, however, this "vacant stare" is always of serious importance, signifying mental retardation or visual defect. Sometimes both handicaps are operative, e.g., when the optic nerves are implicated in widespread cerebral trauma, so that stunted mental development is associated with bilateral optic atrophy.

Whereas the adult eye is almost a perfect sphere (with the qualification that the anterior one-sixth representing the cornea bulges forward with a slightly sharper convexity), the eye of early infancy is not. The horizontal diameter is slightly greater than the sagittal while the reverse is the case in the eye of an adult. The anterioposterior diameter varies from 12.5 to 17.9 mm, the vertical diameter from 14.5 to 17.3 mm, and the transverse diameter from 16.0 to 18.4 mm (Fig. 1). The eye grows rapidly in the first year of life, with the vertical diameter expanding faster so that the eye becomes more nearly spherical. The growth rate then decreases until puberty, when it again becomes more rapid until the early twenties. To offset the comparative shortness of the infant eye, which would make it exceedingly hyperopic, the media are more highly refractive than in the adult, the seat of the excess of refractivity being located in the lens. Retinoscopic examination practically always shows between +3 and +6 diopters of hyperopia. This situation—which is the normal refractive state during infancy and early childhood—entails no appreciable disability in the majority of instances, and appears to be easily overcome. When a small child is found to be free of hyperopia, subsequent examination at intervals will often reveal the onset of myopia before growth has ceased. It would seem that the type of eye is developmentally or even genetically determined long before the appropriate refractive error appears. For the next few years, the amount of hyperopia tends to diminish steadily as the eye attains its full anterior-posterior length. The increase in axial length would result in excessive myopia were it not for another factor: flattening of the lens.

The shape and the outside diameters of the eyeball reach a steady state around the age of fourteen years. The same may be said for most of the anatomic and histologic characteristics of the ocular tissue with the exception of the ciliary body and the crystalline lens, both of which continue to change grossly throughout life and thereby affect the fluid spaces around them, particularly the depth of the anterior chamber. Such differences in shape are shown diagrammatically in Figure 2, which represents the eyes of a newborn and an adult rendered approximately the same size and superimposed. It is obvious that the differences are most marked in the anterior part of the globe.

THE ORBIT

As shown in Figure 3, the fetal skull has a large cranium (orbital roof) and a small face (orbital floor). The orbit margin is sharp and well ossified at birth, which affords the eye protection from stress and injury during delivery. As the eye is relatively large in relation to the orbit and in an advanced stage of development at birth, such protection is desirable. The rarity of injuries to the globe in cases of unassisted labor attests to the efficacy of this protection.

In the newborn the orbit forms an ellipse, higher on the lateral side than on the medial side. This changes with age so that, on coronal section behind the orbital margin, the shape becomes that of a quadrilateral with rounded corners. The infant orbit is more lateral than in the adult—that is, the axes (or the lines drawn from the middle of the orbital opening to the optic foramen) make an angle of 115 degrees and if produced backward meet in the middle at the

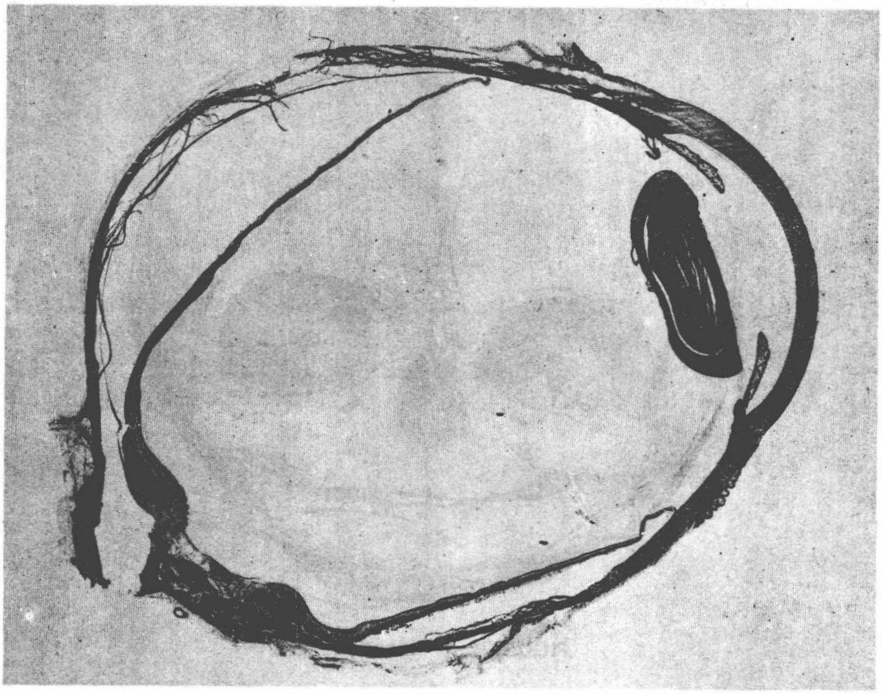

FIGURE 1 Eye of a one-month-old infant.

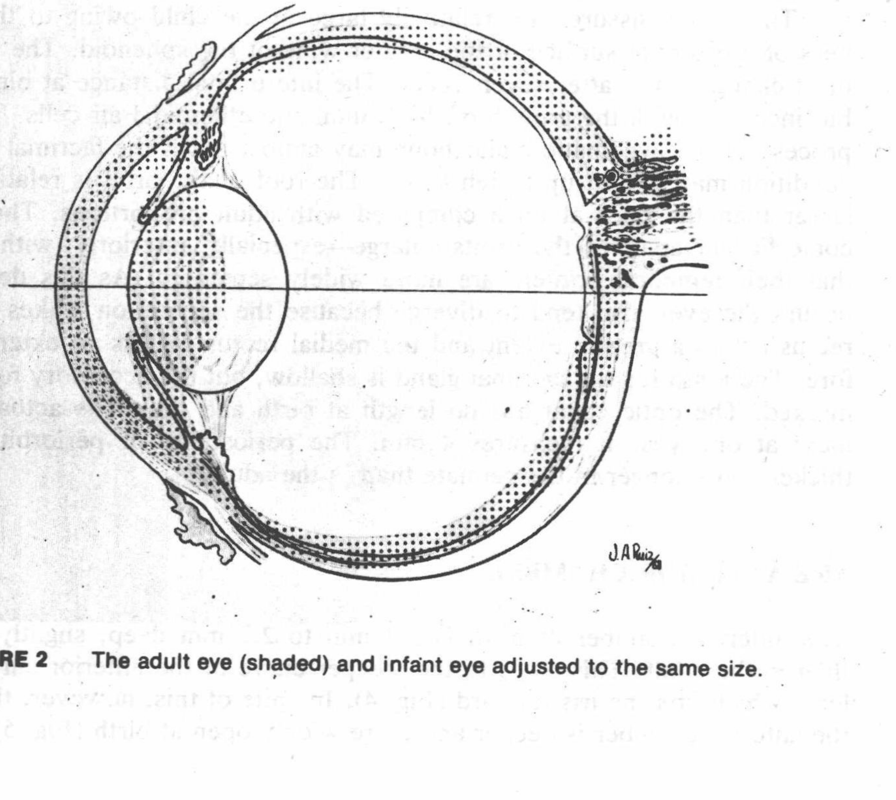

FIGURE 2 The adult eye (shaded) and infant eye adjusted to the same size.

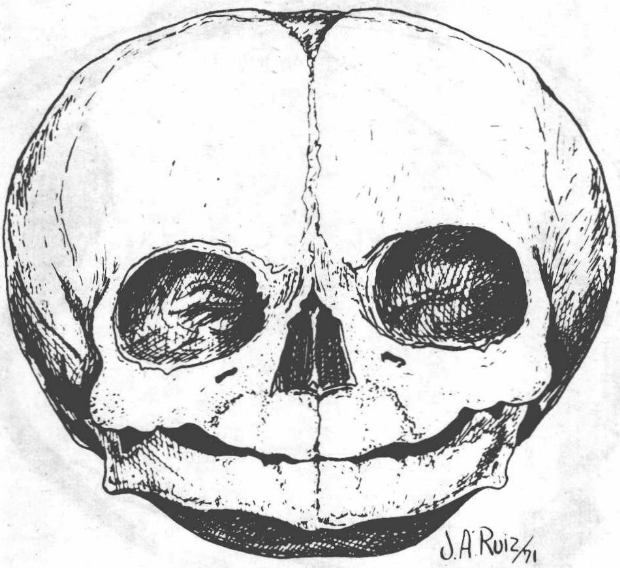

FIGURE 3 Infant skull.

nasal septum. In the adult the axes make an angle of 40 to 45 degrees with each other and if produced backward meet at the upper part of the clivus of the sphenoid.

The orbital fissures are relatively large in the child owing to the narrowness of the orbital surface of the greater wing of the sphenoid. The size of the orbit changes little after seven years. The interorbital distance at birth is small but increases with the growth of the frontal and ethmoidal air cells. The orbital process of the zygomatic malar bone may almost reach the lacrimal fossa; this condition may persist up to ten years. The roof of the orbit is relatively much larger than the floor at birth compared with adult proportions. The eyes become farther apart as the orbits enlarge—especially anteriorly, with the effect that their temporal borders are more widely separated. As this development occurs the eyes also tend to diverge because the separation makes the lateral rectus act to a greater extent and the medial rectus to less an extent than before. The fossa for the lacrimal gland is shallow, but the accessory fossa is well marked. The optic canal has no length at birth and thus it is actually a foramen; at one year it measures 4 mm. The periosteum or periorbita is much thicker and stronger in the neonate than in the adult.

THE ANTERIOR CHAMBER

The anterior chamber at birth is 2.3 mm to 2.7 mm deep, slightly shallower than in the adult. This owes to the steeper curve of the anterior surface of the lens, which lifts the iris forward (Fig. 4). In spite of this, however, the angle of the anterior chamber is deeper and more widely open at birth (Fig. 5).

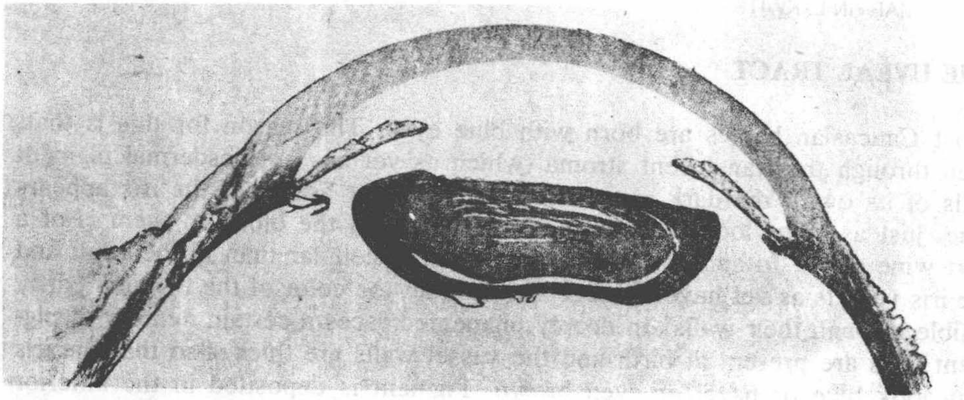

FIGURE 4 Anterior chamber of eye in a one-month-old infant.

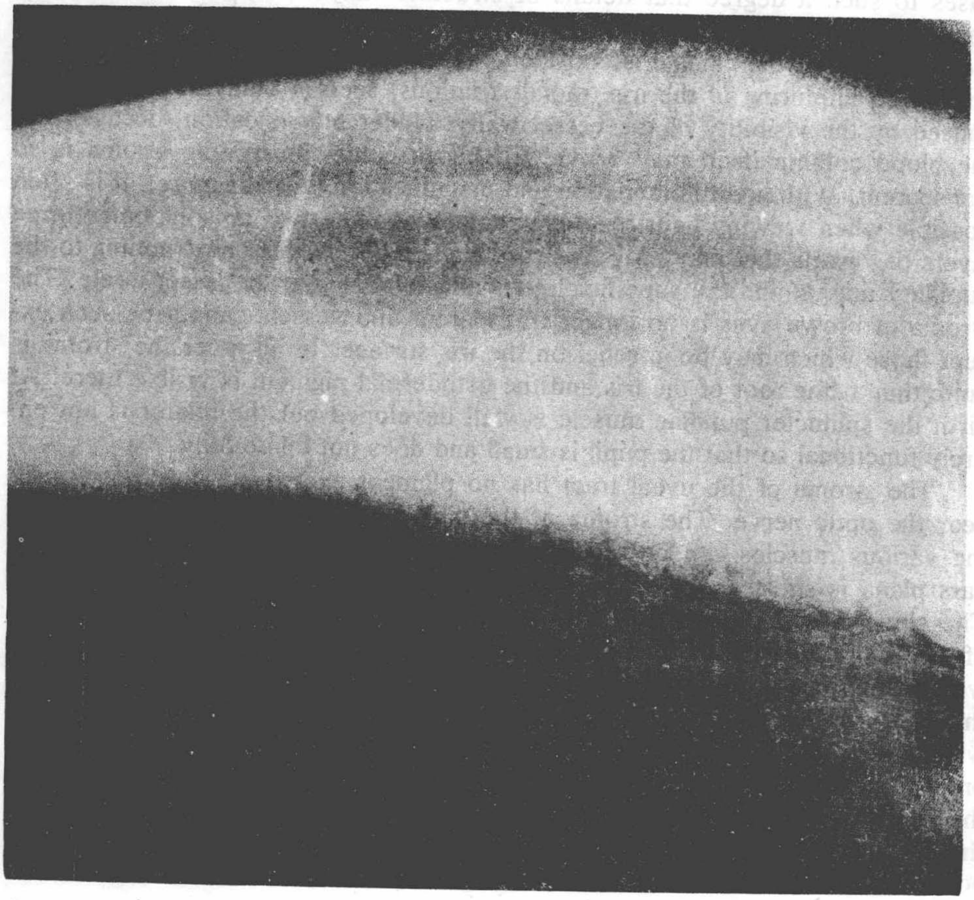

FIGURE 5 Filtration angle of normal black child. Remnants of the uveal meshwork are still present. (Courtesy of JGF Worst.)

THE UVEAL TRACT

Most Caucasian babies are born with blue eyes. The reason for this is that, seen through the translucent stroma (which as yet has no mesdermal pigment cells of its own), the dark pigment on the posterior aspect of the iris appears blue, just as veins look blue through skin although the blood in them is of a port wine color. In addition, the stroma is more cellular than in the adult and the iris vessels as yet have no adventitia so that the color of the blood is partly visible through their walls. In deeply pigmented races a certain number of pigment cells are present at birth and the vessel walls are thicker so that the iris may look blue or hazel or even brown. Pigment is deposited in the anterior limiting layers or the stroma in the first few days of life; varying with the amount laid down, the color changes. If little pigment is deposited the eye remains blue or gray; if much is laid down, the eye becomes brown—in some cases to such a degree that details of structure may be entirely hidden. The change is gradual and spreads over periods of varying length in different subjects. As a rule, the change is considerable within the few weeks of birth. The so-called sculpturing of the iris (radial striations) seen in blue and gray eyes is caused by the visibility of the vessel walls. Under magnification, occasionally the blood column itself may be viewed because the intervening stroma is so transparent. With good illumination and magnification (24× or more), it is often possible when viewing light blue eyes actually to see two or sometimes three layers of vessels that may cross at acute angles, the deeper ones running to the pupillary margin and the superficial ones anastomozing at the lesser circle. The stroma of brown eyes is no longer transparent and vessels cannot be seen except those which may be in relief on the iris surface. In all races the stroma is quite thin at the root of the iris and the ectodermal pigment is visible there. At birth the sphincter pupillae muscle is well developed but the dilator is not entirely functional so that the pupil is small and does not dilate fully.

The stroma of the uveal tract has no pigment except possibly posteriorly near the optic nerve. The stroma of the ciliary body is markedly cellular but the various muscles can be recognized, especially the meridional fibers. The pars plana is short and the ciliary processes are still in contact with the iris. The choroid is slightly thicker and more cellular but otherwise resembles that of the adult. The line of demarcation between the retina and the ciliary body is well defined but does not reach adult relationships until about seven years. As the ciliary processes are displaced backward, the angle of the anterior chamber widens to adult size between two and four years. There is no muscle of Müller present at birth. It is only after the fifth year that the ciliary muscle (and thus the whole ciliary body) takes on a triangular form. There is a great increase in the amount of connective tissue in the uveal tract; consequently the ciliary body thickens and the circumlental space is diminished.

THE LENS

The neonatal lens is more spherical than in the adult. The curvature of the anterior surface is exaggerated in the newborn as a means of increasing the total refractive power of the eye, which is necessary because the anterior-posterior diameter of the eye measures only about 17 mm, compared with a corresponding dimension of 23.5 mm in the adult. The lens occupies a disproportionately large area in the infant eye and is much rounder, resulting in a shallower anterior chamber (Fig. 2). The lens grows rapidly in the first years of life and becomes flatter owing to the pull of the ever-widening circle formed by the ciliary body. Growth and development of the lens continues throughout life (Table 1).

TABLE 1 Comparative Dimensions of the Lens

	Newborn mm	Adult mm
Equatorial diameter	6.7	9.1
Anterior-posterior diameter	3.76	3.6
Anterior radius	5.0	10.0
Posterior radius	4.0	6.0

FLUID CONTENT OF THE INFANT EYE

The fluid content of the eye consists of vitreous humor, which is static, and aqueous humor, which is constantly changing.

Aqueous Humor

Aqueous humor is secreted by the ciliary body into the posterior chamber; after it enters the anterior chamber through the pupil, it transverses the trabecular meshwork to reach Schlemm's canal. Approximately thirty collector channels conduct aqueous humor to the scleral plexus, which is in communication with the blood vascular system outside the eye. In the normal adult eye, there is a drop in pressure of 5 to 10 mm Hg across this barrier and obstruction to aqueous outflow in glaucoma of whatever type occurs somewhere in the drainage pathway between the anterior chamber and episcleral plexus (Fig. 6).

Vitreous Humor

At birth Cloquet's canal extends horizontally from a point a little below and to the nasal side of the posterior pole of the lens backward to the optic disc. The extreme anterior end of the main trunk of the hyaloid artery extends horizontally backward from the lens capsule along the first part of the canal. After birth this vascular remnant undergoes further atrophy and it gradually drops until it hangs down perpendicularly from the lens. It also becomes curled into a spiral form. At the same time, the walls of Cloquet's canal become quite lax. The whole structure tends to sag down so that its anterior open mouth—instead of pointing straight backward—comes to lie well below the posterior pole of the lens and finally on a level with the lower border of the dilated pupil.

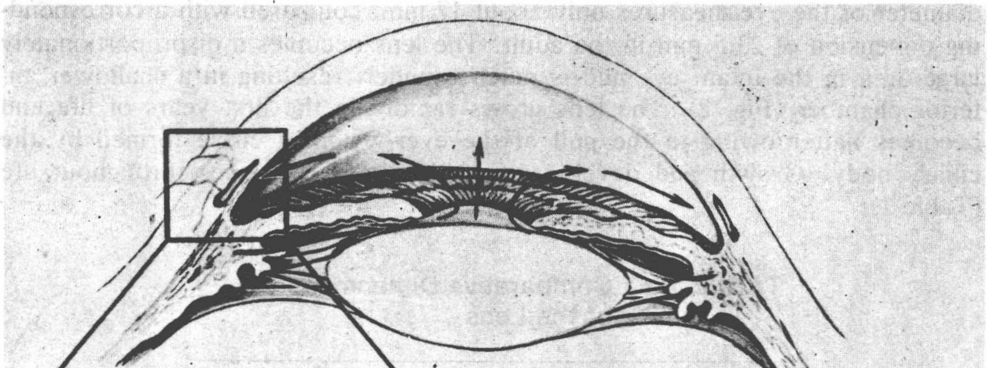

FIGURE 6 Drawings showing the pathways through which aqueous humor passes upon leaving the anterior segment of the eye. *C.M.*, ciliary muscle; *C. of S.*, canal of Schlemm; *C.S.M.*, corneoscleral meshwork; *E.M.*, endothelial meshwork; *E.P.*, episcleral plexus; *S.P.*, scleral plexus; *S.C.*, Sondermann's canal; *U.M.*, uveal meshwork. (Adapted from Speakman JS: Can Med Assoc J 84:1066, 1961.)

Thus, with the subject in the upright position, the structure is not obvious, although, as viewed with a slitlamp, the backward slope of the vitreous face indicates its continued presence in the lower part of the eye. The walls of Cloquet's canal remain extremely slack; in the adult, the structure can be made to float up and assume its embryonic position for a short time when the subject makes appropriate movements of the head and eyes.

THE CORNEA

The cornea is one of the most advanced ocular structures in the neonatal eye, having already attained more than three-quarters of its adult diameter. Postnatal growth occurs during the first half-year of life and the adult diameter is